WSDOT STORMWATER CHARACTERIZATION/WATER QUALITY MANAGEMENT EFFECTIVENESS MONITORING

2003/2005 SAMPLING SEASON

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Prepared for:

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Environmental Affairs Office
Water Quality Program

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1.0 PROJECT OVERVIEW / DESCRIPTION

The Washington State Department of Transportation (WSDOT) is responsible for the maintenance and operation of thousands of miles of roadway throughout the State of Washington. Much of this roadway resides within the geographic area covered by a series of permits issued pursuant to the requirements of the National Pollutant Discharge Elimination System (NPDES) created by Section 402 of the Clean Water Act (CWA). The Washington State Department of Ecology (Ecology) has been authorized by the U.S. Environmental Protection Agency (EPA) to manage the NPDES permit program in the state of Washington and serves as the permitting authority. Chapter 173-220 of the Washington Administrative Code (WAC 173-220) establishes the state's individual permit program, and outlines specific guidelines for permit application procedures, public notice, and public availability of information. Permittees are subject to monitoring, recording, and reporting requirements to ensure compliance.

WSDOT was previously covered under three different municipal separate storm sewer system (MS4) permits in the Puget Sound Basin. The current Phase I NPDES permits were issued in 1995 with a July 5, 2000 expiration date, but were administratively extended pending issuance of WSDOT's statewide permit. The requirements of the existing NPDES permits are specified in the WSDOT Stormwater Management Plan (SMP) (WSDOT 1997).

1.1 Project Goals and Objectives

The monitoring activities described in this plan are designed to fulfill the monitoring requirements of the NPDES permit. This monitoring plan, however, has been significantly modified in response to changing conditions and actual monitoring results gathered in the three years since the planned expiration date of the Phase I permit. Past runoff characterization monitoring results are consistent with results found by several other state transportation agencies. Accordingly, WSDOT is shifting its monitoring focus to the evaluation of stormwater treatment Best Management Practice (BMP) effectiveness. The monitoring data will more accurately reflect what is discharged from WSDOT outfalls and increase the BMP knowledge base. Runoff characterization data will continue to be gathered as control data for each BMP during the effectiveness monitoring. This goal of the monitoring effort is to support the characterization of pollutant contributions from highway corridors through assessment of Event Mean Concentrations (EMC) of pollutants known to exist in highway stormwater runoff. Grab samples may be necessary in select

locations to approximate the EMC where flow-weighted compositing is not feasible because most stormwater infiltrates, such as in vegetated BMPs.

Project specific monitoring will be performed in addition to the characterization and BMP effectiveness monitoring associated with the Phase I NPDES permit. Water quality will be monitored to satisfy commitments associated with two specific projects in the Olympic Region where innovative treatment facilities have been installed in recent years to remove pollutants. Monitoring will be performed at 7 locations to establish the effectiveness of BMPs at those locations. There will be a total of 12 data sets evaluated; the site locations and automatic sampler locations are further discussed in Section 2.

1.2 Project Roles and Responsibilities

The following personnel will be responsible for the duties described.

WSDOT Project Manager: Richard Tveten, Environmental Affairs Office, Water Quality Program

- Coordinate with contractors
- Review and comment on plans and reports
- Oversee project progress
- Oversee lead agency project personnel

WSDOT Project Scientist: David Moore, Environmental Affairs Office, Water Quality Program

- Coordinate with field sampling team
- Assist with field site set up
- Provide ongoing equipment support

Tetra Tech Task Manager: John Virgin

- Coordinate with WSDOT and Envirovision Project Manager (Joy Michaud)
- Develop monitoring plan and QAPP
- Coordinate with OnSite Environmental, Inc. for laboratory analyses
- Perform detailed analysis of sampling data
- Oversee monitoring and report development
- Final data quality overview

Project Scientists: Janice Martin, Tetra Tech, Inc., David VanderMeulen and Erin Britton, Envirovision

- Assist with field site set up

- Assist with long term maintenance of equipment
- Collect flow, rainfall, and water quality data at sample sites
- Track quality assurance including preliminary review of field and laboratory data
- Document sample collection procedures and QA/QC measures
- Maintain records
- Maintain communications with WSDOT staff
- Data Management
- Assist with development of draft and final reports

Analytical Laboratory Quality Assurance Officer: David Baumeister, Onsite Environmental, Inc.

- Track samples and results in the laboratory
- Provide properly cleaned sample bottles with appropriate preservatives
- Evaluate laboratory compliance with project QAPP and laboratory QA Plan
- Report discrepancies to Tetra Tech Task Manager
- Transmit laboratory results to Tetra Tech Task Manager

1.3 General Scope and Schedule of Monitoring Activities

Site set-up and monitoring for this project is scheduled to occur between August of 2003 through June 2005. The overall intent is to gather data for up to ten storm events per rainy season. The final number of monitoring events that will be conducted will be determined by weather patterns, equipment performance, and potential modifications to sampling that are requested by WSDOT. Sample data collected during the October 2003 through May 2004 rainy season will be evaluated during and at the conclusion of the rainy season, as appropriate. The interim evaluations of monitoring results will incorporate statistical analyses to determine when the confidence and power of the experimental design are achieved. The statistical evaluation commonly requires a minimum number of events to accept or reject the evaluation hypotheses (i.e., demonstrate that there is or is not a treatment level achieved). The coefficient of variation of total suspended solids will be used to quantify the number of samples that provide a statistically valid representation of runoff conditions.

A summary of progress and data available by May 2004 will be included in the WSDOT 2004 NPDES Annual Report. The entire monitoring effort and results will be described in the 2005 NPDES Report Manual. These stormwater characterization-monitoring activities may extend beyond this time period.

This is dependent upon project results, data variability, and the development of revised NPDES reporting requirements as stipulated in the pending re-issuance of WSDOT's permit.

2.0 MONITORING SITES

2.1 NPDES Phase I Stormwater BMP Effectiveness and Runoff Characterization Monitoring Sites

To satisfy phase I NPDES permit requirements, seven sites have been selected to represent the spectrum of BMP types ranging from vegetated shoulders and ditches to vaults. Both pre-treated and treated runoff will be monitored to evaluate BMP effectiveness in 1) reducing pollutant concentrations, 2) reducing stormwater volumes and peak flows and 3) reducing pollutant loads. The monitoring will target the latest BMPs to determine the effectiveness of facilities built in accordance with recent, more protective design criteria. The ADT levels will tend to be higher than the average for State highways, because recent construction activities have largely focused on reducing congestion on highly traveled routes. Sites were given preference for 1) proximity to Seattle or Olympia, Washington, 2) accessibility and security for maintaining sampling equipment, and 3) reliability of defining a highway specific source area. Narrow, low ADT highways were avoided because past sampling efforts indicate that they are unreliable generators of runoff. The sites were selected to improve monitoring efficiency by reducing travel times and identifying sites with potentially consistent runoff. The seven site locations with BMPs selected for the first wet season are described in Table 2.1.

The approximate locations of these sampling stations are shown on Figures 1 and 2. A detailed description of each of the sites follows. These sites experience weather conditions typical of Western Washington; rainfall is the primary form of precipitation, and occurs chiefly between October and March, and storms are generally of low intensity and long duration.

Following the first wet season, data will be analyzed to determine if adequate data has been collected to establish BMP effectiveness. If adequate runoff sampling data is produced during the first wet season, new sites will be selected for monitoring in the second wet season to broaden WSDOT's knowledge base concerning other BMPs and the site-to-site variation in effectiveness among BMPs. Candidate sites will be evaluated during the first wet season and selected based on remaining BMP effectiveness data needs and field observations.

Table 2.1 Stormwater BMP Effectiveness and Runoff Characterization Monitoring Sites					
Site Number and Location	**ADT**	**BMP tested**	**Number of Samplers**	**Control**	**Purpose**
1) SR 5 at Milepost 96.2	90,000	Wet Pond	2	Untreated runoff at inlet	Test effectiveness at reducing pollutant concentrations
2) SR 5 at Milepost 109	130,000	Compost Amended Shoulder and Ditch	2	Untreated runoff at nearby outfall	Test effectiveness at reducing pollutant concentrations and runoff volumes
3) SR 405 at Milepost 27.7	90,000	Unimproved Ditch	1	Untreated runoff at grate inlet	Test effectiveness at reducing pollutant concentrations and runoff volumes
4) SR 5 at Milepost 188.1	160,000	Dry Pond	2	Untreated runoff at pond outlet	Test effectiveness at reducing pollutant concentrations
5) SR 405 at Milepost 26	90,000	Closed Wet Vault	2	Untreated runoff at open vault	Test effectiveness at reducing pollutant concentrations
6) SR 405 at Milepost 26	90,000	Bioswale	2	Untreated runoff at swale inlet	Test effectiveness at reducing pollutant concentrations and runoff volumes
7) SR 405 at Milepost 29.5	90,000	Open Concrete Wet Vault	1	Untreated runoff at catch basin	Test effectiveness at reducing pollutant concentrations and runoff volumes

2.2 Detailed Site Descriptions

Appendix A contains further site descriptions, access details, and photographs of the monitoring sites.

Site 1 – Wet Pond

This structure is located on the shoulder of southbound SR 5 at MP 96.2 in Tumwater. The surface drainage area is approximately 8 acres with untreated runoff from six lanes of traffic, road edge, and median shoulders directed via a series of catch basins and cross-culverts to the pond inlet located on the west side of the highway. Two automated samplers will be used to collect samples at the pond inlet and outlet pipes. No offsite flow has been observed or is expected at this site. This site is accessed by pulling off the shoulder at the "Maytown" road sign at the crest of the hill. Drive on the shoulder to the pond access road and park near the pond gate. These automatic samplers will be installed at the pond inlet and outlet, and monitored by WSDOT and Envirovision Corporation.

Site 2 - Compost Amended Shoulder and Ditch

This structure is located on the shoulder of southbound SR 5 at MP 109, just south of the Martin Way on-ramp in Olympia. The catch basin is located approximately 500 feet west of the College Street overpass and 100 feet west of the "Welcome to Olympia" sign. The surface drainage area is approximately 1 acre with untreated runoff from two lanes of traffic and a road edge shoulder, sheet flowing onto the composted and vegetated shoulder and ditch. One automated sampler is installed at the catch basin and collects samples through a 45-degree v-notched flume, prior to flowing into a grate inlet. A 60-foot long composted and vegetated slope also drains to the structure but neither runoff or offsite flow has ever been observed or is expected from this area. To access the sampler, park on the north (downstream) side of the catch basin.

Control samples will be collected at the inlet pipe to a treatment pond located on northbound SR 5 at MP 106. Taking exit 105 off SR 5, to Wheeler Road, accesses the control sampler. The facility is located at the corner of Wheeler Road and Frederick. These automatic samplers will be installed and monitored by WSDOT and Envirovision Corporation.

Site 3 - Unimproved Ditch

This structure is located on the shoulder of northbound SR 405 at MP 27.7 to 28. The ditch inlet begins immediately downstream of the catch basin at MP 28. The ditch outlet (for the study) is located approximately 1500 feet south of the inlet, near the "Adopt a Highway" sign at MP 27.7. The surface drainage area is approximately 0.75 acre with untreated runoff from two lanes of traffic and the road edge shoulder sheet flowing into the ditch. One automated sampler will be installed to collect samples through a 45-degree v-notched flume. Control samples will be collected at an inlet pipe to the wet vault, located to the north at MP 29.5 (Site 7 inlet). The area near the unimproved ditch sampler includes a wide shoulder, where parking is available to the south of the flume for safe access. The automatic sampler will be installed and monitored by WSDOT and Tetra Tech.

Site 4 - Dry Pond

This structure is located in the median of southbound SR 5 at MP 188.1 in Everett. The surface drainage area is approximately 3 acres. The pond has two inlets that empty into a primary cell. One inlet is a hardpan ditch that drains untreated water from two lanes of traffic and a road shoulder of southbound SR

5. The other inlet is a cross culvert from a ditch that drains four lanes of traffic plus a road shoulder of northbound SR 5. Two automated samplers will be installed, one at the culvert inlet and one at the pond outlet. The site is accessed by driving on the median shoulder of southbound SR 5 to the pond access road, with off-road parking available near the pond. These automatic samplers will be installed and monitored by WSDOT and Tetra Tech.

Site 5 - Closed Wet Vault

This structure is located in the median of SR 405 at MP 26, approximately mid-way between the Canyon Creek and NE 195th (Beardslee Boulevard) exits on SR 405. The closed wet vault is located under the median and road shoulder. The surface drainage area is approximately 1 acre, with untreated runoff from 3 lanes of traffic, median, and road edge shoulder, directed via sheet runoff to the ditch, and via a series of catch basins and cross-culverts to the vault inlet. Two automated samplers will be installed to collect samples; one at the grate and cross-culvert inlet to the wet vault, and one at the vault outlet pipe. This site is accessed by taking pulling off southbound SR 405 into the median, traversing the guard rail, and hiking up the median to the sample locations. These automatic samplers will be installed and monitored by WSDOT and Tetra Tech.

Site 6 – Bioswale

This treatment facility is located in the center median of SR 405 at MP 26, south of the closed wet vault. The surface drainage area is approximately 0.75 acres with untreated runoff from 3 lanes of traffic and a road edge shoulder directed via sheet flow to the side of the swale. One automated sampler will be installed to collect samples through a 45-degree v-notched flume at the swale outlet, south of the closed wet vault. This automatic sampler will be installed and monitored by WSDOT and Tetra Tech.

Site 7 - Open Wet Vault

This structure is located on northbound SR 405 at MP 29.5, behind a jersey barrier, approximately 400 feet south of the Filbert Road underpass location in Lynnwood. The surface drainage area is approximately 7 acres, with untreated runoff from 6 lanes of traffic directed via a series of catch basins and cross-culverts to the vault inlet. One automated sampler will be used to collect samples from the vault outlet pipe. Control samples will be collected at a catch basin which is located approximately 300 feet north, along the embankment to SR 405 from Filbert Road. The catch basin directs stormwater run

off from SR 405 to a wet vault located along the south side of Filbert Road. Reasonably safe shoulder access is available approximately 200 feet north of the open wet vault off SR 405. However, off-street parking and a safer access to the open wet vault and control sample location are available by parking south of Filbert Road along the SR 405 overpass and walking up the embankment. The automatic samplers will be installed and monitored by WSDOT and Tetra Tech.

3.0 ANALYTICAL CONSTITUENTS

Analytical parameters and methods, detection limits and units, preservation methods, and holding times for samples collected during stormwater characterization monitoring are summarized in Table 3.0. OnSite Environmental, Inc. of Redmond, Washington will take the lead on laboratory analysis and QA checks. OnSite Environmental will perform analysis of hardness, total suspended solids, phosphorous, metals, total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbon samples.

TABLE 3.0 WATER QUALITY PARAMETERS AND ANALYTICAL METHODS
WSDOT 2003/2005 BIENNIUM STORMWATER CHARACTERIZATION MONITORING

Analyte	Method Type	Method Number [a] USEPA or Standard Methods	Holding Time[b]	Container Type	Preservation	Reporting Limit/ Resolution	Units
CONVENTIONALS							
Hardness	Titrimetric; Colorimetric; Calculation	130.2; 130.1; SM 2340B	6 months	Glass or PE	4°C and HNO_3 or H_2SO_4 to pH<2	2	mg/L
Total Suspended Solids	Gravimetric	160.2	7 days	Glass or PE	4°C	1	mg/L
NUTRIENTS							
Phosphorus	Colorimetric	365.2	28 days	Glass or PE	4°C and H_2SO_4 to pH<2	0.03	mg/L
METALS							
Cadmium	Inductively Coupled Plasma (ICP)/Atomic Emission Spectrometry, ICP/Mass Spectrometry	200.7, 200.8	6 Months	PE	HNO3 to pH < 2; filter and preserve dissolved samples within 48 hours of collection	0.2	µg/L
Copper		200.7; 200.8				1	
Lead		200.7; 200.8				1	
Zinc		200.7; 200.8				5	
TOTAL PETROLEUM HYDROCARBONS							
TPH (diesel)	Gas Chromatography/Flame Ionization Detection	NWTPH-Dx[c]	Extract – 14 days; Analyze – 40 days	Wide – mouth glass	4°C and HCl or H_2SO_4 to pH<2	5	mg/L
TPH (motor oil)							
MISCELLANEOUS ORGANIC CONSTITUENTS [o]							
Polycyclic Aromatic Hydrocarbons [d]	HPLC-Ultra Violet fluorescence	8310	Extract – 7 days; Analyze – 40 days	Wide mouth glass	4°C	varies	µg/kg
BACTERIOLOGICAL							
Fecal Coliform	Multi-tube fermentation	SM 9221E	8 hours [e]	Sterile glass or plastic	4°C; sodium thiosulfate in the presence of chlorine	2 min., 2E6 max.	MPN/100 mL
Total Coliform		SM 9221B					

Notes for Table 3.

- The 18th edition of Standard Methods for the Examination of Water and Wastewater 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.
- All USEPA 1600 series methods require equipment handling, bottle preparation, sample collection (grab or composite) and sample handling according to USEPA method 1669 protocols.

[a] Equivalent Standard Method can be substituted.

[b] Holding time specified in USEPA guidance or referenced in Standard Method for equivalent method.

[c] Washington State Department of Ecology method, includes silica gel extract cleanup step.

[d] See the USEPA method for a complete list of constituents.

[e] The 8 hour hold time includes the 2 hour delivery and 6 hour set-up time allowances described in Standard Methods 20th edition. All efforts should be made to analyze samples within 6 hours of sampling to conform to the currently adopted edition of Standard Methods.

4.0 DATA QUALITY OBJECTIVES

The data quality objectives (DQOs) for the stormwater monitoring will be used help define the quality and usefulness of the sample data, based on the factors that may impact the overall quality of the data. By defining the limits of the systematic and random errors that can impact data, the quality and usefulness of the data and impacts on decisions can be determined. The measurement quality objectives (MQOs) answer the question of how accurate the measurements need to be in order to get accurate data, and are based on the DQOs. For the stormwater characterization and BMP effectiveness monitoring, individual measurement results will be combined into data sets for statistical evaluation. The MQOs for accuracy, precision, bias, and required reporting limits are presented in Table 4.0 at the end of this section.

4.1 Precision, Bias, Representativeness, Comparability, and Completeness

The following elements define the data quality objectives for the stormwater characterization monitoring, and specify the methods that will be used to evaluate them. Further detail on the use of these methods to evaluate the precision, accuracy, and completeness of data is provided in Section 8.0, Quality Control Procedures.

- **Precision** is a measure of the scatter in the data due to random error and is stated in terms of percent relative standard deviation (RSD) or relative percent difference (RPD). The primary sources of random error are the sampling and analytical procedures. The total precision of results can be estimated from the results of field duplicate samples. For laboratory analysis, precision will be assessed using laboratory duplicates. To assess precision in the field, a water quality field duplicate sample will be collected at one station during each round of monitoring and submitted for all analyses.

- **Bias** is a measure of the difference between the result for a parameter and the true value due to systematic errors**.** Bias is the difference between the mean of an infinite number of replicate results and the true value of the parameter being measured. Potential sources of bias include; (1) sample collection methods, (2) physical or chemical instability of samples, (3) interference effects, (4) inability to measure all forms of a parameter, (5) calibration of the measurement system, and (6) cross contamination.

Previous studies pertaining to the sources of bias due to sampling have lead to the recommended procedures currently in use. Thus, careful adherence to established procedures for collection, preservation, transportation, and storage of samples will reduce or eliminate most sources of bias. Bias affecting laboratory measurement procedures will be assessed by the use of matrix spike recovery, method blanks, and check samples in accordance with the laboratory Quality Assurance (QA) Plan. Analysis of split samples will provide an estimate of overall sampling bias including variation in concentration due to sample heterogeneity. Matrix spikes are used to detect interference effects due to the sample matrix. An estimate of bias due to calibration is calculated from the difference between the check standard results and the true concentration.

- **Representativeness** is achieved by selecting sampling locations, methods, and times so that the data describe the site conditions that the project seeks to evaluate. The representativeness of project data will be achieved by choosing the sampling sites using the criteria specified in section 3.3.7.3 of the WSDOT SMP. Additionally, representativeness of the data is assured through definition of target storms and qualifying conditions, and through programming of the automated samplers to collect aliquots at appropriate intervals during the storm events.

- **Comparability** refers to the ability to compare the data from the project to other data sources. Data comparability is assured by selection of standardized procedures, adherence to appropriate draft assessment protocols (Ecology 2001), and by clearly stating any non-standard requirements.

- **Completeness** refers to the amount of useable data obtained during the project. Data completeness will be determined primarily by the success of flow data, rainfall data, and water quality sample collection during storm events. The preliminary goal for completeness is to obtain flow-weighted samples from 10 qualifying storm events from all seven sites. This will be assessed by ensuring that applicable storm event and sample event criteria are met. Ultimately, completeness of the data set will be determined by a review of the data variability using the coefficient of variation for total suspended solids (TSS) data as described in Section 3.3.7.8 of the SMP (WSDOT 1997).

4.2 Reporting Limits

The reporting limits for the sample analyses are presented in Table 4.0, and are selected to provide accurate results that can be used for regulatory comparison.

TABLE 4.0 MEASUREMENT QUALITY OBJECTIVES

Analyte	Precision [a]	Accuracy [b]	Bias [c]	Reporting Limit/ Resolution	Units
Hardness	± 25 %	± 25 %	± 25 %	2	mg/L
Total Suspended Solids	± 25 %	± 25 %	± 25 %	1	mg/L
Phosphorus	± 25 %	± 25 %	± 25 %	0.03	mg/L
Cadmium	± 25 %	± 10%	± 25 %	0.2	µg/L
Copper		± 10 %		1	
Lead		± 10 %		1	
Zinc		± 10 %		5	
TPH (diesel)	± 25 %	± 25 %	± 25 %	5	mg/L
TPH (motor oil)					
Polycyclic Aromatic Hydrocarbons [d]	± 35 %	± 25 %	± 25 %	varies	µg/kg
Fecal Coliform	± 30 %	± 25 %	± 25 %	2 min., 2E6 max.	MPN/100 mL
Total Coliform		± 25 %			

[a] Based on laboratory duplicate analyses.
[b] Based on laboratory control sample, reference material, and spike sample recoveries.
[c] Based on overall laboratory QC results.

5.0 FIELD EQUIPMENT OPERATION AND MAINTENANCE

Each monitoring site utilizes an automated sampler (ISCO Model 6700 or a 6712) housed in a protective metal box, and a tipping bucket rain gauge mounted on a pole. The automated samplers are connected to both the rain gauge and a flow-measuring device, either a flow transducer or a bubbler line.

When a rain gauge records a specified amount of rain, it will activate the flow level-measuring device, which in turn will activate the sampler. After a pre-specified amount of water has passed by, a sample aliquot will be collected. This will continue until a maximum of 15 aliquots have been collected. In this way a flow-weighted composite sample will be collected at each of the sites. Since both spring and winter storm events will be targeted, the qualifying conditions and sample collection regimes will vary and are purposely designed to be flexible enough to meet different "typical" storm events. Each of the sampling sites will be checked prior to anticipated storm events to ensure proper equipment functioning. The procedures for regular maintenance are described in manufacturers instructions and summarized below.

5.1 Equipment Calibration and Maintenance

At a minimum, all equipment shall be calibrated, maintained and cleaned according to manufacturers specifications. Instruction manuals for the ISCO 6700 and 6712 Portable Samplers, bubbler modules, rain gauges, and associated solar panel and power supplies are available at WSDOT EAO, Tetra Tech, and Envirovision offices as reference materials. These manuals should be reviewed thoroughly by all field personnel prior to any fieldwork.

All of the ISCO 6700 and 6712 portable samplers were calibrated by the manufacturer prior to use and installation at the monitoring sites. Volumes of sample collected will be compared to sampling program records to verify accuracy of sample collection. The bubbler module is calibrated by measuring the depth of the water and adjusting the reading to match. Calibration of the bubbler modules can also be conducted by immersing the line in a container of water and adjusting the reading. The rain gauges are factory calibrated and need no adjustments.

Maintenance of equipment will be conducted on a routine basis during pre-storm checks and while collecting samples. Maintenance procedures and frequencies are summarized in Table 5.0 below.

Table 5.0 Equipment Maintenance Schedule			
Equipment	Item	Procedure	Frequency
Rain Gauge	Level Check	Verify level with bubble indicator	Monthly
Battery/Solar Panel	Available power	Check amperage; clean terminals; check connections	Weekly/per visit; as required
Sampler	Sample tubing	Check integrity; verify no obstructions at opening	Monthly; per visit
	Humidity Indicator	Check surface indicator	Every visit
Bubbler module	Dessicant	Check color – when pink, exchange for new dessicant	Every visit.
	Tubing	Check for obstructions	Every visit

6.0 MONITORING PREPARATION AND LOGISTICS

6.1 Weather Tracking

Antecedent conditions and storm predictions will be monitored via weather radio and 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 (i.e., begin measuring rainfall against the 0.04-inch start-up criteria).

6.2 Storm Selection Criteria

The following conditions will be established to serve as guidelines in defining the acceptability of a storm event for sampling:

- Target Storm Depth: A minimum of 0.25 inches of precipitation over a 24 hour period or greater. (Note: While the goal is to target larger storms, samples from storms as small as 0.15 inches over 24 hours may be accepted as long as the other specified criteria are met.)
- Antecedent conditions: A period of at least 24 hours preceding the event with less than 0.02 inches of precipitation.
- End of Storm: A continuous 6-hour period with no measurable rainfall.

6.3 Sample Bottle Order

Prior to initiation of sampling, sufficient sample bottles will be ordered to conduct a minimum of two sampling events. As each sample event is submitted to the laboratory, a new set of sample containers will be picked-up or sent to the office conducting the sampling to ensure replacement containers are available. Proper sample collection, handling, preservation, transport, and custody procedures will be followed.

6.4 Sample Bottle Labeling

Sample labels will include the following information:

- Sample Date

- Time Collected
- Site Designation
- Analysis requested
- Preservative Type
- Composite or Grab Designation

6.5 Sampler Programming

Programming considerations for the automated sampling systems are based on project specific and location specific considerations. Common programming parameters are listed below in Table 6.0, and location specific programming parameters are presented in Table 6.1.

Table 6.0 Common Sampler Programming Parameters
Data Interval – 15 minutes
Number of Sample Bottles – One
Sample Bottle Size – 9.4 Liters
One part program
Once enabled, stay enabled
Pauses and resumes = 0
No sample at start
Run continuously? = No
Sample at start? = No
Sample at enable
Number of samples = 15
Sample volume = 600 ml (15 x 600 = 9L)
Enable: Inlet: Rain, >0.04”/2:00 hrs Outlet (tentative): Level, >1 inch
Units: Length = feet Volume = cf Flow = cfs

Table 6.1 Location Specific Program Parameters					
Location	Program Parameter				
	Slope (rise/run)	Roughness	Sample Line Length	Diameter (feet)	Phone Number (sampler modem)
SR 5 MP 96.2 Wet Pond – Inlet	NA	0.012	20	2	NA
SR 5 MP 96.2 Wet Pond – Outlet	NA	0.012	40	1.5	NA
SR 5 MP 109 Compost Amended Shoulder and Ditch – Outlet	NA	NA	20	NA	NA
SR 5 MP 109 Indian Creek Stormwater Facility - Inlet	0.005	0.014	35	2	NA
SR 405 MP 27.7 Unimproved Ditch - Outlet	NA	NA	20	NA	360.951.1867
SR 5 MP 188.1 Dry Pond - Inlet	0.03	0.012	25	1	NA
SR 5 MP 188.1 Dry Pond - Outlet	0.03	0.012	30	1	NA
SR 405 MP 29.5 Open Vault - Inlet	0.25	0.013	20	1	360.951.1261
SR 405 MP 29.5 Open Vault - Outlet	0.001	0.013	20	1.5	360.951.1727
SR 405 MP 26 Bioswale - Outlet	NA	NA	10	NA	NA
SR 405 MP 26 Closed Vault - Inlet	0.1 (estimate)	0.012	20	1.5	NA
SR 405 MP 26 Closed Vault - Outlet	0.001	0.012	30	1	NA
NA = Not applicable.					

7.0 SAMPLE COLLECTION, PRESERVATION, AND DELIVERY

7.1 Sample Collection Methods

The total maximum number of anticipated samples for each analytical parameter as outlined in Section 3.0 includes the collection of one replicate sample from one monitoring location during each storm event, for a total of 13 samples to be submitted to the laboratory each event for each parameter. Limited sampling will also be conducted for polynuclear aromatic hydrocarbons (PAHs), total and fecal coliform, and total petroleum hydrocarbons (TPHs).

Samples for TPH analysis and total and fecal coliform will be collected as a grab sample during the rising limb of the storm hydrograph. Therefore, a second field visit will be made early in the storm to collect this sample, which will be labeled and packed on ice, and then transported to the laboratory with the other samples immediately (within 2 hours) after the end of the storm event. The samples for NWTPH-Dx analysis will be collected only at those locations where hydrocarbon sheen is observed during grab sampling. The PAH sediment sampling will be conducted once at each of the BMP locations as a check on whether PAHs represent a problem constituent in sediment runoff.

After each targeted storm event, field staff will return to each site, make visual and operational checks of the system, transfer the carboy into a cooler with ice, replace it with an appropriately cleaned carboy, and turn the automated sampler off.

The automated samplers will be programmed to collect 600-milliliter (mL) sample aliquots at pre-set flow increments. The flow increments used will vary by site, and will be based on drainage area and by season to account for seasonal differences in storm event character. Samples will be collected over a maximum of a 36-hour period. Although the goal is to collect all samples over 24 hours, this additional time will allow for characterization of storms that begin slowly and develop into notable events over a longer timeframe. This will require some subjective assessment on the part of field staff to ensure that representative portions of the overall storm hydrograph and collection criteria are met.

The sample aliquots will be collected into clean polyethylene carboys. The minimum number of composites that will constitute an acceptable sample will be eight. If the sample is acceptable it will be used to fill pre-cleaned, preserved (where appropriate) sample bottles provided by the analytical

laboratory. The possibility exists that not enough water volume will be collected to fill all of the sample bottles for a field duplicate. In these instances the sample bottles will be filled in the order of priority outlined below:

1) Total suspended solids (TSS) (1L)
2) Total Metals (500 mL)
3) Dissolved Metals (500 mL)
4) Hardness, phosphorus (500 mL)

The TPH and coliform samples are collected separately as grab samples and; therefore, will not be not taken from the composited volume in the carboy.

The next step will be to review the data against monitoring goals as follows:

1) Check to ensure that a minimum of eight samples have been collected, then complete a visual check to ensure that appropriate sample volumes were collected [e.g., if eight samples were collected of 600 mL aliquots the total volume in the carboy should equal 4.8 liters (L)].

2) Visually compare rain gage data with flow level data to check for inconsistencies.

3) Estimate the portion of the hydrograph that represents approximately 75 percent of the storm and determine whether the samples collected cover that period.

4) Calculate the storm depth over the sampling period and determine whether depth was at least 0.15 inches to 0.25 inches.

5) If less than 0.25 inches, but greater than 0.15 inches have been recorded, check that at least 75 percent of the hydrograph was captured.

7.2 Field Measurement Methods

There are currently no plans to collect water quality measurements in the field.

7.3 Field Equipment List

A list of field equipment that will be used during sampling is presented in Table 7.0.

Table 7.0 Sampling Equipment List	
Raingear/boots	Write in the Rain notebook
Sterile gloves	Flashlight
Cell phone	Crescent wrench
8-foot PVC pole	Duct tape
Screwdrivers (Phillips and flat head)	Car battery
1/8 inch bubble tubing (for flow meter)	1/4 inch sample tubing
Cinch ties	Battery clips
Wire cutter/stripper	Scissors
Measuring tape	Sharpie
Ladder	Chain-of-Custody forms
Dessicant	Site Visit Forms
Grate hook	Isco 581 Rapid Transfer Device
QAPP	Amp meter
Safety Vest	Car light

7.4 Forms and Procedures for Documenting Sample Collection

Appendix B contains an example site visit field form that will be completed during each site visit.

7.5 Laboratory Communication Procedures

Personnel conducting the field sampling will notify OnSite Environmental, Inc. by telephone at 425.883.3881 following sample collection. The caller should provide an indication of the number of samples and the anticipated delivery schedule.

7.6 Sample shipping Delivery and Chain of Custody

An example of the Chain-of-Custody Form is provided in Appendix B. The Chain-of-Custody will be completed following a determination that appropriate sampling parameters (e.g., minimum of eight aliquots) were achieved during sample collection and transfer of the sample from the carboy to appropriate containers. The sample times listed on the chain-of-custody will be the time that the final aliquot was collected.

8.0 QUALITY CONTROL PROCEDURES

8.1 Field Procedures for QC sample collection

Quality control samples will be collected for both field and laboratory activities. Field quality control samples will include the collection of field duplicate samples. Field duplicates will be collected at a frequency of one per sample event. Laboratory quality control samples will include laboratory blanks, laboratory duplicates, matrix spikes, and laboratory control samples. These will be analyzed with a minimum frequency of 5 percent for each analytical parameter batch. The field and laboratory quality control procedures are summarized as follows:

- **Field Duplicates:** Field duplicates are essentially one sample that has been split into two containers, one of which is labeled and submitted to the laboratory so as not to be identified as a replicate sample. Split sample results within 35 percent of each other will be accepted without qualification. Both results will be reported in the database, but the average of the two results will be used for data evaluation.

- **Laboratory Blanks:** The quality control objective for the laboratory blank is for a concentration less than the specified detection limit. If the blank concentration is greater than the field samples, the values will be rejected or re-analysis will be requested, unless the field samples are non-detect. The laboratory QA Officer will review laboratory procedures and decide if samples should be re-analyzed if blank contamination is noted.

- **Laboratory Duplicates:** If results are below laboratory detection limits, no evaluation of duplicates is required. If duplicates are within 35 percent relative percent difference (RPD) of their twin they are acceptable. For duplicate RPD values that are greater than 35 percent:

  - Duplicate values with concentrations less than five times the detection limit will be accepted if the concentrations vary by less than twice the detection limit.

  - Duplicates values at concentrations greater than five times the detection limit and with concentrations that vary by more than two times the detection limit, will be accepted as estimated values and marked accordingly (“J”).

  - Duplicate values of 35 percent RPD and above will be assigned an estimated (“J”) qualifier.

- **Matrix Spikes:** The quality control (QC) objective for matrix spike percent recovery varies with the analytical method. For samples that show matrix spike recoveries outside the QC criteria, the sample results may be assigned data qualifiers or the sample may be re-analyzed. The laboratory QA Officer will be responsible for making initial determinations, but will include the information with the submitted data.

- **Laboratory Control Samples:** The laboratory control sample (LCS) results will be compared to method QC criteria to determine if the analysis is within control limits. If the LCS results do not meet QC criteria, the laboratory QA officer will be responsible for implementing appropriate corrective actions.

Field data collection QA procedures will include obtaining flow measurements at each site with a hand-held Swoffer7 meter to check the accuracy of the ISCO samplers and input variables for estimating flow. Sample aliquot volumes will be periodically tested to verify volumes, in addition to visual volume checks that will be made as part of each sample collection event.

8.2 Analytical Methods

Methods that will be used for the sample analyses are summarized below, together with the sample bottle requirements.

TABLE 8.0 SAMPLE BOTTLE REQUIREMEMNTS

Analysis	Bottle Type/Number
Hardness – SM 2340B	From Total Metals Container
TSS - EPA 160.2	1 Liter Plastic (Unpreserved) / 1
Total Phosphorus - EPA 365.1	250 mL Plastic (H_2SO_4 Preserved) / 1
Total Metals - EPA 200.8	500 mL Plastic (HNO_3 Preserved) / 1
Dissolved Metals - EPA 200.8	500 mL Plastic (Unpreserved) / 1
Total Petroleum Hydrocarbons as diesel and Lube Oil - NWTPH-Dx	500 mL Amber (HCl Preserved) / 2
Polycyclic Aromatic Hydrocarbons – EPA 8270C	8-oz glass / 1
Fecal Coliform – SM 9221E	4-oz plastic
Total Coliform – SM 9221B	4-oz platic

9.0 DATA MANAGEMENT PROCEDURES

Flow, rainfall, and sampling data will be logged on the ISCO 6700 samplers. Data will be downloaded by field staff at the completion of each storm event and stored electronically using ISCO's data management software package FloLink 4.1.5.

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 designated Task Manager with a narrative of QA/QC results and discussions of any discrepancies. Copies of the data and laboratory analytical reports will be provided to WSDOT. Laboratory water quality reports and case narratives will be included as an appendix in the reports. At the conclusion of each year of monitoring, or as requested by WSDOT, a copy of the Flolink 4 information and project database will be transferred to WSDOT.

10.0 AUDITS AND REPORTS

Assessment of field sampling activities will occur throughout the project by the designated Task Manager. The site visit field form and discussions with field staff will be used after each sample collection event to make a determination on equipment operations, qualifying conditions, and sample acceptance. Modifications to sampler programming or monitoring design will be noted in the field log. Assessment of laboratory activities and any discrepancies identified will be done routinely by the analytical laboratory, and included in a case narrative accompanying the water quality results. The Task Manager will assess QC information and water quality data for completeness. The WSDOT Project Manager will be advised of any QA issues that arise.

At the conclusion of each Fiscal Year in which monitoring activities are conducted (i.e., 2004 and 2005), technical memorandums will be prepared for submittal to WSDOT. The technical memorandum will include a summary of the analytical findings of the monitoring activities conducted during the reporting period of the monitoring and appropriate conclusions and recommendations, any substantive deviations in the monitoring program from the procedures outlined in the associated planning documents, any QA problems and corrective actions, a spreadsheet containing all of the sample data, and an assessment of the completeness of the data for meeting project objectives. Flow data will also be evaluated and summarized to identify potential changes in pollutant loading and concentrations associated with flow characteristics relative to BMP performance.

The data will be presented in a format that is compatible for subsequent use and inclusion in the stormwater facility inventory database, and also in tabular format for inclusion in the WSDOT NPDES reports. The technical memoranda for each of the monitoring activities will be provided to the designated WSDOT Water Quality Program representatives in draft form for review and comment. Upon receipt of comments the documents will be transmitted in both electronic and hard copy formats as final versions.

In addition, the data collected, as a part of this effort will undergo quality assurance review for accuracy as described in Section 11.0.

11.0 DATA REVIEW AND EVALUATION

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 site visit log (Appendix B) contains a checklist for validation of storm and sample event criteria.

Water quality results will first be reviewed at the laboratory for errors or omissions. Laboratory QC 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 QA 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 QC results (i.e., field duplicates) and verify compliance with acceptance criteria.

The first step in the evaluation process will be determining that an adequate number of events have been monitored. The coefficient of variation (CV) of TSS will be used to quantify the number of samples that provide a statistically valid representation of runoff conditions as described in Section 3.3.7.8 of WSDOT's Stormwater Management Plan.

When a statistically valid number of samples have been collected, site EMCs for the selected pollutants will be calculated as described in Section 3.3.7.8 of WSDOT's Stormwater Management Plan.

12.0 REFERENCES

Washington State Department of Ecology (Ecology). 2001. *Technology Assessment Protocol—Ecology (TAPE): Vendor Submission Guidance for Evaluating Emerging Stormwater Treatment Technologies.* Draft dated 19 April 2002. Washington State Department of Ecology. Olympia, Washington.

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