Monitoring Plan

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

City of Portland
Bureau of Environmental Services

Municipal Separate Storm Sewer System (MS4) Permit # 101314

Effective Date

July 1, 2016

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INTRODUCTION

1.1 PURPOSE

This Monitoring Plan (Plan) describes the sampling and analysis program for the collection of stormwater and surface water samples by the City of Portland (City) Bureau of Environmental Services. Stormwater and surface water or "instream" water quality 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 No. 101314) issued to the City by the Oregon Department of Environmental Quality (DEQ). The 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 monitoring-related activities conducted under the permit and will ensure that quality control and consistency are maintained.

1.2 ORGANIZATION

Section 1.0 provides a 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. In the following sections, this Plan covers the main elements of the NPDES MS4 environmental monitoring program including instream monitoring (Section 2.0), continuous instream monitoring (Section 3.0), stormwater monitoring and storm event targeting (Section 4.0), and macroinvertebrate monitoring (Section 5.0). Section 6.0 provides a description of sampling staff, and Section 7.0 provides a description of field sampling procedures. Section 8.0 provides information related to quality control procedures. The last section of this document (Section 9) lists the references cited in this Plan.

The City conducts significant monitoring of stormwater in the underground injection control (UIC) system for compliance with its Water Pollution Control Facility (WPCF) and MS4 permits. The UIC stormwater monitoring program is documented in the WPCF Permit *Sampling and Analysis Plan* (WPCF-SAP) and the WPCF Permit Quality Assurance Project Plan (WPCF-QAPP). Where methods and QA/QC procedures overlap between the City's UIC and MS4 monitoring programs, this document references those sections of the WPCF-SAP and WPCF-QAPP in order to minimize duplication and simplify the process for any potential future modifications.

1.3 MONITORING PROGRAM REQUIREMENTS & OBJECTIVES

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

<u>Required Monitoring Program Objectives, *Schedule B.1.a*</u>:

i. Evaluate the source(s) of the 2004/2006 303(d) listed pollutants applicable to the co-permittees' permit area;

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 meeting TMDL pollutant load reduction benchmarks.*

Table 1.1 (at the end of Section 1.0) shows how the monitoring program elements presented in this plan address each of the objectives.

Required Monitoring Plan Elements, *Schedule B.2.a – d*:

Schedule B.2.a-d requires the City to develop a monitoring plan that:

a. *Identifies how each monitoring objective identified in Schedule B.1.a is addressed and the sources of information used. The co-permittee 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.*

b. *Describes the role of the monitoring program in the adaptive management of the stormwater program.*

c. *Describes the relationship between environmental monitoring and a long-term monitoring program strategy.*

d. *Describes the following information for each environmental monitoring project/task:*

i. *Project/task organization*

ii. *Monitoring objectives, including:*

a) *Monitoring question and background;*

b) *Data analysis methodology and quality criteria; and,*

c) *Assumptions and rationale;*

iii. *Documentation and record-keeping procedures;*

iv. *Monitoring process/study design, including monitoring location, description of sampling event or storm selection criteria, monitoring frequency and duration, and responsible sampling coordinator;*

v. *Sample collection methods and handling/custody procedures;*

vi. *Analytical methods for each water quality parameter to be analyzed;*

vii. *Quality control procedures, including quality assurance, the testing, inspection, maintenance, calibration of instrumentation and equipment; and,*

viii. *Data management, review, validation, and verification.*

This Plan addresses these requirements.

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, QA/QC). Modifications may include, but are not be 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.2.e of the permit, which states:

> *The monitoring plan may be modified without prior Department approval if the following conditions are met. For conditions not covered in this section, the co-permittee must provide the Department with a 30-day notice of the proposed modification to the monitoring plan, and receive written approval from the Department prior to implementation of the proposed modification. If the Department does not respond to the permittee within 30 days, the permittee may proceed with implementation of the proposed modification without written approval.*
>
> *i. The co-permittee is unable to collect or analyze any sample, pollutant parameter, or information due to circumstances beyond the co-permittee's control. These circumstances may 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; or,*
>
> *ii. The modification does not reduce the minimum number of data points, which are a product of monitoring location, frequency, and length of permit term, or eliminate pollutant parameters identified in Table B-1 (of the permit).*

Per Schedule B.2.f of the permit, the City will include a summary and rationale of any modifications in the subsequent MS4 annual compliance report.

1.4.1 Updates to Previous Monitoring Plan

The City's MS4 permit, which expired on January 30, 2016, is currently under administrative extension. The City met its monitoring requirements for the permit term described in the 2013 Quality Assurance Monitoring Plan (QAMP) [1] and as documented in the annual compliance reports. During the permit term, the City also concluded key elements of the monitoring program listed in Schedule B.1 that have been fulfilled, including pesticide and mercury monitoring in stormwater.[2] This Plan effectively updates the City's 2013 QAMP for the timeframe relevant to the administrative extension period.

The City evaluated the monitoring program during the 2015 permit application renewal process and identified some adaptive management changes and new monitoring opportunities to be implemented under this Plan. These changes include a reduction in the number of UIC stormwater monitoring locations and the addition of several fixed land use stations that were historically sampled for direct stormwater monitoring of the MS4. In addition, the City has discontinued macroinvertebrate monitoring specifically in the Columbia Slough, resulting in a small reduction in the number of sites sampled for this monitoring element. The reason for the change is that most metrics used to evaluate the health of aquatic insect communities are developed for pool-riffle stream systems and are not effective in addressing low gradient systems like the Columbia Slough. The City is considering use of a more viable biological index that may be substituted in the Slough.

Under this revised Plan, the City has elected to resurrect four MS4 land use sites that were historically monitored between 1991 and 2011. Revisiting these sites will allow the City to assess whether there have been significant changes or detectable trends in the quality of stormwater runoff over many years, particularly in light of the best management practice (BMP) and green infrastructure implementation that has increased significantly in recent years. The fixed land use monitoring will entail flow-weighted sampling during three storms per year at each of the four sites. Given the labor-intensive nature and cost of the fixed land use monitoring coupled with the robust UIC stormwater dataset that the City has collected over the past 10-plus years, the value of the information gained compared to the reduction of UIC monitoring locations is justified. The re-allocation of resources in this manner brings value and diversity to the City's MS4 monitoring program, as determined per our adaptive management strategies.

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 objectives listed above in Section 1.3 and to inform the City's decisions related to stormwater management priorities per our adaptive management strategies. For both of these monitoring elements (stormwater and receiving water), different types of sampling are conducted in an attempt to answer various questions that will address this purpose. More detail regarding these types of monitoring and how they address the City's long-term strategy is as follows:

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[1] The City submitted its QAMP to the Oregon DEQ on June 1, 2011. DEQ conditionally approved the QAMP with comments that triggered additional revisions. The City subsequently submitted a revised QAMP in accordance with Schedule B.2.e of the permit on January 29, 2013.

[2] The permit-required pesticide monitoring was completed in year 2013-14 in accordance with the City's Pesticide Monitoring Plan that was submitted to DEQ on June 28, 2012. The conclusion of the pesticide monitoring was documented in the City's Year 19 (2013-14) Annual Compliance Report. The mercury monitoring was also concluded in year 2013-14 and the City received approval from DEQ to eliminate the mercury monitoring on January 30, 2014.

1.5.1 Stormwater Monitoring

With respect to stormwater discharges, the City's strategy is to conduct two types of monitoring. The first is referred to as *probabilistic* monitoring[3], which includes the collection of stormwater runoff grab samples from City UIC sites with small drainage areas. This probabilistic method has been used by the City to build a robust inventory of stormwater quality data and to further evaluate pollutant sources that could be related to specific drainage area qualities (e.g., traffic, land use, soils).The second type of stormwater monitoring is the collection of flow-weighted stormwater quality samples from historic fixed land use sites. Data from these sites will be used to evaluate whether detectable trends can be observed in stormwater runoff quality over time and as upstream BMPs have been implemented.

Both types of monitoring include the analysis of a comprehensive list of pollutant parameters.

1.5.2 Instream Monitoring

With respect to sampling Portland's receiving waters, the City's strategy is to conduct four types of instream monitoring: continuous monitoring, dry weather ambient monitoring, storm event monitoring, and macroinvertebrate monitoring. Continuous instream monitoring is conducted for select parameters (typically temperature and flow) and is used to evaluate fluctuations in water quality on a diurnal basis and when storm events occur.

The dry weather ambient 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 whether stormwater discharges are contributing to and/or exacerbating water quality issues or trends.

Results from macroinvertebrate sampling may provide further insight into stream quality. As macroinvertebrates are present in the stream year-round, they 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).

Results from the monitoring described in Section 1 will be used to inform and adaptively manage the City's stormwater management program over time.

[3] Also known as generalized random tessellation stratified (GRTS) design using methods developed by Stevens and Olsen (2004)

Table 1.1 Monitoring Objectives Matrix

Monitoring Objective	Environmental Monitoring Elements				
	Instream Monitoring Dry and Wet Season (Section 2.0)	**Instream Monitoring Continuous (Section 3.0)**	**Stormwater Monitoring Probabilistic UIC Sites (Section 4.0)**	**Stormwater Monitoring Historic Land Use Sites (Section 4.0)**	**Macroinvertebrate Monitoring (Section 5.0)**
i. Evaluate the source of the 2004/2006 303(d) listed pollutants applicable to the co-permittees permit area	Analysis of instream samples includes TMDL and some 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 flow and temperature data (and sometimes turbidity) on a continuous basis can be used in comparison with instream water quality data to identify the relationship between these parameters and pollutant concentrations.	Analysis of stormwater samples includes most TMDL and some 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Comparison of stormwater monitoring results with instream results may provide information to evaluate the role that stormwater plays as a potential source.	Analysis of stormwater samples includes TMDL and some 303(d) listed pollutants (some are monitored using surrogates, such as TSS). Comparison of stormwater monitoring results with instream results may provide information to evaluate the role that stormwater plays as a potential source.	Macroinvertebrate sampling, when combined with instream pollutant concentration results, provides information to support the identification of pollutants of concern.
ii. Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities	In combination with results from stormwater monitoring, instream data can be used to evaluate instream trends and the overall effectiveness of stormwater management program/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.	Stormwater monitoring will provide information to support the evaluation of overall BMP effectiveness in reducing pollutants in the monitored catchment.	Stormwater monitoring will provide information to support the evaluation of overall BMP effectiveness in reducing pollutants in the monitored catchment.	Macroinvertebrate monitoring may be used to assess overall program improvements.
iii. Characterize stormwater based on land use type, seasonality, or geography	N/A	N/A	Probabilistic monitoring may potentially answer more specific questions regarding sources of stormwater pollutant concentrations.	Returning to fixed land use stations for monitoring will be used to answer questions related to whether trends have been observed as a result of upstream management measures, and whether trends vary by land use.	Indirectly provides information to support the characterization of MS4 runoff discharges based on seasonality and/or geography.
iv. Evaluate long-term trends in receiving waters associated with MS4 stormwater discharges	Instream data can be used to assess trends. Both dry weather and wet season data will be collected to evaluate ambient trends reflective of stormwater management program implementation.	N/A	Stormwater monitoring will assist in the interpretation of instream trends analyses.	Stormwater monitoring will assist in the interpretation of instream trends analyses.	Macroinvertebrate sampling will provide information to support the evaluation of trends in receiving waters and may be used for trending as an independent measure.
v. Assess the chemical, biological, and physical effects of MS4 stormwater discharges on receiving waters	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 select physical effects of MS4 runoff on receiving waters.	Stormwater monitoring will assist in the interpretation of instream water quality concerns and will be used to evaluate potential impacts.	Stormwater monitoring will assist in the interpretation of instream water quality concerns and will be used to evaluate potential impacts.	Macroinvertebrate monitoring will provide information to assess the biological effects of MS4 runoff on receiving waters.
vi. Assess progress toward meeting TMDL pollutant load reduction benchmarks	Instream monitoring will provide information regarding progress toward meeting TMDL waste load allocations (used to establish pollutant load reduction benchmarks).	N/A	Stormwater monitoring may provide information (i.e., improved land use concentrations) for use in the pollutant loads modeling to assess progress toward meeting pollutant load reduction benchmarks.	Stormwater monitoring may provide information (i.e., improved land use concentrations) for use in the pollutant loads modeling to assess progress toward meeting pollutant load reduction benchmarks.	N/A

NA = not applicable.

SECTION 2

DRY AND WET SEASON INSTREAM MONITORING

This section provides a summary of the instream portion of the monitoring program. This summary includes a description of the project task/organization, background, monitoring objectives, monitoring locations, and connection to the long-term monitoring strategy.

2.1 PROJECT TASK/ORGANIZATION

Instream monitoring refers to the collection of water quality samples from streams that receive MS4 discharges. Samples will be collected at fixed sampling locations to evaluate receiving water quality and ambient trends over time and to evaluate instream quality during storm events. The samples will be collected by City of Portland staff and analyzed by the City of Portland water pollution control laboratory (WPCL) or Test America as described in Section 9.0 of this document. WPCL staff will be responsible for data management, and MS4 staff will perform data assessment and evaluation.

2.2 BACKGROUND

Since the early 1990s, the City has collected samples from a set of fixed instream monitoring locations representing various receiving water bodies throughout the City. In 2010, the City re-evaluated its instream monitoring program based on national watershed monitoring approaches. The City then transitioned to a new method for continued instream monitoring adapted from the U.S. Environmental Protection Agency *National Rivers and Streams Assessment, Field Operations Manual* (US EPA, 2009). The new method is called the generalized random tessellation stratified, or 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 program includes four rotating panels of sampling locations at both perennial and intermittent stream sites.

As the City transitions to this new instream monitoring protocol, the fixed monitoring sites have also been maintained to allow for continued receiving water quality data analysis and evaluation of ongoing trends (as required by the MS4 permit). Results from the fixed sites can also be used for a comparison between the two monitoring approaches.

2.3 MONITORING OBJECTIVES

Instream monitoring will contribute to monitoring objectives i, ii, iv, v, and vi identified in Schedule B.1 of the MS4 permit (see Table 1.1). 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 during both dry and wet weather conditions. Instream monitoring will also assist in evaluating progress toward addressing TMDL objectives including benchmarks.

2.4 MONITORING LOCATIONS

Table 2.1 lists the fixed instream monitoring locations that will be sampled. These sites were selected as representative of a variety of the major watersheds in Portland and various land uses and geographies.

Table 2.1 Fixed Instream Monitoring Locations

Site ID	Location	Stream Name	Watershed
AWB	NE Airport Way Bridge B	Columbia Slough	Columbia Slough
SJB	St. John's Landfill Bridge	Columbia Slough	Columbia Slough
M2	1900 SE Millport Road	Johnson Creek	Johnson Creek
JC-6	SE 158th Ave. Bridge	Johnson Creek	Johnson Creek
FC-8	4916 SW 56th Avenue	Fanno Creek	Fanno Creek
TC-4	10750 SW Boones Ferry Road	Tryon Creek	Tryon Creek
TC-5	SW 26th Way and Barbur Boulevard	Tryon Creek	Tryon Creek
TC-6	9323 SW Lancaster Road	Tryon Creek	Tryon Creek
WR-BM	Morrison Street Bridge – RM 12.7	Willamette River	Willamette River
WR-CM	St. John's Railroad Bridge – RM 6.8	Willamette River	Willamette River
WR-FM	Waverly Country Club – RM 17.9	Willamette River	Willamette River

2.4.1 Monitoring Frequency & Schedule

A minimum of four samples will be collected per year at each location. Two of the four samples will be collected during storm events unless conditions beyond the City's reasonable control are encountered that prevent the collection of the storm event samples.

As per Schedule B.3 of the permit for instream monitoring:

- A minimum of 50 percent of the water quality sampling events must be collected during the wet season (October 1 to April 30).
- Each unique sample event must occur at a minimum of 14 days apart.

2.4.2 Sample Collection Methodology

Grab samples will be collected at the listed 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. Prior to use in the field, beakers will be decontaminated according to the protocol described in Section 7.64 of the WPCF-SAP. For deeper, faster-moving stream segments, samples are collected from bridges using a column sampler in accordance with BES Field Operations Standard Operating Procedure (SOP) 2.02d.

Field duplicate samples will be collected by filling bottles simultaneously, one in each hand of the sampler. Duplicate samples that are required to be collected in the column sampler or decontaminated stainless steel beaker will be filled by alternating between sample bottles for the same analysis until bottles are filled. The required sample containers, sample volume, preservative requirements, and maximum holding times are provided in Table 2.2. 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 in the field at the time of sample collection.

Table 2.2 Instream Sample Laboratory Analytes, Containers, Volumes, Methods, Preservation, and Holding Times

Analyte [1]	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
Total Metals Cu, Pb, Zn	HDPE	500 mL	EPA 200.8	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
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	Plastic	1 pint	EPA 365.4	H_2SO_4 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
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
BOD_5 (if TMDL is established for this parameter)	Plastic	1 quart	SM5210B	Cool to 4°C +/- 2°C	48 hours
Total Organic Carbon	Amber Glass	250 mL	SM5310B	H_2SO_4 to pH<2; cool to 4°C +/- 2°C	28 days
Total Suspended Solids	Plastic	1 quart	SM2540D	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. See Section 7.0.

2.5 CONNECTION TO LONG-TERM MONITORING STRATEGY

Instream water quality monitoring is one of the monitoring elements that the City has employed to inform the MS4 program management, as well as TMDL development and implementation. Instream water quality monitoring provides a direct measure of the chemical condition of streams within the City that receive MS4 stormwater discharges. In addition to other chemical, physical, and biological data collected instream, as described in Sections 3 and 5, instream water quality monitoring allows for calculating trends analyses, correlating physical and chemical measurements to 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 3
CONTINUOUS INSTREAM MONITORING

This section provides a summary of the continuous instream monitoring portion of the program. The summary describes project task/organization, background, monitoring objectives, monitoring locations, special data quality objectives/criteria, and connection to the long-term monitoring strategy.

3.1 PROJECT TASK/ORGANIZATION

Continuous instream monitoring refers to ongoing physical and chemical stream monitoring at fixed locations within streams that receive MS4 runoff. Continuous instream monitoring is typically conducted every 15 or 30 minutes, depending on the constituent measured. It typically consists of stream gauge 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. The U.S. Geological Survey (USGS) operates the monitoring sites at several instream locations in Portland and they provide data management and storage and limited data interpretation. Information from these sites can be found at http://waterdata.usgs.gov/nwis/rt.

3.2 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 gauge height and calculated discharge. Four gauges also provide temperature monitoring (see Table 3.1). These gauge data can be used to compare chemical monitoring results in terms of their potential relationship with flow. These gauges have also provided valuable information for a variety of permit and TMDL-related activities, such as the creation of flow duration curves in Johnson Creek that were instrumental in establishing the bacteria TMDL.

3.3 MONITORING OBJECTIVES

Continuous instream monitoring, as available, will contribute to monitoring objectives i, ii, and v identified in Schedule B.1 of the MS4 permit (see Table 1.1).

3.4 MONITORING LOCATIONS

Table 3.1 lists current USGS gauges that are either located within the City limits or provide information about a stream within the City limits.

Table 3.1 Continuous Instream Monitoring Locations (Current USGS Gauges)

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

3.4.1 Monitoring Frequency and Duration

All parameters at all the gauges in Table 3.1 are logged every 15 minutes, except the Willamette River gauge, which creates a data point every 30 minutes. Table 3.1 shows the period of record; monitoring is expected to continue into the foreseeable future at all of these sites.

3.4.2 Sample Collection Methodology

The USGS measures gauge height and discharge according to methods described in Rantz and others (1982) and measures temperature and turbidity according to methods described in Wagner et al. (2006).

3.5 SPECIAL DATA QUALITY OBJECTIVES AND CRITERIA

The USGS manages all aspects of the installation, maintenance, calibration, reporting, and storage of data from its gauging stations. USGS data are flagged as provisional until they are reviewed and meet USGS data quality standards. Quality assurance procedures for USGS discharge data are described in Rantz (1982) and described in Wagner et al. (2006) for temperature and turbidity data.

3.6 CONNECTION TO LONG-TERM MONITORING STRATEGY

Continuous instream discharge, temperature, and turbidity monitoring provides a direct measure of chemical and physical conditions of streams within the City that receive MS4 discharges. In connection with other chemical, physical, and biological data collected instream (as described in Sections 2 and 5), continuous instream monitoring allows for calculating trends analyses, 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. Therefore, continuous monitoring, as available from USGS, will remain an element of the City's monitoring program.

SECTION 4
STORMWATER MONITORING

This section provides a summary of the stormwater monitoring portion of the program. The summary describes project task/organization, background, monitoring objectives, monitoring locations, and connection to the long-term monitoring strategy.

4.1 PROJECT TASK/ORGANIZATION

Stormwater monitoring refers to the monitoring of stormwater discharges from a defined point in the stormwater system during defined storm events. All stormwater monitoring sites are manholes within the storm collection system or the UIC system. City of Portland staff will collect the samples, and the City WPCL and the City's contract laboratories will analyze the samples, as described in Section 8.0 of this Plan. WPCL staff will be responsible for data collection and management, and MS4 program staff will perform data evaluation and reporting.

4.2 BACKGROUND

The City began collecting stormwater samples from 10 land use-based monitoring locations in 1991 to meet NPDES permit requirements to characterize stormwater runoff. Monitoring at these 10 land use stations continued through 1997.

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, the 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 water quality conditions from different land uses" (DEQ, June 24, 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 best management practice (BMP) effectiveness and instream surface water monitoring. Subsequently in 1997, only three of the ten land use locations were carried forward in the City's monitoring program until January 2011, when the City's MS4 permit was renewed for the third permit term.

Since 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, the City shifted its stormwater monitoring strategy away from land use sites to the City 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 is that is has been sampled since 2005 and a large stormwater pollutant concentration data set is already available that enables robust statistical analyses. Throughout the 2011 - 2016 MS4 permit term, three different panels of 15 UIC sampling sites were monitored each year for a total of 45 data points per year.

Under this revised Plan, the City has elected to revisit four of the original land use sites with historic data in order to assess whether there have been significant changes or detectable trends in the quality of stormwater runoff. Given a shift of resources to evaluate trends in stormwater pollutant concentrations from historic fixed land use sites, the probabilistic UIC monitoring level has been adjusted to include monitoring of 15 UIC sites per year.

4.3 MONITORING OBJECTIVES

Stormwater monitoring will contribute to monitoring objectives i, ii, iii, iv, v, and vi identified in Schedule B.1 of the MS4 permit (see Table 1.1). More specifically, the City has been interested in gaining a better understanding of the drivers of stormwater pollutant concentrations; this has proven very difficult to date because of the large size of the stormwater catchments sampled. Selecting smaller catchments limits the number of variables that must be considered when trying to determine the factors that influence stormwater quality. Therefore, probabilistic UIC monitoring was initiated during the permit term (January 2011 – January 2016) and will continue under this revised Plan at a modified level. In addition, and as noted above, the resurrection of several land use sites will allow the City to further evaluate runoff trends in targeted MS4 areas that have seen an increased implementation of BMPs since monitoring originally began in 1991.

4.4 PROBABILISTIC UIC MONITORING

The City implements a program to monitor stormwater entering the City's UIC system to comply with both UIC and MS4 permit requirements. A description of this probabilistic stormwater monitoring is provided below and described further in the WPCF-SAP.

4.4.1 Description of Sample Design

With respect to selected monitoring sites from the UIC system (approximately 9,600 UICs), the Stevens and Olsen (2004) generalized random-tessellation stratified (GRTS) design was selected. The method has been used by the U.S. Environmental Protection Agency and state agencies to successfully monitor water quality, physical habitat, and aquatic life for several years. The design has a rigorous statistical foundation, yet is able to adapt to the challenges and complexities of collecting data in the natural environment.

GRTS survey design is specifically designed to efficiently characterize a large system with many potential sampling locations. It randomly selects sampling locations in a manner that produces a spatially balanced sample. The GRTS method is designed for large-scale environmental sampling programs such as those required under the MS4 permit. The GRTS method can also accommodate long-term monitoring programs whose objectives may change over time. With a spatially balanced sample, important subpopulations can be identified throughout the course of the monitoring, and greater sampling efforts can be focused on these subpopulations if supported by a change in the program objectives. In this way, the sampling program can be adaptively managed as it progresses, without losing any statistical power to analyze the collected data.

4.4.2 Target Population

Close to 20,000 potential stormwater sampling locations (every accessible manhole) are within the City's stormwater network. Smaller catchments or drainage basins are targeted to better understand the drivers of stormwater pollutant concentrations. MS4 drainage basins are generally large, ranging from 0.01 acres to 750 acres with an average 9.7 acres, whereas UIC catchments are smaller, ranging in size from 0.1 acres to 75 acres with an average 2.1 acres. Because UIC catchments are monitored for the UIC program and because of the smaller average size of the UIC catchments, these catchments were selected for MS4 probabilistic stormwater monitoring.

4.4.3 Monitoring Locations

The City applies the GRTS survey design for selection of the subset of City UICs located in shallow groundwater to be monitored for permit compliance. Selecting UICs from only the subset located in shallow groundwater is being done to meet a monitoring objective of the City's WPCF permit to target "higher risk" sites. There are approximately 120 UICs located in areas of shallow groundwater, from which different panels of 15 UICs are selected for monitoring each year.[1]

Sampling locations (i.e., UIC identification) for each panel are finalized during the summer months before the monitoring season in which they will be sampled. UIC locations are not duplicated among panels and each UIC is investigated and field verified before the sampling panel is finalized.[2]

Table 4.1 provides a list of all GRTS-selected shallow groundwater UIC locations from which the sampling panels will be selected each year. The WPCF-SAP has additional details on the sampling design and it also includes figures showing these UIC locations.

[1] The first 75 UICs on the list of 120 that are suitable for sampling are used as the sample during the WPCF permit term, with sequential blocks of 15 UICs making up each of the panels. For the purpose of choosing the UIC sampling panels, the entire population of UICs located in shallow groundwater areas was placed into random order as described in the WPCF-SAP.

[2] Before sampling, desktop reconnaissance and field research are performed for each UIC sample location to determine if the UIC is suitable for sampling based on factors such as: unsafe sampling conditions, lack of accessibility, inactive status, etc. If a UIC is deemed unsuitable for sampling, a replacement UIC is selected and documented.

Table 4.1 Probabilistic UIC Monitoring Locations

Site ID	Approximate Address	Estimated Trips per Day (TPD)	Traffic Category (TPD)	DEQ UIC ID	BES UIC ID	Latitude	Longitude	UIC Depth (feet)	Pretreatment System	Separation Distance(ft)	Notes
SG-001	2542 SE 18TH AVE	2315	< 1000	10102-9640	APR303	45.50400000	-122.64800000	23'	No Sed MH	2	Sampled 15/16
SG-002	12140 SE RAMONA ST	11195	> 1000	10102-5319	ADT716	45.48055267	-122.53763580	28'	Sed MH	-11	Sampled 15/16
SG-003	5980 SE 102ND AVE	688	< 1000	10102-5429	ADV146	45.47930145	-122.55857086	22'	Sed MH	3	
SG-004	5031 SE 128TH AVE	1544	< 1000	10102-5921	ADU738	45.48538970	-122.53224182	30'	Sed MH	-11	Sampled 15/16
SG-005	12524 SE SCHILLER ST	416	< 1000	10102-5925	ADU744	45.48737716	-122.53431701	16'	Sed MH	2	Sampled 15/16
SG-006	5710 SE 115TH AVE	521	< 1000	10102-5267	ADV193	45.48116302	-122.54491424	24'	Sed MH	-1	Unsuitable for sampling
SG-007	8312 SE 75TH PL	501	< 1000	10102-120	ADV951	45.46345520	-122.58612823	30'	Sed MH	2	Sampled 15/16
SG-008	4332 SE 130TH AVE	1606	> 1000	10102-822	ADT455	45.49054336	-122.53001403	20'	Sed MH	1	Sampled 15/16
SG-009	5000 SE 122ND AVE	12138	> 1000	10102-5896	ADW266	45.48593139	-122.53773498	20'	No Sed MH	0	Unsuitable for sampling
SG-010	10298 SE ELLIS ST	1051	< 1000	10102-5463	ADV187	45.48181533	-122.55730438	23.5'	Sed MH	0	Sampled 15/16
SG-011	11540 SE FOSTER RD	25775	> 1000	10102-5280	ADW312	45.47639083	-122.54454803	18'	No Sed MH	-6	Sampled 15/16
SG-012	13250 SE HOLGATE BLVD	4710	> 1000	10102-711	ANA590	45.48958969	-122.52693939	Unknown	Sed MH	-1	Sampled 15/16
SG-013	12122 SE HAROLD ST	11646	> 1000	10102-5904	ADW275	45.48316955	-122.53810882	22'	No Sed MH	1	Unsuitable for sampling
SG-014	10357 SE ELLIS ST	279	< 1000	10102-5460	ACP889	45.48178482	-122.55604553	19'	Sed MH	2	
SG-015	6245 NE 80TH AVE	2900	> 1000	10102-870	ANB185	45.56816482	-122.58040618	Unknown	No Sed MH	-11	Sampled 15/16
SG-016	13236 SE CORA ST	419	< 1000	10102-6324	ADT463	45.49154663	-122.52667236	23.3'	Sed MH	-1	Sampled 15/16
SG-017	5403 SE 122ND AVE	11646	> 1000	10102-5900	ADW271	45.48409271	-122.53801727	21'	No Sed MH	-4	Sampled 15/16
SG-018	5803 SE 122ND AVE	11133	> 1000	10102-5288	ADT682	45.48019409	-122.53735351	27'	Sed MH	-11	
SG-019	5905 SE 102ND AVE	553	< 1000	10102-165	ADV144	45.47944641	-122.55856323	20.6'	Sed MH	4	Sampled 15/16
SG-020	13030 SE MITCHELL ST	178	< 1000	10102-5934	ADU753	45.48421096	-122.52912139	30'	Sed MH	2	Sampled 15/16
SG-021	4754 SE 122ND AVE	12363	> 1000	10102-5888	ADW257	45.48746490	-122.53768920	22'	Bioswale	1	Sampled 15/16
SG-022	11246 SE HAROLD ST	3295	> 1000	10102-263	AMY402	45.48283767	-122.54711151	Unknown	No Sed MH	-8	
SG-024	12830 SE HOLGATE BLVD	5035	> 1000	10102-6315	ADT454	45.48972702	-122.53241730	20.6	Sed MH	0	
SG-025	12010 SE REEDWAY ST	205	< 1000	10102-5269	ADV196	45.48127365	-122.53939056	28'	Sed MH	-13	
SG-026	5712 SE 103RD AVE	1109	> 1000	10102-117	AMT874	45.48089981	-122.55725097	21.2'	Bioswale, Sed MH	0	
SG-027	11501 SE FOSTER RD	25775	> 1000	10102-5272	ADW303	45.47650909	-122.54454040	19'	No Sed MH	-9	
SG-028	13515 SE HOLGATE BLVD	4568	> 1000	10102-1908	AMR622	45.48900985	-122.52449035	21'	Sed MH	2	
SG-029	5500 SE 121ST AVE	4885	> 1000	10102-5914	ADU735	45.48327636	-122.53894805	30'	Sed MH	-9	
SG-030	10402 SE ELLIS ST	279	< 1000	10102-169	ADV190	45.48177337	-122.55564880	21'	Bioswale, Sed MH	-1	
SG-031	8111 NE HOLMAN ST	0	< 1000	10102-3106	ADV384	45.56826782	-122.57869720	14'	No Sed MH	-10	
SG-032	13658 SE CORA ST	413	< 1000	10102-6334	ADT474	45.49146270	-122.52229309	19.7'	Sed MH	1	
SG-033	5423 SE 121ST AVE	806	< 1000	10102-5912	ADU734	45.48351287	-122.53894042	30'	Sed MH	-8	
SG-034	12319 SE RAMONA ST	1089	> 1000	10102-5300	ADT696	45.48014068	-122.53573608	20.2'	Sed MH	0	
SG-036	5544 SE 128TH AVE	1298	> 1000	10102-5294	ADT689	45.48270797	-122.53215789	30'	Sed MH	-8	
SG-037	4918 SE 122ND AVE	12138	> 1000	10102-5892	ACK357	45.48641204	-122.53774261	20'	Sed MH	1	
SG-038	11134 SE STEELE ST	173	< 1000	10102-5910	ADU731	45.48452758	-122.54837036	30.1'	Sed MH	-2	
SG-039	5918 SE 122ND AVE	10908	> 1000	10102-5286	ADV203	45.47868728	-122.53705596	30'	No Sed MH	-1	
SG-040	12920 SE HOLGATE BLVD	4814	> 1000	10102-6314	ADT453	45.48973464	-122.53133392	19.6'	Sed MH	0	
SG-041	5601 SE 122ND AVE	11400	> 1000	10102-5281	ADW313	45.48228073	-122.53800201	24'	Sed MH	0	
SG-042	5635 SE 102ND AVE	440	< 1000	10102-164	ADV130	45.48136520	-122.55846405	22'	Sed MH	2	
SG-043	11020 NE MARX ST	1714	> 1000	10102-791	ANB108	45.56054306	-122.54932403	16'	No Sed MH	2	

Table 4.1 Probabilistic UIC Monitoring Locations

Site ID	Approximate Address	Estimated Trips per Day (TPD)	Traffic Category (TPD)	DEQ UIC ID	BES UIC ID	Latitude	Longitude	UIC Depth (feet)	Pretreatment System	Separation Distance(ft)	Notes
SG-044	4406 SE 135TH AVE	186	< 1000	10102-925	AMX686	45.49053573	-122.52488708	25.4'	Sed MH	-9	
SG-045	12532 SE ELLIS ST	236	< 1000	10102-5293	ADT688	45.48248672	-122.53414154	30'	No Sed MH	-8	
SG-046	5736 SE 102ND AVE	426	< 1000	10102-5422	ADV135	45.48060989	-122.55849456	20.7'	Bioswale, Sed MH	3	
SG-047	4022 NE 142ND AVE	426	< 1000	10102-9474	AAV769	45.55256271	-122.51643371	Unknown	Sed MH	-1	
SG-048	4241 SE 136TH AVE	10104	> 1000	10102-6335	ADT475	45.49134826	-122.52353668	27'	Sed MH	-8	
SG-049	5211 SE 122ND AVE	11953	> 1000	10102-574	ADW269	45.48487472	-122.53798675	22'	No Sed MH	1	
SG-050	4736 SE 115TH AVE	821	< 1000	10102-6110	AMR771	45.48759078	-122.54449462	31'	Sed MH	3	
SG-051	9956 SE HAROLD ST	3892	> 1000	10102-855	ANA841	45.48259353	-122.56085968	30'	No Sed MH	4	
SG-052	13033 SE HOLGATE BLVD	4710	> 1000	10102-714	ANA596	45.48972320	-122.52897644	Unknown	Sed MH	-16	
SG-053	4919 SE 122ND AVE	12138	> 1000	10102-5891	ADW261	45.48643875	-122.53794097	21'	No Sed MH	0	
SG-054	5440 SE 111TH AVE	1848	> 1000	10102-5765	ADW230	45.48312759	-122.54922485	19'	No Sed MH	3	
SG-055	11741 SE FOSTER RD	25775	> 1000	10102-5273	ADW304	45.47650909	-122.54300689	19'	No Sed MH	2	
SG-056	13250 SE HOLGATE BLVD	4710	> 1000	10102-713	ANA592	45.48958969	-122.52688598	Unknown	No Sed MH	-1	
SG-057	5500 SE 122ND AVE	11646	> 1000	10102-5903	ADW274	45.48321151	-122.53783416	20.2'	No Sed MH	1	
SG-058	10304 SE ELLIS ST	1051	> 1000	10102-5458	ACP887	45.48181152	-122.55709075	20.5'	Sed MH	2	
SG-059	4656 NE 118TH AVE	436	< 1000	10102-3576	ADQ418	45.55727005	-122.54135131	30.1'	No Sed MH	3	
SG-060	4144 SE 132ND AVE	0	< 1000	10102-6287	ADT426	45.49193954	-122.52745056	30'	Sed MH	-2	
SG-061	12246 SE ELLIS ST	224	< 1000	10102-5292	ADT687	45.48254776	-122.53687286	25'	Sed MH	-4	
SG-062	6034 SE 102ND AVE	894	< 1000	10102-5435	ADV154	45.47859573	-122.55861663	26.1'	Sed MH	0	
SG-063	13820 SE GLADSTONE ST	430	< 1000	10102-6333	ADT473	45.49227905	-122.52095794	20.9'	Sed MH	4	
SG-064	1839 NE MARINE DR	11064	> 1000	10102-1042	ANA900	45.60036468	-122.64641571	10.2'	Sed MH	2	
SG-065	4745 SE 122ND AVE	12363	> 1000	10102-5887	ADW256	45.48761749	-122.53787994	20'	Sed MH	3	
SG-066	8318 SE 78TH AVE	86	< 1000	10102-4830	ADV950	45.46357727	-122.58353424	27.5'	No Sed MH	-13	
SG-067	10246 SE ELLIS ST	1051	> 1000	10102-5462	ACP891	45.48181915	-122.55750274	20.4'	No Sed MH	3	
SG-068	13250 SE HOLGATE BLVD	4710	> 1000	10102-712	ANA591	45.48958969	-122.52690887	Unknown	Sed MH	-1	
SG-069	12210 SE ELLIS ST	11461	> 1000	10102-5291	ADT686	45.48255157	-122.53763580	17'	Sed MH	4	
SG-070	6135 NE 80TH AVE	2900	> 1000	10102-869	ANB182	45.56728363	-122.58050537	17'	Sed MH	-16	
SG-071	5404 SE 122ND AVE	11646	> 1000	10102-5901	ADW272	45.48406600	-122.53781890	17.9'	Sed MH	1	
SG-072	4490 SE 125TH AVE	5249	> 1000	10102-6312	ADT451	45.48973846	-122.53472900	20'	No Sed MH	3	
SG-073	4857 SE 122ND AVE	12261	> 1000	10102-5889	ADW258	45.48686599	-122.53791046	21'	No Sed MH	1	
SG-074	8100 SE CRYSTAL SPRINGS BLVD	895	< 1000	10102-5347	AMR553	45.46509552	-122.58024597	30'	Sed MH	-13	
SG-075	5610 SE 102ND AVE	490	< 1000	10102-5412	ADV127	45.48170852	-122.55844116	21'	No Sed MH	4	
SG-076	13515 SE HOLGATE BLVD	4568	> 1000	10102-352	AMY600	45.48942947	-122.52488708	21'	Sed MH	-2	
SG-077	12500 SE HAROLD ST	1477	> 1000	10102-232	AMS283	45.48330688	-122.53488159	25'	Sed MH	-5	
SG-078	6457 NE 66TH AVE	439	< 1000	10102-9478	ANW740	45.57010269	-122.59515380	18'	Sed MH	4	
SG-079	12204 SE STEELE ST	11953	> 1000	10102-5931	ADU751	45.48472213	-122.53757476	20.4'	Sed MH	0	
SG-080	5608 SE 99TH AVE	557	< 1000	10102-5407	ACP660	45.48171615	-122.56162261	30'	No Sed MH	4	
SG-081	11080 SE HAROLD ST	3791	> 1000	10102-5468	ADV191	45.48280334	-122.54930877	22.9'	Sed MH	-3	
SG-082	4406 SE 136TH AVE	9961	> 1000	10102-558	AMX688	45.49026870	-122.52355194	22.75'	Sed MH	-4	
SG-083	10310 SE ELLIS ST	1051	> 1000	10102-5464	ADV188	45.48180389	-122.55689239	22'	Sed MH	0	
SG-084	4100 SE 133RD AVE	389	< 1000	10102-6326	ADT466	45.49257659	-122.52648925	30'	Sed MH	-1	

Table 4.1 Probabilistic UIC Monitoring Locations

Site ID	Approximate Address	Estimated Trips per Day (TPD)	Traffic Category (TPD)	DEQ UIC ID	BES UIC ID	Latitude	Longitude	UIC Depth (feet)	Pretreatment System	Separation Distance(ft)	Notes
SG-085	12506 SE REEDWAY ST	187	< 1000	10102-5296	ADT691	45.48175430	-122.53427124	25'	No Sed MH	-4	
SG-086	3734 NE 154TH AVE	0	< 1000	10102-4041	ADR048	45.55039215	-122.50386047	30.2'	Sed MH	3	
SG-087	5021 SE 122ND AVE	11953	> 1000	10102-5897	ADW267	45.48545837	-122.53794860	20'	Sed MH	1	
SG-088	3039 SE TOLMAN ST	1503	> 1000	10102-5590	ADW286	45.47599411	-122.63162994	30.2'	Sed MH	-2	
SG-089	5436 SE 109TH AVE	461	< 1000	10102-5764	ADW229	45.48305511	-122.55123901	20.5'	No Sed MH	2	
SG-090	13250 SE HOLGATE BLVD	4710	> 1000	10102-710	ANA589	45.48958969	-122.52696228	Unknown	No Sed MH	0	
SG-091	5436 SE 122ND AVE	11646	> 1000	10102-5902	ADW273	45.48338317	-122.53783416	17.5'	No Sed MH	4	
SG-092	6015 NE 80TH AVE	6658	> 1000	10102-868	ANB179	45.56639480	-122.58049774	19.5'	Sed MH	-7	
SG-093	5825 SE 122ND AVE	11031	> 1000	10102-267	ADV204	45.47970199	-122.53723907	25'	No Sed MH	-6	
SG-094	12908 SE MITCHELL ST	178	< 1000	10102-5938	ADU758	45.48411178	-122.53086853	21'	No Sed MH	3	
SG-095	5732 SE 122ND AVE	11195	> 1000	10102-5311	ADW321	45.48059082	-122.53733062	20'	Sed MH	-3	
SG-096	12780 SE SCHILLER ST	1778	> 1000	10102-5924	ADU743	45.48738098	-122.53247070	15.4'	Sed MH	1	
SG-097	11305 SE HAROLD ST	3295	> 1000	10102-1036	ANA889	45.48294830	-122.54711151	Unknown	No Sed MH	-8	
SG-098	4425 SE 130TH AVE	4814	> 1000	10102-715	ANA598	45.48972702	-122.53005981	15.6'	Sed MH	-2	
SG-099	5605 SE 120TH AVE	192	< 1000	10102-5270	ADV197	45.48211669	-122.54003906	26'	No Sed MH	-5	
SG-100	11540 SE FOSTER RD	25775	> 1000	10102-5280	APV741	45.47600000	-122.54500000	18'	No Sed MH	-1	
SG-101	10398 SE ELLIS ST	279	< 1000	10102-5466	ADV189	45.48178100	-122.55584716	20'	Sed MH	0	
SG-102	13722 SE CORA ST	413	< 1000	10102-6332	ADT472	45.49144363	-122.52182769	19'	Bioswale, Sed MH	1	
SG-103	12230 SE RAMONA ST	11133	> 1000	10102-5289	ADT683	45.48014068	-122.53694915	19.5'	Sed MH	-3	
SG-104	13000 SE HAROLD ST	1341	> 1000	10102-5936	ADU755	45.48346710	-122.52983856	29'	Sed MH	-3	
SG-105	12221 SE REEDWAY ST	11400	> 1000	10102-5295	ADT690	45.48181915	-122.53762054	27'	Sed MH	-7	
SG-106	10900 NE MARX ST	1714	> 1000	10102-1316	ADV974	45.56085205	-122.55072784	16.3'	Sed MH	-2	
SG-107	5500 SE 104TH AVE	4096	> 1000	10102-5768	ADW233	45.48270797	-122.55564117	Unknown	No Sed MH	0	
SG-108	13612 SE CORA ST	10104	> 1000	10102-6331	ADT471	45.49146652	-122.52326202	21'	No Sed MH	-1	
SG-109	5906 SE 122ND AVE	11031	> 1000	10102-5287	ADV205	45.47969436	-122.53704833	28'	Sed MH	-7	
SG-110	13110 SE GLADSTONE CT	0	< 1000	10102-6289	ADT428	45.49228286	-122.52851867	30'	Sed MH	1	
SG-111	4908 SE 122ND AVE	12138	> 1000	10102-5915	ADU725	45.48645782	-122.53776550	19'	Sed MH	2	
SG-112	11716 SE FOSTER RD	25775	> 1000	10102-5279	ACQ013	45.47637176	-122.54296875	20'	No Sed MH	4	
SG-113	6036 SE 102ND AVE	894	< 1000	10102-5436	ACP693	45.47846221	-122.55862426	22'	No Sed MH	4	
SG-114	1801 NE MARINE DR	11064	> 1000	10102-1041	ANA899	45.60034179	-122.64723968	10'	Sed MH	1	
SG-115	5450 SE 114TH PL	3642	> 1000	10102-5894	ADW264	45.48316574	-122.54518127	Unknown	No Sed MH	-5	
SG-116	13008 SE HOLGATE BLVD	4710	> 1000	10102-709	ANA587	45.48961257	-122.52936553	Unknown	No Sed MH	-3	
SG-117	12150 SE RAYMOND ST	12138	> 1000	10102-5895	ADW265	45.48594665	-122.53807830	16.5'	No Sed MH	4	
SG-118	11540 SE FOSTER RD	25775	> 1000	10102-9680	APV742	45.47600000	-122.54500000	13'	No Sed MH	-1	
SG-119	10324 SE ELLIS ST	142	< 1000	10102-5465	ACP892	45.48179626	-122.55660247	21'	Sed MH	0	
SG-120	13326 SE CORA ST	418	< 1000	10102-6325	ADT464	45.49151229	-122.52593231	25'	Sed MH	-4	
SG-121	5988 SE 102ND AVE	688	< 1000	10102-5431	ACP682	45.47921752	-122.55857849	21.8'	Bioswale, Sed MH	3	
SG-122	1445 NE MARINE DR	11064	> 1000	10102-1919	AAC311	45.60037994	-122.65004730	14.9'	No Sed MH	-4	

4.4.4 Monitoring Frequency and Duration

The City will collect one stormwater sample from each of 15 designated sampling locations between July 1 and June 30 of each permit 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 (Permit Schedule B.2.e).

The City will begin targeting storm events for sampling each fall. The remaining sites will be sampled as appropriate storm events are identified throughout the rest of the monitoring season, as storm events allow.

During each permit year, the City will attempt to sample all 15 selected locations during the same storm event. Since storms often fall short of predicted rainfall amounts and/or durations, there is a possibility that rainfall or runoff may cease prior to the collection of all 15 samples during an event. If all locations cannot be sampled during a targeted storm, the remaining locations will be sampled during subsequent storms that meet the criteria required by the permit and referenced in Section 4.6 of this document.

4.4.5 Sample Collection Methodology

The City chose a probabilistic approach to stormwater monitoring, which includes a large number of monitoring locations and annually rotating panels. This approach is only feasible if grab samples are collected because the collection of flow-composite samples is too resource-intensive for such an approach. It is infeasible and cost prohibitive to install flow meters and sampling equipment at 15 different locations every year, as well as to adjust the flow triggers based on weather forecasts that are critical for proper collection of flow-composite samples.

Grab samples will be collected using decontaminated stainless steel beakers connected to telescoping poles by swing samplers. 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.

The beaker will be placed into the flow of stormwater and brought to the surface grade to fill sample containers. To the extent practicable, the beaker will be filled and emptied slowly and carefully to avoid degassing the sample. Samples will be placed in pre-cleaned bottles provided by the analytical laboratory and analyzed for the parameters specified in Table 4.2 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 in the field at the time of sample collection.

4.4.6 Sampling Considerations

Storms may occur at any time; however, the City will primarily target storms during regular business hours to limit overtime hours that would be required of laboratory staff to meet stringent sample holding time requirements.

As described earlier in Section 4, the City will collect stormwater samples one time from 15 designated 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; see Section 6).

The City will begin tracking and targeting storm events each fall that meet the storm criteria presented in Section 4.6. It may take more than one storm to collect samples from all 15 sampling locations. Whichever locations are not sampled during the first storm will be targeted for sampling during subsequent storm events that meet the storm criteria described in Section 4.6.

4.5 FIXED LAND USE MONITORING

This section provides information on the sampling locations and methodologies at fixed land use sites.

4.5.1 Description of Sample Design

In order to evaluate trends at the fixed land use sites, methods for collecting samples will come as close as possible to methods used in collecting the previous historic data. This includes the collection of flow-weighted samples during rain events, aiming for the collection of samples from approximately three storms per year at each of the four land use sites. This will produce a total of 12 data points per year.

4.5.2 Target Population

For this permit term, the City has decided to revisit 4 of the original 10 land use sites in the storm system where significant data have been collected in the past. The purpose of revisiting these sites will be to see whether statistically significant changes have occurred in stormwater pollutant concentrations over time given the implementation of stormwater management BMPs. Sampling will be conducted at each of these four sites each year of the permit term.

4.5.3 Monitoring Locations

A summary of the four fixed land use sites that will be revisited in order to collect data to evaluate trends is provided in Table 4.1.

Table 4.2 Fixed Land Use Stormwater Monitoring Locations

Site Name	Watershed	Predominant land use	Location	BES ID	Dates of previous data collection
OF19	Willamette River	Forest Park and Industrial	NW Front and Kittridge Avenues	AAP918 (OF 19)	2000–2011*
M1	Columbia Slough	Mixed	NE 122nd Avenue at the Columbia Slough	AAS510 (OF 100)	1991-2011
R1	Fanno Creek	Residential	Fanno Creek at SW 56th Street (instream)	X: 45.488333 Y:-122.734444	1991-2001
R2	Columbia Slough	Residential	NE 141st Avenue and Sandy Boulevard	AAV759 (OF AAS905)	1991-1996

* Sampling of this site began in 1995. However, data collection methods were inconsistent and not considered comparable prior to 2000.

4.5.4 Monitoring Frequency and Duration

For each of the four fixed land use sites, the City will attempt to collect samples during three storm events per year meeting the criteria required by the permit and referenced in Section 4.6 of this document. This will produce a total of 12 sampled events per year at the land use stations.

4.5.5 Sample Collection Methodology

To be consistent with historic sampling methods, two station designs will be employed in the field depending on whether the site is an instream or manhole location. Automatic sampling and stage recording equipment will be deployed at each site with each station consisting of the following equipment:

- Ultrasonic level sensor and/or Doppler velocity sensor to measure depth of flow and peak velocity in order to estimate flow rate.
- An automatic water quality sampler for collecting a flow-weighted composite sample. Sampling is actuated by flow as calculated by the system microprocessor based on previously collected flow data. The automatic samplers are used to store the stormwater in glass bottles during monitored events.
- A telemetry or remote sensing system to allow the station to be accessed with a personal computer remotely or via telephone lines.

The instrumentation of the instream station (R1) is contained in an enclosure mounted on a concrete pad. Manhole stations are completely contained within the existing manhole chambers, such that all equipment is suspended just under the manhole cover.

Automated samplers are programmed to deliver samples throughout the event based on a predicted rainfall volume and hence runoff volume. The intent is to obtain a good representation of the predicted storm with a collection of flow-weighted samples that are composited together in the lab. Each composite is typically composed of at least 10 to 15 aliquots of approximately 0.3 to 0.4 liters of sample volume.

4.5.6 Sampling Considerations

For the fixed land use sites, an attempt will be made to collect flow-weighted composite samples during the same three storm events for each of the four sites. The storm events will be targeted to meet the storm criteria presented in Section 4.6.

4.6 STORM EVENT TARGETING

This section provides information on sampling considerations, storm criteria, and weather forecasting, all related to the stormwater sampling described in this section.

4.6.1 Storm Criteria

Adhering to target storm criteria to the extent practicable 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 a storm should be targeted for potential compliance 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 storms, or storms of shorter duration, are considered to have a low probability of producing sufficient runoff to warrant the extensive preparation and mobilization time required for this project.

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

- predicted rainfall amount of $\geq$ 0.1 inch per storm
- predicted rainfall duration $\geq$ 6 hours
- a goal for the antecedent dry period is 24 hours

Storms meeting these criteria that were not predicted or were expected to have less rainfall intensity or duration are not included as potential compliance sampling events.

Hourly and daily rainfall records are available for more than 20 sites on the east side of Portland. These data are maintained in the BES's HYDRA Data Report System and are available at:

http://or.water.usgs.gov/non-usgs/bes/raingage_info/clickmap.html

Storm characteristics for each storm during which samples are collected may be documented and summarized in the City's annual UIC Stormwater Discharge 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.

4.6.2 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 consultant weather forecasts to determine if a predicted storm is likely to meet the criteria for initiating compliance 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 and ultimately making the "go/no go" decision.

Extended Range Forecasting Company, Inc., (ERF) a private Portland weather forecasting service, is the City's weather consultant. The Storm Monitoring Coordinator receives daily weather forecasts from ERF that have a 10-day forecast including quantity of precipitation forecasts for each day. ERF is available on an as-needed, on-call basis for telephone consultations regarding pending storms. When a candidate storm approaches, the Storm Monitoring Coordinator will communicate frequently with ERF to determine whether to mobilize sampling teams to begin sampling operations.

Other forecasting resources used include online resources such as National Weather Service predictions, Doppler radar, and smartphone weather applications. Refer to SOP D-1, provided in Appendix B of the WPCF-SAP, for more weather tracking information.

4.7 PARAMETERS & ANALYTICAL METHODS

Samples from both the probabilistic UIC and fixed land use stormwater monitoring locations will be analyzed for the list of parameters specified in Table 4.3.

Table 4.3 Stormwater Sample Laboratory Analytes, Containers, Volumes, Methods Preservation, and Holding Times

Analyte [1]	Container Type	Sample Volume	Method	Preservation Requirements	Holding Time
Total Metals Cu, Pb, Zn	HDPE	500 mL	200.8	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
Dissolved Metals Cu, Pb, Zn	HDPE	500 mL	200.8	HNO_3 to pH<2; cool to 4°C +/- 2°C	6 months
Ammonia-Nitrogen	Plastic	1 pint	350.1	H_2SO_4 to pH<2; cool to 4°C +/- 2°C	28 days
Nitrate-Nitrogen	Plastic	½ pint	300.0	Cool to 4°C +/- 2°C	48 hours
Total Phosphorus	Plastic	1 pint	365.4	H_2SO_4 to pH<2; cool to 4°C +/- 2°C	28 days
Ortho-Phosphorus	Plastic	½ pint	365.1	Cool to 4°C +/- 2°C	48 hours
E. coli [2]	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 Organic Carbon	Amber Glass	250 mL	SM5310B	H_2SO_4 to pH<2; cool to 4°C +/- 2°C	28 days
Total Suspended Solids	Plastic	1 quart	SM2540D	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. See Section 7.0.

[2] E. coli will only be analyzed in samples collected from the four fixed land use monitoring sites for stormwater monitoring described herein

4.8 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. While the early focus was on characterizing stormwater from various land uses, the focus of the probabilistic monitoring approach is on evaluating other factors that drive stormwater pollutant concentrations. With that, the probabilistic monitoring approach differs from previous land use monitoring as it includes reduced catchment sizes by about two orders of magnitude, and the number of locations and frequency of sampling was increased in order to increase the number of samples collected per year by a factor of almost five. Analysis of this collected data will help to determine how stormwater monitoring will be adaptively managed in future permit terms. In addition, monitoring four of the historic fixed land use monitoring sites should help to indicate whether detectable trends can be observed. Results will be reviewed to identify whether or not improvements have occurred and for which parameters. This will help the City adaptively manage stormwater programs in future permit terms.

SECTION 5
MACROINVERTEBRATE MONITORING

This section provides a summary of the macroinvertebrate monitoring portion of the program. The summary describes project task/organization; background; monitoring objectives; study design and monitoring process; special data quality objectives and criteria; quality control; and connection to the long-term monitoring strategy.

5.1 PROJECT TASK/ORGANIZATION

Macroinvertebrate monitoring refers to the annual instream monitoring of benthic macroinvertebrates in late summer. During the 2011 permit term, samples were collected from the same rotating sampling locations where dry and wet-season instream monitoring occurred (i.e., at the probabilistic instream monitoring locations). Macroinvertebrate monitoring will continue to be conducted at the majority of those sites under this Plan. City WPCL staff will collect the samples, which will be analyzed by a contract taxonomist.

5.2 BACKGROUND

Macroinvertebrate information is useful for evaluating water quality and habitat condition because macroinvertebrates are present in diverse habitat types, represent local conditions due to their limited dispersal ability, they are an important food source for fish and other wildlife and they 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.

5.3 MONITORING OBJECTIVES

Macroinvertebrate monitoring will contribute to monitoring objectives ii, iv, v, and vi identified in Schedule B.1 of the City's MS4 Permit (see Table 1.1). 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 instream monitoring of the fiscal year so biological information is collected at the same time summer water quality samples are collected.

5.4 STUDY DESIGN AND MONITORING PROCESS

Special monitoring and sample collection and preservation procedures will be followed, as described below. These procedures follow *National Rivers and Stream Assessment: Field Operations Manuals*.

https://www.nemi.gov/methods/method_summary/12564/

https://www.nemi.gov/methods/method_summary/12563/

5.4.1 Monitoring Locations

Macroinvertebrate samples will be collected at a minimum of 14 sites per year where instream water quality samples are collected as part of the instream monitoring protocols described in Section 2.2 [1].

Table 5.1 on the following page lists the macroinvertebrate sampling locations.

[1] Historically, the City has collected macroinvertebrate samples at all 20 perennial instream monitoring sites across the local watersheds. However, the City is currently evaluating alternatives to macroinvertebrate monitoring specifically in the Columbia Slough. Most metrics used to evaluate the health of aquatic insect communities are developed for pool-riffle stream systems and are not as effective in addressing low gradient systems like the Columbia Slough. As a result, macroinvertebrate monitoring in the Slough is being discontinued and a more viable biological index may be substituted.

Table 5.1 Macroinvertebrate Instream Monitoring Locations & Panels

Panel	Site ID	Site Location	Watershed
Panel 1	0012	Stephens Creek Tributary - SW Brier & Custer	Willamette River
	0016	Kelley Creek - 17601 SE Foster Rd	Johnson Creek
	0017	Peninsula Drainage Canal - 9111 SE Sunderland Ave	Columbia Slough*
	0058	Woods Creek - 8721 SW 47th Ave	Fanno Creek
	0060	Veterans Creek - S of 10200 SE Mt Scott Blvd	Johnson Creek
	0080	Upper Slough - N of 18008 NE Airport Way	Columbia Slough*
	0122	Golf Creek - SW Barnes Rd near W Burnside	Tualatin River
	0124	Johnson Creek - 6538 Barbara Welch Drive	Johnson Creek
	0129	Upper Slough - 14912 NE Airport Way	Columbia Slough*
	0144	Nettle Creek - 1260 Hideaway Lane, Lake Oswego	Tryon Creek
	0188	Johnson Creek - SE 110th Ave Bridge	Johnson Creek
	0208	Tryon Creek - Tryon Creek State Park	Tryon Creek
	0250	Balch Creek - Lower Macleay Park	Willamette River
	0272	Johnson Creek - 4950 SE 174th Ave	Johnson Creek
	0273	Whitaker Slough - 6455 NE Columbia Blvd	Columbia Slough*
	0298	Cedar Mill Creek - NW Mill Pond Rd at Cedar Creek	Tualatin River
	0314	Fanno Creek - 3455 SW Beaverton-Hillsdale Hwy	Fanno Creek
	0329	Lower Slough - 3841 N Columbia Blvd	Columbia Slough*
	0352	Johnson Creek - 5840 SE Morris St	Johnson Creek
	0524	Stephens Creek - 7720 SW Macadam	Willamette River

Panel	Site ID	Site Location	Watershed
Panel 2	0234	Fanno Creek Tributary - 4241 SW Tunnelwood St	Fanno Creek
	0444	Johnson Creek - 3083 SW 14th Dr	Johnson Creek
	0498	Ash Creek Tributary - 10536 SW 53rd Ave	Fanno Creek
	0513	Middle Slough - 12002 NE Inverness Dr	Columbia Slough*
	0526	Balch Creek - 6131 NW Thompson Rd	Willamette River
	0529	Middle Slough - 6900 NE Cornfoot Rd	Columbia Slough*
	0544	Johnson Creek - 9201 SE McLoughlin Blvd	Johnson Creek
	0554	Cedar Mill Creek Tributary - 9742 NW Miller Hill Rd	Tualatin River
	0592	Tryon Creek Tributary - Tryon Creek State Park	Willamette River
	0633	Willamette River Trib - Forest Park, 2nd Order Stream	Willamette River
	0705	Middle Slough - 4501 NE Crystal Ln	Columbia Slough*
	0720	Willamette River Tributary - 8421 SW Macadam Ave	Willamette River
	0746	Ivey Creek - 4722 SW 42nd Ave	Fanno Creek
	0754	Falling Creek - 9505 SW Jonathan Ct	Willamette River
	0762	Balch Creek - 4300 NW Cornell Rd	Willamette River
	0769	Middle Slough - 11632 NE Ainsworth Circle	Columbia Slough*
	0828	Johnson Creek Tributary - 7017 SE Deardorf Rd	Johnson Creek
	0892	Johnson Creek - 6400 SE 101st Ave	Johnson Creek
	0961	Middle Slough - 2424 NE Riverside Way	Columbia Slough*
	1020	Kelley Creek - 6363 SE 159th Dr	Johnson Creek

Panel	Site ID	Site Location	Watershed
Panel 3	0170	Sylvan Creek - 3223 SW Scholls Ferry Rd	Tualatin River
	0316	Veterans Creek - 11801 SE Mt Scott Blvd	Johnson Creek
	0337	Lower Slough - 437 N Columbia Blvd	Columbia Slough*
	0800	Willamette River Tributary - 01609 SW Radcliffe Ct	Willamette River
	1002	Fanno Creek - 4911 SW Beaverton-Hillsdale Hwy	Fanno Creek
	1104	Upper Slough - NE 185th Drive	Columbia Slough*
	1130	Cedar Mill Creek - 2118 NW Mill Pond Rd	Tualatin River
	1184	Johnson Creek - 8400 SE 26th Pl	Johnson Creek
	1212	Johnson Creek - 1243 SE Brookside Dr	Johnson Creek
	1292	Crystal Springs - 7910 SE 21st Ave	Johnson Creek
	1312	Willamette River Tributary - 01350 SW Radcliffe Rd	Willamette River
	1360	Wilkes Creek - 15416 NE Fremont St	Columbia Slough*
	1376	Johnson Creek - 6709 SE May St	Johnson Creek
	1404	Johnson Creek - 12253 Brookside Dr	Johnson Creek
	1473	Buffalo Slough - 7302 NE 42nd Ave	Columbia Slough*
	1593	Miller Creek - Forest Park	Willamette River
	1781	Columbia Slough - 15840 N Simmons Rd	Columbia Slough*
	1872	Nettle Creek - Tryon Creek State Park	Tryon Creek
	1916	Veterans Creek - 9808 SE Mt Scott Blvd	Johnson Creek
	2000	Tryon Creek - Tryon Creek State Park	Tryon Creek

Panel	Site ID	Site Location	Watershed
Panel 4	1194	Columbia Creek - 3608 SW 60th Pl	Fanno Creek
	1612	Johnson Creek - 4305 SE Harney St	Johnson Creek
	1642	Columbia Creek - 4119 SW 58th Ave	Fanno Creek
	1744	Willamette River Tributary - 8421 SW Macadam Ave	Willamette River
	1769	Miller Creek - 12928 NW Newberry Rd	Willamette River
	1778	Woods Creek - 9715 SW 43rd Ave	Fanno Creek
	1793	Columbia Slough - 10652 NE Holman St	Columbia Slough*
	1809	Columbia Slough Tributary - 2210 NE Riverside Way	Columbia Slough*
	1834	Cedar Mill Creek Tributary - 2317 NW Birkendene St	Tualatin River
	1857	Columbia Slough - 16811 NE Mason Ct	Columbia Slough*
	1865	Columbia Slough - 9645 N Columbia Blvd	Columbia Slough*
	1936	Tryon Creek Tributary - 10719 SW Boones Ferry Rd	Tryon Creek
	2113	Columbia Slough - 6031 NE 92nd Ave	Columbia Slough*
	2154	Cedar Mill Creek Tributary - 2708 NW Mill Pond Rd	Tualatin River
	2185	Saltzman Creek Trib - Forest Park, 2nd order stream	Willamette River
	2208	Johnson Creek - 4938 SE Johnson Creek Blvd	Johnson Creek
	2290	South Ash Creek - 6433 SW Dickinson St	Fanno Creek
	2318	Balch Creek - 5410 NW Cornell Rd	Willamette River
	2320	Johnson Creek - 5509 SE Circle Rd	Johnson Creek
	2377	Lower Slough – 10425 N Bloss Ave	Columbia Slough*

* Beginning FY 16-17 macroinvertebrate sampling is being discontinued at the Columbia Slough instream monitoring sites only, due to the lack of appropriate metrics as footnoted in Section 5.4.1. Alternate biological parameters are being considered for the Columbia Slough.

5.4.2 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 protocol described previously. Table 5.2 below lists the annual panel rotation:

Table 5.2 Macroinvertebrate Frequency & Panel Rotation

Year	Panel Rotation			
FY 14-15	Panel 1			
FY 15-16		Panel 2		
FY 16-17			Panel 3	
FY 17-18				Panel 4
FY 18-19	Panel 1			
FY 19-20		Panel 2		
FY 20-21			Panel 3	
FY 21-22				Panel 4

5.4.3 Sample Collection Methodology

Benthic macroinvertebrate samples will be collected using the following protocols (adapted from the U.S. Environmental Protection Agency *National Rivers and Streams Assessment, Field Operations Manual*, 2009). A sample is collected from one meter downstream of each of 11 cross-section transects at the assigned sampling locations (Figure 5.1) using a D-frame kicknet. The sample location at Transect A is determined at random, and each following transect is assigned a station 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.

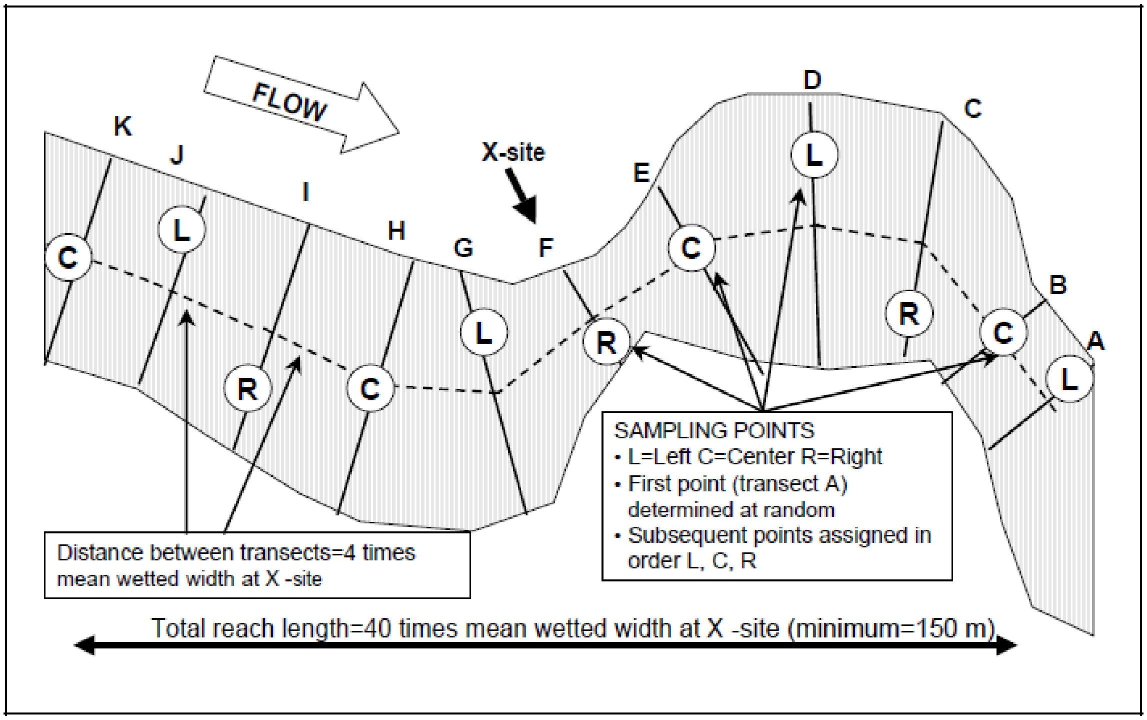

Figure 5.1 Wadeable Site Reach Features with Macroinvertebrate L, C, and R Sampling Points
(from USEPA 2009, p. 45, Figure 4-6)

5.5 SPECIAL DATA QUALITY OBJECTIVES AND CRITERIA

This section includes information on measurement quality objectives and sample handling and custody.

5.5.1 Measurement Quality Objectives

A subsample of 500 organisms will be sorted and identified as described in Section 5.6. Taxonomic identification of organisms will reach the species level whenever possible or cost-feasible. However, the taxonomic resolution will, at a minimum, be to Standard Taxonomic Effort Level 2 per the following:

http://www.pnamp.org/project/4210

5.5.2 Sample Handling and Custody

To adequately track each macroinvertebrate sample, the following parameters are needed: station, site name, site ID (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.

5.6 QUALITY CONTROL

Quality control measures for instream and stormwater sampling are described in Section 9 of this QAMP. Because of the special nature of macroinvertebrate sampling and analyses, additional quality control measures are required, as described below.

5.6.1 Field Quality Control

As shown in Table 5.3, quality control measures for field measurements are evaluated primarily through best professional judgment and by ensuring that the work is performed by experienced and/or well-trained field teams.

Table 5.3 Biological Communities Field Quality Control

Item	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
Use widely/commonly accepted taxonomic references	For all identifications	All keys and references used must be based on a bibliography prepared by another laboratory	If other references desired, obtain permission to use from project lead

5.6.2 Laboratory Quality Control

Table 5.4 summarizes biological laboratory quality control measures. The laboratory will archive sample residuals, vials, and slides until the project leader has authorized the disposition of the samples in writing.

Table 5.4 Macroinvertebrate Laboratory Quality Control

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 (see SOP)	Efficiency >= 95%	Increasing check frequency if acceptance criteria are not met (see SOP)
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

5.7 CONNECTION TO LONG-TERM MONITORING STRATEGY

Since 2010, macroinvertebrate monitoring has been an integral element of the BES's comprehensive instream monitoring program. BES expects to use macroinvertebrates to assess the long-term improvement of the City'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 storm 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 ERF, 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 ERF and sampling teams (via cell phone). The Storm Monitoring Coordinator for this project will be the Field Operations (FO) 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 comprised of two people, primarily from the City's FO 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 very similar weather conditions.

Field staff members are required to read, understand, and follow all procedures documented in this Plan and the WPCF-SAP and WPCF-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 the project Health and Safety Plan (see Appendix C of the WPCF-SAP and WPCF-QAPP).

SECTION 7

FIELD SAMPLING PROCEDURES

As described in Sections 1 and 4, stormwater sampling is also conducted for compliance with the City's WPCF permit. To minimize duplication of documentation, the field sampling procedures for stormwater sampling are not repeated here but can be found in Section 7 of the WPCF-SAP. Section 7 of that document includes a description of the following: personal safety, sample collection location, analytical schedule, sampling equipment preparation, sampling equipment decontamination, sample container preparation, clean sampling techniques, sampling location access procedures, sample collection and handling, field quality control sample collection, sample labeling, sample collection documentation, sample transport and delivery to the laboratory, and change notification.

To supplement Section 7 of the WPCF-SAP, this NPDES MS4 Permit Monitoring Plan includes instream surface water sampling procedures. Some of the analytical parameters required for the NPDES MS4 permit vary from what is required by the WPCF permit. Therefore, sampling equipment described in the WPCF-SAP should be supplemented by this Plan to also include analytical field meters for the analysis of:

- pH
- specific conductance
- dissolved oxygen
- temperature

These field meters will be calibrated at the WPCL prior to initiating stormwater and instream sampling activities using standard field meter calibration procedures. Meters are also checked for drift at 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.

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.

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); and
  - Potential pollutant sources (e.g., pipe discharge, especially during dry conditions).
- Determine if the flow rate in the stream allows for safe access to the stream.

In addition to the personal safety procedures provided in Section 7 of the WPCF-SAP, personal flotation devices should be worn when collecting surface water samples.

SECTION 8

QUALITY CONTROL & QUALITY ASSURANCE

The U.S. Environmental Protection Agency (http://www.epa.gov/quality/glossary.htm#Q) defines "quality assurance" (QA) and "quality control" (QC) as follows:

- **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.
- **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.

The QA/QC procedures that will be followed as part of this management plan are documented in detail in the WPCF-QAPP. The WPCF-QAPP includes the following:

- Project management/data quality objectives
- Sampling handling and custody
- Analytical procedures
- Quality control procedures
- Data management, validation, and reporting
- Data assessment and evaluation
- Inspection and audits
- Deviations, nonconformance, and occurrences
- Monitoring program corrections

Appendices A, B, and C of the WPCF-QAPP provide supporting information, including field sampling and laboratory forms, laboratory method reporting limits, and data qualifiers.

In addition, related to QA/QC, the City has documented standard operating procedures for field measurements of multiple water quality parameters, decontamination of sampling equipment, chain of custody, grab sample collection with bottles, grab sample collection with stainless steel beakers, field filtering of water samples, quality control sample collection, and laboratory analysis.

SECTION 9

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