Cities of Gresham and Fairview

Environmental Monitoring Plan

for
National Pollutant Discharge Elimination System (NPDES)
Municipal Separate Storm Sewer System (MS4)
Permit Compliance

Effective July 1, 2016

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for the Cities of Gresham and Fairview

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1.0 INTRODUCTION

1.1 Overview

Under the federal Clean Water Act and Oregon Revised Statute 468B.050, the Oregon Department of Environmental Quality (DEQ) has issued the Cities of Gresham and Fairview a National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit. As such, both cities are required to develop a monitoring program as described in the Clean Water Act (CWA) 40 CFR 122.26 (d) (2) (iii) (A) through (D) and in Schedule B Monitoring and Reporting Requirements of the NPDES MS4 permit #101315 in order to characterize stormwater discharges, assess trends in water quality and aid the adaptive management of the overall stormwater program within the permit boundary.

The City of Gresham is Co-permittee with the City of Fairview and acts as the lead applicant for the permit and has agreed to be responsible for conducting most of the monitoring program elements on behalf of the City of Fairview via an inter-governmental agreement (**See Appendix D**). The City of Gresham, including the urban growth boundary of Pleasant Valley, Kelley Creek Headwaters and Springwater represents approximately 17,000 acres (about 26.5 square miles). Just over 2,200 additional acres are managed by the City of Fairview. A more detailed discussion of the permit boundary and the history of the Co-permittees may be found in **Section 4.3.3** of Gresham's Stormwater Management Plan (SWMP) which includes Figure 4.3.1 Map of the NPDES MS4 Permit #101315 Boundary and Area Watersheds.

The primary goal for the monitoring program is to support evaluation and adaptive management of the stormwater management program in order to reduce the discharge of pollutants from the MS4 to the maximum extent practicable. The Cities of Gresham and Fairview have developed individual Stormwater Management Plans as directed by the CWA 40 CFR 122.26 (d) (2) (iv) (A) through (D) and in Schedules A, B, and D of the NPDES MS4 permit. These documents are available on the Cities' websites at www.greshamoregon.gov and www.ci.fairview.or.us and are also available upon request from each City.

The City of Gresham is also responsible for implementing a groundwater protection program to comply with a December 2012 Water Pollution Control Facility (WPCF) permit. Currently this plan is written to comply with the NPDES MS4 permit, but may be adapted to include the details necessary to comply with the WPCF permit.

In addition to complying with the NPDES MS4 permit requirements, the goal of this Monitoring Plan is to provide the Cities of Gresham and Fairview with a monitoring program that will consider Total Maximum Daily Load (TMDL) compliance objectives for water quality monitoring; provide data to help answer some of the outstanding questions about stormwater-related pollutant sources; help the Co-Permittees assess water quality impacts related to MS4 discharges; and help identify improvements in water quality over time as a result of the Co-Permittees' stormwater quality management efforts.

This Monitoring Plan reflects the requirements of the NPDES MS4 Permit issued on December 30, 2010.

1.2 Monitoring Program History and Updates

Permit Application (1993)
The Cities of Gresham and Fairview's monitoring program was originally designed by the consultant team that drafted the 1993-95 permit application submittal. A discussion of the permit and SWMP development history are included in the Introduction of the City of Gresham's SWMP. A discussion of the changes to the Monitoring Plan since its original design is included here.

Permit Renewal Submittal (2000)
The monitoring program was updated for the 2000 permit renewal submittal. During the permit renewal process, third party groups expressed concern that the DEQ permit was not protective enough to ensure that creeks, streams, and rivers would eventually meet water quality standards. The permit was initially issued in 2004, but was reconsidered by DEQ as a result of a third party appeal. The permit was reissued in 2005 and required the Co-permittees to review the previously submitted Monitoring Plan to ensure that it met final permit goals and requirements, and report findings and proposed revisions in an "Interim Evaluation Report" due in 2006.

Interim Evaluation Report (2006)
Per the 2005 NPDES MS4 Permit requirement, the Co-Permittees' stormwater monitoring program was reviewed and updated with respect to the NPDES MS4 permit objectives and TMDL requirements. Most of the changes made at that time are still incorporated in the current Stormwater Monitoring Plan. The main recommendation was that resources dedicated to monitoring should continue to be limited, due to the high variability of stormwater and the need to focus resources on activities that reduce pollution.
Monitoring program changes included:

- Added two Kelley Creek monitoring sites (Johnson Creek watershed) to the list of instream sites. Gresham began monitoring these sites in fall 2006 in order to characterize the Pleasant Valley annexation area and the Kelley Creek Headwaters annexation area, which will eventually be incorporated into the City's permit boundary when urban services are provided. Future plans may also include new monitoring site(s) to characterize the Springwater annexation area prior to planned future development.
- In order to assess progress toward meeting the TMDL in Johnson Creek for legacy pesticides, DDT monitoring was added at the two instream sampling locations on Johnson Creek and periodically in stormwater.
- PAH and PCB monitoring was implemented in Johnson Creek with a caveat that monitoring would be re-evaluated after two years if sampling failed to produce values above commercially available quantitation limits.

Permit Renewal Submittal (2008)
In preparation for the 2008 NPDES MS4 permit renewal submittal, the Co-Permittees prepared water quality trend analyses, pollutant load reduction estimates (benchmarks) and pollutant load updates. Additionally, the following activities were conducted:

- Internal reviews of all BMPs
- Review of technical information from external sources and monitoring data, including a formal literature search

- Review of data collected by staff, and knowledge of program effectiveness
- Discussion with other jurisdictions concerning best practices
- Consideration of fiscal constraints
- Input from the general public
- Deliberation by Council

Based on the findings as described above, staff recommended the changes to the Monitoring Plan as follows:

- Added annual macroinvertebrate monitoring to provide measurement of biological communities within MS4 receiving waters, in addition to bacteria. Biological monitoring provides an additional means for evaluating long term trends since these benthic organisms are exposed to chemical, biological and physical conditions of the stream that are not well characterized by point-in-time water quality grab samples for bacteria.
- Removed PCBs and PAHs from list of instream and stormwater constituents monitored in Johnson Creek since all samples analyzed over two years (2006-2008) were below the detection limit (100 ng/L). The USGS data upon which the 303(d) listing is based was a 35-day collection using semi-permeable membranes, with a reported value of 52.9 ng/L. More detail on the 303(d) listing is included in the 303(d) Analysis performed for the 2008 Permit Renewal Submittal. Because the available laboratory quantitation limits are twice the level USGS found over 35 days, grab samples are expected to be below the quantitation limit. Since both constituents have also been found in streambed sediment, the Co-Permittees plan to use TSS as a surrogate measurement for these constituents, as is done in the Columbia Slough. Resources will be reallocated to other monitoring activities.
- Removed total and dissolved nickel from list of ambient and stormwater constituents since levels are always significantly lower than chronic and acute toxicity levels and nickel tracks with other heavy metals, which will serve as surrogate measurements.
- Continue and expand monitoring of the effectiveness of large scale BMP projects built over the past few years. Monitoring will continue at the Fairview Creek Water Quality Facility for at least a portion of the permit term, and additional monitoring will be planned to evaluate the performance of the new Columbia Slough Water Quality Facility.

2010 Update

Slight modifications to the Monitoring Plan were made in 2010 based on requirements in draft NPDES MS4 and WPCF permits, and Multnomah County's application to obtain its own permit and no longer be a Co-permittee. Some cooperative monitoring efforts between Multnomah County and Gresham are still planned to occur via an inter-governmental agreement. (**See Appendix J**.) Additionally, the frequency and location of stormwater sampling were modified to ensure compatibility with the anticipated WPCF permit, as described below:

- Added pesticides (2,4-D and pentachlorophenol) to water quality constituents based on findings from a local USGS study which indicated 2,4-D exceeded an aquatic-life benchmark. Gresham also has a targeted educational BMP for 2,4-D use reduction. Pentachlorophenol has exceeded drinking water standards in stormwater. These pesticides will be monitored for all wet weather stormwater monitoring.
- Reduced instream monitoring frequency from six times to four times per year to free up resources for enhanced stormwater monitoring. Three samples per year will be focused in wet season, with one sample per year being collected during low flow in conjunction with

macroinvertebrate monitoring. Analysis of existing data (described further in **Section 2.0**) indicates no significant loss in ability to recognize changes in water quality based on this modification.

- The stormwater monitoring approach will move from sampling outfalls from three large drainage areas to sampling multiple small drainages (0.5 to 5 acres) selected using a probabilistic (random and spatially-balanced over the selected area) sampling design (see Stevens and Olsen 2004). The benefit to using the probabilistic approach is that the small drainage areas will typically be composed of a single land use, versus the mixed use inherent in the past stormwater outfall monitoring approach that focused on drainage areas that were hundreds of acres in size. This will enable the permittees to better characterize the source of various pollutants.

2011 Update

The Monitoring Plan was reorganized and elements were added to more closely follow the requirements contained in the final NPDES MS4 permit issued to Gresham and Fairview on December 30, 2010. DEQ added a new requirement not included in the applicant review draft of the permit to conduct mercury monitoring as described by the DEQ "Mercury Monitoring Requirements for Willamette Basin Permittees" memo dated December 23, 2010. (See **Appendix H**). As such, the plan was amended to include a description of the effort to monitor for mercury, which includes continued monitoring for total mercury in all stormwater and surface water sampling and adding total and dissolved mercury and methyl mercury at 4 stormwater monitoring locations annually. Additionally, requirements in the draft Water Pollution Control Facility (WPCF) permit for municipal Underground Injection Control Systems (UICs) inspired stratification of the probabilistic sampling design for stormwater based on vehicle trips per day.

The Plan was released for public comment on April 11-25, 2011 and submitted to DEQ on May 1, 2011 for implementation on July 1, 2011. On June 27, 2011, the Co-Permittees received conditional approval of the Monitoring Plan and included comments for the Co-Permittees to address as summarized below:

DEQ Request	Gresham Response
Please submit any Hg monitoring the City of Gresham has collected to date.	Emailed spreadsheet of data to DEQ on June 27, 2011
An updated description of the process for conducting adaptive management should be included in the Monitoring Plan by November 1, 2011. A more specific link between using monitoring data/tracking measures and evaluation efforts within the adaptive management process is necessary.	Additional text was added to Section 1.4 (Adaptive Management).
The study design for instream monitoring should be clarified/refined for purposes of examining the instream water quality improvements associated with BMP implementation.	Added additional language to 3.4.1. The instream monitoring program was not designed to explicitly determine whether or not BMPs improve water quality between the upstream and downstream

	monitoring stations. Rather, long-term instream monitoring trends have been evaluated to determine whether they are consistent with improvements noted with Structural BMP Monitoring (as noted in Section 3.2.4 "Relationship to Long-term Program Strategy," on page 18).
The Monitoring Plan or supporting documentation does not describe how important elements of the study design will be addressed. For example, a description of the calibration or treatment sample collection period for the upstream/downstream study, the timing of upstream/downstream sample collection and evaluation of lag time has not been addressed.	Clarification was added to the Study Design (Section 2.4.1) to describe the rationale used for sample collection timing for upstream/downstream locations.
For NPDES MS4 permit compliance purposes, samples must be analyzed in accordance with EPA approved methods listed in 40 CFR 136. The methods identified for several of the pollutant parameters (e.g., TKN, Hg, DDT, Dieldrin) are not 40 CFR 136 methods. The plan should be revised accordingly.	**TKN**: The listed method (PAI-DK03) is a 40 CFR 136 method (flow injection gas method, see footnote 41, Table 1B, 40 CFR Part 136.3). **Total Hg**: The WPCLSOP M-10.02 method cited for total Hg is EPA 200.8 w/CEM digestion (footnote 4, Table 1B, 40 CFR Part 136.3). **DDT/Dieldrin**: From DEQ response dated 7/27/2011: EPA Method 608 is listed as an approved method for analyzing organochlorine pesticides, including DDT, DDD, DDE and Dieldrin. EPA SW846 Method 8081 is nearly identical and is often used interchangeably with EPA Method 608. Because of the similarities between the methods, method 8081 meets the criteria of a modified version of 608 under the description outlined in 40 CFR Part 136.6 "Method Modifications and Analytical Requirements". As a result, DEQ will accept the use of EPA Method 8081 for use by the City of Gresham to meet the Gresham MS4 Group permit monitoring and analytical requirements for in-stream monitoring for legacy pesticides (DDT, Dieldrin) within the Johnson Creek sub-watershed

The analytical method and Method Reporting Limit (MRL) identified for total Hg for instream and BMP effectiveness monitoring does not meet the intent of DEQ's Mercury Monitoring Requirements for Willamette Basin Permittees memo. Although this monitoring is not specifically required by the MS4 permit, use of this data may be limited if the method and MRL for total Hg are not in accordance with those identified in the referenced memo.	The City has been monitoring total Hg using WPCLSOP M-10.02 for all 1) instream, 2) stormwater, and 3) BMP effectiveness samples since 2004. An evaluation of monitoring results indicates that >60% of instream and >90% of stormwater samples are above the MRL, and therefore the method is deemed to be appropriate for the intended use of the data. The City plans to use the higher resolution data from the low level mercury and methyl mercury study to correlate with the same total mercury monitoring method used since 2004.
Table 6 on page 27 refers to DEQ's guidance for accuracy and precision of field measurements. The table should be revised to reflect the following: Dissolved Oxygen – Precision ± 0.3 mg/L, Accuracy ± 0.2 mg/L Conductivity – Precision ± 10% of Std. Value, Accuracy ± 7% of Std. Value (in this case, the values included in the document are more strict than the DEQ criteria provided here. The permittee may always use more stringent criteria, however, this is the criteria used by DEQ). Turbidity – Precision – include ± 1 NTU if NTU < 20	Changes made to Table 6 and Table 13 to reflect the accuracy and precision targets noted by DEQ.
Instrumentation Calibration should be calibrated to bracket the values expected in the field. Since there is the possibility to record a pH of less than 7 in stormwater, pH meters should be calibrated using 3pt calibration (4, 7, 10). – see pages 28, 52, and 70.	Changed calibration details in Monitoring Plan to reflect 3-point calibration (pH 4, 7 and 10). Began using 3-point calibration for all pH monitoring activities conducted on and after July 1, 2011.
Clarify how the Hg monitoring requirements will be addressed. It is unclear how the sample collection strategy described will result in one wet & one dry sample collection at each of two sites each year during the 1st 2 years.	Mercury monitoring approach outlined in Monitoring Plan was altered to reflect one summer and one winter event being collected at the same 2 sites for the first 2 years of permit. Low level mercury monitoring has been moved from Section 6.0 (wet weather stormwater monitoring) to Section 8.0 (structural BMP monitoring), since incorporating the Hg

	monitoring into this task should better meet the comments provided by DEQ.
Mercury (total & dissolved) monitoring should use EPA 1631E analytical method with the appropriate MRL.	Monitoring Plan has been updated to reflect that the special study low level mercury uses EPA 1631E and methyl mercury is EPA 1630
The wet weather stormwater monitoring for mercury and methyl mercury appear to only include samples from residential land use. This monitoring should include commercial and industrial land use types.	The sites selected to meet the mercury monitoring memo requirements were moved from the smaller UIC drainages described in the wet weather stormwater monitoring Section (6.0) to the larger commercial and industrial land uses draining to the BMP evaluation locations described in Section 8.0
Describe the cleaning procedure or reference a certification that the lab supplying the containers for Hg and methyl Hg monitoring are pre-cleaned.	Test America provides water sample bottle kits that follow the procedures outlined in EPA method 1669. Every bottle kit lot is confirmed to produce methyl mercury bottle blanks <0.05 ng/L.
The Monitoring Plan indicates that small drainage catchments will be monitored as a result of using the probabilistic study design for wet weather stormwater monitoring. DEQ is interested in the site selection procedures and other supporting information. Please provide additional supporting documents related to the use of this site selection and monitoring approach by November 1, 2011. Some of the specific questions are as follows:	Responses next to each item below:
How was the range of areal extent for these smaller drainage catchments (0.5-5 acres) determined?	The City's UICs exist within an area deemed to be representative of the land uses and traffic within the entire city. Sites were selected according to the GRTS procedure (see Section 6.4.1) and the area draining to each UIC varies based upon factors such as infiltration rate and amount of impervious area in the drainage area.
Are larger drainage catchments eliminated from the site selection protocol?	Yes. A few historical large drainage area outfalls will still be monitored as part of BMP Effectiveness Study, but the historic land use based outfalls monitored in the past will no longer be monitored.

Is it possible to use a portion of a larger drainage catchment in delineating a smaller drainage catchment for purposes of site selection?	Yes. But for the study design presented in section 6.0, the discharge point to a UIC was selected as a representative, accessible, and easy to delineate drainage area.
Will all the land use types be captured using the smaller drainage catchment approach?	Yes
What scientific literature was used to support the assumptions related to shifting to small drainage catchments (e.g., Stevens Jr. & Olsen)?	The study design section (6.4.1) discusses the rationale for the switch based on a comparison of monitoring results conducted by Portland and Gresham (analyzed and reported in ACWA 2009), as well as the scientific rationale outlined by Stevens and Olsen (discussed and cited in that section).
The timeframe for evaluating and submitting a report related to considering additional current use pesticides to be monitored was not identified. The evaluation and report should be submitted to DEQ as soon as possible, but no later than November 1, 2011. In addition, the pesticide monitoring should consider when there may be pesticide analyte detection of high frequency, but at a low detection level.	The pesticide assessment conducted to date is being submitted with this annual report. Included in Appendix K.
On page b-5, SOP A-8, the bottle list does not match the needed bottle lists in the tables identified in the plan. Please update the list as appropriate.	The bottle list in SOP A-8 contains the actual bottles and volumes collected. The volumes listed in the Monitoring Plan are minimum volumes required for each analysis. For some analyses, the lab splits the required volume from a larger container (e.g. 1 L plastic bottle collected for nutrients), while for others a larger volume is collected than what is required for analysis (e.g. 250 mL collected for E. coli, but only 1000 mL used).
Verify that equipment blanks are collected prior to sampling to verify equipment is clean and free of contamination. Equipment blanks should be collected 10% of the locations for equipment that is repeatedly used throughout the sample collections.	Field blank collection at 10% of sites was added to in-stream, wet weather stormwater and BMP monitoring sections.
Verify the following information is adequately addressed in the Monitoring Plan:	

Mercury (total and dissolved) and Methyl Mercury (total and dissolved),TSS, flow and Field Constituents are collected at the same time and reported using the MRL and analytical methods specified in the DEQ's Hg memo.	TSS, field constituents, and rainfall (as a surrogate for flow) will be measured at the same time as sample collection for the special mercury monitoring, as well as the total mercury monitoring which will be conducted at all stormwater monitoring locations.
Mercury (total and dissolved) and Methyl Mercury (total and dissolved) should be analyzed with the methods stated DEQ's Hg memo.	This was the original intent, but language was added to explicitly state this.
Collect Mercury (total and dissolved) and Methyl Mercury (total and dissolved) simultaneously. This will allow DEQ to calculate the ratio needed to develop the Bio-Accumulation Factor for the TMDL. This will also allow DEQ to compare ambient monitoring datasets collected by DEQ to the Hg data collected by permittees.	This was the original intent, but language was added to explicitly state this.
Monitoring of Hg should use environmentally relevant and sensitive MRLs to characterize effluent, as specified in DEQ's Hg memo. This is in accordance with a USEPA April 2010 document "Guidance for Implementing the January 2001 Methyl Mercury Water Quality Criterion".	This was the original intent, but language was added to explicitly state this.
Additional Changes – Adaptive Management of Monitoring Plan	
Wet Weather Stormwater Monitoring (Monitoring Plan Section 6.0)	Added additional detail about GRTS site selection procedure, including use of stratification by vehicle trips per day (<1000 and >1000). Strategy for over-sampling high traffic areas is explained. The sampling locations were updated to reflect additional sites being considered (Gresham gained access to all UICs, since 130 of those obtained from Multnomah County were paved over until early 2011.
Dry Weather Field Screening (Monitoring Plan Section 7.0)	Updated list of sites in Table 14 (Priority Outfalls for Illicit Discharge Monitoring/Dry weather Screening) to accurately reflect sites screened annually. Three locations were eliminated (D6B, F2A and F4) since the pipe system they

	are part of is still captured by downstream screening locations, and one site that has been screened annually, but was somehow omitted from the list submitted to DEQ in April 2011, was added to the list (D2B). Additional clarification was also added to some of the sampling locations to more accurately reflect location visited annually.
Appendices J, K, and L	Added IGAs between Gresham and Multnomah County for monitoring (Appendix J) and between Gresham and City of Portland for Columbia Slough monitoring (Appendix F). Also added the pesticide assessment requested in Table B-1 as Appendix K.

Updates During Permit Term

Date	Monitoring Plan Section	Change or Update
11/1/2011	Tables 11 and 12	Deleted chlorophyll-*a* from both tables, since this constituent is not monitored as part of wet weather stormwater monitoring.
11/1/2011	Table 14	Updated list of priority outfalls where dry weather screening occurs to add one major outfall that has been screened annually, but was omitted in July 2011 plan, as well as deleting a couple historic manholes upstream of outfalls already on screening list.
10/26/2012	Entire Document	Changed name of document from "Stormwater Monitoring Plan" to "Environmental Monitoring Plan." Change was made to align with language in MS4 permit and allow wet weather monitoring to be specifically outlined in separate referenced Stormwater Monitoring Plan created to comply with WPCF permit, in addition to wet weather requirements of MS4 permit.
10/26/2012	Section 6.0 "Wet Weather Stormwater Monitoring"	Removed specifics for wet weather stormwater monitoring to a separate Stormwater Monitoring Plan submitted to DEQ for compliance with WPCF permit,

		while also meeting goals, objectives and requirements of NPDES MS4 permit.
10/26/2012	Section 7.6.2 Illicit Discharge Investigation	Added additional language about level of effort City staff will spend investigating sources deemed to be *de minimus*.
10/26/2012	Table 20	The list of rotating panel locations for UIC sampling sites was deleted from the Environmental Monitoring Plan, since this information is contained and updated in the separate Stormwater Management Plan.

Permit Renewal Submittal Proposed Changes (2015)

Updates to be implemented July 2, 2016. There are several proposed minor changes to the Monitoring Plan for the 2015 Permit Renewal Submittal. These changes do not reduce the number of data points sampled or the sampling effort. The proposed changes reduce sampling in well-characterized areas to allow for increased sampling in areas that are more likely to inform stormwater design and management in the future to improve water quality. We plan to adopt these changes on July 1, 2016 as permitted in Schedule B.2.e. of the 2010 NPDES MS4 Permit. After incorporating these changes, the monitoring program will continue to meet or exceed all requirements listed in Table B-1 of the 2010 NPDES MS4 Permit.

Low Level Mercury Monitoring. The City of Gresham conducted low-level mercury monitoring for 2 years in response to DEQ's "Mercury Monitoring Requirements for Willamette Basin Permittees" Memo (Appendix H). Two years of data did not yield environmentally relevant mercury levels, and the city requested in 2013 to eliminate low-level mercury monitoring from the wet weather stormwater monitoring program.

Wet Weather Stormwater Monitoring. Over the past 6 years, Gresham has collected 180 stormwater samples. All sites were selected probabilistically, with the monitoring strategy used over the past 4 years including monitoring of 5 static or "fixed" locations (monitored each year) and 25 rotating sites for a total of 30 underground injection control (UIC) sites monitored annually. Data analysis shows consistent patterns that generally differentiates sites on streets with >1,000 trips/day from those with <1,000 trips/day. We are proposing a decrease in this sampling from 30 sites/year to 10 sites/year (5 fixed and 5 rotating sites). This reduction will allow for an increase in best management practice (BMP) monitoring.

BMP Effectiveness Monitoring. We currently monitor the inlet and outlet of one structural BMP during 2 storms/year. The information from BMP sampling is valuable to inform future design and management of BMPs. The City has recently constructed several BMPs with varying structural design and is interested in understanding the effectiveness of each at removing pollutants. We propose to increase BMP sampling to a total of 4 "facility events"/year; for example, two facilities may be sampled for each of two storms, or four facilities may be sampled during one storm each.

During BMP sampling we currently collect time- or flow-weighted 5-12 part composite samples at the inlets and outlets. Although this is an effective method for characterizing stormwater constituents in some situations, we have found that it is difficult to accurately weight the samples due to the lack of reliable storm forecasts. We propose moving to collecting a minimum of 3 individual grab samples at each inlet and outlet during each storm sampling event so that averages and maxima can be examined for each pollutant.

Dry Weather Field Screening. The City of Gresham currently monitors 30 fixed sites/year for Dry Weather Field Screening. We propose to continue to monitor 8 of these high-priority fixed sites/year while sampling 22 additional sites/year that will be randomly selected based on risk from drainage area and land use. This will allow us to expand our search for illicit connections to the stormwater system.

The sections that follow incorporate the proposed changes, and comprise the commitments of the Monitoring Plan.

1.3 Permit Requirements and Goals of the Monitoring Program

As listed in Schedule B.1.a., the monitoring program must incorporate the following six objectives:

i. Evaluate the source(s) of the 2004-06 303(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 priorities;
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.

The permit also states that:

> *The co-permittees may use Stormwater Management Plan measurable goals, environmental monitoring activities, historical monitoring data, stormwater modeling, national stormwater monitoring data, stormwater research or other applicable information to address the monitoring objectives.*

With the exception of the SWMP and measurable goals, the Co-permittees approach for the monitoring program utilizing the tools and data as listed above are contained within this document.

The plan is required to include the following information for each monitoring project/task:

i. Project task/organization;
ii. Monitoring objectives, including monitoring questions and background, data analysis methodology and quality criteria, and assumptions and rationale;
iii. Documentation and record-keeping procedures;
iv. Monitoring process/study design, including monitoring location, 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.

The Co-permittees have used this as an outline for the structure of the information included for each activity/task described within this document.

1.4 Adaptive Management

As required in the NPDES MS4 permit, Schedule B 2.b. and Schedule D 4. Adaptive Management, the City follows an annual adaptive management process to assess and modify, as necessary, program elements to achieve reductions in stormwater pollutants to the maximum extent practicable. This includes consideration of available technologies and practices; review of monitoring data generated by the implementation of this Plan and corresponding analysis of the data; review of SWMP measurable goals and tracking measures; and evaluation of Co-permittee resources available to implement the technologies and practices. The Adaptive Management Process for annual review and the Permit Renewal Submittal are further described in Section 2 B of the City of Gresham and Fairview's NPDES MS4 Annual Report. The history and process of the stormwater program adaptive management, maximum extent practicable determination and update process for the permit renewal submittals may be found in Gresham and Fairview's respective SWMPs.

The role of the monitoring program is to provide a scientifically based feedback loop to the Co-permittees that enables them to develop and implement programs to address pollutants that are identified as a result of environmental monitoring. Additionally, the Co-permittees utilize the monitoring program, as applicable and as resources allow to assist with BMP evaluation related to performance and effectiveness estimates.

Annual implementation of the monitoring program elements as described within this Monitoring Plan, include but are not limited to: instream monitoring, macroinvertebrate monitoring, wet weather stormwater monitoring, BMP effectiveness monitoring, and dry weather screening. These elements also provide a variety of opportunities to act as an adaptive management tool for the stormwater program. Opportunities are not limited to the evaluation of the data itself, but also include the visual observation of winter weather stormwater system function, dry and wet weather stream conditions, and land use conditions such as development activities, new business openings, etc. Examples of how monitoring data will be used to adaptively manage the stormwater program include:

- Macroinvertebrate monitoring can indicate areas of the City that might be given special protection; for example recent macroinvertebrate study results indicate that the Kelley

Creek subbasin of Johnson Creek could potentially serve as a relatively-undisturbed reference site. Several years of study have supported this finding, and City staff have provided this information to planners to try to protect the subbasin from avoidable human impacts.

- Sampling of the Fairview Creek Water Quality Facility has shown that the facility causes a significant decrease in *E. coli* between influent and effluent. Further study has shown that the detention pond is the portion of the treatment train that is most effective, followed by the wetland. This information will influence the design and retrofit of future regional facilities.
- Long-term instream water quality data obtained at sites located at approximately the upstream and downstream boundaries of the City allow for trend analysis to validate (or invalidate) the benchmarks and load calculations submitted with each permit renewal application.
- Analysis of existing, statewide stormwater data has revealed that vehicle trips per day are highly correlated with pollutant concentrations. This suggests that retrofitting streets with stormwater treatment (especially through surface infiltration or evapotranspiration facilities) is the most effective way to meet benchmarks, and eventually, water quality standards. For this reason, future retrofits are likely to emphasize streets.

As described in Schedule B 2.e. the Monitoring Plan may be modified without prior Department approval if the following conditions are met:

i. *The co-permittee is unable to collect or analyze any sample, pollutant parameter, or information due to circumstances beyond the 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 the permit term, or eliminate pollutant parameters identified in Table B-I [of the NPDES MS4 Permit]*

iii. *The modification is a result of including elements of the City of Gresham's WPCF UIC Permit.*

The City of Gresham's process for updating the SWMP and Monitoring Plan for the permit renewal submittal is more involved than the annual review process and is described in detail in the SWMP **Section 5**.

1.5 Annual Reporting

The Co-Permittees will submit by November 1, of each year, an annual report of the previous year from July 1-June 30 of the same year which has been released for public comment. As stated in Schedule B 5 of the NPDES MS4 Permit, the annual report will contain the following elements related to the implementation of this Monitoring Plan:

f. A summary of monitoring program results, including monitoring data that are accumulated throughout the reporting year and/or assessments or evaluations.

g. Any proposed modifications to the monitoring plan that are necessary to ensure that adequate data and information are collected to conduct stormwater program assessments.

j. Results of [dry weather] screening and follow up activities related to illicit discharges.

As described in 1.4 Adaptive Management above, certain modifications may be made without prior Department approval. When such changes to the Monitoring Plan are made, Schedule B 2. e. requires the annual report to contain:

f. Modifications to the monitoring plan [that describe] the rationale for the modification, and how the modification will allow the monitoring program to remain compliant with the permit conditions.

1.6 Monitoring Program Objectives Summary

The permit objectives are designed to elicit answers to questions that stormwater system managers must answer in order to optimally allocate resources to efficiently and effectively protect beneficial uses and water quality. **Table 1** is a summary of management questions posed by permittees, together with the elements of the Monitoring Plan relate to these objectives. **Appendix A** provides more detail on how the elements address the permit objectives, and describes the source of information to be used to meet each of the objectives.

Table 1: Relationship of Stormwater Management Questions, Monitoring Plan Elements, and Permit Objectives

Stormwater Management-related question	**Monitoring activities proposed to answer this question***	**Objectives addressed by monitoring activities****					
		1	2	3	4	5	6
What is the impact that Gresham and Fairview's stormwater discharges are having on exceedances of instream water quality standards?	Sort and analyze existing instream water quality data by wet/dry weather periods and examine trends in water quality as water enters and exits the permit area (**Section 2.0**). Continue instream sampling in each of the major creeks to examine water quality trends over time, as described in **Sections 3.0 and 4.0**	☒	☒	☒	☒	☒	☒
To what degree and where are stormwater flows affecting water quality and/or aquatic life?	The City of Gresham has a cost-share agreement with the USGS to collect continuous flow and temperature data at a couple fixed locations, as described in **Section 4.0**.	☒	☒	☒	☒	☒	☒
Is stormwater affecting the biological community of the receiving waters?	Macroinvertebrates will be monitored at instream monitoring locations as described in **Section 5.0**	☐	☐	☐	☒	☒	☒

Stormwater Management-related question	**Monitoring activities proposed to answer this question***	**Objectives addressed by monitoring activities****					
		1	2	3	4	5	6
What are typical/average concentrations of pollutants in stormwater runoff?	Evaluate data already collected (ACWA 1997 and ACWA 2009) and augment with additional monitoring where data are lacking (specifically for mercury and toxics--including pesticides). Stormwater monitoring will be conducted as described in **Section 6.0**	☒	☒	☒	☐	☐	☒
What is the significance of illicit discharges in the permit area? Have illicit discharge elimination programs been successful in reducing problems?	The Gresham's historic approach included dry weather screening plus CCTVing of high priority pipes; neither approach revealed significant illicit connections; therefore, future resources will emphasize source control programs (e.g. EPSC and business inspections). Illicit discharge monitoring will occur as described in **Section 7.0** to meet state & federal requirements.	☒	☒	☒	☐	☒	☐
How effective are the various structural BMPs that are being implemented throughout the permit area at reducing pollutants?	Current national and regional literature related to BMP performance will be reviewed. Gresham will conduct structural BMP performance studies as described in **Section 8.0** and the collective effect of structural controls and selected nonstructural controls within the permit area will be modeled.	☐	☒	☐	☐	☒	☒
How effective are the nonstructural/source control BMPs at reducing pollutants?	The list of nonstructural/source controls currently employed will be reviewed and current and on-going research on the effectiveness of source control BMPs will be tracked. An attempt to characterize pollutants associated with the sediment and debris removed through source controls will be conducted as described in **Section 9.0**	☒	☒	☒	☐	☐	☒
Have all pollutants of potential concern been evaluated?	Conduct ongoing literature review of pollutants of concern and effectiveness of BMPs at their removal (described in **Section 9.0**) and conduct a pesticide assessment to determine if additional pollutants should be considered with Wet Weather Stormwater Monitoring (**Section 6.0**)	☒	☒	☐	☐	☐	☐

Stormwater Management-related question	Monitoring activities proposed to answer this question*	Objectives addressed by monitoring activities**					
		1	2	3	4	5	6
How are the answers to the above questions changing over time?	At the end of each year a simple, visual review of data collected in the past year will be conducted. At the end of year 4 for each permit, trends will be evaluated for instream quality, stormwater pollutants, and macroinvertebrates.	☐	☐	☐	☒	☐	☒

* Monitoring data is most useful when evaluated using statistical tools. The study design and anticipated statistical operation planned for use in evaluating the data are discussed in each of **Sections 3** through **8** of this plan, as well as in **Appendix A**.

** Numbers 1-6 correspond with the NPDES MS4 Permit monitoring objectives listed in **Section 1.3** above and Schedule B.1.a.(i-vi) in the 2010 NPDES MS4 permit:

This Monitoring Plan describes eleven different monitoring elements that Gresham and Fairview will utilize to meet these objectives. All eleven are described in **Appendix A-1**, and seven of them are detailed in individual sections of the Monitoring Plan:

- Section 3.0 Instream Monitoring,
- Section 4.0 Continuous Instream Flow and Temperature Monitoring,
- Section 5.0 Macroinvertebrate Monitoring,
- Section 6.0 Wet Weather Stormwater Monitoring,
- Section 7.0 Dry Weather Field Screening,
- Section 8.0 Structural Best Management Practices Monitoring, and
- Section 9.0 Source Control Assessment and Solids Tracking

Appendix A-2 is a summary of Gresham and Fairview environmental monitoring program which provides a concise overview of the location, frequency, type of sample, pollutants analyzed, and potential changes planned for these seven elements.

1.7 The Relationship between Environmental Monitoring and a Long-term Monitoring Program Strategy

The goals for the monitoring program are the objectives listed in the permit (Schedule B.1.a) and in **Section 1.3** above, which relate to the management questions shown in **Section 1.6: Table 1**. The permittees use national, state and local monitoring data and values from scientific studies obtained from literature reviews, together with models and regulatory approaches such as water quality standards, the 303(d) list, and TMDLs to determine which pollutants or channel forming factors are of concern at a given point in time, and how the effects of these things change over time, both in response to Co-permittee actions (e.g. BMPs and regulations), and to outside influences. Based on such findings, Co-permittees are able to adaptively manage best management practices to achieve performance and cost effectiveness to the maximum extent practicable, and regulate/encourage specific actions by the private sector.

Historical monitoring data, along with the data collected during the December 2010 NPDES MS4 permit cycle have answered some management questions—especially with respect to certain pollutants or BMPs, but environmental monitoring will be needed for the foreseeable future, both to allow for more findings of statistical significance, and to address new questions. For each element discussed below, additional detail is provided regarding the relationship between the current approach and long-term goals or strategies.

2.0 DATA GATHERING STRATEGIES

There are three primary strategies that the Co-Permittees will employ to obtain data and information to meet the six monitoring objectives listed in the NPDES MS4 permit:

1. Examine and evaluate historic water quality data and other information collected as part of previous monitoring efforts specifically for meeting monitoring objectives;
2. Collect new water quality data to complement the existing data and address specific objectives that have not been previously examined; and
3. Review data and technical information related to stormwater quality collected by others and track national trends in stormwater water quality assessment and best management practice (BMP) application and performance.

An important aspect of any research is the assurance that the samples collected represent the conditions desired to be tested and that the number of samples to be collected is sufficient to provide statistically relevant conclusions. An experimental design process can be used to estimate the number of samples needed based on the allowable error, the variance of the observations, and the degree of confidence and power needed for each constituent. The number of samples needed is therefore dependent on the objectives of the data (characterization, comparison, trends, etc.), the variation of the concentrations in the category being investigated (the ratio of the mean to the standard deviation or Coefficient of Variation (COV)), and the allowable errors (Burton and Pitt 2001). Due to the variability in stormwater data (COVs greater than 1), it can be difficult to identify trends in water quality, and large sample sizes are often needed to report statistically significant findings.

The Co-Permittees will continue to focus their water quality monitoring efforts related to instream samples on developing more robust information for existing monitoring sites. Trend analysis conducted for the 2010 renewal submittal and the 2014 Pollutant Load Reduction Evaluation identified some significant trends. Based on fourteen years of data, positive trends reinforce our conclusion that the stormwater management program is yielding positive water quality effects and that the monitoring program is resulting in adequate data to help evaluate the program. New monitoring sites may be added in the future to help evaluate the effects of future development in the Springwater annexation area.

Wet Weather Sampling has occurred at 180 UIC sites over the past 6 years. From these data some clear trends have been found. The most apparent trend is that roads with >1000 trips per day have higher levels of most measured pollutants than those with <1000 trips per day. Additionally, sites draining industrial land use had higher levels of total suspended solids and several metals than other land uses, and residential streets had higher levels for some pesticides than other street types.

We plan to prioritize reduction of pollutants from high-traffic streets by targeting these streets in retrofits. Further understanding of pollutant reduction strategies would greatly benefit from more information on the functioning of our BMPs. The City of Gresham has recently constructed several regional facilities with different designs, and several more are planned in the near future. Understanding the effectiveness of each of these facilities will help inform design and planning in the future to reduce pollutants from stormwater. We are currently sampling 2 storm events at 1 facility/year. By decreasing UIC Wet Weather Monitoring we will be able to increase our BMP Monitoring.

We currently collect water quality data during 5 storm events per year: 2 for BMPs and 3 for UIC Wet Weather. We propose to continue monitoring 5 storm events/year by moving effort from UICs to BMPs and collecting water quality data from: 4 events for BMPs and 1 event for UICs. We plan to decrease our UIC monitoring from 30 sites/year to 10 sites per year and to increase BMP sampling from 2 events/year at 1 facility to 4 "facility events"/year (e.g. 2 facilities may be sampled for each of 2 storms, or 4 facilities may be sampled during 1 storm each). The distribution of BMP storm monitoring may change from year to year as we address questions about certain facilities. If logistics allow, we may sample a given storm at two facilities to allow for direct comparisons.

Due to the difficulty in accurately predicting the size and duration of storms, we will collect a minimum of 3 grab samples/BMP location/storm instead of collecting 5 to 12-part composite samples/BMP location/storm. Although composite sampling has been shown to be an effective method for collecting representative water samples during the duration of a storm, in practice the samples are often not taken at the ideal points during the storm due to difficulty in prediction storm patterns. This can lead to mischaracterization of pollutant loads during storms. To account for this, we will be taking a minimum of 3 individual grab samples throughout each sampled storm and looking at the average and peak levels for each pollutant.

The City's dry weather screening monitoring currently occurs at 30 fixed outfalls annually. These outfalls were selected because they drain relatively large or industrial areas. We will continue to monitor 8 of these outfalls every year, while monitoring 22 new outfalls every year. This approach increases the probability of detecting illicitly connections and discovering illicit discharges in areas previously not frequently monitored. The 8 previously-sampled outfalls are prioritized by drainage from high-risk properties and data of past illicit discharges. The rotating 22 new outfalls will be selected using GIS risk attributes of drainage area size and land use. Our proposed approach is supported by a report by the Urban Water Resources Research Council as one of the best methods for addressing the bacteria TMDL in urban areas because it is an easy way to detect illicit connections between the stormwater and sanitary sewer systems (Urban Water Resources Research Council, 2014, Pathogens in Urban Stormwater Systems Technical Report, Eds: Clary, Pitt, Steets).

As required in Schedule B 2 e ii, these changes do not reduce the number of data points sampled by the Monitoring Program.

NPDES MS4 permitting and other programs with surface water monitoring components have helped to identify water quality problems associated with stormwater runoff. In response to these problems, the scientific community, public agencies, and private organizations interested in stormwater management continue to conduct research related to stormwater characterization and treatment. This research is costly and it is often beyond the means of any one permittee to conduct a significant study. Organizations such as the Oregon Association of Clean Water Agencies (ACWA), the Bay Area Stormwater Management Association (BASMA), the Center for Watershed Protection, and others assist public agencies with collaborative projects to examine complex issues that individual permittees could not likely accomplish on their own.

Historically, public departments of transportation (e.g., ODOT and Caltrans) have also performed large scale studies on stormwater pollution distribution, transport, and treatment. Additionally, vendors of proprietary stormwater treatment systems often participate in evaluation studies that follow strict protocols to have their devices approved by local agencies. By participating in these groups and following current research, the Co-Permittees can realize greater benefits from labor and capital investment than if they were to attempt such studies on their own. As such, the Co-Permittees will take advantage of information garnered by these groups to meet some of the more complex and costly objectives of the permit.

The Co-Permittees believe this Monitoring Plan represents the best possible allocation of limited resources, considering that water quality sampling requires significant staff time and funds, yet the activity itself does not result in direct water quality improvements. By continuing to collect data at existing instream sampling locations, and collaborating with other jurisdictions on larger studies and literature reviews, information will be gathered over time that will be useful to make informed adaptive management decisions.

The most resource-intensive element of water quality monitoring is sampling of storms. Because of the difficulty obtaining accurate weather forecasts of suitable storms that meet size and duration requirements, combined with the labor intensive efforts necessary to mobilize staff and equipment during a 24-hr timeframe, each storm may represent one or more failed attempts to sample. Therefore, to achieve the minimum storm sampling commitment represents a significant program administration costs. To this end, staff are assigned other responsibilities in addition to monitoring, such as erosion control inspections, water quality facility inspections, business inspections, spill response, citizen complaint response, and research and program evaluation.

- Thus, to ensure that monitoring does not consume inordinate resources at the expense of activities that prevent or reduce pollution, while still meeting NPDES MS4 and WPCF permit objectives, the following storm sampling limitations apply: In a given year, staff will endeavor to obtain samples from two to four storms at Gresham's structural BMPs, and from 10 stormwater monitoring sites by tracking daily weather patterns. Staff will clear work and/or personal schedules up to fifteen times to allow for mobilization and mobilize up to eight times. Once this level of effort has been made, the Co-Permittees will consider the storm monitoring commitment for the year to have been met.
- Storms will not be sampled on federal holidays such as: Thanksgiving, Christmas, and New Year's Eve.
- The criteria for determining whether a storm is appropriate for sampling will be based on the climate of the Pacific Northwest and the specific weather patterns of a given year. For example, in a dry year, the size of an acceptable storm may be smaller than in a wet year. In a wet year the dry period preceding a storm may be shorter than average.

- The criteria for determining whether a storm is appropriate for sampling will also depend on the size of the drainage area for the stormwater being sampled, and the amount of base flow, if any, that normally exists within the catchment.
- The duration of time between samples taken as part of a composite sample, or as part of a time series will be varied as necessary to meet the goal of obtaining at least five samples per storm. Samples will not be taken more frequently than once each half hour, and a good-faith attempt will be made to characterize the duration of each storm.
- Stormwater sampling will target daylight hours to enhance the safety of sampling staff. A portion of the area to be sampled lies within an area of Gresham that has documented gang activity and experiences higher crime rates than other areas. If daylight hours prove too limiting to collect the required data, the monitoring locations may be adjusted away from some wet weather stormwater sampling sites selected through the GRTS protocol addressed in **Section 6.0** of this plan.

3.0 INSTREAM MONITORING

3.1 Project/Task Organization

As required by the NPDES MS4 permit, Schedule B, Table B-1 and 2. & 3, Instream monitoring refers to the monitoring of major streams and Fairview Lake within the permit area. Routine monitoring began at most in-stream sites in 2000; continued monitoring seeks to determine whether trends are showing improvements in water quality.

3.2 Monitoring Objectives

3.2.1 Monitoring Question and Background

Instream monitoring is intended to track the status and trends of water quality in water bodies receiving MS4 discharges to address the question "What is the impact that Gresham and Fairview's stormwater discharges are having on the exceedances of instream water quality standards?" It is assumed that by comparing water quality as each stream enters and exits the permit area, the effect on water quality of actions under the Co-permittees' jurisdiction may be discerned. It is further assumed that sampling during both wet and dry periods will allow the Co-permittees to distinguish between the effects of runoff, versus other effects, on streams.

As shown in **Appendix A-**, instream monitoring contributes to meeting NPDES MS4 monitoring objectives 1, 2, 3, 4, 5 and 6.

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*
Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities;*
Objective 3. *Characterize stormwater runoff discharges based on land use, seasonality, geography or other catchment characteristics;*
Objective 4. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;*
Objective 5. *Assess the chemical, biological and physical effects of MS4 stormwater discharges on receiving waters;*
Objective 6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

3.2.2 Data Analysis Methodology and Quality Criteria

Instream water quality data will be assessed using a trend analysis, conducted at least once for the NPDES MS4 permit cycle. Since environmental data typically does not follow a normal distribution, a nonparametric equivalent to ordinary least squares regression will be used – the Seasonal Kendall, and the associated statistic, Kendall's tau. Because instream data has been and will be collected during the wet and dry season, trends will be assessed by those two periods. Data may also be evaluated by flow or rainfall data, since data collected in the wet season may not always be associated with higher flows or MS4 discharges. An assessment of trends based on potential for MS4 contribution might focus on instream monitoring events collected after 0.1" or more rain occurred within the preceding 24 hours. The significance of any trend would be evaluated against an alpha (α) value of at least 0.1, with a goal to demonstrate significance at α=0.05.

3.2.3 Assumptions and Rationale

The instream monitoring program described in this section was originally designed to determine whether water quality changes could be measured over time at sites selected to represent the upper and lower bounds of the permit area. Continued monitoring at the same locations will allow for assessing trends over time based on both wet and dry weather conditions. With more than 15 years of monitoring data already collected at most instream monitoring sites, continued monitoring will allow for assessment of long-term water quality trends.

3.2.4 Relationship to Long-term Monitoring Program Strategy

Instream monitoring provides a direct measure of the chemical, physical, and biological condition of waters of the state which receive MS4 stormwater discharges. The periodic water quality measurements described in this section are augmented by 1) correlating this data with continuous monitoring data described in **Section 4.0**, 2) collecting instream macroinvertebrate data as described in **Section 5.0** to assess biological condition, 3) comparing instream data to the Wet Weather Stormwater Monitoring data described in **Section 6.0,** to determine if changes in stormwater quality are related to changes in instream monitoring data, and 4) determining whether pollutant reduction estimates measured through the Structural BMP Monitoring described in **Section 8.0** are validated by trends detected instream. Continuing to conduct instream monitoring using an approach consistent with past instream monitoring efforts should enable the Co-Permittees to determine if short or long-term water quality trends are evident based on MS4 management decisions associated with implementation of their SWMPs.

3.3 Documentation and Record-keeping Procedures

Consistent with permit requirements specified in NPDES MS4 permit Schedule F, Section C.5., the Co-Permittees will retain records of all monitoring information, including: all calibration, major maintenance records, all original lab and field data (see **Appendix C** for example of field data sheet), copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application.

Records will contain:

1. The date, exact place, time, and methods of sampling or measurements;
2. The individual(s) who performed the sampling or measurements;
3. The date(s) analyses were performed;
4. The individual(s) who performed the analyses;
5. The analytical techniques or methods used; and
6. The results of such analyses.

3.4 Monitoring Process/Study Design

3.4.1 Study Design

Instream Monitoring is conducted to help characterize or estimate the potential impacts of MS4 stormwater runoff on streams, as well as the potential benefits of the best management practices being applied by the Co-Permittees as described within their SWMPs. The study design is a paired test, where samples have historically been taken at even intervals throughout the year from where a stream enters and exits the permit boundary. Sites are always sampled in the same order at approximately the same time of day in order to facilitate long term trending of data collected at the same location over time. The timing interval between the paired upstream/downstream locations is always less than 2 hours, with the target being to collect samples on the same stream within an hour of each other.

The current study design has enabled the Co-permittees to conduct a Seasonal Kendall test and to check for trends over time. To date, stream quality has been well characterized, and some differences between upstream and downstream have been identified with statistical significance at the 95% confidence (α=0.05) level. When possible, a relationship will be made between BMP implementation and improving water quality trends, particularly for events collected during rain events or during the wet weather season. Continued monitoring will allow the Co-permittees to look for additional findings of significance.

We will continue to monitor the fixed instream sampling locations in the following ways: water quality 4 times/year, macroinvertebrates 1 time/year, and continuous summer temperatures.

3.4.2 Monitoring Locations

Instream monitoring stations are located in major creeks as close to the upstream and downstream intersections with Gresham and Fairview City boundaries as feasible. There are three major receiving waters for the Co-Permittees' surface water runoff. These include:

1. The Columbia Slough
2. Kelly/Burlingame/Beaver Creek system (Sandy River watershed)
3. Johnson Creek

Samples are also collected at sites in the following water bodies:

1. Fairview Creek (drains to Fairview Lake, and then to Columbia Slough)
2. Fairview Lake (drains to the Columbia Slough)
3. Kelley Creek (tributary to Johnson Creek)

Columbia Slough

The Columbia Slough flows east to west from the north end of the City of Gresham and Fairview toward Portland. The Slough proper begins at the outlet from Fairview Lake, so most of this narrow and shallow channel flows within the City of Portland. Instream Columbia Slough monitoring is being conducted through an inter-governmental agreement (IGA) with the City of Portland Bureau of Environmental Services (BES) **See Appendix F.** In 2010, Portland altered their historic fixed station monitoring and began sampling using a probabilistic spatially-balanced and random approach (description of Oregon master sample in Larsen et al. 2008). Portland's monitoring includes the segment of the Slough within Gresham, but the specific locations to be monitored on their 4-year rotation and are not reflected in **Table 2** or on **Figure 1**. The monitoring complies with the sampling requirements of the 1998 Columbia Slough TMDL. The Co-permittees will review the data Portland collects for the upper Slough in the context of the entire Slough, but the sites within Fairview Creek and Fairview Lake will be used to meet the required number of monitoring sites in the NPDES MS4 permit Table B-1.

Fairview Creek and Fairview Lake

The headwaters of Fairview Creek are within the City of Gresham's boundary. The creek flows through Gresham and Fairview and discharges to Fairview Lake. Fairview Lake discharges to the Columbia Slough. Gresham will conduct instream monitoring at two locations on Fairview Creek and one in Fairview Lake. Currently, the instream locations include one site just north of Stark Street, upstream of the Gresham-Fairview boundary and the other site is located within the City of Fairview just upstream of the discharge to Fairview Lake (see Stations 1, 2, and 3 on **Figure 1**). Monitoring activities at the two stream and one lake locations will be conducted by City of Gresham staff based on an inter-governmental agreement between Gresham and Fairview.

Kelly Creek

Kelly Creek enters and exits the City of Gresham on its eastern boundary. Two instream monitoring locations are located on this creek, one on the upstream section of the creek at the Gresham boundary and the other on the downstream section of the creek near Mount Hood Community College (MHCC) (see Stations 4 and 5 on **Figure 1**). Monitoring on Kelly Creek will be conducted by City of Gresham staff.

Johnson Creek

Johnson Creek flows from east to west across the southern part of the City of Gresham. Two instream monitoring locations are established on this creek, one on the upstream section of the creek near the City's eastern boundary, and a second on the downstream section near the City's boundary with Portland (see Stations 6, and 7, on **Figure 1**). Monitoring on Johnson Creek will be conducted by City of Gresham staff. Before the current permit expires in 2015, the City of Gresham will evaluate financial and staffing resources available to support the addition of one or two additional sampling locations in the Johnson Creek basin in order to characterize the Springwater annexation area prior to future development.

Kelley Creek

Kelley Creek flows from east to west across the southwestern part of Gresham, starting in the Kelley Creek Headwaters area and flowing through the Pleasant Valley area as shown on **Figure 1**. Two instream monitoring locations are established on this creek, one on the upstream section of the creek outside the Gresham's current boundary, and a second on the downstream section near the Gresham's boundary with Portland (see Stations 8 and 9 on **Figure 1**). Monitoring on Kelley Creek will be conducted by City of Gresham staff.

Table 2 summarizes the instream monitoring locations.

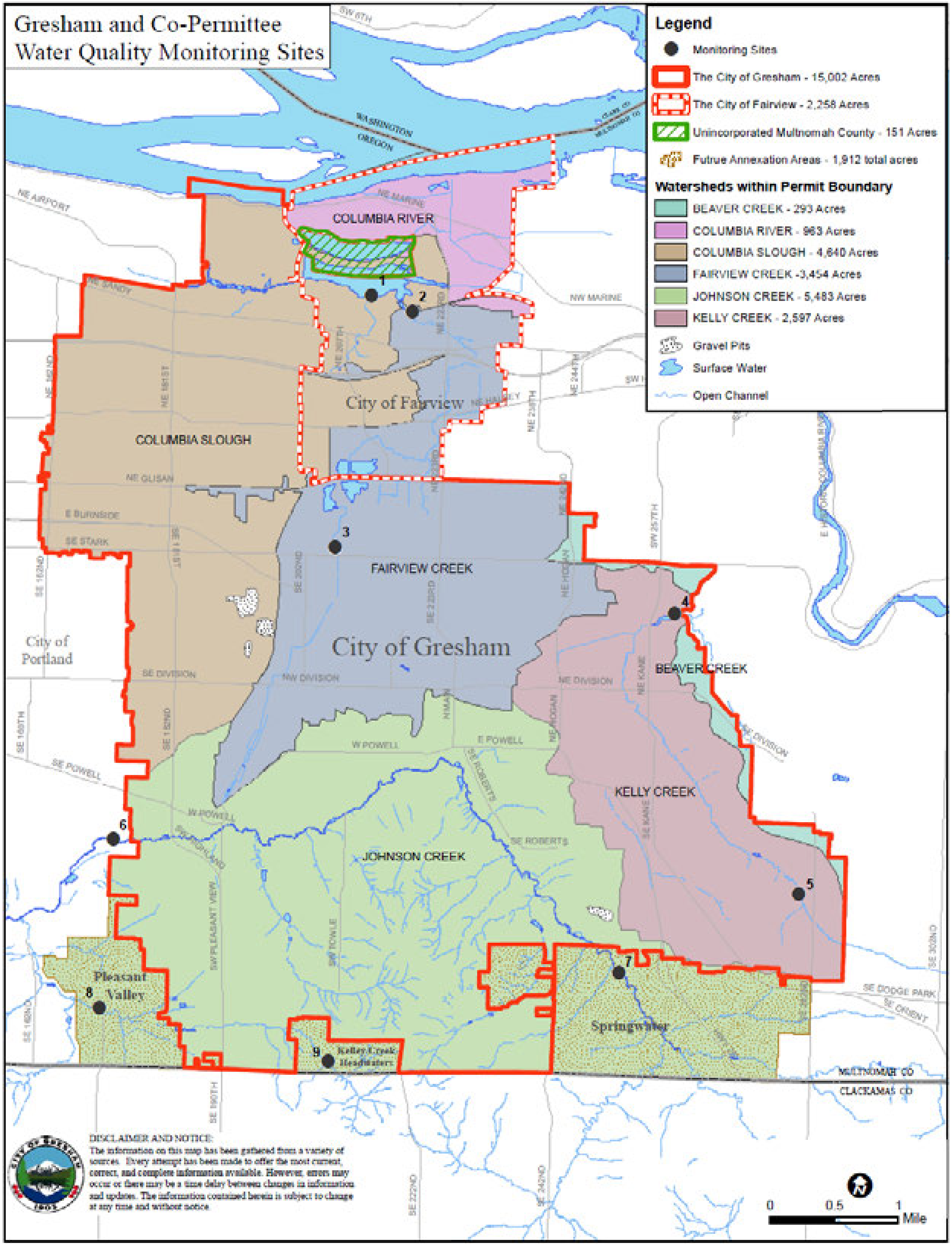
Table 2: Instream Monitoring Locations

Station Number*	Site Code	Stream	Location
Columbia Slough Basin			
1	FVL1	Fairview Lake	Lakeshore Park in City of Fairview

2	FCI0	Fairview Creek	Mobile estates upstream of Fairview Lake in City of Fairview
3	FCI1	Fairview Creek	Conifer Park (205th and Stark) in City of Gresham
Sandy River Basin			
4	KCI1	Kelly Creek	Downstream of Mount Hood Community College pond
5	KCI4	Kelly Creek	Upstream from Kelly Creek Detention Pond
Johnson Creek Subbasin			
6	JCI1	Johnson Creek	Near Jenne Rd Bridge
7	JCI2	Johnson Creek	Near Palmblad Bridge upstream of Gresham
8	KI1	Kelley Creek	Pleasant Valley Grange
9	KI2	Kelley Creek	Rodlun Rd near Alder Ridge

* Station numbers relate to Figure 1.

Figure 1. Instream Monitoring Locations



3.4.3 Sampling Event Criteria

The NPDES MS4 permit (Schedule B.3.a.) requires that a minimum of 50% of instream monitoring be conducted during the wet season (October 1 to April 1) and that each sample event be a minimum of 14 days apart. Reasonable attempts will be made to conduct sampling during storm events, since rainfall is related to stormwater runoff. A 2008 analysis of bi-monthly monitoring over an 8 year period (490 samples) indicated that 50% of monitoring events had measurable precipitation (0.01" min, 0.88" max) in the preceding 24 hours; 35% had 0.10" or more in the preceding 24 hours. This suggests that the current approach of sampling at a fixed date is an effective strategy for gathering wet weather data.

3.4.4 Frequency and Duration

Instream water quality samples will be collected during the dry season and wet season. At a minimum, grab samples will be collected four times per year at the instream sampling locations listed in **Table 2**.

3.4.5 Responsible Sampling Coordinator

This monitoring task is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham and Fairview, who target events, calibrate equipment, perform in-situ field measurements, collect samples for lab analysis, and coordinate delivery to the lab. Laboratory analysis for instream samples is conducted by Portland's Water Pollution Control Laboratory under an IGA with the City of Gresham for laboratory services, included as **Appendix F**.

3.5 Sample Collection and Handling

3.5.1 Sample Collection Method

The sample collection method varies by constituent. **Table 3** shows the collection method for each constituent, the instream monitoring locations, and periods when each constituent is monitored.

Table 3: Sample Collection Methods for Instream Monitoring

Constituents	Collection Method	Stations	Period
Field			
Temperature, DO, Conductivity, pH	In-situ	3-11	Quarterly
Turbidity	Grab	3-11	Quarterly
Conventional			
Biochemical Oxygen Demand (BOD_5), Total Suspended Solids, Hardness, *E. coli*	Grab	3-11	Quarterly
Chlorophyll-*a*	Grab	3-11	Summer*
Total Recoverable Metals			
Copper, Lead, Mercury**, Zinc	Grab	3-11	Quarterly
Dissolved Metals			
Copper, Lead, Zinc	Grab	3-11	Quarterly
Nutrients			

Nitrate + Nitrite Nitrogen, Total Kjeldahl Nitrogen (TKN)**, Ammonia Nitrogen, Total Phosphorus, Ortho-phosphorus	Grab	3-11	Quarterly
Legacy Pesticides			
DDT, Dieldrin	Grab	8, 9	Quarterly

* Chlorophyll-*a* is monitored May through October only.
** Mercury and TKN are not required in Table B-1 of the NPDES MS4 permit, so are subject to the Adaptive Management process described in **Section 1.4**.

3.5.2 Handling and Custody Procedures

Field measurements are collected by placing the multi-meter probe directly into the thalweg of the stream, and waiting for readings to stabilize. For grab samples, samples are collected directly into the appropriate containers directly from the thalweg, when possible. One bottle is field-filtered for ortho-phosphorus analysis. If needed, samples will be collected using a clean stainless steel bailer attached to an extension rod. The stainless steel bailer is cleaned prior to each site using laboratory-grade soap and distilled water or rinsed 3 times with the water to be sampled at each site prior to sampling.

Two-person clean sample collection techniques are followed to minimize the potential for contamination of samples: one person acts as "dirty hands" to move equipment, document field measurements, grab samples using the bailer and remove manhole lids; and one person acts as "clean hands" to fill sample bottles. The "clean hands" person wears powder-free nitrile gloves to avoid contamination of the sample and protect staff from possible health risks.

All samples collected for laboratory analysis are immediately placed into a cooler containing ice and transported to the lab immediately following sample collection. **Table 4** lists the volume of sample collected, the container used and maximum holding time. Once samples are delivered to Portland's Water Pollution Control Laboratory, they are responsible for following their own Quality Assurance Project Plan (QAPP) to ensure that samples are analyzed within the proper holding time (see **Appendix G**).

Table 4: Sample Containers and Holding Times for Instream Monitoring

Constituent	Minimum Sample Volume	Bottle Type	Holding Time
Conventional Constituents			
Biochemical Oxygen Demand (BOD_5)	250 mL	Plastic	24 hours
Total Suspended Solids	500 mL	Plastic	7 days
Hardness	250 mL	Plastic	6 months
E. coli	100 mL	Sterile Plastic	6 hours (max 24 hrs.)
Chlorophyll-*a*	1 liter	Amber Glass	3 weeks once filtered
Nutrients			
Nitrate Nitrogen	100 mL	Plastic	48 hours
Total Kjeldahl Nitrogen (TKN)	100 mL	Plastic	28 days

Ammonia Nitrogen	100 mL	Plastic	28 days
Total Phosphorus	100 mL	Plastic	28 days
Ortho-phosphorus	250 mL	Plastic	48 hours
Total Recoverable Metals			
Copper	400 mL	Plastic	6 months, once preserved
Lead			
Zinc			
Mercury			28 days
Dissolved Metals			
Copper	400 mL	Plastic	6 months, once preserved
Lead			
Zinc			
Legacy Pesticides			
DDT	1 liter	Amber Glass	28 days once extracted
Dieldrin			

After samples have been obtained and the collection procedures properly documented, a written record of the chain of custody for each sample requiring laboratory analysis is completed (see **Appendix C)**. Information included on the chain of custody includes:

- Name of the persons collecting the sample(s)
- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples etc.) and any special instructions (e.g., time sensitive analyses).

To ensure that all necessary information is documented, a chain of custody form will accompany each sample or set of samples and a copy of the form is retained. Each person who takes custody will sign and date the appropriate portion of the chain of custody documentation.

3.6 Constituents and Methods

The analytical methods and method reporting limits (MRLs) for constituents monitored for instream sampling are listed in **Table 5**.

Although iron and manganese are included on the 2004/06 303(d) list for the Columbia Slough and Lower Willamette River, DEQ has stated that these concentrations are naturally elevated due to local geology. DEQ has also stated that a future Willamette River TMDL for iron and manganese is extremely unlikely given the data that the current listings are based upon. Therefore, iron and manganese have not been included in the list of constituents for analyses.

Only total recoverable mercury will be collected based on historic monitoring data for dissolved mercury being below the detection limit. Mercury sampling may be adaptively managed as allowed in the permit in the future to meet other regulatory program requirements.

Table 5: Constituents, Methods and MRLs for Instream Monitoring

Field Constituents	Analytical Method	MRL*	Units
Temperature	SM 2550 B	-5	Degrees C
DO	SM 4500-OG	0.1	mg/L
Conductivity	EPA 120.1	1.0	µs/cm
pH	EPA 150.1	3.0	S.U.
Turbidity	EPA 180.1	0.05	NTU
Conventional Constituents			
Biochemical Oxygen Demand (BOD_5)	SM 5210 B	2	mg/L
Total Suspended Solids	SM 2540 D	2	mg/L
Hardness	SM 2340 B	0.5	mg/L as $CaCO_3$
E. coli	COLILERT QT	10	MPN/100 mL
Chlorophyll-*a*	SM 10200 H	2.0	mg/M3
Nutrients			
Nitrate Nitrogen	EPA 300.0	1.10	mg/L
Total Kjeldahl Nitrogen	PAI-DK03[1]	0.20	mg/L
Ammonia Nitrogen	EPA 350.1	0.02	mg/L
Total Phosphorus	EPA 365.4	0.02	mg/L
Ortho-phosphorus	EPA 365.1	0.02	mg/L
Total Recoverable Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Mercury	WPCLSOP M-10.02 [2]	0.002	µg/L
Zinc	EPA 200.8	0.5	µg/L
Dissolved Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Zinc	EPA 200.8	0.5	µg/L
Legacy Pesticides			
DDT	EPA 8081 [3]	2.5	ng/L
Dieldrin	EPA 8081 [3]	2.5	ng/L

*Method Reporting Limit

[1] The PAI-DK03 method for TKN is a 40 CFR 136 method (flow injection gas method, see footnote 41, Table 1B, 40 CFR Part 136.3).

[2] The WPCLSOP M-10.02 method cited for total Hg is EPA 200.8 w/CEM digestion (footnote 4, Table 1B, 40 CFR Part 136.3)

[3] EPA SW846 Method 8081 is nearly identical to 40 CFR 136 approved method EPA 608 and is often used interchangeably with EPA Method 608 for analyzing organochlorine pesticides, including DDT, DDD, DDE and

Dieldrin. Based on a DEQ response dated 7/27/2011citing similarities between the methods, method 8081 meets the criteria of a modified version of 608 under the description outlined in 40 CFR Part 136.6 “Method Modifications and Analytical Requirements”.

3.7 Quality Control Procedures

3.7.1 Quality Assurance

The data quality objectives for field measurements are listed in **Table 6**. Precision and accuracy are referenced from the DEQ Data Quality Matrix. Because field measurements for temperature, pH, DO and conductivity are made using a multi-meter probe, precision between replicates is usually not assessed since meter values are continuously assessed and not documented until they stabilize. Accuracy for field measurements is determined by measuring standards before and after each sampling event and assessing deviation from the standard in comparison to accuracy ranges in **Table 6**.

Table 6: Accuracy and Precision Targets for Instream Field Measurements

Parameter	Precision	Accuracy	Measurement Range
Temperature	± 1.0 ºC	± 0.5 ºC	-5 to 45 ºC
pH	± 0.3 SU	± 0.2 SU	0 to 14 SU
Dissolved Oxygen	± 0.3 mg/L	± 0.2 mg/L	1 to 50 mg/L
Conductivity	± 10% of Std. Value	± 7% of Std. Value	0 to 200 mS/cm
Turbidity	± 5% of Std. Value ± 1 NTU if NTU <20	± 5% of Std. Value	0 to 1000 NTU

Analytical methods for grab samples analyzed at Portland’s Water Pollution Control Laboratory use an appropriate balance of quality assurance/quality control measures, including replicates, blanks, spiked samples and other measures approved under 40 CFR 136 to ensure that data meet quality objectives appropriate for compliance with state and federal regulatory requirements. A copy of the WPCL’s QAPP is included in **Appendix G**.

Field duplicate samples will be collected at a minimum of 10% of the total number of monitoring locations (1 duplicate for every 10 sites). For in-stream sampling, one lab replicate will be collected from one of the 10 in-stream sampling sites on a random rotating basis. Any data or sample values outside of the expected range for the constituent being measured will be rechecked for validity with the laboratory or in the field by the field team as appropriate. Data that continue to be outside the expected values will be further evaluated to determine potential causes.

Duplicate measurements are not collected for field constituents (DO, pH, temperature, conductivity, turbidity). Instead, quality assurance for field constituents will be assessed by calibrating the equipment prior to mobilization on the day of the monitoring event and by measuring equipment with a known standard after each monitoring event to measure how accurately the equipment can still read the standard within the accuracy ranges specified in **Table 6**.

Field blanks will also be collected for 10% of sampling mobilization events. Equipment blanks will be generated annually by the WPCL to ensure that equipment and bottles provided by the lab are not producing false positive readings.

3.7.2 Representativeness

Instream samples are collected about 4 inches below the water surface from within the thalweg or near the center of the stream channel where the water is assumed to be well mixed and representative of the ambient conditions.

3.7.3 Comparability

The objective is to ensure that collected data are either directly comparable or comparable, with defined limitations, to literature data or other applicable criteria. Instream samples are collected and analyzed in the same manner as those collected for Wet Weather Stormwater Monitoring and Structural Best Management Practice Monitoring. Grab samples are analyzed at Portland's Water Pollution Control Laboratory to minimize variability and increase comparability of data collected on streams flowing through both jurisdictions.

3.7.4 Completeness

Completeness is a measure of the amount of valid data obtained from the analytical measurement system compared to the amount that was expected to be obtained. It is defined as the total number of samples taken for which valid analytical data are obtained divided by the total number of samples collected and multiplied by 100.

The goal for Instream Monitoring is to achieve a 100 percent complete data set for all analyses. It is anticipated that over the 5 year permit term, 20 samples will be collected from each monitoring location. It is understood that due to unforeseen circumstances, such as abnormal climatic conditions, unsafe or impractical sampling conditions, equipment vandalism or equipment failures that occur despite proper operation and maintenance, some results may be lost. Field and Laboratory staff will attempt to minimize data loss to the best of their ability by carefully following all protocols and procedures. If data sets are not 100 percent complete for this study, analyses will be evaluated on a case by case basis to determine whether additional samples are able to be collected considering available time, season, competing regulatory obligations, and cost.

3.7.5 Instrument Inspection and Maintenance

Field sampling equipment is inspected before and after each monitoring event. The multi-meter and turbidimeter will be cleaned and maintained according to the manufacturer's guidelines. Multi-meters will be professionally inspected, maintained and calibrated annually by Quality Control Services (2340 SE 11th Ave, Portland, OR. 503-236-2712).

Portland's Water Pollution Control Laboratory performs inspection and maintenance of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

3.7.6 Instrument Calibration

The multi-meter probe used to collect field measurements (temperature, pH, DO, and conductivity) will be calibrated prior to each event at mobilization. pH will be calibrated using a 3-point calibration (pH 4, 7 and 10 buffers). Conductivity will be calibrated using a standard within the range of expected measurement (typically 100 µS/cm). DO will be calibrated using percent saturation at the current barometric pressure. Meter calibration will be recorded in an electronic calibration log. Meters will be calibrated halfway through the monitoring event if the accuracy of the meter drifts during the monitoring event. After each sampling event the meter will be measured against known standards to check measurement accuracy.

The turbimeter will be calibrated annually. Prior to each sampling event, the meter will be measured against known secondary Gelex sample standards to ensure accuracy. Readings will be recorded in the electronic calibration log.

Portland's Water Pollution Control Laboratory performs calibration of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

3.8 Data Management, Review, Validation and Verification

3.8.1 Data Management

Results will be provided to Gresham by the laboratory in electronic format and shared with the City of Fairview. QA/QC files are included with the electronic reports and will be stored electronically on the City of Gresham's servers. A separate record will be generated for each sample date.

In addition, the key information such as station ID, sample date and time, name of sampler, name of constituent, all results, units, detection limits, EPA methods used, name of the laboratory, and any field notes will be entered into the database. Additional information, such as compositing of multiple samples, or the use of grab or automatic samples, will also be included.

All analytical results and applicable field measurements, including field data sheet information, will be stored in Gresham's Monitoring Program database. Lab data will be reviewed and entered as soon as practicable, with data entry, analysis, and summarization being shared with Fairview and summarized in the NPDES MS4 Annual Report. Additional analysis will be conducted for the permit renewal to assess instream trends. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate.

3.8.2 Data Review, Validation and Verification

The Monitoring Program Coordinator will check all field data sheets for completeness and accuracy at the end of each sampling event. Errors will be corrected prior to sample delivery and data entry. All data will be entered into Gresham's master NPDES MS4 data spreadsheet. The data will be reviewed and input by the sampling team leader. Ideally, the data should be reviewed for input accuracy, however, limited staff time does not typically allow for this step. A secondary check will be used to periodically validate data entry accuracy.

Once the data has been entered in the project database, the Monitoring Program Coordinator will print a paper copy of the data and proofread it against the original field data sheets. Statistical and graphical analysis may be used to reveal whether keystroke errors occurred during data entry. Potential errors in the database will be checked against field data sheets and lab reports. Once verified, errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review, investigation, and if appropriate, discarded. Data quality problems will be discussed as they occur and in the final report to data users.

Reconciliation with data quality objectives as noted above will be performed as soon as possible after each sampling event. Calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. If data quality indicators do not meet the monitoring program's specifications, data may be discarded and re-sampling may occur. The cause of the failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance techniques will be reassessed and improved. If the problem is found to be sampling team error, field techniques will be assessed, revised, and retrained as needed.

4.0 CONTINUOUS INSTREAM FLOW AND TEMPERATURE MONITORING

4.1 Project/Task Organization

As required by the NPDES MS4 permit, Schedule B, Table B-1 and 2. & 3, continuous instream flow and temperature monitoring refers to the ongoing collection of data at short intervals (every 15, 30, or 60 minutes, depending on constituent) at fixed locations throughout key watersheds. There are three different sources of continuous data within the permit area:

1. The USGS operates and maintains gages on Johnson and Fairview Creeks that collect continuous flow data, based on a cost-sharing agreement with the City of Gresham (Johnson Creek gage also collects temperature and turbidity);
2. The City of Gresham deploys continuous temperature data loggers during summer months at the fixed Instream Monitoring locations listed in **Section 3.4.2**, **Table 2.**
3. The City of Portland operates Hydrolabs through Columbia Slough that collect continuous field constituents (temperature, pH, DO and conductivity). Because the City of Portland handles all monitoring and assessment of Columbia Slough through an IGA (see section 3.3.2 and Appendix F), the continuous monitoring for the Slough is not addressed in this Monitoring Plan.

The USGS currently operates stream discharge gages and has a joint funding agreement (see **Appendix E**) with Gresham to do so at two locations. Gresham also contributes to USGS monitoring efforts in the Johnson Creek watershed that cooperatively funds a gaging station at the mouth of Kelley Creek and ongoing USGS monitoring of groundwater in the watershed. **Section 4.4.2**, **Table 7** describes the USGS Gaging Stations.

During the review required for the 2006 Interim Evaluation Report, the City's consultant recommended that the Co-Permittees explore the potential for collecting continuous flow and temperature data at each of the instream monitoring locations. Summer temperature monitoring at each instream location has been conducted since summer 2008. Additional flow sites were considered, but it was determined that the calibration of models developed for the Stormwater Master Plans for each drainage basin has adequately characterized flows, and that additional continuous flow monitoring is not merited, especially given the Gresham's need to maximize the benefit of limited staff and financial resources.

Staff determined that new information on flow would be useful related to areas expected to annex and develop in the future. Gresham contracted with USGS to conduct a well study to determine current base flow conditions in the Pleasant Valley area, since it is expected to develop before the Springwater area. Gresham participates in the Johnson Creek Interjurisdictional Committee which cooperatively funds ongoing USGS monitoring of groundwater in the Johnson Creek watershed.

4.2.1 Monitoring Question and Background

Continuous Instream Flow and Temperature Monitoring is intended to track water quantity trends in two of the major water bodies within the permit area that receive MS4 discharges – Johnson and Fairview Creeks. Together with other data collected by the monitoring program, the use of flow and temperature models, and statistical analysis such as trending, this information should contribute toward an answer to the question: "To what degree and where are stormwater flows affecting water quality and/or aquatic life?" In addition to collecting rainfall data, continuous flow data helps the Co-permittees put the Instream Monitoring data described in **Section 3.0** into perspective and address the question "What is the impact that Gresham and Fairview's stormwater discharges are having on the exceedances of instream water quality standards?" As shown in **Appendix A**, continuous instream monitoring contributes to meeting NPDES MS4 monitoring objectives 1, 2, 3, 4, 5 and 6.

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*
Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities;*
Objective 3. *Characterize stormwater runoff discharges based on land use, seasonality, geography or other catchment characteristics;*
Objective 4. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;*
Objective 5. *Assess the chemical, biological and physical effects of MS4 stormwater discharges on receiving waters;*
Objective 6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

4.2.2 Data Analysis Methodology and Quality Criteria

Continuous instream flow and temperature data will be assessed graphically and through computation of summary statistics. The USGS graphs time plots of data they collect, as well as computing minimum, maximum and mean values. For flow and temperature, extreme values are the most critical for fish and aquatic life, so these extremes will be evaluated for ways the stormwater program can be adaptively managed to improve the chemical, physical and biological health of the MS4 receiving water.

4.2.3 Assumptions and Rationale

The Continuous Instream Flow and Temperature Monitoring performed by the USGS takes place at fixed locations. Continued monitoring at the same locations will allow for assessing long-term trends over time and provide a source of continuous information that can be used to put the Instream Monitoring described in **Section 3.0** into perspective. With 15-25 years of monitoring data already collected at the two continuous monitoring locations, continued monitoring over the next NPDES MS4 permit cycle and into the future will allow for assessment of long-term status and trends.

4.2.4 Relationship to Long-term Monitoring Program Strategy

Continuous flow and temperature monitoring provides a direct measure of the chemical and physical condition of waters of the state which receive MS4 stormwater discharges. The continuous measurements described in this section are augmented by 1) correlating this data with periodic water quality monitoring data described in **Section 3.0**, 2) determining how flow and temperature affect the macroinvertebrate sampling described in **Section 5.0**, 3) comparing rainfall and instream flow data to the Wet Weather Stormwater Monitoring data described in **Section 6.0**, and 4) determining whether BMPs implemented and monitored (described in **Section 8.0**) result in improvements to instream flow or temperature measurements. Continuing to conduct continuous instream monitoring using an approach consistent with past monitoring efforts will assist the Co-Permittees in determining if flow or temperatures trends are evident based on MS4 management decisions associated with implementation of their SWMPs.

4.3 Documentation and Record-keeping Procedures

Consistent with permit requirements specified in Schedule F, Section C.5., the Co-Permittees will retain records of all monitoring information, including: all calibration, major maintenance records, all original data, copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application. The USGS currently manages this data, and all data are available on-line through the Water Resources of Oregon, http://or.water.usgs.gov/

4.4 Sampling Process/Study Design

4.4.1 Study Design

Continuous flow and temperature monitoring conducted by the USGS was established to respond to the need for streamflow data related to the high-flow and low-flow hydrologic conditions. The sites were selected as part of a larger watershed study described in the "Hydrology of the Johnson Creek Basin" scientific investigation report (Lee and Snyder 2009). The City of Gresham began collecting continuous temperature data at fixed instream monitoring locations in an effort to better understand the diurnal fluctuations, determine the magnitude of summer maximums, and to develop a long-term baseline of temperature data that can be used to compare to shade targets established with the temperature TMDL.

4.4.2 Monitoring Locations

The City of Gresham deploys continuous temperature data loggers at the 8 fixed instream sampling locations listed in **Section 3.4.2 Table 2**. As stated in 4.3.1, continuous temperature monitoring may move to other locations if it is determined that annual measurement at the same fixed locations is too frequent for meeting the monitoring program objectives.

The USGS monitors continuous flow at the locations listed in **Table 7**. The first two locations listed are within the City of Gresham, while the third location on Kelley Creek is within Portland, but was added to assess flow from the Pleasant Valley Concept Plan area (See **Figures 1 and 2**), which will eventually be within the cities of Damascus, Gresham, and Portland.

Table 7: USGS Continuous Monitoring Locations*

#	Stream	Location (USGS Station ID)	Type	Constituents
1	Johnson Creek	Regner (USGS # 14211400)	Continuous	Flow Temperature Turbidity
2	Fairview Creek	Glisan (USGS #14211814)	Continuous	Flow
3	Kelley Creek	159th, upstream from Johnson Creek Confluence (USGS #14211499)	Continuous	Flow Temperature Turbidity

*Continuation of these gages is contingent on ongoing support by USGS.

4.4.3 Sampling Event Criteria

Continuous sampling equipment is designed to be in place regardless of any specific flow or temperature extreme. Continuous temperature data loggers deployed by the City of Gresham during months where potential for temperatures to exceed water quality standards is high, generally June through September. USGS gaging stations operate year-round.

4.4.4 Frequency and Duration

Continuous temperature data loggers deployed by the City of Gresham are set to collect data at hourly intervals. Continuous temperature monitoring has been conducted each summer since 2008. This activity will continue to occur annually at the instream monitoring locations in **Section 3.4.2 Table 2**, unless evaluation of data indicates that sampling an equal number of other locations makes more sense.

Continuous flow is measured by the USGS at either 15 or 30 minute intervals, depending upon the gage. The Johnson Creek gage at Regner has been in operation since February 1998. The Fairview Creek gage at Glisan has been in operation since May 1992. The Kelley Creek gage near the confluence with Johnson Creek has been in operation since March 2000.

4.4.5 Responsible Sampling Coordinator

Continuous temperature monitoring is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham and Fairview, who deploy and retrieve data loggers, then download the data.

The U.S. Geological Survey's Oregon Water Resource Center manages the collection of flow and temperature data at their gaging stations, including equipment calibration and maintenance.

4.5 Sample Collection and Handling

4.5.1 Sample Collection Method

Continuous measurements are made in-situ by securing the data collection devices into the stream channel. Measurements are collected at regular intervals ranging from 15-minutes to 1-hour, depending upon the station and constituent.

4.5.2 Handling and Custody Procedures

Because instream flow and temperature measurements are collected in-situ, sample handling is not involved in collection of these measurements.

4.6 Constituents and Methods

Streamflow: The USGS measures streamflow according to methods described in Rantz and others (1982).

Temperature: Continuous temperature data collected by the City of Gresham is obtained using temperature data loggers with a measurement range of –5º C to 35ºC. Methods for USGS measurement of temperature and turbidity are contained in the "National Field Manual for the Collection of Water-Quality Data" (USGS, variously dated).

4.7 Quality Control Procedures

4.7.1 Quality Assurance

The data quality objectives for continuous temperature data measured by the City of Gresham are determined by pre- and post-deployment accuracy checks and by assessing precision between the temperature from the data logger versus in-stream measurements made during Instream Monitoring. The data quality objectives are accuracy: ± 0.5 ºC, precision: ± 0.5 ºC.

The USGS manages all aspects of installation, maintenance, calibration, reporting and storage of data from their gaging stations. USGS data is flagged as provisional until it is reviewed and meets USGS data quality standards. Quality assurance procedures for USGS streamflow data is described in Rantz and others (1982).

4.7.2 Representativeness

All continuous instream monitoring locations are positioned to capture the most representative readings for ambient conditions at each site, considering flow, shading, depth, and other factors. Temperature data loggers are placed in areas where they will not be subject to direct solar radiation, while also targeting locations that will not be vandalized or dry during low summer flows.

4.7.3 Comparability

The USGS uses similar equipment at all of the gaging locations so that flow and temperature data can be compared between locations. The City of Gresham uses the same model of data loggers at all locations, and syncs the internal timing device so that data collected by each device is at the same time. This allows for temperature data to be compared between each of the in-stream sites monitored for temperature.

4.7.4 Completeness

The key period for continuous temperature data is the low flow summer months **–** primarily July, August and September. The goal for continuous instream temperature monitoring is to achieve a 100 percent complete data set for the summer months. Hourly measurements for a 3 month period will result in approximately 2160 data points each summer. Due to unforeseen circumstances some results may be lost. Field and Laboratory staff will attempt to minimize data loss to the best of their ability by carefully following all protocols and procedures. If data sets are not 100 percent complete for this monitoring task, analyses will be evaluated on a case by case basis to determine whether the monitoring program needs to collect additional samples in the future in order to meet monitoring objectives in order to accommodate data loss.

For USGS gaging stations collecting data points every half hour (48 data points per day), an annual period would produce 17,520 data points. USGS stations collecting data points every 15 minutes would produce 35,040 data points annually. The USGS manages all aspects of installation, maintenance, calibration, reporting and storage of data from their gaging stations.

4.7.5 Instrument Inspection and Maintenance

The continuous temperature data loggers are cleaned and inspected annually before and after deployment. The USGS manages all aspects of installation, maintenance, calibration, reporting and storage of data from their gaging stations.

4.7.6 Instrument Calibration

The continuous temperature data loggers cannot be calibrated. Pre- and post-deployment accuracy checks and in-situ precision checks are used to determine whether data meet the quality objectives outlined in **Section 4.7.1**. Accuracy checks are performed using a water bath at both cold and room temperature conditions. All data loggers are deployed and submerged in the water bath; the readouts from each data logger is compared with the other loggers as well as to a NIST-traceable thermometer inserted into the water bath.

The USGS manages all aspects of installation, maintenance, calibration, reporting and storage of data from their gaging stations.

4.8 Data Management, Review, Validation and Verification

4.8.1 Data Management

The continuous temperature data collected by the City of Gresham will be stored in a spreadsheet file stored on the City's server. The USGS manages the flow and temperature data they collect, and all data are available on-line through the Water Resources of Oregon web site at: http://or.water.usgs.gov/

4.8.2 Data Review, Validation and Verification

The Monitoring Program Coordinator will use statistical and graphical analysis to reveal whether errors occurred during data download. Potential errors in the dataset will be checked against field duplicate measurements and date/time of deployment/retrieval. Once verified, errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review, investigation, and if appropriate, discarded. Data quality problems will be discussed as they occur and in the final report to data users.

The USGS utilizes their own documented procedures for validating flow and temperature data that is considered provisional until it has been reviewed and verified. Quality assurance procedures for USGS streamflow data is described in Rantz and others (1982).

5.0 MACROINVERTEBRATE MONITORING

5.1 Project/Task Organization

As required by the NPDES MS4 permit, Schedule B, Table B-1 and 2. & 3, macroinvertebrate monitoring refers to the annual monitoring of benthic macroinvertebrates from the fixed sampling locations where instream monitoring occurs. Monitoring began at most in-stream sites in 2008; continued monitoring seeks to determine whether and to what degree the biological conditions of streams are changing related to habitat, hydrology, or water quality conditions. Macroinvertebrate monitoring may be timed to coincide with instream monitoring in order to collect biological information at the same time summer water quality data is collected.

5.2 Monitoring Objectives

5.2.1 Monitoring Question and Background

Macroinvertebrate monitoring is intended to track the status and trends of the biological community within water bodies receiving MS4 discharges to address the question "Is stormwater affecting the biological community of the receiving waters?" The Co-Permittees will monitor benthic macroinvertebrates at instream sampling sites in order to more adequately assess the long-term trends in objective 4, and the biological component of objective 5, in addition to helping meet objective 6. As shown in **Appendix A**, macroinvertebrate monitoring also helps address other goals as well.

Objective 4. *Evaluate status and long-term trends in receiving waters associated with MS4 stormwater discharges;*

Objective 5. *Assess the chemical, biological and physical effects of MS4 stormwater discharges on receiving waters; and,*

Objective 6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

5.2.2 Data Analysis Methodology and Quality Criteria

The tool(s) used to assess macroinvertebrate data is almost as important as the protocol used for collection and identification. Several tools are available for analyzing macroinvertebrate data, and the preferred choice changes as more knowledge is gained, so it is critical to keep both the data and the tool. Multi-metric indices, such as Oregon's Benthic Index of Biological Integrity (B-IBI), can be used to look at multiple measures of the biological community, including: Total Taxa, Mayfly Taxa, Stonefly Taxa, Caddisfly Taxa, Sensitive Taxa, Sediment Sensitive Taxa, Hilsenhof Biological Index (HBI), Percent Tolerant Taxa, Percent Sediment Tolerant Taxa, and Percent Dominance.

Macroinvertebrates will be identified to a taxonomic level that allows for calculation of an IBI. DEQ has been moving away from the use of the IBI as other tools have become available. Currently, the Predictive Assessment Tool for Oregon (PREDATOR) allows for comparison of the biological community observed in stream sites with the expected community that is present in best available condition reference sites within the same eco-region. DEQ's PREDATOR model can be used with macroinvertebrate data identified to the same taxonomic level required by the IBI, so ensuring that macroinvertebrate samples are identified to the same taxonomic level as DEQ (generally genus/species) is the primary criteria for selection of a taxonomist. To the degree practicable, an attempt will be made to use the same taxonomist over time to maximize consistency.

5.2.3 Assumptions and Rationale

Macroinvertebrates live in the streambed substrate and are therefore affected by short and long-term exposures to pollution. The biological community may be affected by a wide range of factors including temperature, sediment, in-stream and near-stream riparian habitat, hydro-modification, and water quality pollutants from land use in the contributing watershed area. It is assumed that long-term monitoring of macroinvertebrates will aid the Co-permittees in determining whether the physical, biological, and chemical condition of MS4 receiving water bodies is improving over time due to efforts to manage stormwater and improve habitat. Continued monitoring at the same locations will allow for assessing long-term trends over time.

5.2.4 Relationship to Long-term Monitoring Program Strategy

Macroinvertebrate monitoring provides a periodic measure of the biological condition of waters of the state which receive MS4 stormwater discharges. The annual biological monitoring described in this section augments other monitoring efforts by 1) comparing instream water quality trends described in **Section 3.0** with biological conditions, 2) evaluating how the biological community is affected by the flow and temperature data described in **Section 4.0**, and 3) determining if changes in stormwater data described in **Section 6.0** relate to changes in the instream macroinvertebrate community. Continuing macroinvertebrate monitoring using an approach consistent with instream water quality monitoring efforts should enable the Co-Permittees to determine if short or long-term water quality trends are evident based on MS4 management decisions associated with implementation of their SWMPs.

5.3 Documentation and Record-keeping Procedures

Consistent with permit requirements specified in Schedule F, Section C.5., the Co-Permittees will retain records of all monitoring information, including: all original data, copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application.

Records will contain:

1. The date, exact place, time, and methods of sampling or measurements;
2. The individual(s) who performed the sampling or measurements;
3. The date(s) analyses were performed;
4. The individual(s) who performed the analyses;
5. The analytical techniques or methods used; and
6. The results of such analyses.

5.4 Sampling Process/Study Design

5.4.1 Study Design

Collecting benthic macroinvertebrate samples provides a direct measure of the biological health of the streams within the permit area. Macroinvertebrate sampling will be conducted as close to the Co-permittee’s instream fixed sampling locations as possible. Following DEQ’s biological monitoring procedure requires selection of riffles or the best available fast water habitat near the monitoring stations, focusing on an area upstream equal to 40 times the wetted stream width.

5.4.2 Monitoring Locations

Macroinvertebrates are currently monitored at the same fixed instream monitoring locations where instream water quality monitoring occurs. The instream macroinvertebrate sampling locations are listed in **Table 8**. Sampling locations may be moved to random sites selected probabilistically if data analysis reveals that annual monitoring of the same locations is not needed to show long-term changes in the biological community.

Table 8: Instream Macroinvertebrate Monitoring Locations

Station Number*	Site Code	Stream	Location
Columbia Slough Basin			
1**	FCI0	Fairview Creek	Mobile estates upstream of Fairview Lake in City of Fairview
2	FCI1	Fairview Creek	Conifer Park (205th and Stark) in City of Gresham
Sandy River Basin			
3	KCI1	Kelly Creek	Downstream Mount Hood Community College
4**	KCI4	Kelly Creek	Upstream from Kelly Creek Detention Pond
Johnson Creek Subbasin			
5	JCI1	Johnson Creek	Near Jenne Rd Bridge
6	JCI2	Johnson Creek	Near Palmblad Bridge upstream of Gresham
7**	KI1	Kelley Creek	Pleasant Valley Grange
8**	KI2	Kelley Creek	Rodlun Rd near Alder Ridge

* Station numbers refer to locations on **Figure 1** (see **Section 3.0**).

** These sampling locations will be monitored each year only if adequate summer flows, or presence of suitable fast water habitat, are present. Not sampling these sites will still meet the minimum requirements listed in Table B-1 of the NPDES MS4 permit (1 site in Columbia Slough basin, 1 site in the Sandy River basin, and 2 sites in the Johnson Creek subbasin).

5.4.3 Sampling Event Criteria

Macroinvertebrate data collection will occur once each year during summer low flows. This activity will most likely occur during July or August in conjunction with instream water quality monitoring.

5.4.4 Frequency and Duration

A single sample will be collected at each site annually. Sampling began in 2008, and is planned to continue, but changes in location or frequency may be proposed if data analysis reveals that annual monitoring of the same locations is not needed to show long-term changes in the biological community.

5.4.5 Responsible Sampling Coordinator

This monitoring task is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham and Fairview, who determine sample collection timing, gather needed equipment, collect samples for lab analysis, and coordinate delivery to the taxonomist.

5.5 Sample Collection and Handling

5.5.1 Sample Collection Methods

Macroinvertebrate samples will be collected according to DEQ's Field Methods for the Collection of Macroinvertebrates in Wadeable Streams (DEQ 2009). Samples will be collected from suitable fast moving water habitat (riffles, or runs/glides if no riffle is present) once per year during summer/low flow conditions. Eight separate one-foot square (1 ft^2) samples will be collected using a 500 µm kick net from riffle habitat over a reach length of 40 times the average wetted stream width.

5.5.2 Handling and Custody Procedures

The 8-part composite sample is collected following DEQ's 9-cell grid method, moving from downstream to upstream in the fast water habitat from bottom left to center then right for the first three samples, and then moving in the same sequence from left to right upstream until all 8-parts of the composite sample have been collected.

A two-person team is used, where one person holds the D-frame net securely against the bottom of the streambed substrate, while the second person dislodges insects by rubbing rocks and disturbing substrate using their hands, brush or garden tool. Each of the 8 separate 1 ft^2 samples is placed into a sieve bucket with a 500 µm grid. The entire 8-part composite is transferred to Nalgene jars prior to being preserved using 70-95% ethanol or isopropyl alcohol. A Rite-in-the-Rain label with sample information written in pencil will be added inside the sample jar and the alcohol is added to the sample before the jars are sealed. A second label will be added to the outside of the jar before being sent to a professional entomologist for identification.

The label contained in each sample contains the following information:

- Date of sample collection
- Location of sample collection
- Name of sample collectors
- Number of jars used for sample from each site (Jar # __ of __)

Samples held for more than a week prior to shipment to the taxonomist may have the alcohol replaced with fresh ethanol or isopropyl alcohol. This step is most important for samples containing large amounts of organic material. A list of sample details, including site code, stream name, site location, sample date, and number of jars, is provided to the taxonomist to aid in data reporting.

5.6 Constituents and Methods

Macroinvertebrate samples will be collected according to DEQ's Field Methods for the Collection of Macroinvertebrates in Wadeable Streams (DEQ 2009). In order to get samples identified to the taxonomic level required to conduct the data analyses listed in **Section 5.2.2**, specimens will be sent to a professional entomologist for identification.

5.7 Quality Control Procedures

5.7.1 Quality Assurance

A field duplicate will be collected at a minimum of 10% of the total number of monitoring locations (1 duplicate for every 10 sites). The identification results from the field duplicate data will be compared to the results for the site it was collected from to determine the precision of the taxonomists' identification. A lab duplicate is also performed for each sampling period. A lab duplicate differs from a field replicate in that the taxonomist takes a second random subsample from the composite sample for determining precision and representativeness of the subsampling procedure. The accuracy target for field duplicates is to have less than 10% variability between organisms identified and relative abundance of each taxa.

5.7.2 Representativeness

Macroinvertebrate samples are collected from 8 separate locations within riffles or the best available fast water habitat. Based on procedures published by EPA and DEQ, these habitat conditions are believed to be well mixed and provide the most diverse biological community for comparing sites within the same watershed or around the ecoregion or state.

5.7.3 Comparability

The objective is to ensure that collected data are either directly comparable, or comparable within defined limitations, to literature data or other applicable criteria. Macroinvertebrate samples are collected and identified using the same method used by DEQ and other jurisdictions, so data should be comparable among the instream locations monitored as part of this plan, as well as comparable with other macroinvertebrate data collected from sites around the state.

5.7.4 Completeness

The goal for macroinvertebrate monitoring is to achieve a 100 percent complete data set. It is anticipated that over the 5 year permit term, annual sampling at 8 sites will result in 40 data points being collected. Due to unforeseen circumstances some results may be lost. Field and Laboratory staff will attempt to minimize data loss to the best of their ability by carefully following all protocols and procedures. If data sets are not 100 percent complete for this study, analyses will be evaluated on a case by case basis to determine whether the project needs to collect additional samples.

5.7.5 Equipment Inspection and Maintenance

Prior to field data collection, all equipment is cleaned and visually inspected to ensure that the net and sieve bucket do not contain any openings that might allow organisms through during sample collection.

5.7.6 Equipment Calibration

No equipment involved in collection of macroinvertebrates requires calibration.

5.8 Data Management, Review, Validation and Verification

5.8.1 Data Management

All macroinvertebrate data will be stored in an annual summary spreadsheet stored on Gresham's server. Once data is received from the taxonomist, it will be reviewed and analyzed using an analysis tool (B-IBI, PREDATOR or other). Data analysis will occur as soon as practicable, with data summarization being shared with Fairview and summarized in the NPDES MS4 Annual Report. Additional analysis will be conducted for the permit renewal to assess instream trends. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate.

5.8.2 Data Review, Validation and Verification

Once the macroinvertebrate data from the taxonomist has been analyzed, the results will be compared to other sites and past data from the same site to check for consistency. Raw data from the field and lab duplicate measurements will be assessed against the quality assurance objectives listed in **Section 5.7.1** to determine if the collection and identification results meet the 10% target. Calculations and determinations for completeness and accuracy will be made and corrective action implemented if needed. If data quality indicators do not meet the monitoring program's specifications, data may be discarded and re-sampling may occur. The cause of the failure will be evaluated. If the cause is found to be collection method, techniques will be reassessed and staff will be retrained. If the problem is found to be identification, the taxonomist utilized by the Co-permittees will be assessed and a new taxonomist will be rehired as needed.

6.0 WET WEATHER STORMWATER MONITORING

6.1 Project/Task Organization

As required by the NPDES MS4 permit, Schedule B, Table B-1 and 2. & 3, Wet Weather Stormwater Monitoring refers to the monitoring of stormwater runoff from roads and other paved surfaces. While the majority of monitoring is conducted within the City of Gresham, the drainage characteristics (land uses and vehicle trips per day) are also representative of the City of Fairview. Land use based wet weather outfall monitoring has been conducted at four locations throughout the permit boundary, including an ACWA study conducted between 1990-1996 (ACWA 1997), and monitoring conducted by the Co-permittees between 1996-2011 as part of the monitoring requirements in the NPDES MS4 permit. This data, along with other regional jurisdictions' data, was compiled and analyzed through a study managed by the Oregon Association of Clean Water Agencies (ACWA 2009). The 2009 ACWA data analysis provided statewide stormwater characterization and compared the influence of land use and vehicle trips on runoff quality.

The findings from the ACWA (2009) stormwater analysis indicated that stormwater data is highly variable and that vehicle trips per day may be more strongly correlated to differences in the data than land use. Some of the data included in the ACWA (2009) report was collected for compliance with a Water Pollution Control Facility (WPCF) permit for Underground Injection Control systems (UICs). Stormwater data related to UICs showed lower variability, which may be related to the smaller scale drainage basins, or the fact that sites were selected using a spatially balanced and random ("probabilistic") site selection protocol (see **Section 6.4.1**). In an effort to reduce bias in sample site selection, eliminate variability that may be related to large drainage areas and produce stormwater data with greater statistical power, the Co-permittees are changing their monitoring approach from looking at outfalls from large drainage areas to evaluating smaller drainages selected using the probabilistic monitoring design.

6.2 Monitoring Objectives

6.2.1 Monitoring Question and Background

Wet weather stormwater monitoring is intended to characterize the status and, if possible, determine trends in stormwater quality by focusing on the question "What are typical/average concentrations of pollutants in stormwater runoff?" Through evaluation of data that has already been collected (e.g. ACWA 1997 and ACWA 2009), and assessing monitoring approaches used for other stormwater monitoring programs (e.g. Portland's UIC monitoring program), the Co-permittees plan to continue characterizing stormwater and augment with additional monitoring where data are lacking (specifically for mercury and toxics, especially pesticides). To meet monitoring Objectives 1, 3, and 6 from the NPDES MS4 permit, the Co-Permittees will collect stormwater samples from representative locations.

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*

Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities;*

Objective 3. *Characterize stormwater runoff discharges based on land use, seasonality, geography or other catchment characteristics;*

Objective 6. Assess progress towards meeting TMDL pollutant load reduction benchmarks.

Appendix A has a more extensive overview of how storm event monitoring, mercury monitoring and pesticide monitoring address each of the six monitoring objectives.

6.2.2 Data Analysis Methodology and Quality Criteria

Wet weather stormwater monitoring data will be assessed by comparing sites selected using the probabilistic Generalized Random Tessellation Stratified (GRTS) survey design described in **Section 6.4.1**. After randomly selecting sites with small drainage areas, the characteristics of each drainage area will be assessed, and a nonparametric statistical measure of difference between groups (e.g. Mann-Whitney) will be used to determine if stormwater is significantly different between sites based on land use, traffic patterns, power pole density, or other drainage characteristics. The significance of any difference would be evaluated against an alpha (α) value of at least 0.1, with a goal to demonstrate significance at α=0.05.

6.2.3 Assumptions and Rationale

Because patterns of development and management of stormwater are the generally the same across the City, stormwater draining to UICs should not be different from that draining to the MS4. Both the UIC and MS4 areas are comprised of a mixture of residential, commercial, and industrial land uses, and a mixture of high volume and low volume traffic patterns and are therefore also representative of Fairview. The UIC monitoring approach used by Portland has demonstrated lower variability in stormwater data than the historic MS4 data that focused on outfalls from larger drainage areas.

It is assumed that by shifting stormwater monitoring to smaller UIC drainages that can be entirely characterized, versus the larger land use based outfall monitoring conducted in the past, the stormwater data will be less variable and more representative of specific land uses and factors that have the potential to affect stormwater quality. Using a probabilistic approach for selecting monitoring locations will remove any bias associated with site selection, and selecting a large enough number of sites allows for meaningful analysis of the stormwater data regardless of the strata (land use, vehicle trips, etc.) being assessed.

The ACWA evaluation of statewide stormwater data (ACWA 2009) indicated that vehicle trips per day more closely correlates with pollutant concentrations than does land use. It is assumed that the statewide data is relevant to Gresham, and the effect of vehicle trips per day will be a primary factor for further analysis.

6.2.4 Relationship to Long-term Monitoring Program Strategy

Wet Weather Stormwater Monitoring provides a direct measure of the water quality of stormwater within the permit area. Using a probabilistic monitoring design that allows assessment of stormwater within the permit area provides the Co-permittees with useful management information for both the MS4 and UIC system management. The long-term strategy for stormwater monitoring will likely involve keeping a long-term “fixed” panel of 5 sites monitored annually to allow for assessment of long-term trends, while also monitoring a rotating panel of 5 random sites each year to allow for greater assessment of stormwater status within the permit area.

6.3 Documentation and Record-keeping Procedures

Consistent with permit requirements specified in NPDES MS4 permit Schedule F, Section C.5., the Co-Permittees will retain records of all monitoring information, including: all calibration, major maintenance records, all original lab and field data (see **Appendix C** for example of field data sheet), copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application.

Records will contain:

1. The date, exact place, time, and methods of sampling or measurements;
2. The individual(s) who performed the sampling or measurements;
3. The date(s) analyses were performed;
4. The individual(s) who performed the analyses;
5. The analytical techniques or methods used; and
6. The results of such analyses.

6.4 Monitoring Process/Study Design

6.4.1 Study Design

Compared to the historic stormwater data collected at outfalls, the data collected during a one year (2009-2010) wet-weather study of 60 sites conducted by the City of Gresham, as well as the City of Portland's UIC monitoring program data (2007 to present) shows much lower variability and greater consistency than stormwater data collected during the previous decade at outfalls. The wet weather stormwater monitoring approach and locations listed in this plan seeks to continue to build upon those efforts and combine stormwater monitoring requirements, to the extent practicable in order to meet the requirements of both the NPDES MS4 and WPCF permits in order to protect local water resources using the public's rates in the most efficient and scientific manner possible given limited resources.

A major benefit to using a combined stormwater monitoring approach to address both the MS4 and WPCF permit requirements is that rather than using the three large MS4 drainage outfalls, stormwater monitoring would be conducted annually at a greater number of small UIC drainages (0.5 to 5 acres). Sites are selected using a spatially-balanced and random probabilistic approach, which is described below. The greatest benefit to using the Generalized Random Tessellation Stratified (GRTS) survey design (probabilistic approach; see Stevens and Olsen 2004) is that the small drainage areas will be composed of a single land use, versus the mixed use inherent in the past stormwater outfall monitoring approach that focused on drainage areas that were hundreds of acres in size. Based on findings from Portland and Gresham stormwater sampling summarized in ACWA (2009), stormwater data may be affected more by vehicle trips per day than land use. Therefore, monitoring locations will be stratified by vehicle trips (< and > 1000 trips per day), which will also allow data to be comparable to similar sampling locations in nearby Portland.

The GRTS survey design developed by Dr. Don L. Stevens Jr. (Department of Statistics, Oregon State University) and Dr. Anthony R. Olsen (EPA National Health and Environmental Effects Research Laboratory) is specifically designed to efficiently characterize a large system with many potential sampling locations, such as a stream network or stormwater system. It randomly selects sampling locations from a population of potential locations whose members (stormwater structures for potential sampling) are distributed over a large space in a manner that produces a spatially balanced sample. Since the Co-Permittees have a large number of major and minor outfalls draining areas that range from a few acres up to nearly 1000 acres, it is not technically practicable or financially feasible to routinely collect and analyze stormwater from each of these outfalls during every storm event. Due to the large drainage areas and therefore large number of potential confounding factors, the Co-Permittees will monitor smaller stormwater catchments (0.5 to 5 acres) associated with UICs that can be accurately characterized according to land use, vehicular trips, and other characteristics that may influence the water quality of the stormwater effluent. In order to identify small catchments consisting of 1 to 4 catch basins, statistical methods will be applied to select a subset of points for monitoring so that there will be a high degree of confidence that the subset chosen is appropriately representative of stormwater within the permit area.

Stratification

Of the roughly 1100 small City-owned and operated UIC catchments, approximately 60% are in residential areas, and have <1000 vehicle trips per day (TPD), while the other 40% have >1000 TPD and surrounding land use is primarily commercial and multi-family residential with some industrial. In order to ensure that data is collected from a greater number of high vehicle trip sites, a weighting factor will be applied during site selection so that a disproportionately high number of sites with greater than 1000 TPD will be monitored each year. The goal is to have a roughly equal number of sites within the two traffic strata by the end of the permit term. Since the majority of active UICs are in the <1000 TPD, the sample design is conservative in that it will be overly representative of sampling locations from streets with higher traffic counts (>1000 TPD).

6.4.2 Monitoring Locations

Selection of stratified, spatially-balanced and random sampling locations using the GRTS procedure was accomplished by:

- Determining the exact geographic locations (latitude-longitude) of all UICs within the permit boundary that are owned and operated by the City of Gresham;[1]
- Running the GRTS selection tool, which places nested random grids over the City's entire UIC system. Each grid is further divided into smaller nested grids until the smallest grid scales contain only a single UIC;
- In order to have a disproportionately greater number of >1000 TPD sites selected, a weighting factor was applied to the GRTS selection run. For the initial selection run, where a higher number of sites was selected than will be needed to account for sites that eliminated after field screening for determining whether the sampling location is feasible/suitable, 390 locations (188 <1000 TPD and 202 >1000 TPD) were selected using weighting factors of 6.78 for <1000 TPD and 10.25 for >1000 TPD;
- The program systematically selected a random and evenly spaced sample from the UIC locations within the nested grids. Output is a ranked list of locations;
- In order to end up with an equal number of sites in the two traffic strata each year (5 sites in both the <1000 and >1000 TPD), the number of sites randomly selected within each traffic strata were evaluated. Since a fixed panel of 5 locations will be monitored each year

[1] Sites selected from UIC Systemwide Assessment conducted October 2011.

(consisting of the top 3 ranked sites with <1000 TPD and the top 2 ranked sites with >1000 TPD), the rotating panel for each year was determined by selecting the next 2 locations with <1000 TPD and 3 locations from >1000 TPD. Having slightly more sites in the higher traffic strata of the rotating panel was made purposely so that a disproportionately large number of these sites would be sampled over the permit term.

- Before sampling the 5 rotating sites selected for each year, field reconnaissance will be performed to determine if the randomly selected sites were unsuitable for sampling (e.g., unsafe or inaccessible due to design). Replacement sites will be selected in ranked order from the list of oversample panel locations.

The proposed sampling locations for Wet Weather Stormwater Monitoring are listed in **Tables 9 and 10**. Since exact sampling locations to be monitored each year may vary based on changes to the stormwater system, **Table 9** lists the number of fixed and rotating sites that will be monitored in each year. Each year, monitoring will occur at one panel of 5 fixed locations (described in **Table 10**) and one panel of 5 rotating locations that will be monitored once during the permit term (specific list of rotating panel locations detailed in the separate "Stormwater Monitoring Plan" created to meet the requirements of the WPCF permit). The goal of including fixed and rotating sample locations is to assess status and trends in stormwater – status being evaluated by covering a large random sample of the permit area, and trends being evaluated by long-term assessment of the same locations. In the long-term it may make sense to revisit the same rotating locations on a 5 or 10 year cycle; or it may prove scientifically advantageous to *not* re-visit the same locations and rely solely on the fixed panel to evaluate trends. A decision regarding such future monitoring will be based on regulatory requirements, questions raised or answered by the data collected, available resources, and other relevant criteria.

Table 9: Stormwater Sampling Locations to be Monitored During Permit Term

Permit Year	Fixed Locations*	Rotating Locations	Wet Season
1	5	5	2016-17
2	5	5	2017-18
3	5	5	2018-19
4	5	5	2019-20
5	5	5	2020-21

* One panel of five fixed sampling locations will be monitored each year. The 5 rotating sampling locations monitored each year will consist of 3 UICs on >1000 TPD and 2 locations on <1000 TPD locations. Locations of the rotating panel locations are specified in the Stormwater Monitoring Plan.

Both the panel of 5 fixed monitoring locations and the rotating panel of 5 sites consist of sites selected probabilistically using the GRTS survey design described previously. The rotating panel locations to be monitored each year are subject to change as a result of field reconnaissance or system changes, so the list of locations monitored will be reported to DEQ each year as part of the required annual report. The random panel of sites, which are specified in the Stormwater Monitoring Plan, will be representative of any UICs constructed or discovered during the permit term since it was selected from the 1100 active UICs owned and operated by the City of Gresham. The current probability of randomly selecting a single site from a population of 1100 UICs is 1 in

1100 or 0.091%. While new UICs may be constructed or discovered over the permit term, it is anticipated that only 5 new UICs would likely be added annually. Over a 5 year period, this would mean 25 potential new sampling locations could be added. The probability of selecting a single site after those 25 sites were added to the system would be 1 in 1125 or 0.088%. The probability that any of the 25 newly added sites would be selected would be 25 in 1125 or 2.2%. Based on a similar criteria used by Portland in their Sampling and Analysis Plan (Portland 2006), sampling locations will not be re-selected using GRTS unless the probability for selecting a newly constructed or discovered sampling site becomes greater than 5% (more than 55 UICs added over 5 year period). The inventory of UICs will be evaluated annually and a determination will be made prior to the beginning of each wet weather sampling season.

Table 10: Wet Weather Stormwater Monitoring Fixed Locations*

Basin**	System ID	Functional Class	Trips per Day	Land Use
Fairview	3151-F-064	Collector	>1000	MRES
Fairview	3251-F-013	Residential	<1000	SFR
Columbia Slough	3148-W-014	Community	>1000	SFR/COM
Fairview	3150-F-030	Residential	<1000	SFR
Fairview	3153-F-040	Residential	<1000	SFR

* Sites and frequency subject to change contingent upon pending WPCF permit. No decrease in effort or resource allocation will be made should changes be proposed.

**Nonstructural BMPs and requirements for new and redevelopment are consistent throughout the City. Land use and trips per day are considered a better indicator of pollutants than surface water drainage basin.

6.4.3 Sampling Event Criteria

Prior to initiating a sampling event, the storm will be predicted and evaluated against the criteria listed below to assess whether the predicted storm should be targeted as Wet Weather Stormwater Monitoring event. Storm event criteria are as follows:

- Predicted rainfall amount of ≥ 0.2 inches per storm [NPDES MS4 permit B(3)(b)(i.) requires sampling to occur during storms > 0.1”];
- Predicted rainfall duration ≥ 6 hours; and
- Antecedent dry period ≥ 6 hours (as defined by < 0.1 inches of precipitation over the previous 6 hours). When possible, samples will be collected after an antecedent dry period of 24 hours [NPDES MS4 permit B(3)(b)(ii.)].

Based on experience and review of historic weather data related to stormwater monitoring in this region, storms meeting these criteria are expected to provide the volume of runoff necessary to implement sampling. 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 Wet Weather Stormwater Monitoring. It is likely that a sampled storm may not meet the target criteria listed above when the sampling event is completed, or that unpredicted events will occur that do meet the criteria. Thus, the criteria will be used as general guidance to determine when forecasted storms should be targeted for sampling.

Hourly and daily rainfall records are maintained and available on the HYDRA Data Report System. This data is available on the web at:

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

6.4.4 Frequency and Duration

As listed in **Section 6.4.2**, **Table 9**, a single sample will be collected annually for each of the 10 sites per year. As described in Section 6.4.3, storms not likely to result in enough runoff for samples from 5 sites to be collected will not be targeted. This will likely result in average pollutant concentrations that are slightly higher than the true average, because pollutant loads correlate with rainfall intensity.

6.4.5 Responsible Sampling Coordinator

This monitoring task is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham and Fairview, who target events, calibrate equipment, perform in-situ field measurements, collect samples for lab analysis, and coordinate delivery to the lab. Laboratory analysis for instream samples is conducted by Portland's Water Pollution Control Laboratory under an IGA with the City of Gresham for laboratory services (see **Appendix F**).

6.5 Sample Collection and Handling

6.5.1 Sample Collection Method

As described in the NPDES MS4 permit Schedule B 3. b. iv. 1, Co-permittees have selected grab samples for Wet Weather Stormwater Monitoring. The samples will be collected at each of the 10 locations to be sampled in a given year. Because of the spatial extent of this sampling effort (i.e., sites are distant from one another), composite sampling is infeasible. By focusing on a larger spatial area of the stormwater system sampled in a probabilistic manner over a period of hours, the large number of samples should reflect average conditions as well or better than collecting composite samples from fewer sites. Thus, the Co-permittees concluded that flow-weighted composites are scientifically unwarranted and are financially infeasible. To this end, the selection of smaller drainages for sampling allows for the evaluation of the influence of a variety of watershed characteristics, including, but not limited to land use, traffic patterns, and presence of utility poles which are known to leach pentachlorophenol.

6.5.2 Handling and Custody Procedures

For grab samples, samples are collected directly into the appropriate containers from the center of flow, when possible. If needed, samples will be collected using a clean stainless steel bailer attached to an extension rod. A separate laboratory-cleaned stainless steel bailer is used for each sampling location. Field measurements are made by collecting a representative sample using the stainless steel bailer and then pouring the sample into the measurement/storage cup of the multi-meter probe. One bottle is field-filtered for ortho-phosphorus analysis.

Two-person clean sample collection techniques are followed to minimize the potential for contamination of samples: one person acts as "dirty hands" to move equipment, document field measurements, grab samples using the bailer and remove manhole lids; and one person acts as "clean hands" to fill sample bottles. The "clean hands" person wears powder-free nitrile gloves to avoid contamination of the sample and protect staff from possible health risks.

All samples collected for laboratory analysis are immediately placed into a cooler containing ice and transported to the lab immediately following sample collection. **Table 11** lists the volume of sample collected, the container used and maximum holding time. Once samples are delivered to Portland's Water Pollution Control Laboratory, they have their own QAPP to ensure that samples are analyzed within the proper holding time and preservation methods are employed.

Table 11: Sample Containers and Holding Times for Wet Weather Stormwater Monitoring

Constituent	Minimum Sample Volume	Bottle Type	Holding Time
Conventional Constituents			
Biochemical Oxygen Demand (BOD_5)	250 mL	Plastic	24 hours
Total Suspended Solids	500 mL	Plastic	7 days
Hardness	250 mL	Plastic	6 months
E. coli	100 mL	Sterile Plastic	6 hours (max 24 hrs.)
Nutrients			
Nitrate Nitrogen	100 mL	Plastic	48 hours
Total Kjeldahl Nitrogen (TKN)	100 mL	Plastic	28 days
Ammonia Nitrogen	100 mL	Plastic	28 days
Total Phosphorus	100 mL	Plastic	28 days
Ortho-phosphorus	250 mL	Plastic	48 hours
Total Recoverable Metals			
Copper	400 mL	Plastic	6 months if preserved
Lead			
Zinc			
Mercury			
Dissolved Metals			
Copper	400 mL	Plastic	6 months if preserved
Lead			
Zinc			
Pesticides			
2,4-D	250 mL	Amber Glass	14 days
Pentachlorophenol			

After samples have been obtained and the collection procedures properly documented, a written record of the chain of custody for each sample requiring laboratory analysis is completed. Information included on the chain of custody includes:

- Name of the persons collecting the sample(s)
- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples etc.) and any special instructions (e.g., time sensitive analyses).

To ensure that all necessary information is documented, a chain of custody form will accompany each sample or set of samples and a copy of the form is retained. Each person who takes custody will sign and date the appropriate portion of the chain of custody documentation.

6.6 Constituents and Methods

The analytical methods and method reporting limits (MRLs) for constituents monitored for wet weather stormwater monitoring are listed in **Table 12**.

Table 12: Wet Weather Stormwater Monitoring Constituents, Methods, and MRLs

Field Constituents	**Analytical Method**	**MRL****	**Units**
Temperature	SM 2550 B	-5	Degrees C
DO	SM 4500-OG	0.1	mg/L
Conductivity	EPA 120.1	1.0	µs/cm
pH	EPA 150.1	3.0	S.U.
Turbidity	EPA 180.1	0.05	NTU
Conventional Constituents			
Biochemical Oxygen Demand (BOD_5)	SM 5210 B	2	mg/L
Total Suspended Solids	SM 2540 D	2	mg/L
Hardness	SM 2340 B	0.5	mg/L as $CaCO_3$
E. coli	COLILERT QT	10	MPN/100 mL
Total Organic Carbon (TOC)*	5310B	1	mg/L
Nutrients			
Nitrate Nitrogen	EPA 300.0	1.10	mg/L
Total Kjeldahl Nitrogen*	PAI-DK03 [1]	0.20	mg/L
Ammonia Nitrogen	EPA 350.1	0.02	mg/L
Total Phosphorus	EPA 365.4	0.02	mg/L
Ortho-phosphorus	EPA 365.1	0.02	mg/L
Total Recoverable Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Zinc	EPA 200.8	0.5	µg/L
Mercury*	WPCLSOP M-10-02*[2]	0.002	µg/L
Dissolved Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Zinc	EPA 200.8	0.5	µg/L
Pesticides			
2,4-D	EPA 515.3	0.2	µg/L

Pentachlorophenol	EPA 515.3	0.08	µg/L

* TOC, Mercury, and TKN are not required in Table B-1 of the NPDES MS4 permit, so are subject to the Adaptive Management process described in **Section 1.4**.
** Method Reporting Limit
[1] The PAI-DK03 method for TKN is a 40 CFR 136 method (flow injection gas method, see footnote 41, Table 1B, 40 CFR Part 136.3).
[2] The WPCLSOP M-10.02 method cited for total Hg is EPA 200.8 w/CEM digestion (footnote 4, Table 1B, 40 CFR Part 136.3).

Pesticides

Based on a preliminary assessment of current use pesticides used within the permit area, the Co-permittees will conduct sampling for the following:

- **2,4-D (Dichlorophenoxyacetic acid, dimethylamine salt):** The most widely available and used phenoxy herbicide; selected because of its widespread use, known toxicity to fish and aquatic invertebrates, potential for groundwater pollution (due to high mobility), and likelihood for transport in urban stormwater. In addition, the City has conducted residential outreach to discourage use of this and other lawn chemicals, and trends over time are of interest.
- **Pentachlorophenol:** A previously widely used, but now is a restricted-use fungicide that was identified through Portland's stormwater monitoring as a potential concern based on use as a utility pole wood preservative. Gresham also found pentachlorophenol during a special stormwater study conducted in wet season 2009-10. This chemical has the potential to be a surface and groundwater pollutant, is known to be toxic to aquatic organisms and humans and is a suspected carcinogen, mutagen and teratogen.

The two pesticides slated for monitoring are not the only pesticides of interest (see **Appendix K**). However, they are two of the more widely applied pesticides, which local laboratories are capable of analyzing at levels that are anticipated to be found in storm, surface, and ground water. Screening tests that quantify large numbers of pesticides are not currently available to detect pesticides at relevant concentrations.

In addition to these two pesticides, Gresham staff have prepared an assessment of the pesticides included in Schedule B of the NPDES MS4 permit; the pesticides used by the Co-permittees during operations and maintenance activities; the pesticides identified by DEQ or other regional research in local water bodies; and pesticides available to residents based on a shelf survey conducted by Metro. The "Pesticide Assessment for Stormwater Monitoring" (2011) is submitted in **Appendix K**.

6.7 Quality Control Procedures

6.7.1 Quality Assurance

The data quality objectives for field measurements are listed in **Table 13**. Precision and accuracy are referenced from the DEQ Data Quality Matrix. Because field measurements for temperature, pH, DO and conductivity are made using a multi-meter probe, precision between replicates is usually not assessed since meter values are continuously assessed and not documented until they stabilize. Accuracy for field measurements is determined by measuring standards before and after each sampling event and assessing deviation from the standard in comparison to accuracy ranges in **Table 13**.

Table 13: Accuracy and Precision Targets for Stormwater Field Measurements

Parameter	Precision	Accuracy	Measurement Range
Temperature	± 1.0 ºC	± 0.5 ºC	-5 to 45 ºC
pH	± 0.3 SU	± 0.2 SU	0 to 14 SU
Dissolved Oxygen	± 0.3 mg/L	± 0.2 mg/L	1 to 50 mg/L
Conductivity	± 10% of Std. Value	± 7% of Std. Value	0 to 200 mS/cm
Turbidity	± 5% of Std. Value ± 1 NTU if NTU <20	± 5% of Std. Value	0 to 1000 NTU

Analytical methods for grab samples analyzed at Portland's Water Pollution Control Laboratory use an appropriate balance of quality assurance/quality control measures, including replicates, blanks, spiked samples and other measures approved under 40 CFR 136 to ensure that data meet quality objectives appropriate for compliance with state and federal regulatory requirements. A copy of the WPCL's QAPP is included in **Appendix G**.

Field duplicate samples will be collected at a minimum of 10% of the total number of monitoring locations (1 duplicate for every 10 sites). For wet weather stormwater sampling, one lab replicate will be collected from one of the 10 stormwater sampling sites. Any data or sample values outside of the expected range for the constituent being measured will be rechecked for validity with the laboratory or in the field by the field team as appropriate. Data that continue to be outside the expected values will be further investigate to determine the cause.

Duplicate measurements are not collected for field constituents (DO, pH, temperature, conductivity, turbidity). Instead, quality assurance for field constituents will be assessed by calibrating the equipment prior to mobilization on the day of the monitoring event and by measuring equipment with a known standard after each monitoring event to measure how accurately the equipment can still read the standard within the accuracy ranges specified in **Table 13**.

Field blanks will also be collected for 10% of sampling mobilization events. Equipment blanks will be generated annually by the City of Portland WPCL to ensure that equipment and bottles provided by the lab are not producing false positive readings.

6.7.2 Representativeness

Stormwater samples are collected from the center of the flow to obtain a well-mixed sample representative of the stormwater conditions. Sampling sites are selected using the GRTS study design, so data collected using this random and spatially balanced approach is assumed to be representative of conditions within the entire permit area.

6.7.3 Comparability

The objective is to ensure that collected data are either directly comparable, or comparable with defined limitations, to literature data or other applicable criteria. Wet Weather Stormwater samples are collected and analyzed in the same manner as those collected for Instream Monitoring and Structural Best Management Practice Monitoring. Grab samples are analyzed at Portland's Water

Pollution Control Laboratory to minimize variability and increase comparability of data collected on streams flowing through both jurisdictions. Portland utilizes the GRTS approach in the selection of their stormwater sampling locations, so regional assessment of stormwater data will be possible based on using a similar study design.

6.7.4 Completeness

Completeness is a measure of the amount of valid data obtained from the analytical measurement system compared to the amount that was expected to be obtained. It is defined as the total number of samples taken for which valid analytical data are obtained divided by the total number of samples collected and multiplied by 100.

Based on QA/QC procedures outlined in this Stormwater Monitoring Plan, the Wet Weather Stormwater monitoring goal is to achieve a 100 percent complete data set for all analyses. It is anticipated that 10 samples will be collected annually. Over the 5 year permit term, 50 samples will be collected consisting of 5 monitoring locations being "fixed" sites monitored each year and 25 spatially balanced and random sites selected probabilistically that are each monitored once. It is understood that due to unforeseen circumstances some results may be lost. Field and Laboratory staff will attempt to minimize data loss to the best of their ability by carefully following all protocols and procedures. If data sets are not 100 percent complete for this study, analyses will be evaluated on a case by case basis to determine whether the project needs to collect additional samples.

6.7.5 Instrument Inspection and Maintenance

Field sampling equipment is inspected before and after each monitoring event. The multi-meter and turbidimeter will be cleaned and maintained according to the manufacturer's guidelines. Multi-meters will be professionally inspected, maintained and calibrated annually by Quality Control Services (2340 SE 11th Ave, Portland, OR. 503-236-2712).

Portland's Water Pollution Control Laboratory performs inspection and maintenance of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

6.7.6 Instrument Calibration

The multi-meter probe used to collect field measurements (temperature, pH, DO, and conductivity) will be calibrated prior to each event at mobilization. pH will be calibrated using a 3-point calibration (pH 4, 7 and 10 buffers). Conductivity will be calibrated using a standard within the range of expected measurement (typically 100 µS/cm). DO will be calibrated using percent saturation at the current barometric pressure. Meter calibration will be recorded in an electronic calibration log. Meters will be calibrated halfway through the monitoring event if the accuracy of the meter drifts during the monitoring event. After each sampling event the meter will be measured against known standards to check measurement accuracy.

The turbidimeter will be calibrated annually. Prior to each sampling event, the meter will be measured against known secondary Gelex sample standards to ensure accuracy. Readings will be recorded in the electronic calibration log.

Portland's Water Pollution Control Laboratory performs calibration of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

6.8 Data Management, Review, Validation and Verification

6.8.1 Data Management

All analytical results and applicable field measurements including field data sheet information will be stored in Gresham's master Monitoring Program database. Lab data will be reviewed and entered as soon as practicable, with data entry and analysis always taking place annually for meeting NPDES MS4 annual reporting requirements. Final reporting will be performed in conjunction with the NDPES Annual Report and the permit renewal to assess stormwater status. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate as described in **Section 1.4**.

6.8.2 Data Review, Validation and Verification

Once the data has been entered in the monitoring program database, the Monitoring Program Coordinator will print a paper copy of the data and proofread it against the original field data sheets. Statistical and graphical analysis may be used to reveal whether keystroke errors occurred during data entry. Potential errors in the database will be checked against field data sheets and lab reports. Once verified, errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review, investigation, and if appropriate, discarded. Data quality problems will be discussed as they occur and in the final report to data users.

Reconciliation with data quality objectives as noted above will be performed as soon as possible after each sampling event. Calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. If data quality indicators do not meet the monitoring program's specifications, data may be discarded and re-sampling may occur. The cause of the failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance techniques will be reassessed and improved. If the problem is found to be sampling team error, field techniques will be assessed, revised and retrained, as needed.

7.0 DRY WEATHER FIELD SCREENING

7.1 Project/Task Organization

As required by the NPDES MS4 permit Schedule A 4. a iii- vii and ix-xii, Dry Weather Field Screening is part of an overall Illicit Discharge Detection and Elimination (IDDE) program and refers to the annual inspection of priority outfalls during the dry season. The screening includes documentation of visual observations, uncharacteristic odors and certain field measurements (if sufficient flow is observed). Water quality samples will be collected for laboratory analyses when field screening test values exceed the Co-permittee's protocol. The Co-permittee's existing pollutant parameter action levels protocol will be refined by July 1, 2012 to ensure NPDES MS4 permit compliance.

7.2 Monitoring Objectives

7.2.1 Monitoring Question and Background

The goal for dry weather screening is to identify illicit discharges to the MS4 system. Dry Weather Field Screening seeks to answer the questions "What is the significance of illicit discharges in the permit area?" and "Have illicit discharge elimination programs been successful in reducing problems?" Illicit discharge sources may vary, but of primary interest are wastewater cross connections, floor drains or catch basins capturing wash water or fluids from industrial or commercial facilities, and spills and dumping. Flows from non-stormwater discharges such as landscape irrigation and car washing are addressed by the Co-permittee's education and outreach program and are not a priority for follow-up response given limited staff resources and the limited potential for harm. Note that annual assays are less likely to catch spills and dumping than illicit connections, since the former are typically intermittent.

During permit years 1-10, alternate screening protocols were employed including screening on different days of the week and times of day to see whether discharges due to spills and dumping were more likely to be caught in the evening or on weekends than during the workweek; however no temporal differences were observed. In 2003-2005, Gresham hired contractors to investigate the piped system in industrial and commercial areas using closed circuit television, with the goal of identifying all cross connections. No illicit cross connections were identified.

Dry weather screening will address the following four monitoring objectives from the permit, in addition to other dry weather field screening requirements that are listed in the permit under Schedule A(4)(a)(iv).

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*

Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities;*

Objective 3. *Characterize stormwater runoff discharges based on land use, seasonality, geography or other catchment characteristics;*

Objective 5. *Assess the chemical, biological and physical effects of MS4 stormwater discharges on receiving waters;*

7.2.2 Data Analysis Methodology and Quality Criteria

Dry Weather Field Screening data is continually evaluated to determine the range of values typically present in non-stormwater discharges found in the MS4 during the dry season. After 15 years of screening values, follow up laboratory testing, and tracing sources back to permitted, natural, or illicit sources, the outliers in the field screening data were used to establish the evaluate where Pollutant Parameter Action Levels described in **Section 7.5.3**.

7.2.3 Assumptions and Rationale

Dry Weather Field Screening is most likely to detect illicit connections to the storm system rather than identify pollutants related to spills or dumping. In the past, Gresham used closed circuit television (CCTV) equipment to inspect high priority commercial and industrial areas, including some major arterials and the downtown area for cross connections with the wastewater system. In additional to high priority outfall dry weather screening for Gresham and Fairview, currently, Gresham conducts periodic camera inspections of pipes, and video inspects all new piped systems that will become publically owned to the point of the private connection within its boundary and the City of Fairview conducts inspections within its boundary of additional outfalls annually. Conducting dry weather screening following a sufficient dry period will allow for the identification of any additional on-going discharges that result in discoloration, odor or changes over background in field screening tests.

7.2.4 Relationship to Long-term Monitoring Program Strategy

Dry Weather Field Screening provides an opportunity for monitoring staff to evaluate the Co-permittee's major pipesheds on an annual basis. This monitoring activity helps the Co-permittees identify potential sources of pollutants that exist within the storm system that could potentially be contributing to pollutant loads observed during Wet Weather Stormwater Monitoring (**Section 6.0**). Since the IDDE Program's inception in 1995, Gresham has identified very few illicit discharges, and as such prefers to limit the amount of staff time devoted to this activity in order to balance competing permit requirements and given the resource limitations with regard to staff and financial resources.

7.3 Documentation and Record-keeping Procedures

Consistent with permit requirements, the Co-Permittees will retain records of all monitoring information, including: all calibration, major maintenance records, all original data, copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application.

7.4 Monitoring Process/Study Design

7.4.1 Study Design

The Co-permittees have identified all priority outfalls within the permit area based on more inclusive criteria than the original description in the code of federal regulations. The original program identified major outfalls as 36" or greater, but the Co-Permittees have also selected some outfalls that are smaller. The goal of dry weather screening is to determine whether any illicit discharges are present at the priority outfalls as illustrated in **Figure 2**. A combination of visual observations and field measurements is used to determine the source of any non-stormwater discharge present. The Co-permittees have a process for tracing sources and following up on any suspected illicit discharges identified through the screening process that is described in **Section 7.6.2.**

7.4.2 Monitoring Locations

The Co-Permittees will continue to perform dry-weather outfall monitoring at a revised list of priority outfalls originally identified in the Part II NPDES MS4 Application dated May 17, 1993. Revisions to the original outfall list account for upgrades to the MS4 system which have been made since 1993. The Co-permittee's proposed list of priority outfalls to be screened during this permit term is provided in Table 14. The priority locations are located at the outfall or at the most accessible downstream location from any potential source of suspected illegal or illicit activity that might occur within major pipesheds. Twenty-two sites/year will rotate. They will be selected using a randomized selection process to increase the likelihood of identifying illicit connections.

Eight fixed Dry Weather Screening Locations are listed in **Table 14** and in **Figure 2**. They were selected from the 30 priority outfalls previously monitored after data analysis. These outfalls were the most likely to have illicit discharges due to land use within the drainage area and findings from past years. These fixed sites are distributed between the Columbia Slough, Fairview Creek, and Johnson Creek watersheds. We will monitor 22 additional outfalls each year which will be selected based on hydrological conditions, land use, size of drainage area, traffic density, age of structures or buildings in the area, history of the area, personnel safety, accessibility, historical complaints, and whether new development or redevelopment has occurred within the drainage area.

Table 14: Fixed Illicit Discharge Monitoring/Dry Weather Screening Locations

Site ID	Location	Watershed	Channel Type	Land Use
D2A	MH south of NE 181st Ave Bridge (CSO1) (Drains 181st St)	Columbia	MH	I/C
F2	OF @ Sandy (open channel) north of Boeing (Stormdrain Cr)	Columbia	MH	I/C
G1	Boeing Outfall (east outfall entering CSWQF)	Columbia	OF	I/Ag
3250-F-004	Manhole at inlet to Fairview Creek facility	Fairview	MH	C/R

N15B	NE Elliott & Powell, north bank of trib to Johnson	Johnson	OF	R/C
J18A	OF @ Eastman/Towle on South side of Johnson Creek	Johnson	OF	R
M16	West OF in Main City Park (JCOS1)	Johnson	OF	C
N16	East OF in Main City Park (JCO3)	Johnson	OF	C/R

Channel Types
OF = outfall
MH = manhole

Land Uses
R = residential
I = industrial
C = commercial

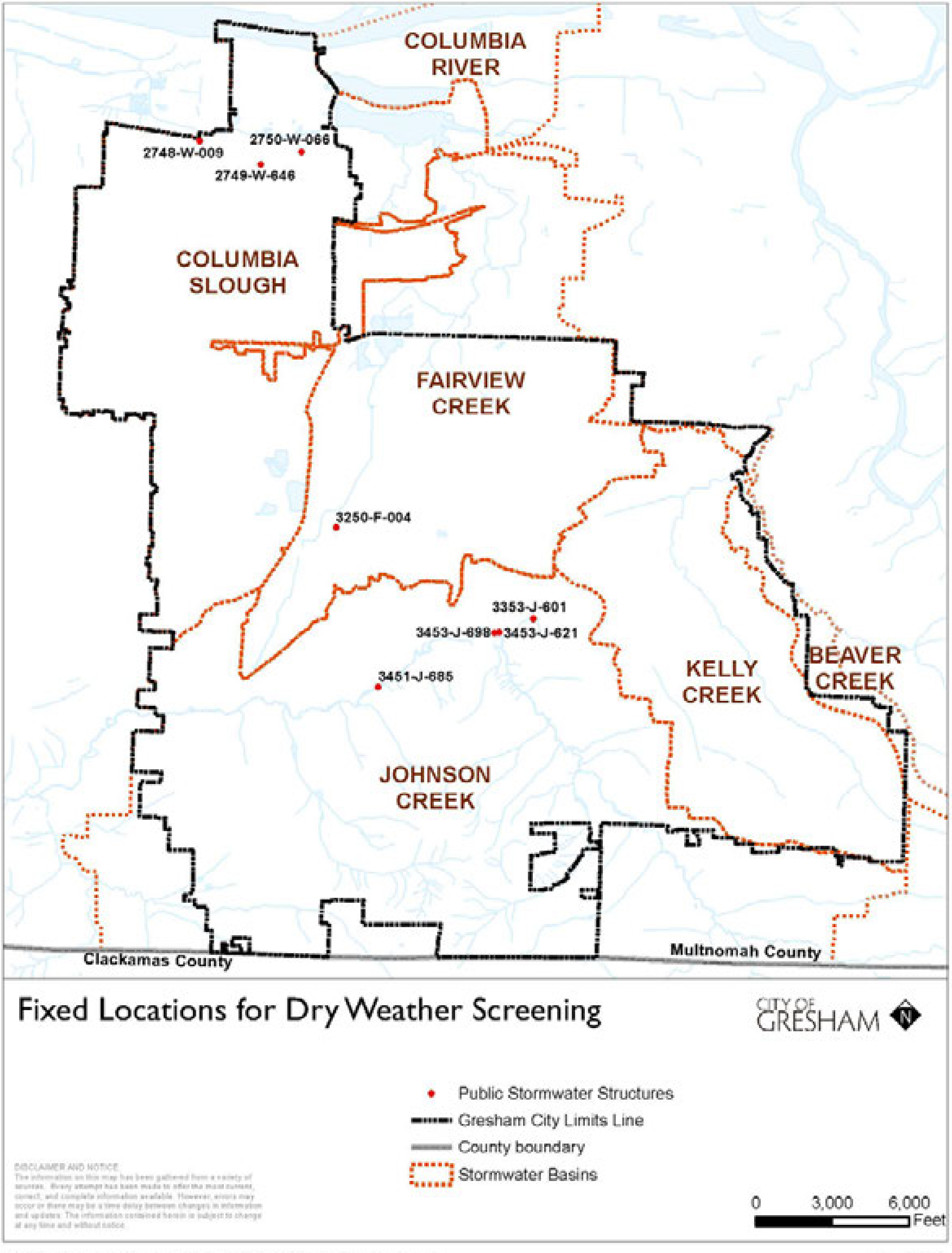
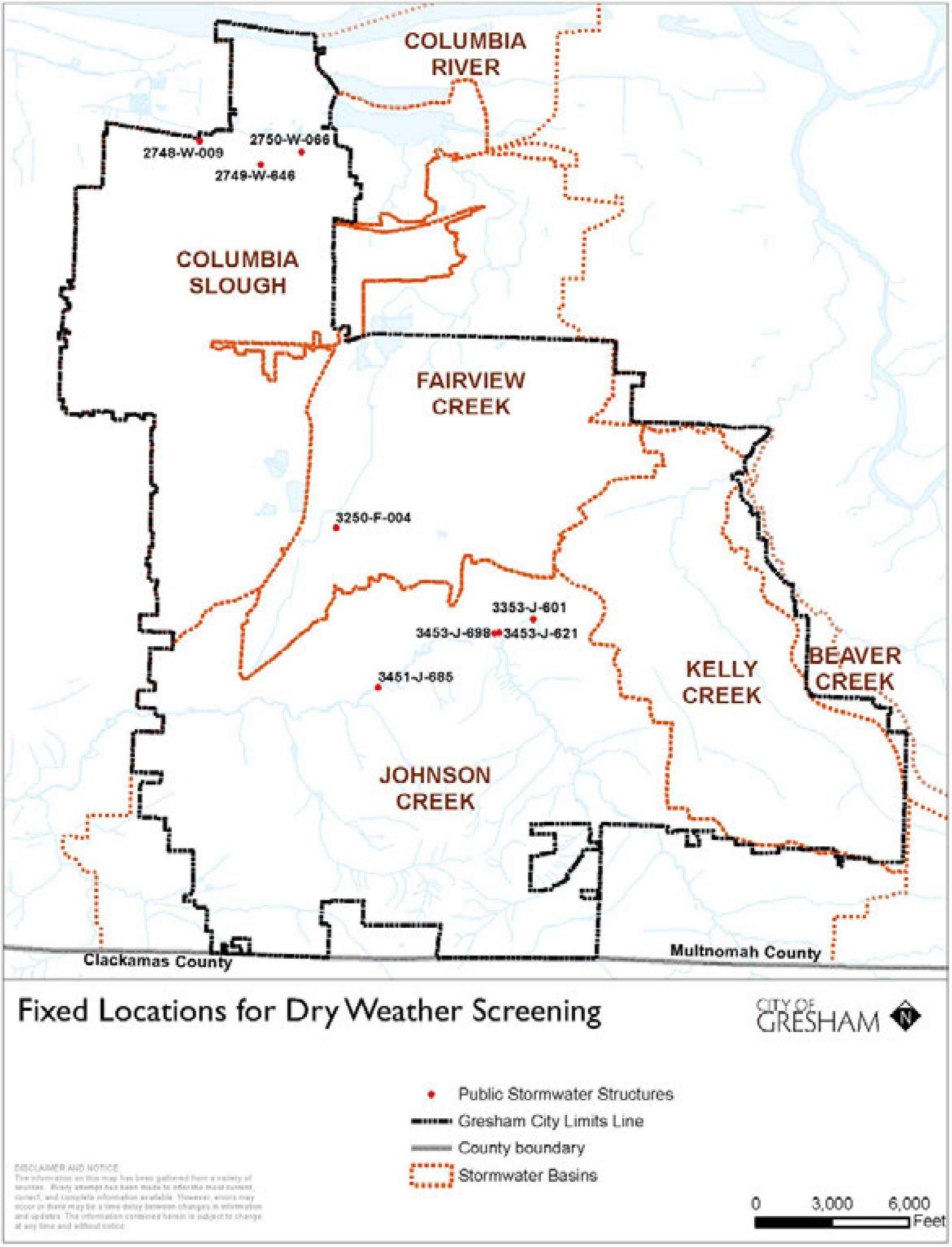


Figure 2. Fixed Dry Weather Screening Locations



7.4.3 Sampling Event Criteria

Dry weather screening will be conducted during the dry summer months, typically during July, August or September. As required by the permit, dry weather screening will be conducted following at least a 72-hour antecedent dry period.

7.4.4 Frequency and Duration

Dry weather field screening will be conducted one time annually at each of the locations listed in **Table 14**. Sampling frequency may be adaptively managed as additional outfalls are assessed.

7.4.5 Responsible Sampling Coordinator

This monitoring task is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham, who target proper dry weather conditions, calibrate equipment, perform field observations and screening, collect samples for lab analysis, and coordinate delivery to the lab. Laboratory analysis for any sample collected for laboratory analysis is conducted by Portland's Water Pollution Control Laboratory under an IGA with the City of Gresham for laboratory services (see **Appendix F**).

7.5 Dry Weather Screening Activities

7.5.1 General Observations

For each of the sites listed in **Section 7.4.2.**, **Table 14**, the following conditions are noted – odor, color, clarity, floatable, deposit/stains, vegetative condition (if applicable), structural condition, biological, and other observations that may indicate presence of non-stormwater or illicit discharges.

7.5.2 Field Screening

When flow is present, a sample will be collected and screened for illicit discharges using field measurements of temperature, pH, conductivity, turbidity, ammonia, and chlorine. If any of the observations or screening data indicate an illicit discharge may be present, the source is investigated within the drainage system. If a source cannot be identified or the pollutant parameter action level indicates there is a need for additional information, a sample may be collected and sent to the laboratory for analysis.

7.5.3 Pollutant Parameter Action Levels

As described in **Section 7.2.2**, field observations and screening values are compared against historic information for each monitoring location and the system. Screening values which indicate that an illicit discharge may be present will be investigated using the process described in **Section 7.6**. **Table 15** contains the pollutant parameter action levels and suspected sources the Co-permittees will investigate based on action levels.

The Co-permittees have evaluated field screening constituents listed in **Section 7.5.2** as required in Schedule A(4)(a)(iii). The values in Table 15 at based on evaluation of our Dry Weather Screening data and Herrera's 2013 Illicit Discharge Indicator Thresholds Memo which reviewed the literature as well as jurisdictional levels.

Table 15: Pollutant Parameter Action Levels

Parameter	Action level [1]	Suspected Source and Action
Ammonia	> 0.5 mg/L	Presence of ammonia >0.5 mg/L likely indicates

nitrogen		sewage, industrial waste or pets/wildlife. Action: conduct source identification investigation looking for upstream bacteria or waste source.
Total chlorine	> 0.5 mg/L [2]	Presence of chlorine, absent other parameters that exceed action levels, likely indicates municipal treated water, a discharge of municipal water, residential car washing, or pool/hot tub water. If greater than action level, conduct source identification investigation looking for pool or nearby irrigation discharge to system.
Turbidity	> 15 NTU [3]	Turbidity is a supplemental measurement that is not conclusive by itself, but may help identify problem outfalls that merit follow-up. Turbidity above the action level may indicate whether discharge consists of something other than tap water or groundwater. Action: conduct source identification investigation looking for upstream sediment source.
Conductivity	> 300 µS/cm [4]	Conductivity is a supplemental measurement that is not conclusive by itself, but may help identify problem outfalls that merit follow-up. If turbidity is high, conductivity may indicate whether the turbidity is due to dissolved substances rather than fine particulates. Groundwater typically has higher conductivity than clean stormwater, so conductivity will rarely be indicative of pollution on its own. Action: conduct source identification investigation and, if needed, collect lab sample for appropriate pollutants based on suspected pollutants.
pH	Outside 6.5-8.5 [5]	pH is a supplemental measurement that is not conclusive by itself, but may help identify problem outfalls that merit follow-up. In combination with other screening levels, actions may include conduct source tracing and, if source not found, collect lab sample for pollutants suspected to cause or be associated with pH levels. Discharge sources that may cause high or low pH include among others: natural sources (bacteria, algae) and certain industrial discharges.
Temperature	> ambient air temperature[6]	Water warmer than ambient air temperature may indicate a human-caused heat source.
Flow	Water level above base flow level indicated by pipe staining	Conduct source identification investigation within upstream pipeshed, by lifting manhole lids and checking flow volume against pipe staining level.

7.5.4 Laboratory Analysis

Water quality samples will be collected for additional analysis when visual observations or field screening tests indicate a potential pollutant for which the source cannot be identified through source identification investigation (Section 7.6). Typically, this will be determined after source identification investigation has occurred, and no discharge source has been identified. However, there can be cases in which none of the field measurements exceed action levels, but sensory observation indicates the presence of pollutants. Additional analyses may consist of bacteria, metals, nutrients, phenols, hydrocarbons or other analyses deemed appropriate based on observations and field screening. Analyses are deemed appropriate if the pollutant relates to a suspected type of source or discharge; or known land uses or activities in the pipeshed. Once water quality results are received from the lab—which is typically several days to weeks after samples were taken, additional source identification investigation may occur.

7.6 Source Identification Investigation

7.6.1 Source Tracing

If any of the observations or field screening outlined in **Section 7.5** indicate an illicit discharge may be present, the source is investigated within the drainage system using GIS mapping to illustrate the stormwater system and corresponding tax lots and follow the system upstream to investigate. Upstream points such as manholes and catch basins will be observed visually for connections to the system. Based upon experience, staff generally investigate a minimum of ¼ mile and up to ½ a mile from the screening location or until flow is no longer observed and/or no probable source can be identified for further investigation, which are described below in **Section 7.6.2**.

If general observations, field screening action levels, or source tracing indicate that the flow present is a non-stormwater discharges as described in the NPDES MS4 permit Schedule A 4. a. xii, an illicit discharge investigation (**Section 7.6.2**) will not be conducted. Some of the most commonly occurring non-stormwater discharges include: landscape irrigation, lawn watering, discharges from potable water sources, residential car washing, charity car washing, flows from diverted streams or wetlands, springs, infiltration or pumping of groundwater, foundation drains, and footing drains.

7.6.2 Illicit Discharge Investigation

When field screening indicates there may be an illicit discharge to the MS4, the upstream area will be inspected in an attempt to identify the pollutant(s) source. The level of effort staff spend investigating potential illicit discharges will be evaluated on a case-by-case basis, but will consider the following factors:

- Volume and extent of discharge (detectable at outfall to waters of state, or only in localized area within pipe system);
- Frequency and duration of discharge (isolated episode, intermittent, or ongoing);
- Suspected type of discharge (determined by screening criteria – color, smell, water quality measurements); and
- Risk and potential to impact surface water quality or harm human health or aquatic life.

Some discharges detected during dry weather screening may be deemed to be low risk to the MS4 based on the above listed criteria. If a source cannot be identified with a reasonable amount of effort, it may be determined that the risk from the discharge is low enough that the effort needed to identify the source is not cost–effective, and that other measures (e.g., inspections or outreach programs to educate and prevent against dumping and spills) are a better expenditure of program resources. Small or episodic contributions to the MS4 can be deemed *de minimus* after city staff have expended a reasonable amount of investigational effort with no positive results.

Sources that are deemed to pose a moderate or high level of risk to the MS4 or waters of the state due to either the quantity or type of pollutant will be investigated immediately and will receive a high level of effort. In addition to visual investigation of the upstream system, water flushing, dye testing, closed circuit television, or other such methods may be used to aid in source identification. Additionally, if any field screening action level indicates a need for additional information, a sample may be collected and sent to the laboratory for analysis.

If the suspected illicit discharge is deemed to be a threat to water quality and originates from private property, permission for inspection may be required from the property owner or tenant; if denied, an Administrative Inspection Warrant can be obtained within 3-5 days.

Once a source has been identified, an initial evaluation to eliminate the discharge will be completed within 5 working days. If the elimination of the illicit discharge will take more than 15 working days due to technical, logistical or other reasonable issues, an action plan to eliminate the discharge in an expeditious manner will be created. The action plan will be completed within 20 working days of determining the source of the illicit discharge and submitted to DEQ as required by the permit. City Code allows for the use of civil penalties and/or abatement for stormwater violations where a responsible party has been identified and provided with direction from the City with regard to gaining compliance, but has not complied within the specified timeframe.

To this end, the permit further requires that illicit discharges entering or exiting one Co-permittee's area into the other requires notification to the affected jurisdiction within one working day.

7.7 Data Management, Review, Validation and Verification

7.7.1 Data Management

All applicable field observations and measurements will be stored in Gresham's dry weather screening database. Field observations and screening data are typically entered directly into the database during dry weather field screening activities. When laboratory analysis is conducted, data will be reviewed and entered as soon as practicable so that follow up source identification investigation can take place.

Dry weather field screening data entry and analysis will occur annually and will be reported to DEQ with the NPDES MS4 Annual Report. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate.

7.7.2 Data Review, Validation and Verification

Once the data has been entered in the monitoring program database, the Monitoring Program Coordinator will review the data to determine if all values are within the expected range, and detect any outliers due to keystroke errors during data entry. If the error can be identified, errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review, investigation, and if appropriate, discarded. Data quality problems will be discussed as they occur and in the final report to data users.

8.0 STRUCTURAL BEST MANAGEMENT PRACTICE MONITORING

8.1 Project/Task Organization

Structural Best Management Practice Monitoring refers to the effectiveness monitoring of structural BMPs recently constructed by the City of Gresham. The city currently has four regional-scale facilities. Since the City has proposed constructing other regional facilities as part of the Springwater and Pleasant Valley Plan Districts, which will be incorporated into the City in the future, assessing the effectiveness of regional facilities is important for the adaptive management of Gresham's stormwater program, as well as for refining the values used in TMDL pollutant reduction benchmarks.

The Fairview Creek Water Quality Facility provides stormwater treatment for a combined drainage area of approximately 959 acres of residential, commercial, and industrial development that previously discharged partially treated stormwater (e.g., catch basin filters and street sweeping) directly to Fairview Creek. The single large outfall, which is now the inlet to this BMP, was previously monitored as part of the land use based monitoring performed in permit years 1, 2 and 3 during the first 5-year permit cycle, and continued as a stormwater outfall monitoring site (mixed land use) in permit years 7, 8, 9, and 10.

The Columbia Slough Water Quality Facility will provide stormwater treatment for a combined drainage area of approximately 709 acres of primarily commercial and industrial development that previously discharged partially treated stormwater (e.g., catch basin filters and street sweeping) directly to the Columbia Slough. There are 2 major outfalls that drain similar land uses that discharge to this facility. Since the facility contains multiple components, including sedimentation forebays, vegetated swales and holding cells for base and low flows, as well as wetland detention with emergent vegetation, and riparian forest for periodic inundation, monitoring of the facility would provide pollutant removal effectiveness for this specific large-scale facility.

The Kelly Creek detention pond is an in-line facility in Kelly Creek that drains into Beaver Creek. It was retrofitted in 2013-2014 to improve water quality in a stream that receives water from mostly residential use. The Brookside Regional Facility was constructed at the base of a new housing sub-development project in Pleasant Valley area. It contains a meandering swale within a detention pond that was designed to slow water and allow for longer contact time with plants and soil before entering Kelley Creek.

Each of these facilities has a unique design, and monitoring data on the effectiveness of stormwater treatment at the various facilities would greatly inform future design and management.

8.2 Monitoring Objectives

8.2.1 Monitoring Question and Background

Structural BMP effectiveness monitoring is intended to answer the question "How effective are the various structural BMPs that are being implemented throughout the permit area at reducing pollutants?" The City of Gresham plans to examine the performance of at least one of the structural BMPs recently constructed to enhance water quality. As shown in **Appendix A**, Structural BMP monitoring contributes to meeting NPDES MS4 monitoring objectives 1, 2, 3, and 6.

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*
Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) to assist in identifying BMP priorities;*
Objective 3. *Characterize stormwater runoff discharges based on land use, seasonality, geography or other catchment characteristics;*
Objective 6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

8.2.2 Data Analysis Methodology and Quality Criteria

Structural BMP Effectiveness Monitoring requires a paired sampling design, with the event mean concentrations being compared for influent and effluent. Because stormwater data typically doesn't follow a normal distribution, a nonparametric statistic, such as Mann-Whitney, will be used to compare the influent and effluent concentrations to determine if there is a significant change in stormwater quality. The current TMDL benchmark approach requires calculation of an effluent concentration for specific BMPs, so the effluent concentrations from various events will be evaluated for central tendency and variability. Based on findings from other BMP effectiveness studies, a reliable estimate of effluent water quality can be determined using 5-20 samples.

8.2.3 Assumptions and Rationale

Based on other BMP effectiveness studies (see International BMP Database), influent concentrations are more variable than effluent concentrations. Based on this assumption, enough data may be collected to accurately represent the mean effluent concentration after monitoring 2 events per year for 3-5 years (6-10 events total).

8.2.4 Relationship to Long-term Monitoring Program Strategy

The structural BMP Effectiveness Monitoring described in this section provides a direct measure of innovative regional CIP projects constructed to treat stormwater within the permit area. The two facilities described in this section are each composed of a different series of BMPs (FCWQF has sedimentation forebay → wet detention pond → constructed wetland; CSWQF has sedimentation manhole → sedimentation forebay → series of terraced wetland swales → wet detention pond) that will be evaluated to determine overall effectiveness of the different combination of these BMPs. Gresham has proposed constructing other regional facilities as part of the Springwater and Pleasant Valley Plan Districts, which will be incorporated into the City of Gresham in the future, so assessing the effectiveness of regional facilities is important for the adaptive management of Gresham's stormwater program; specifically, determining what components of a BMP "treatment train" will be incorporated into future regional facilities. Data collected for the two regional facilities described in this section will provide values to be used in future TMDL pollutant load reduction benchmark calculations.

8.3 Documentation and Record-keeping Procedures

Consistent with permit requirements specified in NPDES MS4 permit Schedule F, Section C.5., the Co-Permittees will retain records of all monitoring information, including: all calibration, major maintenance records, all original lab and field data (see **Appendix C** for example of field data sheet), copies of all reports required by the NPDES MS4 permit, and records of data used to complete the application for the NPDES MS4 permit for a period of at least 3 years from the date of the sample, measurement, report, or application.

Records will contain:

1. The date, exact place, time, and methods of sampling or measurements;
2. The individual(s) who performed the sampling or measurements;
3. The date(s) analyses were performed;
4. The individual(s) who performed the analyses;
5. The analytical techniques or methods used; and
6. The results of such analyses.

8.4 Monitoring Process/Study Design

8.4.1 Study Design

The study design for Structural BMP Effectiveness Monitoring is a paired study looking at influent and effluent concentrations. Because the facilities are designed to provide detention time, as well as water quality treatment, obtaining representative samples involves collecting several grab samples throughout the duration of the event as stormwater enters and leaves the facility. Flow and rainfall data are used to determine representativeness of the water quality data collected.

8.4.2 Monitoring Locations

Gresham has sampled at the inlet and outlet of the Fairview Creek Water Quality Facility (FCWQF) or the Columbia Slough Water Quality Facility (CSWQF) every year since spring 2006. Over the next permit cycle, the City of Gresham will continue to sample these water quality facilities to some extent. Once staff determine that the FCWQF and CSWQF have been sufficiently characterized to meet the objectives in **8.2**, monitoring efforts may switch to sampling other structural BMPs. Proposed sampling locations for the four regional facilities are listed in **Table 16**.The Kelly Creek Detention Pond (KCDP) and the Brookside Regional Water Quality Facility (BRWQF) each have one inlet and one outlet location.

Table 16: Structural Best Management Practices Sampling Locations

Station Number	Site Code	Location	Sample Frequency	Duration
12	FWQF-1	Inlet of FCWQF	1-2 Events/Year	0-5 years
13	FWQF-2	Outlet of FCWQF	1-2 Events/Year	0-5 years
17	CSWQF-1	Inlet #1 of CSWQF	1-2 Events/Year	1-5 years
18	CSWQF-2	Inlet #2 of CSWQF	1-2 Events/Year	1-5 years
19	CSWQF-3	Outlet of CSWQF	1-2 Events/Year	1-5 years
20	KCDP-1	Inlet of KCDP	1-2 Events/Year	1-5 years
21	KCDP-2	Outlet of KCDP	1-2 Events/Year	1-5 years
22	BRWQF-1	Inlet of BRWQF	1-2 Events/Year	1-5 years
23	BRWQF-2	Outlet of BRWQF	1-2 Events/Year	1-5 years

8.4.3 Sampling Event Criteria

Prior to initiating a sampling event, the storm will be predicted and evaluated against the criteria listed below to assess whether the predicted storm should be targeted as a potential sampling event. Storm event criteria are as follows:

- Predicted rainfall amount of ≥ 0.5 inches per storm;
- Predicted rainfall duration ≥ 6 hours; and
- Antecedent dry period ≥ 24 hours (target is <0.1 inches of precipitation).

Since the goal for Structural BMP Effectiveness Monitoring is to determine how effective regional facilities are at pollutant removal, longer antecedent dry periods may be required to ensure that stormwater from previous wet weather events is no longer being detained in the facility. Discrete precipitation events with greater than 24 hours meeting the antecedent dry period condition listed above preceding and following the wet weather event will be targeted when feasible, as described in section 2.0.

Hourly and daily rainfall records are maintained and available on the HYDRA Data Report System. This data is available on the web at:
http://or.water.usgs.gov/non-usgs/bes/raingage_info/clickmap.html.

8.4.4 Frequency and Duration

A total of four "facility events" will be sampled per year; for example, two facilities may be sampled for each of two storms, or four facilities may be sampled during one storm each. The decision of which BMPs to monitor will depend on the results of the sampling, the status of the facilities, and the related management objectives.

8.4.5 Responsible Sampling Coordinator

This monitoring task is coordinated by the City of Gresham's Water Resources Division on behalf of Gresham, Fairview Gresham will target events, calibrate equipment, perform in-situ field measurements, collect samples for lab analysis, and coordinate delivery to the lab. Laboratory analysis for instream samples is conducted by Portland's Water Pollution Control Laboratory under an IGA with the City of Gresham for laboratory services (see **Appendix F**).

8.5 Collection Method and Handling

8.5.1 Sample Collection Method

The four regional facilities described above have continuous flow monitoring equipment installed at the inlets and outlets. Data from past events will be used to determine when to take representative grab samples.

Table 17: Sample Collection Method and Timing for Structural BMP Monitoring

Constituents	Number of Samples	Collection Method	Timing
Field			
Temperature, Conductivity, pH, Turbidity	≥3	Grab/in situ	Periodic
Conventional			

E. coli	1-3	Grab	Rising Limb, Middle**, Falling Limb
Biochemical Oxygen Demand (BOD_5), Total Suspended Solids, Hardness, Particle Size Distribution	≥3	Grab	Rising Limb, Middle, Falling Limb
Total Recoverable Metals			
Copper, Lead, Mercury, Zinc	≥3	Grab	Rising Limb, Middle, Falling Limb
Dissolved Metals			
Copper, Lead, Zinc	≥3	Grab	Rising Limb, Middle, Falling Limb
Mercury			
Total mercury	1	Grab	1/3
Nutrients			
Nitrate + Nitrite Nitrogen, Total Kjeldahl Nitrogen, Ammonia Nitrogen, Total Phosphorus, Ortho-phosphorus	≥3	Grab	Rising Limb, Middle, Falling Limb

** When the decision is made to collect only a single bacteria sample, the sample is typically collected 1/3 of the way through sample collection. Based on sampling history, the rising limb of an event hydrograph is usually well represented by a sample collected 1/3 of the way into an event, and a falling limb sample collected approximately 2/3 of the way through an event.

8.5.2 Handling and Custody Procedures

For grab samples, samples are collected directly into the appropriate containers directly from the center of flow, when possible. If needed, samples will be collected using a clean stainless steel bailer attached to an extension rod. The stainless steel bailer is cleaned prior to each site using laboratory-grade soap and distilled water. Field measurements are made by collecting a representative sample using the stainless steel bailer and then pouring the sample into the measurement/storage cup of the multi-meter probe.

Two-person clean sample collection techniques are followed to minimize the potential for contamination of samples: one “dirty hands” to move equipment, document field measurements, grab samples using the bailer and remove manhole lids; and one “clean hands” to fill sample bottles. The “clean hands” member wears powder-free nitrile gloves to avoid contamination of the sample and protect the sampler from possible health risks.

All samples collected for laboratory analysis are immediately placed into a cooler containing ice and transported to the lab immediately following sample collection. **Table 17** lists the volume of sample collected, the container used and maximum holding time. Once samples are delivered to Portland’s Water Pollution Control Laboratory, they have their own QAPP to ensure that samples are analyzed within the proper holding time and preservation methods are employed.

Table 18: Sample Containers and Holding Times for Structural BMP Monitoring

Constituent	Minimum Sample Volume	Bottle Type	Holding Time
Conventional Constituents			
Biochemical Oxygen Demand (BOD_5)	250 mL	Plastic	24 hours
Total Suspended Solids	500 mL	Plastic	7 days
Hardness	250 mL	Plastic	6 months
E. coli	100 mL	Sterile Plastic	6 hours (max 24 hrs)
Particle Size Distribution	1 liter	Plastic	28 days
Nutrients			
Nitrate Nitrogen	100 mL	Plastic	48 hours
Total Kjeldahl Nitrogen	100 mL	Plastic	28 days
Ammonia Nitrogen	100 mL	Plastic	28 days
Total Phosphorus	100 mL	Plastic	28 days
Ortho-phosphorus	250 mL	Plastic	48 hours
Total Recoverable Metals			
Copper	400 mL	Plastic	6 months if preserved
Lead			
Zinc			
Mercury			
Dissolved Metals			
Copper	400 mL	Plastic	6 months if Preserved
Lead			
Zinc			

After samples have been obtained and the collection procedures properly documented, a written record of the chain of custody for each sample requiring laboratory analysis is completed (see **Appendix C**). Information included on the chain of custody includes:

- Name of the persons collecting the sample(s)
- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory
- Laboratory analysis requested and control information (e.g., duplicate or spiked samples etc.) and any special instructions (e.g., time sensitive analyses).

To ensure that all necessary information is documented a chain of custody form will accompany each sample or set of samples and a copy of the form is retained. Each person who takes custody will sign and date the appropriate portion of the chain of custody documentation.

8.6 Constituents and Methods

The analytical methods and method reporting limits (MRLs) for constituents monitored for structural BMP monitoring are listed in **Table 18**.

Table 19: Structural BMP Monitoring Constituents, Methods, and MRLs

Field Constituents	**Analytical Method**	**MRL**	**Units**
Temperature	SM 2550 B	-5	Degrees C
DO	SM 4500-OG	0.1	mg/L
Conductivity	EPA 120.1	1.0	µs/cm
pH	EPA 150.1	3.0	S.U.
Turbidity	EPA 180.1	0.05	NTU
Biochemical Oxygen Demand (BOD_5)	SM 5210 B	2	mg/L
Total Suspended Solids	SM 2540 D	2	mg/L
Hardness	SM 2340 B	0.5	mg/L as $CaCO_3$
E. coli	COLILERT QT	10	MPN/100 mL
Particle Size Distribution	OPTICAL	1000	# Part/100 mL
Nutrients			
Nitrate Nitrogen	EPA 300.0	1.10	mg/L
Total Kjeldahl Nitrogen	PAI-DK03 [1]	0.20	mg/L
Ammonia Nitrogen	EPA 350.1	0.02	mg/L
Total Phosphorus	EPA 365.4	0.02	mg/L
Ortho-phosphorus	EPA 365.1	0.02	mg/L
Total Recoverable Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Zinc	EPA 200.8	0.5	µg/L
Mercury	WPCLSOP M-10.02 *[2]	0.002	µg/L
Dissolved Metals			
Copper	EPA 200.8	0.2	µg/L
Lead	EPA 200.8	0.1	µg/L
Zinc	EPA 200.8	0.5	µg/L

* Mercury and TKN are not required in Table B-1 of the NPDES MS4 permit (beyond the 2 sites twice per year in DEQ's Mercury memo), so are subject to the Adaptive Management process described in **Section 1.4**.

[1] The PAI-DK03 method for TKN is a 40 CFR 136 method (flow injection gas method, see footnote 41, Table 1B, 40 CFR Part 136.3).

[2] The WPCLSOP M-10.02 method cited for total Hg is EPA 200.8 w/CEM digestion (footnote 4, Table 1B, 40 CFR Part 136.3).

8.7 Quality Assurance

8.7.1 Quality Control Objectives

The data quality objectives for accuracy and precision for field and lab analysis of Structural BMP monitoring are the same as those listed under Wet Weather Stormwater Monitoring. Because Structural BMP monitoring often occurs at the same time as other instream or wet weather stormwater monitoring, and because greater than 10% duplicates are typically collected, duplicates are not typically collected for this monitoring activity, but instead included as part of Wet Weather Stormwater Monitoring. Field duplicates will be collected for a minimum of 10% of the combined BMP and wet weather sampling events. Field blanks will also be collected for 10% of sampling mobilization events. Equipment blanks will be generated annually by the WPCL to ensure that equipment and bottles provided by the lab are not producing false positive readings.

8.7.2 Representativeness

Stormwater samples are collected from the center of the flow to obtain a well-mixed sample representative of the stormwater conditions. Composite sampling is used for most constituents to ensure that samples collected are representative of conditions that likely occur throughout the entire event.

8.7.3 Comparability

The objective is to ensure that collected data are either directly comparable, or comparable within defined limitations, to literature data or other applicable criteria. Structural Best Management Practice Monitoring samples are collected and analyzed in the same manner as those collected for Instream Monitoring and Wet Weather Stormwater. Samples are analyzed at Portland's Water Pollution Control Laboratory to minimize variability and increase comparability of data collected by both jurisdictions.

8.7.4 Completeness

The Structural BMP monitoring goal is to achieve a 100 percent complete data set for all analyses. It is anticipated that 2 events will be collected annually, so over the 5 year permit term, 10 samples will be collected. It is understood that due to unforeseen circumstances some results may be lost. Field and Laboratory staff will attempt to minimize data loss to the best of their ability by carefully following all protocols and procedures. If data sets are not 100 percent complete for this study, analyses will be evaluated on a case by case basis to determine whether the project needs to collect additional samples.

8.7.5 Instrument Inspection and Maintenance

Field sampling equipment is inspected before and after each monitoring event. The multi-meter and turbidimeter will be cleaned and maintained according to the manufacturer's guidelines. Multi-meters will be professionally inspected, maintained and calibrated annually by Quality Control Services (2340 SE 11th Ave, Portland, OR. 503-236-2712).

Portland's Water Pollution Control Laboratory performs inspection and maintenance of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

8.7.6 Instrument Calibration

The multi-meter probe used to collect field measurements (temperature, pH, DO, and conductivity) will be calibrated prior to each event at mobilization. pH will be calibrated using a 3-point calibration (pH 4, 7 and 10 buffers). Conductivity will be calibrated using a standard within the range of expected measurement (typically 100 μS/cm). DO will be calibrated using percent saturation at the current barometric pressure. Meter calibration will be recorded in an electronic calibration log. Meters will be calibrated halfway through the monitoring event if the accuracy of the meter drifts during the monitoring event. After each sampling event the meter will be measured against known standards to check measurement accuracy.

The turbimeter will be calibrated annually. Prior to each sampling event, the meter will be measured against known secondary Gelex sample standards to ensure accuracy. Readings will be recorded in the electronic calibration log.

Portland's Water Pollution Control Laboratory performs calibration of laboratory instruments used for analysis of grab samples. A copy of the WPCL's QAPP is included in **Appendix G**.

8.8 Data Management, Review, Validation and Verification

All analytical results and applicable field measurements including field data sheet information will be stored in Gresham's master NPDES MS4 data spreadsheet. Lab data will be reviewed and entered as soon as practicable, with data entry and analysis always taking place annually for meeting NPDES MS4 annual reporting requirements. Final reporting will be performed in conjunction with the NDPES Annual Report and the permit renewal to assess instream trends. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate.

8.8.1 Data Management

All analytical results and applicable field measurements including field data sheet information will be stored in Gresham's Stormwater Database. Lab data will be reviewed and entered as soon as practicable, with data entry and analysis taking place prior to calculating benchmarks due with the permit renewal submittal. Periodic analysis of data may also occur to assess whether adaptive management of the Monitoring Plan or program is appropriate.

8.8.2 Data Review, Validation and Verification

Once the data has been entered in the project database, the Monitoring Program Coordinator will print a paper copy of the data and proofread it against the original field data sheets. Statistical and graphical analysis may be used to reveal whether keystroke errors occurred during data entry. Potential errors in the database will be checked against field data sheets and lab reports. Once verified, errors in data entry will be corrected at that time. Outliers and inconsistencies will be flagged for further review, investigation, and if appropriate, discarded. Data quality problems will be discussed as they occur and in the final report to data users.

Reconciliation with data quality objectives as noted above will be performed as soon as possible after each sampling event. Calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. If data quality indicators do not meet the project's specifications, data may be discarded and re-sampling may occur. The cause of the failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance techniques will be reassessed and improved. If the problem is found to be sampling team error, field techniques will be assessed and revised as needed.

9.0 SOURCE CONTROL ASSESSMENT AND SOLIDS TRACKING

Each Co-Permittee's source control best management practices are described in their respective Stormwater Management Plans, which include the type of activity, frequency of implementation, and measurable goals. Gross solids are collected during various operations & maintenance activities as described in the SWMP and will be reported in the annual NPDES report to DEQ.

Gresham developed a debris characterization study to attempt to identify specific contaminants that may be related to gross solids and debris (see **Appendix I**). Data has been collected and will be assessed to determine whether additional chemical analyses would provide more detailed characterization of contaminants associated with solids being removed by source controls.

Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;*
Objective 6. *Assess progress towards meeting TMDL pollutant load reduction benchmarks.*

9.1 Literature Tracking

Stormwater management is a continually evolving field, covering many disciplines. There is extensive existing and new literature on treatment system performance monitoring conducted by researchers, public entities, and private companies to meet both regulatory and non-regulatory needs. Some of these studies provide estimates of effectiveness of treatment controls. An important part of the Co-Permittees' strategy for collecting information to aid their stormwater management efforts is to track current and developing literature on relevant topics. In particular, literature related to the performance and cost effectiveness of both treatment and source control best management practices will be followed.

The Co-Permittees are currently involved with AWCA, which provides an open forum for stormwater management discussions. Additionally, managers and staff attend local conferences, coordinate with other agencies, and track stormwater management related literature. These activities aid in addressing:

Objective 1. *Evaluate the source(s) of the 2004-06 303(d) listed pollutants applicable to the co-permittees' permit area*
Objective 2. *Evaluate the effectiveness of Best Management Practices (BMPs) in order to help determine BMP implementation priorities;*

The Co-Permittees will track and review the literature in order to keep current with innovations and technological advances that may be utilized to enhance treatment and source controls. Typically, the Co-permittee will review research to determine whether the findings merit changes to their respective SWMPs that will be submitted for DEQ's consideration during the permit renewal submittal. Changes that can be made with adaptive management may occur annually, but the Co-permittees may not always have the resources to do ongoing annual analysis. Examples of resources that provide data relevant to performance monitoring and evaluation for potential tracking are given below. The Co-Permittees also contributed to development of a BMP effectiveness database that ACWA commissioned. The database is available from ACWA in electronic format.

9.2 Literature Search Resources

Technical literature and research that is available for review includes but is not limited to the following sources:

- ASCE and USEPA. 2004. International Stormwater Best Management Practices (BMP) Database. [Online] http://www.bmpdatabase.org.
- WERF and NCHRP Stormwater Research Efforts. Both organizations are active in preparing research documents on stormwater runoff and best management practices performance.
- Federal Highway Administration (FHWA). 2000. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. Prepared by Tetra-Tech, Inc. and Hagler Bailly Services, Inc. FHWA-EP-00-002, Washington, DC.
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