Quality Assurance Project Plan For King County Stormwater Monitoring Under the NPDES Phase 1 Municipal Permit WAR04-4501 (Issued February 2007)

Updated November 2010

King County

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King County
Department of
Natural Resources and Parks
Water and Land Resources Division

Record of Changes		
Section Changed	**Date**	**Description**
2.3	Nov 2010	Updated sediment sampling methods description
Table 2	Nov 2010	Updated schedule of due dates
Figure 1	Nov 2010	Added drainage basin to figure
6.1	Nov 2010	Updated rain gauge descriptions
Table 5	Nov 2010	Updated rain gauge locations
6.3	Nov 2010	Updated sample and handling procedures for grab samples
6.9	Nov 2010	Updated methods description for collecting sediment samples
Table 10	Nov 2010	Sediment Holding times and storage conditions updated to current practices
Table 14	Nov 2010	Sediment Analytical Methods: total mercury method corrected to EPA 7471B
Table 32	Nov 2010	Laboratory Qualifiers: SH added B2 and B3 added KL qualifier changed to JL (KL was a typo)
Tables 2, 3, 12, 13	Nov 2010	Revised required reporting limits to match app 9 of permit
Table 9	Nov 2010	Removed Trip and Temp blanks, added field filtration blank for metals
Table 24	Nov 2010	Added table of surrogate recoveries for BNA analyses on water samples
Table 22, 23	Nov 2010	Removed un-necessary compounds from the list
Table 28, 29	Nov 2010	Revised surrogate control limits

Table 32	Nov 2010	Added missing table of QC limits for microbiology analysis
9.4	Nov 2010	Updated loading calculations to reflect Ecology's loading calculation SOP published in 2009

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APPROVALS

Dean Wilson King County Date
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Environmental Laboratory Quality Assurance Officer

Certification

I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Distribution List

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1.0. BACKGROUND

The Washington State Phase I Municipal Stormwater Permit (Phase I Permit) applies to all entities in Washington State required to have permit coverage under current (Phase I) U.S. Environmental Protection Agency (EPA) stormwater regulations, which includes cities and unincorporated portions of counties whose populations exceed 100,000. The Washington State Phase I permittees include:

- King County
- Pierce County
- Snohomish County
- Clark County
- City of Seattle
- City of Tacoma

Under the 2007 Phase I Permit, two Phase I Secondary Permittees are required to conduct Stormwater Monitoring in accordance with S8.D (Ecology, 2007):

- Port of Seattle
- Port of Tacoma

Stormwater runoff discharges are not continuous, and storm events in themselves can be unpredictable. These discharges are intermittent and weather-dependent in nature (i.e., rainfall amount, duration, intensity, etc.). There is a wide range of pollutants and concentrations in stormwater runoff from one storm event to another. Municipal stormwater discharges are not centrally located but consists of large numbers of outfalls where stormwater is being discharged throughout an entire city (hundreds or even thousands of outfalls within a city are typical). Conventional end-of-pipe treatment options such as treatment plants are difficult to apply to the hundreds/thousands of stormwater discharges.

Three basic control strategies exist for stormwater. First, prevent pollutants from coming into contact with stormwater by using source control best management practices (BMPs). Second, apply treatment BMPs prior to discharge to surface or ground waters to reduce pollutants in the discharge. Third, control the flow rate of stormwater through flow control BMPs

The complexity inherent in stormwater discharges and the difficulty of controlling such discharges means that it will take many years for full implementation that adequately mitigates or prevents their adverse environmental impacts.

The primary goals of the monitoring program described in S8.D of the Phase I Permit is to characterize stormwater runoff based on landuse type and to detect trends from these same landuses in stormwater quality and quantity over time. This information will be used to inform King County's stormwater management program.

Areas in King County have been selected to represent high density residential, low density residential, and commercial land uses. This QAPP describes the process for data collection from these sites. Samples will be collected from these sites so that a calculation of average concentrations during a sampled storm for a specified parameter list can be made (event mean concentrations). Combining this with hydraulic data will yield pollutant loadings. Collecting this data for many storms during the year may allow characterization of the stormwater quality and quantity from these three different landuse types. Collecting this data at these same locations using the same methods for many years may enable the detection of changes in water quality and quantity over time.

Stormwater at each selected site will be monitored in the following ways, as required in S8.D of the Phase I NPDES Permit:

- Continuous flow monitoring (for the first year) and during all sampled storm events
- Flow weighted-composite sampling for chemical analyses
- Grab sampling for limited chemical analyses
- Toxicity testing of seasonal first-flush stormwater
- Sediment sampling for chemical analyses

2.0. PROJECT DESCRIPTION

The sampling design for stormwater monitoring under S8.D contains three primary components that will be conducted at each monitoring site through the remainder of the Phase I Permit cycle:

- Stormwater Sampling
- Toxicity Testing
- Sediment Sampling

2.1 Stormwater Sampling

Stormwater samples will be collected from three different landuse types: commercial, high density residential, and low density residential. To capture the average chemical concentrations (event mean concentration) of a sampled storm, flow-weighted composite samples will be collected. Flow-weighted composite samples are collected from the entire duration of a storm and are proportional to the stormwater flow at the sampling site (i.e. if the stormwater volume increases then the amount of sample collected increases proportionally). To better characterize stormwater quality and quantity over a range of seasons and conditions, up to 11 qualifying storms will be sampled per year. A goal of 60% to 80% of the stormwater samples will be collected during the wet season each year (October 1 to April 30), and 20% to 40% will be collected during the dry season (May 1 to September 30). King County will target 67% of the qualifying storms up to 11 qualifying storms.

Grab samples will be collected for parameters that are not suitable for flow-weight composite samples (e.g. TPH, bacteria) (For further information on grab sampling see SOP NPDES-DS-2000).

Continuous flow data will be collected at each selected site during storm events for one year to establish rainfall and runoff relationships at each stormwater monitoring sites (For further information on flow metering see SOP NPDES-CM-1000).

2.2 Toxicity Sampling

In addition to chemical analysis of stormwater, the toxicity of stormwater will be tested once per year. Toxicity samples will also be collected using composite sampling equipment at each stormwater monitoring site (For further information on composite sampling equipment see SOP NPDES-CM-2000). An attempt will be made to collect the toxicity sample during the seasonal first flush. The seasonal first flush storm is defined as a storm during August or September with a one week dry antecedent period. If no storm can be sampled in August or September, a storm in October with no required antecedent dry period will be sampled. Ecology requires a good faith effort to collect a sample during this time for toxicity sampling. If two attempts are made but fail, then no further toxicity testing is required that year.

The stormwater sample for toxicity testing will also include chemical analyses on the same sample or synoptically collected stormwater sample. The purpose of the chemical analysis for toxicity testing is to measure the concentration of toxic substances that could cause toxicity in stormwater.

2.3 Sediment Sampling

Sediments will be collected at each stormwater monitoring site using a PVC core tube and stainless-steel spatula (KCEL SOP #237 v0) or if access is constricted, an Eckman sediment grab sampler or similar. Collected sediments will be analyzed annually for parameters that have shown to be associated with stormwater discharges.

3.0. ORGANIZATION AND SCHEDULE

Table 1. Project Team.

Name/phone number	Responsibility	Organization
Dean Wilson 206-296-8252	Project Manager	King County WLRD, Science
Dave Funke 206-296-8066	Engineer	King County WLRD, Science
Jim Crawford 206-296-8276	Engineer	King County Roads
Fritz Grothkopp 206-684-2327	Laboratory Project Manager	King County Environmental Lab
Colin Elliott 206-684-2343	Quality Assurance Officer	King County Environmental Lab
Diane McElhany 206-684-2304	Metals Laboratory Supervisor	King County Environmental Lab
Brian Prosch 206-684-2331	Conventionals Laboratory Supervisor	King County Environmental Lab
Eric Thompson 206-684-2340	Microbiology Laboratory Supervisor	King County Environmental Lab
Jeff Droker 206-684-2309	Environmental Lab Scientist	King County Environmental Lab
Fran Sweeney 206-684-2358	Aquatic Toxicology Supervisor	King County Environmental Lab

The following tables indicate the *approximate* implementation schedule for permit-related activities for stormwater monitoring.

Table 2. Collaboratively Developed Monitoring Program Schedule Overview.

Activity	Anticipated Date of Initiation	Anticipated Date of Annual Completion	Deliverable	Deliverable Due Date
Continuous Flow Recording of Storm Events	10-1-08	9-30-09	Establish a baseline rainfall/runoff relationship	Not reported to Ecology
Monitoring program will	8-15-09		Implementation of	

begin			Monitoring Program	
Dry-weather storm events	8-15-09	9-30-09	Stormwater Monitoring Report*	3/31/11
Wet-weather storm events	10-1-09	4-30-10	Stormwater Monitoring Report*	3/31/11
Dry-weather storm events	5-1-10	9-30-10	Stormwater Monitoring Report*	3/31/11
Sediment Sampling	8-16-09	9-30-10	Stormwater Monitoring Report*	3/31/11

Collaboratively Developed Monitoring Programs for Remaining Reporting Years: 2009, 2010, and 2011				
Activity	**Anticipated Date of Initiation**	**Anticipated Date of Annual Completion**	**Deliverable**	**Deliverable Due Date**
Toxicity Sampling (First flush event)	8-1-11	9-30-11	Stormwater Monitoring Report*	3/31/12
Wet-weather storm events	10-1-10	4-30-11	Stormwater Monitoring Report*	3/31/12
Dry-weather storm events	5-1-11	9-30-11	Stormwater Monitoring Report*	3/31/12
Sediment Sampling	10-1-10	9-30-11	Stormwater Monitoring Report*	3/31/12

Wet season extends from October 1 each year until April 30 each year and Dry season extends from May 1 each year through September 30 each year.

RY=Reporting year.

*Submitted with Annual Report.

4.0. QUALITY OBJECTIVES

4.1 Precision, Accuracy and Bias

Precision, accuracy and bias for analytical chemistry and microbiology may be measured by one or more of the following quality assurance/quality control (QA/QC) procedures:

- Collection and analysis of field replicate samples (field replicates should show a relative percent difference of less than 150 percent).
- Collection of a field blank (results should be <MDL for all appropriate parameters)
- Analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory duplicates or triplicates.

4.1.1 Representativeness

Samples are to be collected in such a manner as to minimize potential contamination and other types of degradation in the chemical and physical composition of the water. This can be achieved by following guidelines for sampler decontamination, sample acceptability criteria, sample processing, observing proper hold-times, preservation, storage and preparation of samples.

4.1.2 Completeness

Sampling according to project sampling criteria along with adherence to standardized sampling and testing protocols outlined in this QAPP, will aid in providing a complete set of data for this project. The goal for completeness is 100%. The samples from each event should produce greater than 90% acceptable chemical and biological data under the QC conditions described elsewhere in this QAPP. However, hold-time limitations for fecal coliform may have an adverse effect on completeness.

4.1.3 Comparability

Comparability is addressed through use of standard techniques to collect and analyze representative samples, along with standardized data verification and reporting procedures described below in this QAPP. Changes or updates to analytical methods and sampling techniques midway into the project must be tested, validated, and shown to be equivalent to existing methods. This validation must be approved by the project manager and QA officers before being implemented.

4.2 Reporting Limits

Table 3. Analytical Method Reporting Limits for Water Matrix Parameters

Parameter	Required Reporting Limit
Total suspended solids	1.0 mg/L
Turbidity	±0.2 NTU
Conductivity	±1 umhos/cm
Chloride	0.2 mg/L
BOD5	2.0 mg/L
Particle size distribution	NA
pH	0.2 units
Hardness as CaCO3	1.0 mg/L
Methylene Blue Active Substances (MBAS)	0.025 mg/L
Fecal coliform	2 min., 2E6 max cfu/100mls
Total phosphorus	0.01 mg P/L
Orthophosphate Phosphorus	0.01 mg P/L
Total kjeldahl nitrogen	0.5 mg/L
Nitrate-nitrite Nitrogen	0.01 mg/L
Total recoverable zinc	5.0 µg/L
Dissolved zinc	1.0 µg/L
Total recoverable lead	0.1 µg/L
Dissolved lead	0.1 µg/L
Total recoverable copper	0.1 µg/L
Dissolved copper	0.1 µg/L
Total recoverable cadmium	0.2 µg/L
Dissolved cadmium	0.1 µg/L
Total mercury	0.1 µg/L
Dissolved mercury	0.1 µg/L

Parameter	Required Reporting Limit
PAHs	0.1 µg/L
Phthalates	1.0 µg/L
Herbicides	0.01 – 1.0 µg/L
Pesticides, Nitrogen	0.01 – 1.0 µg/L
Pesticides, Organophosphorus	0.01 – 1.0 µg/L
Semi-Volatile Petroleum Products (NWTPH-Dx)	0.25 - 0.50 mg/L
TPH (NWTPH-Gx)	0.25 mg/L

King County Environmental Laboratory detection limit for total and dissolved copper is 0.4 ug/L, total and dissolved lead is 0.1 ug/L, and dissolved and total cadmium is 0.05 ug/L using EPA method 200.8 without using a "clean hands/dirty hands" method based on EPA 1669 sample collection for ultra low trace metals. This type of field sampling methodology is not suitable for use with automatic sampling devices. Therefore, this slightly higher detection limits will be used for this project.

Table 4. Analytical Method Reporting Limits for Sediment Sampling Parameters

Parameter	Required Reporting Limit
Grain size	NA
Total solids	NA
Total organic carbon	0.1%
Total recoverable zinc	5.0 mg/Kg wet
Total recoverable lead	0.1 mg/Kg wet
Total mercury	0.1 mg/kg wet
Total recoverable copper	0.1 mg/Kg wet
Total recoverable cadmium	0.1 mg/Kg wet
PAHs	70 µg/Kg dry
Phthalates	70 µg/Kg dry
Phenolics	70 µg/Kg dry

PCBs	80 µg/Kg dry
Pentachlorophenol	1.0 µg/Kg wet
Diazinon	50 µg/Kg wet
Chloropyrifos	25 µg/Kg wet
Malathion	25 µg/Kg wet

5.0. SAMPLING DESIGN

5.1 Site Descriptions

Monitoring sites draining a specific land use type were selected based on a number of factors. An attempt was made to locate sites both outside of incorporated areas and outside of the potential annexation areas identified in King County. Rational for these criteria include sampling stormwater within King County's jurisdiction and potentially sampling a site where the jurisdiction of the sampling location may change within the projected timeframe of the long-term monitoring project. Other factors included logistics, such as proximity to where sampling crews are based (reduce hold-time violations, transit time, costs etc), proximity of power for sample refrigeration, access, etc.

5.1.1 Commercial Site

King County will monitor a commercial site in Fall City along highway 202, which is waterfront along the Snoqualmie River, and along the Preston-Fall City road. Businesses along both highway 202 and Preston-Fall City road comprise a commercial area that include a gas station, taverns, restaurants, and various other small shops. The catch-basin storm drain system drains areas along both highway 202 and the Preston-Fall City road. Both sections of the stormdrain system connect at a catch basin, which will serve as the monitoring location near the corner of highway 202 and the Preston-Fall City road. Stormwater from this system drains from the bottom of the catch basin/monitoring location and flows under highway 202 and flows directly to the Snoqualmie River. This site was selected as it included several different types of businesses and is an older development with even a few of the structures built in the 1920s. This site is intended to represent older commercial development that has a stormdrain system without mitigation BMPs or stormwater treatment of any kind.

The catch basin/monitoring location does not store water during a storm nor does it provide any water quality treatment or attenuation. Autosampler intake tubing will be installed into the catch basin/monitoring location so that when stormwater from both arms of the storm drain system mixes in the catch basin/monitoring location, the autosampler will draw sample water from these combined flows thereby obtaining a sample representative of the larger commercial area.

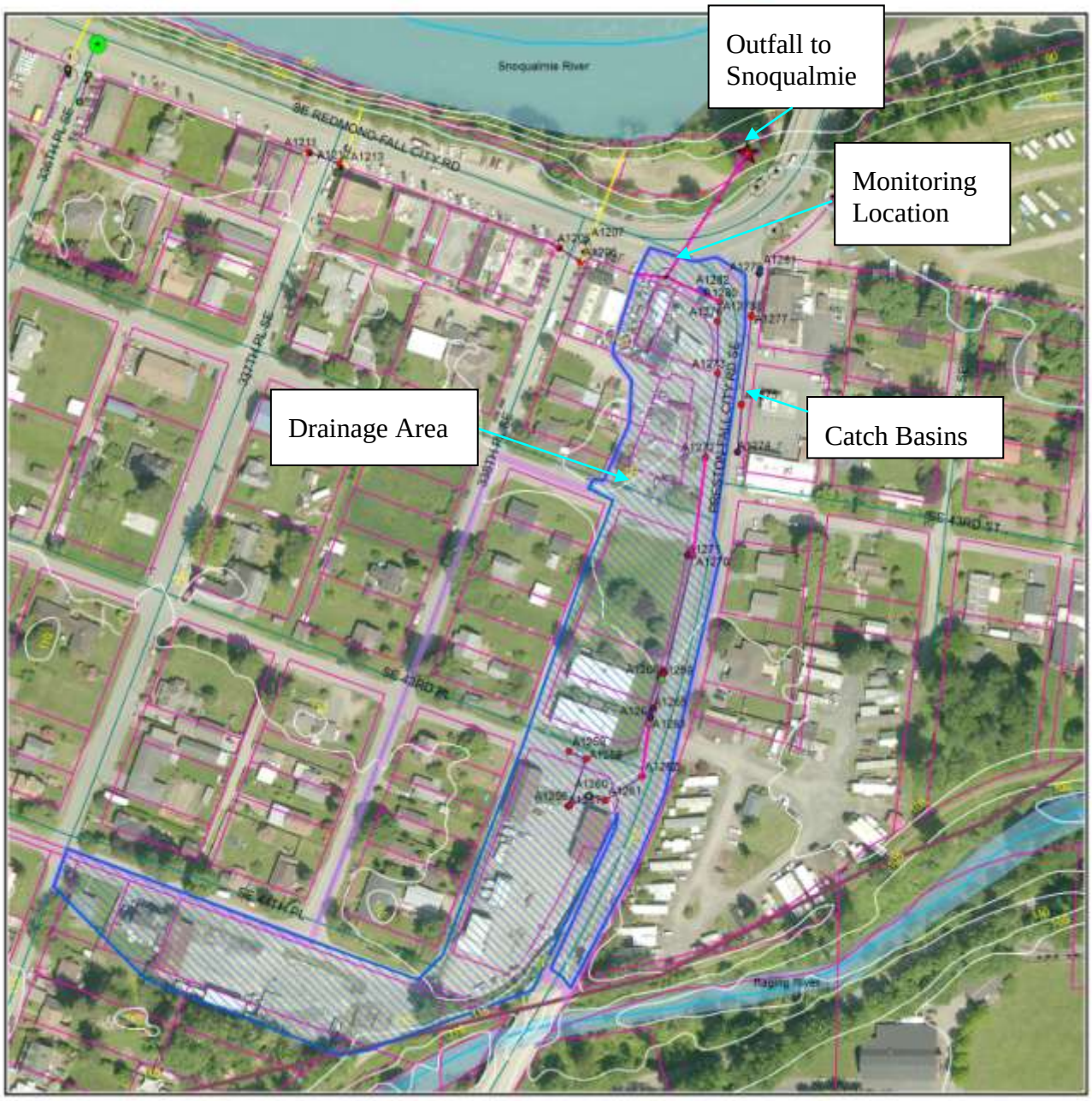

Figure 1. Fall City Commercial Monitoring Area.

5.1.2 High Density Residential

King County will monitor a high-density residential area also in Fall City. High density for this study is defined as four houses per acre or more. The neighborhood is accessed by 335th place SE and 44th Lane. Density in the monitoring area is approximately four houses to an acre. The stormdrain system serving the neighborhood is a curb and catchbasin system that flows into an

infiltration vault. The neighborhood was developed in the early 1970s and street, drainage, and house construction are all typical of this time period. The drainage basin is approximately $5^{1/4}$ acres consisting of 21 single family houses and is approximately 50 percent impervious. The monitoring location will be set up to collect stormwater immediately prior to flowing into the infiltration vault.

Figure 2. Fall City High Density Residential Monitoring Area

5.1.3 Low Density Residential

King County will monitor a low density residential neighborhood near Renton. Low density for this study is defined as one house per 1 to 5 acres. The site is characterized by open ditches bisected by residential driveways and connected with 12 inch culverts following the east shoulder of 148th Avenue SE north from SR900 and drain to May Creek. The watershed for this section of ditch is dominated by rural residential properties on the east side of 148th Ave SE and collects runoff from this busy county road. The monitoring site is at the Southwest corner of the lot at 10222 148th Avenue SE. Flow will be measured either by installing a weir into existing culverts or placing trapezoidal flumes in the ditch. Monitoring stations will be established within King County road right-of-way on the east side of the ditch. A raingage will be located at the BMP site; a permanent gage is located at the King County Roads Renton Maintenance Facility.

This monitoring location is also being used for the upstream/downstream ditch-retrofit monitoring for the NPDES required program effectiveness monitoring. The monitoring location for the low-density residential stormwater characterization (S8.D) is upstream of the ditch retrofit installation.

This street is located fairly close to the King County Renton Maintenance Facility. The site has a high traffic volume and narrow shoulders on the ditch side of the road. Right-of-way space between the east side of the ditch and private property line will allow for site access away from the road shoulder. Shoulder parking is available on the west side of the road. Lack of sidewalks may limit opportunities for vandalism at this site.

Figure 3. Low Density Residential Monitoring Area.

Table 5. Monitoring Site Characteristics.

	Monitoring Site Name		
Site Characteristics	**Commercial**	**High Density Residential**	**Low Density Residential**
Location	Fall City	Fall City	Near Renton
Drainage Area (acres)	5 acres	$5^{1/4}$ acres	42.7 acres
% Commercial	80	0	0
% Low Density Residential	0	0	100
% High Density Residential	20	100	0
% Impervious Area	80	50	17
Rain Gauge Location (State Plane NAD83)	1,378,430E 208,006N	1,378,430E 208,006N	1,308,856E 178,651N

5.2 Qualifying Storm Event Criteria for Stormwater Sampling

Samples will be collected and reported based on water year. The water year is defined as October 1st through September 30th each year. An attempt will be made to collect rainfall and runoff data for a year prior to the sample program beginning in August of 2009. Storm criteria for the wet season (October 1 through April 30) are: rainfall volume is at least 0.2 inches with no maximum, no maximum or minimum duration, antecedent dry period is less than or equal to .02 inch of rain in the previous 24 hours, and the inter-event dry period is 6 hours. Storm criteria for the dry season (May 1 through September 30) are: rainfall volume is at least 0.2 inches with no maximum, no maximum or minimum duration, antecedent dry period is less than or equal to 0.02 inch of rain in the previous 72 hours, and the inter-event dry period is 6 hours. Storm event criteria are summarized in Table 6.

Table 6. Storm Criteria for Stormwater Sampling.

	Wet Season	**Dry Season**
Seasonal Period	October 1 through April 30	May 1 through September 30
Minimum Amount of Rainfall	0.20 min. no fixed max.	0.20 min. no fixed max.

Rainfall Duration	No fixed min. or max.	No fixed min. or max.
Antecedent Dry Period	< or equal to 0.02 rain in previous 24-hours	< or equal to 0.02 rain in previous 72-hours
Inter-event Dry Period	6 hours	6 hours

5.3 Parameters for Stormwater Sampling

Flow-weighted composite samples will be analyzed for the following parameters:

- BOD5
- Hardness
- TSS
- Turbidity
- Conductivity
- Chloride
- Orthophosphate phosphorus
- Total phosphorus
- Nitrate/nitrite
- Total kjeldahl nitrogen
- Phthalates
- Polycyclic aromatic hydrocarbons (PAHs)
- Methlyene Blue Active Substances (MBAS)
- Metals (total and dissolved zinc, copper, cadmium and lead). Mercury is required for commercial and industrial land uses only.
- Pesticides including: 2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos, Dichlobenil, Prometon and Pentachlorophenol

Grab samples will be analyzed for the following parameters:

- Fecal coliform
- Semi-Volatile Petroleum Products (NWTPH-Dx)and Volatile Petroleum Products (NWTPH-Gx)

If the volume of stormwater sample collected from a qualifying storm is insufficient to allow analysis for all parameters required in the permit, samples will be analyzed for as many parameters as possible in the following priority order:

Table 7. Summary of Parameter Types Analyzed by Land Use

All Land Use Types	Industrial/Commercial	Residential
TSS	PAHs	Nutrients
Conductivity	Phthalates	Pesticides

MBAS	Pesticides	PAHs
Metals	Nutrients	Phthalates
Hardness	BOD5	BOD5
	Chlorides	Chlorides

If insufficient volume exists to run the next highest priority pollutant, that analysis should be bypassed and analyses run on lower priority pollutants in accordance with the remaining priority order to the extent possible.

5.4 Parameters for Chemical Analysis associated with Toxicity Sampling

The following parameters will be analyzed in a stormwater sample collected for the purposes of toxicity testing:

- TSS
- Chloride
- Hardness
- MBAS
- Metals including total and dissolved copper, zinc, cadmium and lead (mercury in commercial or industrial land use areas only)
- PAHs
- Phthalates
- Pesticides including: 2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos, Dichlobenil, Prometon and Pentachlorophenol

5.5 Parameters for Chemical Analysis in Sediment Samples

The following parameters will be analyzed for in sediments:

- Total solids (% solids)
- Grain size
- Total organic carbon
- PAHs
- Phthalates
- Phenolics
- PCBs*
- Pesticides (diazinon, chloropyrifos, malathion, pentachlorophenol)
- Metals (total copper, zinc, cadmium, lead and mercury*)

*For monitoring sites representing industrial and commercial land uses only.

The following table provides a list of parameters to analyze in order of priority from the top if insufficient volume is collected to analyze all required parameters.

Table 8. Parameter Analysis Priority

All Land Use Types	Industrial/Commercial	Residential
*Grain size	PAHs	Pesticides
Total organic carbon	Phthalates	PAHs
Metals	Phenolics	Phthalates
	PCBs	Phenolics
	Pesticides	

*If enough sample is available for all parameters, use grain size method in Appendix 9, otherwise characterize grain size qualitatively

6.0. SAMPLING PROCEDURES

6.1 Stormwater Monitoring Equipment and Installation

Composite water quality samples will be collected using ISCO autosamplers equipped with 15-liter glass, or suitable fluorinated plastic sample carboys. Autosamplers will be installed at monitoring sites in locked housings or utility boxes. When a storm is predicted to arrive that will rain enough to meet storm criteria, autosamplers will be set to automatically trigger by flow monitoring equipment when flow begins. A target amount of 15 liters of stormwater will be collected over the course of each sampled storm. The total time of collection will not exceed 24 hours. The end of the compositing period will be considered the start of the holding time period for the composite samples. (For further information on autosamplers see SOP NPDES-CM-2000)

A flow velocity meter will be installed for continuous flow data recording for as much as one year and for each stormwater event thereafter. Continuous flow recordings of storm events will be conducted for one year to establish rainfall/runoff relationships at each stormwater monitoring site. This data will provide information necessary for programming the sampler by using the estimates of runoff through the outfall. (For further information on flow metering see SOP NPDES-CM-1000)

One rain gauge will be installed at the high density residential monitoring site in Fall City. For the rural residential site, a rain gauge will be installed near the rural monitoring site. A permanent rain gauge, installed at the King County Roads Facility in Renton, will also be used.

Composite sampling equipment and containers will be set up to minimize contamination of the sample for metals analysis. The composite sample containers will be fitted with a cap designed to prevent contamination of the sample during the sampling process. The sample will remain capped until a standard cap is fitted onto the carboy for transportation to the laboratory.

For equipment installation into manholes or other confined spaces, confined space entry training and certification will be completed prior to sampling.

Equipment installation includes, but is not limited to:

- Installing sampler tubing in outfall pipe
- Installing mounting rings for sampler tubing and flow/velocity meter probe
- Installing a suspension harness to hang sampler in manhole
- Installing a liquid level actuator or telemetry equipment
- Installing any other necessary sampler equipment into/onto sampler (bottles, flow meter)

During equipment installation, the sampler and the flow meter will be programmed and tested. If flow is not available for a test run, a test run may be scheduled later to ensure the equipment is working properly. During sampler programming, field staff will be trained (if needed) to calibrate and program the equipment.

6.2 Stormwater Monitoring Sampling Deployment

6.2.1 Monitor Forecast

Sampling staff will monitor the weather forecast Sampling staff should document the forecast for each event. This documentation will show due diligence for the decisions to deploy, not to deploy or to set sampler program based on the predicted rainfall amount. When antecedent conditions have been or will be met and the forecast is for a qualifying storm, the sampling staff will deploy for the upcoming event. Staff will use weather forecast information to program the composite samplers.

6.2.2 Composite Sampler Deployment

Once the decision is made to deploy, field staff will complete the following:

- Program each site's sampler for the upcoming event.
- Gather all materials for deployment which may include; decontaminated containers, bases, batteries and ice.
- Proceed to sampling sites
- Prepare sampler for event which may include; replacing battery, rinsing tubing, placement of container(s), placement of ice, programming sampler.
- Verify flow measurement and actual depth and velocity if possible.

Field staff will wear powder-free nitrile gloves for safe handling to prevent cross contamination of samples. Either ice or refrigerated samplers will be used to keep sample temperature within Ecology's guidelines (WQ-R-95-80 or most up to date).

Sampling staff should continue to monitor the targeted storm event throughout the event. If a storm is larger than expected, field staff may have to replace bottles with empty bottles to capture the entire storm event or until 24 hours passes.

6.3 Sample Collection and Handling Procedures

As soon as possible after the event ends, sampling staff will retrieve the samples. Once at site, staff will review flow data to confirm that stormwater runoff has subsided or sampling occurred for a maximum of twenty-four hours. If storm flow is still present and it has been less than 24 hours, the sampling program will continue. Once stormwater runoff has subsided based on flow monitoring or visual observation, or the sampler has sampled for 24 hours, the container(s) will be removed, capped and placed on ice.

Grab samples will be collected during qualifying storms for total petroleum hydrocarbon and fecal coliform bacteria. Composite samples are not appropriate for these parameters due to their tendency to adhere to sampling equipment or change in concentration after a short period. (For further information on grab sampling see SOP NPDES-DS-2000). Also, pH and temperature data will be collected in the field during qualifying storms. (SOP NPDES-FS-1000). However, if the timing of a storm event requires the collection of grab samples in unsafe conditions, such as when it's dark, or that the initiation of bacteria samples occur outside the lab's normal working hours, then the grab samples can be collected during another qualifying storm event. King County will target eleven grab sampling events per year.

Once samples are collected, field staff will download flow rate and rainfall data, ensure the samplers are cooled, and determine hydrograph conditions. Precipitation data will be collected from a rain gauge located within the drainage area of each stormwater monitoring site.

Sampling staff will review the following information to determine if the sample is representative of the runoff event and the rain event meets storm criteria:

- Rainfall hydrograph (to determine if rainfall amount met storm criteria, e.g. 0.2 inches)
- Hydrograph (to determine if samples were collected during at least 75% of the storm, or 75% of the first 24 hours of the storm)

Once the storm event is determined to meet criteria, samples should be placed on ice with proper chain of custody forms. Field splitting will be conducted in the field as soon as the auto-sampler has finished collecting the composite sample. The composite sample will then be transferred into the appropriate laboratory sample containers. This will be done by continuously agitating the sample in the 15-liter glass carboy while transferring sample aliquots to the appropriate laboratory containers using a Teflon siphon tube. Each sample container will be filled to the appropriate level from the autosampler carboy. This procedure will ensure a representative sample from the carboy in each laboratory sample container. Once the sample has been split, both the dissolved metals sample and the orthophosphorus sample will be filtered. Dissolved metals samples will be drawn through a cleaned Nalgene 500 ml filtration apparatuses with 0.45 micron filters using a peristaltic pump. Orthophosphorus will be filtered using a 0.45 micron syringe filter.

If the sample collection crew is unable to split the composite sample and filter the appropriate sub-samples immediately, the composite sample will be stored on ice and transported back to the King County Environmental Laboratory for splitting and filtration. Appropriate hold-time violation flags will be added to the data. During evenings, weekends, and other "off hours" when a sample is collected, access to the King County Environmental Laboratory for login, sample splitting, filtration steps, refrigeration and other necessary preservation will be maintained.

During sample preparation, all field quality assurance (QA)/quality control (QC) samples (duplicates, equipment blanks, trip blanks, hold times) that require analysis should be recorded in field notebooks, on chain-of-custody forms and placed on ice in the same cooler with stormwater samples for laboratory delivery.

6.4 Field Data and COC Forms

During sample collection, field data forms and/or field notebooks should be used to document data collection procedures. Ecology recommends developing data forms and attaching a sample to your QAPP. Field data forms can include the following information:

- Field staff present (on-site)
- Weather conditions
- Date and time of site arrival
- Time of Sample collection/sample distribution into bottles w/preservative
- Equipment calibration performed and results of calibrations
- Bottle configuration
- Time of download of data
- Number of samples collected
- Any problems that occur in the field
- Signature of field staff project manager
- Number of days of preceding dry conditions
- Rainfall amount in inches of the storm event from when sampling begins

Chain-of-custody (COC) forms should be used to accompany samples being transported from the site. These forms are typically provided by the laboratory and can include the following information:

- Sample time and date
- Preservatives used
- Name of sampler
- Analytical test method requested
- Parameter to be analyzed
- Field Quality Assurance/Quality Control samples collect such as duplicates, trip blanks, temperature blanks, etc.
- Coordination with bottle labels

6.5 Decontamination Procedures

Once samples are collected, all re-usable equipment should be decontaminated with wash and rinse water. EPA approved detergents and de-ionized water (ASTM I or II) should be used to provide efficient decontamination of equipment. Equipment blanks will be analyzed to check for possible cross contamination between sampling events. The amount of equipment blanks collected is optional, based on data quality objectives established earlier in this document. Proper personal protective equipment (new powder-free gloves) should be worn during sampling activities and during decontamination processes. (for more information on decontamination procedures see KCEL SOPs 06-05-002-001 and 07-04-001-002).

6.6 Collection of QA/QC Samples

The table below provides a list of blanks that will be collected in the field to meet QAPP objectives:

Table 9. Quality Control Sample Summary.

Blank Type	Frequency of Collection	Collection Procedure
Equipment Blank	Twice per year at each site	Run ASTM Type I or II de-ionized water through equipment after decontamination and collect samples in the appropriate container with preservative for a full analysis of all parameters collected during a sampled storm event. Place immediately on ice.
Dissolved Metals field filtration blank	Every event	Carry R.O. water to field and filter through field equipment during sample collection.
ORTHOP field filtration blank	Every event	Carry R.O. water to field and filter through field equipment during sample collection.

6.7 Periodic Preventative Maintenance

Periodic preventative maintenance of equipment can occur between storm events to ensure equipment is operating properly. Signs of vandalism, rusting equipment, equipment failure or other maintenance issues will be documented in field notebooks or on field data forms. Any significant changes in site conditions that will affect sampling should be revised in the QAPP.

6.8 Additional Toxicity Testing Sample Collection Procedures

Toxicity samples will be collected from each stormwater monitoring site during the first flush storm event occurring between August 1st and September 30th. If by the end of September no qualifying storm was sampled, one last attempt will be made to collect a toxicity sample in October. Additional composite sample volume can be collected by deploying an additional sampler and carboy setup at each monitoring location.

Field decisions are crucial for toxicity sampling. In order to catch the first flush, storm forecasting models will be used to notify the permittee of incoming storms. The permittee must then notify the toxicity laboratory approximately 2 days prior to the date of the forecasted storm event. If gametes/eggs are available and a forecasted storm meets required storm event criteria, field staff will be deployed to collect samples. If gametes/eggs are not available, field staff is not required to deploy, and should be recorded in the Annual Stormwater Monitoring Report. The holding time for gametes/eggs at the laboratory is 2 days and the holding time for the toxicity water sample is 36 hours. Contact the WET Coordinator (rmar461@ecy.wa.gov or 360-407-

6445) for conditional acceptance if the holding time is between 36 and 72 hours. Holding times in excess of 72 hours will not be accepted.

6.9 Sediment Collection

Sediments will be collected at each stormwater monitoring site using a PVC core tube and stainless-steel spatula (KCEL SOP #237v0) or if access is constricted, an Eckman sediment grab sampler or similar. At the high density residential site, sediment will be collected from the street catch basin that flows into the infiltration basin. At the rural residential site, sediments will be collected from sampling location at the Southwest corner of the lot at 10222 148th Avenue SE. Core tubes will be pushed down into sediment and a spatula will be inserted under the core tube to hold sediment while the core tube is lifted out of the sediment. Sediments from the core tubes will be emptied into pre-cleaned stainless-steel bowls, one for each monitoring site. Once enough has been collected, sediments in the bowls will be composited and then transferred to appropriately labeled sample jars, using pre-cleaned stainless-steel spoons. The sample jars will then be placed on ice and delivered to the laboratory.

At the commercial site in Fall City, sediments will be collected from in the catch basin/monitoring location with an Eckman sediment grab sampler. The sampler will be lowered into the catch basin by a rope. The sampler will be triggered by a messenger and then the sampler will be retrieved. Once the sampler is retrieved, it will be emptied into a pre-cleaned stainless-steel bowl. Once enough has been collected, sediments in the bowls will be composited and then transferred to appropriately labeled sample jars, using pre-cleaned stainless-steel spoons. The sample jars will then be placed on ice and delivered to the laboratory.

6.10 Additional Resources or References to Assist with this Section

6.10.1 For Weather Forecasting

1. Federal Register, EPA 40 CFR Part 136 July 2007 and March 2007.
2. King 5 Doppler: http://www.king5.com/weather/doppler/indexrad.html?http://www.king5.com/live/weather_image/K5-340mileAnim-640x480.gif&Title=340%20Mile%20Range
3. UW Atmospheric Science: http://www.atmos.washington.edu/~ovens/loops/wxloop.cgi?mm5d1_pcp3+///3
4. NOAA QPF: http://www.wrh.noaa.gov/forecasts/graphical/sectors/sewWeek.php?page=3&element=QPF
5. COLA: http://wxmaps.org/pix/meteograms.html
6. East Pacific IR Loop: http://www.wrh.noaa.gov/sew/ir4kmP.php

7.0. MEASUREMENT PROCEDURES

7.1 Sample Volume, Containers and Hold Time

The table below includes stormwater sample volume, container type, holding time and preservative needed for each required parameter.

Table 10. Stormwater sample volume, container types, holding time and preservation requirements.

Parameter	Recommended Quantity	Container	Holding Time	Preservation
Stormwater Monitoring Samples – All Water Matrices				
Total suspended solids (TSS)	1000 mL	1000 mL CWM HDPE	7 days	Refrigerate at <6°C
Turbidity (TURB)	500 mL	500mL CWM HDPE (Collect together with COND)	2 days	Refrigerate at <6°C
Conductivity (COND)	500 mL	500 mL CWM HDPE (Collect together with TURB)	28 days	Refrigerate at <6°C
Chloride	125 mL	125 mL CNM HDPE	28 days	Refrigerate at <6°C
Biochemical Oxygen Demand (BOD5)	2L	2L CWM HDPE	2 days	Refrigerate at <6°C
Methylene Blue Active Substances (MBAS)	250 mL	1-L Amber glass	48 hours	Refrigerate at <6°C
Total phosphorus	250 mL	250mL CWM HDPE	28 days	Freeze at -18°C
Orthophosphate Phosphorus (ORTHOP)	60 mL	60 mL CWM HDPE (Collect together with NO23)	Field filter within 15 minutes of collection, then 14 days frozen	Freeze at -18°C
Total Kjeldahl Nitrogen (TKN)	250 mL	250 mL CWM HDPE	28 days	H_2SO_4 to pH<2 within 15 minutes of collection, then refrigerate at <6°C
Nitrate-nitrite Nitrogen (NO23)	60 mL	60 mL CWM HDPE (Collect together with ORTHOP)	Filter within one day, then 14 days frozen	Freeze at -18°C

Parameter	Recommended Quantity	Container	Holding Time	Preservation
Dissolved Metals (copper, zinc, cadmium, lead)	250 mL	Acid washed 500 mL HDPE	6 months	Field Filter within 15 minutes; then HNO_3 to pH<2 at lab
Dissolved Mercury	500 mL	Acid washed 500 mL HDPE bottle	28 days	Field Filter within 15 minutes; then HNO_3 to pH<2 at lab
Total Mercury	500 ml	Acid washed 500 mL HDPE bottle	28 days	HNO_3 to pH<2
Total Metals (copper, zinc, cadmium, lead)	250 mL	Acid washed 500 mL HDPE bottle	6 months	HNO_3 to pH<2
Hardness (CaCO3) (may be included in Total Metals bottle)	250 ml	Acid washed 500 mL HDPE bottle	6 months	HNO_3 to pH<2
PAH, Phthalate and, pentachlorophenol	4 X 1 liters	1 liter amber glass jar	7 days	pH tested adjusted 6 to 9 within 15 min. of sampling. Store at 4 degrees C
Herbicides: 2,4-D, MCPP, triclopyr,	2 X 1 liters	1 liter amber glass jar	7 days	Store at 4 degrees C
Pesticides: Nitrogen, organophosphate, and/or chlorinated includes:, diazinon, malathion, Chlorpyrifos dichlobenil, prometon	4 X 1 liters	1 liter amber glass jar	7 days	pH tested adjusted 5 to 9 within 15 min. of sampling. Store at 4 degrees C
Fecal coliform	500 mL	500 mL polypropylene autoclaved bottle	6+2 hours	If chlorine is expected in the sample, then request thiosulfate preservative
Semi-Volatile Petroleum Products (NWTPH-Dx)	1 L	100 mL amber glass bottle with Teflon-lined cap (volume affects reporting limit)	7 days (14 days if pH adjusted to 2 with 1:1 HCl)	Refrigerate all samples at 4ºC (for 14 day hold time adjust pH to 2 with 1:1 HCl)
Total petroleum hydrocarbons – NWTPH-Gx	120 mL + 40 mL	(3) 40-mL vials w/ septum	7 days	none

Parameter	Recommended Quantity	Container	Holding Time	Preservation
Sediment Samples -All Soil Matrices				
Total solids (% solids)	60 g	4 oz. CWM PP or glass (Collect together with TOC)	14 days, 6 months if frozen	Freeze at -18°C
Grain Size	300g	16 oz. CWM PP or glass*	6 months	Refrigerate at 4°C
Total organic carbon (TOC)	25g	4 oz. CWM PP or glass (Collect together with TOTS)	14 days, 6 months if frozen	Freeze at -18°C
Total metals: Copper, zinc, cadmium, lead	fill jar	4 oz. PP jar	6 months, 2 years if frozen	Refrigerate at 4°C
Mercury (can be combined with Total Metals jar)	fill jar	4 oz. PP jar	28 days	Freeze at -18°C
PAH, Phthalates, Phenolics and Pentachlorophenol	250g	8 oz glass jar	14 days, 1 year if frozen	Refrigerate at 4°Ce
PCBs	250g	8 oz. glass jar	14 days, 1 year if frozen	Refrigerate at 4°C
Pesticides: Nitrogen, organophosphate, and/or chlorinated includes: diazinon, malathion, chlorpyrifos	250g	8 oz glass jar	14 days, 1 year if frozen	Refrigerate at 4°C

***** A second 16 oz. container should be collected for PSD QC (1 per 20 samples).

7.2 Stormwater Sample Volumes

Sample volume requirements can also vary from laboratory to laboratory. Additionally, some parameters can be combined into one sample volume, reducing the need to collect individual samples for each parameter. The following table includes parameters to be monitored with estimated volumes.

Parameter/Specific Analyte		Volume in Liters
Herbicides: 2,4-D, MCPP and Triclopyr		2
Insecticides: Diazinon, Malathion, Chloropyrifos, Dichlobenil, and Prometon Fungicides: Pentachlorophenol		4
Phthalates and PAHs		4
Total Mercury		0.500
Dissolved Mercury		0.500
Total Metals: Copper, Zinc, Cadmium, Lead		0.250
Hardness (may be included in Total Metals Bottle unless a different sample)		0.250
Dissolved Metals: Copper, Zinc, Cadmium, Lead		0.250
TSS		1
Turbidity and Conductivity		0.5
Chloride		0.1
BOD5		2
Total Phosphorus		0.25
Orthophosphate Phosphorus		0.06
NO23		0.06
MBAS***		0.50
TKN		0.25
	Total Composite Sample Volume Needed	~15 L
Grab Samples	Semi-Volatile Petroleum Products (NWTPH-Dx)	1L
	TPH – NWTPH-Gx	120 mL+ 40 mL
	Fecal coliform	250 mL

7.3 Sediment Sample Volumes

The following table lists the estimated sediment volume needed to analyze the required parameters in the permit.

Table 11. Sediment sample volume requirements.

Parameter/Specific Analyte – Sediment Sampling	Volume in Ounces
Grain Size	16.0
Total Metals	4.0
Total organic carbon and total solids	4.0
PAHs, phthalates, PCBs, Herbicides, Pesticides	32.0 oz.
Phenolics	3.5 oz.
Total in ounces	63.5 oz

The Ecology-designed catch basin inserts can hold a maximum of 34 ounces of sediment. The amount of sediment typically collected in a single sediment sampler ranges from 2 ounces to as much as 10 ounces depending on sedimentation in the storm flow. To obtain the required volume, more than one sediment samplers may have to be installed at one location or other equipment used.

7.4 Analytical Methods and Reporting Limits

The analytical methods selected for this project must correspond with those provided in Appendix 9 of the Phase I permit and in the addition guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit*. Alternative analytical methods not listed in the above references may be used with prior approval by Ecology. Appendix 9 of the Phase I Permit requires the following reporting limits to be met:

Table 12. Analytical Method Reporting Limits for Water Matrix Parameters

Parameter	Reporting Limit Target
Total suspended solids	1.0 mg/L
Turbidity	±0.2 NTU

Parameter	Reporting Limit Target
Conductivity	±1 umhos/cm
Chloride	0.2 mg/L
BOD5	2.0 mg/L
pH	0.2 units.
Hardness as CaCO3	1.0 mg/L
Methylene Blue Activating Substances (MBAS)	0.025 mg/L
Fecal coliform	2 min., 2E6 max cfu/100mls
Total phosphorus	0.01 mg P/L
Orthophosphate	0.01 mg P/L
Total kjeldahl nitrogen	0.5 mg/L
Nitrate-nitrite	0.01 mg/L
Total recoverable zinc	5.0 µg/L
Dissolved zinc	1.0 µg/L
Total recoverable lead	0.1 µg/L
Dissolved lead	0.1 µg/L
Total recoverable copper *	0.1 µg/L
Dissolved copper *	0.1 µg/L
Total recoverable cadmium	0.2 µg/L
Dissolved cadmium	0.1 µg/L
Total mercury	0.1 µg/L
Dissolved mercury	0.1 µg/L
PAHs	0.1 µg/L
Phthalates	1.0 µg/L
Herbicides	0.01 – 1.0 µg/L

Parameter	Reporting Limit Target
Pesticides, Nitrogen	0.01 – 1.0 µg/L
Pesticides, Organophosphorus	0.01 – 1.0 µg/L
Semi-Volatile Petroleum Products (NWTPH-Dx)	0.25 - 0.50 mg/L
TPH (NWTPH-Gx)	0.25 mg/L

* King County Environmental Laboratory detection limit for total and dissolved copper is 0.4 ug/L using EPA method 200.8 without using a "clean hands/dirty hands" method based on EPA 1669 sample collection for ultra low trace metals. Automated samplers are not suitable for ultra-low detection limits. Therefore, this slightly higher detection limits will be used for this project.

Table 13. Analytical Method Reporting Limits for Sediment Sampling Parameters

Parameter	Reporting Limit Target
Grain size	NA
Total solids	NA
Total organic carbon	0.1%
Total recoverable zinc	5.0 mg/Kg
Total recoverable lead	0.1 mg/Kg
Total mercury	0.1 mg/kg
Total recoverable copper	0.1 mg/Kg
Total recoverable cadmium	0.1 mg/Kg
PAHs	70 µg/Kg dry
Phthalates	70 µg/Kg dry
Phenolics	70 µg/Kg dry
PCBs	80 µg/Kg dry
Pentachlorophenol	1 µg/kg wet
Diazinon	50 µg/kg wet
Chloropyrifos	25 µg/kg wet

Malathion	25 µg/kg wet

7.5 Methods Table

The following analytical methods will be used for stormwater monitoring chemical analysis:

Parameter	Method	Method Detection Limit	Reporting Detection Limit
Total suspended solids	SM2540D	0.5 mg/L	1.0 mg/L
Turbidity	SM2130B	0.2 NTU	0.5 NTU
Conductivity	SM2510B	1 umhos/cm	5 umhos/cm
Chloride	SM4110B	0.05 mg/L	0.1 mg/L
BOD_5	SM5210B	2 mg/L	2 mg/L
pH	SM4500-H-B	NA	NA
Hardness as $CaCO_3$	EPA 200.8/SM2340B.ED19	0.066 (mg $CaCO_3$/L)	0.33 (mg $CaCO_3$/L)
Methylene Blue Activating Substances (MBAS)	SM5540C	0.025 mg/L	0.025 mg/L
Fecal coliform	SM9222D[1]	1 cfu/100mls	1 min., 1E6 max cfu/100mls
Total phosphorus	SM4500-P-B,F	0.005 mg/L	0.01 mg /L
Orthophosphate Phosphorus	SM4500-P-F	0.002 mg/L	0.005 mg /L
Total Kjeldahl Nitrogen	EPA 351.2	0.1 mg/L	0.2 mg/L
Nitrate-nitrite Nitrogen	SM4500-NO3-F	0.01 mg/L	0.04 mg/L
PAHs	SW846-8270D	0.05 ug/L	0.1 µg/L
Phthalates plus pentachlorophenol	SW846-8270D	0.5 ug/L	1.0 µg/L
Pesticides, Nitrogen (Dichlobenil, Prometon)	SW846-8270D-SIM	0.05 ug/L	0.1 µg/L
Pesticides, Organophosphorus (Diazinon, Malathion, Chlorpyrifos)	SW846-8270D-SIM	0.05 ug/L	0.10 µg/L

Parameter	Method	Method Detection Limit	Reporting Detection Limit
Semi-Volatile Petroleum Products (NWTPH-Dx)	NWTPH-Dx (GC/FID) Ecology, 1997 (Publication No. ECY-97-602)	0.2 mg/L	0.2 mg/L
TPH (NWTPH-Gx)	NWTPH-Gx (GC/FID) Ecology, 1997 (Publication No. ECY-97-602)	0.25 mg/L	0.25 mg/L

NTU = Nephelometric Turbidity Units

1. For turbid samples 9221E will be used.

Umhos/cm = micromho per centimeter

Su = Standard Units

Parameter	Method	Method Detection Limit (a)	Reporting Detection Limit (b)	Practical Quantitation Limit (c)
Total recoverable zinc	EPA 200.8	0.081 ug/L	0.5 ug/L	2.5 ug/L
Dissolved zinc	EPA 200.8	0.081 ug/L	0.5 ug/L	2.5 ug/L
Total recoverable lead	EPA 200.8	0.0047 ug/L	0.1 ug/L	0.5 ug/L
Dissolved lead	EPA 200.8	0.0047 ug/L	0.1 ug/L	0.5 ug/L
Total recoverable copper*	EPA 200.8	0.043 ug/L	0.4 ug/L	2.0 ug/L
Dissolved copper*	EPA 200.8	0.043 ug/L	0.4 ug/L	2.0 ug/L
Total recoverable cadmium	EPA 200.8	0.0027 ug/L	0.05 ug/L	0.25 ug/L
Dissolved cadmium	EPA 200.8	0.0027 ug/L	0.05 ug/L	0.25 ug/L

Total mercury (CVAA-M)	EPA 245.1	0.0046 ug/L	0.05 ug/L	0.10 ug/L
Dissolved mercury (CVAA-M, DISS)	EPA 245.1	0.0046 ug/L	0.05 ug/L	0.10 ug/L

(a) Method Detection Limit: King County Environmental Laboratory's empirically derived EPA 40 CFR MDL may change annually when MDL studies are performed. These values do not show up on any reported data.

(b) Reporting Detection Limit: King County Environmental Laboratory's Reporting Detection Limit. King County Environmental Laboratory reports show this as the "LIMS MDL".

(c) Practical Quantitation Limit: King County Environmental Laboratory's limit for accurate quantification as defined by EPA SW846 procedures. A low level check standard at or near this concentration must yield +/- 30% of the True Value. King County Environmental Laboratory reports show this as the "LIMS RDL".

* King County Environmental Laboratory reporting limit for total and dissolved copper is 0.4 ug/L using EPA method 200.8 without using a "clean hands/dirty hands" method based upon EPA 1669 sample collection for ultra low trace metals. Automated samplers are not suitable for ultra low detection limits. Therefore, this slightly higher reporting limit will be used for this project.

The following table contains the analytical method that will be used for this project for sediment analysis:

Table 14. Sediment Analytical Methods and Detection Limits

Parameter	Method	Method Detection Limit
Grain Size	ASTM D422	Sieve (Gravel & Sand) 0.1% Hydrometer (Silt & Clay) 0.5 %
Total solids (% solids)	SM2540G	0.005%
Total organic carbon	EPA9060-PSEP96	0.05%
Total recoverable zinc	EPA3050B/6010C	0.25 mg/Kg wet weight
Total recoverable lead	EPA3050B/6010C	1.0 mg/Kg wet weight
Total mercury (CVAA-M)	EPA 7471B	0.005 mg/kg wet weight
Total recoverable copper	EPA3050B/6010C	0.2 mg/Kg wet weight
Total recoverable cadmium	EPA3050B/6010C	0.1 mg/Kg wet weight
PAHs	SW846-8270D	70 µg/Kg dry
Phthalates	SW846-8270D	70 µg/Kg dry

Parameter	Method	Method Detection Limit
Phenolics	SW846-8270D	70 µg/Kg dry
PCBs	SW846-8082A	80 µg/Kg dry
Fungicides: Pentachlorophenol	SW846-8270DSIM	1.0 µg/Kg
Pesticides, organophosphates (diazinon, chloropyrifos, malathion)	SW846-8270DSIM	0.05 µg/Kg

7.6 Toxicity Sample Volumes

A sufficient sample for toxicity consists of the following:

- Approximately 12.7 liters (3.4 gallons) for the analysis of the required chemistry parameters listed in the following table, and
- Approximately 24 to 44 liters (6.4 to11.6 gallons) for toxicity testing.

Table 15. Chemical Parameters and Volumes for Toxicity Sampling.

Parameter/Specific Analyte		Volume in Liters*
Herbicides: 2,4-D, MCPP and Triclopyr		2.0
Insecticides: Diazinon, Malathion, Chloropyrifos, Dichlobenil, and Prometon Fungicides: Pentachlorophenol		4.0
Phthalates and PAHs		4.0
Total Metals: Copper, Zinc, Cadmium, Lead		0.25
Dissolved Metals: Copper, Zinc, Cadmium, Lead		0.25
Total Mercury		0.5
Dissolved Mercury		0.5
TSS		1.0
Chloride		0.1
Hardness**		0.25

MBAS*		0.50
	Total Chemistry Sample Volume Needed	13.35 L
	Total # of Samples Derived from Composite Sample	8

*Volume estimates provided by Columbia Analytical Laboratory

*** The hardness sample referenced above is the optional hardness sample collected from the receiving water in order for the laboratory to adjust the sample hardness to match receiving water*

As demonstrated above, BOD_5, fecal coliform, TPH, turbidity, nutrients and conductivity are not required for analysis for toxicity. The following will be measured at the toxicity laboratory upon sample receipt:

- Conductivity
- pH
- DO
- alkalinity
- hardness (stormwater sample)
- ammonia

Table 16. Toxicity Testing Parameters, Recommended Quantity, Container Type, Holding Time and Preservative

Analysis	Recommended Quantity	Container	Holding Time	Preservation
Toxicity Samples				
Environment Canada Trout Embryo Viability	11.6 gallons – 6.4 gallons	5 gallon glass containers	36 hours	Dark, minimal headspace, 0-6 º C

*Information in this table was provided by Nautilus Laboratory.

*Container type, holding times and recommended quantity may vary between laboratories

7.6.1 Toxicity Sample of Insufficient Volume

KCEL estimates that a total of 30L of each sample is required to run the embryo test (29L for water hardening, rinsing of eggs and testing; 900 mL for chemistry). An additional 7L may be required for a tissue sample replicate. Sufficient sample for test setup and daily renewals must

be collected at the time of the storm event; subsequent samples will not qualify as first-flush, and precipitation may cease after one or two days.

If the total sample volume after the qualifying storm is less than 11.6 gallons (44 liters) but greater than 6.3 gallons (24 liters) then the volume that was collected will determine changes in the toxicity testing configuration described above in accordance with the following:

- 10 gallons (38 liters) of sample – base the concentration series on a 0.3 dilution factor.
- 8.7 gallons (33 liters) of sample – base the concentration series on a 0.3 dilution factor and reduce the number of replicates to three.
- 7.9 gallons (30 liters) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three and the number of replicates in the test itself to three.
- 6.9 gallons (26 liters) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three and base the concentration series on a 0.3 dilution factor.
- 6.3 gallons (24 liters) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three, base the concentration series on a 0.3 dilution factor, and reduce the number of replicates in the test itself to three.

If the sample volume falls between the values listed above, then the test configuration must match the next lowest volume and the excess sample used for additional replicates of 100% sample to improve the detection limit for the yolk/embryo analysis. If sample volume is less than 6.3 gallons (24 liters), toxicity sample analysis will not be conducted.

7.7 Temperature

Sample holding times, temperatures, and handling shall meet Ecology's guidance (WQ-R-95-80) or version current at the permit revision date. If the sample temperature exceeds 6 degrees Celsius at receipt by the laboratory, then the WET Coordinator, Randall Marshall (rmar461@ecy.wa.gov or 360-407-6445) will be contacted in accordance with Department of Ecology publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* to get acceptance for the sample temperature deviation. Acceptance will not be given for samples warmer than 14 degrees Celsius unless the sample is received by the laboratory within one hour after collection. Samples should meet the required temperature stated in the reference above, which is available from Ecology's website: http//www.ecy.wa.gov/programs/wq/wet.

7.8 Holding Time

If the maximum holding time of the toxicity sample is exceeded (36 hours), staff will contact Ecology's WET Coordinator for conditional acceptance. Sample holding times in excess of 72 hours will not be accepted by the laboratory or Ecology. The date and time of test initiation will be recorded on laboratory data forms or in laboratory notebooks.

7.9 Toxicity Testing Procedures (7-day Test)

Rainbow trout eggs are dry-fertilized in the lab, the embryos exposed to sample solutions, and the test ended 7 days after fertilization, with the endpoint consisting of embryo viability. The rainbow trout embryo survival test is used to evaluate the effects of storm water (seasonal first-flush) and in monitoring of receiving waters. The toxicity test shall have five concentrations and a control with four replicates at each concentration. An additional seven replicates of 100% sample and control water shall be run in order to provide tissue for yolk/embryo analysis if needed. The test concentration series shall be determined using a 0.5 dilution factor.

Procedures for the 7-day toxicity test are illustrated in the following references:

- Environment Canada. 1998. Biological Test Method: Toxicity Tests Using Early Life Stages of Salmonid Fish (Rainbow Trout). Environmental Protection Series 1/RM/28 Second Edition.
- Canaria, E.C., J.R. Elphick, and H.C. Bailey. 1999. A Simplified Procedure for Conducting Small Scale Short-Term Embryo Toxicity Tests with Salmonids. *Env. Toxicol.* 14, 301-307.
- WaDOE, 2005. Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria. p39.*

Green eggs and sperm will be obtained primarily from:

Trout Lodge
12000 McCutcheon Road (or P.O. Box 1290)
Sumner, WA 98390
Phone: (253) 863-0446; Fax: (253) 863-4715; Web: troutlodge.com

However, alternative gamete sources (to be determined) may be used to achieve greater scheduling flexibility if QA/QC goals of the project can still be met.

The test is terminated at 7 days, at which time D.O., pH and temperature are measured and samples for water quality are collected. Dead embryos are counted, recorded and removed. Remaining embryos are counted, collected by pouring through a nylon screen and placed into 14-mL plastic screw-cap vials each containing 10 mL Stockard's solution as a clearing and preservative solution. After approximately 20-30 minutes, the embryos will be "cleared" of the opaque outer coating sufficiently for examination. Preserved embryos are stored in the dark at room temperature until observation. The eggs are then visually tested for viability. Nonviable eggs are described as eggs failing to complete morphogenesis. The endpoint of this test includes:

- Eggs that did not survive during exposure to the stormwater sample
- Eggs that inhibited development
- Eggs that were not successfully fertilized initially

Bench sheets will be developed during the 7-day test and included in the final data report.

An EC_{50} will be calculated for each test result using the Spearman-Karber Method. Abbot's correction may be applied to the data before deriving the point estimations. A minimum of five concentrations and a control will be used. If an EC_{50} is 100% sample or less, then the permit requires follow-up actions. Information on follow-up actions can be found in Section 8, *Sampling Procedures*.

7.10 Invalid or Anomalous Tests

Invalid toxicity tests may occur if the laboratory does not follow the test protocol or when the results do not meet the test acceptability criteria in the test protocol. The laboratory will usually identify invalid tests and arrange to repeat them. Ecology will also identify invalid tests when the laboratories do not. Anomalous test results happen when the laboratory appears to have conducted the toxicity test in accordance with the test protocol, but the results are considered unreliable according to the anomalous test identification criteria in Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.* Only Ecology may identify a test result as anomalous. Invalid or anomalous tests will be repeated with freshly sampled stormwater in accordance with Section 4, *Project Description*.

If a test is found invalid or anomalous, the Permittee will keep the results on file and report the information in the Annual Stormwater Monitoring Report. A second attempt for toxicity testing is necessary (see Section 4, *Project Description*).

7.11 Follow-up Actions When Toxicity Is Detected

Follow-up actions when toxicity is detected ($EC_{50} \leq 100\%$ sample) are based upon an evaluation of water quality sample chemistry compared to an existing library of fish embryo toxicity test results (Trout Library).

If the EC_{50} from any valid and non-anomalous test is 100% stormwater or less, the following procedures will be followed:

- Preserve terminated organisms for up to six months. Embryos in the extra replicates in the 100% sample treatment are sampled for tissue analysis by GC/MS by pouring the embryos onto a nylon screen, patting them lightly with a paper towel to remove excess water, placing them into a 40-mL amber glass screw-cap vial, and freezing them at -20°C. The additional 7 replicates will yield approximately 24.5 grams of tissue for analysis.
- Compare the water quality analytical results to the Trout Library to determine the presence of a detected toxicant within sixty (60) days after final validation of the data.
- Determine, through a good faith effort, if the presence of a detected parameter is within the range reported in the Trout Library that may adversely affect fish embryos and if so, review the source literature found in the trout library.

The results of the toxicity testing, and documentation of follow-up actions, will be submitted to Ecology with the appropriate Annual Stormwater Monitoring Report. Section 12, *Audits and Reports*, describes the contents of reporting on toxicity.

The follow-up actions when toxicity is detected should also anticipate potentially adding other chemicals to the parameter list for future sampling. Chemicals found by yolk analysis (described below) may be worth measuring in stormwater to allow a quantitative comparison to the Trout Library. The list of PAHs, pesticides, and other chemicals analyzed may be expanded for future samples if additional analyses may possibly help resolve toxicant identity. The list of analyses should be expanded only if knowledge of industrial or commercial activity within the drainage area suggests the presence of a chemical which the fish embryo toxicity library (Trout Library) shows could be toxic to this life stage or if a potentially toxic chemical has been found in the yolk.

If the concurrent chemical analyses of the sample do not detect any chemicals at concentrations known to adversely affect fish embryos, then a Gas Chromatograph/Mass Spectrometer (GC/MS) scan-type analysis of the yolk tissue from the highest test concentration (usually 100%) is needed. The GC/MS need not be quantitative but only capable of identifying stormwater contaminants present in the embryo or yolk tissue.

Example procedures include, but are not limited to the following:

- Washington State Department of Ecology Manchester Environmental Laboratory, Standard Operating Procedures for Micro-Acetonitrile Back Extraction Clean-up of Fish Tissue, Version 1.0, 2006
- Puget Sound Water Quality Action Team, Recommended Guidelines for Sampling Marine Sediment, Water Column and Tissue in Puget Sound, April 1997
- Environmental Protection Agency, SW-846, Method 3500B, Organic Extraction and Sample Preparation, 1996
- U.S. Geological Survey, EPA Extraction and Lipid Separation of Fish Samples for Contaminant Analysis and Lipid Determination, Standard Operating Procedure # HC521A, Great Lakes Science Center, Ann Arbor, Michigan, Version 1, 1995
- Washington State Department of Health, Human Health Evaluation of Contaminants In Puget Sound Fish, 2006

To be most useful, a yolk/embryo analysis should not be restricted to the list of chemical parameters required by the Phase I Permit. The GC/MS scan should capture and identify as many chemicals as it reasonably can. The Trout Library has many more chemicals than the required parameters, and will be useful for comparing GC/MS results. Yolk tissue analysis need not be quantitative because the Trout Library is based upon water and not tissue concentrations. The presence of a chemical within the yolk/embryo tissue means that the exposure can be considered significant enough to warrant checking the Trout Library to see if the chemical might be toxic to the embryo life stage.

A chemical detected in the yolk/embryo tissue testing may be added to the list of parameters measured in stormwater samples at the investigators discretion. Quantitative analysis would be useful so that concentrations may then be compared to fish embryo toxicity data. Ecology will be entering the results of the chemical analyses and trout embryo toxicity testing into a database for evaluation over the long term. Examination of results at the same outfall over time and from different outfalls from around the state may reveal patterns of chemical analytical results related to toxicity test results. The overall goal of toxicity data is to update our understanding of stormwater toxicity and provide information upon which to base adaptive stormwater

management. As long as this goal is being met, confirmation of toxicant identity is not necessary.

7.12 Additional Resources or References to Assist with this Section

1. Ecology's Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria, June 2005 (Canary Book Reference)
2. Environmental Protection Agency's Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms, Appendix I, Spearman-Karber Method pages 439 – 443.
3. Department of Ecology Phase I Municipal Stormwater Permit Fact Sheet
4. Ecology's Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria, June 2005, http://www.ecy.wa.gov/pubs/9580.pdf.
5. Environment Canada, Environmental Toxicology Section, Standard Operating Procedures for the Toxicity Test Using Early Life Stages of Rainbow Trout, SOP ID RBTELS11. SOP, February 1999
6. Environmental Protection Agency's Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms, Appendix I, Spearman-Karber Method pages 439 – 443. http://www.epa.gov/waterscience/methods/wet/disk1/
7. A Simplified Procedure for Conducting Small Scale Short-Term Embryo Toxicity Tests with Salmonids, E.C. Canaria, J.R. Elphick, H.C. Bailey, March 1998.

8.0. QUALITY CONTROL

8.1 Conventionals

Laboratory QC samples for conventional analyses and associated control limits are summarized below. These QC samples will be analyzed at a frequency of one per analytical batch of 20 or fewer samples.

Table 17. Conventionals QC – Liquid Matrices

Parameters	Method Blank	Lab Duplicate %RPD	Spike Blank %Recovery	Matrix Spike %Recovery	Lab Control Sample %Recovery
Biochemical Oxygen Demand	<MDL	NA	80-120%	NA	NA
Chloride	<MDL	20%	80-120%	75-125%	85-115%
Conductivity	NA	10%	NA	NA	90-110%
Methylene Blue Active Substances	<MDL	Subc.	Subc.	Subc.	Subc.
Nitrate-Nitrite	<MDL	20%	80-120%	75-125%	85-115%
Orthophosphate Phosphorus	<MDL	20%	80-120%	75-125%	85-115%
Total Kjeldahl Nitrogen	<MDL	20%	80-120%	70-130%	80-120%
Total Phosphorus	<MDL	20%	80-120%	75-125%	85-115%
Total Suspended Solids	<MDL	25%	N/A	N/A	80-120%
Turbidity	NA	25%	N/A	N/A	90-110%

Table 18. Conventional QC – Solid Matrices

Parameters	Method Blank	Lab Triplicate %RSD	Matrix Spike %Recovery	Lab Control Sample[1] %Recovery
Grain Size	N/A	20%	N/A	N/A

Total Organic Carbon	<MDL	20%	75-125%	80-120%
Total Solids	<MDL	20%	N/A	N/A

1: This may be an SRM, LCS or SB depending on method

8.2 Metals

Laboratory QC samples for trace metals analyses and associated control limits are summarized below. These QC samples will be analyzed at a frequency of one per analytical batch of 20 or fewer samples.

Table 19. Metals QC – Liquid Matrices

Parameters	Method Blank	Lab Duplicate %RPD	Matrix Spike %Recovery	Spike Blank %Recovery
Dissolved Metals	<MDL	20%	75-125	85-115
Total Metals and Hardness	<MDL	20%	75-125	85-115

Table 20. Metals QC – Solid Matrices

Parameters	Method Blank	Lab Duplicate %RPD	Matrix Spike %Recovery	Spike Blank %Recovery	LCS % Recovery
Total Metals	<MDL	20%	75-125	85-115	Performance Based

8.3 Organics

Laboratory QC samples for organics analyses associated control limits are summarized below. Unless otherwise noted below, these QC samples will be analyzed at a frequency of one per analytical batch of 20 or fewer samples.

Table 21. Organics QC – Liquid Matrices

Analysis	Method Blank	Spike Blank (% Recovery)	Matrix Spike % Recovery	MS/MSD RPD	Lab Duplicate (RPD)	Surrogate % Recovery
Semi-Volatile Petroleum Products (NWTPH-Dx)	<MDL	50-150	NA	NA	100 [a]	50-150

Table 22. Trace Organic Parameters Spike Blank Recovery Limits

Analyte	Lower % Limit	Upper % Limit	%RPD
2-Methylnaphthalene	46	97	100
Acenaphthene	50	100	100
Acenaphthylene	51	107	100
Anthracene	50	116	100
Benzo(a)anthracene	55	122	100
Benzo(a)pyrene	59	125	100
Benzo(b)fluoranthene	52	120	100
Benzo(g,h,i)perylene	59	116	100
Benzo(k)fluoranthene	47	140	100
Benzyl Butyl Phthalate	49	143	100
Bis(2-ethylhexyl)Phthalate	10	196	100
Chrysene	48	127	100
Dibenzo(a,h)anthracene	57	122	100
Diethyl Phthalate	54	136	100
Dimethyl Phthalate	53	118	100
Di-N-Butyl Phthalate	48	133	100
Di-N-Octyl Phthalate	43	156	100
Fluoranthene	54	131	100
Fluorene	54	117	100
Indeno(1,2,3-cd)Pyrene	59	120	100
Naphthalene	39	94	100
Pentachlorophenol	44	102	100
Phenanthrene	55	104	100
Phenol	37	97	100
Pyrene	52	123	100
Chlorpyrifos	55	147	100
Diazinon	63	129	100
Malathion	62	152	100
2,4-D	10	200	100

Analyte	Lower % Limit	Upper % Limit	%RPD
MCPP	10	200	100
Triclopyr	10	200	100
Dichlorobenil	detect	200	100
Prometon	detect	200	100

Table 23. Trace Organics Parameters – Matrix Spike Recovery Limits

Analyte	Lower % Limit	Upper % Limit	%RPD
2-Methylnaphthalene	41	94	100
Acenaphthene	45	101	100
Acenaphthylene	45	98	100
Anthracene	49	103	100
Benzo(a)anthracene	62	112	100
Benzo(a)pyrene	66	108	100
Benzo(b)fluoranthene	48	118	100
Benzo(g,h,i)perylene	59	109	100
Benzo(k)fluoranthene	55	116	100
Benzyl Butyl Phthalate	48	134	100
Chrysene	52	110	100
Dibenzo(a,h)anthracene	60	107	100
Diethyl Phthalate	44	142	100
Dimethyl Phthalate	48	114	100
Di-N-Butyl Phthalate	62	125	100
Di-N-Octyl Phthalate	71	120	100
Fluoranthene	48	131	100
Fluorene	34	128	100
Indeno(1,2,3-cd)Pyrene	60	109	100
Naphthalene	43	77	100
Pentachlorophenol	38	119	100
Phenanthrene	59	93	100
Phenol	37	97	100
Pyrene	47	123	100
Chlorpyrifos	55	147	100
Diazinon	63	129	100
Malathion	62	152	100
2,4-D	10	200	100

Analyte	Lower % Limit	Upper % Limit	%RPD
MCPP	10	200	100
Triclopyr	10	200	100
Dichlorobenil	detect	200	100
Prometon	detect	200	100

Table 24. Laboratory QC Limits for Water BNAs, Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
2-Fluorobiphenyl	31	101
d14-Terphenyl	51	130
D10-Chlorpyrifos	54	164
2,4-dichlorophenylacetic acid	10	200
2,6-dichlorophenylacetic acid	10	200

[a] For NWTPH-Dx, the Lab Duplicate will be analyzed at a frequency of one per 10 samples or fewer.

* Extraction batch = 20 samples or less prepared within a 12 hour shift

**QC batch = 20 samples or less prepared over a 14-day period. Samples must be of the same matrix.

< MDL = Method Blank result should be less than the *method detection limit*.

RPD = Relative Percent Difference

NA = Not Applicable

Table 25. Laboratory QC Limits for Sediment BNAs, Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
2,4,5-Trichlorophenol	23	166	Benzo(k)fluoranthene	10	192
2,4,6-Trichlorophenol	26	153	Benzyl Butyl Phthalate	41	145

2,4-Dichlorophenol	24	142	Bis(2-Ethylhexyl)Phthalate	10	189
2,4-Dimethylphenol	10	150	Chrysene	14	184
2,4-Dinitrophenol	18	134	Di-N-Butyl Phthalate	10	194
2-Chlorophenol	10	112	Di-N-Octyl Phthalate	52	151
2-Methylnaphthalene	22	112	Dibenzo(a,h)anthracene	10	166
2-Methylphenol	10	142	Diethyl Phthalate	31	150
2-Nitrophenol	20	107	Dimethyl Phthalate	13	162
4,6-Dinitro-O-Cresol	40	145	Fluoranthene	12	188
4-Chloro-3-Methylphenol	48	132	Fluorene	22	147
4-Methylphenol	10	163	Indeno(1,2,3-Cd)Pyrene	10	177
4-Nitrophenol	45	153	Naphthalene	12	97
Acenaphthene	25	130	Pentachlorophenol	17	170
Acenaphthylene	27	132	Phenanthrene	10	200
Anthracene	10	181	Phenol	10	127
Benzo(a)anthracene	32	168	Pyrene	20	174
Benzo(a)pyrene	10	200	Diazinon	65	138
Benzo(b)fluoranthene	10	199	Malathion	42	178
Benzo(g,h,i)perylene	10	173	Chlorpyrifos	69	130

Table 26. Laboratory QC Limits for Sediment BNAs, Blank Spike Recoveries

Parameter	**Lower Limit (%)**	**Upper Limit (%)**	**Parameter**	**Lower Limit (%)**	**Upper Limit (%)**
2,4,5-Trichlorophenol	33	113	Benzo(k)fluoranthene	58	128
2,4,6-Trichlorophenol	27	98	Benzyl Butyl Phthalate	15	183

2,4-Dichlorophenol	24	103	Bis(2-Ethylhexyl)Phthalate	10	182
2,4-Dimethylphenol	10	81	Chrysene	69	111
2,4-Dinitrophenol	10	149	Di-N-Butyl Phthalate	17	180
2-Chlorophenol	10	102	Di-N-Octyl Phthalate	10	200
2-Methylnaphthalene	22	99	Dibenzo(a,h)anthracene	53	129
2-Methylphenol	16	91	Diethyl Phthalate	51	118
2-Nitrophenol	21	98	Dimethyl Phthalate	38	114
4,6-Dinitro-O-Cresol	18	157	Fluoranthene	55	132
4-Chloro-3-Methylphenol	50	105	Fluorene	39	106
4-Methylphenol	10	125	Indeno(1,2,3-Cd)Pyrene	51	132
4-Nitrophenol	40	170	Naphthalene	17	94
Acenaphthene	29	102	Pentachlorophenol	38	124
Acenaphthylene	31	101	Phenanthrene	57	104
Anthracene	45	114	Phenol	10	107
Benzo(a)anthracene	69	117	Pyrene	48	132
Benzo(a)pyrene	15	137	Diazinon	65	138
Benzo(b)fluoranthene	50	121	Malathion	42	178
Benzo(g,h,i)perylene	46	126	Chlorpyrifos	69	130

Table 27. Laboratory QC Limits for Sediment BNAs, Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
2,4,6-Tribromophenol	29	112
2-Fluorophenol	10	112
d5-Phenol	10	106
d5-Nitrobenzene	28	94

d4-2-Chlorophenol	11	105
d4-1,2-Dichlorobenzene	24	91
2-Fluorobiphenyl	31	101
d14-Terphenyl	51	130
D10-Chlorpyrifos	50	150

Table 28. Laboratory QC Limits for Sediment PCBs, Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Aroclor 1016	32	164
Aroclor 1260	28	144

Table 29. Laboratory QC Limits for Sediment PCBs, Blank Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Aroclor 1016	39	121
Aroclor 1260	53	140

Table 30. Laboratory QC Limits Sediment PCBs, Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Decachlorobiphenyl	12	158
2,4,5,6-Tetrachloro-m-xylene	10	118

Table 31. Analytical QC Limits for Sediment Semi-Volatile Petroleum Products.

Analysis	Method Blank	Spike Blank (% Recovery)	Matrix Spike % Recovery	MS/MSD RPD	Lab Duplicate (RPD)	Surrogate % Recovery
Semi-Volatile Petroleum Products (NWTPH-Dx)	<MDL	50-150	NA	NA	100 [a]	50-150

* Extraction batch = 20 samples or less prepared within a 12 hour shift

**QC batch = 20 samples or less prepared over a 14-day period. Samples must be of the same matrix.

< MDL = Method Blank result should be less than the *method detection limit*.

RPD = Relative Percent Difference

NA = Not Applicable

8.4 Microbiology QC

Laboratory QC samples for microbiology analyses associated control limits are summarized below. Unless otherwise noted below, these QC samples will be analyzed at a frequency of one per analytical batch of 20 or fewer samples.

Table 32. Microbiology QC Limits

Parameter	QC	Lab Duplicate	Before Filtration	After Filtration
Fecal Coliform	One set per 20 samples*	One per 20 samples*	One per 20 samples*	One per 20 samples*
	Positive and Negative Controls		One MF filter run before samples are processed through filtration system	One MF filter run after samples are processed though filtration system

*= If batches are less then 20 in size and received throughout the working day, then QC, LD, BF and AF are run on samples received over a 4 hour period of time.

Note: To meet NPDES requirements for fecal coliform analysis, samples must be delivered to the laboratory no later then 6 hours after collection.

8.5 Laboratory Quality Assurance/Quality Control Samples

Laboratory analytical quality control (QC) procedures involve the use of four basic types of QC samples. QC samples are analyzed within a batch of client samples to provide an indication of the performance of the entire analytical system. Therefore, QC samples go through all sample preparation, clean up, measurement, and data reduction steps in the procedure. In some cases, the laboratory may perform additional tests that check only one part of the analytical system.

8.6 Types of Laboratory Quality Control Samples

8.6.1.1 Check standards

Check standards are QC samples of known concentration prepared independently of the calibration standards. They are sometimes called laboratory control samples (LCS) or spiked blanks. Results are used to verify that analytical precision in the control and whether or not the level of bias due to calibration is acceptable. If the results for the check standards do not fall within established control limits, the measurement system should be re-calibrated. In some analytical methods, sample results may be qualified when associated check standard results are not within acceptable limits. Check standards are usually prepared in de-ionized water by the laboratory. Their concentration should be in the range of interest for the samples, and at least one check standard should be analyzed with each batch of 20 samples or fewer. Reference materials that more closely match the matrix of environmental samples may be used as check standards for the project. Some proficiency testing (PT) samples from commercial vendors can be stored and used as check standards once the true values are known. The acceptance limits for the results of analyses of these commercial samples should not be those set by the vendor but should be established in the laboratory by replicate analyses of the PT sample. An exception may occur when reference materials are sent to the laboratory for analysis as blinds. Ecology's Laboratory Accreditation Section can help identify suppliers of PT samples and certified reference materials.

8.6.1.2 Laboratory Analytical duplicates

The laboratory can analyze duplicate samples of one or more samples within each sample batch. Results are used to estimate analytical precision for that matrix at that concentration. The project manager may specify which samples are to be analyzed in duplicate. If the samples selected for duplicate analyses do not contain measurable amounts of the analyte of interest, the results provide no information on precision. In addition, if the laboratory selects samples from another study with significantly different levels of the analyte or different matrices, the estimate of precision may not be applicable to your samples. *One of the field duplicates is a good choice for an analytical duplicate since you may then estimate total and analytical variability from results for the same sample.*

8.6.1.3 Matrix spikes

A matrix spike is an aliquot of a sample to which a known amount of analyte is added at the start of the procedure. Matrix spike recoveries may provide an indication of bias due to interference from components of the sample matrix. Since the percent recovery is calculated from the difference between the analytical results for the spiked and un-spiked samples, its precision may be relatively poor if the spiked amount is much less than the sample concentration. If the spike is too high relative to the sample concentration, any interference effect at the sample concentration level could be masked. The laboratory will spike at a concentration approximately equal to the concentration in the sample before spiking. The project manager may indicate to the laboratory,

which samples might be most appropriate for use as matrix spikes and, if necessary, larger sample volumes will be provided to the laboratory for this purpose. In some cases, many replicate spikes would need to be analyzed in order to distinguish bias from the effects of random error on the recoveries. Matrix spike results will only be used in conjunction with other QC data to qualify them. The primary use of matrix spikes is to indicate the presence of bias, duplicate spike results can be used to estimate analytical precision at the concentration of the spiked samples. The project manager may instruct the laboratory to spike certain samples since matrix spikes are not automatically included in all analytical methods.

8.6.1.4 Laboratory blanks

Blanks are prepared and analyzed in the laboratory to document the response of the measurement system to a sample containing effectively none of the analyte of interest. Depending on the analytical method, the analyst will analyze one or more blanks with each batch of samples and compare the results to established acceptance limits. A positive blank response can be due to a variety of factors related to the procedure, equipment, or reagents. Unusually high blank responses indicate laboratory contamination. The blank response becomes very important when the analyte concentration is near the detection limit. Blank responses are sometimes used to correct the sample responses and to determine the limit of detection.

8.7 Types of Field Quality Control Samples

8.7.1 Replicates

Replicates are two samples collected at the same time and place. Replicate results provide a way to estimate the total random variability (precision) of individual results. If conditions in the medium being measured are changing faster than the procedure can be repeated, then the precision calculated from replicate results will include that variability as well. Section 6, *Quality Objectives* includes a formula for relative percent difference (RPD) to check precision of duplicate field samples.

8.7.2 Field blanks

Field blanks are samples of "clean" material, which are exposed to sample collection procedures in the field. They should be analyzed like any other sample. The results for field blanks may indicate the presence of contamination due to sample collection and handling procedures (in the field or during transport to the laboratory) or to conditions in the field, such as boat or vehicle exhaust. Clearly identify field blanks so that they are not selected for analytical duplicates or matrix spikes. Field blanks are used when there is reason to expect problems with contamination or to meet programmatic or contractual requirements to demonstrate absence of contamination**.** Field blanks can be used to determine whether or not consistent and adequate field procedures are conducted during sampling. The use of good operational procedures in the field and

thorough training of field staff reduces the risk of contamination. Several types of field blanks are described below. The pure water or other "clean" material used to prepare them must be obtained from the laboratory or other reliable supplier.

Field blanks can include:

- Transport blanks (trip blanks): A container of pure water, which is prepared at the laboratory and carried unopened to the field and back with the other sample containers to check for possible contamination in the containers or for cross-contamination during transportation and storage of the samples.
- Equipment blanks: Prepare by exposing clean material to the sampling equipment after the equipment has been used in the field and cleaned. The results provide a check on the effectiveness of the cleaning procedures. The rinsate blank may also detect contamination from the surroundings, from containers, or from cross-contamination during transportation and storage of the samples and is therefore the most comprehensive type of field blank.
- Filter blanks: Prepare by filtering pure water through the filtration apparatus after routine cleaning. The filter blank may detect contamination from the filter or other part of the filtration apparatus. Ideally, the results for your field blanks will be "not detected." If the results are positives, you will need to consider them when reporting sample results and determining whether your MQOs have been met.
- Field filtration blank: (e.g. field filtration blank for orthophosphorus filtration) Carry R.O. water into the field and filter using field equipment.
- Temperature blanks: Prepared in the field using distilled or de-ionized water and placed in the sampler cooler and transported to the laboratory. The laboratory can use this blank to check the temperature of the samples upon receipt.

8.8 Toxicity Testing Quality Assurance

Toxicity tests should meet quality assurance criteria in the most recent versions of the Environment Canada manual EPS 1/RM/28 and the Department of Ecology Publication #WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. The toxicity test shall have five concentrations and a control with four replicates at each concentration. An additional seven replicates of 100% sample shall be run in order to provide tissue for yolk/embryo analysis if needed. The test concentration series shall be determined using a 0.5 dilution factor.

Quality control is maintained through:

- test acceptance criteria based upon control performance and
- control charting of results from reference toxicant tests.
- Monitoring of test conditions to ensure they are within acceptable limits

The criterion for test acceptance is 70% or greater viable embryos in the controls (percent non-viable embryos, including unfertilized eggs, must be < 30%).

A concurrent reference toxicant test (e.g. positive control) will be performed with each sample or batch of samples run at one time. The IC25 for SDS will be compared to current laboratory

control limits of mean IC25 ± 2SD. The comparison will give an indication of the relative sensitivity of a given batch of embryos. However, an IC25 that falls outside the current control limits will not automatically invalidate an otherwise valid test.

Test results may be confounded if incubation conditions (*e.g.* temperature, D.O.) fall outside of acceptable limits. In these situations, the WA DOE (2005) laboratory guidance document is consulted and, if necessary, the client and regulatory authority are

Notified in order to discuss recommendations regarding test acceptability. Test conditions are summarized below:

- Test species: *Oncorhynchus mykiss*
- Approved test method: E Test in Environment Canada EPS 1/RM/28 (Small volume modification is allowed.)
- Test type: 7-day static-renewal (80% renewal of test solution in each test chamber daily and all settled material removed from contact with embryos)
- Temperature: 14° ± 1°C
- Illumination: dark with dim or red light only during test solution renewals
- Test chamber size: 1 L
- Test solution volume: 500 mL
- Age of test organisms: maximum 30 minutes after fertilization
- Number of organisms/chamber: 30
- Number of replicates/concentration: 4 (minimum)
- Feeding: none
- Aeration: continuous gentle aeration (< 100 bubbles/minute)
- Test duration: 7 days
- Endpoints: number of viable embryos at end of test
- Control performance criteria: ≥ 70% embryo viability

9.0. DATA QUALITY ASSESSMENT, QUALIFICATION, AND REPORTING

Data reported by the lab, including field measurements, must pass a review process before final results are available to the client. A "Peer Review" process is used where a second analyst or individual proficient at the method reviews the data set. The reviewer will complete a data review checklist which will document the completeness of the data package and if any QC failures exist. The Laboratory Project Manager will coordinate this data review.

Once data review is complete and all data quality issues have been resolved or corrected, the status of the data in LIMS will be changed to "approved". Once a data set has been approved, it is "posted" or transferred to the portion of the LIMS database known as the Environmental Data System (EDS) where all historical LIMS data are maintained. Signatures or initials of the lab lead and reviewer(s) indicate formal approval of hardcopy data or reports (non-LIMS), typically on the review checklist. A copy of this approved checklist should be stored with the final hardcopy data package.

Flow and precipitation data collected in association with this monitoring program will be reviewed for quality assurance purposes. These data will be examined for gaps, anomalies, or inconsistencies between the discharge, water level, and/or precipitation data from the various monitoring stations. In the event that quality assurance issues are identified on the basis of these reviews, a site visit will be performed immediately to troubleshoot the problem and to implement corrective actions if possible. Any quality assurance issues that are detected through these reviews will be documented in the electronic data record and in separate tracking forms. 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. Quality control elements identified in the Quality Objectives section will also be examined to determine whether the data quality objectives for the project have been met. Results from these reviews will be documented in quality assurance worksheets that will be prepared for each batch of samples. In the event that a potential quality assurance issue is identified through these reviews, the quality assurance technical lead will review the data to determine whether any response actions are required.

King County will retain records of all monitoring information, including all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least five years.

Flow measurement devices and methods will be consistent with accepted scientific practices and will be selected and used to ensure the accuracy and reliability of measurements of the volume of monitored discharges. The devices will be installed, calibrated, and maintained to ensure that the accuracy of the measurements are consistent with the accepted industry standard for that type of device. Frequency of calibration will be in conformance with manufacturer's recommendations or at a minimum frequency of at least one calibration per year. Calibration records will be maintained for a minimum of three years.

9.1 Data Storage

Data will not be distributed outside each lab unit or to clients until it has met the full definition of final data. "Final Data" is defined as approved data posted to the historical database (EDS) or is otherwise in its final reportable and stored format (if not a LIMS parameter). This implies the data has been appropriately peer reviewed, properly qualified and is in its final format in terms of units and significant figures. Not only is final data assured of a higher level of quality through peer reviewing and qualification, but it will also match any future reports since it has come from the final storage location.

9.2 Data Reduction, Review, and Reporting

All lab and field measurements will follow the procedures outlined in the KCEL's SOPs and QA Manual. Laboratory staff will be responsible for internal quality control verification, proper data transfer, and reporting data to the Project Manager via the Laboratory Information Management System (LIMS).

The annual stormwater monitoring report will include:

- The location, land use, drainage area size, and hydrology at each monitoring site.
- The Quality Assurance/Quality Control (QA/QC) report.
- The annual water-year pollutant load for each monitoring site expressed in total pounds, and pounds/acre.
- The wet and dry season pollutant loads based on the water-year expressed in total pounds, and pounds/acre.
- Once enough data has been collected, an assessment of strategies for handling non-detected data (e.g. Helsel and Hirsch, 2002) will be conducted.

In addition, the report on the toxicity testing will include:

- Documentation of any invalid or anomalous test results, good faith attempts to collect the required volume, and any unsuccessful second attempts
- Bench sheets for toxicity 7-day E-tests
- An analytical report for the chemistry analysis
- A toxicity data analytical report (if available in electronic format, this is the preferred submittal method to Ecology)
- CETIS export files for the 7-day Embryo Test
- Reference toxicant results for test methods
- A summary of the Trout Library comparison findings
- A summary review of relevant source literature used from the Trout Library
- The GC/MS data analytical results (if applicable)

9.3 Proposed Laboratory Qualifiers.

Qualifiers will be applied to both water and sediment quality data during the data quality review process.

Table 33. Laboratory Qualifiers

Qualifier	Description
General	
H	Indicates that an analysis holding time criterion was not met..
SH	Indicates that a sample handling criterion was not met. The sample may have been compromised during the sampling procedure or may not comply with storage conditions or preservation requirements.
R	Indicates that the data are judged unusable by the data reviewer. The qualifier is applied based on the professional judgment of the data reviewer rather than any specific set of QC parameters and is applied when the reviewer feels that the data may not or will not provide any useful information to the data user.
<MDL	Applied when a target analyte is not detected or detected at a concentration less than the associated method detection limit (MDL). The MDL is the lowest concentration at which a sample result will be reported.
<RDL	Applied when a target analyte is detected at a concentration greater than or equal to the associated MDL but less than the associated reporting detection limit (RDL). RDL is defined as the lowest concentration at which an analyte can reliably be quantified.
RDL	Applied when a target analyte is detected at a concentration that, in the raw data is equal to the RDL.
TA	Applied to a sample result when additional narrative information is available in the text field. The additional information may help to qualify the sample result but is not necessarily covered by any other qualifier.
Chemistry	

Qualifier	Description
B, B2 or B3	Applied to a sample result when an analyte was detected at a concentration greater than the MDL in the associated method blank. The qualifier is applied when the sample concentration is >MDL but less than ten times the blank concentration. The qualifier indicates that the analyte concentration in the sample may be significantly influenced by laboratory contamination.
E	Applied to a sample result that was measured at a concentration greater than the calibration range of the method. It is applied when the detected analyte concentration exceeds the upper instrument calibration limit and further dilution is not feasible. The reported value is an estimated analyte concentration.
J	Applied to a sample result that is considered an estimated value.
JG	Applied to a sample result that is considered an estimated value with a low bias. This will typically be applied when QC results indicate the recovery of the analyte is below the expected limits of the method.
JK	Applied to a sample result that is considered an estimated value with an unknown bias. This will typically be applied when QC results indicate the method precision did not meet the expected limits of the method.
JL	Applied to a sample result that is considered an estimated value with a high bias. This will typically be applied when QC results indicate the recovery of the analyte is above the expected limits of the method.
Microbiology	
FAIL	The result of the positive or negative control failed (applied to QC results only)
PASS	The result of the positive or negative control passed (applied to QC results only)
C	Value is an estimate, based on presence of confluent growth

9.4 Calculating Pollutant Loads

These methods follow the procedures provided by Ecology in their 2009 document Standard Operating Procedures for Calculating Pollutant Loads for Stormwater Discharge. The methods below assume there is no base flow at any of the three outfall monitoring sites.

1) Calculate total storm flows and volumes on a seasonal and annual basis

$$V_{st} = V_{sw} + V_{sd}$$

Where:

V_{st} = Total annual storm flow volume

V_{sw} = Storm flow volume in the wet season

V_{sd} = Storm flow volume in the dry season

2) Seasonal Flow-Weighted Mean Storm Flow Concentration

$$C_{sw} = \sum(EMC_{sw\text{-}i} \text{ X } SF_{w\text{-}i})/\sum SF_{w\text{-}i} \quad (i = 1 \text{ to } n)$$

$$C_{sd} = \sum(EMC_{sd\text{-}i} \text{ X } SF_{d\text{-}i})/\sum SF_{d\text{-}i} \quad (i = 1 \text{ to } n)$$

Where:

C_{sw} = Wet season flow-weighted mean storm flow concentration

C_{sd} = Dry season flow-weighted mean storm flow concentration

$EMC_{sw\text{-}i}$ = Wet season event mean concentration for storm flow event *i*, and [n] = number of wet season storm flow sampling events

$SF_{w\text{-}i}$ = Average storm flow rate of wet season sampled storm flow event

EMC_{sd-i} = Dry season event mean concentration for storm flow event *i*, and [n] = number of dry season storm flow sampling events

SF_{d-i} = Average storm flow rate of dry season sampled storm flow event

3a) Wet and Dry Season Pollutant Load (total pounds)

$$L_{sw} = V_{sw} \; X \; C_{sw}$$

$$L_{sd} = V_{sd} \; X \; C_{sd}$$

Where:

L_{sw} = Wet season pollutant load

L_{sd} = Dry season pollutant load

3b) Annual Pollutant Load (total pounds)

$$L_{st} = L_{sw} + L_{sd}$$

4a) Wet and Dry Season Pollutant Yield (pounds/acre)

$$Y_{sw} = L_{sw}/Ac_{db}$$

$$Y_{sd} = L_{sd}/Ac_{db}$$

Where:

Y_{sw} = Wet season pollutant yield

Y_{sd} = Dry season pollutant yield

Ac_{db} = Drainage basin size in acres

4b) Annual Pollutant Yield (pounds/acre)

$$Y_{st} = Y_{sw} + Y_{sd}$$

10.0.REFERENCES

Canaria, E.C., J.R. Elphick, and H.C. Bailey. 1999. A Simplified Procedure for Conducting Small Scale Short-Term Embryo Toxicity Tests with Salmonids. *Env. Toxicol.* 14, 301-307.

Ecology, 2007. Washing State Department of Ecology. Phase 1 Municipal Stormwater Permit. Olympia WA. January 17, 2007

Environment Canada. 1998. Biological Test Method: Toxicity Tests Using Early Life Stages of Salmonid Fish (Rainbow Trout). Environmental Protection Series 1/RM/28 Second Edition.

Helsel, D.L. and R.M. Hirsh. 2002. Statistical Methods in Water Resources. U.S. Geological Survey. Reston, VA.

King County Environmental Laboratory (KCEL) Standard Operating Procedure. Sampling Methods for Wadeable Stream Sediments. SOP #237v0. January 1, 2004.

Seattle Public Utilities, 2008. Quality Assurance Project Plan. Phase 1 Municipal Stormwater NPDES Permit. Seattle, WA. February 2008.

WaDOE, 2005. Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria. p39.*

Appendix A

Alternative, Additional Methods to the Phase 1 Municipal Stormwater Permit Methods Listed in Appendix 9

The purpose of this table is to provide alternative laboratory methods approved by the Department of Ecology (Ecology) in advance of the Permittees' QAPP submittals under the Phase I Municipal Stormwater Permit (Permit). In developing this table, Ecology evaluated the current EPA-approved analytical methods listed in 40 CFR Part 136 for consistency with the methods listed in Appendix 9 of the Permit. Some methods originally listed in Appendix 9 of the Permit do not reflect current changes to 40 CFR Part 136 because the CFR has been updated since permit issuance. Ecology has evaluated all methods listed in Appendix 9 and, where applicable, has identified alternative, approved laboratory methods. All identified alternative methods have an equal or lower reporting limit to those limits stated in Appendix 9.

This table does NOT substitute, modify or revoke Permit language. Permittees still have the option to propose additional alternative methods to Ecology for review as stated on Page 1 of Appendix 9. That language is as follows:

> *Any alternative method proposed by the Permittee must have a similar reporting limit, or must be justified as adequate for the likely range of concentrations. Permittees are not guaranteed approval of their alternative methods or reporting limits.*

Unless alternative methods are approved by Ecology, the analytical methods indicated in column #2 (Method in Water/Sediment per Appendix 9) or column #5 (Approved Additional Methods) shall be used by Permittees when analyzing stormwater samples as required by section S8 of the permit. Any alternative method proposed by the Permittee must have a similar reporting limit, or must be justified as adequate for the likely range of concentrations. Permittees are not guaranteed approval of their alternative methods or reporting limits.

Table 34. Alternative Analytical Methods for Liquid Matrices

Analyte (or surrogate)	Method in Water Per Appendix 9	40 CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM) 20th Edition		
Total suspended solids	EPA Method 160.2 or SM 2540B	160.2	2540D	2540D	1.0 mg/L
Turbidity	EPA Method 180.1	180.1	2130B	SM 2130B	+/- 0.2 NTU
Conductivity	SM 2510 or EPA Method 120.1	120.1	2510B		+/- 1 umho/cm
Chloride	EPA Method 300.0 or 325.2	300.0, 300.1	4110B	SM4110B	0.2 mg/L
BOD_5	EPA Method 405.1[1]	405.1	5210B	SM 5210B	2.0 mg/L
Particle Size Distribution	Coulter Counter, Laser diffraction, or comparable method - *see attached method*	None listed	2560B (Coulter Counter)	2560B	NA
Grain Size	Ecology method sieve and pipette (PSEP 1997), or comparable method	None listed	None listed		NA
pH	EPA Method 150.1 or SM $4500H^+$	150.2	$4500H^+$	EPA 150.2	0.2 units

[1] EPA Method 405.1 for BOD5 was discontinued, effective April 11, 2007; therefore, should not be used.

Analyte (or surrogate)	**Method in Water Per Appendix 9**	**40 CFR Part 136 List of Methods (October 4, 2007)**		**Approved Additional Methods**	**Reporting Limit Target Per Appendix 9**
		EPA Method	Standard Method (SM) 20th Edition		
Hardness as $CaCO_3$	EPA Method 200.7, SM 2340B (ICP) or 2340C (titration)	130.1	2340 B or C	SM 3120B	1.0 mg/L
Methylene Blue Activated Substances (MBAS)	CHEMetrics Colorimetric	None listed	5540C	SM 5540C	0.025 mg/L
Fecal Coliform	SM 9221E	None	9221 C or E		2 min., 2E6 max
Total phosphorus	EPA Method 365.3 or SM 4500-P I[2]	365.3, 365.1, 365.4	4500 P B.5, 4500P E or F	EPA 365.1, 365.4 and SM4500P E or F	0.01 mg P/L
Orthophosphate	EPA Method 365.3 or SM 4500-P G[2]	365.3, 365.1, 300.0, 300.1	4500 P E, or F and 4110B	EPA 365.1, and SM4500 P E or F	0.01 mg P/L
Total kjeldahl nitrogen	EPA Method 351.2	351.2, 351.1	4500-Norg B or C and 4500 NH_3 B,	EPA 351.1 and SM 4500-Norg B or C and 4500 NH_3 D,G,E, and F	0.5 mg/L
Nitrate-Nitrite	EPA Method 353.2 or SM 4500 -NO3 I [1]	353.2, 300.0	4500-NO3-E, F, H, 4110B	SM4500-NO_3 E	0.01 mg/L

[2] Method SM 4500 P G and SM 4500 –NO3 I are no longer listed in 40CFR 136 (March 2007); therefore, should not be used.

Analyte (or surrogate)	Method in Water Per Appendix 9	40 CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM) 20th Edition		
Total recoverable zinc	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B	200.7	5.0 ug/L
Dissolved zinc	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		1.0 ug/L
Total recoverable lead	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.1 ug/L
Dissolved lead	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.02 ug/L
Total recoverable copper	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.1 ug/L
Dissolved copper	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.1 ug/L
Total recoverable cadmium	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.2 ug/L
Dissolved cadmium	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS)	200.8	3120B		0.02 ug/L
Total Mercury	EPA Method 7470 (CVAA)[2]	245.1, 245.2, 245.7	3112B	EPA 245.7 and EPA	0.1 ug/L

[2] The method detection limit for 7470 (CVAA) is higher than the target reporting limit, 0.2 ug/L and 0.1 ug/L, respectively. This method should not be used for analysis.

Analyte (or surrogate)	**Method in Water Per Appendix 9**	**40 CFR Part 136 List of Methods (October 4, 2007)**		**Approved Additional Methods**	**Reporting Limit Target Per Appendix 9**
		EPA Method	Standard Method (SM) 20th Edition		
				1631E[3]	
Dissolved Mercury	EPA Method 7470 (CVAA)	245.1, 245.2, 245.7	3112B	EPA 245.7 and EPA 1631E[3]	0.1 ug/L
PAH Compounds	EPA Method 8310 or 8270D SIM	610, 625, 1625	6410B, 6440B		0.1 ug/L
Phthalates	EPA Method 8270D	606, 625, 1625	6410B		1.0 ug/L
Herbicides (2,4-D, MCPP, Triclopyr, Dichlobenil, Pentachlorophenol)	EPA Method 8270D SIM or 8151				0.01 – 1.0 ug/L
Pesticides, Nitrogen (Prometon)	EPA Method 8270D SIM				0.1 – 5.0 ug/L
Pesticides, Organophosphates (Diazinon, Malathion, Chloropyrifos)	EPA Method 8270D SIM or 8141				0.01 – 1.0 ug/L
TPH	NWTPH-Dx - Ecology, 1997, (Publication No. 97-602)				0.25 mg/L

[3] SM 1631E is not listed in 40 CFR but can be used to obtain the lower reporting limit for mercury.

Analyte (or surrogate)	Method in Water Per Appendix 9	40 CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM) 20th Edition		
TPH	NWTPH-Gx - Ecology, 1997, (Publication No. 97-602)				0.25 mg/L

SIM = Selective Ion Monitoring – a way to get a lower detection.

Table 35. Alternative Analytical Procedures for Sediment Matrices

Analyte (or surrogate)	Method in Sediment Per Appendix 9	40CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM)		
Total Solids	EPA Method 160.3 or SM 2540B	None listed	None listed		NA
Total Organic Carbon	Puget Sound Estuary Protocols: (PSEP 1997)	None listed	5310 B, C or D	SM5310 B,C, or D or EPA 9060	0.1%
Grain-size	Ecology Method Sieve and Pipet (PSEP 1997) or ASTM F312-97	None listed	None listed	ASTM D422	NA
Total Recoverable Zinc	EPA Method 200.8	200.8	3120B	EPA 6010 and EPA	5.0 mg/kg

Analyte (or surrogate)	Method in Sediment Per Appendix 9	40CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM)		
	(ICP/MS), or SM 3125 (ICP/MS), or EPA Method 200.7 (ICP)		200.7	6020	
Total Recoverable Lead	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS), or EPA Method 200.9[4] (ICP)	200.8	3120B	EPA 6010 and EPA 6020	0.1 mg/kg
Total Recoverable Copper	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS), or EPA Method 200.9[4] (ICP)	200.8	3120B	EPA 6010 and EPA 6020	0.1 mg/kg
Total Recoverable Cadmium	EPA Method 200.8 (ICP/MS), or SM 3125 (ICP/MS), or EPA Method 200.9[4] (ICP)	200.8	3120B	EPA 6010 and EPA 6020	0.1 mg/kg
Total Recoverable Mercury	None Currently Listed for Mercury in Sediment			EPA 245.5	0.1 mg/kg

[4] This is a permit error. ICP should be 200.7 not 200.9; however, 200.7 is not an adequate method to meet the target reporting limit.

Analyte (or surrogate)	Method in Sediment Per Appendix 9	40CFR Part 136 List of Methods (October 4, 2007)		Approved Additional Methods	Reporting Limit Target Per Appendix 9
		EPA Method	Standard Method (SM)		
				EPA 7471B	
PAH Compounds	EPA Method 8270D				70 ug/kg dry
Phthalates	EPA Method 8270D				70 ug/kg dry
Phenolics	EPA Method 8270D			PSEP 1997	70 ug/kg dry
PCB's	EPA Method 8082				80 ug/kg dry
Herbicides (pentachlorophenol)	EPA Method 8270D SIM or 8151				1.0 ug/kg
Pesticides, organophosphate (Diazinon, Chlorpyrifos, Malathion)	EPA Method 8270D SIM or 8141				Diazinon= 50 ug/kg, Chlorpyrifos and Malathion = 25 ug/kg
NWTPH-Dx	Ecology, 1997 (Publication No. 97-602) or EPA SW-846 method 8015B				25.0-100.0 mg/kg