# Quality Assurance Project Plan for King County BMP Effectiveness Monitoring Conducted Under the Phase 1 Municipal Stormwater Permit WAR04-4501 (Issued February 2007)

Updated November 2010

King County

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# Quality Assurance Project Plan for King County BMP Effectiveness Monitoring Conducted Under the Phase 1 Municipal Stormwater Permit WAR04-4501 (Issued February 2007)


## Submitted by:

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

| Record of Changes | | |
|---|---|---|
| **Section Changed** | **Date** | **Description** |
| Table 1 | November 2010 | Removed name for organics supervisor, positionis currently vacant |
| 6.3 | November | Added sediment collection information |
| Table 4 | November 2010 | Removed trip blank and temp blank |
| Table 5 | November 2010 | Added information for fecal coliform and NWTPH-Dx analysis, revised total solids information |
| Table 6 | November 2010 | Added information for fecal coliform, revised metals information |
| Table 7 | November 2010 | Revised total lead information |
| Table 8 | November 2010 | revised recovery limits for matrix spike |
| Table 13 | November 2010 | revised RPD information for NWTPH-Dx |
| Sec 8.6.2 | November 2010 | Revised list of field plants to match table 4 |
| Table 14 | November 2010 | Added microbiology QC information |
| Table 15 | November 2010 | Revised or added several data flags and flag descriptions |
| Appendix B | November 2010 | New random sampling date tables |
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# APPROVALS

Dean Wilson  King County  Date

Monitoring Program Manager

Colin Elliott King County  Date

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**

Rachael McCrae  Washington Department of Ecology

# 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:

- Port of Seattle
- Port of Tacoma

## 1.1 Project Specific NPDES Phase I Requirements

Section 8 of King County's NPDES Phase I Permit, effective February 16, 2007 discusses monitoring requirements of the permit. This Quality Assurance Project Plan (QAPP) focuses on the permit requirements under Section 8, F Stormwater Treatment and Hydrologic Management Best Management Practice (BMP) Evaluation Monitoring. Section 8, F, which states:

> Each Permittee listed in S1.B. and the Ports of Seattle and Tacoma shall conduct full scale field monitoring to evaluate the effectiveness and operation and maintenance requirements of stormwater treatment and hydrologic management BMPs applied in their jurisdiction. A QAPP is required for each BMP and flow reduction strategy being monitored.
>
> Each Permittee listed in S1.B. shall monitor at least two treatment BMPs, at no less than two sites per BMP. The Port of Seattle and the Port of Tacoma shall each monitor at least one treatment BMP, at no less than two sites. To ensure a range of BMP types are monitored, Ecology will restrict the total number of monitoring sites for a BMP category to no more than four. BMPs shall be selected from the following list:

- Basic Treatment Category: Biofiltration swale, Filter strip, Basic wetpond, Treatment wetland, and Sand filter.
- Metals/Phosphorus Treatment Category: Amended sand filter, Two facility treatment train, Compost amended filter strips, Bioretention, and Large wetpond.
- Oil Control Category: Linear sand filter, and Catch basin insert.

BMPs shall be designed in accordance with the 2005 *Stormwater Management Manual for Western Washington* unless Ecology approves of an alternate design in the QAPP review. Permittees may also petition Ecology to monitor a BMP that is not on the above list.

Permittees must use appropriate sections of Ecology's guidance for "Evaluation of Emerging Stormwater Treatment Technologies" (available on Ecology's website) for preparing, implementing, and reporting on the results of the BMP evaluation program.

The statistical goal is to determine mean effluent concentrations and mean percent removals for each BMP type with 90 - 95 percent confidence and 75 - 80 percent power of detecting the effect.

Permittees must use USEPA publication number 821-B-02-001, "Urban Stormwater BMP Performance Monitoring," as additional guidance for preparing the BMP evaluation monitoring, and must collect information pertinent to fulfilling the "National Stormwater BMP Data Base Requirements" in section 3.4.3. of that document.

The parameters to be monitored in whole water at each test site include:

- For Basic, Enhanced, or Phosphorus treatment BMPs: Total suspended solids, Particle size distribution, pH, Total and orthophosphate phosphorus, Hardness, and Total and dissolved copper and zinc.
- For Oil Control BMPs: Total suspended solids, Particle size distribution, pH, WTPH-Dx and –Gx, and Oil sheen

Parameters to be monitored in accumulated sediment at each test site for Basic, Enhanced, Phosphorus treatment, or Oil Control BMPs include: Percent total solids, Particle size distribution, Total volatile solids, NWTPH-Dx, Total phosphorous, and Total cadmium, copper, lead, and zinc.

Each Permittee listed in S1.B. shall monitor the effectiveness of one flow reduction strategy that is in use or planned for installation in their jurisdiction.

Monitoring of a flow reduction strategy shall include continuous rainfall and surface runoff monitoring. Flow reduction strategies shall be monitored through either a paired site study or against a predicted outcome.

# 2.0. PROJECT DESCRIPTION

King County will monitor two large sand filters and two pre-settling basins. These stormwater facilities are located at a multi-family development on the East-Lake Sammamish Plateau (Fig 1). The sand filters are considered long-term detention BMPs because they can capture and release stormwater over the course of days. Short-term BMPs can capture and release stormwater over the course of minutes to hours. To characterize this discharge, King County will be using the Department of Ecology's modified Technology Assessment Protocol-Ecology (TAPE) (Ecology 2007) to evaluate stormwater treatment technologies with long term detention times. This methodology calls for a stratified-random approach rather than a storm based approach. King County will select, prior to the sampling period, random days to collect stormwater samples at the inlet and outlet of the treatment facility. The sampling strategy is not paired, therefore the inflow and outflow samples are not related, so the random days selected for the inflow and outflow will be chosen separately.

Automated samplers will be used in conjunction with flow meters to collect flow-weighted composite samples. A flow meter will continuously collect flow data from the site, but the stormwater sampler will not collect samples from the sampling point until it's previously selected sampling day. Prior to the randomly selected day the sampler will be programmed to collect samples during the scheduled 24-hour period. If stormwater flow is present a sample will be taken, if not, the sampler will shut off to wait until its next scheduled sampling day. Accumulated sediment will also be sampled at each site annually or until the stormwater sampling meets the statistical requirements and/or the BMP sampling program is completed (SOP TBD).

Additionally, King County will be monitoring one flow reduction BMP. In this case, the flow reduction strategy is organic compost added as a soil amendment to the housing developments in the urban planned development of the Redmond Ridge project. Amending soil in a new residential development is an attempt to mitigate the traditional clearing and grading of land for building that leaves little organic soil in place after construction has been completed. It is hypothesized that the additional organic compost in the native soils will not only absorb more stormwater than un-composted soil, it will enhance the growth of the planted landscape that will additionally prevent more runoff. Flow will be monitored in both a basin with compost-amended soils and a basin in a similar development without compost-amended soils. The paired data will be compared to determine differences between the basins.

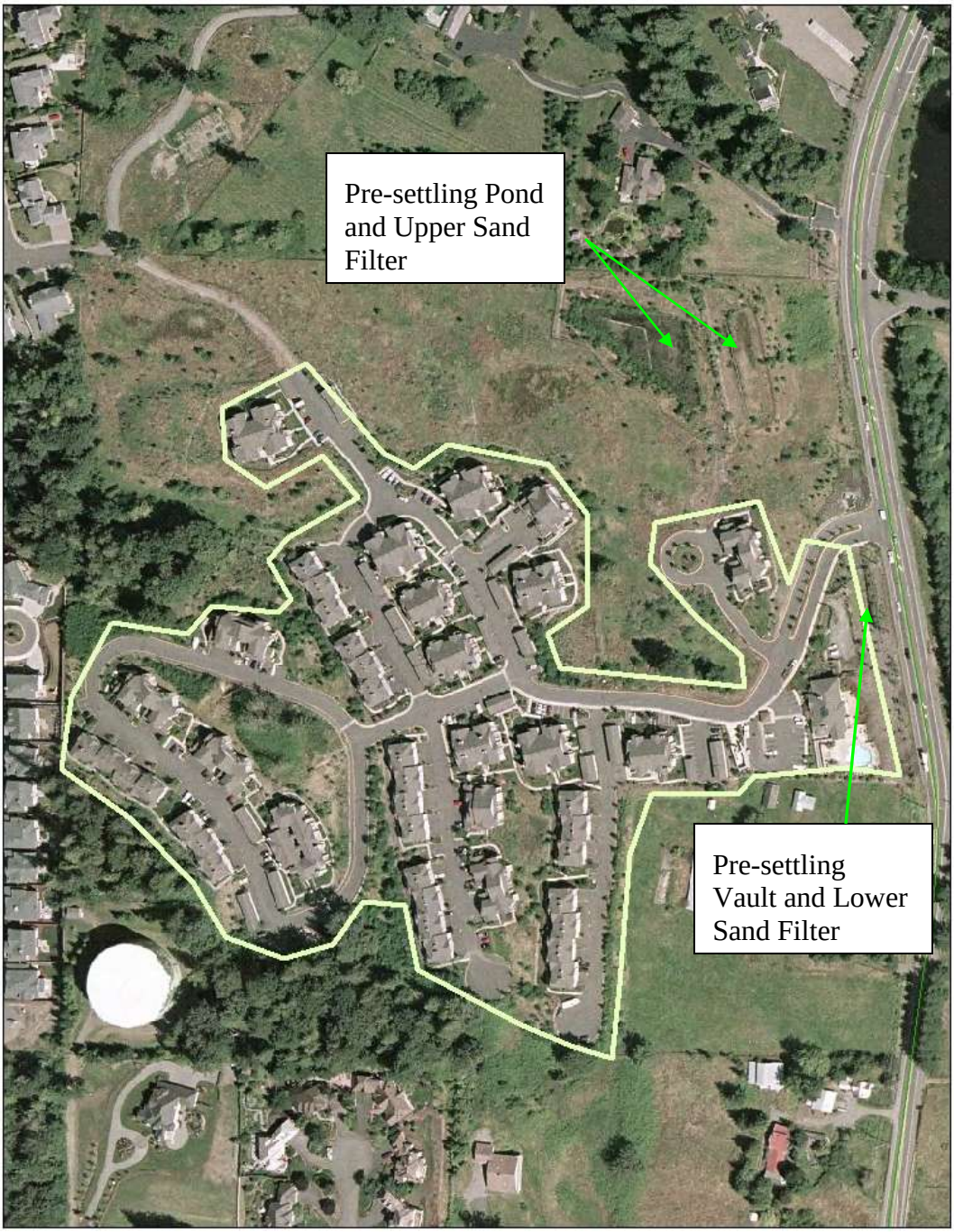


**Figure 1. Location of Pre-settling Facilities and Sand Filters.**

# 3.0. ORGANIZATION AND SCHEDULE

**Table 1. Project Team**

| Name/phone number | Responsibility | Organization |
|---|---|---|
| Dean Wilson<br>206-296-8252 | Project Manager | King County WLRD, Science |
| Dave Funke<br>206-296-8066 | Autosamplers, Hydrology | King County WLRD, Science |
| Mary Lear<br>206-296-1953 | Project Engineer | King County WLRD, Stormwater Services |
| Fritz Grothkopp<br>206-684-2327 | Laboratory Project Manager | King County Environmental Lab |
| Colin Elliott<br>206-684-2343 | Quality Assurance Officer | King County Environmental Lab |
| Diane McElhany<br>206-684-2304 | Metals Laboratory Supervisor | King County Environmental Lab |
| Brian Prosch<br>206-684-2331 | Conventionals Laboratory Supervisor | King County Environmental Lab |
| Eric Thompson<br>206-684-2340 | Microbiology Laboratory Supervisor | King County Environmental Lab |
| Jeff Droker<br>206-684-2309 | Environmental Lab Scientist | King County Environmental Lab |

The project schedule is as follows:

| | |
|---|---|
| August 16, 2008 | QAPP due to Ecology |
| November, 2008 | Begin monitoring rainfall and flow at BMP sites. |
| August 16, 2009 | BMP stormwater quality monitoring program begins. |
| March 31, 2011 | First annual monitoring report due covering the period between August 16, 2008 and September 30, 2010. |
| March 31, 2012 | Second annual monitoring report due covering the period between October 1, 2010 and September 30, 2011. |

# 4.0. QUALITY OBJECTIVES

The data quality objective for stormwater treatment monitoring identified in the permit under section S.8.F.4 states:

> *The statistical goal is to determine mean effluent concentrations and mean percent removals for each BMP type with 90-95 percent confidence and 75-80 percent power.*

To ensure that the project objectives are met, the quality of the data collected will be measured at each stage of data collection and analysis. Data quality will be assessed by determining the bias, precision, and accuracy of the data

## 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.

## 4.2 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. Following guidelines for sampler decontamination, sample acceptability criteria and sample processing will help ensure that samples are representative. Proper preservation and storage of samples and preparation for analysis achieve laboratory representativeness.

## 4.3 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.

## 4.4 Comparability

Comparability is achieved through use of standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. Changes or updates to analytical methods and sampling techniques midway into the project must be validated and shown to be equivalent to existing methods before being implemented.

# 5.0. SAMPLING DESIGN

## 5.1 Pre-Settling Detention Facility and Sand Filter Design

Pre-settling Detention Facility

According to the 1998 King County Surface Water Design Manual (KCSWDM), a sand filter requires a pre-settling basin since infiltration facilities are susceptible to clogging. A detention facility designed for Level 2 Flow Control meets the requirements for pre-settling. The detention facilities for this project have at least one foot of dead storage that can be used for sedimentation. The sand filter at the lower half of the site is preceded by a detention vault sized for Level 2 Flow Control. See Figures A-1 and A-2 for the detention vault plan views and Figures A-3 and A-4 for the cross-sectional views. A detention pond sized for Level 2 Flow Control meets the pre-settling requirement for the upper half of the site's sand filter. See Figures A-5 and A-3 for the plan and cross-sectional views of the detention pond respectively.

Sand Filter Description

The sand filter design is described in the 1998 KCSWDM as media filtration facility for which a sand layer is the media. The filtration works by flowing vertically through the constructed sand bed and entering the underdrain system below the bed. The water that flows through the underdrain system enters the downstream drainage system. The sand filters are sized to treat 95% of runoff volumes. The 5% of high flows greater than this volume exit through the emergency overflow in the upstream detention facility, which is also the pre-settling basin.

The large sand filters remove pollutants mostly via filtration though biological treatment may occur after time if soil bacteria grow in the sand bed. The large sand filters are designed to remove 50% of the total phosphorus according to the Sensitive Lake Protection menu goal.

The applications that work well for a sand filter include locations where the underdrain can flow freely and is not influenced by a high ground water table. Anoxic conditions could exist where the underdrain system allows for standing water. Some pollutants may be released from the filter to downstream receiving waters under anoxic conditions. Also the sand filters perform better without heavy sediment loads or leaf litter, which may clog the filter.

Both the lower and the upper sand filters were sized using the King County Runoff Time Series (KCRTS) model detailed method since they have detention facilities immediately upstream which were also sized using KCRTS. Using an iterative process with KCRTS, the large sand filter is sized to treat 95% of the runoff volume as required. The underdrain collector pipes were required to be sized to convey the 2-year, 15-minute peak flow with one foot of head above the invert of the upstream end of the collector pipe.

King County personnel will verify the functioning of the sand filters during a rain event.

Sand Filter Design Criteria

According to the 1998 KCSWDM, the sand filter can be any shape as long as it has a minimum of 18 inches of sand and a maximum of six feet of storage over the filter bed. Again, the pre-settling requirement was met by the detention facilities. For erosion protection and even distribution of the inflow, a flow spreader must be placed in the filter. Both the lower and upper sand filters have flow spreaders. The depth of sand will be verified in the field before monitoring begins.

Both sand filters were designed as flow-through systems with flows above the 95% volume simply passing through the filter untreated. The overflows are designed with the same criteria as a detention facility overflow.

The filter composition requires three layers. The top layer is sand, the middle layer is a geotextile fabric and the bottom layer is the underdrain pipe system. The specifications for the sand layer are seen below in Table 1.

**Table 2. Sand media specifications**

| U.S. Sieve Size | Percent passing |
|---|---|
| U.S. No. 4 | 95 to 100 percent |
| U.S. No. 8 | 70 to 100 percent |
| U.S. No. 16 | 40 to 90 percent |
| U.S. No. 30 | 25 to 75 percent |
| U.S. No. 50 | 2 to 25 percent |
| U.S. No. 100 | Less than 4 percent |
| U.S. No. 200 | Less than 2 percent |

The geotextile fabric design criteria are seen below in Table 2.

**Table 3. Geotextile specifications**

| Geotextile Property | Value | Test Method |
|---|---|---|
| Grab strength (lbs) | 75 (min) | ASTM D4632 |
| Burst strength (psi) | 130 (min) | ASTM D3786 |
| Trapezoid tear (lbs) | 40 (min) | ASTM D4533 |
| Permeability (cm/sec) | 0.2 (min) | ASTM D4491 |
| AOS (sieve size) | #60 - #70 | ASTM D4751 |
| Ultraviolet resistance | 70 percent or greater | ASTM D4355 |
| *Notes:* | | |

- Acceptability of geotextile material shall be based on ASTM D-4759.
- Minimum values should be in the weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled lot shall meet or exceed the minimum values in the table). Stated values are for noncritical and nonsevere applications.

The underdrain design requires that a geotextile fabric be placed between the sand and the drain rock or gravel and also have one inch of drain rock above the fabric. The position of the geotextile serves as a transition layer with the sand and the gravel mixing to allow for continuous flow through the layers. Otherwise an abrupt interface between fine and course material may cause water to pool at the interface and not readily drain downward due to the greater capillary forces in the finer material.

The underdrain systems for these sand filters are a central collector pipe with lateral feeder pipes in an 8-inch drain rock bed or gravel backfill. The drain rock around the underdrains is $1^1/_2$ to $^3/_4$ –inch rock or gravel backfill free of clay or organic matter. The drain rock or gravel backfill is placed at a minimum depth of 8 inches over the pipes with 6 inches along each side of the pipes.

The collector pipes have a minimum slope of 0.5%. The invert of the underdrain outlet is placed above the seasonal high groundwater table. There are cleanouts at each end of the central collector pipes. The lower sand filter has a 12-inch-diameter perforated pipe as the collector pipe and the upper sand filter has an 8-inch-diameter collector pipe.

An access road shall be provided to the inlet and outlet of a sand filter for inspection and maintenance purposes.

The lower sand filter has 500 square feet of filter area arranged as 50 feet long by 10 feet wide. The upper sand filter is larger with 4,400 square feet of filter area at 170 feet long by 26 feet wide. See Figure A-1 for the lower sand filter plan views and Figures A-3 and A-4 for the cross-sectional views. For the upper sand filter, see Figures A-5 and A-3 for the plan and cross-sectional views of the sand filter respectively.

## 5.2 Pre-Settling Detention Facility and Sand Filter Sampling Design

Sampling design for the pre-settling detention facilities and sand filters is based on TAPE Modification: *Evaluating Stormwater Treatment Technologies with Long Detention Time* (Ecology, 2007). This long detention protocol recognizes that flow into the long-term detention facility is not likely related to the out-flow at the same moment. The long term protocol, then, characterizes both the inflow and the outflow separately. (For further discussion see Ecology, 2007).

Rainfall data collected at the nearby Mystic Lake rain gauge between October 1, 2000 and September 30, 2008 was analyzed to develop the random sampling strategy. Using a minimum rainfall criteria of 0.2 inch of rain indicated that on average 66 days during a year, or 18 percent

of the time this criteria was met. King County will initially target 15 samples to characterize the water quality at these BMP sampling locations. Variability will be calculated as data become available to insure that 90 to 95 percent of the variability can be characterized with 75 to 80 percent power. The monitoring program may be modified to meet these goals as necessary. With an 18 percent chance of collecting an adequate sample, 83 days will be scheduled for random sampling to insure that 15 samples are collected during the year. A separate schedule of randomly selected days will be developed for both inflow and outflow stations.

Auto samplers will be used so that flow-weighted composite samples will be collected during 24-hour periods on the scheduled sampling days. If no flow is recorded, then the samplers will be retrieved and then set up for the next scheduled sampling day. The scheduled sampling days will be stratified by wet season (October 1 through March 31) and dry season (April 1 through September 30) to ensure that sample days will be proportional to seasonal rainfall. According to the rainfall record analyzed, 70 percent of rain fell between October 1 and March 31. Therefore, 70 percent or 58 days will be targeted during October 1 and March 31 (wet season), and 30 percent or 25 days will be targeted during April 1 and September 30 (dry season) to achieve a goal of collecting 10 samples during the wet season and 5 samples during the dry season (see appendix B).

Samples will be collected from 3 monitoring locations at each facility, 3 at the lower settling vault and sand filter and 3 at the upper settling pond and sand filter. Flow will be monitored and samples will be collected from (1) flow going into the pre-settling valult/pond, (2) from the flow out of the pre-settling vault/pond--into the sand filters, and (3) out of the sand filters. (Figs. 4 and 5)

## 5.3 Flow Reduction BMP

Approximately eight inches of organic compost was added to the remaining native soils after construction was completed at the urban planned development at Redmond Ridge. This soil amendment was part of a stormwater mitigation plan to protect sensitive areas around the development by reducing storm runoff. Soil amendment was not part of the stormwater mitigation plan at the neighboring Trilogy at Redmond Ridge development. For this study, two stormwater basins were selected, one in Redmond Ridge and one in Trilogy, for volume comparison of stormwater runoff between a compost amended basin and a basin with no amendment. Each basin is similar in size, housing density, and impervious area percentage. Each development was built at approximately the same time using similar building techniques.

Flow monitoring equipment will be installed in each basin where stormwater drains from each development and before it enters stormwater detention ponds (Figs. 2 and 3). Rain gauges will be installed in each basin to record the rainfall amounts local to each flow monitoring station. Continuous flow monitoring data and rainfall data will be collected in both basins during the course of one year. The amount of effective impervious area will be verified for each basin. Roof downspouts connectivity to storm drain networks will be identified as well as any significant irrigation practices. If there are any water storage facilities in the drainage system upstream of the monitoring locations, they will be accounted for.

Numerical models will be developed and calibrated using observed conditions for each of the drainage areas. Depending on climatic patterns experienced during the monitoring period, model development would not start until at least one complete wet season (October through May) and dry season (June through September) has been monitored. The numerical models will be designed in such a way to facilitate the isolation of pervious land segments and the underlying soil characteristic effects on hydrology.

If the amended soil treatment is effective, we may see reductions in runoff volume due to increased infiltration and less flashy hydrographs. Metrics like the two listed below may be used in the analysis evaluating site conditions affect to the hydrologic regime.

1. To test if volume from the treated basin is less than the untreated basin, mean monthly discharge will be calculated and normalized to discharge per acre foot of rainfall for each basin. Each month will give a pair of values. A non parametric sign test statistic on the pairs will be computed (Helsel, D.R. and R. M. Hirsch, 2002. **Statistical Methods in Water Resources** Techniques of Water Resources Investigations, Book 4, chapter A3. U.S. Geological Survey.) The hypothesis is that runoff volume from the basin with amended soils (x) will be less than that from the untreated basin (y): Probability [x>y] <0.5. The result of the test will be compared to a standard binomial probability distribution for the number of samples at a 0.1 significance.

2. The affect of the amended soil on the hydrograph will be tested by calculating a $T_{Qmean}$ using the proportion of the annual 15 minute discharge values above the mean annual flow. A less flashy stream will have a larger proportion of the 15 minute values above the annual mean. We will consider it significant If the treated basin $T_{Qmean}$ is more than 10% higher than the untreated basin both sampling years.

## 5.4 Site Locations

### 5.4.1 Pre-Settling Detention Facility and Sand Filter

The sand filter facilities are located in the City of Sammamish and serve a multi-family apartment development at 4425 Issaquah Pine Lake Rd SE. Two sand filters serve the apartment complex with each treating roughly half of the developed area. Both sand filters will be monitored to satisfy the requirements of S8.F.

The treatment facility serving the lower half of the apartment complex consists of a pre-settling vault, which drains to a sand filter. The treatment facility serving the upper half of the apartment complex consists of a pre-settling pond draining to another sand filter. Monitoring stations at each treatment facility will be located at the inflow to the presettling facilities, at the inflow to the sand filters (outflow from the presettling facilities), and at the outflow from the sand filters.

### 5.4.2 Flow Reduction BMP Monitoring

The flow reduction BMP basins are located in Redmond Ridge and Trilogy urban planned developments near Novelty Hill Rd. Each basin consists of single family homes on approximately 7000 square-foot lots.

**Figure 2. Redmond Ridge Organic-Compost Soil Amended Basin**

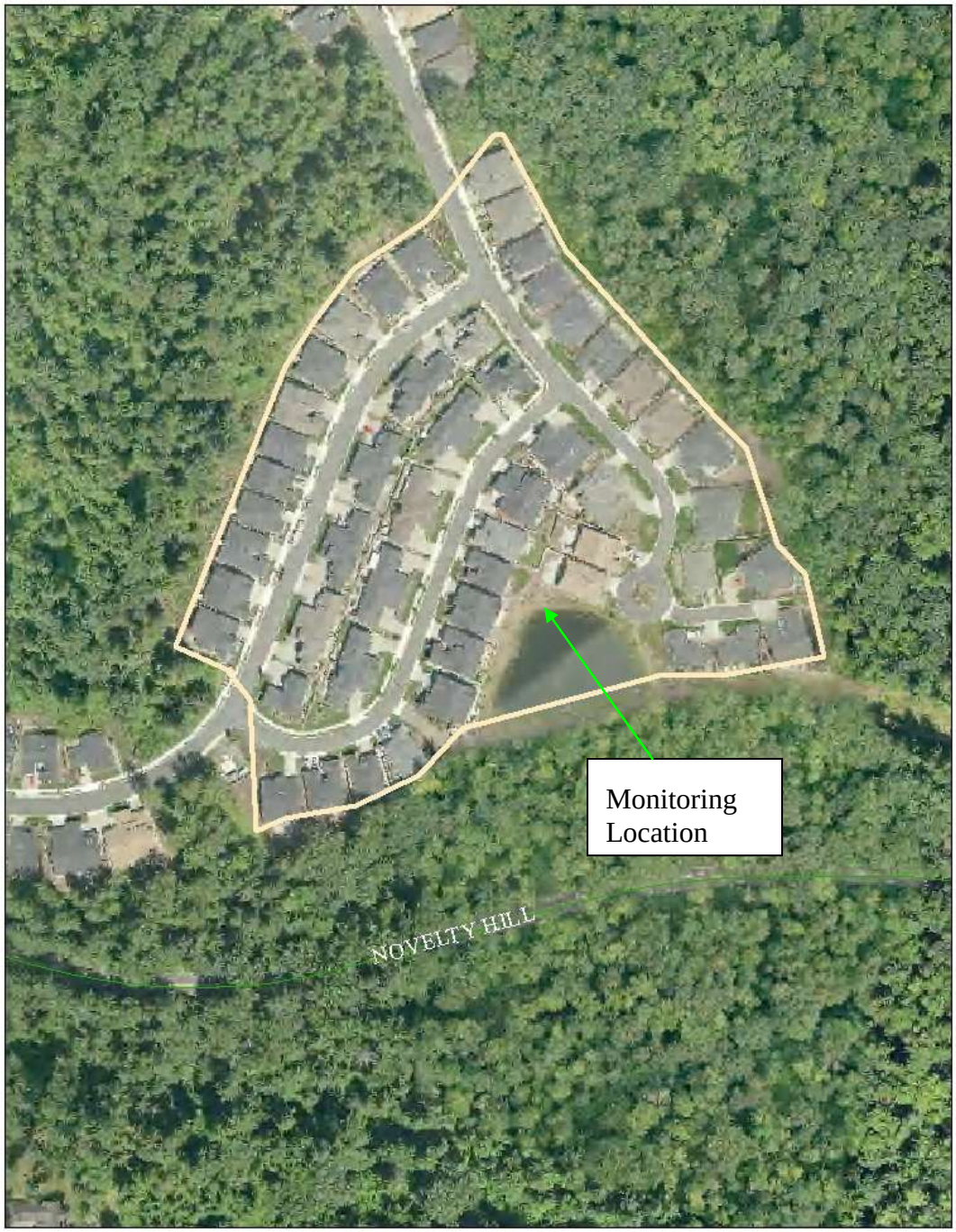


**Figure 3. Trilogy Non-Amended Soils**

# 6.0. SAMPLING PROCEDURES

## 6.1 Monitoring Equipment Installation

Composite samplers and flow monitoring equipment will be installed at each BMP monitoring site at both sand filter treatment facilities (figs 4 and 5). Flow data will be collected for one year prior to when water quality monitoring begins and for each stormwater event thereafter. Continuous flow recordings of all 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)

Rain gauges will be installed at each monitoring site or a suitable currently installed raingauge will be used. (SOP TBD).

For flow reduction BMP monitoring, flow meters will be installed at each flow reduction BMP monitoring site. The flow meters will measure stormwater volumes prior to draining into detention ponds (Figs 2 and 3). These meters will record flow continuously throughout the monitoring period. To determine if compost amended soils are having an effect on flow volumes, raingauges will also be installed near each monitoring site. Raingauges at each site may assist in understanding whether any differences in flow volumes are a result in differences in local weather patterns.

## 6.2 Sample Collection

For the collection of water quality samples, sampling staff will consult the randomly generated sampling schedule. It is up to the sampling crew to determine if there is enough flow through the BMP facility to collect a random sample. Telemetered flow devices may help with this decision.

When it is time to sample, field staff will complete the following:

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

Field staff will wear a new pair of powder-free gloves for safe handling of each sample to prevent contamination of samples.

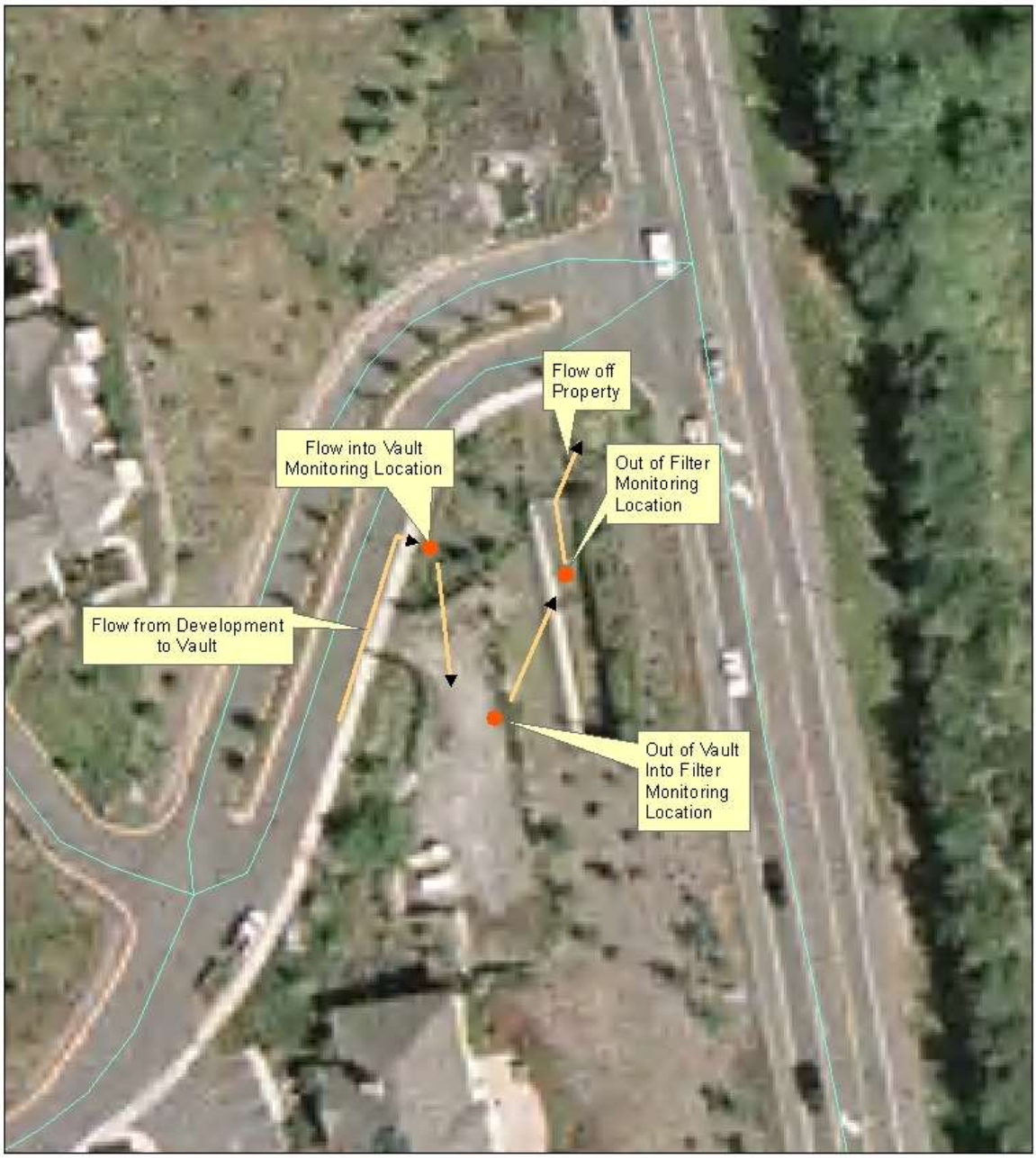


**Figure 4. Lower Sand Filter Monitoring Locations**

**Figure 5. Upper Sand Filter Monitoring Locations**

## 6.3 Sample Collection and Handling Procedures

As soon as the 24-hour period ends, sampling staff will retrieve the samples. Sampling staff will review the following information to determine if the sample meets project criteria:

- Rainfall hydrograph and ID location
- Flow volume hydrograph and ID location
- Event runoff volume,
- Time and number of aliquots collected, and
- Runoff volume sampled.

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 at the end of the 24-hour sampling period and the composite sample will be transferred into the appropriate laboratory sample containers. This will be done by continuously agitating the composite sample container 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 composite sample container. This procedure will ensure a representative sample from the composite sample in each laboratory sample container. Once the sample has been split, both the dissolved metals sample and the orthophosphate 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. Orthophosphate 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.

An attempt to collect sediment samples from each of the six sampling locations will be made. Samples will be collected by lowering an Ekman grab sampler (or similar e.g. Petite Ponar) through access ports at each location. The sampler will collect sediments that have accumulated on the bottom of each of the vault/catchbasins.

### 6.3.1 Field Data Collection

A multiprobe will be used to collect pH and temperature data in the field (See "Procedures for field measurement" SOP #NPDES FM – 1000 – 5000).

Field notes will be maintained for all field activities, both the collection of samples and the gathering of environmental data. Field notes will be kept on water-resistant paper and all field

documentation will be recorded in indelible, black ink. Field notes will be recorded on pre-printed field sheets, prepared specifically for this project. A sample field sheet is shown in Figure 5. Information recorded on field notes will include, but not be limited to:

- Name of recorder,
- Sample or station and replicate number,
- Sample station locator information,
- Depth of sediment sampled
- Sample depth (water depth above the surface of the sediment),
- Date and time of sample collection (all times will be recorded for multiple sampler deployments),
- Physical characteristics of sediment such as color, gross grain size distribution, debris, and odor,

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

### 6.3.2 Chain of Custody

During sample collection, all sample containers will be either installed in the autosamplers at the sampling site or in the custody of the sampling personnel. After collecting the samples, field personnel will deliver all samples to laboratory's Sample Receiving area and enter them into the Sample Receiving Logbook, as described in ESS SOP # 103v4 (Sample Management). The possession of the samples by the lab is effective at the time the Logbook is signed by sampling personnel and the lab sample manager.

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

- Sample time and date
- Preservatives used
- Name of sampler
- Number of containers per sample
- Analytical test method requested
- Parameter to be analyzed
- Field Quality Assurance/Quality Control samples collect such as duplicates, trip blanks, temperature blanks, etc.
- Date, Time, name and signature of the person relinquishing and the person receiving the samples.

## 6.4 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 proceedures see KCEL SOPs 06-05-002-001 and 07-04-001-002).

## 6.5 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 4. QA/QC Samples Collected**

| 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. |

## 6.6 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. Ecology recommends including preventative maintenance in your project schedule provided in Section 5, *Organization and Schedule*.

## 6.7 Additional Resources or References to Assist with this Section

### 6.7.1 For NPDES Sample Preservation and Analysis

1. Federal Register, EPA 40 CFR Part 136 July 2007 and March 2007.

### 6.7.2 For Weather Forecasting

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

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

**Table 5. Stormwater sample volume, container type, holding time, and preservatives.**

| 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 |
| Total phosphorus | 250 mL | 250mL CWM HDPE | 28 days | Freeze at -18°C |
| Orthophosphate Phosphorus | 60 mL | 60 mL CWM HDPE | Field filter within 15 minutes of collection, then 14 days frozen | Freeze at -18°C |
| Particle Size Distribution | 500 mL | 500 mL CWM HDPE or glass | 7 days | Refrigerate at <6°C |
| Dissolved Metals (copper, zinc) | 250 mL | 500 mL Acid washed HDPE bottle | 6 months | Field filter within 15 minutes of collection; then $HNO_3$ to pH<2 at lab |
| Total Metals (copper, zinc, calcium and magnesium) & Hardness Calculation | 250 mL | 500 mL Acid washed HDPE bottle | 6 months | $HNO_3$ to pH<2 at lab |
| Fecal coliform | 500ml | 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) | 1000ml | 1000ml amber narrow mouth amber glass | 7 days to extraction, 40 days for the extract | Refrigerate at <6°C |
| **Sediment Samples -All Soil Matrices** | | | | |
| Total solids (% solids) | 60 g | 4 oz. CWM PP or glass | 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 |

| Parameter | Recommended Quantity | Container | Holding Time | Preservation |
|---|---|---|---|---|
| Total Volatile Solids | 60 g | 4 oz. CWM PP or glass | 14 days, 6 months if frozen | Freeze at -18°C |
| Metals: copper, zinc, cadmium, lead | fill jar | 4 oz. PP container | 6 months | Refrigerate at 4°C |
| Semi-Volatile Petroleum Products (NWTPH-Dx) | Fill jar | 8 oz. glass jar with Teflon-lined lid | 14 days | Refrigerate at 4ºC |
| Total Phosphorus | Fill jar 2/3 | 4 oz. CWM PP or glass | 28 days, 6 months if frozen | Freeze at -20 |

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

## Table 6. Parameters, Methods, and Detection Limits for Water Samples

| Water Quality Parameters | Method | Method Detection Limit | Reporting Detection Limit |
|---|---|---|---|
| Total suspended solids | SM2540D | 0.5 mg/L | 1.0 mg/L |
| Particle size distribution | Laser diffraction | 0.1% | NA |
| pH | SM4500-H-B | NA | NA |
| Hardness as CaCO3 | EPA 200.8/SM2340B.ED19 | 0.066 mg/L | 0.33 (mg $CaCO_3$/L) |
| 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 |
| Fecal coliform | SM9222D[1] | 1 cfu/100mls | 1 min., 1E6 max cfu/100mls |
| 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 |

| 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 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 |

(a) Method Detection Limit: King County Environmental Laboratory's empirically derived EPA 40 CFR MDL. Changes at least 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.

## Table 7. Parameters, Methods, and Detection Limits for Sediment Samples

| Sediment Quality Parameters | Method | Method Detection Limit (wet weight) | Reporting Detection Limit (wet weight) |
|---|---|---|---|
| Total solids | SM 2540-G | 0.005% | 0.01% |
| Grain size | ASTM D422 | Sieve (Gravel & Sand) 0.1%<br><br>Hydrometer (Silt & Clay) 0.5 % | 1.0% for all categories |
| Total Volatile Solids | SM 2540-G | 0.005% | 0.01% |
| Semi-Volatile Petroleum Products (NWTPH-Dx) | NWTPH-Dx (GC/FID) Ecology, 1997 (Publication No. ECY-97-602) | 25 mg/Kg | 25 mg/Kg |
| Total phosphorus | EPA 3050B/6020A | 25 mg/kg | 125 mg/kg |
| Total cadmium | EPA 3050B/6020A | 0.013 mg/kg | 0.0625 mg/Kg |
| Total copper | EPA 3050B/6020A | 0.1 mg/kg | 0.5 mg/Kg |
| Total lead | EPA 3050B/6020A | 0.025 mg/kg | 0.125 mg/Kg |
| Total zinc | EPA 3050B/6020A | 0.13 mg/kg | 0.625 mg/Kg |

# 8.0. MEASUREMENT QUALITY CONTROL OBJECTIVES

## 8.1 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 8. Metals QC Limits for 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 (liquids) | <MDL | 20% | 75-125 | 85-115 |

**Table 9. Metals QC Limits for Solid Matrices**

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

## 8.2 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 10. Conventionals QC Limits for Liquid Matrices**

| **Parameters** | *Method Blank* | *Lab Duplicate* | *Matrix Spike* | *Lab Control* |
|---|---|---|---|---|

| | | *%RPD* | *%Recovery* | *Sample %Recovery* |
|---|---|---|---|---|
| Orthophosphate Phosphorus | <MDL | 20% | 75-125% | 85-115% |
| Total Phosphorus | <MDL | 20% | 75-125% | 85-115% |
| Total Suspended Solids | <MDL | 25% | N/A | 80-120% |

**Table 11. Conventional QC Limits for Solid Matrices**

| **Parameters** | *Method Blank* | *Lab Triplicate %RSD* | *Matrix Spike %Recovery* | *Lab Control Sample[1] %Recovery* |
|---|---|---|---|---|
| Particle Size Distribution. | N/A | 20% | N/A | N/A |
| Total Solids | <MDL | 20% | N/A | N/A |
| Total Volatile Solids | <MDL | 20% | N/A | N/A |

## 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 12. Organics QC Limits for Liquid Matrices**

| ***Analysis*** | *Method Blank* | *Lab Duplicate RPD* | *Spike Blank %Recovery* | *Surrogate % Recovery* |
|---|---|---|---|---|
| Semi-Volatile Petroleum Products (NWTPH-Dx) | <MDL | 100 [a] | 50-150 | 50-150 |

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

**Table 13. Organics QC Limits for Solid Matrices**

| ***Analysis*** | *Method Blank* | *Lab Duplicate RPD* | *Spike Blank % Recovery* | *Surrogate % Recovery* |
|---|---|---|---|---|
| Semi-Volatile Petroleum Products (NWTPH-Dx) | <MDL | 35 [a] | 50–150 | 50-150 |

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

## 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 14. 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 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.

### 8.6.2 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.*

### 8.6.3 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.

### 8.6.4 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

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:

- 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.

# 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.

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.

Data will fulfill the National Stormwater BMP Data Base Requirements.

## 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).

Annual report will include the location, land use, drainage area size, rainfall, and hydrology at each monitoring site. The Quality Assurance/Quality Control (QA/QC) report. Calculations of removal efficiencies and a discussion of sampling events and any issues that may affect data quality.

Once enough data has been collected, an assessment of strategies for handling non-detected data (e.g. Helsel and Hirsch, 2002) will be conducted.

## 9.3 Proposed Laboratory Qualifiers

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

**Table 15. Proposed 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. |

| Qualifier | Description |
|---|---|
| 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** | |
| 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. |

| Qualifier | Description |
|---|---|
| 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 |

# 10.0.REFERENCES

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

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

# Appendix A
# Engineering Plans

Figure A-1

Figure A-2

Figure A-3

Figure A-4

Figure A-5

# Appendix B Random Sampling Schedule

Randomly Scheduled Sampling Days

| Inflow Wet season | Outflow Wet Season | Inflow Dry Season | Outflow Dry season |
|---|---|---|---|
| 6-Oct-10 | 13-Oct-10 | 1-May-11 | 12-May-11 |
| 8-Oct-10 | 14-Oct-10 | 7-May-11 | 25-May-11 |
| 19-Oct-10 | 16-Oct-10 | 31-May-11 | 28-May-11 |
| 20-Oct-10 | 21-Oct-10 | 16-Jun-11 | 4-Jun-11 |
| 1-Nov-10 | 29-Oct-10 | 19-Jun-11 | 18-Jun-11 |
| 7-Nov-10 | 1-Nov-10 | 20-Jun-11 | 22-Jun-11 |
| 8-Nov-10 | 3-Nov-10 | 5-Jul-11 | 2-Jul-11 |
| 11-Nov-10 | 7-Nov-10 | 15-Jul-11 | 13-Jul-11 |
| 12-Nov-10 | 8-Nov-10 | 18-Jul-11 | 14-Jul-11 |
| 14-Nov-10 | 9-Nov-10 | 20-Jul-11 | 15-Jul-11 |
| 22-Nov-10 | 13-Nov-10 | 21-Jul-11 | 19-Jul-11 |
| 27-Nov-10 | 14-Nov-10 | 24-Jul-11 | 28-Jul-11 |
| 28-Nov-10 | 15-Nov-10 | 30-Jul-11 | 29-Jul-11 |
| 30-Nov-10 | 18-Nov-10 | 1-Aug-11 | 2-Aug-11 |
| 5-Dec-10 | 19-Nov-10 | 2-Aug-11 | 12-Aug-11 |
| 13-Dec-10 | 23-Nov-10 | 12-Aug-11 | 15-Aug-11 |
| 16-Dec-10 | 7-Dec-10 | 22-Aug-11 | 16-Aug-11 |
| 18-Dec-10 | 9-Dec-10 | 25-Aug-11 | 21-Aug-11 |
| 22-Dec-10 | 12-Dec-10 | 28-Aug-11 | 22-Aug-11 |
| 23-Dec-10 | 15-Dec-10 | 29-Aug-11 | 23-Aug-11 |
| 24-Dec-10 | 16-Dec-10 | 8-Sep-11 | 11-Sep-11 |
| 28-Dec-10 | 25-Dec-10 | 14-Sep-11 | 12-Sep-11 |
| 29-Dec-10 | 26-Dec-10 | 19-Sep-11 | 21-Sep-11 |
| 2-Jan-11 | 10-Jan-11 | 26-Sep-11 | 26-Sep-11 |
| 3-Jan-11 | 11-Jan-11 | 30-Sep-11 | 28-Sep-11 |
| 7-Jan-11 | 12-Jan-11 | | |
| 13-Jan-11 | 16-Jan-11 | | |
| 21-Jan-11 | 19-Jan-11 | | |
| 23-Jan-11 | 21-Jan-11 | | |
| 26-Jan-11 | 22-Jan-11 | | |

| | |
|---|---|
| 30-Jan-11 | 31-Jan-11 |
| 8-Feb-11 | 2-Feb-11 |
| 9-Feb-11 | 6-Feb-11 |
| 24-Feb-11 | 7-Feb-11 |
| 25-Feb-11 | 8-Feb-11 |
| 26-Feb-11 | 12-Feb-11 |
| 2-Mar-11 | 13-Feb-11 |
| 5-Mar-11 | 16-Feb-11 |
| 7-Mar-11 | 21-Feb-11 |
| 8-Mar-11 | 25-Feb-11 |
| 12-Mar-11 | 27-Feb-11 |
| 16-Mar-11 | 3-Mar-11 |
| 19-Mar-11 | 5-Mar-11 |
| 20-Mar-11 | 6-Mar-11 |
| 23-Mar-11 | 9-Mar-11 |
| 24-Mar-11 | 11-Mar-11 |
| 29-Mar-11 | 14-Mar-11 |
| 30-Mar-11 | 15-Mar-11 |
| 4-Apr-11 | 22-Mar-11 |
| 7-Apr-11 | 24-Mar-11 |
| 11-Apr-11 | 4-Apr-11 |
| 13-Apr-11 | 5-Apr-11 |
| 15-Apr-11 | 18-Apr-11 |
| 19-Apr-11 | 23-Apr-11 |
| 20-Apr-11 | 24-Apr-11 |
| 23-Apr-11 | 27-Apr-11 |
| 25-Apr-11 | 28-Apr-11 |
| 28-Apr-11 | 30-Apr-11 |