# 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.

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

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.

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

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[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 ≥ 0.1 inch per storm
- predicted rainfall duration ≥ 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.

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[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 1**

| Site ID | Site Location | Watershed |
|---|---|---|
| 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 2**

| Site ID | Site Location | Watershed |
|---|---|---|
| 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 3**

| Site ID | Site Location | Watershed |
|---|---|---|
| 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 4**

| Site ID | Site Location | Watershed |
|---|---|---|
| 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.

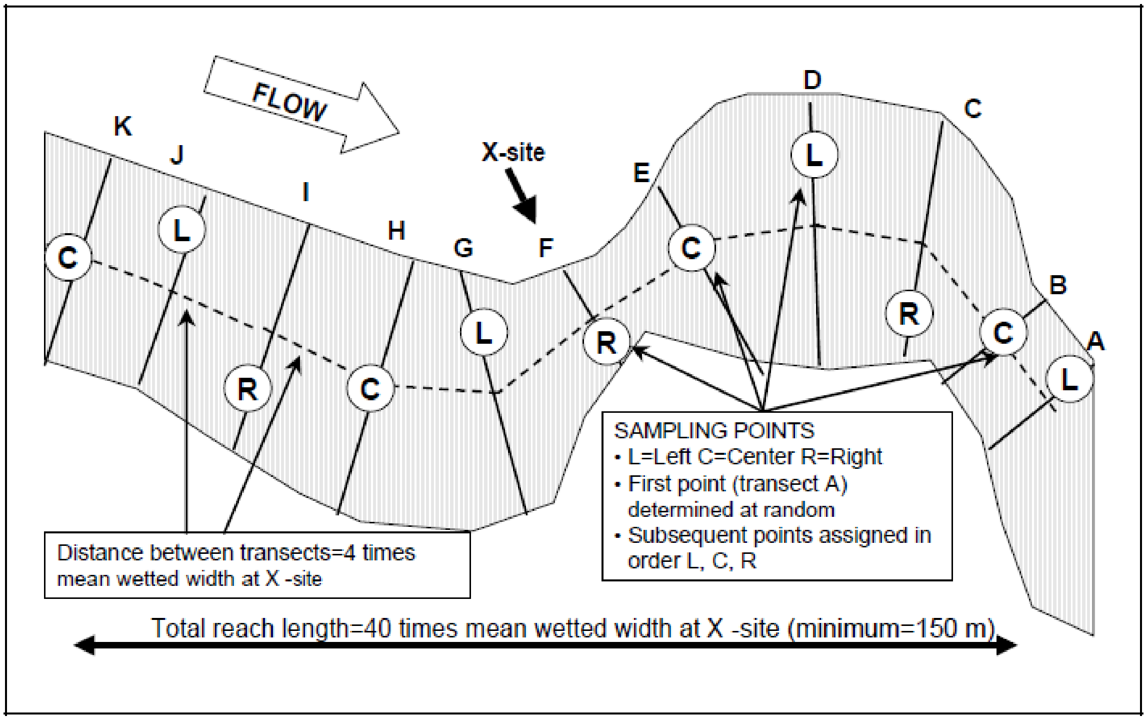


**Figure 5.1 Wadeable Site Reach Features with Macroinvertebrate L, C, and R Sampling Points**
*(from USEPA 2009, p. 45, Figure 4-6)*

## 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

# REFERENCES


City of Portland, Bureau of Environmental Services. 2005. WPCL Quality Manual. Revision 6.

City of Portland, Bureau of Environmental Services. 2006. WPCF Permit Sampling and Analysis Plan. (http://www.portlandonline.com/bes/index.cfm?c=50442&a=282500)

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

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

Oregon Department of Environmental Quality. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams (November 2005 models). Prepared by Shannon Hubler.

Oregon Department of Environmental Quality. 2009a. High Level Indicators or Oregon's Forested Streams. Prepared by Shannon Hubler. (http://www.deq.state.or.us/lab/techrpts/docs/10-lab-003.pdf)

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.

Stevens Jr, D. & Olsen, A. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association, ASA 99, 262-278.

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

U.S. EPA. 2004. Wadeable Streams Assessment: Field Operations Manual. EPA 841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C

U.S. EPA. 2009. National Rivers and Streams Assessment, Field Operations Manual. EPA 841-B-07-009.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., 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.