MUNICIPAL SEPARATE STORM SEWER SYSTEM MONITORING PLAN

City of Portland, Oregon
November 1, 2022

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

MUNICIPAL SEPARATE STORM SEWER SYSTEM MONITORING PLAN

November 1, 2022

Prepared by the
City of Portland Bureau of Environmental Services
Portland, Oregon

For Stormwater and Surface Water Monitoring by the City of Portland in Compliance with MS4 Permit Requirements

MS4 Permit #101314

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Acronyms and Abbreviations

ATP	Alternate Test Procedure
BES	Bureau of Environmental Services
BMP	best management practices
City	City of Portland
COC	chain of custody
CSE	confined space entry
DEQ	Oregon Department of Environmental Quality
DFR	daily field report
EPA	U.S. Environmental Protection Agency
FDS	field data sheet
GRTS	Generalized Random Tessellation Stratification
IBI	indicators of biotic integrity
IPM	integrated pest management
LIMS	Laboratory Information Management System
MCPA	2-methyl-4-chlorophenoxyacetic acid
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
OE	observed/expected
PP&R	Portland Parks and Recreation
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
SOP	standard operating procedure
SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
UIC	Underground Injection Control
USGS	U.S. Geological Survey
WPCF	Water Pollution Control Facility
WPCL	Water Pollution Control Laboratory

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Section 1
Introduction

1.1 Purpose

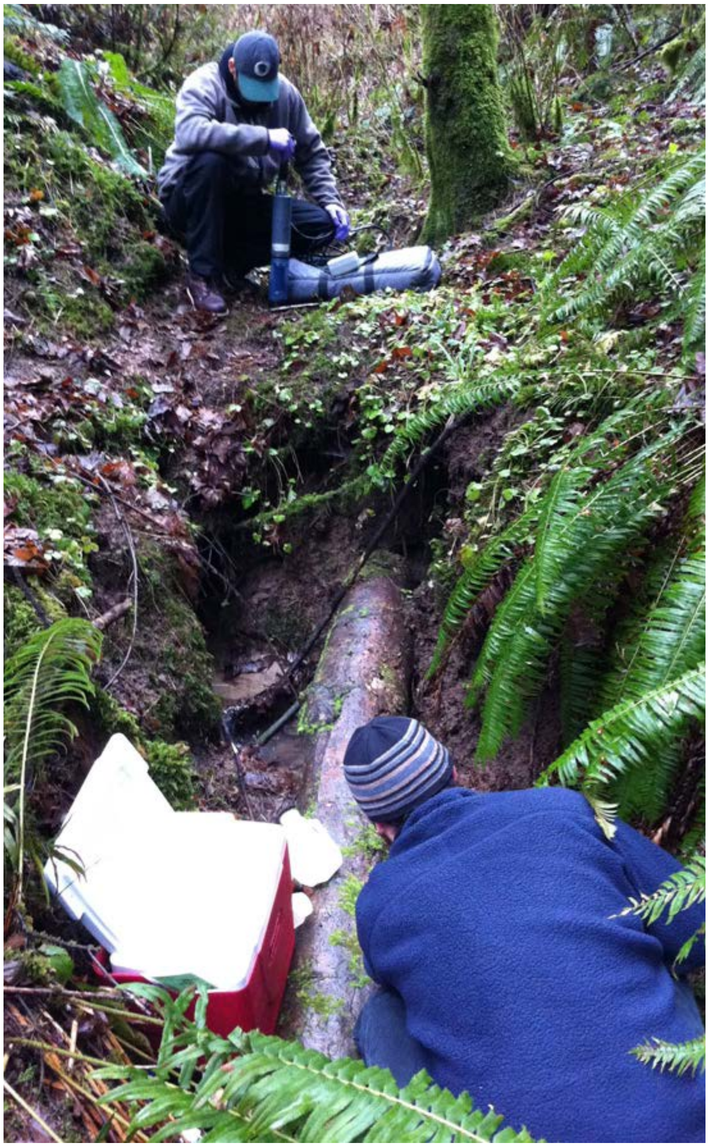
This Monitoring Plan (Plan) describes the sampling and analysis program for stormwater, surface water, macroinvertebrate, and continuous instream monitoring by the City of Portland (City) Bureau of Environmental Services (BES). Stormwater and surface water (instream) water quality data and biological data will be collected and reported annually from representative monitoring locations for compliance with the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit (Permit Number 101314) issued to the City by the Oregon Department of Environmental Quality (DEQ). The NPDES MS4 Permit requires the City to monitor stormwater and surface water during each 5-year permit term.

This Plan will guide (or provide reference to appropriate documents) all sampling, analyses, data assessment, data management, and other requirements per Schedule B.1 of the permit and will ensure that quality control and consistency are maintained.

1.2 Plan Organization

This Plan is organized into the following sections:

- **Section 1:** Summary of the MS4 permit requirements related to monitoring, procedures for making modifications to this Plan, and a summary of the overall long-term monitoring strategy
- **Section 2:** Main elements of the NPDES MS4 environmental monitoring program, including stormwater monitoring and storm event targeting
- **Section 3:** Instream monitoring
- **Section 4:** Continuous instream monitoring
- **Section 5:** Macroinvertebrate monitoring
- **Section 6:** Description of sampling staff
- **Section 7:** Description of field sampling procedures



Appendices to this Plan include the standard operating procedures (SOPs) used by City and contract staff to complete the monitoring described in this Plan.

The City has also developed a Quality Assurance Project Plan (QAPP) for this monitoring effort (included in Appendix B). The QAPP describes the procedures employed by all those involved in the implementation of permit monitoring to maintain quality control and consistency of the data.

1.3 Monitoring Program Requirements and Objectives

Schedule B.1 of the City's MS4 permit specifies minimum monitoring and reporting requirements. It lists the following six objectives that the monitoring program must incorporate:

Required Monitoring Program Objectives, *Schedule B.1.a*

- i. *Evaluate the source(s) of and means for reducing the pollutants of concern applicable to the co-permittees' permit area, including 2018/2020 303(d) listed pollutants, as applicable*
- ii. *Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities*
- iii. *Characterize stormwater based on land use type, seasonality, geography or other catchment characteristics*
- iv. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges*
- v. *Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters*
- vi. *Assess progress towards reducing TMDL pollutant loads*

Table 1 shows how the monitoring program elements presented in this Plan address each of the objectives included in the permit.

Required Monitoring Plan Elements, *Schedule B.1.c*

Schedule B.1.c requires the City to develop a monitoring plan that:

- i. *Identifies how each monitoring objective identified in Schedule B.1.a is addressed and the sources of information used. The co-permittees may use Stormwater Management Plan measurable goals, environmental monitoring activities, historical monitoring data, stormwater modeling, national stormwater monitoring data, stormwater research, or other applicable information to address the monitoring objectives*
- ii. *Describes the role of the monitoring program in the adaptive management of the stormwater program*
- iii. *Describes the relationship between environmental monitoring and a long-term monitoring program strategy*
- iv. *Describes in detail or includes by reference to external documents the following information for each environmental monitoring project/task:*
  - A. *Project/task organization*
  - B. *Monitoring objectives, including monitoring question and background, data analysis methodology and quality criteria, and assumptions and rationale*
  - C. *Documentation and record-keeping procedures*
  - D. *Monitoring process/study design, including monitoring location, description of sampling event or storm selection criteria, monitoring frequency and duration, and responsible sampling coordinator*
  - E. *Sample collection methods and handling/custody procedures*
  - F. *Analytical methods for each water quality parameter to be analyzed*
  - G. *Quality control procedures, including quality assurance, the testing, inspection, maintenance, calibration of instrumentation and equipment*
  - H. *Data management, review, validation, and verification*

Table 1. Relationship Between Monitoring and Permit Objectives

Monitoring Objectives	Stormwater Monitoring	Instream Monitoring	Continuous Instream Monitoring	Macroinvertebrate Monitoring
i. Evaluate the source(s) of and means for reducing the pollutants of concern applicable to the co-permittees' permit area, including 2018/2020 303(d) listed pollutants, as applicable	Analysis of stormwater samples includes most TMDL and selected 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Comparison of stormwater monitoring results with instream results will provide information to evaluate the role that stormwater plays as a potential pollutant source.	Analysis of instream samples includes TMDL and selected 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Evaluating instream pollutant concentrations in dry weather versus wet weather conditions will assist in identifying the role that stormwater plays as a contributing source of these pollutants.	Evaluating stream flow and temperature data (and sometimes turbidity) on a continuous basis can be used in combination with instream water quality data to identify the relationship between these parameters and pollutant concentrations allowing for more targeted source control.	Macroinvertebrate sampling, when combined with instream pollutant concentration results, provides information to support the identification of pollutants of concern by assessing their impact on instream biological communities.
ii. Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities	The stormwater monitoring approach does not directly support the evaluation of BMP effectiveness, but may be paired with other data sources to support BMP analysis in the monitored catchment.	In combination with results from stormwater monitoring, instream data will be used to evaluate instream trends and the overall effectiveness of stormwater management programs/BMP implementation.	If a relationship is identified between flow/turbidity data and pollutant concentrations, that information may be used to select and refine BMPs to enhance effectiveness.	Macroinvertebrate monitoring may be used or paired with other data to assess overall program improvements.
iii. Characterize stormwater based on land use type, seasonality, geography or other catchment characteristics	When paired with information about catchment characteristics (such as land use), stormwater monitoring provides information about potential sources of stormwater pollutants.	Instream data provides information on cumulative impacts of conditions across the watershed. It identifies areas where stormwater or other land use factors may be having the greatest impact on stream health.	N/A	Provides information on the natural characteristics of streams, and the instream biological impacts of land use.
iv. Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges	Stormwater monitoring will assist in the interpretation of instream trends in MS4 receiving waters.	Instream data will be used to assess trends in MS4 receiving waters. Both dry weather and wet season data will be collected to evaluate ambient trends reflective of stormwater management.	Continuous data will be used to support assessment of dissolved oxygen and eutrophication issues in the Columbia Slough.	Macroinvertebrate sampling will provide information to support the evaluation of trends in MS4 receiving waters.
v. Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters	Stormwater monitoring will assist in the interpretation of instream water quality concerns from potential chemical and hydrologic impacts.	Instream monitoring will provide information to assess the chemical and physical effects of MS4 runoff on receiving waters.	Continuous instream monitoring will provide information to assess some physical effects of MS4 runoff on receiving waters.	Macroinvertebrate monitoring will provide information to assess the biological effects of MS4 runoff on receiving waters.
vi. Assess progress towards reducing TMDL pollutant loads	Stormwater monitoring may provide or be paired with information for use in pollutant load modeling to assess progress toward meeting pollutant load reduction benchmarks.	Instream monitoring will provide information regarding progress towards meeting water quality criteria and the success of implementing practices to meet TMDL goals.	Continuous instream monitoring will provide information on stream temperatures that will be used to assess progress towards meeting TMDL goals.	N/A

BMP = best management practice; MS4 = Municipal Separate Storm Sewer System; N/A = not applicable; TMDL = Total Maximum Daily Load; TSS = total suspended solids.

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1.4 Monitoring Plan Modifications

Modifications to the Plan may be prompted by recommendations from field sampling or laboratory staff, during review and evaluation of the field and/or analytical data, or as part of changes to the monitoring approach. Modifications will be addressed by either revising the Plan or preparing addenda to the Plan. The revised Plan or addenda will describe both the need for the modifications and how the planned changes will be implemented (e.g., sampling and analyses, quality assurance/quality control [QA/QC]). Modifications may include, but are not limited to:

- Modifications to the data management system
- Selection of monitoring locations
- Changes in field procedures or analytical methods
- Changes in monitoring protocols
- Change in contract laboratory
- Change in stormwater data evaluation reporting (e.g., graphs, calculations, correlations) and trend analyses reporting (e.g., graphs, statistical methods)

Modifications to the Plan will be made in accordance with Schedule B.1.c.v. and B.1.c.vi. of the permit, which states:

The monitoring plan may be modified without prior DEQ approval if the following conditions (A) or (B) are met. For conditions not covered in this section, the co-permittees must provide DEQ with the proposed modification to the monitoring plan, and receive written approval from DEQ prior to implementation of the proposed modification. The conditions are as follows:

A. The modification does not reduce the minimum number of data points, which is a product of the number of monitoring locations, frequency, duration, and pollutant parameters identified in Table 2; or,

B. The modification is the result of including elements of another permit, such as a WPCF UIC permit.

Per Schedule B.1.c.vi of the permit, any modification to the Monitoring Plan will be documented in the subsequent annual report. Documentation will include a description of the rationale for the modification and how the modification will allow the monitoring program to remain compliant with the permit conditions.

1.5 Long-Term Monitoring Strategy

The City's long-term strategy for environmental monitoring is focused on evaluating the quality of both stormwater discharges and receiving waters. The purpose of the environmental monitoring is to meet the permit objectives listed above in Section 1.3 and to inform the City's decisions related to stormwater management priorities and adaptive management strategies. For both of these monitoring elements (stormwater and receiving waters), different types of sampling and analyses are conducted in an attempt to answer various questions that will address this purpose. Streams receive runoff and associated pollutants from within and outside MS4 drainage areas. Instream monitoring assesses the overall impact of all sources; Stormwater Monitoring helps assess how much of the impacts are due to activities within MS4 basins. More details regarding these types of monitoring and how they address the City's long-term monitoring strategy are described in the following sections.

Together, the different monitoring approaches described in this Plan provide a robust set of information that the City will use to adaptively manage its stormwater program. The collected data will feed into BES' planning process where it will be used to identify potential sources of impairments and to prioritize areas of concern.

Table 2. Monitoring Types and Frequencies			
Monitoring Type	**Number of Stations Sampled**	**Frequency**	**Approach**
Stormwater Outfall Monitoring	15 outfalls per year	Each outfall sampled three times per year	Outfalls currently prioritized for sampling using instream pollutant concentrations and modeled stormwater loadings. New outfalls are sampled each year to increase spatial coverage.
Pesticide Monitoring	Same 15 outfalls as stormwater outfall monitoring	Each outfall sampled once in fall or spring for three storm events over the permit term	Same as stormwater outfall monitoring.
Instream Monitoring	16 perennial streams	Quarterly seasonal (non-storm) sampling and one instream storm sample	Stations randomly selected through Generalized Random Tessellation Stratification (GRTS).
Continuous Instream Monitoring	Eight USGS permanent stream gauges Three continuous data logger sites	Continuous	City continuous data loggers: Currently continuous year-round sampling in Lower, Middle, and Upper Slough. May be re-deployed as appropriate in other TMDL-listed streams.
Macroinvertebrate Monitoring	12 perennial streams	Annually during the index period (July – October)	GRTS

The City's monitoring schedule aligns with the fiscal year, with each monitoring year beginning on July 1 and concluding on June 30.
Perennial streams have year-round water flow during years with normal amounts of rainfall.

1.5.1 Stormwater Monitoring

With respect to stormwater discharges, the City has conducted and will continue to conduct water quality sampling that can be used to characterize stormwater runoff in Portland. Through past monitoring, the City has compiled a robust inventory of stormwater quality data, allowing for the evaluation of pollutant sources and the specific drainage area qualities that may drive these sources (e.g., land use, soils). Starting with this Plan, the City is adjusting the emphasis of its stormwater sampling to focus on specific areas of the City's stormwater system that have not historically received intensive monitoring. This change in focus will target the sampling of runoff that discharges to waterbodies located in parts of the city where instream water quality issues have been identified. This change will complement both the City's past monitoring efforts and other ongoing stormwater monitoring programs (e.g., Underground Injection Control stormwater monitoring), allowing the City to utilize the stormwater monitoring to identify potential sources of pollutants across Portland.

1.5.2 Instream Monitoring

With respect to sampling Portland's receiving waters, the City's strategy is to conduct three types of instream monitoring: continuous monitoring, ambient surface water monitoring (during both the dry and wet seasons), and macroinvertebrate monitoring. Continuous instream monitoring is conducted for certain parameters (primarily water temperature and flow) and is used to evaluate fluctuations in water quality on a diurnal basis and when storm events occur.

The ambient surface water monitoring will be used to evaluate instream trends over time and to assess compliance with water quality standards and Total Maximum Daily Load (TMDL) goals. Comparing dry weather instream data with instream storm event data will also provide insights into stormwater discharge influences on water quality issues or trends.

Results from macroinvertebrate sampling may provide further insight into stream conditions. As macroinvertebrates are present in the stream year-round, the communities present can show the effects of degraded water quality and habitat. Some macroinvertebrates are more sensitive to pollution than others. Therefore, if a receiving stream is inhabited by macroinvertebrates that are more tolerant than others, a pollution problem could exist. Comparing information on the presence of various macroinvertebrate communities to water quality data from the same site will provide indications regarding the potential problems (e.g., low dissolved oxygen, high temperatures and sedimentation) and overall condition of the stream reach.

Section 2

Stormwater Monitoring

The City's stormwater monitoring includes the monitoring of stormwater discharges from specific points in the City's stormwater system during defined storm events. Stormwater monitoring sites are typically manholes or outfalls within the stormwater conveyance system. City of Portland staff or its contractors will collect the samples, and the City's Water Pollution Control Laboratory (WPCL) and the City's contract laboratories will analyze the samples, as described in the QAPP. City staff will be responsible for data collection and management, as well as data evaluation and reporting.

2.1 Background

The City began collecting stormwater samples from land use-based monitoring locations in 1991 to meet NPDES permit requirements to characterize stormwater runoff.

In 1997, a comprehensive stormwater land use characterization report (ACWA, 1997) was developed that compiled stormwater characterization data from all Phase I permittees in Oregon. The study concluded that for most parameters, stormwater pollutant concentrations by land use are similar across all six participating jurisdictions. To date, this is still the most comprehensive stormwater characterization study conducted in Oregon. Based on this report, DEQ agreed that "a good deal of this characterization has been completed, at least to a point where additional information is not likely to significantly improve our current knowledge of general stormwater quality conditions from different land uses" (DEQ, 1997). Therefore, beginning in 1997, land use-based stormwater monitoring was gradually reduced, and funds were shifted to other aspects of the MS4 monitoring program, including BMP effectiveness and instream surface water monitoring.

The 1991—1996 stormwater monitoring study (ACWA, 1997) and rainfall quality study (Sullivan, 2005) indicated that differences in rainfall and stormwater pollutant concentrations are predominantly driven by land use and not geography, consequently the City shifted its stormwater monitoring strategy away from land use sites to the City Underground Injection Control (UIC) network for the new 2011 permit term. In January 2011, the City initiated a probabilistic stormwater monitoring approach, which included sampling runoff at City UIC locations. The advantage of targeting the UIC stormwater network for MS4 compliance monitoring was that it had been sampled to meet Water Pollution Control Facility (WPCF) Permit requirements since 2005, and a large stormwater pollutant concentration data set was already available that enabled robust statistical analyses.

In addition, under the previous monitoring plan, the City elected to resume monitoring at four of the original land use sites with historic data in order to assess whether there were significant changes or detectable trends in the quality of stormwater runoff at these sites. In the City's *Annual Compliance Report No. 26 Fiscal Year 2020-2021*, long-term trends in water quality concentrations were evaluated for all four sites (BES, 2021). No significant trends in water quality were observed to be either positive or negative over the 20-year period at three of the sites for any of the parameters. Decreasing trends in water quality concentrations (improving water quality) were identified at one site for some metals. No corresponding trend in total suspended solids was observed. Given the limited trends observed in the stormwater results from the land use sites and the resource intensity required to implement this type of sampling, the City is discontinuing this monitoring effort of revisiting four of the land use sites in favor of the updated approach described in Section 2.3.[1]

1. The monitoring approach for the land use sites included the collection of flow-weighted composite stormwater samples. Each individual stormwater sample required multiple days of field work, as well as intensive staff oversight during the storm to ensure that the appropriate sub-samples were collected. Issues with the sampling equipment were regularly encountered, often requiring staff to re-sample a location to meet sampling objectives. DEQ was notified of these changes in a memo from Loren Shelley (City of Portland BES) to Pablo Martos (Oregon DEQ) dated July 11, 2022. Subject: City of Portland's intent to implement an updated MS4 Monitoring Plan; and Intent to continue using an alternative analytical procedure for mercury. MS4 NPDES Permit #101314.

In this Plan, the City is adjusting the stormwater monitoring approach to focus on areas of the City's stormwater system that have not been well represented in past stormwater monitoring. This Plan will use observed instream water quality issues or impairments associated with stormwater pollutants to target areas of the city for sampling. The City will target stormwater runoff sample collection from MS4 outfalls in these areas. Targeted areas may change over time as instream water quality impairments or other issues of interest are identified.

Pesticide Monitoring

As part of the City's previous MS4 permit, the City implemented a pesticide monitoring plan beginning in 2012. The City employed a phased approach to pesticide sampling, initially analyzing stormwater samples for a large number of pesticides using the Multi-Residue Pesticide Profile created by Pacific Agricultural Laboratory, followed by targeted analysis of specific pesticides (BES, 2012). The results of the broad sampling detected very few of the pesticides above the detection limit (BES, 2014).

Review of past pesticide monitoring and products currently in use in the Portland area identified 57 pesticides that are either used or have been detected in the Portland area (Blischke and Kohlbecker, 2009). Of these pesticides, 24 do not have U.S. Environmental Protection Agency (EPA) or DEQ risk-based screening levels. Of the 33 pesticides with screening levels, 25 have low mobility and persistence or low toxicity. Only eight pesticides with screening levels have either moderate or high mobility or moderate to high persistence, and moderate or high toxicity. These eight are: atrazine, chlorothalonil, dinoseb, diuron, p,p′-DDE, p,p′-DDT, 2-methyl-4-chlorophenoxyacetic acid (MCPA), and simazine.

The Portland Parks and Recreation (PP&R) Integrated Pest Management Plan (IPM; PP&R, 2019) guides the use and application of pesticides in public parks. BES staff also use pesticides to control invasive plants on City property (BES, 2020). While the list of approved pesticides in the City's IPM is substantial, many of the pesticides are used in very localized areas for specialty applications, such as rose gardens and high-value trees, or they are used inside greenhouses where the probability of runoff into the City's stormwater system is negligible. Across both programs, the most commonly used products include glyphosate and triclopyr. It is important to note that private parties also apply these and other products to private property. The results from the pesticide monitoring will provide insight into which products may be present in stormwater; however, they will not distinguish between public or private sources.

As part of this Plan, the City will employ a monitoring approach similar to the previous MS4 pesticide monitoring plan. Stormwater will be collected annually in the fall or spring. Samples will be analyzed using the Multi-Residue Pesticide Profile, which evaluates samples for 232 pesticides that represent a wide range of possible pesticides in stormwater. In addition to the broad panel analysis, the City will analyze samples for dichlorodiphenyldichloroethylene/dichlorodiphenyltrichloroethane (DDE/DDT), dieldrin, dinoseb, glyphosate, MCPA, and triclopyr based on results of previous pesticide monitoring for this and other programs (see Section 2.5 for details).

2.2 Monitoring Objectives

Stormwater monitoring will contribute to Monitoring Objectives i to vi identified in Schedule B.1.a of the MS4 permit (Table 1). Specifically, stormwater monitoring is critical for evaluating the sources and means of reducing pollutants, as well as characterizing stormwater based on multiple catchment conditions. Stormwater monitoring will also assist in evaluating progress toward addressing TMDL objectives and providing valuable water quality data for the City's future pollutant load reduction evaluation.

2.3 Approach

Stormwater sampling will focus on collecting grab samples from locations representative of the City's MS4 outfall basins using the selection process described below. Site selection will target outfalls that discharge to waterbodies located in parts of the city where instream water quality issues have been identified based on modeling and statistical analysis of instream water quality data. To maximize the spatial coverage of the program, a new set of 15 outfalls will be sampled each year, with three sampling events per outfall. Previous stormwater monitoring indicates that rotating stations provides the greatest amount of new information – spatial variability among outfalls is high, whereas repeated sampling of the same outfalls tends to yield consistent results with only a small amount of year-to-year variation (BES, 2021; J. Law, personal comm[2].).

The City currently conducts and oversees multiple stormwater sampling efforts to address other City objectives and regulatory requirements, such as the Portland Harbor Joint Source Control Strategy and other program needs that are outside the scope of this Plan. The stormwater monitoring approach outlined in this Plan can be paired with these other monitoring efforts to provide useful data at a citywide scale.

2.3.1 Site Selection

Portland's municipal stormwater conveyance system includes approximately 1,700 stormwater outfalls that are covered by the City's MS4 permit. These outfalls vary in size, with catchment areas ranging from 0.01 to 750 acres with a mean of 9.7 acres. The outfall basins comprise a variety of different land uses and are located throughout the city in all watersheds and subwatersheds.

Outfalls in subwatersheds that have historically been underrepresented in the City's stormwater monitoring will be the initial focus of this Plan (i.e., Years 1 and 2).[3] Outfalls that discharge to surface waters with identified water quality impairments will be further prioritized within this scope. Observed and modeled water quality data will be used to target MS4 outfalls located in receiving waters with higher pollutant loads. This will provide valuable information that informs source control and stormwater management actions. This adaptive stormwater monitoring approach prioritizes Monitoring Objectives i and iii in Table 1 and can be used to calibrate pollutant load models for these areas. The approach of focusing on and rotating within smaller geographic areas also increases the City's ability to obtain all samples during the same storm event, which is useful for data quality and comparative analyses.

Within the geographic focus area, five target subwatersheds were initially prioritized based on estimates of pollutant concentrations from instream monitoring (City's MS4 Monitoring Web Map): Upper Tryon, Tryon Creek State Natural Area, Fanno Mainstem, Fanno Tributaries, and Lower Johnson Creek. From these five priority subwatersheds, Upper Tryon will be sampled in the first year of this Plan.[4] Fifteen outfalls have been identified and field-visited for sampling feasibility. In Year 2 of this Plan, a panel of 15 new monitoring locations will be identified within the Fanno Mainstem and Fanno Tributaries subwatersheds.

Prior to Years 3 to 5 of this Plan, the City will evaluate the data from the first 2 years to inform the sampling strategy for the remaining years. For example, the strategy may shift to an approach to obtain unbiased citywide estimates of stormwater loading to better support Monitoring Objective v in Table 1. The strategy may also use a hybrid approach, where a subset of the sites is used to estimate stormwater system-wide conditions (to support Monitoring Objectives iii and v) and a subset targeted to areas with higher potential pollutant loading to address objectives i and iii.

Existing and potential future monitoring locations are identified on the City's MS4 Monitoring Web Map. New rotating panels will be added to the map as they are identified and field-verified.

2. Jason Law, BES Statistician, personal communication July 7, 2022.

3. The targeted areas will initially exclude outfall basins in the Columbia Slough and Willamette River mainstem, as these areas have had extensive and ongoing source control and stormwater investigations through the Portland Harbor and Columbia Slough Sediment programs. Willamette River and Columbia Slough basins will be included in future MS4 sampling as the geographic disparity in stormwater outfall sampling effort is reduced.

4. Upper Tryon has extensive urbanization that flows to a large state natural area downstream. Candidate outfalls were less numerous in Lower Johnson (because of combined sewer overflows [CSOs] and UICs) and the Tryon Creek State Natural Area. Upper Tryon is at the top of the catchment, meaning that local effects of stormwater can be more readily separated from upstream sources.

2.3.2 Monitoring Frequency and Duration

The City will collect three stormwater samples from each of the 15 designated sampling locations between July 1 and June 30 of each year unless conditions beyond the City's reasonable control are encountered that prevent the collection of samples during a rain event or prevent analyzing any sample or pollutant parameter. Per Schedule B.1.d, the City will notify DEQ in writing with the submission of the annual monitoring report if any such circumstances are encountered.

The City will begin targeting storm events for stormwater sampling each fall. Sites will be sampled as appropriate storm events are identified throughout the monitoring season and as storm events allow.

During each permit year, the City will attempt to sample as many of the 15 selected locations during the same storm event as possible.[5] If all locations cannot be sampled during a single targeted storm, the remaining locations will be sampled during subsequent storms that meet the criteria required by the permit.

For pesticide monitoring specifically, the City will target three storm events during the permit term to collect samples from 15 locations. The City will aim to collect pesticide samples during the fall or spring (i.e., when pesticide applications are typically higher).

2.3.3 Sample Collection Methodology

The City will collect grab samples at each of the stormwater monitoring locations. Grab samples will be collected by placing the sample bottle directly in the flow of water, facing upstream. If site conditions preclude the direct collection of grab samples, samples will be collected using decontaminated stainless-steel beakers. If used at the site, the beaker will be placed into the flow of stormwater and brought to the surface grade to fill sample containers. To eliminate the need for field decontamination, a separate decontaminated beaker will be dedicated to each sample location. The sampling team will take care not to place the decontaminated beaker on the ground or hit any part of the manhole or stormwater pipe during sampling activities. For trace-level contaminant monitoring where sample bottles cannot be filled directly, field crews utilize a clean hands/dirty hands sampling methodology. The "clean hands" members are responsible for:

- Removing sampling containers from the sample cooler
- Removing foil from decontaminated stainless-steel beakers
- Placing and removing the beaker from the swing sampler (if used)
- Filling and capping sample containers
- Placing full sample containers back into the cooler
- Placing field meter probes into stormwater for field parameter measurements

"Dirty hands" members are responsible for:

- Removing manhole covers with a manhole puller
- Using the swing sampler and beaker to collect the stormwater sample
- Ensuring that they do not contact the stormwater sample

5. Storm events often fall short of predicted rainfall amounts and/or durations. Therefore, there is a possibility that rainfall or runoff may cease prior to the collection of all 15 samples during a single event.

Samples will be placed in precleaned bottles provided by the analytical laboratory and analyzed for the parameters specified in Table 3, which shows the required sample containers, sample volume, preservative requirements, and maximum holding times. A separate cooler will be prepared for each site and provided with a zip-tied cooler tag that can be labeled with the sample point code (i.e., location) in the field at the time of sample collection.

Dissolved oxygen, pH, specific conductivity, and temperature will be measured *in situ* at each sample location. Field measurements will be taken from collected stormwater water samples by inserting the analytical field meter probes into the stainless-steel beaker or by directly inserting the analytical field meter probes into the flow of surface water.

Field meters will be calibrated at the WPCL prior to initiating stormwater sampling activities using standard field meter calibration procedures (BES Field Operations SOP 1.06a, Appendix A). Meters are also checked for drift at the WPCL at the end of the field day prior to relinquishing samples. For field parameters that fail drift checks, data is either flagged or rejected as appropriate.

2.3.4 Sampling Considerations

Storms may occur at any time; however, the City will primarily target storms during regular business hours for safety concerns and to limit overtime hours for laboratory staff to meet stringent sample holding time requirements.

As described above, the City will collect stormwater samples three times from 15 sampling locations between July 1 and June 30 unless conditions are encountered that are beyond the City's reasonable control (e.g., atypical climatic conditions such as extended drought). The City will begin tracking and targeting storm events each fall that meet the storm criteria presented in Section 2.4. It may take more than one storm to collect samples from all 15 sampling locations. The locations that are not sampled during the first storm will be prioritized for subsequent storms that meet the criteria described in Section 2.4.

2.4 Storm Event Targeting

2.4.1 Storm Criteria

The City will adhere to the target storm criteria included in Schedule B.1.d.ii, as noted below, of the permit to the extent practicable. Targeting these criteria will help ensure that stormwater runoff will be adequate for sample collection, representative of stormwater runoff, and consistent across sampling events. Before initiating sampling, the storm forecast will be evaluated against the criteria listed below to assess whether the storm should be targeted for potential sampling. Based on the City's extensive experience with stormwater monitoring in this region, storms meeting these criteria are expected to provide the volume, intensity, and duration of runoff necessary to collect individual samples. Smaller or shorter storms are considered to have a low probability of producing sufficient runoff to warrant the extensive preparation and mobilization time required for stormwater sampling.

It is likely that a storm may not meet all the criteria below when sampling is completed due to the inherent uncertainty of weather. The following criteria from the permit will therefore be used as guidance to determine when storms should be targeted for sampling during this project:

- All water quality samples must be collected during a storm event that is predicted to be greater than 0.1 inch of rainfall.
- When possible, samples should be collected after an antecedent dry period of a minimum of 12 hours.
- Precautions should be taken to avoid the collection of samples lacking stormwater runoff, such as when the intra-event dry period of a storm exceeds 6 hours.
- Samples should be collected during stormwater runoff-producing events that represent the local or regional rainfall frequency and intensity, including event types that may be expected to yield high pollutant loads/ concentrations.

Characteristics for each storm during which samples are collected will be documented and summarized in the City's Annual Monitoring Report. If the City is unable to collect all samples because of atypical climatic conditions, representative climatic data will be provided to document these conditions.

2.4.2 Rainfall Data

The City operates a network of approximately 50 rainfall gauges throughout the Portland area. The rainfall gauges record precipitation amounts in 0.01 inch increments. Rainfall data are managed by BES and are available to the public online.[6] The City will use the rain gauges closest to the sampling locations to document the total rainfall for the sampled storm events.

2.4.3 Weather Forecasting

The Storm Monitoring Coordinator for this project is the BES Field Operations supervisor or a designated alternate (see Section 6). The Storm Monitoring Coordinator is responsible for tracking storms and reviewing weather forecasts to determine if a predicted storm is likely to meet the criteria for initiating sampling. If the weather forecast predicts that the storm criteria will be met, the Storm Monitoring Coordinator is responsible for mobilizing the BES sampling teams, coordinating with the laboratory, and ultimately making the "go/no go" decision on sampling.

The City also engages a private local weather forecasting service as a weather consultant. The Storm Monitoring Coordinator receives daily weather forecasts from the City's weather consultant that have a 10-day forecast including the quantity of precipitation forecasts for each day. The City's weather consultant is available on an as-needed, on-call basis for telephone consultations regarding upcoming storms. When a candidate storm

6. Rainfall data is available online: https://or.water.usgs.gov/non-usgs/bes.

approaches, the Storm Monitoring Coordinator will communicate frequently with the City's weather consultant to determine whether to mobilize sampling teams to begin sampling operations.

Other forecasting resources include online resources such as National Weather Service predictions, Doppler radar, and smartphone weather applications.

2.5 Parameters and Analytical Methods

Samples from the stormwater monitoring locations will be analyzed for the list of parameters specified in Table 3 using the listed analytical methods.

Table 3. Laboratory Parameters and Methods for Stormwater Samples

Analyte[1]	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
Total Recoverable Metals (Cu, Pb, Zn)	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Total Recoverable Metals (Hg)	HDPE	500 mL	WPCL SOP M-10[2]	HNO_3 to pH<2; cool to 4°C ±2°C	28 days
Dissolved Metals (Cu, Pb, Zn)	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	EPA 350.1	HNO_3 to pH<2; cool to 4°C ±2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	EPA 300.0	Cool to 4°C ±2°C	48 hours
Total Phosphorus	Plastic	1 pint	EPA 200.8[2]	HNO_3 to pH<2; cool to 4°C ±2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	EPA 365.1	Cool to 4°C ±2°C	48 hours
Alkalinity	Plastic	1 pint	SM 2320B	Cool to 4°C ±2°C	14 days
BOD_5 (if TMDL is established)	Plastic	1 quart	SM 5210B	Cool to 4°C ±2°C	48 hours
Dissolved Organic Carbon	Amber glass	125 mL	SM 5310B	H_2SO_4 to pH<2; Cool to 4°C ±2°C	28 days
E. coli	Sterile plastic	250 mL	Colilert QT	Cool to 4°C ±2°C	8 hours
Hardness	Plastic	½ pint	SM 2340B	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Total Suspended Solids	Plastic	1 quart	SM 2540D	Cool to 4°C ±2°C	7 days

Table 3. Laboratory Parameters and Methods for Stormwater Samples					
Analyte[1]	**Container Type**	**Sample Volume**	**Method**	**Preservation Requirements**	**Holding Time**
Organochlorine Pesticides (p,p'-DDE, p,p'-DDT, dieldrin)	Amber glass	1 liter	EPA 608.3	Cool to 4°C ±2°C	7 days (extraction) 40 days (analysis)
Glyphosate and degradate (AMPA)	Amber glass	1 liter	EPA 547.1	Cool to 4°C ±2°C	14 days
Chlorinated Herbicides (dinoseb, MCPA, triclopyr)	Amber glass	1 liter	EPA 8151A	Cool to 4°C ±2°C	7 days (extraction) 40 days (analysis)
Pesticide Multi-Residue Screen	Amber glass	1 liter	EPA 8321B/ 8270D	Cool to 4°C ±2°C	7 days (extraction) 40 days (analysis)

[1] Samples will also be analyzed in the field for dissolved oxygen, specific conductivity, pH, and temperature.
[2] DEQ-approved Alternate Test Procedure (ATP).

As noted in Schedule B.1.d.iii of the permit, a co-permittee may propose an alternative sampling or analytical method to those prescribed in the Code of Federal Regulations (40 CFR 136) to DEQ for review and approval. In 2006, the WPCL received approval to perform an ATP for total mercury from the EPA (2006) and from DEQ (2006). The 2006 ATP was approved for compliance testing required under four of the City's NPDES permits including the NPDES MS4 Permit #108015. An updated mercury ATP was approved by DEQ in 2017 in addition to an ATP for phosphorus. The City submitted a letter in July 2022 notifying DEQ of the intention to use these alternate procedures in this Plan. [7]

2.6 Connection to Long-Term Monitoring Strategy

The City's stormwater monitoring approach has evolved over the years from the stormwater monitoring that began in 1991. The early monitoring focus was on characterizing stormwater from various land uses using more intensive sampling techniques. The outfall monitoring described in this Plan is a continuation of the City's work to characterize stormwater discharges to receiving waters. The stormwater monitoring described in this Plan builds upon the City's prior monitoring efforts by expanding the scope of sampling to include parts of the city that historically have not been as intensively monitored. Additionally, the data collected as part of this monitoring will be used by the City as a tool for identifying the sources of pollutants to the City's storm conveyance system. The stormwater monitoring data may also be used to support the City's upcoming TMDL pollutant load reduction evaluation required under Schedule D.3.c of the permit.

7. Memo from Loren Shelley (City of Portland BES) to Pablo Martos (Oregon DEQ) dated July 11, 2022. Subject: City of Portland's intent to implement an updated MS4 Monitoring Plan; and Intent to continue using an alternative analytical procedure for mercury. NPDES MS4 Permit #101314.

Section 3

Instream Monitoring

The City's instream monitoring includes the collection and analysis of water quality samples from surface waters that receive MS4 discharges. Samples are collected during both wet and dry weather conditions. City staff will collect the samples, and the City WPCL and the City's contract laboratories will analyze the samples, as described in the QAPP (Appendix B). City staff will also be responsible for data collection, data management, analysis, and reporting.

3.1 Background

Starting in the early 1990s, the City collected samples from a set of fixed instream monitoring locations representing various receiving water bodies throughout the city. In 2010, the City re-evaluated and revised its instream monitoring program based on national watershed monitoring approaches to better capture the variability in stream conditions throughout Portland and to align with other regional and national monitoring efforts. The City transitioned to a new method for continued instream monitoring adapted from the EPA *National Rivers and Streams Assessment, Field Operations Manual* (EPA, 2019). The method is based on the generalized random tessellation stratified (GRTS) design. The design has a rigorous statistical foundation yet is able to adapt to the challenges and complexities of collecting data in the natural environment. This instream monitoring approach, which will be continued under this Plan, includes four rotating panels of sampling locations at perennial stream sites.

3.2 Monitoring Objectives

Instream monitoring will contribute to Monitoring Objectives i, ii, iv, v, and vi identified in Schedule B.1.a of the MS4 permit (Table 1). Specifically, instream monitoring is critical for evaluating long-term trends in receiving waters with MS4 discharges, as well as for assessing the effects of MS4 discharges on receiving waters by evaluating and comparing data collected during both dry and wet weather conditions. Instream monitoring will also assist in evaluating progress toward addressing TMDL objectives.

3.3 Approach

Instream sampling will focus on collecting grab samples from streams throughout the Portland area. Instream sampling sites will be located on perennial streams across Portland's watersheds. To maximize the spatial coverage of the program, the instream monitoring approach will include the sampling of a rotating panel of sites with a minimum of 16 sites sampled each year.

3.3.1 Site Selection

As noted above, the instream monitoring approach employs a probabilistic approach using a GRTS sampling design. Instream sampling sites are randomly selected from across the city in a way that balances the number of sites within each of Portland's major watersheds. Sites are then divided into monitoring panels. Each panel of sites is composed of a minimum of 16 perennial stream sites.

3.3.2 Monitoring Frequency and Duration

A minimum of four grab samples will be collected per year at each instream sampling location. Per Schedule B.1.d of the permit, the instream samples will be collected to meet the following conditions:

- A minimum of 50 percent of the water quality sampling events will be collected during the wet season (September 1 to April 30).
- Each unique sample event at a location of a given type (wet weather or dry weather) must occur at a minimum of 72 hours apart.

The instream monitoring will employ a probabilistic survey design to monitor Portland's waterways, with a total target of 80 perennial sites across the city's watersheds. The sample sites are divided into four panels that are sampled on a 4-year rotating basis, with a target of 16 perennial sites included in each panel. Seasonal (once per quarter) water quality samples will be collected at each perennial site each year. Additionally, the City will aim to collect one targeted sample during a storm event at each instream site each year.

3.3.3 Instream Monitoring Frequency and Panel Rotation

Instream monitoring uses a 4-year rotational panel design (see Figure 1). Sixteen stations are sampled each fiscal year from July to June. A different set of stations is sampled each year for 4 years, and then the panels are repeated. A map of each sampling station is available on the City's MS4 Monitoring Web Map.

Figure 1. Instream Monitoring Panel Rotation

Year	Panel Rotation			
FY 22-23	Panel 1			
FY 23-24		Panel 2		
FY 24-25			Panel 3	
FY 25-26				Panel 4
FY 26-27	Panel 1			
FY 27-28		Panel 2		
FY 28-29			Panel 3	
FY 29-30				Panel 4

3.3.4 Sample Collection Methodology

For instream monitoring activities, sampling teams will use the following procedures to access each sampling location:

- Set up a staging area close to but at a safe distance from the surface water body
- Observe and document conditions near the sampling location that may affect surface water quality, such as:
  - Physical characteristics (e.g., bank condition, vegetation, shading)
  - Human activities (e.g., homeless camps, trash)
  - Potential pollutant sources/pathways (e.g., pipe discharge, upstream land use activities)
- Determine if the flow rate in the stream allows for safe access to the stream

Additional personal safety procedures are described in Section 7. For stream sites accessed by boat, a personal flotation device should be worn by all staff while on the water.

Grab samples will be collected at the selected instream sites, facing upstream. At wadeable sites, the sample bottle or beaker will be submerged upside down, then slowly turned right side up while bringing it up through the water column. Samples will be collected directly into the analyte-specific bottle if there is sufficient water depth. If water depth is insufficient for direct collection into bottles, samples will be collected into a decontaminated stainless-steel beaker and then transferred into the analyte-specific bottles. For trace-level contaminant monitoring where sample bottles cannot be filled directly, field crews use the clean hands/dirty hands sampling methodology described in Section 2.3.3. Prior to use in the field, beakers will be decontaminated according to the protocol described in Section 7.3. For deeper, faster-moving stream segments, samples are collected from bridges using a column sampler in accordance with BES Field Operations SOP 2.02d (Appendix A).

The required sample containers, sample volume, preservative requirements, and maximum holding times are provided in Table 4.

Since sample bottles are typically submerged during sample collection, necessary preservatives must be added after sample collection. Sample preservation will be conducted in the field if analytical methods require immediate sample preservation. Otherwise, preservatives will be added to samples by WPCL staff within the timeframe specified by the appropriate analytical methods. Samples will be placed in pre-prepared coolers with ice immediately after sample collection and labeling.

Sample kits are prepared at the WPCL prior to going out in the field. A separate cooler will be prepared for each site and provided with a zip-tied cooler tag that can be labeled with the sample location code in the field at the time of sample collection.

Dissolved oxygen, pH, specific conductivity, and temperature will be measured *in situ* at each sample location. Field measurements will be taken from collected surface water samples by inserting the analytical field meter probes into the stainless-steel beaker or by directly inserting the analytical field meter probes into the flow of surface water.

Field meters will be calibrated at the WPCL prior to initiating instream sampling activities using BES Field Operations SOP 1.06a (Appendix A), Field Measurement of Multiple Water Quality Parameters. Meters are also checked for drift at the WPCL at the end of the field day prior to relinquishing samples. For field parameters that fail drift checks, data is either flagged or rejected as appropriate.

3.4 Parameters and Analytical Methods

Samples from the instream monitoring locations will be analyzed for the list of parameters specified in Table 4 using the listed analytical methods.

Table 4. Laboratory Parameters and Methods for Instream Samples

Analyte[1]	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
Total Recoverable Metals (Cu, Pb, Zn)	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Total Recoverable Metals (Hg)	HDPE	500 mL	WPCL SOP M-10[2]	HNO_3 to pH<2; cool to 4°C ±2°C	28 days
Dissolved Metals (Cu, Pb, Zn)	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	EPA 350.1	H_2SO_4 to pH<2; cool to 4°C ±2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	EPA 300.0	Cool to 4°C ±2°C	48 hours
Total Phosphorus	HDPE	500 mL	EPA 200.8[2]	HNO_3 to pH<2; cool to 4°C ±2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	EPA 365.1	Cool to 4°C ±2°C C	48 hours
Alkalinity	Plastic	1 pint	SM2320B	Cool to 4°C ±2°C	14 days
BOD_5 (if TMDL is established)	Plastic	1 quart	SM5210B	Cool to 4°C ±2°C	48 hours
Dissolved Organic Carbon	Amber glass	125 ml	SM5310B	H_2SO_4 to pH<2; cool to 4°C ±2°C	28 days
E. coli	Sterile Plastic	250 mL	Colilert QT	Cool to 4°C ±2°C	8 hours
Hardness	Plastic	½ pint	SM2340B	HNO_3 to pH<2; cool to 4°C ±2°C	6 months
Total Suspended Solids	Plastic	1 quart	SM2540D	Cool to 4°C ±2°C	7 days

[1] Samples will also be analyzed in the field for dissolved oxygen, specific conductivity, pH, and temperature.
[2] DEQ-approved Alternate Test Procedure (ATP).

As noted at the end of Section 2.5, the City's MS4 permit allows co-permittees to propose alternative sampling or analytical methods to those prescribed in 40 CFR 136 to DEQ for review and approval. In 2006, the WPCL received approval to perform an ATP for total mercury from EPA and from DEQ. The 2006 ATP was approved for compliance testing required under four of the City's NPDES permits including the NPDES MS4 Permit #108015.

3.5 Connection to Long-Term Monitoring Strategy

Instream water quality monitoring is one of the monitoring elements that the City has employed to inform MS4 program management, as well as TMDL development and implementation and watershed protection and restoration actions. Instream water quality monitoring provides a direct measure of the chemical condition of streams within the City that receive MS4 stormwater and other discharges. In addition to other chemical, physical, and biological data collected instream, instream water quality monitoring allows for the evaluation of long-term trends, correlating physical and chemical measurements to the biological health of the stream, tracking long-term climatic changes, and evaluating the cumulative effect of implementing the City's NPDES MS4 Stormwater Management Plan (SWMP). Therefore, instream water quality monitoring will remain a central element of the City's monitoring program.

Section 4

Continuous Instream Monitoring

Continuous instream monitoring includes ongoing physical and chemical stream monitoring at fixed locations within streams that receive MS4 runoff. Permanent stream gauges are a typical setup, recording frequent measurements as well as the calculation of stream flow (discharge) based on the cross-section of the stream at the monitoring location and the recorded stream gauge height. Continuous instream monitoring typically records a measurement every 15 or 30 minutes. The U.S. Geological Survey (USGS) operates multiple stream gauges at several instream locations in Portland, providing robust data management, storage, and hosting the data on a publicly accessible web site.[1]

In addition to permanent stream gauges, continuous monitoring equipment may be deployed in certain locations to record other parameters, such as dissolved oxygen and pH. The City is deploying time-series data loggers to measure instream conditions for TMDL-listed streams. The focus in past years has been on the Columbia Slough but the City may re-deploy data loggers as appropriate in other TMDL-listed streams.

4.1 Background

The USGS operates stream gauges in many Portland streams. Some sites have been monitored since 1940, but more typically, monitoring started in the 1980s. All gauges provide water level and calculated discharge. Five gauges also provide temperature monitoring (Table 5). These gauge data can be used to compare water quality results and their potential relationship with flow. These gauges have also provided valuable information for a variety of MS4 permit and TMDL-related activities, such as the creation of flow duration curves in Johnson Creek that were instrumental in establishing the bacteria TMDL[2] and flood monitoring.

The City relies on the USGS stream gauges to meet the requirements included in Schedule B of the permit to conduct continuous instream monitoring at three sites for flow and temperature. To ensure the long-term operation of the gauges, the City and other stakeholders in the area partner with USGS to assist with funding the USGS stream gauges. The City provides partial funding for the monitoring sites through a joint funding agreement. The current agreement between the USGS and the City includes funding for the stream gauges listed in Table 5.[3]

The City also conducts continuous instream monitoring in the Columbia Slough. The 1998 Columbia Slough TMDL identifies the City as a designated management agency (DMA). As a DMA, the City has conducted continuous instream monitoring of dissolved oxygen, pH, specific conductance, and temperature to support TMDL[4] implementation. In the past, this continuous monitoring in the Slough has been managed separately from the City's MS4 monitoring efforts. To facilitate the integration of the City's monitoring efforts across MS4 and TMDL obligations, the City is incorporating the continuous monitoring into this Plan.

4.2 Monitoring Objectives

Continuous instream monitoring will contribute to Monitoring Objectives i, ii, iv, v, and vi identified in Schedule B.1 of the MS4 permit (Table 1). Additionally, the continuous instream monitoring will support the implementation of the TMDLs by including the collection of continuous dissolved oxygen and pH data to help assess progress towards meeting the TMDL goals for biological oxygen demand and eutrophication.

1. USGS stream gauge data is available online from the National Water Information System: https://waterdata.usgs.gov/nwis.

2. See chapter 2 of the Willamette Basin TMDL approved by EPA on Sept 29, 2006: https://www.oregon.gov/deq/FilterDocs/chpt2bacteria.pdf

3. U.S. Department of the Interior, U.S. Geological Survey 2019 Joint Funding Agreement for Water Resource Investigations, https://efiles.portlandoregon.gov/Record/13152687.

4. Willamette Basin TMDLs - https://www.oregon.gov/deq/FilterDocs/columbiasloughtmdl.pdf, https://www.oregon.gov/deq/FilterDocs/chpt4temp.pdf, https://www.oregon.gov/deq/FilterDocs/tmdlwqmp.pdf, and https://www.oregon.gov/deq/wq/Documents/willHgtmdlwqmpF.pdf

4.3 Approach

Continuous instream monitoring will rely on the operation of the USGS stream gauges in the Portland area and will include the deployment of multiprobe meters in the Columbia Slough.

4.3.1 Site Selection

The City relies on eight existing stream gauges operated by the USGS in the Portland area. Gauge locations and the associated parameters recorded at each station are included in Table 5.

The City currently deploys continuous loggers at three locations along the Columbia Slough, with one station in each of the main slough segments (lower, middle, and upper). These sites and associated parameters recorded at each station are included in Table 5. The City may re-deploy data loggers as appropriate in other TMDL-listed streams. Locations of continuous loggers also need to be managed due to vandalism, theft, and other reasons.

Table 5. Continuous Instream Monitoring Locations

	Location	Parameter	Period of Record
USGS STREAM GAUGES	Columbia Slough, RM 0.25 USGS Gauge #14211820	Gauge height	10/01/1989 – to date
		Discharge	
	Fanno Creek at SW 56th Ave, RM 11.9 USGS Gauge #14206900	Gauge height	10/01/1990 – to date
		Discharge	
	Crystal Springs Creek at Bybee, RM 1.0 USGS Gauge #14211542	Gauge height	09/05/2019 – to date
		Discharge	
		Temperature	
	Johnson Creek at Sycamore, RM 10.2 USGS Gauge #14211500	Gauge height	07/01/1940 – to date
		Discharge	10/01/2001 – to date
		Temperature	04/28/1998 – to date
	Johnson Creek at Milwaukie, RM 0.7 USGS Gauge #14211550	Gauge height	04/22/1989 – to date
		Discharge	05/07/1998 – to date
		Temperature	11/10/2004 – to date
	Kelley Creek at 159th Dr, RM 0.0 USGS Gauge #14211499	Gauge height	03/11/2000 – to date
		Discharge	01/29/2000 – to date
		Temperature	07/27/2010 – to date
	Tryon Creek near Lake Oswego, RM 1.0 USGS Gauge #14211315	Gauge height	08/03/2001 – to date
		Discharge	08/02/2001 – to date
	Willamette River at Morrison Bridge, RM 12.8 USGS Gauge #14211720	Gauge height	10/11/1987 – to date
		Discharge	10/01/1972 – to date
		Temperature	11/07/1975 – to date
		Turbidity	01/22/2009 – to date
		Specific conductance	12/02/1975 – to date
		Stream velocity	10/01/1972 – to date
		Dissolved oxygen	01/22/2009 – to date
		pH	01/22/2009 – to date
		Chlorophyll	01/22/2009 – to date
		Cyanobacteria	06/08/2013 – to date
		Nitrate, *in situ*	06/08/2013 – to date

Table 5. Continuous Instream Monitoring Locations			
	Location	**Parameter**	**Period of Record**
COLUMBIA SLOUGH SITES	Lower Slough: N Vancouver St Bridge	Dissolved oxygen	07/07/1999 – to date
		pH	
		Specific conductance	
		Temperature	
	Middle Slough: NE 21st Ave Bridge	Dissolved oxygen	12/20/1996 – to date
		pH	
		Specific conductance	
		Temperature	
	Upper Slough: NE 158th Ave Bridge	Dissolved oxygen	12/20/1995 – to date
		pH	
		Specific conductance	
		Temperature	

4.3.2 Monitoring Frequency and Duration

All parameters at all the USGS stream gauges in Table 5 are recorded every 15 minutes, with the exception of some parameters at the Willamette River gauge where measurements are recorded every 30 minutes. Table 5 shows the period of record at each site for each parameter. The joint funding agreement is in place through September 30, 2024, and monitoring is anticipated to continue as described in Table 5 into the foreseeable future at all of the USGS sites.

Continuous instream monitoring at the three BES sites will be conducted on a continuous year-round basis. Dissolved oxygen, pH, specific conductance, and temperature will be recorded at each of the three sites at 15-minute intervals.

4.3.3 Sample Collection Methodology

Streamflow data will be collected according to the Oregon Water Science Center Surface Water Quality Assurance/Quality Control Plan (Conn et al., 2017). The USGS measures gauge height and discharge according to methods described in Rantz and others (1982) and measurements of temperature and turbidity according to methods described in Wagner et al. (2006). The USGS manages all aspects of the equipment installation, maintenance, calibration, reporting, and storage of data from its gauging stations. USGS data are available online in real-time and are flagged as provisional until they are reviewed and meet USGS data quality standards.

4.4 Connection to Long-Term Monitoring Strategy

Continuous instream discharge, temperature, and turbidity monitoring provides a direct measure of the chemical and physical conditions of streams within the city that receive MS4 discharges as well as other sources across the watershed. In connection with other chemical, physical, and biological data collected instream (as described in Sections 3 and 5), continuous instream monitoring allows for the evaluation of trends, correlating the biological health of streams to physical and chemical measurements, tracking long-term climatic changes, and evaluating the cumulative effect of implementing the MS4 SWMP. Additionally, continuous instream monitoring in the Columbia Slough provides the data necessary to evaluate progress towards meeting TMDL objectives.

Section 5

Macroinvertebrate Monitoring

Macroinvertebrate monitoring refers to the annual sampling of benthic macroinvertebrates in late summer. The City collects macroinvertebrate samples drawing from the same set of rotating sampling locations where the instream monitoring is conducted (Section 3). Macroinvertebrate monitoring will continue to be conducted at the wadeable stream sites under this Plan. City staff will collect the samples, which will be analyzed by a contract taxonomist.

5.1 Background

Macroinvertebrate community composition can be used to evaluate water quality and stream habitat conditions (Karr and Chu, 1999; DEQ, 2020). They are often used as indicators of impairments as macroinvertebrates are present in diverse habitat types, represent local conditions due to their limited dispersal ability, are an important food source for fish and other wildlife, and are sensitive to changes in physical habitat and water chemistry.

Macroinvertebrate communities are evaluated through observed/expected (OE) ratio of taxa loss and through indicators of biotic integrity (IBIs). OE ratio of taxa loss is developed using models based on data from reference and/or "least disturbed" sites. Metrics used to develop macroinvertebrate IBIs generally include (EPA, 2004):

- Taxonomic *richness*, composition, and diversity — i.e., the number of distinct taxa and relative abundance of organisms
- Feeding groups: *Diversity* in feeding groups — i.e., those that depend on cold water environment vs. those that are algal-feeding, warm-water species
- *Habits* — e.g., burrowing vs. clinging macroinvertebrates as indicators of sediment transport within a stream
- *Pollution tolerance* — Presence or absence of sensitive taxa reflects changes in physical habitat and water chemistry

5.2 Monitoring Objectives

Macroinvertebrate monitoring will contribute to Monitoring Objectives i, ii, iii, iv, and v identified in Schedule B.1 of the City's MS4 permit (Table 1). Macroinvertebrate monitoring is intended to track the status and trends of biological communities within water bodies that receive MS4 discharges. Macroinvertebrate monitoring will be timed to coincide with the first monitoring event of the permit year (i.e., post June 30) at the instream monitoring sites (Section 3) so biological information is collected at the same time summer water quality samples are collected.

5.3 Approach

Macroinvertebrate sampling will focus on collecting samples from wadeable perennial streams throughout the Portland area. To maximize the spatial coverage of the program, the macroinvertebrate monitoring approach will follow the instream monitoring approach and will include the sampling of a rotating panel of stream sites, with a minimum of 12 sites sampled each year.

5.3.1 Site Selection

The macroinvertebrate monitoring will be conducted at the same rotating sampling locations where the instream monitoring occurs (Section 3), however, samples will only be collected at wadeable sites. Many of the instream sampling sites located in the Columbia Slough cannot be sampled using the standard protocols for wadeable streams (EPA, 2019). Macroinvertebrate samples will be collected at a minimum of 12 sites per year where instream water quality samples are collected.

5.3.2 Monitoring Frequency and Duration

Macroinvertebrate samples will be collected once per year, concurrent with the summer dry weather (July 1 through September 30) instream water quality sampling conducted at the rotating perennial instream sampling sites under the instream monitoring approach described in Section 3.

5.3.3 Sample Collection Methodology

Benthic macroinvertebrate samples will be collected using the protocol adapted from the EPA *National Rivers and Streams Assessment, Field Operations Manual* (EPA, 2009). Macroinvertebrate samples will be collected from 11 evenly spaced cross-sectional transects from along a stream (reach lengths vary with the wetted width of the stream; Figure 2) and combined into a single composite sample. A sample will be collected from one foot downstream of each of the 11 cross-section transects at the assigned cross-section sampling locations (Figure 2) using a D-frame kicknet.

Macroinvertebrate samples are collected from alternating locations along each of the 11 cross-sections. The sample location at Transect A (the first transect located at the downstream end of the reach) is determined at random, and each following transect is assigned a sample location based off the pattern right (R), center (C), left (L). At transects where a center sampling point is assigned and the stream width is between one and two net widths wide, the left or right sampling point is picked randomly instead. If the stream width is only one net width wide at a transect, the net is placed across the entire stream width and the sampling point is designated as center. If a sampling point is located in water that is too deep or too swift to safely sample, an alternate sampling point on the transect will be selected at random. The kick area at each transect is approximately one square foot for a total area of approximately 11 square feet for each composite sample.

Figure 2. Wadeable Site Reach Features with Macroinvertebrate Left (L), Center (C), and Right (R) Sampling Points

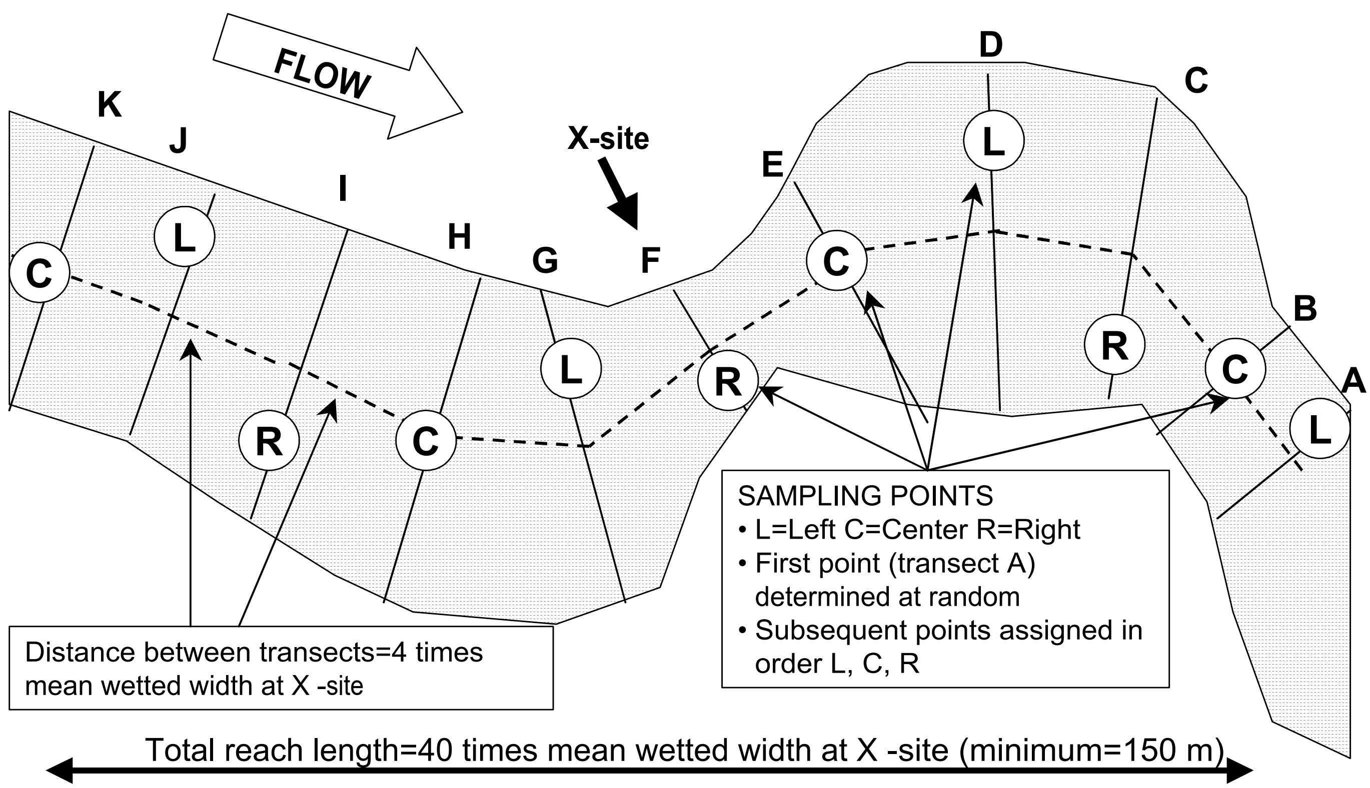

Figure from EPA 2009, p. 45, Figure 4-6.

The field crews will follow the quality control field measures outlined in Table 6. These quality control measures are evaluated primarily through best professional judgment and by ensuring that the work is performed by experienced and/or well-trained field teams.

Table 6. Biological Communities Field Quality Control

Action	Frequency	Acceptance criteria	Corrective actions
Inspect kick net	Prior to each use	No holes or tears, no foreign matter on nets	Repair, clean, or replace as necessary
Time collection with stopwatch	20 seconds kicking, 60 seconds picking	Required time ±3 seconds to ensure consistency of collection at each site	Add time or repeat sample
Check net	Each collection site	No clinging organisms	Remove any clinging organisms and add to sample

Macroinvertebrates from each cross-section will be combined into a single sample jar. To preserve the sample, the jar will be completely filled with 95 percent ethanol with no remaining headspace. Crews will take care to ensure that any existing water in the jar will not dilute the concentration of ethanol below 70 percent.

5.4 Connection to Long-Term Monitoring Strategy

Since 2010, macroinvertebrate monitoring has been an integral element of the City's comprehensive stream monitoring program. The City expects to use macroinvertebrates to assess the long-term improvement of Portland's watersheds and evaluate the correlation among macroinvertebrates and water quality, hydrology, and physical habitat.

Section 6

Sampling Staff

Sampling staff refers to all personnel who are involved in logistical support, sample collection, traffic control, and safety during the sampling event. At a minimum, the sampling staff will include a Storm Monitoring Coordinator (one person; can be remote) and field sampling teams, as described below.

6.1 Storm Monitoring Coordinator

The Storm Monitoring Coordinator is responsible for tracking weather patterns and selecting the storms to be monitored. The Storm Monitoring Coordinator will work directly with a private Portland weather forecasting service to obtain the latest weather forecasts and updates and make the "go/no go" decision. The Storm Monitoring Coordinator should attempt to notify the sampling teams and the analytical laboratory 72 hours in advance of a potential qualifying storm. The Storm Monitoring Coordinator directs sampling activities by tracking real-time weather conditions and using dependable two-way communication with the weather forecasting service and sampling teams (via cell phone). The Storm Monitoring Coordinator for this project will be the Field Operations Supervisor, or a designee.

Instream monitoring events, as opposed to stormwater monitoring events, are typically scheduled in advance, but the Storm Monitoring Coordinator makes the final decision on whether sampling occurs on any given day at which locations.

6.2 Field Sampling Teams

Multiple teams are sometimes used during a single stormwater sampling effort to decrease the length of field time and the number of individual storms needed to collect samples from all stormwater monitoring locations. Sampling teams are each composed of two people, primarily from the City's Field Operations staff. Generally, multiple sampling teams will be used as the season progresses, particularly if samples have been difficult to collect. Instream monitoring will also be conducted by multiple teams to increase the probability of collecting all samples under similar weather conditions.

Field staff members are required to read, understand, and follow all procedures documented in this Plan and the QAPP. At a minimum, field sampling personnel will be responsible for the following:

- Inspecting field sampling equipment before use to ensure that it is in proper working order and calibrated
- Ensuring that all field sampling collection forms (e.g., chain-of-custody forms, field data sheets, daily field report) are properly and completely filled out
- Ensuring that samples are collected, stored, and delivered to the laboratory in accordance with documented procedures

Field staff members also are responsible for performing all the field sampling activities in accordance with the procedures and standards established in City health and safety protocols and procedures (see Section 7.1).

Section 7
Field Sampling Procedures

Guidelines for sample collection procedures have been developed for this Plan to provide data of sufficient quality to demonstrate MS4 permit compliance and/or evaluate potential risks to human health and the environment associated with stormwater discharges from the City's storm conveyance system. SOPs were developed for tasks that are routinely performed by BES staff (Appendix A). Adherence to the procedures described in this Plan and the project QAPP will help ensure consistency among sampling events and will prevent sample contamination caused by field activities. This section focuses primarily on field sampling procedures.

7.1 Personal Safety

All sampling locations associated with this Plan are located in dense urban areas and, therefore, impart very real and specific hazards. Sample collection typically involves management of high-traffic areas and/or exposure to dangerous persons (e.g. high-risk encampments, high-crime pockets). The City's sampling efforts require prolonged field work hours and occasionally are performed at night and on weekends. Sleep deprivation, fatigue, increased exposure to drunken drivers, etc., are all increased risk factors associated with this type of work. Personal safety is of primary concern while conducting all stormwater and instream sampling-related activities. Given the hazardous nature of performing this type of sampling, at least one member of each sampling team should have the following certifications (at a minimum) to be able to identify and avoid hazards:

- 40-hour HazMat training and annual 8-hour refreshers
- Confined Space Entry and Work Practices certification
- Traffic Control and Flagging certification
- First aid and cardiopulmonary resuscitation (CPR) certification

Persons involved in sampling will be made aware of the hazards associated with the fieldwork and are encouraged to freely voice any concerns. If potential hazards become apparent and personal safety is an issue, sampling will be terminated. The following list provides basic health and safety recommendations specific to this project to minimize risks to sampling personnel:

- Before initiating field activities, turn on vehicle hazard lights and overhead yellow warning lights.
- If required, do not access sampling stations until traffic control has been established. Sampling teams will develop a traffic control plan for each location requiring traffic control.
- At certain times of day or during certain traffic scenarios (e.g., rush hour, delivery zone, police activity), it may not be possible to safely access a sampling location. If a location cannot be accessed safely or becomes unsafe during sampling, proceed to other locations and return to the location later during the storm or a subsequent storm.
- Remove and replace manhole covers using a manhole cover puller. Sampling teams should always wear steel-toed boots in the field.
- Never leave an open manhole unattended.
- Avoid confined space entries (CSEs). Because only grab sampling is required for this project, no CSE should be required. Break the manhole plane with equipment only.
- Accessing and navigating stream channels can be challenging. Extreme care should be taken when accessing streams to avoid serious injury.
- For instream sampling conducted by boat, a personal flotation device must be worn by crew members at all times while on the water.
- Field staff should be familiar with the symptoms of temperature-related illness (e.g., heat stroke, hypothermia) and be prepared to mitigate symptoms for suffering individuals.

7.2 Sampling Equipment Preparation

The equipment required for collecting grab samples includes:

- Stainless-steel beakers (decontaminated at the WPCL)
- Swing sampler with telescoping pole
- Laboratory-provided sample containers
- Field meters
- Disposable gloves (latex or nitrile)
- Coolers with ice
- Manhole cover puller
- Traffic control equipment
- Sample collection documentation (daily field report [DFR], field data sheet [FDS], and chain of custody [COC] forms)
- Field file with checklist, location maps, location photos, and traffic control plans

For macroinvertebrate sampling:

- D-frame kicknet
- Stopwatch

Detailed equipment lists are included with the respective SOPs in Appendix A.

7.3 Sampling Equipment Decontamination

Strict adherence to correct decontamination procedures is a vital link in the integrity of the sampling process and will help ensure that equipment used during the sampling process is free from pollutants that could bias analytical results.

The only equipment that will contact the sample media (stormwater or surface water) is the stainless-steel beaker used to collect the grab samples or the sample bottles. The stainless-steel beakers will be decontaminated, dried, and wrapped in aluminum foil at the WPCL before initiating fieldwork. Each sampling team will take a sufficient number of beakers for the planned sampling. Refer to SOP 7.01a, provided in Appendix A, for sampling equipment decontamination procedures.

D-frame kicknets used to collect macroinvertebrates will be inspected prior to use at each site. Nets will be repaired, cleaned, or replaced as necessary before use at each site to ensure there are no holes, tears, or foreign matter on the nets.

7.4 Sample Container Preparation

All sample containers for this project will be provided precleaned and, if required, pre-preserved from the laboratory. Table 3 and Table 4 provide the required sample volumes, containers, and preservatives required for laboratory analyses, based on standard EPA-approved methodologies. If additional sample volume is necessary (e.g., matrix QC samples), additional sample containers will be prepared.

7.5 Clean Sampling Techniques

To minimize the potential for introducing contamination to stormwater discharge samples, field personnel will direct fill sample bottles wherever possible. Where direct fill is not possible, field personnel will use the clean sampling techniques described in Section 2.3.3.

Care must be taken during all sampling operations to avoid contamination of the samples by human, atmospheric, or other potential sources of contamination. The sampling team should prevent contamination of stainless-steel beakers, sample bottles, lids, and sample media. Whenever possible, samples should be collected upstream and upwind of sampling personnel to minimize contamination potential. Gloves used during sampling also can be a source of contamination. Sampling teams will use new latex or nitrile gloves when sampling for all analytes.

7.6 Sample Collection and Handling

Grab samples will be collected using decontaminated stainless-steel beakers or directly into the sample bottle. To eliminate the need for field decontamination, a separate decontaminated beaker will be dedicated to each sample location. The sampling team will take care not to place the decontaminated beaker on the ground or allow it to come into contact with other potential sources of contamination during sampling activities.

Samples will be placed in coolers and will be iced ("wet" ice or "blue ice") immediately after sample collection and labeling, pending transport to the WPCL. Refer to SOPs 2.02b and 2.02c, provided in Appendix A, for stormwater grab sample collection.

Field parameters will be measured at each sample location immediately after filling the last sample container. Field measurements will be taken from collected stormwater or surface water samples by inserting the analytical field meter probes into the stainless-steel beaker or by directly inserting the analytical field meter probes into the flow of surface water.

7.7 Sample Labeling

Sample labels are necessary to prevent misidentification of samples. Each sample collected will have a unique sample point code applied in the field and a unique sample identification code applied upon receipt at the WPCL. Each sample that is collected in the field will be labeled with the sample point code on a sample cooler tag; sample bottles are transported in individual coolers, stocked one site per cooler. Upon receipt at the WPCL, the unique sample identification code is affixed directly onto the sample bottles. This number also is recorded on the COC and FDS forms.

To adequately track each macroinvertebrate sample, the following parameters are needed: station, site name, site identification (depending on project), collection date, habitat sampled, whether or not the sample was a field duplicate, the number of jars used for the entire macroinvertebrate sample, the collector's initials, and/or the field taxonomist's initials. Labels with all of the information listed above will be placed inside the container and also attached (taped) to the outside. Macroinvertebrate samples will be placed in plastic sealable bins or a cooler and shipped to the contractor for identification.

7.8 Sample Collection Documentation

Each sampling team will complete three separate documents while performing sampling activities: DFR, FDS, and COC forms (see Appendix C). All times on field sampling documents are recorded in current local time.

7.8.1 Daily Field Reports

DFRs serve as a general log of the field activities for each sampling team. Each DFR has a title block area for project name, date, author, and page number. Required information to be recorded on the main body of the DFRs includes:

- Name of the person(s) on each sampling team
- Location and times of each sampling site visited
- Summary of sampling activities and significant unusual observations (list specific sample details on the FDS)

Information recorded should be detailed enough to allow the sampling event to be reconstructed without having to rely on memory and to allow the sampling team at subsequent sampling events to recognize or identify any changes in the immediate proximity of the sampling site that may impact sample collection. The sampling team should photo-document significant site features and/or changes.

7.8.2 Field Data Sheets

An FDS will be completed for each sample collected. The FDS details specific observations pertaining to each sample. Required information to be recorded on the FDS includes:

- Date, arrival time, departure time, and personnel present for each sample collected
- Sample site address and sample point code
- Weather and flow conditions at each sampling location
- Flow rate estimate at sampling site
- Presence of floatable objects, oily sheens, potential pollution sources, or other conditions that may impact the water quality observed at the time of sample collection
- Sample collection start time and end time
- Sample collection point
- Deviations to sampling procedure
- Collection of field QC samples

For surface water and macroinvertebrate samples, the National Rivers and Streams Assessment iPad App (EPANRSA1819) functions as the field data sheet.

7.8.3 Chain of Custody

A COC form is a legal document designed to track samples and the persons responsible during preparation of the sample container, sample collection, sample delivery, and sample analysis. "Chain of custody" refers to both the form and the documented account of changes in possession that occur for samples. For each sample collected, sample information must be recorded on the sampling event-specific COC form. Required information on the COC includes:

- Sampling event
- Sample date and time (collection start time)
- Name of person(s) collecting the samples
- Sample point code
- Analysis requested
- Printed name, signature, date, and time for each person relinquishing or receiving the samples

To ensure that all necessary information is documented, a COC form must be completely filled out and accompany each set of samples. COC forms will be printed on "Rite in the Rain" paper and will be scanned after the laboratory personnel have signed off on sample receipt. When transferring custody of samples, the transferee will sign and record the date and time of each transfer. Each person who takes custody will complete the appropriate portion of the COC form.

7.8.4 Photographic Documentation

In addition to the DFR, FDS, and COC documents, the sampling teams will take digital photographs if unusual or noteworthy conditions are present at the sampling sites during sample collection. Site photographs are not necessary for every site visit if reasonably normal site conditions seem to exist while the sampling team is onsite. If digital photographs are taken, they must be documented on the FDS. Upon return to the laboratory, digital photographs must be downloaded, labeled, and electronically filed in accordance with the data management plan described in the QAPP.

7.9 Sample Transport and Delivery to the Laboratory

Immediately following sample collection, sample containers will be placed on ice in coolers and protected from breakage. The sampling team will submit samples to the WPCL under strict COC procedures. The Sample Custodian or designated alternate will assign a unique sample identification code to each sample. The code consists of a unique identification number generated by the WPCL Laboratory Information Management System (LIMS) software. These codes are printed during sample log-in on adhesive labels with bar codes and are affixed to the sample containers during the sample receiving and log-in process. Samples analyzed at both the WPCL and any contract laboratories are labeled with these unique codes.

Each sample collected will have a unique sample point code and sample identification code. These codes will be included on the sample label and COC forms and will be used by the laboratory to identify the analytical data.

The sampling team will attempt to deliver samples to the WPCL within 6 hours of sampling. After log-in, sample containers destined for an external laboratory will be stored on a designated shelf in the temperature-controlled and monitored sample receiving refrigerator. The Sample Custodian will generate a subcontract order from the WPCL LIMS and schedule a pick-up by the contract laboratory. Samples will be retrieved from the WPCL by the contract laboratory courier, transported in coolers containing blue ice packs, and delivered to the external laboratory following standard COC procedures. Samples may be shipped by the contract laboratory for analyses performed by other labs in their network. When sample collection occurs after normal business hours, the sampling team will sign and date the COC form and place the samples in the sample-receiving refrigerator. The laboratory will accept samples as soon as possible, following COC procedures.

7.10 Change Notification

7.10.1 Field Procedures

Any deviation from field sampling procedures, including the reason for the change, will be recorded on field documentation maintained by sampling teams. If substantial modifications to procedures are identified for future sampling events, the City will prepare Plan addenda and/or modifications per Schedule B.1.c.v of the MS4 permit.

7.10.2 Sample Waivers

The City's MS4 permit requires the City to collect stormwater, surface water, and biological samples as outlined in the permit, unless conditions are encountered that are beyond the City's reasonable control that prevent required monitoring. These include, but are not limited to abnormal climatic conditions, unsafe or impracticable sampling conditions, equipment vandalism or equipment failures that occur despite proper operations and maintenance. If the City is unable to collect or analyze any sample, pollutant parameter, or information due to circumstances beyond the City's reasonable control, DEQ will be notified in writing.

Section 8
References

ACWA. 1997. Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990 to 1996. Oregon Association of Clean Water Agencies. Prepared by Woodward-Clyde Consultants.

BES. 2012. City of Portland and Port of Portland Municipal Separate Storm Sewer System (MS4) Permit Pesticide Monitoring Plan. June 30, 2012. City of Portland Bureau of Environmental Services.

BES. 2014. Annual Compliance Report No. 19 Fiscal Year 2013–2014. City of Portland Bureau of Environmental Services. https://www.portlandoregon.gov/bes/article/508089

BES. 2020. BES Watershed Revegetation Program Vegetation Management Guidance and Procedures for the Prevention, Control, and Removal of Nuisance Vegetation. City of Portland Bureau of Environmental Services.

BES. 2021. Annual Compliance Report No. 26 Fiscal Year 2020-2021. City of Portland Bureau of Environmental Services. https://www.portlandoregon.gov/bes/article/796928.

Blischke, H. and Kohlbecker, M. 2009. Pesticide Usage in Willamette Valley Urban Areas. Technical Memo to Barb Adkins on October 20, 2009. Prepared by GSI Water Solutions, Inc., for City of Portland Environmental Services.

Conn, K.E., Huffman, R.L., and Barton, Cynthia, 2017, Quality-assurance plan for water-quality activities in the U.S. Geological Survey Washington Water Science Center: U.S. Geological Survey Open-File Report 2017–1044, 66 p., https://doi.org/10.3133/ofr20171044.

DEQ. 1997. Letter to Janet Gillaspie at the Oregon Association of Clean Water Agencies regarding: MS4 Permit Modification. June 24, 1997. Oregon Department of Environmental Quality. Prepared by Neil Mullane.

DEQ. 2006. Letter to Charles Lytle at City of Portland Bureau of Environmental Services Water Pollution Control Laboratory. Total Mercury Alternative Test Procedure Approval. November 21, 2006. Oregon Department of Environmental Quality.

DEQ. 2020. Methodology for Oregon's 2018 Water Quality Report and List of Water Quality Limited Waters Pursuant to Clean Water Act Sections 303(d) and 305(b) and OAR 340-041-0046. Oregon Department of Environmental Quality. Prepared by Becky Anthony.

EPA. 2004. Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams. EPA 841-B-06-002. Office of Water and Office of Research and Development, US Environmental Protection Agency, Washington, DC.

EPA. 2006. Letter to Charles Lytle at City of Portland Bureau of Environmental Services Water Pollution Control Laboratory. Total Mercury Alternative Test Procedure Approval. October 24, 2006. U.S. Environmental Protection Agency.

Karr, J.R. and Chu, E.W., 1999. *Restoring Life in Running Waters*. Island press. 225 pgs.

PP&R. 2019. Integrated Pest Management Program. City of Portland, Portland Parks and Recreation. https://www.portlandoregon.gov/parks/article/116237.

Rantz, S.E. and others. 1982. Measurement and Computation of Streamflow, Volume 1: Measurement of stage and discharge. Volume 2: Computation of Discharge. U.S. Geological Survey Water Supply Paper 2175. https://pubs.usgs.gov/wsp/wsp2175/wsp2175.pdf.

Sullivan, L. 2005. Preliminary Study Comparing Precipitation Quality Between Nominal Land Uses in Portland, Oregon. Master's of Environmental Management. Environmental Sciences and Resources, Portland State University.

USEPA. 2009. National Rivers and Streams Assessment: Field Operations Manual. EPA-841-B-07-009. U.S. Environmental Protection Agency, Washington, DC.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, CJ., and Smith, B.A. 2006. Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting. U.S. Geological Survey Techniques and Methods 1-D3. https://pubs.er.usgs.gov/publication/tm1D3.

Section 9

Appendix A: Standard Operating Procedures

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF MULTIPLE WATER QUALITY PARAMETERS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the maintenance, calibration and use of multi-parameter water quality meters (multiprobes) for obtaining real-time in-situ measurements for a single or multiple water quality parameters.

2.0 SCOPE AND APPLICABILITY

Procedures in this SOP describe the use of a single monitoring device to take real-time measurements, potentially for multiple parameters. The parameters routinely monitored using these devices include temperature, dissolved oxygen (DO), specific conductance, pH, Redox and depth, although devices can be modified to monitor several additional parameters. Procedures for collecting real-time measurements using meters designed for a single parameter are described in *SOPs 1.01a - 1.05b*, however as multiprobes have gotten smaller and easier to use, these single-parameter meters are less frequently utilized, even when monitoring for a single parameter. The exception to this is designated pH meters used for Industrial Wastewater monitoring (SOP 1.01b) and the use of a digital thermometer for field temperature measurement (SOP 1.05a). The procedures for using a multi-parameter water quality meter for unattended continuous monitoring are described in *SOP 1.06b - Continuous Field Measurement of Multiple Water Quality Parameters*.

Individual guidance documents exist for each of the distinct models of multiprobes used by Field Operations. These explain the particularities of each model and provide step-by-step instructions unique to each model for navigating menus on the display/interface. These include the following documents: *InSitu SmarTroll instructions*, *YSI 600XL & 6820 instructions*, and *YSI ProDSS instructions*.

3.0 EQUIPMENT AND MATERIALS

The following is a list of equipment and materials needed to maintain, calibrate, and take measurements using a multi-parameter water quality meter:

Multiprobe (i.e. YSI 600XL, YSI 6820, YSI ProDSS, In-Situ SmarTroll)
Dish soap/tap water solution
Toothbrush
Cotton swabs
Deionized (DI) water
Portable display/communication device or smartphone

Communication cable
Calibration cups
Potassium chloride (KCl) conductivity standard solution
pH 4, 7 and 10 buffers
0.0 (ultra-pure deionized water), 12.7 and 126 NTU turbidity standard
pH reference electrolyte (for pH probes with a refillable electrolyte reservoir)
DO sensor electrolyte solution and membranes (for polarographic cell probes)
Turbidity sensor wiper arm and wiper pads and appropriate hex key
Primary Reference Thermometer (PRT) and large beaker of water
Chlorine bleach/tap water solution (1:1 dilution)
Multiprobe Calibration Record (For Non-Logging Units)

4.0 PROCEDURE

4.1 Maintenance

Maintenance of the monitoring device is not necessarily required before each use. Each maintenance activity should be performed based on the recommended frequency, or if visual inspection of the sensors dictates that maintenance is necessary even if the prescribed time has not elapsed. Some maintenance activities should be performed several hours prior to calibration to allow sensors to equilibrate after being maintained. Record all maintenance activities in the *Notes* section of the *Multiprobe Calibration Record*.

4.1.1 General

If necessary, perform a general cleaning of the unit and all sensors with mild detergent, such as dishwashing liquid. If necessary, scrub the body with an abrasive cellulose pad.

4.1.2 Dissolved oxygen sensor

Non-logging multiprobes are equipped with one of two styles of DO sensor; a polarographic sensor or an optical sensor A polarographic sensor utilizes a cathode and anode in an electrolyte solution, sealed by a semi-permeable membrane. Visually check the membrane for wrinkles, air bubbles, rips and tears, or evidence of having been dried-out. The DO sensor will need to be maintained if any of these conditions exist. See section 5.1.2 below if maintenance is required. An optical sensor measures oxygen concentration by emitting light of a specific wavelength and measuring the luminescence of a dye in the sensing element. The duration of the luminescence is dependent on the oxygen concentration. These sensors require no routine maintenance, other than a visual inspection of the sensing element to ensure that the dye layer is intact and has not been scraped or scratched off. The sensing element requires replacement every 12 to 18 months.

4.1.3 Conductivity sensor

Visually inspect the openings on the conductivity sensors for debris. If debris is present, gently clean with a Q-tip or toothbrush. Rinse sensor with DI water. Maintenance on the conductivity sensor is only performed when debris is visible. If problems persist, consider probe replacement

4.1.4 pH sensor

The pH sensor may be a sealed gel type or may have a refillable reference electrolyte reservoir. Sealed gel sensors require only to be visually inspected and gently cleaned with a wet cotton swab if any film, sediment or biological fouling are present on the glass bulb.

In addition to the inspection and potential cleaning of the glass bulb, refillable sensors require periodic refreshing of the reference electrolyte. The refreshment interval will depend on the frequency of use but can be identified when the pH sensor becomes slow to reach stable readings. To refresh the reference electrolyte, unscrew the porous junction on the tip of the reservoir, invert and shake to remove the old electrolyte. Using the electrolyte fill bottle with a narrow rigid tubing extension, refill the reservoir completely and reinstall the porous junction ensuring that all air is excluded from the reservoir.

4.1.5 Optical Turbidity Sensor

Currently the YSI 6820 and YSI ProDSS units support a turbidity probe. The probe itself does not require much maintenance. The two small optical windows on the end of the probe need to be inspected and cleaned. The YSI 6820 is equipped with a mechanical wiper. Under normal use conditions, the automatic wiper should be sufficient for cleaning the optical windows. If extreme conditions exist, the optical windows on the end of the probe may need to be cleaned using a soft cloth towel or lint free wipes. The wiper and wiper arm should be inspected for any cracks and/or tears and then be replaced when necessary. Under normal conditions, the wiper should last up to a year before it needs replacement. If replacement is necessary, remove the wiper arm using the small hex key (this should be located with the YSI maintenance supplies). If the wiper arm is still serviceable, simply replace the wiper material with new material. If the arm is broken or damaged, replace the whole thing with a new arm and wiper material. The YSI ProDSS is not equipped with a wiper.

4.2 Calibration

Calibration should be conducted several hours after maintenance activities, to allow the sensors sufficient time to equilibrate after being maintained. If the meter must be used immediately and is overdue on one or more maintenance items, it is best to calibrate the meter without performing maintenance, note that the meter was overdue for maintenance on the *Multiprobe Calibration Record*, and maintain the meter after it is used. Failure to allow adequate time for equilibration will result in readings drifting after calibration. If any parameter fails to calibrate, consult section 5.1 *Inability to Calibrate Parameters* for troubleshooting guidance. If a parameter still fails to calibrate, a different multi-parameter water quality meter, or individual field meters will need to be used until the problem is resolved. During the calibration process, either a computer or portable display/communication device can be used to communicate with the meter.

4.2.1 Temperature

Install the sensor guard and place the inverted multiprobe and the Primary Reference Thermometer (PRT) into the large beaker of water equipped with an air stone. Allow sufficient time for both sets of readings to stabilize. Record both sets of readings on the *Multiprobe Calibration Record*, with the PRT reading as the calibration standard. Temperature cannot be adjusted on the multi-parameter water quality meter. The calibration standard is used as a comparison, to verify that the meter is reading within the acceptable range. If the meter reading and the calibration standard vary by more than 0.5°C, a different multi-parameter water quality meter, or individual field meters will need to be used until the problem is resolved. Be aware that it may take up to several minutes for the PRT, multi-parameter water quality meter thermistor, and water in the calibration cup to all reach thermal equilibrium.

4.2.2 Dissolved oxygen
Remove the unit from the beaker and wrap the sensor guard with a moist paper towel. Allow the DO readings to stabilize and record the DO value (using percent saturation as the units) on the *Multiprobe Calibration Record*. Calibrate the DO to 100 percent saturation, which is pre-printed on the form.

4.2.3 Specific conductance
Rinse the sensors with DI water. Fill the calibration cup with fresh conductivity standard. After shaking excess water off the meter, attach the cup over the sensors and invert to fully submerge the conductivity sensor. Remove the calibration cup and discard the standard as a rinse. Repeat this process with fresh conductivity standard. Allow the meter to take measurements until the readings have stabilized and record that value on the *Multiprobe Calibration Record*. Using the computer or portable display/communication device, calibrate the meter to the specific conductance value of the standard, and record that value on the *Multiprobe Calibration Record*. Remove the cup from the unit and discard the solution.

4.2.4 Level
If the multiprobe being used lacks a level sensor, this step is skipped. With the multiprobe out of the water allow the depth readings to stabilize and record this value on the *Multiprobe Calibration Record*. Record zero as the calibration standard and calibrate the depth to zero.

4.2.6 Turbidity
The turbidity probe is calibrated using two points that best bracket the conditions expected to be found at the sampling site. The first point will always be the Zero NTU standard. This standard is Ultra-Pure Deionized water (UPDI) that has been allowed to degas so no small bubbles interfere with the optics of the turbidity sensor and is stored in a designated flask. The second point should be either the 12.7 NTU or 126 NTU standard. Depending on the sensing technology utilized, some models of probe may measure the standard at a slightly different value and may require different units during calibration (e.g. 12.4 and 124 FNU). These variations are detailed in the model-specific instructions. For most dry weather applications, the 12.7 standard should work well, whereas periods during or following rain events the 126 NTU standard should be used as the second point of the calibration. Some multiprobes models have a turbidity-specific calibration cup to ensure that a minimum sample depth is achieved, while minimizing the amount of standard that is required. Rinse the probes and calibration cup with a small amount of UPDI. Place the cup cap-side down and fill with the first standard (i.e. UPDI) ensuring there is sufficient depth to submerge the face of the turbidity sensor. Carefully put the multiprobe into the calibration cup, keeping the cup-side down. Allow the readings to stabilize and record the reading as the *Equilibrated Value*. Calibrate the unit to 0.0, which is already populated as the *Calibration Standard* on the on the *Multiprobe Calibration Record*. Next, rinse with a small amount of the appropriate second point standard. (If it is available, due to the cost of the turbidity standard, use recycled turbidity standard for the rinses. Only recycle fresh standard, recycled rinse standard should be discarded after the rinse.) Fill the calibration cup with fresh standard, insert multiprobe, and calibrate to the appropriate value. Record the *Equilibrated Value* and the *Calibration Standard* on the *Multiprobe Calibration Record*. This fresh standard can then be added to the recycled standard bottle.

4.2.5 pH
Remove the sensor guard. Rinse the sensors and the calibration cup with DI water and fill with new pH 7 buffer solution, attach the cup over the sensors and invert to fully submerge the sensors. Allow the meter to take measurements until the readings have stabilized and record that value on the *Multiprobe Calibration Record*. Consult the *Value of pH Buffers at Temperature* chart and find the value of the pH 7 buffer at the current temperature. Calibrate the unit to this value and record this value as the *Calibration Standard* on the *Multiprobe*

Calibration Record. Remove the cup from the unit, discard the solution and rinse the calibration cup and sensors with DI water. Repeat this process using either the pH 4 or pH 10 buffer solution. Use the standard that is closer to anticipated pH of the water to be monitored.

Place a wetted sponge or a small volume of tap water in the calibration cup to keep the sensors moist while transporting the unit to and between the monitoring locations.

4.3 Measurement

Multi-parameter water quality meters are ideally suited for in-situ measurement. If access or other site issues, such as insufficient water depth preclude in-situ monitoring, a sample can be retrieved, and the sensors submerged into the sampling vessel. The steps below describe in-situ measurement.

1. Remove the protective storage cup from over the sensors and attach the weighted sensor guard. Connect the unit to a portable display/communication device and turn the power on.
2. If specific depths and precise locations have been identified for the monitoring location, lower the meter through the water column until the sensors reach that depth. If no precise point has been designated, lower the sensors to approximately three feet below the water surface at the midpoint of the channel. If the water is less than three feet deep position the sensors at the midpoint of the water column.
3. Monitor the readings until they have stabilized. If the turbidity sensor is equipped with a wiper, activate the wiper to dislodge any air bubbles or particles adhering to the face of the sensor. In moving water parameters may not lock on a single value, but a parameter can be considered stable when it is no longer actively climbing nor dropping. Record values on the *Chain of Custody* or *Field Data Sheet* along with the identifying number of the multiprobe used.
4. Retrieve unit. Replace protective storage cup before transporting the unit to the next site or returning to the lab. Alternatively, the unit can be transported with the sensor guard wrapped in a moist paper towel to prevent the sensors from desiccation.

4.4 Post Measurement Calibration Check

For quality assurance, a post measurement check of all monitored parameters is performed upon return to the lab. The goal of the check is to quantify the drift that has occurred in each monitored parameter since the unit was calibrated. The amount of drift that is acceptable and the procedures to follow when the drift exceeds acceptable limits are discussed in section 6.0 *Quality Assurance and Quality Control*.

1. Remove the storage cup from the sensors and flush the sensors with a very gentle stream of DI water. This is not intended to clean the sensors, but rather to remove any material that would otherwise contaminate the standards to be tested.
2. Test the drift of all monitored parameters by measuring known standards and comparing the measured reading with the known value for that standard. Record the results on the *Multiprobe Calibration Record (For Non-Logging Units)*.

4.4.1 Temperature

Install the sensor guard and place the multiprobe and the Primary Reference Thermometer (PRT) into the large beaker of DI water equipped with an air stone. Record the stabilized temperature value and record the PRT temperature reading as the standard for temperature.

4.4.2 Dissolved oxygen
Remove the unit from the beaker and wrap a moistened paper towel around the sensor guard. Allow the readings to stabilize and record the DO value in percent saturation. The standard value, 100 percent, is pre-printed on the calibration record.

4.4.3 Specific conductance
Fill the calibration cup with conductivity standard and attach over the sensors. Invert so the sensors are fully submerged. Remove the calibration cup and discard the standard as a rinse. Repeat this procedure with fresh standard. Allow the readings to stabilize and record the reading and the value of the standard.

4.4.4 pH
Empty the calibration cup and fill with DI water and rinse sensors. Discard the rinse water then fill with pH 7 buffer solution. Invert so that the sensors are fully submerged in the buffer. Allow the readings to stabilize and record the pH reading as the *Equilibrated Value* on the *Calibration Record*. Consult the *Value of pH Buffers at Temperature* chart and find the value of the pH 7 buffer at the current temperature and record this as the standard. Repeat the process with pH 4.00 buffer if field readings were less than 7.00, or pH 10.00 buffer if pH readings were greater than 7.00. Record both the stabilized value and the temperature adjusted value of the standard used, on the calibration record.

4.4.5 Turbidity
Rinse probes and calibration cup with UPDI and then fill the calibration cup with sufficient zero turbidity standard (UPDI) to submerge the face of the sensor. Clean optics (if applicable), allow to equilibrate, and record the reading on the *Calibration Record*. Select 12.7 or 126 NTU standard based turbidity values seen in the field. Rinse probes and calibration cup with the selected standard (using recycled standard and discarding it after). Then using fresh standard, fill the calibration cup with sufficient standard to submerge the face of the sensor, insert multiprobe, clean optics (if applicable), allow equilibration, and record the value on the calibration record. Transfer the standard into the recycled standard bottle.

5.0 POTENTIAL PROBLEMS

5.1 Inability to Calibrate Parameters

5.1.1 Specific conductance
The most common problem with the calibration of specific conductance is the contamination of the conductivity standard as a result of insufficiently cleaning the unit or inadequately rinsing the calibration cup. If the unit will not calibrate because the adjustment is beyond the acceptable tolerance, discard the conductivity standard, rinse the sensors thoroughly first with DI water then with conductivity standard, and decant fresh conductivity standard for another calibration attempt. If calibration still fails, repeat the conductivity sensor maintenance, taking special care to remove any corrosion or deposits from the electrodes.

5.1.2 Dissolved oxygen
Troubleshooting activities will differ depending on whether the unit is equipped with a polarographic sensor or an optical sensor. If the unit has a polarographic sensor and the DO will not calibrate because the adjustment is beyond the acceptable tolerance, or if the readings do not seem accurate, examine the dissolved oxygen sensor membrane for wrinkles or bubbles under the membrane, and replace if necessary (calibration cannot occur for

several hours after the membrane is changed). If there are chronic problems with calibration or stabilization of readings, the gold cathode or silver anode may need maintenance. A darkening of the anode and/or a tarnishing of the cathode typically reveals this. Clean the gold cathode by gently polishing with a soft pencil eraser. If either of the silver electrodes are black in color, the probe should be resurfaced using the fine sanding disk in the DO repair kit located in the field lab. Usually, 10-15 strokes of the sanding disk are sufficient to remove the deposits on the silver electrode(s). Sanding strokes occur in the direction parallel to the gold electrode (located between the two silver electrodes), using a motion similar to striking a match. This activity is only performed when one or both electrodes appears dark and fouled. If resurfacing was required, rinse unit with DI water before continuing. Refill the chamber with fresh electrolyte solution until there is a perceptible meniscus of electrolyte rising above the chamber. Carefully lay a new membrane over the sensor surface. After verifying that no bubbles exist inside the chamber, roll the O-ring into position over the membrane without causing wrinkles or air bubbles to form under the membrane. Trim away excess membrane and replace the DO sensor guard. Rinse the sensor with DI water. Allow the unit to sit overnight before attempting calibration.

If problems are encountered with a unit equipped with an optical DO probe, the source is most frequently with the sensing element, sometimes referred to as the sensing foil, which has a finite life-span of typically 12-18 months. It may require replacement sooner depending on conditions encountered in the field. Some manufacturers (e.g. In-situ) have a "hard-stop" on the sensing element and will not allow calibration to continue a prescribed time after the sensing element has been installed.

5.1.3 pH

If pH will not calibrate, or if pH readings are very slow to equilibrate, the pH probe and/or the pH reference probe may need additional maintenance. If the unit is equipped with a refillable reference electrolyte reservoir, begin by refreshing the electrolyte. If the conditions persist, change the porous junction cap which can become plugged over time. If pH problems still exist, consider swapping the old pH probe for a new pH probe.

5.1.4 Turbidity

Ensure that there are no air bubbles adhering to the face of the turbidity sensor. Operate the wiper to clear the sensor face if the unit is so equipped. Also, be sure that the standards have not been shaken up, which could result in bubble formation that would effectively change their turbidity. If calibration difficulties are encountered, check to ensure the small window is not scratched or otherwise compromised. Service if the window is damaged.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control measures include routine and standardized procedures for the operation and maintenance of the multi-parameter water quality meter, thorough documentation of maintenance and calibration activities, and quantification of the drift of each monitored parameter. Perform the maintenance activities for each parameter as discussed in section 4.1 *Maintenance*. This routine maintenance regimen is conservatively frequent and ensures the timely care, and if necessary replacement of sensitive components. Record all maintenance activities on the *Non-Logging Multiprobe Maintenance Record* and consult this record prior to performing any maintenance in order to remain on the correct schedule. Complete a *Multiprobe Calibration Record (for non-logging units)* each time the multi-parameter water quality meter is used, while following the steps in section 4.2 *Calibration*.

This form is also a place to document the drift that occurred while the meter was in use and provides guidance for the actions to be taken based on the amount of drift witnessed. Complete the post measurement section of the *Multiprobe Calibration Record* while following the steps in section 4.4 *Post Measurement Check*. The following are the acceptance ranges for each parameter: specific conductance: 15 uS/cm greater or less than the standard (132 – 162 uS/cm for a standard of 147 uS/cm), dissolved oxygen: 90 – 110 percent saturation, temperature: 0.5 degrees Celsius greater or less than the PRT measurement, pH: 6.85 – 7.15 for a standard of 7.00, 3.85 – 4.15 for a standard 4.00, and 9.85 – 10.15 for a standard of 10.00 (note that the precise range will vary slightly depending on the temperature of the standard, but is 0.15 pH units above and below the pH value of the standard at the current temperature. For turbidity the acceptance range is +/- 10% of the value of the non-zero standard used. If the 12.7 NTU calibration standard is used, the acceptance range for the zero NTU standard would be -1.27 – 1.27, and the acceptance range for the 12.7 NTU standard would be 11.4 -14.0. If the 126 NTU calibration standard is used, the acceptance range for the zero NTU standard would be -12.6 – 12.6 and the acceptance range for 126 NTU standard would be 113 – 139. These acceptance ranges are listed on the *Multiprobe Calibration Record* for reference. If any parameter falls outside of the acceptance range during the post measurement calibration check, make a record of this in the *Notes* section of the *Multiprobe Calibration Record*. Additionally, the field measurement recorded for that parameter will have to be considered as an estimate and will be documented on the *Chain of Custody (COC)* as such. Because the post measurement check is typically performed after the *COC* has been submitted, the Sample Custodian will likely need to be consulted in order to make the appropriate additions to the *COC* or *FDS*. Add the following phrase in the comments section of the *COC* or *FDS*: *"The result for* (name of parameter out of acceptance range) *should be considered an estimate due to the post measurement calibration check of the field meter being outside of the acceptance range."* In addition, if space permits, "EST", as an abbreviation for estimate, should precede each reading on the COC or FDS, for the offending parameter.

7.0 RESOURCES

(1) *National Field Manual for the Collection of Water-Quality Data,* U.S. Geological Survey, Denver, CO 1998.
(2) *Multiparameter Water Quality Monitoring Instruments - Operating Manual,* Hydrolab Corporation, Austin, TX, 1993.
(3) *Water Quality Multiprobes - User's Manual,* Hydrolab Corporation, Austin, TX, 1997
(4) *The Dissolved Oxygen Handbook,* YSI Incorporated, Yellow Springs OH, 2009

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

CONTINUOUS FIELD MEASUREMENT OF MULTIPLE WATER QUALITY PARAMETERS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the maintenance, calibration and use of multi-parameter water quality meters (multiprobes) for the purpose of continuously measuring and recording in-situ readings for a number of water quality parameters over an extended period.

2.0 SCOPE AND APPLICABILITY

Procedures in this SOP apply to the use of a single, unattended monitoring device to measure and internally record values for multiple water quality parameters. The standard parameters monitored using these devices include depth, dissolved oxygen (DO), pH, specific conductance, temperature, and turbidity, although devices can be modified to monitor several additional parameters. These devices can continuously log these parameters for several weeks at a choice of intervals; however the sensors on these units become fouled over time causing the accuracy of the readings to deteriorate. The rate of this deterioration will depend on the conditions of the water body. As a result of this fouling, the unit has to be periodically removed, maintained, calibrated, and then redeployed. These procedures are described in this SOP, along with steps for quantifying the degree of fouling, or drift, as a tool for assessing the quality of the data generated by the unit. *SOP 1.06a - Field Measurement of Multiple Water Quality Parameters*, describes the procedures for using a multi-parameter water quality meter to obtain real-time in-situ measurements for several water quality parameters, without utilizing the unit's logging functions. *SOP 1.05b – Continuous Temperature Measurement*, describes the procedures and equipment used for the unattended measurement and logging of in-situ data for temperature only.

3.0 EQUIPMENT AND MATERIALS

The following is a list of equipment and materials needed to maintain, calibrate, and record measurements using a multi-parameter water quality meter:

Multi-parameter water quality meter
Calibrated non-logging multi-parameter water quality meter with display for field audit
Removal / deployment equipment (boat, float tube, dry suit, flippers etc.)
Cooler with damp sponge or towel
Dish soap/tap water solution
Cellulose pad
Toothbrush

Isopropyl alcohol
Cotton swabs
Deionized (DI) water
Computer or portable display/communication device
Communication cable
Large capacity beaker of DI water with tubing and airstone
Calibration cups
Potassium chloride (KCl) conductivity standard solution
pH 4.00 , 7.00 and 10.00 buffers
Primary Reference Thermometer (PRT)
Multiprobe Maintenance and Calibration Record

4.0 PROCEDURE

4.1 Field Audit and Removal

Multiprobes are typically mounted on bridges, pilings, staff gauges, or buoys, and may require the use of specialized equipment for their retrieval. Required equipment will include a cooler with a damp sponge or towel and might include a boat, float tube, dry suit, floatation vest, flippers, waders, shin boots, or a combination of these. Prior to removing the multiprobe from water, use the calibrated non-logging multi-parameter water quality meter to collect field audit values. The sensors of the non-logging water quality meter should be placed in close proximity to the multiprobe sensors. Record the stabilized readings in the *Multiprobe Maintenance and Calibration Record*. Upon removal from the water, place the multiprobe in the cooler with the damp sponge or towel. This will provide the sensors with a stable environment intended to preserve their condition until a drift check can be performed. Prior to transport to the laboratory attach any other guards or plugs designed for the protection of sensitive components.

4.2 Post – Measurement Check (Drift Check)

In the lab, use the DI water faucet to gently flush any large debris or residue off of the sensors. This is not intended to clean the sensors, but rather remove any material that might contaminate the calibration standards. Use the manufacturer's instructions to establish communication between the unit and the computer to have it continually display real-time measurements. The following check activities vary depending on the specific water quality meter. For specific instructions refer to the current multiprobe manual.

4.2.1 Date and time

Begin the drift check by confirming the date is correct and the multiprobe is accurately reading in Pacific Standard Time (PST). On the *Multiprobe Maintenance and Calibration Record,* record this correct date and time as the standard and record the date and time from the multiprobe as the reading. If the date or time is significantly off (greater than 1 hour), it may be necessary to adjust the date and time of the data in the data file when it is retrieved.

4.2.2 Depth

With the sensors not in water or a solution, allow the depth reading to stabilize. Record this depth reading on the *Multiprobe Maintenance and Calibration Record*. The depth value of 0.00 is already printed on the *Multiprobe Maintenance and Calibration Record* as the standard.

4.2.3 Dissolved oxygen

Submerge the sensors in a beaker containing DI water and an airstone. Allow the airstone to bubble in the beaker with DI for several hours prior to performing the drift check to ensure the DI is fully saturated with oxygen. Allow the unit to take measurements until the readings have stabilized. Record the value of the stabilized reading, expressed as percent saturation, on the *Multiprobe Maintenance and Calibration Record*. The oxygen content of the air in the beaker is 100 percent saturation, and this value is already printed on the *Multiprobe Maintenance and Calibration Record* as the dissolved oxygen standard.

4.2.4 Specific conductance

Fill a calibration cup designated for conductivity standard with fresh KCl conductivity standard and submerge the sensors in the conductivity standard. Allow the unit to take measurements until the readings have stabilized. Record the value of the stabilized reading on the *Multiprobe Maintenance and Calibration Record*. The value of the conductivity standard is pre-printed on the sheet. Remove the cup of KCl standard and discard the solution. Rinse the sensors gently with DI water.

4.2.5 pH

Fill a calibration cup designated for pH 7 standard with fresh pH 7.00 buffer and submerge the sensors in the buffer. Allow the unit to take measurements until the readings have stabilized. Record the value of the stabilized reading on the *Multiprobe Maintenance and Calibration Record*. The value of the standard is pre-printed on the worksheet. Remove the cup of buffer and discard the solution. Rinse the sensors gently with DI water. This process is then repeated with pH 4.00 or pH 10.00 buffer, using the standard that is closest to the field readings witnessed.

4.2.6 Temperature

Submerge the sensors in the beaker containing DI and the airstone. Submerge the Primary Reference Thermometer (PRT) in the beaker. Allow both the multiprobe unit and the PRT to stabilize. Record the stabilized multi-parameter water quality meter reading and the stabilized PRT reading on the *Multiprobe Maintenance and Calibration Record*. The PRT reading is considered the standard.

4.2.7 Turbidity

Thoroughly rinse the sensors in ultra pure deionized water (UPDI) and submerge the sensors in a beaker containing UPDI. Allow the turbidity readings to stabilize. Record the value of the stabilized reading on the *Multiprobe Maintenance and Calibration Record*. The turbidity value of UPDI water should be 0.0 Nephelometeric turbidity units (NTU), and is pre-printed on the *Multiprobe Maintenance and Calibration Record* as the turbidity standard.

4.3 Maintenance

After completing the drift/fouling quantification, begin maintenance with the general cleaning of the unit and all sensors with a mild detergent, such as liquid dishwashing soap. Scrub the body of the unit (and battery pack if separate) with an abrasive cellulose pad to remove mud and biological growth. Use a soft toothbrush and cotton swabs to clean off the individual sensors. After the general cleaning, perform the sensor specific maintenance activities as described in the current multiprobe instructions. These activities vary depending on the specific type of water quality meter being used; refer to the current multiprobe manual for specific instructions. Additionally, trouble-shooting maintenance activities are discussed in section 5.0 *Potential Problems*. Document all maintenance activities (both routine and non-routine) in the *Maintenance* section of the *Multiprobe Maintenance and Calibration Record*.

4.4 Data Retrieval
Follow the manufacturer's instructions to communicate with the water quality meter and to extract the data. Established conventions for naming and formatting the data files are found in the current multiprobe instructions. Record the file name and other relevant information in the spaces provided in the *Data Retrieval* section of the *Multiprobe Maintenance and Calibration Record*.

Perform a cursory data quality review, recording notes in the designated space on the *Multiprobe Maintenance and Calibration Record.* It may be necessary to import the data into a spreadsheet or other type of program in order to view the data graphically. If the date and time were off by more than an hour, record in the data quality report. Check that the data file spans the entire range of deployment and delete all data recorded after the multiprobe was pulled from the water. Document any interruptions or periods of power loss in the data quality report. Note if any parameters exceed the measurable range (specifically DO), or drop to zero. Check for indications of the sensors being outside the water, such as very low conductivity or level readings. Look for typical daily fluctuations that can be expected in parameters such as DO and temperature. This brief data review should not be focused on data interpretation, but rather should simply serve as a check that the sensors on the unit are functioning correctly and are providing representative readings of the monitoring location.

Transfer the data file to the appropriate place on the network, keeping a back-up copy on disk.

4.5 Calibration
Multi-parameter water quality meters are always calibrated prior to being deployed for continuous monitoring. Calibration should be conducted at least six hours after maintenance activities, to allow the sensors sufficient time to equilibrate after being maintained. Failure to allow adequate time for equilibration will result in readings drifting after calibration. Ideally, calibration will occur the day following maintenance. If any parameter fails to calibrate, consult section 5.2 *Inability to Calibrate Parameters* for troubleshooting guidance. If a parameter still fails to calibrate, a different multi-parameter water quality meter will need to be used until the problem is resolved. If the software used for calibration permits, create an electronic file that documents the adjustment made during the calibration process. This file should be saved to the network, with the data file.

4.5.1 Date and Time
Begin the calibration by confirming the date and time is correct; multiprobe units are to be calibrated and kept in PST. Establish communication between the computer and the unit. On the *Multiprobe Maintenance and Calibration Record,* record the date and time the unit is currently displaying as the equilibrated value. Correct the date on the unit if incorrect. If there is more than three minutes of disagreement between the times, adjust the clock on the unit. Record the current date and time (in PST) as the calibration standard on the *Multiprobe Maintenance and Calibration Record*.

4.5.2 Depth
With the sensors not in water or a solution, allow the depth reading to stabilize. Record this depth on the *Multiprobe Maintenance and Calibration Record*. Calibrate the depth to 0.00 feet and record this value as well.

4.5.3 Dissolved oxygen
Rinse the sensors thoroughly with DI water. Submerge the sensors in a beaker containing DI water and an airstone. Allow the airstone to bubble in the beaker with DI for several hours prior to performing the calibration to ensure the DI is fully saturated with oxygen. Once DO readings have stabilized, record the DO value (using percent

saturation as the units) on the *Multiprobe Maintenance and Calibration Record*. Using the computer or portable display/communication device, calibrate the multiprobe to 100.0 percent saturation. The calibration standard of 100.0 percent saturation is pre-printed on the *Multiprobe Maintenance and Calibration Record*.

4.5.4 Specific conductance

Fill a calibration cup designated for conductivity standard with fresh KCl conductivity standard and submerge the sensors in the conductivity standard. Allow the unit to take measurements until the readings have stabilized. Record the value of the stabilized reading and the current value of the conductivity standard on the *Multiprobe Maintenance and Calibration Record*. Using the computer or portable display/communication device, calibrate the meter to the specific conductance value of the standard, and record that value on the *Multiprobe Maintenance and Calibration Record*. Remove the sensors from the KCl standard and discard the solution. Rinse the sensors gently with DI water.

4.5.5 pH

Fill a calibration cup designated for pH 7 standard with fresh pH 7.00 buffer. Fully submerge the sensors in the buffer. Allow the meter to take measurements until the readings have stabilized and record that value on the *Multiprobe Maintenance and Calibration Record*. Using the computer or portable display/communication device, calibrate the meter to 7.00 (this value is already printed as the calibration standard on the *Multiprobe Maintenance and Calibration Record*). Remove the sensors from the pH 7.00 buffer and discard the solution. Repeat this process using either the pH 4.00 or pH 10.00 buffer solution. Use the standard that is closer to anticipated pH of the water to be monitored.

4.5.6 Temperature

With the sensors submerged in a beaker of DI with an airstone, place the PRT in the vicinity of the multiprobe's temperature sensor. Allow sufficient time for both sets of readings to stabilize. Record both sets of readings on the *Multiprobe Maintenance and Calibration Record*, with the PRT reading as the calibration standard. The calibration standard is used as a comparison, to verify that the meter is reading within the acceptable range because temperature cannot be adjusted on the multiprobe. If the meter reading and the PRT reading vary by more than 1.0 degrees C, a different multiprobe will need to be used.

4.5.7 Turbidity

Place the sensors in ultra pure deionized water (UPDI); this serves as the zero turbidity standard. Wait for the turbidity readings to stabilize and record the stabilized value on the *Multiprobe Maintenance and Calibration Record*. The calibration standard of 0.0 NTU is pre-printed on the sheet as the calibration standard. Follow the meters' instructions to calibrate to 0.0 NTU. Pour off the UPDI water. Next, select either the 11.2 NTU standard solution or the 123 NTU standard solution, depending on the expected turbidity of the water to be monitored. Submerge the sensors in the selected standard solution. Allow the unit to take measurements until the turbidity readings have stabilized. Record the equilibrated value and the value of the turbidity standard on the *Multiprobe Maintenance and Calibration Record*. Adjust the meter to read the value of the standard. Remove the sensors from the solution and retain the turbidity standard. This is the one standard that, due to its great expense, is reused for non-logging multi-parameter water quality meter check-in purposes.

Replace the sensor guard and store the multiprobe in a cooler with a damp sponge or towel, until the unit is deployed.

4.6 Reprogramming and Deployment

Follow the manufacturer's instructions to communicate with the water quality meter. Delete the data from the previous monitoring run from the water quality meter memory (be sure that the steps in section 4.4 *Data Retrieval* have been completed first). Reprogram the water quality meter for the upcoming monitoring run. Confirm that the appropriate monitoring parameters are enabled. Program the monitoring interval. Program the meter to begin recording data shortly after deployment, being careful to enter the date and time correctly. If it is necessary to enter a stopping date and time, set the stopping date well into the future, well beyond the anticipated retrieval date. Record the date and time that the unit is scheduled to begin logging, along with the unit serial number and other relevant information in the spaces provided in the *Programming* section of the *Multiprobe Maintenance and Calibration Record*.

5.0 POTENTIAL PROBLEMS

Due to the complexity of logging multi-parameter water quality meters, there are numerous problems that can arise.

5.1 Maintenance

A common problem is the inability to communicate with the meter. Some potential solutions include checking all connections (at meter bulkhead, power source, and computer or display device), checking the power source and fuses, and checking the software communication settings.

The power supply, especially if it is a separate external device, is a frequent source of problems. When maintaining the power supply, be sure that batteries are installed in the proper orientation, taking care not to stress any wiring. Ensure that all gaskets are in good condition and replenish silicone grease if necessary. When sealing the battery compartment be sure that no wires or other material prevents the compartment from sealing completely. Most lost data is the result of power failure, caused by a poorly maintained or damaged power supply.

5.2 Inability to Calibrate Parameters

The most common problems are encountered during the calibration process and are discussed in detail below.

5.2.1 Dissolved oxygen

If DO will not calibrate because the adjustment is beyond the acceptable tolerance, or if the readings do not seem accurate, examine the dissolved oxygen sensor membrane for wrinkles or bubbles under the membrane. Replace the membrane if there are any large wrinkles or bubbles larger than one-eighth inch in diameter (calibration cannot occur for six hours after the membrane is changed). If the multiprobe is equipped with an optical DO sensor, check the sensing foil on the optical window for biological growth or accumulated sediment. If present, remove gently with a cotton swab. If the sensing foil is torn or otherwise heavily damaged, it will need to be replaced. If there are chronic problems with calibration or stabilization of readings, change the sensor following the manufacture's instructions.

5.2.2 pH

If pH will not calibrate, or if pH readings are very slow to equilibrate, the pH probe and/or the pH reference probe may need additional maintenance. If the glass bulb on the pH sensor is coated with a film or biological growth use a cotton swab to rub methanol on the bulb. If a coating cannot be removed with methanol, invert the unit and fill an open topped calibration cup with 0.1 M Hydrochloric Acid until the glass bulb is just submerged. Allow the sensor to soak in the acid for five minutes, then rinse with DI water, and soak in pH 7.00 buffer for ten minutes.

If the porous junction on the tip of the pH reference probe appears dirty remove the covering sleeve, pour off the electrolyte and replace the threaded porous junction. Refill the electrolyte and reseat or rethread the sleeve, inverting it once snug in order to purge out any air trapped inside.

5.2.3 Specific conductance

The most common problem with the calibration of specific conductance is the contamination of the conductivity standard as a result of insufficiently cleaning the unit or inadequately rinsing the calibration cup. If the unit will not calibrate because the adjustment is beyond the acceptable tolerance, discard the conductivity standard, rinse the sensors thoroughly first with DI water then with conductivity standard, and decant fresh conductivity standard for another calibration attempt. If calibration still fails repeat the conductivity sensor maintenance, taking special care to remove any corrosion or deposits from the electrodes.

5.3 Programming

When preparing a multiprobe for a monitoring run, pay close attention to several key items to avoid losing data. Confirm that all parameters to be monitored are enabled and disable all other parameters. Confirm that the internal clock on the unit is reading the date and time correctly. In addition confirm that the monitoring interval, the start time and the end time has been set correctly. An error in any of these programming items can result in lost data.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) measures include routine and standardized procedures for the operation and maintenance of the logging multi-parameter water quality meter, thorough documentation of maintenance and calibration activities, comparison of multiprobe readings to field audit readings, and quantification of the drift of each monitored parameter.

The field audit, described in section 4.1 *Field Audit and Removal,* provides a useful gauge to the quality of the multiprobe readings just prior to removal. These audit values are recorded on the *Multiprobe Maintenance and Calibration Record* and compared with the last in situ multiprobe values but there is no acceptance range for the audit values.

The drift check, described in section 4.2 *Post-measurement check (drift check)* provides guidance for the actions to be taken based on the amount of drift/fouling witnessed. The drift check values are recorded on the *Multiprobe Maintenance and Calibration Record*. The drift check acceptance ranges depend on current standards and are preprinted on the *Multiprobe Maintenance and Calibration Record*. If any parameter falls outside of the acceptance range during the drift/fouling check, record that information in the annual *QA/QC Report*. This document provides data users with our data quality specifications and provides guidance on what data does and does not meet our data quality standards. Because the accuracy of offending parameters are only known at the point of calibration (when it presumably reading the standard exactly) and at the point when the drift check is performed (when it is reading outside of the acceptance range), the data for the entire duration of the monitoring run must be seen as not meeting the data quality standards. However, because it is likely that the data for a large portion of the monitoring run is accurate, the data will still be reported, but with the qualification that it does not meet our quality assurance specifications.

The routine maintenance regimen, discussed in section 4.3 *Maintenance*, is conservatively frequent and ensures the timely care, and if necessary replacement of sensitive components. All maintenance activities are recorded on the *Multiprobe Maintenance and Calibration Record*. Results from the QC procedures, including a record of any parameters that failed to meet data quality acceptance range, and an explanation for any missing data, accompany the data files.

The Multiprobe Maintenance and Calibration Record is also a place to document the drift and fouling that occurred over the course of the monitoring run, and provides guidance for the actions to be taken based on the amount of drift/fouling witnessed. Complete the drift check section of the *Multiprobe Calibration Record* while following the steps in section 4.2 *Drift/Fouling Quantification*. The following are the acceptance ranges for each parameter: specific conductance: 132 – 162 uS/cm (assuming that a standard of 147 uS/cm is being used, dissolved oxygen: 90 – 110 percent saturation, temperature: 1.0 degrees Celsius greater or less than the reference thermometer measurement, and pH: 6.50 – 7.50 for a standard of 7.00, 3.50 – 4.50 for a standard 4.00, and 9.50 – 10.50 for a standard of 10.00. These acceptance ranges are listed on the *Multiprobe Maintenance and Calibration Record* as well. If any parameter falls outside of the acceptance range during the drift/fouling check, record that information in the annual *QA/QC Report*. This document provides data users with our data quality specifications and provides guidance on what data does and does not meet our data quality standards.

7.0 RESOURCES

(1) *National Field Manual for the Collection of Water-Quality Data,* U.S. Geological Survey, Denver, CO 1998.

(2) *Multiparameter Water Quality Monitoring Instruments - Operating Manual,* Hydrolab Corporation, Austin, TX, 1993.

(3) Water Quality Multiprobes - User's Manual, Hydrolab Corporation, Austin, TX, 1997.

City of Portland
Bureau of Environmental Services
Information Delivery Division

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FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

DIRECT GRAB SAMPLE COLLECTION WITH SAMPLE BOTTLE

REVIEW AND APPROVAL

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FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

DIRECT GRAB SAMPLE COLLECTION WITH SAMPLE BOTTLE

1.0 PURPOSE

This Standard Operating Procedure (SOP) details procedures for collecting grab samples directly into sample bottles or containers for the purposes of surface water and/or stormwater sampling and analyses.

2.0 SCOPE AND APPLICABILITY

Water samples that are obtained by instantaneously filling a sample container are referred to as "grab" samples. The procedures described in this document pertain to the proper collection of grab samples from surface water and stormwater monitoring sites that allow for direct access to the flow stream or sample medium. It is intended that this document pertain only to surface water and stormwater sampling sites that allow access to the entire flow stream and/or when sampling is done just beneath the water's surface (i.e., up to 12 inches beneath the water's surface). If the flow stream is well mixed and the chemistry is relatively uniform, the methods described in this SOP are sufficient to represent the water body. If the water body is very deep and there is vertical stratification, a direct grab sample may not be representative of the entire flow stream. Depending on the project objectives it may be necessary to collect multiple sub-samples at different depths. If this is the case, or if direct access is not possible, refer to *SOP 2.02b - Grab Sample collection with Stainless Steel Bailer, SOP 2.02c - Grab Sample Collection with Peristaltic Pump,* and *SOP 2.02d - Grab Sample Collection with Column Sampler*. The procedure involving grab sample collection for chlorophyll *a* analysis is described in *SOP 2.02e - Grab Sample Collection for Chlorophyll a*. Refer to *SOP 4.01b Grab Sample Collection of Industrial Wastewater* and *SOP 4.01c Grab Sample Collection for Cyanide Analysis* for a description of grab sample procedures that apply to industrial wastewater. Refer to *SOP 7.01a - Decontamination of Sampling Equipment, SOP 7.01f Bottle Rinsing and Filling, and Bottle List - FO* for more details concerning the selection and decontamination of bottles to be used in the context of this SOP.

3.0 EQUIPMENT AND MATERIALS

The following is a list of required equipment for collecting surface water and stormwater grab samples directly into sample bottles:

Disposable gloves appropriate for intended analytes (see *Glove Selection for Water Quality Sampling*)
Analyte-specific sample bottles and/or containers
Manhole puller for access to stormwater sewers
Chain-of-Custody form
Site files detailing sample site information, past site visits, and sampling locations
Cooler(s) and ice packs

Required sample collection apparatus (i.e., weighted bottle harness for oil and grease/bacteria samples or extendable sampling pole)

4.0 PROCEDURE

The following procedure relates to the direct collection of surface water and stormwater samples with the sample container itself. It is assumed that analyte-specific containers and bottles will be used as necessary and that sampling equipment is decontaminated as required (reference *SOP 7.01a - Decontamination of Sampling Equipment, SOP 7.01f Bottle Rinsing and Filling, and Bottle List - FO* for more details).

4.1 Sample Collection

1. Assemble the necessary field/sampling documentation and site-specific information.
2. Reference the project checklist and/or field file to gather the appropriate number of sample bottles in accordance with the analytical tests to be performed. If sample collection requires confined space entry into a stormwater sewer, please refer to City of Portland, Bureau of Environmental Services document entitled *Confined Space Entry Policy and Procedures*.
3. As indicated by the project site map and/or field file documentation, access the monitoring site(s) as specified. At each sampling location, samples should be collected at the point that best represents the entire stream cross section at the time of sampling. Typically this will be the mid-span of the creek or flow channel. If the appropriate point cannot be accessed directly, a different collection method, described in the previously referenced SOPs, will need to be employed. Avoid near-shore samples and the disturbance of bottom sediments.
4. While wearing a clean pair of disposable gloves, carefully remove cap, lid, and/or seal to the sample bottle to be used.
5. Submerge the sample bottle facing upstream into the flow, rinse (if needed), and fill to the shoulder. See *SOP 7.01f Bottle Rinsing and Filling* for detailed guidance and for analyte-specific requirements and precautions. To avoid the capture of surface debris that may be present (i.e., leaves and twigs), lower the opened sample bottle into the representative flow stream opening first to a depth of roughly 12 inches, then tip upwards toward the direction of flow. If the water depth is less than 12 inches, submerge the bottle to the approximate midpoint of the water column and tip upwards toward the direction of flow. In very shallow water seek out a pour point (small waterfall-like feature) where the lip of the bottle can be positioned to capture the cascading water. If necessary, use the cap to scoop sample media into the container to fill the bottle to the required level. Sample bottles containing preservative must not be filled by the direct collection method. To avoid dilution of the preservative concentration, use an appropriately decontaminated intermediate vessel to pour sample into the bottle and do not overfill. Repeat steps 5 and 6 until all bottles are filled.
6. Record the sample time and date on the *Chain of Custody*.
7. Store filled sample bottles in a cooler with ice. In general, all samples require storage at 4 degrees Celsius during transport to the lab for analysis (reference *WPCL, Quality Manual, Appendix L).*
8. Deliver samples to the laboratory with all field and sample documentation for analysis using chain of custody procedures described in *SOP 7.01d Sample Chain-of-Custody*. When relinquishing samples, allow the laboratory sufficient time to process the samples with respect to analyte-specific holding times.

4.2 Common analyses with special requirements for bottle filling

- Oil & Grease: collect directly without the use of an intermediate vessel

- E. coli: collect directly into a sterile bottle without the use of an intermediate vessel
- VOCs: collect into 3 glass vials with rubber septa, one of those preserved with HCl. Use an intermediate vessel to pour the sample media into the vials, pouring down the side wall to limit as much as possible the formation of bubbles (and loss of the intended analytes). Do not overfill the preserved vial to limit the loss of preservative. The cap may be filled with the sample media and used to "top off" the vial, creating a convex meniscus at the top of the vial. When capping, ensure that the convex meniscus is not disturbed, and that no bubbles are present in the vial after capping, if possible.
- Alkalinity: collect with no headspace in the bottle. Use the cap to "top off" the bottle, creating a convex meniscus at the top of the bottle prior to capping. Cap without disturbing the meniscus. Do not squeeze the bottle to artificially create the meniscus, as the bottle will fill with air later through the threads on the cap and potentially alter the sample.
- Ortho-phosphate: a minimum sample volume of 100mL, field-filtered through a 0.45um syringe filter approved for nutrients analysis
- Cyanide: collect sample into a bottle preserved with NaOH tablets or liquid so that the sample reaches a pH of 12 within 15 minutes of collection. If collecting industrial wastewater samples, refer to *SOP 4.01c - Grab Sample Collection for Cyanide Analysis.*

5.0 POTENTIAL PROBLEMS

Careful attention should be employed during the manual collection of surface water and stormwater grab samples so as to avoid possible contamination and to secure accurate representation of the sample media. By not following specified requirements pertaining to decontamination, clean sampling technique, proper sampling methodology, and bottle rinsing and filling; the accuracy of the sampling procedure can be jeopardized. Contamination of the sample(s) may occur through the use of unclean sampling equipment that will introduce foreign material (e.g., dust, dirt, and organic material) into the sample container and/or the flow stream to be sampled. Improper activity in or around the sample site (e.g., physical disturbance of a creek bottom by walking in it) will also negatively affect the representation of the sample and must be avoided before and during the collection of the samples. The operation of equipment in or around the sample site that may compromise the representative nature of the grab samples must also be avoided. If you are required to deploy a water quality meter in the flow stream in addition to collecting samples, either collect the samples before deploying the meter or position the meter adjacent to the sampling location such that sediment disturbed by the meter does not influence the samples and vice versa.

Refer to *WPCL, Quality Manual, Appendix L Containers, SOP 7.01f Bottle Rinsing and Filling, and Bottle List-FO* for guidance on the necessary sample bottle selection, pre-preservation, filtration, as well as rinsing and filling techniques for each analyte as well as analyte-specific requirements.

Be aware that oil and grease samples as well as bacteria samples must be collected by the direct method described in this SOP. Use of an intermediate device for these analytes has the potential to bias the results. Conversely, bottles that contain a preservative, such as those used for volatile organics analysis, must not be filled by the direct collection method to avoid dilution of the preservative; therefore one must use an intermediate device. Refer to the appropriate SOP for a description of the procedures for the chosen device

All procedures related to proper decontamination and sample handling must be followed accordingly to safeguard sample integrity. Special consideration concerning sample preservation and sterile sampling methods also pertain directly to the desired analysis and should be noted prior to the sample operation as well.

Sampling documentation must be reviewed before conducting the sampling operation to verify analytical requirements and to ensure effective communication to the laboratory regarding the processing of the samples in accordance to the needs of the sampling project. Before sampling occurs, past sampling and/or field documentation should be referenced for information related to monitoring site characteristics and required sampling protocol. Activities conducted in the field must also adhere to BES safety procedures and guidelines.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) samples may be taken to assure the accuracy of the sampling operation and to verify sample representation. A duplicate or bottle blank may be used within the context of this SOP. Refer to *SOP 7.01c – Field Quality Control Sample Collection* for QA/QC procedures, including more information on how to collect a duplicate and the appropriate bottle blank collection procedure.

6.1 Collection of a duplicate

The collection of a duplicate serves to quantify variability from field sampling practices, quantify variability from laboratory procedures, and quantify the precision of the sampling method in determining the quantity of an analyte in the media being sampled.

To collect a duplicate, follow the appropriate sampling procedures as described in section 4.1, with the following variations.

1. When setting up bottles to be filled, lay two replicate bottle sets out side by side, organized by type of bottle.
2. When filling bottle directly from flow or water source, collect like bottles (same type or used for the same analyte) in quick succession to limit the potential of the flow source changing during the sampling process.
3. Ice and transport the two duplicate bottle sets to the laboratory. The grab and duplicate will have the same location code and collection time on the COC. Label the grab "G" under sample type. Label the duplicate "DUP" under sample type.

7.0 RESOURCES

(1) *EPA Compendium of ERT Surface Water and Sediment Sampling Procedures,* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC, 1991.

(2) *National Field Manual for the Collection of Water-Quality Data,* U.S. Department of the Interior, U.S. Geological Survey, United States Government Printing Office: 2015.

(3) *Water Quality Monitoring, Technical Guide Book,* The Oregon Plan for Salmon and Watersheds, 1999.

City of Portland
Bureau of Environmental Services
Information Delivery Division

SOP No.: 2.02a
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Author: CMH/ECP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

DIRECT GRAB SAMPLE COLLECTION WITH SAMPLE BOTTLE

REVISION HISTORY

Revision Date	By	Revisions Made
05/15/02	JBB	Date of origination
11/04/03	DJH	Revision 2 – Modified language throughout document to increase clarity. 2.0 – Described surface water conditions having to do with depth and stratification that might preclude using this method. 4.1 – Added details to step three regarding where, at an individual monitoring location, samples should be collected, and advised reader to consider a different method if an appropriate point is not accessible. Added language to step six describing how to avoid including surface debris in a sample and removed language redundant with procedures described in step three. Added language to step nine regarding analyte holding time considerations. 6.0 – Added reference to *SOP 7.01c Field Quality Control Sample Collection.*
???	???	Revision 3- Modified language throughout document to increase clarity. 5.0 – Added reference to WPCL document titled *Sample Bottle and Preservation Requirement.* Added numerous analyte-specific bottle rinsing and filling requirements.
1/19/21	CMH/ECP	Revision 4 - Modified language throughout document to increase clarity. -Changed "Environmental Investigations Division" to "Information Delivery Division" to reflect organizational restructuring 2.0 – Added references to SOPs that describe grab sample collection procedures for industrial wastewater as well as *SOP 7.01f Bottle Rinsing and Filling* 3.0 - Changed glove language to "Disposable gloves appropriate for intended analytes (see *Glove Selection for Water Quality Sampling*)" 4.0 - Added new reference to *SOP 7.01f Bottle Rinsing and Filling* as well as the supporting document, "Bottle List – FO" 4.1 - Added new references to *SOP 7.01f Bottle Rinsing and Filling* and removed language in *SOP 2.02a* that is redundant with *SOP 7.01f* - Added description of how to collect grab samples in very shallow conditions - Added new reference to "WPCL, Quality Manual, Appendix L -. Added background info regarding coordinating sample delivery to the lab 4.2 – Added section "Common analyses with special requirements for bottle filling" 5.0 – Added a description of how to collect grab samples and deploy a field meter simultaneously - Added new reference to *SOP 7.01f Bottle Rinsing and Filling* and removed

		language in *SOP 2.02a* that is redundant with *SOP 7.01f* - Added language stipulating that oil and grease as well as bacteria samples MUST be collected by the direct method, and that analytes requiring pre-preserved containers MUST NOT be collected by the direct method - Added language describing when it's appropriate to collect a bottle blank 6.1 – Added section outlining the basic procedures for collecting a duplicate with a bottle 7.0 – Updated USGS Field Manual Reference to current version

City of Portland
Bureau of Environmental Services
Information Delivery Division

SOP No.: 2.02b
Revision No.: 6
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Author: ECP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

GRAB SAMPLE COLLECTION WITH STAINLESS STEEL BEAKER

REVIEW AND APPROVAL

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City of Portland
Bureau of Environmental Services
Information Delivery Division

SOP No.: 2.02b
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Author: ECP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

GRAB SAMPLE COLLECTION WITH STAINLESS STEEL BEAKER

1.0 PURPOSE

This Standard Operating Procedure (SOP) details procedures for collecting surface water, stormwater, and municipal wastewater grab samples with a stainless steel beaker or bailer.

2.0 SCOPE AND APPLICABILITY

The following procedure applies to the collection of aqueous sample media (such as stormwater, surface water or municipal wastewater) using a stainless steel beaker, bailer, or flat bladed shovel. For the purposes of this SOP, a beaker is defined as a cylindrical stainless steel bucket with a pour spout. A bailer is defined as a beaker with two holes drilled equidistantly in the side and a stainless steel cable crimped on with an aluminum crimp to provide a handle. These are offered in a variety of sizes, the most commonly used for this SOP are the 1 Liter and 2 Liter size. A flat bladed shovel is defined as a small, flat bladed device with side walls extending perpendicular to the wide blade of the shovel. Stainless steel is the only appropriate material for a beaker, bailer, or shovel used in the application of this SOP.

This technique is primarily used in four ways: to access water at distance beneath the location of the technician, such as an underground pipe or a stream below a bridge, to access a lateral discharging into a manhole using a beaker mounted on a swing sampler, a beaker may be used to assist in the collection of water samples when grab sample collection with a sample bottle is not possible due to depth or other practical reasons, or to collect sheet flow runoff on the surface.

When direct access to the sample media is possible, refer to *SOP 2.02a - Grab Sample Collection with Sample Bottle.* The procedure involving grab sample collection for *chlorophyll a* analysis is described in *SOP 2.02e - Grab Sample Collection for chlorophyll a*. For information concerning the filling of sample bottles, refer to *SOP 7.01f - Bottle Rinsing and Filling*. For the collection of industrial wastewater samples with a beaker or bailer, refer to *SOP 4.01b - Grab Sample Collection of Industrial Wastewater Samples.*

3.0 EQUIPMENT AND MATERIALS

The following is a list of required equipment for collecting surface water, stormwater, and municipal wastewater grab samples using a beaker or bailer:

Blue nitrile gloves (see *Glove Selection for Water Quality Sampling*)
Stainless steel beaker (decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment*)
Stainless steel bailer with stainless steel cable handle (decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment*)

Stainless steel flat shovel (decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment*)
Unused, clean nylon or polypropylene string (>100lbs tensile strength)
Aluminum foil
Extendable swing sampler
Analyte-specific sample bottles and/or containers
Stainless steel hose-clamp and zip tie apparatus for sampling oil and grease, if applicable
Stainless steel hose-clamp and weight apparatus for sampling E. coli, if applicable
Dedicated polycarbonate carboy with spigot
Cooler(s) and ice packs
Chain-of-Custody
Field data sheets
Site files detailing sample site information, past site visits, and sampling locations
Manhole puller for access to stormwater sewers
Traffic control equipment
Job Safety Analysis (JSA) form

4.0 PROCEDURE

The following procedure describes the collection of surface water, stormwater, and municipal wastewater samples with a stainless steel beaker or bailer. The sample collected will be transferred to analyte specific containers and bottles (see *SOP 7.01f - Bottle Rinsing and Filling*).

4.1 Preparation

Assemble the necessary field equipment, sampling documentation and site specific information. Refer to the project checklist and/or field file to gather the appropriate sample bottles for the analytical tests to be performed.

4.2 Traffic Control/Site Safety

The *Job Safety Analysis (JSA)* form describes any real or potential hazards at the sampling location and documents the appropriate traffic control configuration required to safely access manhole locations. Refer to the *JSA* form to determine the appropriate way to access the monitoring location. Sampling with a stainless steel beaker or bailer usually does not involve performing a confined space entry and as such, field personnel should not break the plane of the manhole with any part of their body when performing the sampling. This form also provides guidance on any safety considerations involved in working above open channels.

4.3 Sample Collection

Samples can be collected using the following methods. Method selection is dependent on the type of sampling location. For example, the use of a stainless steel bailer and string may be appropriate when sampling from a manhole that exceeds more than ~6 feet in depth. Swing samplers are appropriate when sampling laterals at end of pipe in a manhole less than ~15 feet in depth or when accessing a outfall that is perched or inaccessible for direct sampling due to the surrounding landscape. A bailer or beaker may be used as in intermediate vessel when flow is shallow in a pipe, or it is more ergonomic for the sampling team. When capturing stormwater sheet flow, a stainless steel shovel can be used in coordination with a beaker or bailer.

4.3.1 Sample collection using a stainless steel bailer and string

1. While wearing a clean pair of gloves, remove the bailer from its protective aluminum foil covering. Cut a sufficient length string and use a bowline knot to tie it to one end to the stainless steel cable handle.

2. Using the string, slowly lower the bailer to the surface of the water, submerge and retrieve.
3. The first sample retrieved is used as a rinse of the bailer. Swirl the sample to completely rinse the interior of the bailer and discard the sample in a location where it will not contaminate the next sample that is retrieved.
4. Again, lower the bailer to the surface of the water, submerge and retrieve
5. Fill the sample bottle(s) according to *SOP 7.01f - Bottle Rinsing and Filling.*
6. Once the sample bottle(s) are rinsed, lower and submerge the bailer into the sample flow. Retrieve the bailer and fill the sample bottle(s), repeat as needed to fill all sample bottles.
7. When collecting oil and grease or E. coli samples, refer to *SOP 7.01f - Bottle Rinsing and Filling*, as these containers must be filled directly and not from the bailer. Use the appropriate hose-clamp sampling apparatus to lower the bottle to the surface of the water, submerge, and retrieve in a single dip.
8. Store filled sample bottles in a cooler with ice for transport back to the laboratory.

4.3.2. Sample collection using a stainless steel beaker and a swing sampler

1. While wearing a clean pair of gloves, remove beaker from its protective aluminum foil covering. Carefully insert the beaker into the swing sampler, securing the beaker with the Velcro strap without contacting the interior surface of the beaker or knocking debris into the beaker.
2. Using the pole, extend the beaker on the swing sampler just below the lateral taking care not to contact the walls of the manhole or the lateral pipe itself. If the beaker cannot be filled without contacting the lateral pipe or the manhole walls, sampling cannot occur until flow conditions improve.
3. Allow water from the lateral to fill the beaker. The first sample retrieved is used as a rinse of the beaker. Swirl the sample to completely rinse the interior of the beaker and discard the sample.
4. Again, extend the beaker on the swing sampler and fill the beaker. Fill the sample bottle(s) according to *SOP 7.01f - Bottle Filling and Rinsing*.
5. Once the sample bottle(s) are rinsed, continue to fill and retrieve beakers to fill the sample bottle(s), repeat as needed to fill all sample bottles.
6. When collecting oil and grease and E.coli samples, place the sample container into the swing sampler, securing the beaker with the Velcro strap without contacting the mouth of the bottle. With clean gloves, remove the cap from the sample container and extend to just below the lateral in order to capture the flow directly into the container. Oil and grease and E.coli samples must be collected directly into the analysis bottle. Refer to *SOP 7.01f - Bottle Rinsing and Filling* for additional information about the collection of oil and grease and E. coli.
7. Store filled sample bottles in a cooler with ice for transport back to the laboratory.

4.3.3 Sample collection using a stainless steel beaker as an intermediate vessel

1. While wearing a clean pair of gloves, remove a beaker from its protective aluminum foil covering. Without touching the inside or lip of the beaker, insert the beaker into the stream of flow. Avoid contact with sediment deposited on the walls of the pipe or in the streambed.
2. The first sample retrieved is used as a rinse of the beaker. Swirl the sample to completely rinse the interior of the beaker and discard the sample.
3. Again, insert the beaker into the flow. Fill the sample bottle(s) according to *SOP 7.01f - Bottle Rinsing and Filling*.
4. Collect oil and grease and E. coli samples by inserting the bottles directly into the flow, in a single dip. For more information on the collection of oil and grease and E. coli samples, refer to *SOP 7.01f - Bottle Rinsing and Filling*.
5. Store filled sample bottles in a cooler with ice for transport back to the laboratory.

4.3.4 Sample collection using a flat stainless steel shovel and a beaker

1. While wearing a clean pair of gloves, remove a shovel from its protective aluminum foil covering. Without touching the blade of the shovel, place the shovel blade parallel to the ground or on the ground to collect sheet flow running across the surface of the ground. Avoid contacting the top of the shovel with the ground to avoid mobilizing sediments not associated with stormwater flow.
2. The first sample retrieved is used as a rinse of the shovel. Flush the sample water over the shovels surface to rinse the entire surface.
3. Again, insert the shovel blade into the flow. Fill the sample bottle(s) according to SOP 7.01f - Bottle Rinsing and Filling.
4. To collect parameters using SOP 1.06a - *Field Measurement of Multiple Water Quality Parameters,* use the shovel to fill a stainless steel beaker. Then, use the shovel to collect flow and rinse the multi-parameter sonde. Finally, insert the sonde into the beaker filled with sample water for the collection of parameters.
5. Store filled sample bottles in a cooler with ice for transport back to the laboratory.

5.0 POTENTIAL PROBLEMS

When using a beaker or bailer to collect samples, it is important to use a new decontaminated stainless steel beaker or bailer for each sample location. When lowering the beaker or bailer into the sample media, keep the beaker or bailer off of the bottom of the storm sewer pipe or the bed of the surface water, if possible, to prevent adding deposited sediment to the sample. Do not allow beaker or bailer to contact manhole walls, pipes, or steps when raising or lowering in a manhole. When transferring sample from a stainless steel beaker or bailer to a sample bottle, it is important to decant the sample as quickly as possible to prevent settling of the sample.

In some cases, it may be necessary to manually create a composite sample by combining individual grabs from a stainless steel beaker. In this case, collect the grab sample as outlined in this SOP. Once the sample has been retrieved, measure the sample with a decontaminated graduated cylinder (plastic or glass depending on analytes and decontamination procedure). Pour the measured sample into the composite bottle. Repeat as many times as necessary given the project requirements to create the composite sample.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field quality assurance and quality control (QA/QC) samples are collected to identify bias and variability in data resulting from the collection of samples. QA/QC samples for grab sampling with a stainless steel beaker or bailer could include duplicate samples, field decontamination blank samples, or field residual blank samples, depending on the field procedures utilized. For details on these procedures refer to *SOP 7.01c - Field Quality Control Sample Collection*. These procedures are used to evaluate the accuracy and repeatability of the sampling method, and possible contamination of sampling equipment.

6.1.1 Collection of a Field Decontamination Blank using a stainless steel bailer and string

1. Prepare a clean, designated polycarbonate carboy with a spigot.
2. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping it, shaking

uncapping it, and dumping the rinsate. Fill the carboy to the shoulder with ultrapure deionized water and close the lid tightly.

3. Bring the carboy to the sampling location with the other equipment as described above.
4. The purpose of the field decontamination blank is to both confirm effectiveness of decontamination procedures (the decontamination of the beaker and the carboy) and quantify contamination from field sampling activities (contamination from gloves, rainwater, atmospheric deposition, runoff from rain gear, etc.). To ensure that the blank captures the contamination that may be introduced from field sampling activities, replicate the physical positioning and order of operations that the sampling team would use while taking a sample as described in section 4.3.1.
5. Upon arriving at the sampling location, set out the carboy on the lid of a cooler near the manhole or sampling location.
6. While wearing a clean pair of gloves, remove the bailer from its protective aluminum foil covering.
7. Open the spigot on the carboy and fill the bailer. Close the spigot on the carboy. The first sample retrieved is used as a rinse of the bailer. Swirl the sample to completely rinse the interior of the bailer and discard the sample in a location where it will not contaminate the next sample that is retrieved.
8. Again, open the spigot on the carboy and fill the bailer. Close the spigot on the carboy.
9. Fill the sample bottle(s) according to *SOP 7.01f - SOP Title*. Repeat steps 8 and 9 until all the bottles are filled.
10. When collecting oil and grease or E. coli samples, refer to *SOP 7.01f - SOP Title*, as these containers must be filled directly and not from the bailer. Fill the containers directly from the carboy spigot.
11. Store filled sample bottles in a cooler with ice for transport back to the laboratory.
12. Upon return to the laboratory, empty the UPDI water out of the carboy, and refill the carboy with no headspace remaining.

6.1.2 Collection of a Field Decontamination Blank using a stainless steel beaker and swing sampler

1. Prepare a clean, designated polycarbonate carboy with a spigot.
2. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping and shaking it, uncapping it, and dumping the rinsate. Fill the carboy to the shoulder with ultrapure deionized water and close the lid tightly.
3. Bring the carboy to the sampling location with the other equipment as described above.
4. The purpose of the field decontamination blank is to both confirm effectiveness of decontamination procedures (the decontamination of the beaker and the carboy) and quantify contamination from field sampling activities (contamination from gloves, rainwater, atmospheric deposition, runoff from rain gear, Velcro, swing sampler, etc.). To ensure that the blank captures the contamination that may be introduced from field sampling activities, replicate the physical positioning and order of operations that the sampling team would use while taking a sample as described in section 4.3.2.
5. Upon arriving at the sampling location, set out the carboy on the lid of a cooler near the manhole or sampling location.
6. While wearing a clean pair of gloves, remove beaker from it's protective aluminum foil covering. Carefully insert the beaker into the swing sampler, securing the beaker with the Velcro strap without contacting the interior surface of the beaker or knocking debris into the beaker.
7. Using the pole, extend the beaker on the swing sampler under the spigot on the carboy. Open the carboy spigot and allow the beaker to fill. Close the carboy spigot. The first sample retrieved is used as a rinse

of the bailer. Swirl the sample to completely rinse the interior of the bailer and discard the sample in a location where it will not contaminate the next sample that is retrieved.

8. Again, extend the beaker on the swing sampler under the spigot on the carboy. Open the carboy spigot and allow the beaker to fill. Close the carboy spigot.
9. Replicating the procedure and physical positioning used while conducting environmental samples, fill the sample bottle(s) according to *SOP 7.01f - Bottle Rinsing and Filling*. Repeat steps 8 and 9 until all the bottles are filled.
10. When collecting oil and grease or e. coli samples, refer to *SOP 7.01f - Bottle Rinsing and Filling*, as these containers must be filled directly and not from the bailer. Fill the containers directly from the carboy spigot.
11. Store filled sample bottles in a cooler with ice for transport back to the laboratory.
12. Upon return to the laboratory, empty the UPDI water out of the carboy, and refill the carboy with no headspace remaining.

6.1.3 Collection of a Field Decontamination Blank using a stainless steel beaker as an intermediate vessel

1. Use the same procedure as in section 6.1.1

6.1.4 Collection of a Field Decontamination Blank using a flat stainless-steel shovel and a beaker

1. Prepare a clean, designated polycarbonate carboy with a spigot.
2. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping and shaking it, uncapping it, and dumping the rinsate. Fill the carboy to the shoulder with ultrapure deionized water and close the lid tightly.
3. Bring the carboy to the sampling location with the other equipment as described above.
4. The purpose of the field decontamination blank is to both confirm effectiveness of decontamination procedures (the decontamination of the beaker and the carboy) and quantify contamination from field sampling activities (contamination from gloves, rainwater, atmospheric deposition, runoff from rain gear, etc.). To ensure that the blank captures the contamination that may be introduced from field sampling activities, replicate the physical positioning and order of operations that the sampling team would use while taking a sample as described in section 4.3.2.
5. Upon arriving at the sampling location, set out the carboy on the lid of a cooler near the manhole or sampling location.
6. While wearing a clean pair of gloves, remove a shovel from its protective aluminum foil covering. Without touching the blade of the shovel, place the shovel blade below the spigot of the carboy. Open the carboy spigot and allow the shovel to fill. Close the carboy spigot. Swirl the blank water in the shovel to completely rinse the interior and discard the blank water in a location where it will not contaminate the next sample that is retrieved.
7. Replicating the procedure and physical positioning used while conducting environmental samples, fill the sample bottle(s) according to *SOP 7.01f - Bottle Rinsing and Filling*. Repeat steps 8 and 9 until all the bottles are filled.
8. When collecting oil and grease or e. coli samples, refer to *SOP 7.01f - Bottle Rinsing and Filling*, as these containers must be filled directly and not from the bailer. Fill the containers directly from the carboy spigot.
9. Store filled sample bottles in a cooler with ice for transport back to the laboratory.
10. Upon return to the laboratory, empty the UPDI water out of the carboy, and refill the carboy with no headspace remaining.

6.2.1 Collection of a duplicate using a stainless steel beaker, bailer, or shovel

The collection of a duplicate serves to quantify variability from field sampling practices, quantify variability from laboratory procedures, and quantify the precision of the sampling method in determining the quantity of an analyte in the media being sampled.

To collect a duplicate, follow the appropriate sampling procedures as described in section 4.3, with the following variations.

1. When setting up bottles to be filled, lay two replicate bottle sets out side by side, organized by type of bottle.
2. Pour some of each beakerful or shovel-full of sample into like bottles (such as all 1 L ambers) so that the bottles are filled equally with each beakerful of sample retrieved. Take care to transfer the sample from the beaker, bailer, or shovel to the bottle quickly to prevent settling of the sample. If the sample settles, swirl the sample in the beaker prior to transfer to the bottle to ensure even mixing within the beaker and therefore between like containers.

7.0 RESOURCES

(1) EPA Guidance for Quality Assurance Project Plans, U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, 1998.

(2) *National Field Manual for the Collection of Water-Quality Data,* U.S. Department of the Interior, U.S. Geological Survey, United States Government Printing Office: 2015.

City of Portland
Bureau of Environmental Services
Information Delivery Division

SOP No.: 2.02b
Revision No.: 6
Date: 10/22/20
Author: ECP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

GRAB SAMPLE COLLECTION WITH STAINLESS STEEL BEAKER

REVISION HISTORY

Revision Date	By	Revisions Made
2/5/02	CJE	Date of origination
1/28/05	CJE/MJH	Revision 2 - Changed “Bailer” to “Beaker” throughout document 4.1 - Added language indicating the beaker should be stored in a protective covering (either/both aluminum foil, zip loc bag) 5.0 - Added “Do not allow beaker to contact manhole walls, pipes, or steps when raising or lowering in a manhole”
6/11/07	MJS	Revision 3 - Modified language throughout document to increase clarity, no procedural changes
7/16/07	MJS	Revision 4 - Modified language throughout document to increase clarity 3.0 - Added “Swing sampler with pole (telescoping pole if necessary) to Equipment and Materials List 4.1 - Changed this section to indicate there are two ways to sample with a beaker. Section 4.1 outlines sampling with a rope tied to the handle. Section 4.2 outlines sampling with a extendable pole. Inserted a rinse step in step 6: “The first sample retrieved is used as a rinse of the beaker. Swirl the sample to completely rinse the interior of the beaker and discard the sample” 4.2 - added section 4.2, “Sample Collection using a swing sampler”
6/18/18	MJS	Revision 5 3.0 - Added “stainless steel beaker with beaker with stainless steel cable handle (decontaminated)”, “unused white nylon or polypropylene string”, “Ziploc® bag”, “aluminum foil”, “stainless steel scissors”, and “Job Safety Analysis (JSA) form” to Equipment and Material List 4.1 - Changed section 4.1 to a new section, “Preparation” ; Added Traffic Control/Site Safety Section ; Moved “Sample collection using a rope” and “Sample Collection using a swing sampler” to section 4.3.1/4.3.2
10/22/20	ECP	Revision 6 - Defined two different devices used in the SOP, the beaker and the bailer, language added throughout to include both - Modified language throughout for clarity - Changed “Environmental Investigations Division” to “Information Delivery Division” to reflect organizational restructuring 2.0 - Defined a beaker and a bailer - Mentioned that this SOP can be used to sample municipal wastewater and other liquid sample media, but for industrial wastewater readers should refer to *SOP 4.01b - Grab Sample Collection of Industrial Wastewater Samples*

		- Added an introduction to a third use of this SOP, when a beaker or bailer may be used to assist in the collection of water samples when grab sample collection with a sample bottle is not possible due to depth or other practical reasons - Added a reference to a new SOP, 7.01f. 3.0 - Changed glove language to "Disposable gloves appropriate for intended analytes (see Glove Selection for Water Quality Sampling-r3.xlsx)" - Added a new reference to the supporting document, *Glove Selection for Water Quality Sampling* - Removed the reference to white colored string - Removed Ziploc bags from the checklist - Added "Stainless steel hose-clamp and zip tie apparatus for sampling oil and grease" to the equipment and materials list - Added "Stainless steel hose-clamp and weight apparatus for sampling E .coli" to the equipment and materials list - Added "Dedicated polycarbonate carboy with spigot" 4.3.1 - Removed Ziploc bag reference - Added reference to new SOP 7.01f for bottle rinsing and filling instructions - Added new instructions on how to sample oil and grease and E .coli directly with hose clamp sampling apparatus' 4.3.2 - Removed Ziploc bag reference - Added reference to new SOP 7.01f for bottle rinsing and filling instructions - Added new instructions on how to sample oil and grease and E .coli directly with a swing sampler 4.3.3 - Added a new section for sample collection using a stainless steel beaker as an intermediate vessel 6.0 - Added section 6.1.1 "Collection of a Field Decontamination Blank using a stainless steel bailer and string" - Added section 6.1.2 "Collection of a Field Decontamination Blank using a stainless steel beaker and swing sampler" - Added section 6.1.3 "Collection of a Field Decontamination Blank using a stainless steel beaker as an intermediate vessel" - Added section 6.2.1 "Collection of a duplicate using a stainless steel beaker or bailer" 7.0 - Removed duplicate reference to USGS National Field Manual and updated reference to most current version

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

GRAB SAMPLE COLLECTION WITH COLUMN SAMPLER

1.0 PURPOSE

This Standard Operating Procedure (SOP) details procedures for collecting surface water grab samples with a column sampler.

2.0 SCOPE AND APPLICABILITY

The following procedure applies to the collection of surface water samples from a discrete depth below the surface of the water. When direct access to the sample media is possible and collection at the water surface is acceptable, techniques described in *SOP 2.02a - Grab Sample Collection with Sample Bottle* can be utilized. If the sample can be collected from the surface of the water, but direct access is not available, *SOP 2.02b - Grab Sample Collection with Stainless Steel Bailer* can be followed. Procedures involving grab sample collection for chlorophyll *a* analysis are described in *SOP 2.02e - Grab Sample Collection for Chlorophyll a*.

3.0 EQUIPMENT AND MATERIALS

The following is a list of required equipment for collecting surface water grab samples using a column sampler:

Gloves (vinyl and/or latex)
Column sampler (decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment*)
Rope with messenger (weight) graduated with one-foot depth increments
Analyte-specific sample bottles and/or containers
Cooler(s) and ice packs
Chain-of-Custody and/or *Field data sheets*
Site files detailing sample site information, past site visits, and sampling locations

4.0 PROCEDURE

The following procedure relates to the collection of surface water grab samples with a column sampler. The sample collected in the column sampler will be transferred to analyte specific containers and bottles immediately following sample collection (please see City of Portland, *Water Pollution Control Laboratory Bottle/Sample Quantity Requirements Water Samples Document*).

4.1 Sample Collection

1. Assemble the necessary field/sampling documentation and site-specific information.

2. Refer to the project checklist and/or field file to gather the appropriate number of sample bottles in accordance with the analytical tests to be performed.
3. As indicated by the project site map and/or field file documentation, access the monitoring site(s) as specified.
4. While wearing a clean pair of gloves, slip the rope through the messenger and attach the rope to the column sampler.
5. Carefully open both end seals and affix each in the open position.
6. Using the rope, with messenger in hand, slowly lower the column sampler to the designated water column depth for that monitoring location. If no precise point has been designated, lower the column sampler to approximately three feet below the water surface at the midpoint of the channel. If the water is less than three feet deep position the column sampler at the midpoint of the water column. Try to minimize the disturbance of the water column. Allow ambient water to completely flush through the column.
7. Isolate the sample by releasing the messenger down the rope to activate the device that releases the end seals to close the sampler.
8. Retrieve the column sampler.
9. Discard this first column sampler's entire volume to rinse the sampler.
10. Repeat steps 5-8 and fill the sample bottle(s) approximately ¼ full by pouring from one end of the sampler, apply the cap or lid, shake vigorously, and pour the sample over the cap to rinse the bottle(s). Sample bottles/containers that are pre-preserved, sterile, and/or pre-cleaned should not receive a sample rinse.
11. Once the sample bottle(s) are rinsed repeat steps 5-8 as needed to fill all sample bottles.
12. Store filled sample bottles in a cooler with ice.

5.0 POTENTIAL PROBLEMS

When using a column sampler to collect surface water samples, the integrity of the sample is easily compromised. Some of the problems and potential solutions include the following:

1. Use a decontaminated column sampler at each sample location. Alternatively, if the data quality objectives permit, a field rinse can be performed between sites to minimize cross contamination of the samples.
2. When lowering the column sampler into the sample media, try to limit the disturbance to the water column.
3. It is possible that the messenger will not close all of the open-end seals to the sampler. If this occurs, recollect the sampler by repeating steps 5-7 in section 4.1. A small, upward pull on the rope immediately before the messenger hits the sampler can help ensure that the messenger strikes the closure mechanism cleanly, closing the seals.
4. When transferring sample from the column sampler to the analyte-specific sample bottles it is important to gently swirl the column sampler to keep particulates in the sample suspended.
5. While filling a preserved sample container, be sure not to overfill the bottle. If overfilling occurs, it could cause the concentration of the preservative to decrease and cause inaccurate results.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field quality assurance and quality control (QA/QC) samples may be taken to ensure the accuracy of the sampling operation. QA/QC samples for grab sampling with a column sampler could include collection of duplicate, field decontamination blank, and/or field residual blank samples. These procedures are used to evaluate the accuracy and repeatability of the sampling method, and possible contamination of sampling equipment. For more information on quality assurance and quality control please see *SOP 7.01c - Field QC Sample collection.*

7.0 RESOURCES

(1) *National Field Manual for the Collection of Water-Quality Data,* U.S. Department of the Interior, U.S. Geological Survey, United States Government Printing Office: 1998-99.

(2) U.S. Geological Survey, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, 2 v., variously paged.

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

DECONTAMINATION OF SAMPLING EQUIPMENT

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes decontamination procedures for soil and water sampling equipment. This SOP is applicable to samples to be analyzed for organic constituents, metals, nutrients/general chemistry, and microbiological constituents.

The general approach to equipment decontamination is stated by EPA: "*The method of cleaning should be adapted to both the substances that are to be removed and the determination to be performed*". This principle has been adapted to develop this set of procedures to produce clean, uncontaminated equipment. Following correct decontamination procedures will protect sample integrity, increase data quality and reliability, minimize contaminant spread and reduce potential for worker exposure. This SOP is a vital link in the integrity of the sampling process and will help ensure that equipment used during the sampling process is free from contaminants that could bias analytical results.

2.0 SCOPE AND APPLICABILITY

The procedures set forth in this SOP are applicable for the decontamination of sampling equipment when collecting soils, sediments, groundwater, surface water, stormwater, and wastewater for the analysis of organic, metals, nutrients/general chemistry and microbiological constituents. This SOP describes the correct procedures to decontaminate equipment that comes into contact with the sample matrix including sampling spoons, bowls, augers, beakers, bailers, dredges, composite containers, column samplers, and sample tubing. This practice is applicable to most conventional sampling equipment constructed of metallic and synthetic materials. The manufacturer of a specific sampling apparatus should be contacted if there is concern regarding the reactivity of a decontamination solution with the equipment.

These procedures do not apply to pre-cleaned or disposable equipment intended for single use.

3.0 EQUIPMENT AND MATERIALS

Latex, vinyl or nitrile gloves
Splash apron/visor/goggles
Decontamination solutions:
- Laboratory grade phosphate-free detergent (1% solution)
- Tap water
- Nitric Acid (10% solution)
- Organic solvents (acetone and/or methanol)

Deionized (DI) water
Ultrapure deionized water
Five-gallon plastic buckets, clean, designated for each solution
Two and one-half gallon stainless steel pail for 10% solvent solution and ultrapure deionized water
Peristaltic pump (if necessary)
Plastic scrub brushes
New, clean aluminum foil and plastic bags
Sodium bicarbonate and 5-gallon plastic bucket for neutralization

4.0 PROCEDURE

4.1 Determination of Decontamination Sequence

Equipment decontamination is dependent upon the equipment to be cleaned and the analysis to be performed. Prior to starting decontamination procedures, it is vital to review these two issues in order to determine the correct decontamination procedure.

1. To determine the correct decontamination sequence, locate the analysis to be performed on the *"Analyte Classification List*" in Appendix A. For each analysis to be performed on the sample, note whether each analysis is listed in the "organics," "metals," "nutrients," or "general chemistry" section.
2. Review sampling equipment to be used. Note if sampling equipment has metal or plastic components.
3. Using Table 1 - *Stepwise Decontamination Procedure (*next page*)* determine the correct decontamination sequence. Follow the procedure as shown, answering the questions and moving on to the next steps. Check the steps to be followed.

4.2 Decontamination Solutions

Assemble all of the decontamination solutions that will be needed based on the sequence established above. Not all of the solutions detailed below may be required.

1. 1% detergent solution: Fill the designated plastic five-gallon bucket with a solution of one part laboratory grade non-phosphate detergent and 99 parts tap water.
2. Tap water: Fill the designated plastic five-gallon bucket with municipal tap water.
3. 10% nitric acid solution: Note that when using nitric acid, it is particularly critical that the appropriate personal protective equipment is utilized, especially adequate eye protection. Fill the designated plastic five-gallon bucket with a solution of nine parts DI water and one part reagent grade nitric acid. If a smaller volume of nitric acid solution is sufficient, use a designated one-gallon high density polyethylene (HDPE) bottle that has been graduated for appropriate DI water and nitric acid amounts. The stainless-steel pails should never be used with a nitric acid solution. Always add the nitric acid to an existing volume of DI water to preclude a possibly violent reaction and diminish splash hazards.
4. DI water: Fill the designated five-gallon plastic bucket with deionized water from supply taps.
5. Organic solvents: Acetone is aggressive in the removal of hydrocarbon contamination from the surface of sampling equipment and is therefore the preferred organic solvent. Residue from acetone has the potential to cause contamination if analyzing for volatile organic compounds (VOCs). If analyzing for VOCs, perform a methanol rinse after allowing the equipment to air dry following the acetone rinse. Fill a designated, chemically compatible spray bottle or wash bottle with the selected organic solvent. A wash bottle will dispense a solid stream of liquid while a spray bottle will deliver a mist. Select the dispenser that will most completely rinse the equipment based on the size and geometry of the piece of equipment. If decontaminating tubing, create a 10% solvent solution by filling a two- and one-half gallon stainless steel pail with nine parts DI water and one part organic solvent. Create a volume of solution equal to at least five times the interior volume of the tubing. The plastic five-gallon buckets are not compatible with organic solvents and should not be used for an organic solvent solution.

STEPWISE DECONTAMINATION PROCEDURE

Use the following steps to determine the correct decontamination process. First, determine what items are to be decontaminated. Then, beginning with Step 1, answer the questions and proceed to the next Step indicated. Check the appropriate boxes in the right column. The resulting checked boxes indicate the appropriate decontamination sequence.

Project Name: ____
Date: ____________________

Description of item to be decontaminated: ______________________________

Step Number	**Decontamination Process**	Check boxes below as necessary
Step 1	Wash with a 1% laboratory grade non-phosphate detergent solution. ***Proceed to Step 2***	□1% detergent wash
Step 2	Rinse with tap water. ***Proceed to Step 3***	□ Tap water rinse
Step 3	Is sample to be analyzed for metals? No – ***Proceed to Step 4*** Yes – Does equipment have metal parts? Yes – Skip this step. ***Proceed to Step 4*** No – Rinse with 10% nitric acid solution. ***Proceed to Step 4***	□ 10% nitric acid wash
Step 4	Rinse with DI water. ***Proceed to step 5***	□ DI water rinse
	Is sample to be analyzed for organics? No – ***Proceed to Step 6*** Yes – Does analyte list include TOC and/or DOC and are they prioritized above all other organic analytes? Yes – Omit this step. ***Proceed to Step 6 **** No – Does equipment contain plastic parts? Yes – Omit this step. ***Proceed to Step 6***** No – Is sample to be analyzed for VOCs? Yes – Rinse with acetone and allow to air dry, then rinse with methanol, allow to air dry. ***Proceed to Step 6*** No – Rinse with acetone, allow to air dry ***Proceed to Step 6***	□ Acetone rinse □ Methanol rinse
Step 6	Rinse with ultrapure DI water.	□ Ultra Pure DI rinse

*If analytical priorities dictate, organic solvents can be used to assure the removal of any organic contaminants even if analyzing for Organic Carbon (TOC or DOC), knowing that the organic solvent rinse may leave an organic residue that may result in erroneously high Organic Carbon results.
**Fluorocarbon polymer (e.g. Teflon) is the only plastic material that is acceptable for organics analysis and compatible with organic solvents.

6. Ultrapure DI water: Fill the designated five-gallon bucket with ultrapure deionized water from a DI water polishing station. If analyzing for organics fill a two- and one-half gallon stainless steel pail with ultrapure deionized water.

4.3 Decontamination Process

1. Prepare a contaminant free space for cleaning and drying the sampling equipment. The decontamination area should be clean and free from contaminants and blowing dust and be large enough to accommodate decontamination activities. Whenever possible decontamination activities should be performed in the field laboratory where there is a fume hood, an ample supply of water, sinks, and other amenities. If nitric acid or organic solvents are to be used it is best to perform that portion of the decontamination inside the fume hood.
2. Put on coveralls, protective apron, gloves, and safety glasses.
3. Assemble equipment to be decontaminated. Inspect equipment for stains, cuts, or abrasions. Replace parts as needed. Do not use tubing that is moldy, mildewed, or discolored; or if imbedded sediment cannot be removed.
4. Decontamination Wash Procedures.
   a) Using soapy water, scrub equipment surfaces with a firm sponge or soft brush to remove any adhering material such as oil and grease, sediment, algae, or chemical deposits. Pay particular attention to grooves, crevices, or other places where material may become trapped. If decontaminating tubing, pump at least five times the tubing volume of solution through tubing.
   b) Using the tap water, rinse equipment thoroughly to remove detergent residue. Equipment rinsing is complete when no soap bubbles appear after agitating the rinse water. If performing decontamination in the laboratory, equipment can be rinsed directly under the tap or overhead nozzle rather than using a five-gallon bucket. If decontaminating tubing, pump at least five times the tubing volume of tap water through tubing.
   c) If analyzing for metals: Rinse equipment in nitric acid solution. For smaller equipment, a wash bottle filled with nitric acid solution can be used to rinse equipment rather than submerging it in a five-gallon bucket. If decontaminating tubing, pump at least five times the tubing volume of nitric solution through tubing. Capture all waste nitric acid into a designated five-gallon bucket and neutralize with sodium bicarbonate prior to disposal.
   d) Rinse the equipment thoroughly in a five-gallon bucket filled with DI water from the gray supply taps. If performing decontamination in the laboratory, equipment can be rinsed directly under a stream of DI water rather than using a five-gallon bucket. If decontaminating tubing, pump at least five times the tubing volume of DI water through tubing.
   e) If analyzing for organics, change to gloves that are chemically resistant to acetone (i.e. latex, or nitrile if analyzing for metals). All decontamination activities that utilize organic solvents should be conducted under the fume hood to mitigate respiration hazards. Using a spray or wash bottle, rinse the equipment with acetone. A wash bottle will dispense a solid stream of liquid while a spray bottle will deliver a mist. Select the dispenser that will most completely rinse the equipment based on the size and geometry of the piece of equipment. If decontaminating tubing, pump at least five times the tubing volume of a 10% acetone solution through tubing (note that only Fluorocarbon polymer-lined tubing is compatible with acetone).
   f) If analyzing for VOCs, perform a methanol rinse after allowing the equipment to air dry following the acetone rinse. All decontamination activities that utilize organic solvents should be conducted under the

fume hood to mitigate respiration hazards. If decontaminating tubing, pump at least five times the tubing volume of a 10% methanol solution through the tubing (note that only Fluorocarbon polymer-lined tubing is compatible with methanol).

g) Place equipment in a bucket of ultra-pure deionized water. If performing decontamination in the laboratory, equipment can be rinsed directly under a stream of ultrapure DI water rather than using a five-gallon bucket. If decontaminating tubing, pump at least five times the tubing volume of ultrapure DI water through tubing.
h) If collecting an equipment blank or a field decontamination blank sample, collect blank samples following the ultrapure DI rinse
i) Allow equipment to air dry. Wrap equipment in inert material if equipment is to be stored or transported into the field. If analyzing for organics, aluminum foil should be used, with the dull side contacting the equipment. If not analyzing for organics, a clean plastic bag can be used.

5.0 POTENTIAL PROBLEMS

Care must be taken when establishing the correct decontamination solutions and sequence. Review the analytes and the sampling equipment material. There is the potential for the objective of contaminant removal to be in conflict with the chemical compatibility of the sampling equipment material. For example, a stainless-steel beaker or soil auger being used to collect a sample to be analyzed for metals could not be exposed to the prescribed nitric acid rinse, as the nitric acid could cause the target analyte to leach from the equipment into the sample. Similarly, a polyethylene groundwater bailer, or an acrylic Van Dorn water sampler being used to collect a sample for organics analysis can not be exposed to organic solvents. In these situations, if comparable equipment is available in a compatible material it should be used (a fluorocarbon polymer groundwater bailer for example). If the required equipment does not exist in a compatible material, that decontamination step is omitted.
Another problem arises when a decontamination solution utilized to assure contaminant removal for one analyte has the potential to result in contamination for another analyte. For example, an organic solvent rinse is required to remove any poly-chlorinated biphenyls (PCBs) from sampling equipment. The organic solvent however can result in contamination for organic carbon analysis. If the sample is to be run for both analytes a priority must be established. If the organic carbon analysis is prioritized the organic solvent step would be omitted. However, if the PCB analysis is prioritized, the organic solvent rinse would be performed. In this example an equipment blank sample could be collected following the decontamination process to quantify the degree, if any, of organic carbon contamination. If the sample matrix is soil or sediment the concern for contamination for organic carbon analysis by an organic solvent rinse is dramatically diminished. A soil or sediment sample will have such a high content of organic carbon that any residual organic solvent from a properly performed decontamination process would be negligible.

6.0 QUALITY ASSURANCE & QUALITY CONTROL

Whenever possible conduct equipment decontamination in the lab or in an enclosed, clean environment where a supply of clean tap water, DI water and ultra pure water are available. Refrain from handling dirty or other equipment during the decontamination process. Replace gloves when necessary. Utilize an assistant when handling cumbersome equipment or tubing. Do not let equipment or tubing touch the ground or any other surfaces or objects during or after the decontamination process. If this occurs, re-start the decontamination process from the beginning.

Typically, individual projects will specify the types of quality assurance/quality control samples to be collected from a specific project. If it is important to document the effectiveness of the decontamination process, a blank sample should be collected from the equipment or tubing at the conclusion of the decontamination procedure. To confirm the efficacy of the decontamination itself, an equipment blank is collected. To investigate the effectiveness of field decontamination in conjunction with the potential for contamination from field sampling activities, collect a field decontamination blank sample. Refer to *SOP 7.01c – Field Quality Control Sample Collection* for more information on blank sample collection.

7.0 RESOURCES

(1) *Standard Practice for Decontamination of Field Equipment used at Non-radioactive Waste Sites,* American Society for testing and Materials, Philadelphia, PA, 1990.
(2) *National Field Manual for the Collection of Water Quality Data* Techniques of Water Resources Investigations Book 9 Handbooks for Water-Resources Investigations, Unites States Geological Survey.
(3) *Standard Practices for Sampling Water,* ASTM Method D 3370-82
(4) *Handbook for Analytical Quality Control in Water and Wastewater Laboratories,* EPA –600/4-79-019, March 1979
(5) *City of Portland WPCL Analyte List,* City of Portland Water Pollution Control laboratory, 2002
(6) *Sampling Equipment Decontamination, SOP #2006,* Environmental Protection Agency, 1994

City of Portland
Bureau of Environmental Services
Information Delivery Division

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FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

FIELD FILTERING WATER SAMPLES

REVIEW AND APPROVAL

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FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

FIELD FILTERING WATER SAMPLES

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes general guidelines for field filtering water samples.

2.0 SCOPE AND APPLICABILITY

This procedure is applicable to water samples that are filtered in the field immediately after collection. Filtration is the physical process of separating the particulate and aqueous fractions of water samples for analysis of solely the aqueous component. For the purposes of this SOP, the particulate fraction of a water sample is considered to be anything larger than 0.45 μm. Field filtration is currently required for Nitrate-Nitrogen, Nitrite-Nitrogen, O-Phosphate Phosphorous, and Dissolved Organic Carbon. Additional analytes can be field filtered using this procedure if the filtration device is found to be free from contamination. Two types of field filtration devices are covered within the scope of this SOP. The first uses a peristaltic pump and silicone or vinyl tubing to push water through a disposable capsule filter. This method is used when a high volume of water needs to be filtered or there is a large volume of particulates that requires a larger filter surface area. The second uses a polyethylene syringe to push water through a polyethylene disc filter that contains a filter paper. This method is appropriate when there is a small sample volume, low volume of particulates, and/or the location is impractical for the use of a peristaltic pump. Other filtration devices are not covered within the scope of this SOP. When direct access to the sample media is possible, refer to *SOP 2.02a - Grab Sample Collection with Sample Bottle.* For information concerning the filling of sample bottles, refer to *SOP 7.01f - Bottle Rinsing and Filling*.

3.0 EQUIPMENT AND MATERIALS

Filtration equipment should be blanked prior to use to determine if the filter media and housing is appropriate for its intended analytical use (see section 6.0 Quality Assurance and Quality Control). Filter media and housing should be free of Nitrate-Nitrogen, Nitrite-Nitrogen, O-Phosphate Phosphorous, and Dissolved Organic Carbon, in addition to being free of any other requested analytes.

3.1 Equipment and Materials for Field Filtration Using a Peristaltic Pump and Capsule Filter

Sample collection apparatus (e.g. groundwater bailer, stainless steel bailer, etc.) decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment*
Whole Water bottle: an unused disposable plastic sample container for unfiltered sample (volume of container > 150% of final filtered sample volume) (labeled “Whole Water” or “WW”)
Sample containers for filtered sample (labeled “field-filtered” or “FF”)
Disposable gloves appropriate for intended analytes (see *Glove Selection for Water Quality Sampling*)
Cooler(s) and ice packs
Chain-of-Custody and/or *Field Data Sheets*

Portable peristaltic pump
Fully charged 12-volt rechargeable lead-acid battery
Unused ¼ inch diameter peristaltic pump tubing (decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment)*
0.45 µm, sealed disposable capsule filter
For QC samples: dedicated polycarbonate carboy

3.2 Equipment and Materials for Field Filtration Using a Syringe and Disc Filter
Sample collection apparatus (e.g. groundwater bailer, stainless steel bailer, etc.) decontaminated according to *SOP 7.01a - Decontamination of Sampling Equipment,* if necessary
Whole Water bottle: an unused disposable plastic sample container for unfiltered sample (volume of container > 150% of final filtered sample volume) (labeled "Whole Water" or "WW")
Sample containers for filtered sample (labeled "field-filtered" or "FF")
Disposable gloves appropriate for intended analytes (see *Glove Selection for Water Quality Sampling-r3.xlsx*)
Cooler(s) and ice packs
Chain-of-Custody and/or *Field Data Sheets*
Disposable 60 ml poly syringe
Disposable 0.45 µm pore size disc filters
For QC samples: dedicated polycarbonate carboy with spigot

4.0 PROCEDURE

4.1 Preparation

1. Decontaminate sample collection equipment to be used. The sample container for the unfiltered sample may need to be decontaminated depending on the analysis to be performed. Refer to *SOP 7.01a - Decontamination of Sampling Equipment* for decontamination guidance.

4.2.1 Sample filtration using a peristaltic pump and capsule filter

1. Collect the unfiltered sample using the appropriate method (see *SOP 2.02b - Grab Sample Collection with Stainless Steel Bailer, 2.02c - Grab Sample Collection with Peristaltic Pump, 2.02d - Grab Sample Collection with Column Sampler, or 3.02a - Groundwater Sampling with Disposable Bailer*).
2. Pour the raw sample into the plastic container designated for the unfiltered sample (referred to as the "Whole Water" bottle). Be sure to collect at least 150 percent of the required filtered sample volume. This additional volume will be used to condition the filter and to rinse the filtered sample bottles.
3. Connect a charged battery to the peristaltic pump.
4. Install a new, decontaminated section of ¼ inch peristaltic pump tubing into the pump.
5. Remove a new 0.45 µm capsule filter from the package; place the outlet end of the pump tubing over the inlet fitting of the filter (align the flow arrow on the filter with the pumping flow direction). Insert the fitting far enough to avoid leakage around the seal.
6. Place the inlet end of the tubing into the unfiltered sample.
7. Invert the capsule filter so that the outlet is pointed upward. Turn the pump controller on and pump until the flow of sample forces all of the trapped air out of the capsule. Once all of the air has been purged from the capsule (a few seconds), right the filter and pump filtrate into the sample bottle designated for the filtered sample. Fill the sample bottle(s) according to *SOP 7.01f - Bottle Filling and Rinsing*.
8. Cap bottle and place in cooler with ice packs.

9. Properly dispose of the used filter. Filters are single use only.

4.2.2 Sample filtration using a syringe and disc filter

1. Remove a new clean syringe from the package
2. Collect the unfiltered sample using the appropriate secondary device or by filling the syringe directly from the source.
3. If using a secondary device, pour the unfiltered sample into the whole water bottle. Collect at least 150 percent of the required filtered sample volume to ensure an adequate volume for rinsing.
4. Withdraw sample from the whole water bottle or source to fill the syringe. Purge the water in the syringe away from the sampling location in order to rinse the interior of the syringe.
5. Again, fill the syringe.
6. Firmly attach a new clean disc filter to the full syringe.
7. If bottles require a rinse, rinse with filtered water. Fill the sample bottle(s) according to *SOP 7.01f - Bottle Filling and Rinsing*. Typically, one filter is used per 60mL syringe, although more may be necessary depending on the particulate content of the sample.
8. Cap bottle and place in cooler with ice packs.
9. Properly dispose of the used filter(s).

5.0 POTENTIAL PROBLEMS

Depending on sample turbidity and composition, the filter's pore size may decrease, or pores may become obstructed as the volume of sample passed through the filter increases. For samples with elevated turbidity levels, it may be necessary to use more than one filter.

When beginning the filtration process with a capsule filter, invert the filter so that the outlet of the filter points upward away from the ground. As water is pumped into the filter from below, all the corrugations inside the filter will be fully wetted. This promotes filtration across the entire surface area of filter material, avoiding preferential flow which could result in filter-bypass. When the capsule filter is full, water will flow from the outlet. At this point, the filter may be righted to proceed with sampling.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field quality assurance and quality control (QA/QC) samples are collected to identify bias, variability, and contamination in data resulting from the collection of samples. QA/QC samples for field filtration could include equipment blank samples, duplicates, or field decontamination blanks, depending on the field procedures utilized. For details on these procedures refer to *SOP 7.01c - Field Quality Control Sample Collection*. These procedures are used to evaluate the accuracy and repeatability of the sampling method, and possible contamination of sampling equipment. Methods for the collection of some QA/QC procedures within the scope of this SOP are described below.

6.1 Collection of an Equipment Blank Using a Syringe and Disc Filter

1. Don a new pair of disposable gloves.
2. Fill syringe directly with ultrapure deionized (UPDI) water by separating the plunger from the syringe body, filling the syringe from the opening where the plunger is inserted, and then reinserting the plunger into the syringe body.
3. Purge syringe of UPDI to replicate the rinse of the syringe in section 4.2.2.

4. Refill the syringe.
5. Attach the syringe filter to be blanked.
6. Filter UPDI through the filter into appropriate sample collection bottles (See *SOP 7.01f - Bottle Rinsing and Filling*).
7. Use a fresh syringe and filter to rinse and fill each sample collection bottle so that the maximum contamination concentration is captured in each bottle and is not diluted by previous filtration.
8. Record the procedure, model numbers, brands, and purchasing information on a Field Data Sheet.

6.2 Collection of an Equipment Blank Using a Peristaltic Pump and a Capsule Filter

1. Don a new pair of disposable gloves.
2. Prepare a clean, designated polycarbonate carboy.
3. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping it, shaking uncapping it, and dumping the rinse. Fill the carboy to the shoulder with ultrapure deionized water and close the lid tightly.
4. Connect a charged battery to the peristaltic pump.
5. Install a new decontaminated section of ¼ inch peristaltic pump tubing into the pump.
6. Place the inlet end of the tubing into the UPDI carboy so that the minimum amount of tubing surface area comes in contact with the blank water. Keep a hold of the tubing and lower it with the level of the water as it is pumped out.
7. Rinse the tubing with at least 3x the internal volume of the length of tubing being used.
8. Remove a new 0.45 µm capsule filter from the package; place the outlet end of the pump tubing over the inlet fitting of the filter (align the flow arrow on the filter with the pumping flow direction). Insert the fitting far enough to avoid leakage around the seal.
9. Invert the capsule filter so that the outlet is pointed upward. Turn the pump controller on and pump until the flow of sample forces all of the trapped air out of the capsule. Once all of the air has been purged from the capsule (a few seconds), right the filter and pump filtrate into the sample bottle designated for the filtered sample. Fill the sample bottle approximately 10 percent full and use this initial filtrate to rinse the sample bottle and cap (unpreserved sample containers only). Empty the rinsate where it will not contaminate future samples.
10. Insert the outlet end of the filter into the sample container and pump until the required sample volume of filtered sample is collected.
11. Cap bottle.
12. Use a fresh capsule filter for each bottle being filled so that the maximum contamination concentration is captured in each bottle and is not diluted by previous filtration.
13. Record the procedure, model numbers, brands, and purchasing information on a Field Data Sheet.

6.3 Collection of a Field Decontamination Blank Using a Syringe and Disc Filter.

1. Prepare a clean, designated polycarbonate carboy with a spigot.
2. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping it, shaking uncapping it, and dumping the rinse. Fill the carboy to the shoulder with UPDI water and close the lid tightly.
3. Bring the carboy to the sampling location with the other equipment as described above.
4. The purpose of the field decontamination blank is to both confirm effectiveness of decontamination procedures (the decontamination of the any intermediary sampling devices), quantify contamination from field sampling activities (contamination from surfaces, atmospheric deposition, gloves, etc.), and quantify contamination from disposable sampling equipment. To ensure that the blank captures the contamination

that may be introduced from field sampling activities, replicate the physical positioning and order of operations that the sampling team would use while taking a sample as described in section 4.2.1.

5. Upon arriving at the sampling location, set out the carboy on a cooler or table.
6. Either use the spigot to fill the intermediate sampling device, then filter the sample according to the procedure outlined in section 4.2.2; or fill the syringe directly from the carboy if the sample is being collected directly from the source without an intermediate sampling device or bottle.
7. Cap the bottle, place in a cooler with ice packs for transport.

6.4 Collection of a Field Decontamination Blank Using a Peristaltic Pump and a Capsule Filter

1. Prepare a clean, designated polycarbonate carboy.
2. To fill the carboy, empty any ultrapure deionized (UPDI) water out of the carboy. Rinse the interior of the carboy three times with UPDI water by filling it approximately $1/10^{th}$ full, capping it, shaking uncapping it, and dumping the rinse. Fill the carboy to the shoulder with UPDI water and close the lid tightly.
3. The purpose of the field decontamination blank is to both confirm effectiveness of decontamination procedures (the decontamination of the any intermediary sampling devices), quantify contamination from field sampling activities (contamination from surfaces, atmospheric deposition, gloves, etc.), and quantify contamination from disposable sampling equipment. To ensure that the blank captures the contamination that may be introduced from field sampling activities, replicate the physical positioning and order of operations that the sampling team would use while taking a sample as described in section 4.2.2.
4. Upon arriving at the sampling location, set out the carboy near the peristaltic pump. This procedure should occur prior to the collection of an environmental sample. The tubing may then be reused after the field decontamination blank sample collection to take the environmental sample at the designated location.
5. Insert and lock the appropriate pump tubing into the peristaltic pump head.
6. Open the lid to the carboy.
7. While wearing a clean pair of gloves, dip one end of the decontaminated, unused tubing into the UPDI water in the carboy so that the minimum amount of tubing surface area contacts the water, while still sucking it into the tubing. Flush the tubing with a volume of UPDI at least three times the internal volume of the tubing (this can be calculated prior to departure and marked on the carboy for ease in the field) and discard this rinse.
8. After the tubing has been flushed, fill the bottles according to *SOP 7.01f - Bottle Rinsing and Filling.*
9. Cap the bottle, place in a cooler with ice packs for transport.
10. Turn off the pump and remove the tubing from the carboy. The tubing may now be reused to take the environmental sample at that location.

7.0 RESOURCES

(1) *National Field Manual for the Collection of Water-Quality Data,* U.S. Department of the Interior, U.S. Geological Survey, United States Government Printing Office: 1998-99.

(2) *Method 365.1, Revision 2.0: Determination of Phosphorus by Semi-Automated Colorimetry*, US EPA, 1993.

(3) *Method 300.0 Determination of Inorganic Anions by Ion Chromatography*, US EPA, 1993.

(4) *Method 353.2, Revision 2.0: Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry*, US EPA, 1993.

(5) *Standard Method 5310 Total Organic Carbon (TOC)*, Standard Methods for the Examination of Water and Wastewater, 2007.

City of Portland
Bureau of Environmental Services
Information Delivery Division

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Author: ECP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

FIELD FILTERING WATER SAMPLES

REVISION HISTORY

Revision Date	By	Revisions Made
10/28/03	MJS	Date of origination
9/9/13	MJS	Revision 2 2.0 - Modified language to increase clarity. Mentions field filtration is always required for orthophosphate samples. 3.0 - Added equipment and materials required for the process of field filtration with a syringe filter, in addition to the process of field filtration with a peristaltic pump described in revision 1. 4.1 - Limited the scope of this section to just decontamination of the sampling equipment. 4.2 - This section captures all the steps for Sample Filtration Using a Peristaltic Pump and Capsule Filter, which was the only method described in Revision 1. 4.2 - A new section is added, Sample Filtration Using a Syringe and Disc Filter
10/27/20	ECP	Revision 3 - Updated “Environmental Investigations Division” to “Information Delivery Division” - Named the “plastic container designated for the unfiltered sample” as the “Whole Water bottle” and placed where relevant throughout document 2.0 - Described analytes that are frequently field filtered - Added language describing the two types of filtration devices used in this method - Added language that other types of field filtration devices are not covered within the scope of this SOP - Added language describing that other analytes could be field filtered if the filter media and housing were found free of that analyte 3.0 - Added language indicating that filtration devices should be blanked to ensure they are free of contamination - Modified checklist into two separate sections: 3.1 Equipment and Materials for field filtration using a peristaltic pump and capsule filter & 3.2 Equipment and Materials for field filtration using a syringe and disc filter - Modified glove language to “Disposable gloves appropriate for intended analytes (see *Glove Selection for Water Quality Sampling*)” 4.0 - Added language to increase clarity about section purpose 4.2 – Added reference to *SOP 7.01f - Bottle Filling and Rinsing* - Added language indicating that the syringe can draw unfiltered water directly from the source stream or pipe - Modified steps and language to increase clarity 5.0 - Added description of how to avoid “filter bypass” when using the capsule filters

		6.0 - Updated language to be consistent with other SOPs - Added sections 6.1 Collection of an equipment blank using a syringe and disc filter, 6.2 Collection of an equipment blank using a peristaltic pump and a capsule filter, 6.3 Collection of a field decontamination blank using a syringe and disc filter, & 6.4 Collection of an field decontamination blank using a peristaltic pump and a capsule filter 7.0 - Added references 2 through 5, Standard Methods related to the use of this SOP

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

FIELD QUALITY CONTROL SAMPLE COLLECTION

1.0 PURPOSE

This Standard Operating Procedure (SOP) specifies the types of Quality Control (QC) samples collected and describes the procedures used in their collection.

2.0 SCOPE AND APPLICABILITY

Field QC samples are intended to evaluate the sampling operation and to quantify and document bias that can occur in the field. QC samples offer sampling crews the ability to assess the quality of the data they produce and a means for quantifying sampling bias. By incorporating QC procedures into a sampling and monitoring plan, confidence in standard practices related to sample collection, preservation, and storage can be assured. Sampling crews must understand the purpose of the sampling operation and how the data from the QC samples will be utilized. When collecting QC samples it is important to develop an understanding of the analytical requirements involved and to employ good field practices. Certain projects may require specific collection techniques and sampling methods, and the QC samples should reflect those methods.

The following table lists the types of QC samples utilized. Project specific objectives will determine which of the following QC samples will be collected.

QC Sample Type	Purpose/Information Provided
Field Duplicate	Quantify variability from field sampling activities Quantify variability from laboratory procedures
Equipment Blank	Confirm effectiveness of decontamination procedures Confirm cleanliness of disposable sampling equipment
Field Decontamination Blank	Confirm effectiveness of decontamination procedures Quantify contamination from field sampling activities
Field Residual Blank	Quantify degree of cross-contamination between sites Quantify contamination from field sampling activities
Trip Blank	Identify sample handling and transport bias Quantify sample cross-contamination
Bottle Blank	Confirm cleanliness of sample container

3.0 EQUIPMENT AND MATERIALS

QC samples should be collected using the same equipment and following the same procedures utilized during the sampling operation. In addition to the project specific sampling equipment and materials, QC sample collection may require the following:

- Ample supply of ultrapure, deionized water (blank water)
- Analyte-specific sample containers, bottles, and/or jars for the additional QC samples
- Extra supply of nitrile gloves
- Additional cooler with ice for sample storage

4.0 PROCEDURE

Since QC samples are used to evaluate the sampling procedure, the collection of QC samples must be performed using the same protocols used for the water quality samples. This includes such things as equipment decontamination, equipment and sample bottle selection, and collection method (if applicable for that QC sample).

4.1 Collection of Field Duplicate Samples

1. Prepare to collect duplicate samples following the procedure outlined by the project of concern. Reference analytical requirements, proper sampling methodology, sampling site location, and sampling apparatus decontamination. Special attention should be applied to differences in protocol concerning composite and grab samples.
2. Fill the duplicate sample bottles along side the sample bottles in a corresponding manner related to analysis (e.g., grab metals bottle with duplicate grab metals bottle). When a representative flow stream is accessible for direct collection, fill the duplicate and sample bottles simultaneously or as close to as possible. If sampling requires the use of a sampling device, such as a dredge or water column sampler; an aggregate of the sample should be compiled and then partitioned into the duplicate and sampling bottles in an alternating fashion until all bottles are filled.
3. Deliver duplicate bottles with the grab samples to the laboratory. In order to be a legitimate duplicate sample, the laboratory must receive the duplicate sample without knowledge of the sample source. Record the sample on the Chain of Custody (COC) as "DUP", preceded by the project initials, and leave the sample collection time blank. Assign the sample a sample identification number on the COC. Record the duplicate sample collection location and collection time on the Quality Control Field Data Sheet (QCFDS), and record the sample identification number. The QC FDS is filed for future interpretation of the duplicate sample data, without being shared with the laboratory.

4.2 Blank Sample Collection

There are four types of blank samples: the field decontamination blank, the field residual blank, the trip blank, and the bottle blank. Project specific data quality objectives and method of sampling will determine which, if any of these samples will be collected. Some of these blank samples are only suitable in certain sampling situations and/or analytes.

4.2.1 Equipment blank collection

Equipment blanks are used to confirm the effectiveness of decontamination procedures, or to confirm that disposable sampling equipment is sufficiently free of contaminants. It is intended to isolate contamination originating from the sampling equipment without the influence of field sampling activities. For this reason the equipment blank is collected under controlled conditions in the laboratory.

1. Perform the necessary decontamination of the sampling equipment to be used prior to the collection of the samples per *SOP 7.01a Decontamination of Sampling Equipment*. If using disposable equipment, remove the sanitary packaging, verifying that the equipment has been stored with the protective packaging intact.
2. While wearing a clean pair of vinyl or latex gloves, fill the sampling equipment with blank water and empty to rinse. While pouring the blank water into the sampling device, make sure to rinse the interior surfaces of the device thoroughly. Do this for each component of the sample collection equipment chain.
3. Fill the sampling apparatus once again with blank water, transferring the water into each component of the sample collection equipment chain. Transfer this water into the appropriate sample bottles. Perform a ¼ bottle rinse of the sample bottles before the bottles are filled and capped. This rinse is not performed when filling pre-cleaned or pre-preserved sample bottles.
4. Record the time and date that the sample was collected on the COC and the QCFDS. Record the sample location, along with any other pertinent comments on the QCFDS.

4.2.2 Field decontamination blank collection

Field decontamination blanks are used to confirm the effectiveness of decontamination procedures while simultaneously identifying contamination that occurs from the exposure of the sample to its collection, transport, handling and processing environment.1. Perform the necessary decontamination (per *SOP 7.01a Decontamination of Sampling Equipment*) for the sampling equipment to be used prior to the collection of the samples. Sampling devices should be stored in clean carrying cases and wrapped in plastic bags or aluminum foil (as appropriate) to avoid contamination while in transit to the sampling location.

2. The Field Decontamination Blank is collected upon arrival at the first sampling location, prior to actual sampling. Remove the sampling equipment from the protective plastic or foil wrapping.
3. While wearing a clean pair of vinyl or latex gloves, fill the previously decontaminated sampling equipment with blank water and empty to rinse. While pouring the water into the sampling device, make sure to rinse the interior surfaces of the device thoroughly.
4. Fill the sampling apparatus once again with blank water and fill the required sample bottles. Perform a ¼ bottle rinse of the sample bottles with the water from the sampling apparatus before the sample bottles are filled and capped. This rinse is not performed when filling pre-cleaned or pre-preserved sample bottles.
5. Record the time and date that the sample was collected on the COC. Record the sample location, along with any other pertinent comments on the QCFDS.
6. Proceed with the collection of the environmental sample for that site.

4.2.3 Field residual blank collection

Field residual blanks are used to identify contamination that remains on or in sampling equipment after sampling, while simultaneously identifying contamination that occurs from the exposure of the sample to its collection, handling, transport and processing environment.

1. Perform the necessary decontamination for the sampling equipment as required by that project per *SOP 7.01a Decontamination of Sampling Equipment*.
2. Collect the environmental samples at all of the sampling locations.

3. After collection of the final sample of the project, don a clean pair of vinyl or latex gloves, fill the previously used sampling equipment with blank water and empty to rinse. While pouring the blank water into the sampling device, make sure to rinse the interior surfaces of the device thoroughly.
4. Fill the sampling apparatus once again with blank water and fill the required sample bottles. Perform a ¼ bottle rinse of the sample bottles with the water from the sampling apparatus before the bottles are filled and capped. This rinse is not performed when filling pre-cleaned or pre-preserved sample bottles.
5. Record the time and date that the sample was collected on the COC. Record the sample location, along with any other pertinent comments on the QCFDS.

4.2.4 Trip blank collection

Trip blanks are used to measure cross-contamination from sample containers and preservative during the handling, transport, and storage of samples. Trip blanks are typically collected when sampling for volatile organic compounds (VOC)

1. Prior to conducting the sampling operation, acquire a VOC vial, pre-preserved with HCl.
2. Without overfilling to avoid washout of preservative, fill the VOC vial to zero headspace with blank water by creating a convex meniscus and then capping. To achieve the convex meniscus without allowing the washout of preservative, the vial cap can be filled with the blank water and used to drip small amounts of water into the vial at a time. If air bubbles are noted in the vial, additional water should be added to force out the bubbles. However if preservative is lost during this part of the procedure, the vial should be discarded and a new vial used in its place.
3. Inscribe the date and time on the vial and place it into the cooler adjacent to the unused VOC grab sample vials. The trip blank sample should be stored in this manner from the time the sampling crews leaves the lab, during the sampling operation, and until the samples are relinquished to the lab. Record the date and time, as well as any additional sampling information, on the appropriate field documentation and COC forms.
4. Deliver the trip blank sample to the laboratory with the VOC grab samples and all field and sample documentation for analysis.

4.2.5 Bottle blank collection

Bottle blanks are used to identify if the sample container is responsible for introducing contaminants into the sample. Bottle blanks are collected under controlled conditions in the laboratory.

1. Select the appropriate sample bottle for the analysis to be performed.
2. Don the appropriate glove type for the analysis to be performed.
3. Perform a ¼ bottle rinse of the sample bottles with blank water. This rinse is not performed when filling pre-cleaned or pre-preserved sample bottles.
4. Fill the sample bottle with blank water and submit to the laboratory for analysis.

5.0 POTENTIAL PROBLEMS

Careful attention should be employed while conducting QC sampling procedures to avoid possible contamination and to secure accurate representation. By not following specified requirements pertaining to decontamination, clean sampling technique, and proper sampling methodology; the accuracy of the sampling procedure can be jeopardized. Contamination of the sample(s) may occur through the use of unclean sampling equipment that will introduce foreign material (e.g., dust, dirt, and organic material) into the sample container and/or the sampling area. Improper activity in or around the sample site will also negatively affect the representation of the sample and must be avoided before and during the collection of the samples. The operation of equipment in or around the sample site that may compromise the representation of the samples must also be avoided.

All procedures related to proper decontamination and sample handling must be followed accordingly to safeguard sample integrity. Special consideration concerning sample preservation and sterile sampling methods also pertain directly to the desired analysis and should be noted prior to the sampling operation as well. Sample bottles that contain a preservative must not be filled by the direct collection method to avoid dilution of the preservative concentration and may require the use of additional sampling devices (e.g., bailers, water bottle samplers). Refer to the appropriate SOP for the operation procedures of those sampling devices.

Sampling documentation must be reviewed before conducting the sampling operation to verify analytical requirements and to ensure effective communication to the laboratory regarding the processing of the QC samples in accordance to the needs of the sampling project. Before sampling occurs, past sampling and/or field documentation can be referenced for information related to monitoring site characteristics and required sampling protocol. Activities conducted in the field must also reinforce adherence to BES safety procedures and guidelines.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field quality control samples identify, quantify, and document bias and variability in data resulting from the collection and handling of samples by field personnel. The development of a sound quality assurance and quality control plan demand accurate QC sampling procedures. The number and type of QC samples utilized depends upon the objectives of the monitoring project and the sampling media involved. Sampling crews should conduct a thorough review of the sampling and monitoring plan prior to performing the sampling operation. In the field, all sampling documentation and field data should be checked for accuracy and completeness before the samples are shipped to the laboratory. Collect all field QC samples on the same day the environmental samples are collected, using the same equipment utilized during collection of the environmental samples.

7.0 RESOURCES

The following publications were utilized in the development of this Standard Operating Procedure:

(1) *EPA Guidance for Quality Assurance Project Plans,* U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, 1998.
(2) *National Field Manual for the Collection of Water-Quality Data,* U.S. Department of the Interior, U.S. Geological Survey, United States Government Printing Office: 1998-99.
(3) *Guidelines and Specifications for Preparing Quality Assurance Project Plans,* Washington State Department of Ecology, May 1991.
(4) *U.S. Geological Survey, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations*, book 9, chaps. A1-A9, 2 v., variously paged. [Chapters were published from 1997-1999; updates and revisions are ongoing and can be viewed at: http://water.usgs.gov/owq/FieldManual/mastererrata.html]

FIELD OPERATIONS
STANDARD OPERATING PROCEDURE

SAMPLE CHAIN-OF-CUSTODY

1.0 PURPOSE

This Standard Operating Procedure (SOP) contains procedures for the appropriate storage, transport and relinquishment of environmental samples under chain-of-custody (COC) procedures. The COC process defines and documents the chronological history of sample collection and custody from the time of collection until samples have been relinquished to the Bureau of Environmental Services (BES), Water Pollution Control Laboratory (WPCL). This SOP covers the procedures and documentation utilized by BES Field Operations and WPCL staff to ensure sample integrity through the COC process. COC documentation provides a legally defensible audit trail of all persons having physical custody of samples, documenting the date, time and signatures showing when and by whom samples are collected, relinquished and received.

2.0 SCOPE AND APPLICABILITY

Strict adherence to the COC procedures described in this document shall apply to the handling of all samples collected by the BES Field Operations section. This includes, but is not limited to, samples of water, soil, sediment, gas, insects, fish and synthetic media. Specific handling techniques may vary according to sample type, analysis to be performed and/or site conditions. This document describes the COC process in terms broad enough that special cases are ensured to be sufficiently consistent with standard procedures and provides for the appropriate handling and tracking of all samples. In cases where sample handling requirements demand different procedures, it shall be expected that those differences will be addressed in the project-specific Sampling and Analysis Plan (SAP). Field Operations staff performing sample collection are responsible to know and adhere to the requirements of the COC process described in this document. Staff are also responsible for completing COC forms, sample labeling and ensuring that protocol governing sample handling and transport is followed during the time between sample collection and relinquishment.

The key requirements of a defensible audit trail satisfied by the COC process are:

- Record of the date, time and responsible persons when samples are collected
- Record of the date, time and responsible persons when samples are relinquished to storage or laboratory
- Documentation of the security of the storage area or laboratory sample receiving area
- Documentation indicating whether samples are intact or have been compromised in any way during transport, delivery, storage and relinquishment
- Record of the time of removal from storage and signature of the receiving party

Sample handling and transport protocol are outlined in this document to support the purpose of the COC process and to ensure that samples are preserved and reach the laboratory in optimal condition.

2.1 WPCL-Specific Procedures

The Water Pollution Control Lab (WPCL) is an accredited, full-service analytical laboratory owned and operated by BES. The resource of this internal laboratory makes the COC process more efficient and helps to simplify the procedures normally required in the handling and analysis of environmental samples. Typically, all samples collected by Field Operations staff are hand-delivered and analyzed in-house. This system assures that all samples are relinquished to the laboratory within 12 hours of collection and avoids the complications associated with shipping to outside laboratories. It also eliminates the need for custody seals on sample containers since only Field Operations or the lab staff have custody of the samples. Occasionally, industrial wastewater samples are split with an industry that retains the split sample for analysis by the laboratory of their choice. These samples are affixed with COC seals bearing the BES name and logo and are signed and dated by the field staff relinquishing custody.

Because most of the sampling work conducted by Field Operations is routine and long-term in nature (i.e., the same locations are sampled at a regular interval), COC forms are customized for specific projects and include the analyte list and blank fields for field parameter measurements. Field staff print out a project-specific COC form prior to collecting samples and keep the form with all samples until relinquishment to the Sample Custodian at the WPCL.

The COC form also serves as the request-for-analysis documentation. The Sample Custodian's (lab staff member designated to receive all samples) responsibility at the WPCL is broader in scope than at typical analytical laboratories. Sample Custodians at the WPCL receive samples from field staff, but are also responsible for data entry and have access to project-specific work orders, including information such as sampling schedule, analyte lists and sampling location codes. The ability for the Sample Custodian to cross-reference the COC form and specific instructions from field staff against current work order details guards against mistakes or omissions in COC documentation and helps to ensure that sample analysis requirements are fulfilled. If the required analysis is outside the scope of services provided by the WPCL and samples must be analyzed by another lab, field staff relinquish samples to the Sample Custodian who then assumes responsibility for sending the samples to a contracted laboratory for analysis.

3.0 EQUIPMENT AND MATERIALS

Required always:

- COC forms (make sure the form matches the sampling event, e.g., monthly, quarterly, etc.)
- Sample labels with unique identification numbers (point codes)
- Sample containers
- Indelible ink pen
- Cooler(s) with enough space to safely protect and transport sample containers
- Sufficient ice to preserve expected sample volume (1:1 ratio of ice:sample volume is minimum)

Sometimes needed:

- Additional dedicated cooler for Volatile Organic Compounds (VOC) samples
- Clear packaging tape
- Re-sealable plastic bags
- Buckets
- Plastic trash bags
- White labeling tape

4.0 PROCEDURE

The step-by-step procedure for the collection, transport and relinquishment of samples follows.

4.1 Equipment and COC Forms

Prior to sample collection, assemble all necessary items as dictated by the equipment list above. Be sure to include additional required equipment as outlined in the specific project field file. Part of this process will include the acquisition of the appropriate COC form(s) needed for the project(s) requiring sample collection. Often, a project will have multiple COC forms. In these cases, the list of analytes or field parameters may differ. For example, a quarterly or semi-annual analyte list may be more comprehensive than the list associated with more frequent sampling. Be sure you have the correct COC form and assemble sample containers and equipment accordingly. Assure that adequate cooler space and ice will be available on-site to accommodate the total volume of the samples to be collected.

If samples are collected at different times, separate COC forms must be used. If all the samples for a project cannot be collected during the same event, submit a separate COC form as each sub-group is relinquished.

4.2 Sample Collection and Field Parameter Measurement

Collect samples per the Standard Operating Procedure (SOP) documenting the specific techniques for that type of sample.

4.3 Sample Labeling

Sample labels are necessary to prevent misidentification of samples. Each sample shall be labeled using indelible ink according to the unique sampling location point code. Point codes are generated by the work request process prior to sample collection. While point codes may not be unique between projects, they shall always be unique within a project. For this reason, separate coolers, labeled with project name, should be used when sampling for multiple projects. In the field, point codes will be written directly onto the sample container (polyethylene bottles) or onto permanently affixed labels (glass jars). Ensure the matching point code is entered on the COC form. This will often be preprinted on the form. An example of point code generation for groundwater monitoring follows:

MW-X
Where: MW = Monitoring Well
X = Well Number (e.g., -5)

A unique sample identification code shall be generated by the Sample Custodian upon receipt at the WPCL. See section 4.7 for a discussion of sample identification codes.

4.4 Sample Documentation

Use the COC form to record field parameter measurements for each sampling location. While on-site and performing sample collection, be sure the COC form is completely filled out. Data should be recorded directly and legibly in indelible ink onto the appropriate fields with all entries initialed and dated. Use the comments field to record site conditions that may have an effect on sample analysis and to document unusual site conditions. Examples of conditions warranting comments include, but are not limited to, disturbance due to storm events, maintenance or construction activities, modification of the channel, flow conditions or riparian corridor, evidence of spills or contamination and changes that restrict site access routes or access to the normal sampling location. If entries must be changed, the change should not obscure the original entry. Changes will be made by a single line through the original entry with the change dated and initialed. Before leaving a site, compare the form and the number of sample containers to ensure that samples for all analytes have been collected and that all field parameters have been measured. Refer to the project specific field file for a list of analytes and the required bottles.

A single COC form may not be used for samples that are brought to the lab at two different times. If samples from a single project are collected over a long period of time, there are two choices for relinquishing them with proper chain-of-custody. First, the person relinquishing the samples may maintain custody of all samples until ready to submit them to the lab all at one time, using a single COC form. Or, second, a separate form may be submitted at the time each sub-group of samples is relinquished.

Additional components to be included on COC documents include:

- Project name
- Type of sample (e.g., grab, composite)
- Matrix (i.e., project type, such as surface water, groundwater, wastewater, stormwater, etc.)
- Sample location address and point code
- Requested analytes
- Field parameter measurements and reporting units (if applicable)
- Model and ID of meter(s) used for field parameter measurements (if applicable)
- Comments or special instructions including the analyte list for any quality control samples
- Additional comments concerning sample quality or special analytical requirements

4.5 Sample Packaging and Preservation

Once samples have been collected, ensure the proper preservation of sample quality by following the packaging and preservation guidelines presented below.

- Pack samples in a cooler to prevent breakage or leakage. Samples must be labeled prior to placement in the cooler. Provide additional protection for glass sample bottles (e.g., foam or bubble wrapping).
- Some projects may require that each cooler with samples contains a temperature blank. Be sure to include a trip blank all coolers with samples for VOC analysis.
- Sample containers should be packed with ice or an ice substitute (e.g., blue ice) in sufficient quantity to maintain a sample temperature of 4 degrees C during shipping. The recommended minimum ratio of ice:sample volume is 1:1, with a ratio of up to 2:1 during high ambient temperature. To prevent leakage during transport, ice should be double-wrapped in watertight bags. Ice substitute should be wrapped if the potential for leakage exists.

4.6 Sample Transport

Samples are transported to the WPCL in city vehicles. Transport procedures shall remain consistent, regardless of whether analysis is to be performed by the WPCL or by an outside laboratory. Ensure that coolers are closed and samples remain packed in ice during transport.

In the case where analysis is to be completed by an outside lab, the Sample Custodian at the WPCL shall be responsible for shipping samples or arranging for pickup.

4.7 Sample Processing

Some samples, specifically stormwater composite samples, require additional processing in the laboratory prior to being relinquished. The multiple stormwater sample bottles are combined into a single homogenous sample with the use of a churn splitter (refer to SOP *7.01e - Processing Water Samples Using a Churn Splitter*). This process is performed cooperatively by Field Operations staff and the Sample Custodian. The homogenized samples are decanted into the individual analysis bottles and are then relinquished to the Sample Custodian as detailed below.

4.8 Sample Delivery and Relinquishment

Samples shall be hand-delivered by Field Operations staff to the WPCL following sample collection. The Sample Custodian will generate a work order number that is unique to the batch of samples submitted, and will write that work order number on the COC form. Each distinct sample is assigned a unique identification code, the prefix of which is the work order number and the suffix being at two digit sequential lab number corresponding to the order of the sample on the COC form. The Sample Custodian will generate a series of self-adhesive sample labels, containing each sample's unique identification code and information indicating the bottle size and type, and any preservation requirements. Affix the specified sample identification label to each corresponding container. All samples, including those analyzed at the WPCL and any contract laboratories, shall be labeled with these unique sample identification codes. These identification codes will be included on the sample label and COC forms and will be used to identify the analytical data.

In the event that samples cannot be delivered to the WPCL by the field staff that has collected them, the samples may be relinquished to other field staff members. Under these circumstances, the staff collecting the samples will sign the COC and relinquish custody to the staff that will deliver samples, who then signs to receive them.

To the extent possible, samples should be received in person. If the Sample Custodian is not present, a sampler should attempt to contact him/her before leaving samples on the counter in the sample receiving area. Any member of the WPCL lab staff may sign and receive samples, once the samples are in the secure area of the lab. If samples will not be processed immediately, they should be placed in the left side of the sample receiving refrigerator. The refrigerator is labeled "AL" above the doors. The COC form and any other paperwork should be left on the counter across from the refrigerator.

4.9 Relinquishment After Normal Business Hours

Occasionally, sampling is performed outside the normal business hours of the WPCL. The sample receiving area at the WPCL is staffed during standard business hours Monday through Friday from 0900 to 1700 and during reduced hours on weekends. If the Sample Custodian or designated alternate is not present when the sampling team arrives at the laboratory, the sampling team will sign and date the COC form and place the samples in the refrigerator labeled "AL" located in the sample receiving room. Unless instructed to do otherwise, place samples on the left side of the refrigerator and leave the COC form on the counter across from the refrigerator. The refrigerator is temperature-controlled and monitored. The laboratory will accept samples as soon as possible the next morning, ensuring that samples are relinquished to the Sample Custodian within 12 hours of collection. A signed copy of the COC with the assigned work order and sample identification numbers can be obtained from the Sample Custodian on the next business day. Otherwise a scanned copy of the COC will be available in the laboratory information management system. QA/QC for COC procedures under these circumstances are addressed in the WPCL Policy Statement titled *Chain of Custody Procedures for Indirectly Relinquished Samples* published in March 2004. Please see section 5.0, Potential Problems, for further discussion of COC documentation and off-hours relinquishment.

If any sample is brought in on the weekend, someone in the lab must be notified because the sample receiving room is not staffed on the weekend.

4.10 Security in the Laboratory

Access to the entire laboratory is controlled by a card-key security system that logs the time and identity of each person passing into secured areas. In addition to the main laboratory, the secure areas include the sample receiving area and the Field Operations' Staging Area. Only Field Operations and WPCL staff have access to these areas, maintaining a secure environment for sample storage. Any breach of security triggers an alarm and initiates a response from the security company.

5.0 POTENTIAL PROBLEMS

The COC process provides a framework to ensure that consistent procedures are used in the collection and analysis of environmental samples. Strict adherence to the procedures outlined in this SOP helps to guard against errors and omissions in sample collection and data records and ensures that sample quality will be preserved. However, there still exists the need for diligence and close attention to the many details associated with collecting samples and documenting environmental conditions. Under the following conditions, follow the recommended course of action.

- If the incorrect COC form has been printed and brought into the field, refer to the field file to see if the difference between sampling regimes can be determined. For example, if the monthly form has been printed for the quarterly sampling, it may be possible to compensate for discrepancies in analytes and required bottles. If the information in the field file is insufficient to make this determination, it may be necessary to refer to the work order. If possible, contact another Field Operations or Investigations and Monitoring Services (IMS) staff member to pull the file and check the requirements.
- When field conditions differ from anticipated, check the COC requirements and modify if needed. If insufficient sample is available, analysis requests may need to be reduced. Review the project SAP and contact the project manager if necessary.
- If the pre-printed COC form calls for analysis that is not part of the current routine, cross out the extraneous analyses. For example, if there is a notation that quarterly samples require Pesticides analysis, but the samples listed are not the quarterly samples, then cross out the notation about Pesticides.
- Discrepancies between bottle labels and the COC description can occur. Whenever possible the person who physically collected the sample should verify sample ID and COC to resolve the discrepancy.
- When samples cannot be relinquished to lab by the same Field Operations staff collecting the samples, the sample collector must sign the COC form to relinquish samples to other Field Operations staff who will later deliver and relinquish to lab. Be sure to record any transfer of custody within Field Operations.
- The "time received" should match the "time relinquished". If the two times do not match, the samples must have been kept in a secure area of the lab during the interim period of time. The left side of the refrigerator labeled "AL" is the preferred location of storage for samples relinquished outside of normal lab hours. The sample receiver should use the actual time that he/she takes custody of the samples the following morning. Also, the sample receiver must make a note indicating that the sample was received by the lab at the time it was relinquished by the sample collector to the lab refrigerator. If the samples were delivered after the time indicated, the sample collector will be asked to correct the "time relinquished". This will be accomplished by a single strike through the original entry and must be initialed and dated by the sample collector.
- If there are errors on the COC form, the person who filled out the form should make the corrections whenever possible. That person is responsible for the accuracy of the sample information on the form. However, if that person is not available to make the corrections, the person who received the samples should make the corrections, with a note of explanation. Whoever makes a change or correction on a COC form must initial and date the change.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

The following practices will help ensure that samples collected by Field Operations will meet the highest possible standards for data quality. The COC process is approved by the laboratory's Quality Assurance Specialist and is consistent with the broader policies and operating procedures used by staff at the WPCL.

- If bottles cannot be labeled prior to leaving the WPCL due to the nature of the project, label bottles in the field as samples are collected to minimize labeling errors.
- The co-sampler (if applicable) must always review the COC and make sure the form is complete and makes sense. Ensure all field parameter measurements are entered and rounded to significant figures.
- When collecting samples for two or more different projects, keep samples in separate coolers.
- Unloading samples in an orderly way helps verify that all required bottles were collected and relinquished. Organize bottles on the counter in the order they appear on the COC form. This will help ensure that labels are attached correctly and will assist the Sample Custodian in the verification that all samples are present. It will also enhance the efficiency of the labeling process and ensure that the sample labels are sequential and follow the order shown on the COC form.
- Take a copy of the signed COC form to keep with other field records.

This document defines the field methods and documentation procedures necessary to preserve sampling data quality. The Sample Custodian at the WPCL provides another check to ensure that COC forms are filled out completely and that project sampling requirements are being met. The Quality Assurance Specialist for the WPCL works to ensure that procedures within the laboratory, including sample receiving, analysis and data entry, are effective and provide excellence in environmental sampling analysis.

7.0 RESOURCES

(1) *Chain of Custody Procedures for Indirectly Relinquished Samples*, WPCL Policy Statement, City of Portland, Bureau of Environmental Services, Water Pollution Control Lab, Quality Assurance / Quality Control, March 2004.

Section 10

Appendix B: Quality Assurance Project Plan

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

working for clean rivers

Municipal Separate Storm Sewer System Quality Assurance Project Plan

November 2022

Prepared by the
City of Portland Bureau of Environmental Services
Portland, Oregon

For Stormwater, Surface Water, and Macroinvertebrate Sampling by the City of Portland in Compliance with MS4 Permit Requirements

MS4 Permit # 101314

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Chapter 1. Introduction

1.1. Introduction and Purpose

This Quality Assurance Project Plan (QAPP) outlines the quality assurance/quality control (QA/QC) procedures for the collection of stormwater, instream, and biological samples by the City of Portland (City) Bureau of Environmental Services (BES). Water quality and biological data will be collected and reported annually for compliance with the Municipal Separate Storm Sewer System (MS4) permit (Permit Number 101314) issued to the City by the Oregon Department of Environmental Quality (DEQ) in 2021. The MS4 permit requires the City conduct stormwater and surface water monitoring throughout the life of the permit.

This QAPP, in conjunction with the Monitoring Plan (Plan), will guide all sampling, analysis, data assessment, data management, and other monitoring-related activities and ensure that QC and consistency are maintained. The Plan presents the methodology for selecting sampling locations and for collecting and analyzing samples.

1.2. Quality Assurance/Quality Control

The U.S. Environmental Protection Agency (EPA) defines the terms “quality assurance” and “quality control” as follows:

Quality assurance (QA) is the integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected.

Quality control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the established requirements

1.3. Objectives

As presented in Section 1 of the Plan, Schedule B.1.a of the City’s MS4 permit lists the following six objectives that the monitoring program must incorporate.

Required Monitoring Program Objectives, *Schedule B.1.a*:

i. Evaluate the source(s) of and means for reducing the pollutants of concern applicable to the co-permittees' permit area, including 2018/2020 303(d) listed pollutants, as applicable;
ii. Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;

iii. *Characterize stormwater based on land use type, seasonality, geography or other catchment characteristics;*

iv. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;*

v. *Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters; and,*

vi. *Assess progress towards reducing TMDL pollutant loads.*

1.4. QAPP Organization

This QAPP covers project management, sample collection and handling, analytical and quality control procedures, data management and evaluation, inspections, deviations, and corrective action. The appendices provide supporting information, including field sampling and laboratory forms, laboratory method reporting limits, and data qualifiers.

1.5. QAPP Modifications

Potential modifications of the QAPP may be identified by field sampling staff, laboratory staff, or during review and evaluation of the field and/or analytical data. Modifications will be addressed by either revising the QAPP or preparing addenda. The revised QAPP or addenda will describe both the need for the modifications and how the planned changes will be implemented. Per Schedule B.1.c.v of the MS4 permit, if the modification does not reduce the minimum number of data points specified in Schedule B or the modification is the result of including elements of another permit, then the modifications may be made without DEQ approval. Per Schedule B.1.c.vi of the permit, any modification to the Plan (including the associated QAPP) will be documented in the subsequent annual report. Documentation will include a description of the rationale for the modification and how the modification will allow the monitoring program to remain compliant with the permit conditions.

Chapter 2. Project Management/Data Quality Objectives

2.1. Project Organization

The City will be responsible for the technical components of this project and for management of task assignments. Samples will be collected by the BES Field Operations (FO) section and analyzed by the BES Water Pollution Control Laboratory (WPCL) and its contract laboratories. Responsibilities for data validation, assessment, and other related activities are outlined in Table 2-1 and discussed later in this document.

2.2. Project Team Roles and Responsibilities

The roles and responsibilities of the different team members are presented in Table 2-1. The contract laboratories will provide analytical services that the WPCL is not capable of performing. This includes the analysis of certain parameters such as pesticides and taxonomic identification of macroinvertebrates.

Table 2-1. Project Team Roles and Responsibilities

Staff Name	Organization	Role	Responsibility
Barbara Adkins **Loren Shelley** **Julia Bond**	BES	MS4 Program Staff	Responsible for coordinating and communicating MS4 program needs (stormwater event sampling, source investigations, or response actions) with applicable BES WPCL personnel. Responsible for data evaluation, assessment, annual monitoring reports, and technical memoranda.
Peter Abrams **Aaron Wieting** **Jason Law**	BES	Monitoring Coordinator	Responsible for coordinating and communicating the sampling and analytical requirements with the field and laboratory staff. Responsible for organizing, compiling, and managing data.
Jason Law	BES	Project Statistician	Responsible for developing the sampling design and performing statistical data analyses.

Staff Name	Organization	Role	Responsibility
Randy Belston	BES	Storm Event and Sampling Coordinator	Responsible for weather tracking and overseeing sample collection, sample handling, chain-of-custody, and delivery of samples to the BES WPCL or contract laboratory.
Jennifer Shackelford	BES	Water Pollution Control Laboratory Manager	Responsible for overseeing management of BES WPCL. Final authority for data validity.
Cara Jung	BES	Laboratory QA Coordinator	Responsible for validating data generated by the WPCL according to the requirements of the project QAPP and WPCL Quality Manual. Ensures that laboratory protocols and QC are followed and that all corrective actions are implemented. Reviews contract laboratory data for QA/QC issues.
Mike Reiner	BES	Risk Manager	Responsible for ensuring that the City's safety policies and procedures are implemented.
Michael Cole	Cole Ecological, Inc.	Contract Laboratory Project Manager	Responsible for validating data generated by the contract laboratory according to the requirements of the project QAPP and the laboratory's Quality Assurance Manual. Ensures that laboratory protocols and QC are followed and that all corrective actions for analysis of data are implemented. Submits laboratory reports to the WPCL.
Howard Holmes	ALS, Kelso, Washington	Contract Laboratory Project Manager	Responsible for validating data generated by the contract laboratory according to the requirements of the project QAPP and the laboratory's Quality Assurance Manual. Ensures that laboratory protocols and QC are followed and that all corrective actions for analysis of data are implemented. Submits laboratory reports to the WPCL.

Staff Name	Organization	Role	Responsibility
Polly Miller	Specialty Analytical, Clackamas, Oregon	Contract Laboratory Project Manager	Responsible for validating data generated by the contract laboratory according to the requirements of the project QAPP and the laboratory's Quality Assurance Manual. Ensures that laboratory protocols and QC are followed and that all corrective actions for analysis of data are implemented. Submits laboratory reports to the WPCL.
Steve Thun	Matrix Sciences (formerly Pacific Agricultural Laboratory)	Contract Laboratory Project Manager	Responsible for validating data generated by the contract laboratory according to the requirements of the project QAPP and the laboratory's Quality Assurance Manual. Ensures that laboratory protocols and QC are followed and that all corrective actions for analysis of data are implemented. Submits laboratory reports to the WPCL.

2.3. Project Task Descriptions

In accordance with the Plan, stormwater grab samples will be collected from the City's MS4 outfalls between July 1 and June 30 each year. Instream grab samples will be collected from surface waters between July 1 and June 30 each year with a least 50 percent of the samples collected during the wet season (October 1 to April 30). Benthic macroinvertebrate samples will be collected once per year, concurrent with the summer dry weather (July 1 through September 30) instream water quality sampling. These samples will be measured annually at the laboratories for the analytes listed in Table 2-2. These data will be used to demonstrate permit compliance. Sampling data will be evaluated each year in accordance with this QAPP and reported to DEQ in the annual Monitoring Report.

Table 2-2. Stormwater and Instream Water Quality Analytes

Analyte	Method	Analytical Laboratory
Total Copper	EPA 200.8	BES Water Pollution Control Laboratory
Total Lead	EPA 200.8	
Total Zinc	EPA 200.8	
Total Recoverable Mercury	WPCL SOP M-10	
Dissolved Copper	EPA 200.8	
Dissolved Lead	EPA 200.8	
Dissolved Zinc	EPA 200.8	
Ammonia-Nitrogen	EPA 350.1	BES Water Pollution Control Laboratory
Nitrate-Nitrogen	EPA 300.0	
Total Phosphorus	EPA 200.8	
Ortho-Phosphorus	EPA 365.1	
Alkalinity	SM 2320B	
Biochemical Oxygen Demand	SM5210B	
Dissolved Organic Carbon	SM 5310B	
E. coli	Colilert QT	
Hardness	SM2340B	
Total Suspended Solids	SM2540D	
DDT	EPA 608.3	ALS, Kelso, Washington
Dieldrin	EPA 608.3	
2,4-D	EPA 615	Specialty Analytical, Clackamas, Oregon
Dinoseb, MCPA, Triclopyr	EPA 8151	Matrix Sciences (formerly Pacific Agricultural Laboratory), Sherwood, Oregon
Glyphosate and degradate (AMPA)	EPA 547	
Pesticide Panel	EPA 8321B/8270D	

2.4. Data Quality Objectives

Data quality objectives (DQO) are defined for environmental sampling and laboratory activities as qualitative and quantitative statements that specify the quality of the data required to support the project objectives. DQOs provide the driving force for the level of QC required for any particular sampling or analytical task. The key DQOs for the City's MS4 permit compliance monitoring program are designed to provide environmental data that are of known and acceptable quality, are scientifically defensible, and demonstrate compliance with the MS4 Permit. The quality of data is known when all components associated with data generation are thoroughly documented. Data are of acceptable quality when a rigorous QA/QC program is implemented and the QC indicators fall within predefined limits of acceptability. One of the primary functions of the QAPP is to detail the methods of documentation and to define the mechanisms to be used to attain data of acceptable quality.

The quantitative goals for analytical data DQOs and the level of effort expended to assess them is dictated by the intended use of the data and by the nature of the analytical methods and sampling procedures. For this project, analytical data will be used to demonstrate permit compliance. Table 2-3 summarizes the project DQOs for analytical data. Because of the wide variation in precision and accuracy control limits of the analytical methods used in this project, the DQO targets must be broken down into analytical compound classes (e.g., pesticides, metals). Representativeness, comparability, and sensitivity cannot be distilled into numeric targets and are therefore not included in Table 2-3; however, those DQO targets are discussed in the following sections.

Table 2-3. Project Data Quality Objectives

Analyte	Precision	Accuracy	Completeness
Total Metals	± 20%	± 25%	95%
Dissolved Metals	± 20%	± 25%	95%
Pesticides	varies	varies	95%
Conventionals	± 20%	± 25%	95%

The QA mechanisms used to attain predefined DQOs fall within six broad categories: precision, accuracy, representativeness, completeness, comparability, and sensitivity, collectively referred to a PARCCS. The characteristics of these mechanisms for analytical data are discussed in the following sections. Given the variety and variability of other types of data collected for this project, PARCCS cannot be numerically defined to describe data quality. For these data types, the data quality will be qualitatively described, and associated uncertainties will be discussed in appropriate reports or technical memoranda.

2.4.1. Precision

Precision is the reproducibility of measurements under a given set of conditions. Laboratory precision may be assessed through the comparison of parent and matrix duplicate sample analysis and serial dilution analyses.

For two measurements (duplicates), the relative percent difference (RPD) will be used to estimate precision:

$$RPD\ (\%) = |X1 - X2| / [(X1 + X2)/2] \times 100$$

Where: X1 = measured sample concentration; and

X2 = measured duplicate concentration.

The precision goal ranges for analytical laboratory data are between ±20 and ±30 percent (Table 2-3). Note that collection of stormwater and instream samples with precision is problematic because of the dynamic temporal and hydraulic conditions within the drainage system. However, results will be verified by the laboratory, and a thorough review of field and laboratory procedures will be performed to identify and correct problems, if any, and a case-by-case determination will be made regarding data usability.

2.4.2. Accuracy

Accuracy is the agreement between a measured value and its accepted "true" value. Accuracy is estimated from the measurements of samples of known composition. The accuracy of laboratory procedures is estimated by the analysis of calibration check standards, laboratory fortified blanks, surrogates, internal standards, and/or matrix spikes. Results outside of acceptance criteria are addressed according to policies outlined in the WPCL Quality Manual (BES, 2021).

For the analysis of standards (initial and continuing calibration verification, laboratory fortified blanks, surrogates, standard reference materials), the percent recovery is calculated as follows:

$$Recovery\ (\%) = (X/Y) \times 100$$

Where: X = analysis result; and

Y = "true" value.

For the analysis of spiked samples, the percent recovery is calculated as follows:

$$Recovery\ (\%) = [(SSR - SR)/SA] \times 100$$

Where: SSR = sample plus spike amount,

SR = sample result, and

SA = spike added.

The accuracy goals for analytical laboratory data are shown in Table 2-3 and vary by analytical laboratory method. Accuracy failures are documented, results are qualified as necessary, and corrective actions initiated as needed.

2.4.3. Representativeness

Representativeness is the degree to which sample data accurately reflect conditions in the environment. The collection of representative stormwater and surface water samples is problematic because of the dynamic temporal and hydraulic conditions within the drainage system, such as storm event size (precipitation quantity), antecedent dry period, storm duration, flow rates, etc. Given these inherent characteristics, representativeness cannot be distilled into numeric DQOs. Representativeness is maximized by following written standard operating procedures (SOPs) in the field and in the laboratory. These SOPs include statistical methods for choosing an appropriate sampling design, how and where samples are physically taken, how subsamples are split from bulk samples, laboratory procedures for the creation of matrix spikes and matrix spike duplicates, laboratory digestion procedures, and laboratory instrumental methods.

2.4.4. Completeness

Completeness is a measure of the amount of valid data generated relative to the actual amount planned for collection. Completeness measures the effectiveness in sample collection, handling and transport, analysis, and result reporting for the entire investigation, and is calculated on a per-analyte basis by the following equation:

$$\text{Completeness (\%)} = (X/Y) \times 100$$

Where: X = number of valid results,

Y = number of possible results

The main limitations to completeness for this project are likely to be associated with incidental and unavoidable problems: accidental sample bottle breakage, instrument failure resulting in missed holding times, power outages, inability to collect samples because of the lack of adequate precipitation, etc. Failing to follow correct procedures in the field or laboratory also impacts completeness. Having detailed field and laboratory SOPs and thoroughly training all personnel involved in this project will minimize the samples lost because of avoidable procedural lapses. In the event a sample or an analytical result is lost because of such circumstances, corrective actions will be implemented. Examples of these corrective actions include additional training, adding additional personnel, extending the sampling schedule to avoid working too fast for conditions, assessing whether digestion/analytical equipment are adequate for the sample load, and re-assigning personnel who cannot perform adequately.

2.4.5. Comparability

Comparability is defined as the confidence with which one data set can be compared to another. Comparability is especially important in projects where sample collection and analysis occur continuously over many days, sporadically over long periods of time, under different weather conditions, or among different field collection personnel, sampling procedures, and/or laboratories.

Comparability is maximized by following written SOPs for sample collection and other field activities, standardized analytical methods, and standardized reporting requirements (e.g., analytical laboratory data reports, units of measure, field data collection sheets).

To ensure data comparability, standardized analytical methods and QA/QC protocols will be used to the extent practicable. However, if it is determined that an analytical method is available that is more accurate or provides better precision or lower method reporting limits (MRLs), the analytical method may be changed during the course of this project after it is adequately demonstrated that the results of the method are comparable to results derived using standard reference methods. Changes to the analytical program described in the QAPP will be made in accordance with Section 1.5. Comparability will be qualitatively described and data uncertainties will be discussed in appropriate reports or technical memoranda.

2.4.6. Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit. Definitions for common detection limits are defined in the WPCL QAM. MRLs and MDLs are determined as required by 40 CFR part 136.

1) Method detection limit (MDL) is a statistically determined concentration. It is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero.
2) MRL is equal to or greater than the MDL and is regarded as the minimum level of target analyte in a sample that can be reliably achieved within specified limits of precision and accuracy. The MRL is variable and highly matrix-dependent.

The MDLs and MRLs for the analytical methods to be used for this project are presented in Chapter 4 for both the WPCL and the contract laboratories.

2.5. Special Training/Certification

2.5.1. Field Operations

Fieldwork for this project will be performed under City and BES health and safety policies and procedures. The Storm Event Coordinator is responsible for ensuring that all field staff members involved in this project adhere to BES health and safety policies. At least one member of each sampling team should have the following certifications:

- 40-hour Hazmat training and annual 8-hour refreshers
- Confined Space Entry and Work Practices certification
- Traffic Control and Flagging certification
- First aid and cardiopulmonary resuscitation (CPR) certification

Maintaining training records and certifications will be the responsibility of individual team members and are available upon request. The BES Training Coordinator also will maintain copies of appropriate training records for permanent FO section staff members.

2.5.2. Analytical Laboratories

The WPCL and contract laboratories follow EPA-approved analytical methods and QA/QC protocols and maintain employee-training programs. Staff members at all laboratories must demonstrate proficiency regarding laboratory equipment, analytical chemistry, analytical methods safety, math, and QC. Staff members attend training courses, workshops, and seminars on specific instrumentation, analytical techniques, and other specialized topics for continuing education.

The WPCL Laboratory Manager and QA Coordinator are responsible for ensuring that all WPCL personnel follow QA/QC requirements specified in the WPCL QA manual (BES, 2021) and sound scientific practices. The WPCL is accredited through the Oregon Environmental Laboratory Accreditation Program (ORELAP). ORELAP is recognized by the National Environmental Laboratory Accreditation Program (NELAP) to accredit environmental testing laboratories to national standards as adopted by the NELAC Institute (TNI). The WPCL maintains a training program as required by TNI standards.

The WPCL participates in blind proficiency testing (PT) samples twice per year as required by ORELAP accreditation standards. These samples are purchased from a vendor certified under the National Voluntary Laboratory Accreditation Program or an equivalent accrediting program. The analysis of PT samples is used for regulatory and accreditation requirements and as a learning tool with the goal of continuous improvement in data quality. Additional information is included in the WPCL QA Manual (BES, 2021).

ALS also is accredited through ORELAP and the ALS Quality Manual (ALS, 2021) provides additional information regarding special training and certifications. A copy of ALS's ORELAP certification is available on the ALS website. Matrix Sciences is primarily a food testing laboratory and is accredited by International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 17025:2017.

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Chapter 3. Sample Handling and Custody

The following sections describe sample identification; recommended sample volumes, containers, preservation, and holding times for the proposed analyses; and sample custody procedures. Appendix A of the Plan includes detailed sample collection SOPs for this project.

3.1. Sample Identification

Sample labels are necessary to prevent misidentification of samples. Each sample location will have a unique sample point code applied in the field and a unique sample identification code applied upon receipt at the WPCL. These codes will be included on the chain of custody (COC) forms and field data sheets (FDS).

3.1.1. Field Identification

A sample point code will be assigned to each monitoring location at the beginning of each monitoring season, following site reconnaissance and location suitability evaluation. Identification numbers will remain the same unless a location is replaced. For stormwater outfall sites, the point code will include the outfall name or number, a dash, and SW#. For instream sample sites (for both water quality samples and macroinvertebrate samples), the point code will begin with the letter 'P' followed by the four-digit site number, as follows:

Pxxxx

Where: x = 0-9

A separate sample kit will be prepared in advance for each sampling location, with each kit in a separate cooler. Each sample kit will have a tag attached to the cooler that is labeled in indelible ink with the sample location at the time of sample collection by field personnel.

3.1.2. Laboratory Identification

The sampling team will submit samples to the WPCL under strict COC procedures. The sample custodian will log in water quality samples to the WPCL Laboratory Information and Management System (LIMS) system under the project name and sample location ID. The LIMS generates a unique work order number for each COC (e.g., W21L041), in addition to a unique sample number for each sample (e.g., W21L041-01, -02, -03, etc.). These codes are printed on adhesive labels with bar codes and are affixed to the sample containers during the sample receiving and login process. The work order number and sample number are entered on the COC by the sample custodian. Samples analyzed at both WPCL and any contract laboratories are labeled with these unique codes.

3.2. Sample Volumes, Containers, Preservation, and Holding Times

3.2.1. Samples Volumes

Table 3-1 summarizes typical sample volumes required for the proposed analyses. The reported volumes are the recommended minimum field sample sizes for a single analysis, based on standard EPA-approved methodologies. If additional analyses are required (e.g., laboratory QC samples, allowance for potential repeat analyses), the sample volume collected will be increased accordingly.

Table 3-1. Sample Containers, Volumes, Preservation and Holding Times

Analyte (1)	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
Total Recoverable Metals Cu, Pb, Zn	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
Total Recoverable Metals Hg	HDPE	500 mL	WPCL SOP M-10 (2)	HNO_3 to pH<2; cool to 4°C +/- 2°C	28 days
Dissolved Metals Cu, Pb, Zn	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	EPA 350.1	HNO_3 to pH<2; cool to 4°C +/- 2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	EPA 300.0	Cool to 4°C +/- 2°C	48 hours
Total Phosphorus	Plastic	1 pint	EPA 200.8[2]	HNO_3 to pH<2; cool to 4°C +/- 2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	EPA 365.1	Cool to 4°C +/- 2°C	48 hours
Alkalinity	Plastic	1 pint	SM2320B	Cool to 4°C +/- 2°C	14 days
BOD_5 (if TMDL is established)	Plastic	1 quart	SM5210B	Cool to 4°C +/- 2°C	48 hours
Dissolved Organic Carbon	Amber glass	125 mL	SM5310B	H_2SO_4 to pH<2; Cool to 4°C +/- 2°C	28 days

Analyte [1]	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
E. coli	Sterile Plastic	250 mL	Colilert QT	Cool to 4°C +/- 2°C	8 hours
Hardness	Plastic	½ pint	SM2340B	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
Total Suspended Solids	Plastic	1 quart	SM2540 D	Cool to 4°C +/- 2°C	7 days
Organochlorine Pesticides (p,p'-DDE, p,p'-DDT, Dieldrin)	Amber Glass	1 liter	EPA 608.3	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)
Glyphosate and degradate (AMPA)	Amber Glass	1 liter	EPA 547.1	Cool to 4°C +/- 2°C	14 days
Chlorinated Herbicides (Dinoseb, MCPA, Triclopyr)	Amber Glass	1 liter	EPA 8151A	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)
Chlorinated Herbicides (2,4-D)	Amber Glass	1 liter	EPA 8151A	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)
Pesticide Multi Residue Screen	Amber Glass	1 liter	EPA 8321B/8 270D	Cool to 4°C +/- 2°C	7 days (extraction) 40 days (analysis)

[1] Samples will also be analyzed in the field for dissolved oxygen, specific conductivity, pH, and temperature.

[2] DEQ-approved Alternate Test Procedure (ATP)

3.2.2. Sample Containers

All samples will be collected into certified contaminant-free containers, according to analytical method specifications. The WPCL and contract laboratories will provide all appropriate sample containers, coolers, and additional supplies (e.g., bottle labels, custody seals) required for sample collection and transport. Table 3-1 summarizes typical sample containers for the proposed analyses.

3.2.3. Sample Preservation and Storage

Certain analytes may require chemical preservation before analysis, in order to minimize potential chemical changes or degradation that could occur in a sample before analysis. Table 3-1 summarizes typical preservation and storage conditions for the proposed analyses.

3.2.4. Sample Holding Times

Technical holding times are the recommended maximum lengths of time allowed between when a sample is collected and when the extraction and/or analyses are initiated to ensure analytical accuracy and representativeness. All samples will be submitted to the WPCL as soon as practicable, generally within 8 to 12 hours of collection. Samples that will be submitted to a contract laboratory will be delivered as soon as possible after collection or processing. Table 3-1 summarizes technical holding times for the proposed analyses.

3.3. Sample Custody

COC procedures will be strictly followed to provide an accurate written record of the possession of each sample from the time it is collected in the field through laboratory analysis. The sampling team will fill out a COC form at the time of sample collection and submit it to the laboratory along with the samples. Every sample accepted by the WPCL is recorded on a COC form. Upon receipt of the samples, the Sample Custodian or designated alternate will check and sign the COC, record the date and time received, record the sample temperature using an infrared thermometer, assign sample identification numbers, store the samples in a temperature-controlled refrigerator, and log the samples into the computerized data management system. When sample collection occurs after normal business hours, the sampling team will sign and date the COC form and place the samples in the sample-receiving refrigerator. The laboratory will accept the samples as soon as possible, following COC procedures.

Samples submitted to contract laboratories are provided with a subcontract order generated using the WPCL LIMS system. The subcontract order accompanies the samples during transport to the contract laboratory by a laboratory courier or WPCL personnel. Subcontract orders are signed in accordance with standard COC procedures.

At a minimum, the COC form will contain the following information for each sample listed:

- Project name
- Sample date and time
- Sample matrix and type
- Name of person(s) collecting the samples
- Sample point code
- Sample identification code
- Field parameter measurements
- Analysis requested
- Sample temperature
- Printed name, signature, date, and time for each person relinquishing or receiving the samples

Appendix A of the Plan describes COC procedures for this project in detail, and Appendix B of the Plan includes an example of the WPCL COC form. Immediately following each field event, the Storm Event Coordinator or designee will verify that COC forms are completely filled out and correct. Any changes will be marked in ink and initialed.

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Chapter 4. Analytical Procedures

4.1. Field Observation Procedures

Field observations and measurements will be made during sample collection operations, as described in the Plan. Field observations will be recorded on daily field reports (DFRs) and field data sheets (FDSs). Appendix B of the Plan includes examples of these forms.

Immediately following each field event, the Storm Event Coordinator or designee will verify that DFR and FDS forms are completely filled out and correct. Changes or deletions to these forms will be made with a single line drawn through the incorrect entry and the recorder's initials and the date added next to the revised entry. Information recorded should be detailed enough to allow the sampling event to be reconstructed without having to rely on memory and to allow the sampling team for subsequent sampling events to recognize or identify any changes in the immediate proximity of the sampling location that may impact the quality of the sample.

4.2. Laboratory Equipment Maintenance and Calibration Process

All laboratory equipment and instruments used by the WPCL and contract laboratories are maintained and calibrated according to the applicable analytical SOPs, the instrument manufacturer's specifications, and any specific method requirements. The need for routine maintenance is based on the performance of the instrument and is carried out by the responsible chemist or analyst. Manufacturer service technicians perform preventative maintenance and major repairs. Complex instruments are under maintenance contracts with the manufacturers. All instruments have an associated bound maintenance logbook in which all problems, repairs, and service visits are documented. The Laboratory QA Coordinator reviews these books regularly.

4.3. Analytical Methods, Reporting Limits, and Detection Limits

Table 4-1 identifies the analytical methods and the corresponding laboratory MDLs and MRLs for the analytes of interest. The proposed analytical methods for this project have been selected to achieve low-level MRLs. All analyses will be conducted according to the project Plan and QAPP, the laboratory quality manuals, and any specific analytical SOPs.

The sensitivity and precision of an analytical method are determined before the method is used. Statistical MDLs are established according to the EPA procedure at 40 Code of Federal Regulations (CFR) Part 136-Appendix B. This type of MDL study is performed for complex instrumental analysis and for bench methods where applicable.

The laboratory sets MRLs based on the established MDLs and estimates of recoverability and precision at concentrations near the MDL. In most instances, the MRL is three to five times the MDL. An MRL may be set to more than five times the MDL to account for possible matrix variability. For metals analysis, instrument detection limits (IDLs) are established as part of the instrument start-up protocols before establishing the MDLs.

It should be noted that MRLs/MDLs are approximate, particularly for the pesticides listed below. MRLs/MDLs can vary slightly from one sample to another, or reporting limits, particularly for organochlorine pesticides, can be elevated due to matrix interferences in a specific sample.

Table 4-1. Detection Limits for Water Quality Analytes

Analyte	Analytical Laboratory	Method	Method Detection Limit	Method Reporting Limit
Total Recoverable Metals Cu, Hg, Pb, Zn	WPCL	EPA 200.8	n/a	0.2, 0.0005, 0.1, 0.5 ug/l
Dissolved Metals Cu, Pb, Zn	WPCL	EPA 200.8	n/a	0.2, 0.1, 0.5 ug/l
Ammonia-Nitrogen	WPCL	EPA 350.1	n/a	0.02 mg/l
Nitrate-Nitrogen	WPCL	EPA 300.0	n/a	0.10 mg/l
Total Phosphorus	WPCL	EPA 200.8	n/a	0.01 mg/l
Ortho-Phosphorus	WPCL	EPA 365.1	n/a	0.02 mg/l
Alkalinity	WPCL	SM2320B	n/a	1.0 mg/l
Biochemical Oxygen Demand	WPCL	SM5210B	n/a	2 mg/l
Dissolved Organic Carbon	WPCL	SM5310B	n/a	1.0 mg/l
E. coli	WPCL	Colilert QT	n/a	10 MPN/100ml
Hardness	WPCL	SM2340B	n/a	0.25 mg $CaCO_3$/l
Total Suspended Solids	WPCL	SM2540D	n/a	3 mg/l
DDE	ALS	EPA 608.3	0.00077 ug/l	0.01 ug/l
DDT	ALS	EPA 608.3	0.00077 ug/l	0.01 ug/l

Analyte	Analytical Laboratory	Method	Method Detection Limit	Method Reporting Limit
Dieldrin	ALS	EPA 608.3	0.0005 ug/l	0.01 ug/l
Glyphosate	PAL	EPA 547	n/a	10 ug/l
2,4-D	Specialty	EPA 615	0.052 ug/l	0.1 ug/l
Dinoseb	PAL	8151	n/a	0.08 ug/l
MCPA	PAL	8151	n/a	0.08 ug/l
Triclopyr	PAL	8151	n/a	0.08 ug/l
Pesticide Panel	PAL	EPA 8321B/8270D	n/a	varies

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Chapter 5. Quality Control Procedures

5.1. Field QA/QC

Standard field QA/QC procedures will be followed for this project. General field QA protocols include SOPs for sample collection and handling, COC and field data documentation, and training programs for personnel.

Field QC samples are used to assess sample collection procedures, environmental conditions during sample collection and shipment, and the adequacy of equipment decontamination. They also are used to estimate field precision and accuracy. If problems are identified using the field QC samples, the results may be verified by the laboratory, data may be flagged, and/or a thorough review of field and laboratory procedures may be performed to identify and correct problems, if any. A case-by-case determination will be made regarding data usability. If necessary, the Plan and/or QAPP will be modified in accordance with the procedures described in Section 1.4 of the Plan or Section 1.5 of this document.

5.1.1. Trip Blanks

Trip blanks are vials of analyte-free water (i.e., de-ionized water) created in the laboratory and transported to the field and back to the laboratory unopened. They are used to evaluate the potential introduction of contaminants during sampling handling and transport or potential laboratory contamination. Currently, the only trip blanks for this monitoring program may be mercury trip blanks for the stormwater mercury monitoring.

5.1.2. Sample Temperature

The temperature will be read and recorded on the COC form by the Sample Custodian or designated alternate upon receipt at the laboratory. Temperature is measured directly on a sample bottle using an infrared thermometer. The laboratory does not reject samples based on temperature at receipt.

5.2. Laboratory Quality Control

Standard laboratory QA/QC procedures will be followed for this project. General laboratory QA protocols include good laboratory practices; SOPs for sample handling, analysis, and data management; training programs for personnel; and analytical QC.

Specific procedures and frequencies for analytical quality control samples are detailed in the WPCL and ALS Quality Manuals (BES, 2021, ALS 2021) and specific analytical SOPs. Table 5-1 summarizes guidelines for the minimum laboratory QC analyses.

Table 5-1. Guidelines for Minimum QC Samples for Laboratory Analyses

System QC			Matrix QC		
Method Blank	LCS[b] or LFB[c]	CCV[b,c] and CCB[c]	Duplicate[c]	MS[c] and MSD[d]	Surrogate[b]
1 per batch[a]	1 per batch	Method-specific	1 per batch	1 per batch	Each Sample

Notes:

[a] Laboratory batches are 10 or 20 samples depending on the method

[b] Organics

[c] Inorganics

[d] For organics, duplicate precision is calculated on the MS and MSD pair. An LCS duplicate is used if insufficient volume is available for MS/MSDs

LCS: Laboratory Control Sample
LFB: Laboratory Fortified Blank
CCB: Continuing Calibration Blank
CCV: Continuing Calibration Verification
MS/MSD: Matrix Spike/ Matrix Spike Duplicate

5.2.3. System Quality Control

5.2.3.1. Method Blank

Method blanks are analyzed and assessed for contamination as required by analytical methods and the WPCL QAM. Method blanks are laboratory pure water taken through all procedural steps, reagents, and glassware used during sample preparation and analysis. A minimum of one laboratory blank per analytical batch will be prepared and analyzed to evaluate potential laboratory contamination. If a target analyte is detected at or above the MRL, appropriate corrective actions are taken including repreparing and reanalyzing a batch, qualifying the data, or investigating the source of contamination.

5.2.3.2. Laboratory Control Samples (LCSs) and Laboratory Fortified Blanks (LFBs)

LCS consist of a clean matrix (e.g., deionized water) that has been spiked with a known analyte concentration. Acceptable recovery verifies that the analytical system, including the analyst's performance, is in control. Recovery outside the acceptance range indicates a system nonconformance; the cause must be determined and corrective action taken. The frequency of LCS and LFB samples required is defined in each analytical method and/or SOP (WPCL Quality Manual; BES, 2021).

5.2.3.3. Continuing Calibration Verification (CCV)/Continuing Calibration Blank (CCB)

CCVs are used to verify that instrument response remains relatively constant over the course of an instrument run. CCBs are used to monitor carryover contamination. CCVs/CCBs are analyzed at a frequency as required by methods. If a result falls outside the acceptance limits, corrective action is taken.

5.2.4. Matrix Quality Control

5.2.4.1. Laboratory Duplicates

Laboratory duplicates are separate analytical samples prepared from the same parent sample and are treated the same throughout all steps of preparation and the analytical method. They are used to evaluate the precision of the analytical method, including sample preparation and the homogeneity of the sample matrix, by evaluating the RPD between the two results. If an RPD is above acceptance limits, the data are examined to determine whether that is due to analytical or matrix problems. Samples are either reanalyzed or the data are flagged (WPCL Quality Manual; BES, 2021).

5.2.4.2. Matrix Spike (MS) and Matrix Spike Duplicate (MSD)

MS/MSD are prepared and analyzed as required by analytical methods. The MS is used to provide an indication of bias due to interference from components of the sample matrix. Recovery within acceptance limits indicates that the matrix is not significantly affecting the analysis. If MS recovery is outside acceptance limits, then corrective action is taken. MSD samples may also be prepared at the same frequency as MS samples in order to evaluate analytical accuracy and precision.

5.2.4.3. Surrogate Compounds (Organics only)

For organic analyses, all samples are routinely spiked with a series of surrogate compounds (i.e., analogues of the target analytes) before any sample preparation steps. Recoveries of these compounds are used to assess the behavior of actual analytes in individual samples during the preparation and analysis steps. Recoveries outside the acceptance limits require that the sample results be flagged as estimates due to matrix interference.

Table 5-2 presents analyte-specific QC limits. The control limits in this table are generally taken from the EPA reference method.

Table 5-2. Quality Control Limits

Analyte	Duplicate	Matrix Spike		Blank Spike	
	RPD (%)	%R	RPD (%)	%R	RPD (%)
Total Metals	20	70-130	n/a	85-115	n/a
Dissolved Metals	20	70-130	n/a	85-115	n/a
Total Mercury	20	70-130	n/a	85-115	n/a
Ammonia Nitrogen	20	80-120	n/a	90-110	n/a
Nitrate-Nitrogen	20	80-120	n/a	90-110	n/a
Total Phosphorus	20	70-130	n/a	85-115	n/a
Ortho Phosphorus	20	80-120	n/a	90-110	n/a
Alkalinity	20	n/a	n/a	90-110	n/a
Biochemical Oxygen Demand	20	n/a	n/a	n/a	n/a
Dissolved Organic Carbon	15	85-115	n/a	90-110	n/a
Escherichia coli	100	n/a	n/a	n/a	n/a
Hardness	20	70-130	n/a	85-115	n/a
Total Suspended Solids	20	80-120	n/a	90-110	n/a
DDE	n/a	n/a	n/a	30-145	35%
DDT	n/a	n/a	n/a	25-160	42%
Dieldrin	n/a	n/a	n/a	36-146	49%
Glyphosate	n/a	n/a	n/a	78-123	n/a
2,4-D	20%	23-105	20%	23-105	20%
Triclopyr	n/a	n/a	n/a	48-138	30%
Pesticides Screen	30	n/a	n/a	varies	varies

5.2.5. Macroinvertebrate Laboratory Quality Control Measures

A subsample of 500 organisms will be sorted and identified for each macroinvertebrate sample. Taxonomic identification of organisms will reach the species level whenever possible or cost-feasible.

Table 5-3 summarizes the biological laboratory quality control measures that will be used to assess the macroinvertebrate samples. The laboratory conducting the taxonomic identification will archive sample residuals, vials, and slides until the project leader has authorized the disposal of the samples in writing.

Table 5-3. Macroinvertebrate Laboratory Quality Control Measures

Check description	Frequency	Acceptance criteria	Corrective actions
Sample residuals examined by different analyst within lab	10% of all samples completed per analyst	Efficiency of sorting >= 95%	If < 95%, examine all residuals of samples by that analyst and retrain analyst
Duplicate identification by different taxonomist within lab	5 to 25% of all samples completed per laboratory	Efficiency >= 95%	Increasing check frequency if acceptance criteria are not met
Independent identification by outside taxonomist	All uncertain taxa	Assigned certainty rating of 1 to 5, reviewed by outside expert if necessary	Reviewed by QC taxonomist, sent to outside expert if "unknown"
Prepare reference collection	Each new taxon per laboratory	Complete reference collection to be maintained by each individual laboratory	Benthic lab manager periodically reviews data and reference collection to ensure reference collection is complete and identifications are accurate

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Chapter 6. Data Management, Validation, and Reporting

6.1. Data Management and Storage

Technical data that will be generated by the MS4 monitoring program include, but are not limited to:

- Field data
- Analytical laboratory data
- Storm event data (e.g., precipitation data)
- Calculated or manipulated data

Discrepancies in existing and historical data discovered during implementation of the MS4 monitoring program will be documented and revised or updated as appropriate. Records will be retained for a minimum of ten years, and no records will be destroyed without prior permission of the City's MS4 Program Manager, since this project is a long-term monitoring program that has regulatory commitments and implications.

6.1.1. Field Data

All sampling locations are field verified to confirm that they are representative of the intended sampling scenario and are suitable for sampling. Field documentation and data management are an integral part of the QA/QC in order to:

- Verify adherence to Plan protocols
- Track nonconforming events, corrective actions, and inherent data uncertainties
- Demonstrate that field procedures do not impact samples through collection of appropriate QC samples
- Ensure that field records cannot be tampered with or accidentally lost or damaged
- Maintain project schedules and analytical holding times

Document safe work practices field data will be recorded on project-specific paperwork, as described in the Plan. Data should be recorded directly and legibly in indelible ink onto the appropriate forms, with all entries initialed and dated. When entries must be changed, the original entry will be crossed out with a single line so that the original entry is still legible. The change will be initialed by the person making the revised entry. At a minimum, the field records maintained will include (but are not limited to):

- DFRs, FDSs, and COC forms
- Field meter calibration and maintenance records (as applicable)
- Sample collection SOPs

Field records will be maintained in both hard copy and electronic (.pdf file) formats.

6.1.2. Laboratory Data

Sample information and analytical results from the WPCL are transferred automatically into BES' LIMS from most of the laboratory instruments. Analyses that do not support automatic data transfer (i.e., bacteria) are manually entered into the LIMS.

The LIMS functions as the primary BES database for data storage, sample tracking, and reporting. The LIMS in use at the WPCL is Element by Promium and is backed up daily. In addition, the WPCL maintains project files containing any records necessary to reconstruct the analytical events associated with this project. All procedures for storage of hardcopy and electronic data will comply with the WPCL Quality Manual (BES, 2021). At a minimum, records maintained include (but are not limited to):

- COC forms
- Instrument calibration and tuning records (as applicable)
- Analytical standards preparation logs
- Method SOPs
- Analytical QC results (including method blanks, internal standards, surrogates, replicates, and spike and spike duplicate results, as applicable)
- Raw data, specifically instrument printouts
- Bench work sheets and/or quantification reports
- Corrective action reports (if any)
- Details of the QA/QC program in place at the time that the project analyses were conducted

Once data are validated and all analyses are complete, results are spooled from Element each night and transferred automatically to Janus, a SQL server database and the City's primary database for environmental monitoring data. Contract laboratory data are also received as electronic data deliverables (EDDs) and uploaded to the water quality database. If data do not transfer properly due to missing or incorrect information in project or sample location fields, data for those samples are not transferred, and an error report is generated. Errors are addressed the following business day, and data are resubmitted overnight for data transfer.

Precautions will be taken in the analysis and storage of data to prevent the introduction of errors or loss or misinterpretation of data. Original laboratory data sheets (i.e., hard copy) will be maintained in a secure location where they will not be lost or tampered with. Copies of original data should be used for compiling the data to prevent loss or damage.

Sampling and analysis documents and records associated with this project will be stored and maintained in hard copy and/or electronic versions at the WPCL. Hardcopy information will be kept on file. Electronic information will be maintained on current industry-standard hardware and software. The BES computer network is backed up nightly by information technology personnel. The Monitoring Coordinator will be responsible for ensuring that the project field and laboratory activities are properly documented and that those records are stored and maintained.

6.2. Data Validation

6.2.1. Field Data

The Storm Event Coordinator or designated alternate will conduct a thorough review of all field data to ensure that data collection was conducted according to procedures specified in the Plan and QAPP. The Storm Event Coordinator or designated alternate will also review the DFRs, FDSs, and COC forms for completeness. Incomplete field notes or forms, or abnormal or irregular values will be identified and resolved as soon as possible. If an error is made on a document, the sampler will be asked to make corrections by drawing a line through the error and entering the correct information. Any subsequent error discovered on a document will be corrected either by the sampler or project manager. All corrections will be initialed and dated.

6.2.2. Laboratory Data

6.2.2.1. Laboratory Validation of Data

Data generated by the WPCL, ALS, Specialty Analytical, and Matrix Sciences will be reviewed and validated following guidelines described in their respective quality manuals (BES, 2021 ALS 2021). The Laboratory Manager or designee will review analytical reports submitted by ALS to verify acceptable QC results. A qualified member of the laboratory staff may perform data validation. Validation occurs throughout the analytical process. Initial validation is performed during sample receipt and log-in and includes examining the integrity of sample containers and labels, including suitability of containers for requested analyses; examining the COC form for the presence of all required information and signatures; and verifying sample container identification numbers against those listed on the COC form.

Results that do not meet quality criteria will be flagged (Section 6.3). Data are most often flagged for reasons relating to sample integrity, sample matrix, analytical error, or sample uncertainty. Some examples include:

- Holding time exceedance
- Incorrect sample bottle or preservation
- Results reported to the MDL
- Matrix problems causing QC failures
- Loss of sample due to broken sample bottle or laboratory glassware

The WPCL and contract laboratories use customized flags to qualify results and provide explanations for the flags in the "comments" section of the laboratory analysis reports. Definitions for these data qualifiers are included in the data reports.

6.2.2.2. Independent Data Validation of Contractor Laboratory Data

City staff will review data provided by the contractor laboratories during data upload, analysis, compilation, and validation. The City will independently check the contractor laboratory data reports to ensure that data meet the project DQOs. The extent of the review will be determined on a case-by-case basis, depending on the purpose and ultimate use of the data package. If data QA/QC issues are identified during the City's review of the data, the contract laboratory will be contacted and the source of the error traced and corrected if possible. Corrected laboratory data sheets will then be provided to the City. If the error cannot be corrected, the City or laboratory may assign appropriate data qualifier codes to those data to indicate that QA parameters do not meet the acceptance criteria presented in Section 2.4. Data quality issues and data usability will be evaluated in general accordance with EPA guidance (EPA, 2002), using the data validation criteria listed above. Results of the data validation will be documented in the annual Monitoring Reports, or technical memoranda, as appropriate, and maintained in the City files in accordance with Section 6.1. Data usability will be determined on a case-by-case basis, based on consideration of the nature of the issue, analytical method, analytical result, results of reanalyzed samples, and nature and evaluation of the QA/QC results. A full EPA contract laboratory procedure (CLP) validation will not be performed; calibration curves, response factors, and independent confirmation of mass spectral identifications will not be verified or calculated. The contract laboratory will not submit full CLP deliverable packages.

6.3. Data Usability

The data are deemed acceptable and usable if no field or laboratory issues are identified that compromise the anticipated use of the data and if DQOs are met. If data are considered potentially unacceptable (e.g., flagged data or sample analysis/ sample collection problems), the appropriate WPCL staff (e.g., Laboratory QA Coordinator, Storm Event Coordinator, Monitoring Coordinator, Statistician) will review the specific issue(s) and recommend whether or not the data are usable on a case-by-case basis, as dictated by the data. DEQ may be consulted on specific data usability issues. If data are subsequently determined to be acceptable, they will be used for data evaluation. If, however, data are determined not to be acceptable, they will be flagged and reported, but they will not be used for data evaluation. To the extent practicable, data or samples determined to be unusable will be recollected and analyzed to maintain the intent and integrity of the data set. If additional data cannot be collected in a timely manner, the MS4 Program Manager or designee will determine if data evaluation can proceed with the existing, acceptable data set, if alternative evaluation methods are needed, or if additional data are needed. If additional data are needed, more samples will be collected if weather conditions meeting the sampling criteria occurs before June 30, the end of the monitoring period. If additional samples cannot be collected, DEQ will be notified.

All data usability issues and their resolution will be documented in the annual Monitoring Report.

6.4. Reporting

The following sections summarize laboratory data reporting, deliverables, and data management procedures for both the WPCL and contract laboratories. Final reports will be available and may be included as attachments or appendices to the annual Monitoring Report, or provided to DEQ upon request.

6.4.1. Water Pollution Control Lab

The WPCL Laboratory Analysis Report will be created by the Laboratory QA Coordinator after all data have been reviewed, flagged as needed, entered into LIMS, and checked for data entry accuracy following data validation procedures outlined in the WPCL Quality Manual (BES, 2021). Standard laboratory analysis reports created in LIMS will be available in hard copy and electronic (.pdf file) formats. In addition, data will be available in spreadsheet format (e.g., Microsoft Excel) for use in data interpretation and analyses. The laboratory analysis reports will include the following information:

- Sample date and time
- Sample ID
- Project name
- Sample point code
- Laboratory and field comments
- Sample type and matrix
- Test analytes
- Results
- Units
- Data flags
- MRLs
- Analytical methods

Electronic data can be customized to include additional sample information entered into LIMS, but these data will not be included in the standard laboratory analysis reports.

6.4.2. Contract Laboratories

Contract laboratories will prepare and submit analytical reports in accordance with the terms of their contract and in accordance with this QAPP. The analytical report will be created by the Project Manager or designee at the contract laboratory, after all data have been reviewed and flagged as needed. The analytical reports will include, at a minimum, the project name, sample date and time, sample identification number, sample point code, test analyte, analytical method, MRL, result, data flags, and any appropriate comments.

Analytical reports and EDDS will be sent to the WPCL QA Coordinator and checked following procedures outlined in the WPCL Quality Manual (BES, 2021). A copy of the contract laboratory report will be attached to the final WPCL report. EDDs will be uploaded electronically to the water quality database.

Chapter 7. Data Assessment and Evaluation

7.1. Data Assessment

Before data assessment, the data will be validated (described in Section 6.2) to verify that they are of acceptable quality and meet project DQOs. Data assessment and validation will be performed by various members of the City's MS4 program team (e.g., Monitoring Coordinator, Storm Event Coordinator, Laboratory QA Coordinator, Statistician) as appropriate for the data use. Assessment will include (but is not limited to) the following:

- Review of any information collected regarding sampling locations for consistency, reasonableness, and accuracy to the extent practicable, before use;
- Identification of potential errors or inconsistencies in data obtained from available resources that may require further evaluation, before use of the data;
- Review of applicable field and laboratory documentation to ensure that the applicable SOPs were followed;
- Review of field and laboratory QC reports to understand quality and usability of data including:
    - Results of QC samples that were collected and analyzed;
    - Overall DQO performance for analytical laboratory data by reviewing precision, accuracy, and completeness, and evaluating representativeness, comparability, and sensitivity; and
    - Data qualifier flags assigned to analytical laboratory data to assess sample collection, handling, or laboratory QC issues.
- Calculation of basic quantitative characteristics of the data using common statistical parameters (e.g., range, mean, medium, frequency of detection);
- Graphing the data using appropriate methods to identify patterns or trends in the data. These patterns or trends may be used to describe the data, identify potential correlations or problems with the data set, and to convey information to others.

Data assessment activities will be performed in general accordance with EPA Guidance (EPA, 2006a).

7.2. Data Evaluation

Data evaluation for this project addresses permit compliance and the City's watershed health goals. Section 1 of the Plan describes the overall objectives of the monitoring program. Data analysis to achieve those objectives will include:

- Evaluation of analyte concentrations relative to factors that may have influenced water quality
- Evaluation of landscape conditions that may influence stormwater characteristics

- Evaluation of the status and long-term trends in receiving waters
- Evaluation of analyte concentrations related to actions taken to improve stormwater quality to evaluate the effectiveness of the actions as appropriate

This analysis may be used to develop recommendations for changes to stormwater management and necessary adjustments to the Plan or QAPP.

7.2.1. Data Analysis Issues

Environmental data sets often contain non-detects, estimated values, missing data, and outliers. This section describes how these issues may be addressed during data evaluation. Statistical methods, which may be used for data evaluation, are briefly discussed in the following sections. While these methods may be appropriate, the City reserves the right to modify the method or select other methods more appropriate for the actual data. The data analyses method used and the results of data analysis will be described in the annual Monitoring Report.

7.2.1.1. Non-Detects

An analytical result that is designated as a “non-detect” indicates that the specific analyte was analyzed, but not detected at a concentration equal to or greater than the MRL for that analyte. There are several methods for handling non-detects. A commonly used method for environmental data is to substitute one-half the analyte’s MRL. However, this method produces biased results by assuming that the values for the non-detects are known when they really are not. The value substituted is not a function of anything known about the water sampled or the laboratory methods used to evaluate analyte concentrations. Furthermore, substitution with one-half the MRL can generate different results for statistical tests by overestimating or underestimating concentrations.

Non-detect data also occur in the medical sciences, social sciences, economics, and industry. The suggested methods below for evaluating non-detects have been widely used in these fields for quite some time and are equally appropriate for handling non-detect environmental data.

Unlike substitution methods, the following methods take into account the nature of the data: whether it follows a normal distribution or lognormal distribution, how many data points are available, and how many non-detected values exist. As a result, these methods likely provide a more accurate representation of the water quality sampled by the City than the substitution method of one-half the MRL.

The methods listed below may be applied to obtain descriptive statistics, such as means, as well as perform statistical tests to compare two or more groups. These methods can also handle data with multiple detection limits. Depending on the number of data points and the percentage of those data points that are non-detects, the most appropriate method will be selected and used to develop estimates for analytes that have been reported by the laboratory as non-detect. The potential methods that may be selected for analyses of "non-detect" data are summarized below and in Table 7-1:

- The Kaplan-Meier method is a nonparametric method used widely in biomedical statistics. It is appropriate if less than 50 percent of the data are non-detect.
- Regression on order statistics (ROS) (Helsel, 2005) is a method that assumes the non-detected values follow a specific distribution, such as the lognormal distribution. Actual numerical values are estimated for the non-detected data points, using the lognormal distribution. These estimated values are then combined with the detected data points to compute descriptive statistics and perform statistical tests. This method is appropriate if 50-80 percent of the data are non-detect.
- Maximum likelihood estimation (MLE) is a parametric method and is appropriate if there are more than 50 data points in the analysis and 50-80 percent of those data points are non-detect. Cohen's method, which is recommended by the EPA's Practical Method for Data Analysis, is an example of MLE. However, Cohen's method can only be applied to data with only one detection limit. Fortunately, other MLE methods can handle multiple detection limits. If more than 80 percent of the data are non-detect, reporting the percentage of data points above the action level or reporting the 90th or 95th percentiles is most appropriate.

Table 7-1. Statistical Methods for Datasets Containing Non-Detects

Percentage of Non-Detects	Available Data	
	< 50 Observations	≥ 50 Observations
< 50%	Kaplan-Meier	Kaplan-Meier
50% – 80%	ROS	MLE
> 80%	Report % above action level	Report high sample percentiles (90 or 95th)

If estimated data are available and determined to be usable, the estimated value would be used for purposes of compliance determination rather than an estimated value derived from one of the statistical methods described above. In these cases, the estimated value is expected to be somewhere between the MDL and the MRL for an individual analyte.

7.2.1.2. Missing Data

If there are missing data due to field or laboratory error (e.g., bottle breakage, equipment failure), the locations with missing data will be resampled, if possible. If it is beyond the reasonable control of the City to provide all required data for each sampling location in one year, data analysis will proceed with the amount of data available. Missing data will be included in evaluation of the 95 percent completeness DQO.

7.2.1.3. Estimated Data

Final and validated data that are of known and acceptable quality are generally considered appropriate for data evaluation and will be used without modification. Examples of situations where estimated data are considered appropriate for use include:

- Data from samples with known matrix effects; and
- Data with associated known analytical QC issues, such as matrix spike recoveries, surrogate recoveries, exceedance of holding times, etc. These data will be appropriately flagged to track the issue.

Data usability will be determined on a case-by-case basis, based on consideration of the nature of the issue, analytical method, analytical result, results of reanalyzed samples, and nature and evaluation of the QA/QC results. DEQ will be consulted on data usability issues, as needed.

7.2.1.4. Outliers

Outliers will be retained to the extent practical. However, data resulting from known equipment malfunction or sample collection errors may be rejected. Statistical methods that are robust to outliers will be preferred in order to incorporate outliers into the data analysis rather than discarding them, when possible. Any outliers and discussion about how outliers are included in the data analyses will be discussed in the annual Monitoring Report.

Chapter 8. Inspections and Audits

Inspections or audits are performed to evaluate the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents; determine the effectiveness of implementation; and ensure that project expectations are being met. The objectives of an audit are to:

- Assess activities that have a significant impact on the project or the project's performance
- Ensure that the data being collected fulfill the DQOs established for this project
- Identify any areas requiring field or laboratory corrective action.

Inspection activities should assess technical competence and proficiency, compliance with approved procedures, verification of data and statistical computations, and effectiveness of internal QC procedures. The City will be responsible for internal audits and inspections. DEQ will be responsible for external audits and inspections, if deemed necessary.

8.1. Field Inspections and Audits

The project Storm Event Coordinator will be responsible for ensuring that all fieldwork performed meets the objectives established for this project. Field staff are required to read, understand, and follow all procedures documented in the Plan. At a minimum, field sampling personnel will be responsible for:

- Inspecting field sampling equipment before use to ensure it is in proper working order and calibrated
- Ensuring that all field sampling collection forms (e.g., COC forms, FDSs) are properly and completely filled out
- Ensuring that samples are collected, stored, and delivered to the laboratory in accordance with the project Plan.

An audit of field sampling activities will be conducted and documented on an as-needed basis by either the Storm Event Coordinator or City personnel not directly involved in the activity being addressed. Additional field audits will be performed as needed or if an apparent sampling inconsistency or deficiency is discovered by reviewing project documentation, analytical data, or QA/QC results. The type of field audit required will be based on the inconsistency or deficiency in question. Observations and corrective actions will be documented in writing for all audits performed. The results of any field audits will be included in the annual Monitoring Report.

8.2. Laboratory Inspections and Audits

The WPCL and contract laboratories conduct internal audits of laboratory activities as part of their respective QA programs. A multi-day audit of the WPCL is conducted according to ORELAP requirements.

The City reserves the right to conduct an inspection or audit of contract laboratories, if determined to be necessary. If this occurs, qualified WPCL personnel will be responsible for ensuring that all work performed meets the objectives established for this project and all corresponding internal SOPs and quality manuals. An audit consists of a site visit to interview contract laboratory personnel; examine sampling handling, preparation, and analysis procedures; observe personnel engaged in laboratory work; and review all QA/QC, data reporting, and safety procedures and laboratory guidance documents. If concerns are raised, WPCL personnel will meet with contract laboratory personnel to discuss corrective actions. Follow-up inspections may be performed to ensure corrective actions have been fully implemented.

The City may at its discretion submit a duplicate sample(s) (i.e., split sample) to another analytical laboratory to verify the performance of the WPCL or contract laboratory.

The City will document laboratory inspections and audits and any corrective actions implemented as a result. The results of any audits or inspections will be included in the annual Monitoring Report.

Chapter 9. Deviations, Nonconformance, and Occurrences

9.1. Deviations

A deviation is a planned or unplanned departure from a procedure, deemed reportable and tracked by the City's MS4 Program Manager. DEQ must preapprove planned deviations (i.e., those made with foreknowledge), as discussed in Section 1.5. Unplanned deviations to the Plan or QAPP encountered during field activities will be documented on field sheets or COC forms. The laboratory will document deviations from analytical methods. Deviations will be reported to the City's MS4 Program Manager. The MS4 Program Manager or designee will determine if the deviation will or may significantly impact data quality and if a corrective action is needed (e.g., data qualification flags, uncertainty discussion). The MS4 Program Manager may consult with the DEQ permit manager to discuss significant deviations and agree on an appropriate corrective action. Significant deviations and related corrective actions, if needed, will be described in the annual Monitoring Report.

9.2. Nonconformance

Nonconformance is a deficiency in characteristics, documentation, or procedures that renders the quality of an item or activity unacceptable or indeterminate. Nonconformance may be those items or activities not conforming to specified requirements that are identified before their use, acceptance, or intended purpose. A nonconforming item or activity has the potential to affect other programs. Depending on the nature of the nonconformance, field and laboratory corrective action protocols may be initiated. The MS4 Program Manager will be notified of any nonconformance that affects data quality. The MS4 Program Manager or designee will determine the cause and significance of the nonconformance and whether a corrective action is needed. Corrective actions may include redoing the item or activity determined to be unacceptable or indeterminate (e.g., reinspect, resample, reanalyze). The MS4 Program Manager may consult with the DEQ permit manager to discuss nonconformance and agree on an appropriate corrective action. Nonconformance incidents and related corrective actions, if needed, will be described in the annual Monitoring Report.

9.3. Occurrences

An occurrence is any condition or event that could affect the health and safety of the public, have an adverse effect on the environment, endanger the health and safety of workers, affect the operations and intended purpose of a facility, or result in loss or damage of property. Occurrences may be a specific type of deviation or nonconformance. Routine or preventive maintenance, personnel issues, or similar issues covered by existing administrative programs are typically not included. Occurrences will be documented and reported to the City's MS4 Program Manager. Any occurrence that could affect health and safety will also be immediately reported to the City's Risk Manager. The MS4 Program Manager or designee will determine the significance of the occurrence and if a corrective action is needed (e.g., modifications to the Plan or QAPP; storm system cleaning; public notification). The MS4 Program Manager may consult with the DEQ permit manager to discuss the occurrence and agree on an appropriate corrective action. Occurrences and related corrective actions, if needed, will be described in the annual Monitoring Report.

Chapter 10. Monitoring Program Corrections

An integral part of quality improvement includes corrective action planning based on cause analysis to ensure that identified problems are analyzed and corrected in a manner likely to prevent recurrence. For the purposes of this QAPP, corrective action is defined as a measure taken to rectify and/or to prevent recurrence of a field or analytical laboratory quality failure. Project personnel should take a proactive approach to identify activities requiring improvement, modification, and/or additional training. Events, external inspections or audits, and/or data evaluation may require changes to the Plan or QAPP to ensure high-quality data and the safety of field and laboratory personnel.

These actions may include, but are not limited to:

- Implement a quick fix (i.e., correct the error or problem during or immediately following the assessment)
- Resample the location(s) where either field or laboratory procedures may have invalidated the data
- Discuss the negative observations and the requirements or procedures concerning the deviation with the person(s) responsible and discuss how the work can/will be corrected following appropriate procedures
- Conduct a follow-up inspection to ensure that the problem or deficiency has been corrected
- Conduct retraining and reevaluation of technical proficiency.

Corrective actions that occur as a result of independent, external assessments will be documented and reported to the City's MS4 Program Manager or designee for resolution. Responses to deficiencies identified in an independent audit should identify:

- The cause of the problem
- Actions taken to resolve the problem
- Actions that will be taken to prevent recurrence
- Actions to be taken for improvement

Corrective actions will be discussed in the annual Monitoring Report.

10.1. Field Corrective Actions

Field sampling personnel are responsible for documenting and reporting any field activity that results in a deviation, nonconformance, or occurrence. These will be documented in the DFRs and/or FDSs and reported to the City's MS4 Program Manager. If problems associated with field measurements or field sampling equipment are observed, sampling personnel will take appropriate actions to correct the problem. Actions may include repeating measurements taken, retraining personnel, or repairing or correcting field measurement instruments and sampling equipment. If necessary, work should be stopped until the problem can be corrected. Problems and associated corrective actions will be documented on a corrective action report (CAR). Corrective actions will be described in the annual Monitoring Report, as appropriate.

10.2. Laboratory Corrective Actions

The WPCL and contract laboratories are responsible for maintaining internal quality control and for taking corrective actions when quality control criteria are not met, in accordance with internal SOPs and quality manuals. The QA Coordinator will be responsible for issuing, tracking, and documenting any corrective actions and should address all problems or deficiencies found. Problems and associated corrective actions will be documented on a CAR. Each completed CAR becomes part of the laboratory QA record as evidence that nonconformances have been investigated and corrected. Project-related deviations and corresponding corrective actions should be reported immediately to the City's MS4 Program Manager. Corrective actions will be described in the annual Monitoring Report, as appropriate.

Chapter 11. References

City of Portland, Bureau of Environmental Services (BES). 2021. WPCL Quality Manual. Revision 11.0.

Environmental Protection Agency (EPA). 2002. Guidance on Environmental Data Verification and Data Validation. EPA/240/R-02/004.

Environmental Protection Agency (EPA). 2006a. Data Quality Assessment: A Reviewers Guide. EPA/240/B-06/002.

Helsel, D.R. 2005. Nondetects and Data Analysis: Statistics for Censored Environmental Data. Wiley.

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Appendix: Laboratory Forms

- WPCL Cooler Receipt Form

WPCL Cooler Receipt Form

Work Order Number: ____________________ **Cooler Receipt Form Filled Out By:** ______

Project: ____

Received on ice: YES NO (circle one) *[If directly from field, indicate here:_____]*

Sample(s) Received From: CBWTP fridge______ Client______ Courier______ SR fridge ______

Temperature (°C): ________

	Yes	No	N/A
Is the COC present and signed?			
Are sample bottles intact?			
Do the COC and sample labels match?			
Are the appropriate containers used?			
Are samples appropriately preserved?			
Are VOA vials completely filled (zero Headspace)?			
Are alkalinity bottles completely filled (zero Headspace)? Note if filled in lab.			
Are samples received within holding times (except for pH and residual chlorine)?			

Pres. #	Preservative	LIMS ID	Standard Preservation Amounts
1	**HNO_3 (1:1) to pH <2**		0.5mL/250mL; 1.0mL/500mL; 4-5 drops/50mL centrifuge tube
2	**H_2SO_4 (18N) to pH <2**		0.4mL/250mL; 0.8mL/500mL ; 1.6mL/1000mL
3	**HCl (1:1) to pH <2**		2.0mL/500mL; 4.0mL/1000mL
4	**HCl (1:1) to pH 2-3**		For TOC: 2-5 drops/250mL
5	**NaOH to pH >12**		4-10 pellets/500mL; 4 mL 10N/1000mL

Date	Time	Analyst	Sample LIMS ID	Bottle ID	Pres. #	Comments

Comments:____

Section 11

Appendix C: Field Sampling Forms

Field Data Sheet Daily

Field Report

Chain-of-Custody Forms

Date: ____________

City of Portland Field Data Sheet

Bureau of Environmental Services

Collected By: ____________

Client Name: MS4

Project Name: **NPDES Stormwater**

Matrix: Stormwater

Sample Appearance

Location ID	Sample Date	Sample Time	Sample Type	Color	Odor	Turbidity	Floating Solids	Drainage Area Conditions	Remarks
			G						
			G						
			G						
			G						
			G						
			G						
			G						
			G						
			G						
			G						
			G						
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			G						
			G						
			G						

G = grab

City of Portland
Environmental Services
Field Operations

DAILY FIELD REPORT

Page ___________ of ___________

Project ____

Location ____ Date _____________________________

Subject ____ Personnel ________________________

Attachments:

Date: ______________

Water Pollution Control Laboratory
6543 N. Burlington Ave.
Portland, Oregon 97203-4552
Sample Custodian: (503) 823-5696
General Lab: (503) 823-5681

City of Portland Chain-of-Custody

Bureau of Environmental Services

Work Order #: ______________

Collected By: ______________

Client Name:	Watershed Regulatory Strategy	Matrix:	Surface Water
Project Name:	**PAWMAP**		

Requested Analyses

Special Instructions:

1 = Field Filtered
2 = E. coli has 8-hr hold time
3 = Mercury detection limit is 0.5 ng/L per NPDES Permit

Lab Number	Location ID	Sample Date	Sample Time	Grab or Comp	Alkalinity	E. coli[2]	Hardness	TSS	Total Mercury[3]	Total Metals (Cu, Pb, Zn)	Diss. Metals (Cu, Pb, Zn)	Ammonia-Nitrogen	Nitrate-Nitrogen	O-Phosphate Phosphorus[1]	Total Phosphorus	DOC[1]	BOD									Conductivity (umhos/cm) Meter:	Dissolved Oxygen (mg/L) Meter:	pH (pH units) Meter:	Temperature (Deg C) Meter:	Turbidity (NTU) Meter:
				G	●	●	●	●	●	●	●	●	●	●	●	●	●													
				G	●	●	●	●	●	●	●	●	●	●	●	●	●													
				G	●	●	●	●	●	●	●	●	●	●	●	●	●													
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				G	●	●	●	●	●	●	●	●	●	●	●	●	●													
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Relinquished By:	**Received By:**	**Relinquished By:**	**Received By:**
Signature: **Date:**	**Signature:** **Date:**	**Signature:** **Date:**	**Signature:** **Date:**
Printed Name: **Time:**	**Printed Name:** **Time:**	**Printed Name:** **Time:**	**Printed Name:** **Time:**

Date: ______________

Water Pollution Control Laboratory
6543 N. Burlington Ave.
Portland, Oregon 97203-5452
Sample Custodian: (503) 823-5696
General Lab: (503) 823-5681

City of Portland Chain-of-Custody

Bureau of Environmental Services

Work Order #: ______________

Collected By: ______________

Client Name: MS4

Matrix: Stormwater

Project Name: **NPDES Stormwater**

Requested Analyses

Special Instructions:
1 = Field Filtered
2 = E. coli has 8-hr hold time
3 = Mercury detection limit is 0.5 ng/L per NPDES Permit

Lab Number	Location ID	Sample Date	Sample Time	Sample Type	E. coli[2]	Total Mercury[3]	Total Metals (Cu, Pb, Zn)	Diss. Metals (Cu, Pb, Zn)[1]	Hardness	Ammonia-Nitrogen	Nitrate-Nitrogen	Total Phosphorus	o-phosphorus Phosphate[1]	Alkalinity	BOD	DOC[1]	TSS	Organochl. Pesticides (608.3)	Glyphosate	Pest. Multi-residue Screen	Chlorinated Herbicides (615)							Conductivity (umhos/cm) Meter:	Dissolved Oxygen (mg/l) Meter:	pH (pH units) Meter:	Temperature (Deg C) Meter:	# of Cont's	Remarks
				G	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●												
				G	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●												
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Signature:	Date:	Signature:	Date:	Signature:	Date:	Signature:	Date:
Printed Name:	Time:	Printed Name:	Time:	Printed Name:	Time:	Printed Name:	Time:

Cole Ecological, Inc.
Macroinvertebrate Samples
Chain-of-Custody Form
Version: 13 April 2013

Client:	City of Portland , BES	**CE Project Number:**	
Client Address:	6543 N Burlington Ave, PDX, OR	**Destination CE Lab:**	Portland, OR
Client Contact Name:	Peter Abrams	**CE Lab Contact:**	Alden Miller
Client Contact Phone:	(503) 823-5533	**CE Contact Phone:**	503-978-0576
Client Contact Email:	peter.abrams@portlandoregon.gov	**CE Contact Email:**	amiller@coleecological.co

Instructions to client:
Please fill out, print, sign and send with samples
Email electronic version to mcole@abrinc.com
Add additional rows to table, as needed

Client Sample Code identifies each individual sample collected and is a required field, while the station code idenitifies the sample location(s) from which (one or more) samples were collected and is optional

Count	CE Sample Code	Client Sample Code	Station Code	Waterbody Name	Collection Date	Habitat	# Sample Vessels	Duplicate Sample?	Sampling Method	Client Sample Notes
	EXAMPLE	*HGBM01-01-11*	*HGBMO1*	*Hinesburg Brook*	*9/19/01*	*riffle*	*2*	*N*	*8-kick composite*	
1	*PLEASE LEAVE*									
2	*THIS COLUMN*									
3	*BLANK*									
4										
5										
6										
7										
8										
9										
10										
11										
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SIGNATURES:

Relinquished By/Affiliation:	Date:	Comments:	Exhange 1
Received By/Affiliation:	Date:	Comments:	
Relinquished By/Affiliation:	Date:	Comments:	Exhange 2
Received By/Affiliation:	Date:	Comments:	
Relinquished By/Affiliation:	Date:	Comments:	Exchange 3
Received By/Affiliation:	Date:	Comments:	

ENVIRONMENTAL SERVICES
CITY OF PORTLAND

working for clean rivers

The City of Portland Bureau of Environmental Services is committed to providing meaningful access. To request translation, interpretation, modifications, accommodations, or other auxiliary aids or services, please call 503-823-7740, or use City TTY 503-823-6868, or Oregon Relay Service: 711.

口笔译服务 | Chiaku me Awewen Kapas | अनुवादन तथा व्याख्या | Traducere și interpretariat | Устный и письменный перевод | Turjumaad iyo Fasiraad | Traducción e interpretación | Письмовий і усний переклад | Biên Dịch và Thông Dịch |
Translation or Interpretation: 503-823-7740