QUALITY ASSURANCE PROJECT PLAN FOR STORMWATER TREATMENT AND HYDROLOGIC MANAGEMENT BEST MANAGEMENT PRACTICE EVALUATION MONITORING (S8.F)

CONDUCTED UNDER THE PHASE 1 MUNICIPAL STORMWATER PERMIT

BY

PORT OF TACOMA

Final

February 2010
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Title: Quality Assurance Project Plan: Port of Tacoma Municipal Phase I Permit Stormwater BMP Evaluation Monitoring of Filterra® Bioretention Filtration System

Author: Port of Tacoma

Adapted from Plan prepared by: Herrera Environmental Consultants, Seattle, Washington, April 2008 and an Addendum dated 17 June 2008

Date: August 2009

Project Manager: Lisa Rozmyn, Port of Tacoma Date: 2/20/10

Supervisor: Sue Mauermann, Director Environmental Programs Date: 3/30/10
Section 1: Introduction

The Port of Tacoma (Port) is subject to the requirements of the Phase I Municipal Stormwater Permit under the Washington State Department of Ecology (Ecology) National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems (Permit) as a Secondary Permittee. As outlined in Section S8.F of the Permit, the Port must conduct Stormwater Treatment Best Management Practice (BMP) Evaluation Monitoring.

The purpose of this Quality Assurance Project Plan (QAPP) is to establish and present the quality assurance/quality control procedures for field work and laboratory analysis associated with this BMP monitoring. This QAPP was prepared using appropriate sections of Ecology’s Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology (TAPE).

Bioretention shows significant potential for removal of total and dissolved metals and total suspended solids (TSS), which are the primary pollutants of concern at the Port and similar facilities. Based on the specific site conditions, the Filterra® Bioretention Filtration System (Filterra) was considered appropriate for use and was selected for installation and evaluation.

In accordance with the permit, the statistical goals of 90-95% confidence and 75-80% power for the mean effluent concentrations will be met. In addition, the data will be collected pertinent to fulfill the National Stormwater BMP Database requirements.
Section 2: Background

2.1 Technology Description

The Filterra® system is a self-contained stormwater treatment system manufactured by Americast, Inc. (Americast). The technology packages soil media, plants, and drainage infrastructure found in typical bioretention best management practices (BMPs) into a pre-fabricated concrete housing. The Filterra® system is a flow-through stormwater treatment device, and is intended for removal of suspended sediments, nutrients, heavy metals, and oil and grease from stormwater flows within small-scale catchments such as parking lots and streetscapes (see photographs below).

Typical Filterra® stormwater treatment applications.

The Filterra® unit is available in a range of sizes (i.e., surface area, depth). The standard configuration has a 6 x 6 foot surface area, however the actual dimensions of the unit selected for monitoring performance were determined based upon the site and installation requirements. The filter media for the standard unit consists of a 3-inch mulch layer, 21 inches of specially engineered soil media and 6 inches of gravel, which provides a bed for the perforated underdrain. The Filterra® unit also includes specified vegetation that may include flowers, grasses, a shrub, or tree. The Pacific Wax Myrtle was selected for the test units at the Port.

The overall stormwater treatment performance of the Filterra® system is dependent on a balance between flow-through capacity (the percentage of total runoff volume captured) and the ability of the plant/soil/microbial complex to remove target pollutants from the captured runoff.

The Filterra® system is intended to provide water quality treatment of captured flows through a broad assortment of physical, chemical, and biological unit processes, including sedimentation, filtration, adsorption, volatilization, evapotranspiration, and biological measures supported by the high organic content of the soil media and the vegetative substrate (see figure below).
2.2 Operation and Maintenance

Maintenance is recommended on a semiannual basis, consisting of unit inspection (structure and media), trash and silt removal, mulch replacement, media replacement (if necessary), plant pruning and/or replacement (if necessary), and disposal of all removed items.
Section 3: Project Description

3.1 Study Site Description

As described above, two Filterra® systems were installed on properties associated with the Port for testing purposes in March 2008. The Port occupies approximately 2,400 acres (972 hectares) of land area adjacent to Commencement Bay in Tacoma, Washington. Established in 1918, the Port has a history of industrial landuse for shipping terminal activity including storage, distribution, and manufacturing (Port of Tacoma 2008). Since the 1800’s, the surrounding area has a history of industrial landuse and waterway contamination due to ship building, oil refining, chemical manufacturing and storage. The Commencement Bay nearshore/tidal flats were listed as a Superfund site in 1983 due to this hazardous waste contamination (EPA 2008). Due to clean-up activities by the Port, the Department of Ecology, and a local company in the Sitcum and St. Paul waterways, these portions of Commencement Bay were removed from the Superfund site list in 1996 (EPA 2008).

As shown in Figure 1, the two Filterra® systems were installed at the Maintenance Shop at Terminal 7 of the Olympic Container Terminal. This terminal straddles two cargo loading terminals that are associated with the Sitcum and Blair Waterways. More detailed information on the location of each Filterra® system is provided in the following section.
Figure 1. Vicinity map for the Filterra® Bioretention Filtration Systems at the Port of Tacoma, Tacoma, Washington.
Section 4: Test Description

Design of the systems and the installation were conducted cooperatively by the Port and Americast with the assistance of Kennedy/Jenks Consultants and Herrera Environmental Consultants.

POT1 Test System Description

The installation location, drainage basin characteristics, and basis of design for the POT1 test system are described in detail below. The installation drawings and site plans are provided as Appendix A.

4.1.1 Location and Drainage Basin Characteristics

As shown in Figure 2, the POT1 test system is located on the west side of Port Center Road. Design plans for the system (see Sheet C1 and C2 in Appendix A) indicate the associated drainage basin includes 10,701 square feet (0.246 acres) of impervious asphalt for a parking lot that is used for Port maintenance vehicles and large cargo loaders. Potential pollutant sources in the drainage basin include oil and grease from the parked maintenance vehicles and cargo loaders. Tire wear and leaking hydraulic fluid from the cargo loaders is also a source for metals, especially zinc. A wash area for cargo loaders in the northwest corner of the parking lot (see Figure 2) may contribute additional pollutants to the system. Finally, atmospheric deposition from the adjacent rail yard, cargo loading, and other industrial activities may be a pollutant source. Treated runoff from POT1 test system is routed into the existing stormwater conveyance system for the Port and ultimately discharges to the Blair waterway in Commencement Bay.

4.1.2 System Basis of Design

In accordance with Ecology requirements (Ecology 2005), the POT1 test system must provide effective treatment for 91 percent of the annual runoff volume. Manufacturer’s design guidelines (Americast, Inc. 2006) indicated that the POT1 test system should be sized with a standard 4-foot by 6-foot box based on the area of the contributing drainage basin (0.246 acres). To confirm this sizing assumption is correct, modeling was performed using the Western Washington Hydrology Model, Version 3 (WWHM3) to determine the actual percentage of the annual runoff volume that would be treated with a system this size given local precipitation patterns. WWHM3 is a continuous hydrologic model that simulates rainfall runoff based on topography, soils, and vegetation. For this evaluation, the sand filter module in WWHM3 was run at an hourly timestep for a 48-year simulation period (October 1948 to September 1996) using the Pierce County precipitation series from the McMillian rain gauge. The following parameters were specifically used as inputs to the sand filter module:

- Bottom length: 6 feet
- Bottom width: 4 feet
- Effective depth: 0.5 feet
- Infiltration: yes
- Hydraulic conductivity: 40 inches/hour
- Filter material depth: 2 feet
- Riser height: 0.45 feet
- Riser diameter: 100 inches
- Riser type: flat.

Screen shots from model showing these inputs and the associated results are provided in Appendix B. These results indicate the POT1 test system will treat approximately 92.3 percent of the annual runoff volume with the standard 4-foot by 6-foot box. The design flow rates obtained from the model for the associated drainage basin are listed below in Table 1.

### 4.2 POT2 Test System Description

The installation location, drainage basin characteristics, and basis of design for the POT2 test system are described in detail below.

#### 4.2.1 Location and Drainage Basin Characteristics

As shown in Figure 2, the POT2 test system is located is located to the west of POT1 test system in a parking lot between the Port Maintenance Facility and two storage containers. Design plans for the system (see Sheet C1 and C3 in Appendix A) indicate the associated drainage basin includes 6,080 square feet of impervious asphalt, in addition to two corrugated metal rooftops of approximately 870 square feet. Thus, the total drainage area for the POT2 test system is approximately 6,950 square feet (0.160 acres). The potential pollutant sources in the drainage basin include oil and grease from parked vehicles, and metals, especially zinc, from the buildings’ roofs. Similar to the POT1 test system, atmospheric deposition from the adjacent rail yard, cargo loading, and other industrial activities may influence the stormwater runoff quality. Treated runoff from POT2 test system is routed into the existing stormwater conveyance system for the Port and ultimately discharges to the Blair waterway in Commencement Bay.

#### 4.2.2 System Basis of Design

In order to provide effective treatment for 91 percent of the annual runoff volume, manufacturer’s design guidelines (Americast, Inc. 2006) indicated that the POT2 test system should be sized with a 4-foot by 4-foot box based on the area of the contributing drainage basin (0.160 acres). To confirm this sizing assumption is correct, modeling was again performed using WWHM3 to determine the actual percentage of the annual runoff volume that would be treated with a system this size given local precipitation patterns. The same modeling approach described above for the POT1 test system was used for this evaluation with the exception that the input value for “bottom length” in the sand filter module was changed to 4 feet.
Figure 2. Site map for the Filterra® Bioretention Filtration Systems at the Port of Tacoma, Tacoma, Washington.
Table 1: Flow rates obtained from WWHM3 for predeveloped conditions and the developed, mitigated condition for the POT1 test system.

<table>
<thead>
<tr>
<th>Flow (cubic feet per second)</th>
<th>Predeveloped</th>
<th>Developed, Mitigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality design flow</td>
<td>n/a</td>
<td>0.0334</td>
</tr>
<tr>
<td>2-year peak flow</td>
<td>0.0054</td>
<td>0.0695</td>
</tr>
<tr>
<td>10-year peak flow</td>
<td>0.0110</td>
<td>0.1100</td>
</tr>
<tr>
<td>100-year peak flow</td>
<td>0.0182</td>
<td>0.1692</td>
</tr>
</tbody>
</table>

Screen shots from model showing the associated input and results are provided in Appendix B. These results indicate the POT2 test system will treat approximately 92.7 percent of the annual runoff volume with a 4-foot by 4-foot box. The design flow rates obtained from model for the associated drainage basin are listed below in Table 2.

Table 2: Flow rates obtained from WWHM3 for predeveloped conditions and the developed, mitigated condition (with Filterra® unit) at the POT2 test system.

<table>
<thead>
<tr>
<th>Flow (cubic feet per second)</th>
<th>Predeveloped</th>
<th>Developed, Mitigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality design flow</td>
<td>n/a</td>
<td>0.0217</td>
</tr>
<tr>
<td>2-year peak flow</td>
<td>0.0035</td>
<td>0.0452</td>
</tr>
<tr>
<td>10-year peak flow</td>
<td>0.0070</td>
<td>0.0715</td>
</tr>
<tr>
<td>100-year peak flow</td>
<td>0.0116</td>
<td>0.1100</td>
</tr>
</tbody>
</table>
Section 5: Organization and Schedule

The Port will be soliciting an environmental monitoring consultant to serve as an independent technical professional to assist with evaluation and field sampling for the Filterra® system. A qualified laboratory (or laboratories) will be chosen as the analytical laboratory for the majority of the water quality analysis. Current project organization and personnel for this study are identified in Table 3. Additional project organization and personnel information will be provided with an addendum to this QAPP when it is established.

Table 3: Project organization and key personnel for the Filterra® monitoring program.

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Lisa Rozmyn</td>
<td>Port of Tacoma</td>
</tr>
<tr>
<td>Project Supervisor</td>
<td>Cindy Lin</td>
<td>Port of Tacoma</td>
</tr>
<tr>
<td>Monitoring Project Manager</td>
<td>Mark Rettmann</td>
<td>Port of Tacoma</td>
</tr>
</tbody>
</table>

5.1 Project Responsibilities

Project responsibilities are listed below for personnel identified in Table 3.

Project Manager – Lisa Rozmyn

Lisa Rozmyn will oversee project progress, oversee the monitoring consultant, and review and comment on the technical work and deliverables. She will be the primary point of contact for the Port.

5.2 Project Contacts

Contact information for the Port of Tacoma and the Monitoring Project Manager are provided below:

Port of Tacoma
Attn: Lisa Rozmyn
One Sitcum Plaza
Tacoma, WA 98421
Phone: 253-383-5841

Port of Tacoma
Attn: Mark Rettmann
One Sitcum Plaza
Tacoma, WA 98421
Phone: 253-383-5841
5.3 Project Schedule

The estimated project schedule for the BMP Evaluation monitoring program is outlined in Table 4.

Table 4: Project milestones for the BMP Evaluation monitoring program.

<table>
<thead>
<tr>
<th>Project Milestone</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finalize QAPP</td>
<td>February 2010 (August 2009 – Conditional)</td>
</tr>
<tr>
<td>Begin performance monitoring</td>
<td>September 2009</td>
</tr>
<tr>
<td>Projected stamping end date</td>
<td>September 30, 2010 (will be extended for a second sampling season, if necessary)</td>
</tr>
<tr>
<td>Complete analysis of monitoring data and performance evaluation</td>
<td>January 31, 2011</td>
</tr>
<tr>
<td>Submit evaluation monitoring data and report with 4th year Phase I Annual Report</td>
<td>March 31, 2011</td>
</tr>
</tbody>
</table>
Section 6: Measurement Quality Objectives

The goal of this QAPP is to ensure that data collected through this study are scientifically accurate and legally defensible. To meet this goal, the collected data will be evaluated relative to the following quality assurance objectives:

- **Precision** is a measure of the variability in the results of replicate measurements due to random error.
- **Bias** is the systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected measurement is different from the true value).
- **Representativeness** is the degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency, and sampling methods.
- **Accuracy**.
- **Completeness** is the amount of data obtained from the measurement system.
- **Sensitivity**.
- **Comparability** is the ability to compare data from the current project to data from other similar projects, regulatory requirements, and historical data.

Method Quality Objectives (MQOs) are performance or acceptance criteria that are established for each of these quality assurance objectives. The specific MQOs that have been identified for this project are described below and summarized in Table 5.

- **Precision.** Precision will be assessed using laboratory and field duplicates. Precision for laboratory duplicates will be ± 25 percent relative percent difference (RPD) for all of the water quality parameters. Precision for field duplicates will be ± 35 percent RPD for all of the water quality parameters. In all cases, the RPD of duplicate samples will be calculated using the following equation:

  \[ RPD = \frac{(C_1 - C_2) \times 100%}{(C_1 + C_2) / 2} \]

  where:  
  \( RPD \) = relative percent difference  
  \( C_1 \) = larger of two values  
  \( C_2 \) = smaller of two values.

  Table 5 provides the measurement quality objectives that will be used as acceptance thresholds for project data.
Table 5: Method quality objectives for water quality data for the Filterra® monitoring program.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Detection Limit</th>
<th>Units</th>
<th>Method Blank</th>
<th>Field Blank</th>
<th>Control Standard Recovery</th>
<th>Matrix Spike/ Duplicate Matrix Spike Recovery</th>
<th>Laboratory Duplicate RPD&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Field Duplicate RTD&lt;sup&gt;(a)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>2</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤20% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>0.5</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>NA</td>
<td>≤25% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>0.002</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤20% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Orthophosphorus</td>
<td>0.001</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤20% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Copper, dissolved</td>
<td>0.001</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤20% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Copper, total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc, dissolved</td>
<td>0.005</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤20% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Zinc, total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>NA</td>
<td>std. units</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>NA</td>
<td>≤10% or ±2 x RL</td>
<td>≤15% or ±2 x RL</td>
</tr>
<tr>
<td>Oil sheen</td>
<td>Visual</td>
<td>Yes/No</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TPH (gas)</td>
<td>0.05</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤25% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>TPH (diesel)</td>
<td>0.05</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤25% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>TPH (motor oil)</td>
<td>0.10</td>
<td>mg/L</td>
<td>&lt;RL</td>
<td>&lt;2 x RL</td>
<td>90 - 110%</td>
<td>75 - 125%</td>
<td>≤25% or ±2 x RL</td>
<td>≤25% or ±2 x RL</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td>0.5</td>
<td>microns</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Notes:
(a) The relative percent difference will be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit, and ±2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

mg/L = milligrams per liter.
std. units = standard units.
RL = reporting limit.
RPD = relative percent difference.
NA = not applicable.
TPH = total petroleum hydrocarbon.
• **Bias.** Bias will be assessed based on analyses of method blanks, matrix spikes, and control standards. The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and laboratory control samples will be ± 25 percent for all of the water quality parameters. Duplicate matrix spikes will also be run on a portion of the samples. The bias of the overall laboratory quality control results will be ± 25 percent for all parameters. Percent recovery for matrix spikes will be calculated using the following equation:

\[
\%R = \left( \frac{S - U}{C_{sa}} \right) \times 100\%
\]

where:
- \(\%R\) = percent recovery
- \(S\) = measured concentration in spike sample
- \(U\) = measured concentration in unspiked sample
- \(C_{sa}\) = actual concentration of spike added.

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for control standards will be calculated using the following equation:

\[
\%R = \left( \frac{M}{T} \right) \times 100\%
\]

where:
- \(\%R\) = percent recovery
- \(M\) = measured value
- \(T\) = true value.

• **Representativeness.** The sampling design will provide samples that represent a wide range of water quality conditions during storm flow conditions. Sample representativeness will be ensured by employing consistent and standard sampling procedures.

• **Completeness.** A minimum of 95 percent of the samples submitted to the laboratory will be judged valid. An equipment checklist will be used to prevent loss of data resulting from missing containers or inoperable instruments prior to embarking on field sampling trips. Automatic recording equipment will be checked regularly to ensure that it is in good working order.

• **Comparability.** Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. The results will be tabulated in standard spreadsheets to facilitate analysis and comparison with water quality threshold limits (e.g., WAC 173-201A).
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Section 7: Sampling Process Design

The following sections discuss storm tracking and monitoring preparation and sampling procedures to be implemented for the Filterra® monitoring program.

7.1 Storm Tracking and Monitoring Preparation

Sampling events will be selected to represent a range of conditions with respect to rainfall volume and intensity to ensure the representativeness of the data. The following criteria will serve as guidelines for defining the acceptability of specific storm events for sampling. These criteria are identical to the storm criteria listed in the TAPE guidelines (Ecology 2008).

- Target storm depth: A minimum of 0.15 inches of precipitation over a 24 hour period.
- Antecedent conditions: A period of at least 6 hours preceding the event with less than 0.04 inches of precipitation.
- Minimum duration: Target storms must have a duration of at least 1 hour.
- End of storm: A continuous 6-hour period with no measurable rainfall.

The guidance also states that at least half of the sampled storm events should have an average intensity >0.03 inches/hour.

Antecedent conditions and storm predictions will be monitored via the internet and a determination will be made as to whether to target an approaching storm. Once a storm has been targeted, field staff will visit each site to verify that equipment is operational and to start the sampling program.

7.2 Number of Stormwater Samples

According to the Permit and guidance in Ecology 2008, the statistical goal for sampling is to determine the mean effluent concentrations and mean percent removals with 90-95 percent confidence and 75-80 percent power. A minimum of 12 inlet and 12 outlet samples will be collected. If after the 12 pairs of samples are collected, the statistical goals are not yet met, additional samples will be collected until statistical goals are met. A maximum of 35 pairs of samples will be collected, regardless of the resulting statistics. Appendix A in the TAPE Guidance (Ecology 2008) provides a complete description of these statistical considerations.
Section 8: Site-Specific Monitoring Procedures

As shown in Figure 3, Filterra® systems are constructed with the following components: concrete container, filter media, observation / cleanout pipe, an under-drain system, and an appropriate type of plant (i.e., flowers, grasses, shrub, or tree). During operation, untreated stormwater runoff (influent) from the surrounding drainage basin enters the Filterra system through an inlet structure in the concrete box and flows through the mulch, plant, and soil filter media. Treated water (effluent) flows out of the system via the under-drain system, which is connected to a storm drain pipe or other appropriate outfall. If the infiltration capacity of the filter media is exceeded during any given storm event, the excess stormwater will bypass the system and enter a nearby storm drain inlet or other appropriate discharge point.

![Diagram of Filterra® system design](image)

**Figure 3. Typical Filterra® system design.**

In order to evaluate the treatment performance of the POT1 and POT2 test systems, automated monitoring equipment was installed in association with each system to monitor the flow rate of influent, effluent, and bypassed stormwater. To facilitate interpretation of these data, a rain gauge was also installed in association with the POT1 test system. This equipment will be operated continuously over the monitoring period. Automated equipment was also installed to collect flow-weighted composite samples of the influent and effluent. In addition, grab samples will be collected and analyzed for parameters that cannot be measured based on flow-weighted composite samples. Data obtained from this sampling will subsequently be used to verify the performance of the Filterra® system.
A generalized schematic of the equipment that was installed in association with the POT1 and POT2 test systems is provided in Figure 4. The actual equipment installations for each system were completed in April 2008. Photo documentation of these installations is provided in Appendix C. The following subsections provide more detailed descriptions of the specific equipment and procedures that will be used to collect hydrologic and water quality data at each system.

8.1 Continuous Hydrologic Monitoring

As shown in Figure 4, continuous hydrologic monitoring will be performed in conjunction with the POT1 test systems at three separate monitoring stations: POT1-Influent, POT1-Effluent, and POT1-Bypass. An identical suite of hydrologic monitoring stations was also established in conjunction with the POT2 test system and identified with the same naming convention (i.e., POT2-Influent, POT2-Effluent, and POT2-Bypass).

To facilitate continuous flow monitoring at the Influent stations, separate 60° large trapezoidal flumes were installed to intercept stormwater entering each of the test systems (see Figure 4). This stormwater is directed into the flumes using a system of curbs that are located both in front of and adjacent to each test system (see design plans in Appendix A and photo documentation in Appendix C). Automated flow monitoring equipment (i.e., ISCO 730 Bubble Flow Modules) was installed in association with each station to continuously record water levels within the flumes using a 5-minute logging interval. These measurements are then converted to estimates of discharge using standard hydraulic equations. Continuous alternating current (AC) power is maintained at each station to operate this monitoring equipment. All this monitoring equipment is housed in a secure enclosure near the test system.

To facilitate continuous flow monitoring at the Bypass stations, separate 60° large trapezoidal flumes were also installed to intercept stormwater bypassing each of the test systems (see Figure 4). Again, this stormwater is directed into the flumes using a system of curbs (see design plans in Appendix A and photo documentation in Appendix C). Automated flow monitoring equipment (i.e., ISCO 4230 Bubbler Flow Meters) was installed in association with each station to continuously record water levels within the flumes using a 5-minute logging interval. These measurements are then converted to estimates of discharge using standard hydraulic equations. Continuous AC power is maintained at each station to operate this monitoring equipment. All this monitoring equipment is housed in a secure enclosure near the test system.

To monitor flow at the Effluent stations, separate 6-inch V-notch weirs (ISCO Flow Metering Insert) were installed sub-grade where the under-drain system for each test system discharges into a downgradient overflow drain (see Figure 4). Automated flow monitoring equipment (i.e., ISCO 730 Bubble Flow Modules) was installed in association with each station to continuously record water levels behind the weirs using a 5-minute logging interval. These measurements are then converted to estimates of discharge using standard hydraulic equations. Continuous AC power is maintained at each station to operate this monitoring equipment. All this monitoring equipment is housed in a secure enclosure near the test system.
Figure 4. Typical site schematic for Filterra® system performance monitoring at the Port of Tacoma.
A rain gauge was also installed in association with the POT1-Influent station to continuously monitor precipitation totals in the drainage basins for both the POT1 and POT2 test systems. This rain gauge will be interfaced with the hydrologic monitoring equipment described previously for this station. The associated data will be used to determine if rainfall totals measured during sampled storm events meet minimum thresholds identified in the TAPE guidelines for acceptance (see next subsection). These data will also be used to facilitate interpretation of the flow monitoring data obtained from the stations described above.

Finally, a telemetry system (ISCO CDMA Cell Phone System) was also installed at the POT1-Influent station to allow remote access to the associated flow and precipitation data. Information obtained from this system will be used to determine when field personnel should be mobilized to collect grab samples for water quality and pick up flow-weighted composite samples after a storm event.

### 8.2 Water Quality Monitoring

To evaluate the water quality treatment performance of the POT1 and POT2 test systems, sampling will be conducted at the associated Influent and Effluent stations. To facilitate this sampling, each station is equipped with automated sampling equipment (ISCO 6712 Full Size Portable Samplers) that is interfaced with the flow monitoring equipment described in the previous section. The sampler intakes for the Influent stations are suspended in a plastic tray mounted within each test system at the point where stormwater enters. At the effluent stations, the sampler intakes are positioned just up gradient of the weirs installed within the under-drain systems. In each case, the sampler intakes are positioned to ensure the homogeneity and representativeness of the collected samples. Specifically, sampler intakes were installed to make sure adequate depth is available for sampling, and to avoid capture of litter, debris, and other gross solids that might be present at the base of the channel. The sampler suction lines consist of Teflon® tubing with a 3/8-inch inner diameter.

As described previously, sampling will be conducted at each station during the period extending from September 2009 through September 2010. The following conditions will serve as guidelines in defining the acceptability of specific storm events for sampling:

- **Target storm depth:** A minimum of 0.15 inches of precipitation over a 24-hour period.
- **Antecedent conditions:** A period of at least 6 hours preceding the event with less than 0.04 inches of precipitation.
- **End of storm:** A continuous 6-hour period with no measurable rainfall.

Antecedent conditions and storm predictions will be monitored via weather radio and the Internet, and a determination will be made as to whether to target an approaching storm. Once a storm has been targeted, field staff will visit each station to verify that the equipment is operational and to start the sampling program. A clean polyethylene carboy and crushed ice will also be placed in the sampling equipment at this time. The speed and intensity of incoming storm events will then be tracked using Internet-accessible images from Doppler radar. Actual rainfall totals during sampled storm events will be quantified on the basis of data from the rain gauge installed at the site.
During the storm event sampling, each automated sampler will be programmed to enable in response to a predefined increase in flow at the respective station. The automated samplers will then collect 150-milliliter sample aliquots at preset flow increments. The particular flow increments will vary by station and the expected storm magnitude. A typical programming scheme for the automated samplers at each station is provided in Table 6. Based on the expected size of the storm, the flow increment will be adjusted to ensure that the following criteria for acceptable composite samples are met at each station:

- A minimum of 10 aliquots will be considered optimal; however a total of 17 aliquots must be collected to meet the sample volume requirements to analyze all of the targeted parameters.

- For storm events lasting less than 24 hours, sampling will be targeted to capture at least 75 percent of the storm event hydrograph. For storm events lasting longer than 24 hours, sampling will be targeted to capture at least 75 percent of the hydrograph of the first 24 hours of the storm.

- Due to sample holding time considerations, the maximum duration of automated sample collection at all stations will be 36 hours.

After each targeted storm event, field personnel will return to each station, make visual and operational checks of the sampling equipment, and determine the total number of aliquots composited. Pursuant to the sampling goals identified above, the minimum number of composites that constitutes an acceptable sample is ten. (A minimum volume of 2.5 liters must be collected to perform all the targeted analytes in this study with the associated laboratory quality control requirements.) If the sample is acceptable, the carboy will be immediately capped, removed from the automated sampler, and kept at 4°C using ice during transport to the laboratory. Once in the laboratory, water from the carboy will be used to fill pre-cleaned, preserved (where appropriate) sample bottles for the required analyses. All collected flow-weighted composite samples will then be analyzed for the following parameters:

- Total suspended solids
- Total phosphorus
- Orthophosphorus
- Particle size distribution
- pH
- Copper, total and dissolved
- Zinc, total and dissolved
- Hardness.
Table 6: Typical programming parameters for standard and used to monitor the Filterra® unit at the Port of Tacoma.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Input Value (Standard Sampling)</th>
<th>Input Value (Duplicate Samples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data interval</td>
<td>5 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Number of sample bottles</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Sample bottle size</td>
<td>9.4 liters</td>
<td>3.7 liters</td>
</tr>
<tr>
<td>One part program</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Once enabled, stay enabled</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pauses and resumes</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Number of samples at start</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Run continuously?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sample at beginning?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sample at enable?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Number of samples</td>
<td>60</td>
<td>36 samples/bottle</td>
</tr>
<tr>
<td>Sample volume</td>
<td>150 mL</td>
<td>100 mL</td>
</tr>
<tr>
<td></td>
<td>(60 samples x 150 mL = 9 liters)</td>
<td>(36 samples x 100 mL = 3.6 liters)</td>
</tr>
<tr>
<td>Rinse Cycles</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Enable</td>
<td>Flow</td>
<td>Flow</td>
</tr>
<tr>
<td>Units</td>
<td>Length = feet; volume = cf; flow = cfs</td>
<td>Length = feet; volume = cf; flow = cfs</td>
</tr>
</tbody>
</table>

Notes:
- cf = cubic feet.
- cfs = cubic feet per second.
- mL = milliliters.
- NA = not applicable.

In addition to the flow-weighted composite samples described above, oil sheen observations will be conducted and samples for total petroleum hydrocarbons (TPH) analysis (gas, diesel, and motor oil range hydrocarbons) will be collected as grab samples from each station during sampled storm events. Once collected, the TPH samples will be kept at 4°C in a cooler and transported to the laboratory with the flow-weighted composite samples after the end of the storm event.

### 8.3 Accumulated Sediment Monitoring

Sediment sampling will be conducted in accordance with the TAP-E protocols to measure the sediment accumulation rate to help demonstrate facility performance and design a maintenance schedule. Sediment depth will be measured immediately before sediment cleaning and following test completion. Sediment samples will be analyzed for the following constituents:

- Percent total solids
- Grain size
- Total volatile solids
- NWTPH-Dx
- Total phosphorus
- Total cadmium
- Total copper
- Total lead
- Total zinc

Grab samples will be collected from various locations within the treatment system to create a composite sample. This will ensure that the sample represents the total sediment volume in the treatment system. For QA/QC purposes, a field duplicate sample will be collected.
Section 9: Sampling Procedures

A comprehensive summary of equipment preparation, quality assurance, and sampling protocols are provided in the Standard Operating Procedures in Appendix D. All field activities are subject to the project Health and Safety Plan. All persons involved in the sampling operation shall be made aware of the hazards associated with monitoring.

9.1 Automated Sampling

The automated samplers will be fully programmable, data-logging samplers capable of interfacing with flow meters for flow-weighted composite sample collection. Automated samplers will be programmed to collect a minimum of 10 aliquots of equal volume at equal increments of flow.

Station set-up includes 1) installing sample bottles and 2) programming the sampler and data logger for sample collection. During an event, the field crew will verify the operation of automated samplers. After a sampling event, the field crew will collect the sample bottles, download flow and rainfall data from the data loggers, and secure the site. All water quality samples will be placed on ice immediately following collection and preparation and transported to the laboratory by a designated team member within the minimum designated holding times. Samples for the PSD analysis will be shipped to Environmental Technical Services in Petaluma, California.

At each monitoring station, the following information will be recorded on a standardized field form (see Appendix E) before and after storm sampling events:

- Date
- Time of sample collection, measurement, or observation
- Name(s) of field personnel present
- Station location
- Weather and flow conditions
- Sample volume collected in sample tanks
- Battery voltage
- Desiccant condition
- Presence of obstructions in flow splitter, primary measurement device, runoff collector, and/or sample tank
- Unusual conditions (e.g., oily sheen, odor, color, turbidity, discharges or spills, and land disturbances)
• Modifications of, or unusual, sampling procedures

• Any miscellaneous factors that might influence samples.

9.2 Sample Containers and Preservation

The analytical laboratory will provide clean sample bottles with the appropriate preservatives already added in advance of each storm event. Spare sample bottles will be carried by field personnel in case of breakage or possible contamination. Sample containers and preservation techniques will follow the guidelines outlined in the Code of Federal Regulations [40 CFR 136].

9.3 Sample Identification and Labeling

All sample containers will be labeled with the following information using indelible ink and placed on dry sample container lids with labeling tape:

• Station ID

• Date of sample collection (month/day/year)

• Time of sample collection (military format)

• Sample type (grab/ composite).

9.4 Grab Samples

Stormwater samples for TPHs will be collected near the inlet and upstream of the outlet of the Filterra® unit. Grab samples are typically collected by direct submersion of each individual sample container. Sample bottles should be collected by holding an appropriate container/bottle with the open end of the container facing upstream. Because oil and grease and other petroleum hydrocarbons tend to float, these grab samples should be collected at the air/water interface.

9.5 Sample Delivery

Field personnel will deliver the samples to the analytical laboratory directly following each sampling event. If field personnel are unable to deliver the samples directly to the laboratory (e.g., samples are collected over the weekend or at night) they should be placed in a storage container (e.g., cooler) and packed on ice or an ice substitute and delivered to the laboratory as soon as possible.

9.6 Sample Packing and Shipping

If necessary, samples will be shipped to the selected analytical laboratory. Recommended steps for packing and shipping samples include:

1. Fold the field-sampling sheets and chain of custody record form and place them in plastic bags to protect the sheets during transport.
2. Clearly mark the analyses to be performed for each sample.

3. Pack samples to prevent breakage or leakage (samples should already be labeled).

4. Securely seal shipping containers and affix identification labels to each shipping container.

5. Mark containers THIS END UP and number containers in a shipment.

9.7 Chain-of-Custody

After samples have been obtained and the collection procedures properly documented, a written record of the chain-of-custody of each sample should be made. This is recommended to ensure that samples have not been tampered with or compromised in any way and to track the requested analysis for the analytical laboratory. Information necessary in the chain-of-custody includes:

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

Sample custody will be tracked in the laboratory through the entire analytical process and the signed chain-of-custody forms returned to the Project Manager along with the analytical results. The Monitoring Lead will record the date and time of sample deliveries for the project file.
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Section 10: Measurement Procedures

Laboratory analytical procedures will follow methods that are approved by the U.S. Environmental Protection Agency (APHA et al. 1992, 1998; U.S. EPA 1983, 1984). These methods provide reporting limits that are below the state and federal regulatory criteria or guidelines and will allow direct comparison of the analytical results with these criteria. The preservation methods, analytical methods, reporting limits, and sample holding times are presented in Table 7.

Samples for parameters requiring filtration (i.e., dissolved copper and zinc) will be delivered to the laboratory within 24 hours of their collection. Upon their receipt, laboratory personnel will immediately filter and preserve these samples.

A specific laboratory will be identified for this project. The laboratory will be on that is certified by Ecology and participates in audits and interlaboratory studies by Ecology and EPA. These performance and system audits have verified the adequacy of the laboratory’s standard operating procedures, which include preventive maintenance and data reduction procedures.

The laboratory will report the analytical results within 30 days of receipt of the samples. The laboratory will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. The reports will also include a case narrative summarizing any problems encountered in the analyses.
## Table 7: Methods and detection limits for water quality analyses for the Filterra® monitoring program.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Analytical Method</th>
<th>Method Number(a)</th>
<th>Holding Time(b)</th>
<th>Preservation</th>
<th>Reporting Limit/Resolution</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>Persulfate</td>
<td>SM 2340B or C</td>
<td>28 days</td>
<td>Cool, 4°C; H₂SO₄ to pH&lt;2</td>
<td>0.1</td>
<td>mg/L</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>Gravimetric, 103°C</td>
<td>EPA 160.2</td>
<td>7 days</td>
<td>Cool, 4°C</td>
<td>0.50</td>
<td>mg/L</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>Automated ascorbic acid</td>
<td>EPA 365.1</td>
<td>28 days</td>
<td>Cool, 4°C; H₂SO₄ to pH&lt;2</td>
<td>0.01</td>
<td>mg/L</td>
</tr>
<tr>
<td>Orthophosphorus</td>
<td>Automated ascorbic acid</td>
<td>EPA 365.1</td>
<td>Filter - 12 hours Analyze - 48 hours</td>
<td>Cool, 4°C; filtration, 0.45 µm</td>
<td>0.01</td>
<td>mg/L</td>
</tr>
<tr>
<td>Copper, dissolved</td>
<td>GFAA</td>
<td>EPA 200.8</td>
<td>6 months(c)</td>
<td>Cool, 4°C; filtration, 0.45 µm; HNO₃ to pH&lt;2</td>
<td>0.1</td>
<td>µg/L</td>
</tr>
<tr>
<td>Copper, total</td>
<td>GFAA</td>
<td>EPA 200.8</td>
<td>6 months</td>
<td>Cool, 4°C; HNO₃ to pH&lt;2</td>
<td>0.1</td>
<td>µg/L</td>
</tr>
<tr>
<td>Zinc, dissolved</td>
<td>ICP</td>
<td>EPA 200.8</td>
<td>6 months(c)</td>
<td>Cool, 4°C; filtration, 0.45 µm; HNO₃ to pH&lt;2</td>
<td>1.0</td>
<td>µg/L</td>
</tr>
<tr>
<td>Zinc, total</td>
<td>ICP</td>
<td>EPA 200.8</td>
<td>6 months</td>
<td>Cool, 4°C; HNO₃ to pH&lt;2</td>
<td>5.0</td>
<td>µg/L</td>
</tr>
<tr>
<td>pH</td>
<td>Potentiometric</td>
<td>EPA 150.1</td>
<td>24 hours</td>
<td>Cool, 4°C</td>
<td>0.01</td>
<td>std. units</td>
</tr>
<tr>
<td>Oil sheen</td>
<td>NA - Visual</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Yes/No</td>
<td>NA</td>
</tr>
<tr>
<td>TPH (gas)</td>
<td>GC/FID</td>
<td>NWTPH-Dx(d)</td>
<td>Extract – 14 days; Analyze – 40 days</td>
<td>Cool, 4°C; HCL to pH&lt;2</td>
<td>0.25</td>
<td>mg/L</td>
</tr>
<tr>
<td>TPH (diesel)</td>
<td>GC/FID</td>
<td>NWTPH-Dx(d)</td>
<td>Extract – 14 days; Analyze – 40 days</td>
<td>Cool, 4°C; HCL to pH&lt;2</td>
<td>0.05</td>
<td>mg/L</td>
</tr>
<tr>
<td>TPH (motor oil)</td>
<td>GC/FID</td>
<td>NWTPH-Dx(d)</td>
<td>Extract – 14 days; Analyze – 40 days</td>
<td>Cool, 4°C; HCL to pH&lt;2</td>
<td>0.1</td>
<td>mg/L</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td>Sieve and Filter</td>
<td>ASTM 3977</td>
<td>7 days</td>
<td>Cool, 4°C</td>
<td>4</td>
<td>microns</td>
</tr>
</tbody>
</table>

Notes:
(a) SM method numbers are from APHA et al. 1998; EPA method numbers are from U.S. EPA 1983, 1984. The 18th edition of Standard Methods for the Examination of Water and Wastewater (APHA et al. 1992) is the current legally adopted version in the Code of Federal Regulations (CFR). However, the 20th edition provides additional guidance on certain key items. For this reason the 20th edition is referenced in this table as the best available guidance. An equivalent standard method can be substituted.

(b) Holding time specified in EPA guidance or referenced in Standard Methods for equivalent method.

(c) Sample filtration and/or preservation will occur within 24 hours of sample collection.

(d) Washington State Department of Ecology methods (Ecology 2007) includes silica gel extract cleanup step.

GFAA = graphite furnace atomic absorption.
ICP/AES = inductively coupled plasma/atomic emission spectrometry.
ICP/MS = inductively coupled plasma/mass spectrometry.
GC/FID = gas chromatography/flame ionization detection.
NA = not applicable.
mg/L = milligrams per liter.
µg/L = micrograms per liter
std. units = standard units.
C = Celsius.
Section 11: Quality Control

Field and laboratory quality control procedures that will be implemented for BMP evaluation monitoring program will be discussed in the following sections.

11.1 Field Quality Assurance/Quality Control

This section summarizes the quality assurance/quality control (QA/QC) procedures that will be implemented by field personnel to evaluate sample contamination and sampling precision.

11.1.1 Field Blanks

Automated samplers will be cleaned using the rinse and purge-pump-purge cycle. Field blanks will be collected prior to the first three storm events at both of the monitoring locations. If field blank results indicate negligible contamination, collection frequency will be reduced to one field blank for every three storm events. The field blank will be collected by pumping reagent-grade water through the intake tubing into a precleaned sample container. The volume of reagent grade water pumped through the sampler for the equipment blank will be similar to the volume of water collected during a storm event.

11.1.2 Field Duplicate Samples

Field duplicates will be collected using a four bottle rack in the automated sampler and compositing two sub-samples at the end of the sampled storm event. The number of field duplicates to be collected during the sampling season is listed in Table 8. The station where the field duplicates are to be collected will be chosen at random in advance of the storm event. All duplicate samples will be submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples will then be used to assess variation in the analytical results that is attributable to environmental (natural), sub-sampling, and analytical variability.

11.1.3 Flow Measurements

The accuracy and precision of the automated flow measurement equipment will be tested prior to the first monitoring round and periodically throughout the project.

11.2 Laboratory Quality Control

This section summarizes the quality control procedures the laboratory will perform and report with the analytical results. Accuracy of the laboratory analyses will be verified through the use of blank analyses, duplicate analyses, laboratory control spikes, and matrix spikes in accordance with the EPA methods employed. The selected laboratory(s) will be responsible for conducting internal quality control and quality assurance measures in accordance with their own quality assurance plans.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample Type</th>
<th>Storm Events&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Number of Monitoring Locations</th>
<th>Total Number of Samples</th>
<th>Field Blanks</th>
<th>Method Blanks</th>
<th>Control Standard</th>
<th>Matrix Spike</th>
<th>Duplicate Matrix Spike</th>
<th>Lab Duplicates</th>
<th>Field Duplicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Orthophosphorus</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Copper, dissolved</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Copper, total</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Zinc, dissolved</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Zinc, total</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>pH</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>1 every 3 storm events&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Oil sheen</td>
<td>Visual</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TPH (gas)</td>
<td>Grab</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>NA</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>TPH (diesel)</td>
<td>Grab</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>NA</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>TPH (motor oil)</td>
<td>Grab</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>NA</td>
<td>1 per storm event</td>
<td>1 per storm event</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td>Flow-weighted composite</td>
<td>12 - 35</td>
<td>2</td>
<td>24 - 70</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1 per storm event</td>
<td>25% of storm events</td>
</tr>
</tbody>
</table>

Notes:
(a) A minimum of 12 storm events will be monitored during the sampling season at a total of two monitoring sites (inlet and outlet). Up to 35 storm events may be required if statistical significance is not demonstrated by the sampled storm events.
(b) Field blanks will be collected at both monitoring locations for the first three storm events. If negligible contamination is detected, the sampling frequency will be reduced to one field blank for every three storm events.
NA = not applicable.
The required frequency for quality control procedures and evaluation criteria are summarized in Table 8.

Water quality results will first be reviewed at the laboratory for errors or omissions. Laboratory quality control results will be reviewed by the laboratory to verify compliance with acceptance criteria. The laboratory will also validate the results by examining the completeness of the data package to determine whether method procedures and laboratory quality assurance procedures were followed. The review, verification, and validation by the laboratory will be documented in a case narrative that accompanies the analytical results.

Data will be reviewed and validated within seven days of receiving the results from the laboratory. This review will be performed to ensure that all data are consistent, correct, and complete, and that all required quality control information has been provided. Specific quality control elements for the data (see Table 8) will also be examined to determine if the MQOs for the project have been met. Results from these data validation reviews will be summarized in quality assurance worksheets (see example in Appendix E) that are prepared for each sample batch. Values associated with minor quality control problems will be considered estimates and assigned J qualifiers. Values associated with major quality control problems will be rejected and qualified with an R. Estimated values may be used for evaluation purposes, while rejected values will not be used. The following sections describe in detail the data validation procedures for the quality control elements.
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Section 12: Data Management

Data will be downloaded by field staff at the completion of each storm event using a laptop computer or portable transfer device. Field staff will fill out the chain-of-custody forms and retain copies for the project files following submittal of samples. The laboratory will send water quality data directly to the Project Manager with a narrative of QA/QC results and discussions of any discrepancies.

The selected laboratory(s) will report the analytical results within 30 days of receipt of the samples. The laboratory(s) will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. These reports will include all quality control results associated with the data. The reports will also include a case narrative summarizing any problems encountered in the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifies.

Laboratory data will subsequently be entered into a Microsoft Access® database or Excel® spreadsheet for all subsequent data management and archiving tasks. A Water Quality Data Quality Assurance Lead will perform an independent review to ensure that the data were entered without error. Specifically, ten percent of the sample values will be randomly selected for rechecking and crosschecking with laboratory reports. If errors are detected, they will be corrected, and then an additional 10 percent will be selected for validation. This process will be repeated until no errors are found in the data.
Section 13: Audits and Reports

Results or a status report of the BMP evaluation monitoring will be submitted to Ecology beginning with the fourth year annual report required under the Permit. Information provided will include the following:

- Performance data from the monitoring site.
- All deliverables specified in the QAPP.
- All relevant performance test results, statistical analyses, and operations and maintenance (O&M) activities.
- Any available non-standard data (data not collected per the protocol, such as laboratory testing, out-of-state testing, or field performance testing with real storms not meeting protocol guidelines).
- Conclusions and recommendations including the technology’s development level, recommended O&M procedures and frequency, pretreatment requirements, and use limitations.
- An executive summary.
- Additional testing recommendations, if needed.
Section 14: Data Review, Verification, and Validation

Three types of data will be generated during this project: rainfall, flow, and water quality. The data review, verification, and validation procedures for each data type are discussed below. Data review involves examination of the data for errors or omissions. Data verification involves examination of the QA/QC results for compliance with acceptance criteria. Data validation involves the examination of the complete data package to determine whether the procedures in the QAPP were followed.

Flow and rainfall measurements will be reviewed in the field for gross errors such as irregular spikes or drops. Flow and rainfall measurements will be verified by comparing the hyetograph and hydrograph for consistency and comparing the total amount of rainfall to total flow volume for consistency with previously collected data.

The second data review step entails reviewing rainfall and sample collection information against stated storm event and sample event criteria, and deciding whether to accept or reject a collected sample. The standardized field form (see example in Appendix E) contains a checklist for validation of storm and sample event criteria.

Water quality results will first be reviewed at the laboratories identified for this study for errors or omissions. Laboratory quality control results will then be reviewed by the laboratory to verify compliance with acceptance criteria. The laboratory will also validate the results by examining the completeness of the data package to determine whether method procedures and laboratory quality assurance procedures were followed. The review, verification, and validation by the laboratory will be documented in a case narrative that accompanies the analytical results. Laboratory data will also be reviewed by project personnel to assess field quality control results (i.e., field duplicates) and verify compliance with acceptance criteria.

Data will be reviewed and validated within seven days of receiving the results from the laboratory. This review will be performed to ensure that all data are consistent, correct, and complete, and that all required quality control information has been provided. Specific quality control elements for the data (see Table 8) will also be examined to determine if the MQOs for the project have been met. Results from these data validation reviews will be summarized in quality assurance worksheets (see example in Appendix E) that are prepared for each sample batch. Values associated with minor quality control problems will be considered estimates and assigned a J qualifier. Values associated with major quality control problems will be rejected and qualified with an R. Estimated values may be used for evaluation purposes, while rejected values will not be used. The following sections describe in detail the data validation procedures for the quality control elements.
14.1 Completeness

Completeness will be assessed by comparing valid sample data with this QAPP and the chain-of-custody records. Completeness will be calculated by dividing the number of valid values by the total number of values. Samples may be re-analyzed or re-collected if completeness is less than 95 percent.

14.2 Methodology

Methodologies for analytical procedures will follow EPA approved methods (APHA et al. 1998; U.S. EPA 1983, 1984). Field procedures will follow the methodologies described in this QAPP. Any deviations from these methodologies must be approved by the Port. Deviations that are deemed unacceptable will result in rejected values (R) and will be corrected for future analyses.

14.3 Holding Times

Analysis dates will be reported by the laboratory. Holding time compliance will be assessed by comparing analytical dates and times to sample collection dates and times. For flow-composite samples, sample collection times will be based on the date and time that flow into the carboy began. Data from samples that exceed the maximum holding time specified in 40 CFR 136 by less than 48 hours will be considered estimates (J). Data from samples that exceed the maximum holding times by more than 48 hours will be rejected values (R). Holding times for each analytical parameter in this study are summarized in Table 7.

14.4 Blanks

Blank values will be compared to the MQOs that have been identified for this project (see Table 8). Sample values that are less than five times a detected method blank value will be considered estimates (J).

14.5 Reporting Limits

Reporting limits will be presented in each laboratory report. If proposed reporting limits are not met by the laboratory, the laboratory will be requested to reanalyze the samples and/or revise the method, if time permits. Proposed reporting limits for this project are summarized in Tables 7 and 8.

14.6 Duplicates

Duplicate results exceeding the MQOs for this project (see Table 8) will be noted in the quality assurance worksheets and associated values will be flagged as estimates (J). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (R).
14.7 Matrix Spikes and Duplicate Matrix Spikes

Matrix spike and duplicate matrix spikes results exceeding the MQOs for this project (see Table 8) will be noted in the quality assurance worksheets and associated values will be flagged as estimates ($J$). However, if the percent recovery exceeds 125 and a value is less than the reporting limit, the result will not be flagged as an estimate. Non-detected values will be rejected ($R$) if percent recovery is less than 30 percent.

14.8 Control Standards

Control standard results exceeding the MQOs for this project (see Table 8) will be noted in the QA worksheets and associated values will be flagged as estimates ($J$). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected ($R$).
Section 15: References


