2010 Monitoring Status Report For King County BMP Effectiveness Monitoring Under S8.F of the NPDES Phase 1 Municipal Permit WAR04-4501 (Issued February 2007)

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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. INTRODUCTION

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) and Washington State Department of Ecology (Ecology) stormwater regulations, which includes cities and unincorporated portions of counties whose populations exceed 100,000. The Phase I Permit includes requirements to conduct stormwater-related monitoring in Special Condition 8 (S8). The required monitoring program detailed in S8 includes three components:

- S8.D Stormwater Monitoring
- S8.E Targeted Stormwater Management Program Effectiveness Monitoring
- S8.F Stormwater Treatment and Hydrologic Management Best Management Practice (BMP) Evaluation Monitoring.

Reporting for all three monitoring components is required as part of Special Condition S8.H and S9. These sections require Permittees to complete an annual report for each component, to be submitted no later than March 31, detailing monitoring that occurred during the previous water year. A water year starts on October 1 and ends on September 30 of the following year.

This document serves as King County's (County) water year 2010 (WY2010) BMP Monitoring Status Report, and documents the BMP monitoring conducted under S8.F of the Phase I Permit during WY2010. The BMP monitoring is intended to evaluate the effectiveness and operation and maintenance requirements of selected stormwater treatment and hydrologic management BMPs.

The permit instructs permittees use appropriate sections of Ecology's Guidance for Evaluating Emerging Stormwater Treatment Technologies – Technology Assessment Protocol – Ecology (TAPE) for the BMP evaluation monitoring. The BMPs that King County selected for monitoring (detailed in Section 2.2) are considered long-detention BMPs, therefore monitoring was conducted following Ecology's TAPE Modification: Evaluating Stormwater Treatment Technologies with Long Detention Times (Ecology, 2008).

The permit also requires data meet the statistical goal of determining mean effluent concentrations and mean percent removals for each BMP type with 90 to 95 percent confidence and 75 to 80 percent power. The project QAPP states that initially, 15 samples will be targeted at each monitoring site to characterize the water quality from the BMPs. As of the end of WY2010, 15 samples had not been collected at each site and as a result calculations to determine confidence and power of the mean effluent concentrations and mean percent removals was not completed. Therefore, as outlined in Ecology's Stormwater Monitoring Report Guidance (Ecology, 2010), this document serves as a status report rather than a final BMP report.

2.0. SUMMARY OF THE PURPOSE, DESIGN, AND METHODS OF THE MONITORING PROGRAM

2.1 Overview

Stormwater monitoring, to fulfill requirements of the Phase I Permit (per Permit §S8.F), was performed by King County in accordance with the project quality assurance project plan (QAPP) issued in February 2007, approved by Ecology on April 27, 2009, and updated November 2010 (King County, 2010). The updated QAPP is included as Appendix A. The permit requires each Permittee to monitor at least two treatment BMPs, at no less than two sites per BMP. King County selected to evaluate two large sand filters and two pre-settling detention basins for the Phase I BMP monitoring study, as described below.

2.2 Description of Treatment BMPs

The stormwater treatment BMP facilities are located in the City of Sammamish and serve a multi-family apartment development at 4425 Issaquah Pine Lake Rd SE. There are two BMP facilities located on the site as shown in Figure 1, Boulder Creek Upper BMP and Boulder Creek Lower BMP. Each facility treats runoff from roughly half of the development area. Both facilities include a sand filter preceded by a pre-settling detention facility.

2.2.1 Pre-settling Detention Facility

Pre-settling detention was provided immediately upstream of each of the sand filters. The Boulder Creek Upper BMP pre-settling facility is a detention pond and the Boulder Creek Lower BMP pre-settling facility is a detention vault. Both pre-settling facilities were sized as Level Two Flow Control facilities per the 1998 King County Surface Water Design Manual (KCSWDM) using the King County Runoff Time Series (KCRTS) program.

2.2.2 Sand Filter

The sand filters were designed as large sand filters per the 1998 KCSWDM. The filtration works as flows move vertically through the constructed sand bed and enters the underdrain system below the bed. The sand filters are comprised of three layers. The top layer is sand, the middle layer is a geotextile fabric and the bottom layer is gravel with a underdrain pipe system. Flows from the underdrain system discharge to the downstream drainage system. Both the lower and upper sand filters have flow spreaders for erosion protection and even distribution of the inflow.

The KCRTS program was used for sand filter sizing. These large sand filters were sized to treat 95 percent of runoff volumes. Both sand filters were designed as flow-through systems with flows above the 95 percent volume simply passing through the filter untreated. The overflows are designed with the same criteria as a detention facility overflow.

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.

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.

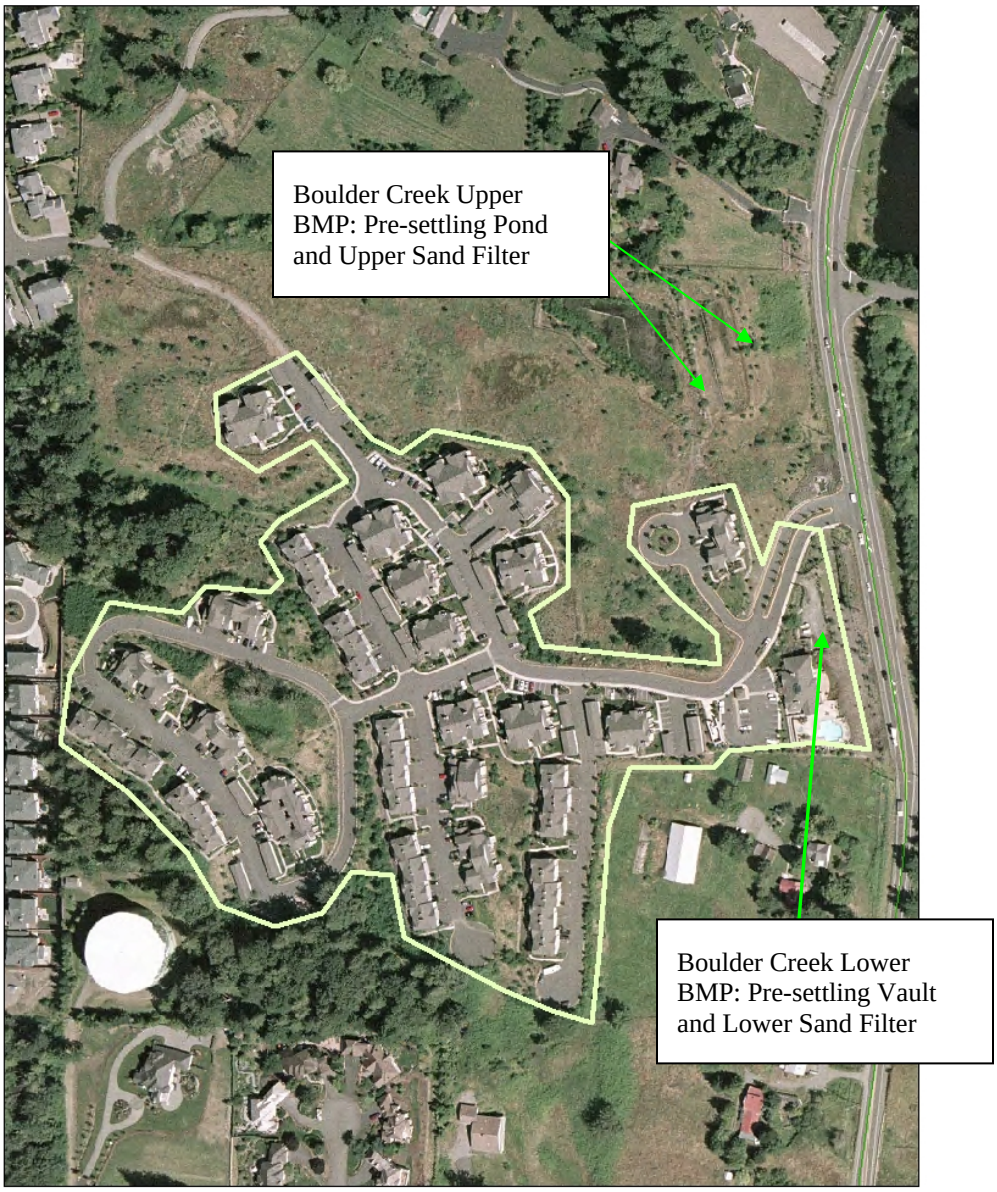

Figure 1. Location of Pre-Settling Facilities and Sand Filters

2.3 Sampling Design

Flow data and water quality samples were collected from three monitoring locations at each BMP facility. For each BMP flow data and water quality samples were collected at the following locations:

(1) inflow to the pre-settling vault/pond
  Boulder Creek Upper Pond Inlet (BC_UPIN)
  Boulder Creek Lower Vault Inlet (BC_LVIN)
(2) outflow from the pre-settling vault/pond (also represents flow into the sand filters)
  Boulder Creek Upper Pond Outlet (BC_UPOL)
  Boulder Creek Lower Vault Outlet (BC_LVOL)
(3) outflow from the sand filters
  Boulder Creek Upper Sand Filter Outlet (BC_USFOL)
  Boulder Creek Lower Sand Filter Outlet (BC_LSFOL)

The sampling locations are shown in Figures 2 and 3.

Sampling design for the BMPs is based on Draft Modification: Evaluating Stormwater Treatment Technologies with Long Detention Times – Technology Assessment Protocol – Ecology (Ecology, 2008) which calls for influent and effluent storm flow samples to be collected independently on randomly selected days. Rainfall data collected at the nearby Mystic Lake rain gauge between October 1, 2000 and September 30, 2008 was analyzed to determine the percentage of time there was expected to be storm flow at the sites, and subsequently how many days would need to be targeted to collect 15 samples at each monitoring site. Based on the analysis of the rain data, it was determined that 83 randomly selected days should be targeted in order to collect 15 storm flow samples.

The scheduled sampling days were stratified by wet season (October 1 through March 31) and dry season (April 1 through September 30) to ensure that sample days were proportional to seasonal rainfall. Based on the rainfall record, 70 percent, or 58 days, were targeted during October 1 and March 31 (wet season), and 30 percent, or 25 days, were 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.

A separate schedule of randomly selected days was developed for the pre-settling detention facility inflow and outflow monitoring stations. Since the sand filter is not a long detention BMP, the sand filter outflow monitoring stations were sampled on the same days as the pre-settling detention facility outflow monitoring stations (which also represents flow into the sand filters). The random sampling schedule is presented in Appendix B.

For samples collected following the random sampling approach, there is no minimum rainfall depth or dry antecedent requirement defining a “qualifying sample event”. The only criteria for a qualifying sample event, as stated in the *TAPE* protocols for long detention BMPs, is the presence of storm flow during the 24-hour sample event period (Ecology, 2008). Auto samplers were used to collect flow-weighted composite samples representing up to 24-hour periods on the scheduled sampling days. If no flow was recorded on a scheduled sampling day, then the samplers were retrieved and set up for the next scheduled sampling day.

Figure 2. Lower Sand Filter Monitoring Locations

Figure 3. Upper Sand Filter Monitoring Locations

2.4 Sampling Procedures

The following sections describe the stormwater and sediment sampling procedures performed by King County staff as part of the WY2010 BMP monitoring. All sampling procedures were conducted following the project QAPP.

2.4.1 Stormwater Sampling Procedures

Monitoring equipment location

Automated composite samplers and flow monitoring equipment were installed at each of the BMP monitoring sites for both BMP facilities (Figures 2 and 3). To meet the requirement that flow in the facilities be measured for a year before sampling began, water level recorders were installed in each of these locations November 12, 2008 with the exception of the lower sand filter outlet. There, the access cover was buried and inaccessible. Also, the lower sand filter required significant unanticipated maintenance before proper function could be expected. The five accessible locations each had an Onset model U20-004 sealed pressure recorder installed. These recorded total pressure (water plus barometric pressure) and water temperature at 15 minute intervals. Another U20 installed at the site recorded barometric pressure for calculating water level from the total pressure record.

In September 2009 water quality sampling equipment was installed at the three Boulder Creek Upper BMP sites. Each site has a housing to contain the automated sampler, flow meter, batteries, and supplies. All sites use an Isco 3700 automatic sampler. To monitor flow, the Boulder Creek Upper Pond Inlet (BC-UPIN) station uses an Isco 4250 area velocity meter installed in an eighteen inch pipe, the Boulder Creek Upper Pond Outlet (BC_UPOL) station uses an Isco 4230 bubbler flow meter installed behind a multiple orifice control structure, and the Boulder Creek Upper Sand Filter Outlet (BC_USFOL) station uses an Isco 4230 bubbler flow meter installed behind an inlet controlled twelve inch diameter round pipe.

The Boulder Creek Lower BMP sites were still not functioning in October 2009. Water quality sampling equipment was installed at the Boulder Creek Lower Vault Outlet (BC_LVOL) station in October 2009. This included an Isco 3700 automated sampler and an Isco 4230 bubbler flow meter installed behind a multiple orifice control structure. The Boulder Creek Lower Vault Inlet (BC_LVIN) station equipment was installed in January 2010, and included an Isco 3700 automated sampler and Isco 4230 bubbler flow meter installed behind an inlet controlled twelve inch diameter round pipe. The Bolder Creek Lower Sand Filter Outlet (BC_LFSOL) station sampling equipment was installed in February 2010, and included an Isco 3700 automated sampler and an Isco 4250 area velocity meter installed in a twelve inch pipe.

A rain gauge was installed at the Boulder Creek Upper BMP location and was used as the project rain gauge for all six BMP monitoring sites. The rain gauge is a Hydrological Services TB3 0.01” tipping bucket rain gauge, which was installed with a Campbell Scientific CR200 data logger. The rain gauge recorded each tip of rain with the data logger logging 15-minute rain totals. A Raven GPRS modem allowed for the automated hourly download of the rain data to a computer at the King County Water and Land Resource Division King Street office, and automatically loaded the data into the Hydrologic Information Center database.

Sample collection & handling

For the collection of water quality samples, sampling staff consulted the randomly generated sampling schedule (Appendix B). Sampling staff then made a determination as to whether or not there was, or was predicted to be, adequate storm flow through the BMP facility to collect a water quality sample on the randomly selected sampling day. If so, field staff set up the appropriate sites for the upcoming event.

For each targeted event, samples were retrieved at the end of the 24-hour period. Sampling staff then reviewed event data, to determine if the sampled event met project criterion that samples should represent storm flow and not include baseflow. Upon confirmation that the sampling event criterion was met, samples were field processed and prepared for transport to the laboratory for analysis. Table 1 lists the project analytical parameters, methods, method detection limits, reporting detection limits, and practical quantification limits.

In-situ (field) data

In addition to the samples collected for laboratory analysis, a multiprobe was be used to collect pH and temperature data in the field. Field notes were maintained for all field activities, both the collection of samples and the gathering of environmental data.

Decontamination procedures

Once samples were collected, all re-usable equipment was decontaminated with wash and rinse water. EPA approved detergents and de-ionized water (ASTM I or II) were used to provide efficient decontamination of equipment. Equipment blanks were analyzed to check for possible cross contamination between sampling events.

QA/QC samples

Stormwater samples were filtered in the field for dissolved metals and orthophosphate. As part of project QA/QC techniques, field filtration blanks were collected to check the cleanliness of the filtration equipment or procedures. Field filtration blanks were generated by carrying reverse osmosis water into the field and pouring it through the filtration equipment into a sample container. The results of the field filtration blanks may indicate the presence of contamination due to sample collection and handling procedures or to conditions in the field.

Table 1. Parameters, Methods, and Detection Limits for Water Samples

Water Quality Parameters	Method	Method Detection Limit	Reporting Detection Limit
Total suspended solids (TSS)	SM2540D	0.5 mg/L	1.0 mg/L
Particle size distribution (PSD)	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 cfu/100mls	1 min., 1E6 max cfu/100mls
NWTPH-Dx Diesel Range	NWTPH-Dx	0.2 mg/L	0.2 mg/L
NWTPH-Dx Lube Oil Range	NWTPH-Dx	0.2 mg/L	0.2 mg/L
Total recoverable zinc	EPA 200.8	0.081 ug/L[a]	2.5 ug/L[b]
Dissolved zinc	EPA 200.8	0.081 ug/L[a]	2.5 ug/L[b]
Total recoverable copper*	EPA 200.8	0.043 ug/L[a]	2.0 ug/L[b]
Dissolved copper*	EPA 200.8	0.043 ug/L[a]	2.0 ug/L[b]
Total recoverable calcium	EPA 200.8	10 ug/L	50 ug/L
Total recoverable magnesium	EPA 200.8	10 ug/L	50 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) King County Environmental Laboratory reporting detection limit for total and dissolved zinc is 0.5 ug/L and for total and dissolved copper is 0.4 ug/L. Value listed for total and dissolved zinc and copper is considered the 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.

2.4.2 Sediment Sampling Procedures

Sediment accumulated at each monitoring location was sampled using a Ponar® grab sampler. The Ponar® sampler was cast one or more times at each location as necessary to obtain adequate sample volume for laboratory analyses. Table 2 lists the parameters, methods, and detection limits for the sediment samples.

Table 2. 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[a]	ASTM D422	Sieve (Gravel & Sand) 0.1% Hydrometer (Silt & Clay) 0.5 %	1.0% for all categories
Total Volatile Solids	SM 2540-G	0.005%	0.01%
NWTPH-Dx Diesel Range	NWTPH-Dx	25 mg/Kg	25 mg/Kg
NWTPH-Dx Lube Oil Range	NWTPH-Dx	25 mg/Kg	25 mg/Kg
Total phosphorus	EPA 3050B/6010A	25 mg/kg	125 mg/kg
Total cadmium	EPA 3050B/6010A	0.01 mg/kg	0.5 mg/Kg
Total copper	EPA 3050B/6010A	0.2 mg/kg	1.0 mg/Kg
Total lead	EPA 3050B/6010A	1.0 mg/kg	5.0 mg/Kg
Total zinc	EPA 3050B/6010A	0.25 mg/kg	1.25 mg/Kg

(a) The MDL and RDL values for grain size will be different for each sample, depending on the amount of solids analyzed for each.

3.0. STATUS OF MONITORING PROGRAM & DATA COLLECTION

The following section outlines the status of the BMP monitoring program, including outlining the number of samples collected in WY2010 along with a summary of their analytical results. In addition, a brief analysis of the pollutant concentration reduction (PCR) for applicable parameters is presented.

3.1 Monitoring and Sampling Status

Six site visits were made during the water year 2009 wet season to make observations and retrieve flow data. The data collected from the upper system showed the system functioning as expected.

The lower system did not function as expected. It was observed that little water was entering the lower sand filter. When access was gained to the lower sand filter outlet basin, it was discovered that flow was exiting the vault through a poorly sealed slide gate into the overflow outlet. This resulted in flows bypassing the sand filter. By late winter, the gate was fixed and flow was able to discharge through the control structure. It was then discovered that the outlet pipe through the vault into the lower sand filter spreader was poorly grouted and flows were leaking into ground. A water level sensor installed in the lower sand filter spreader confirmed that discharge from the vault was not entering the lower sand filter as designed. King County staff began actions to require the property owner to correct the deficiencies.

During water year 2010, site visits to verify flow meter accuracy and change batteries were made at two to three week intervals in the wet season, then six to eight week intervals in the summer. Ants built a nest under the box containing the sampling equipment at BC_LSFOL in the summer, requiring a major maintenance effort. The bubbler line got pinched at BC_UPIN and produced unreliable data between July 9 and Sept 17, 2010, a period of time with very little flow.

3.2 Stormwater Sample Event Characteristics

Due to the random sampling schedule, the number of samples collected to date varies with sampling location. Table 3 presents summary sampling status information for each of the six sampling locations. The analytical results from the grab and composite samples collected during sampled events are summarized for each site in Table 4 through Table 9. analytical laboratory reports for each event are included electronically on an included cd as Appendix C. The sampling event files, including a hydrograph and hyetograph for each sampling event, are included in Appendix D.

Table 3. Sampling Status Summary

Station	Sample Event Dates	# of samples
UPIN	10/14/09, 11/17/09, 11/19/09, 12/21/09, 1/4/10, 1/13/10, 2/24/10, 9/1/10, 9/17/10	9
UPOL	10/14/09, 10/21/09, 11/05/09, 11/18/09, 12/20/09, 1/04/10, 1/14/10, 2/11/10, 3/3/20, 4/22/10, 5/19/10, 6/10/10, 9/17/10	13
USFOL	10/14/09, 10/21/09, 11/05/09, 11/18/09, 12/20/09, 1/04/10, 1/14/10, 2/11/10, 3/3/10, 4/22/10, 5/19/10, 6/10/10, 9/17/10	13
LVIN	1/13/10, 2/24/10	2
LVOL	2/11/10, 3/3/10, 4/22/10, 5/19/10, 6/10/10, 9/18/10	6
LSFOL	2/11/10, 3/3/10, 5/19/10, 6/10/10, 9/17/10	5

Note: Sample collection dates shown above represent the start of the sampling period.

3.2.1 Boulder Creek Upper Pond Inlet (BC_UPIN)

The analytical results for samples collect at BC_UPIN are provided in Table 4. For this site, conventional and nutrient concentrations were above the method detection limit (MDL) for all composite samples. In addition, all samples were above the reporting detection limit (RDL) for all but the following parameters:

- Orthophosphate phosphorus was below the RDL for one sample
- Total copper was below the RDL for four samples
- Dissolved copper was below the RDL for five samples

For the grab samples lube oil concentrations were above the MDL for only one of the samples, while diesel range concentrations were below the MDL for all samples. Fecal coliform grab samples were collected during two sampling events with both concentrations being above the MDL.

3.2.2 Boulder Creek Upper Pond Outlet (BC_UPOL)

For the BC_UPOL conventional and nutrient concentrations (Table 5) were above the MDL for all composite samples. In addition, all samples were above the reporting detection limit (RDL) for all but the following parameters:

- TSS was below the RDL for one sample
- Total copper was below the RDL for eleven samples
- Dissolved copper was below the RDL for twelve samples
- Total zinc was below the RDL for three samples
- Dissolved zinc was below the RDL for six samples.

For the grab samples, lube oil concentrations and diesel range concentrations were below the MDL for all samples. Fecal coliform grab samples were collected during three sampling events with all three concentrations being above the MDL.

Table 4. Sampling Analytical Results for BC_UPIN

Analyte	Units	10/14/09	11/17/09	11/19/09	12/21/09	1/4/10	1/13/10	2/24/10	9/1/10	9/17/10	Mean	Median
pH	pH	NA	7.13	6.72	6.8	6.8	6.84	6.63	7.06	6.95	6.87	6.82
TSS	mg/L	72.3	6.39	5.29	5.6	7.6	6.9	38.8	5.6	114	29.2	6.9
PSD (Mean	µm	10	12.34	10.52	8.38	12.2	10.2	NA	NA	NA	10.6	10.4
Total	mg/L	0.244	0.0368	0.0359	0.0295	0.0271	0.0328	0.127	0.0536	0.202	0.088	0.037
Orthophosphate	mg/L	0.0512,	0.0182,	0.0125	0.0109,	0.00837,	0.0129, H	0.0045,	0.0246,	0.0192,	0.018	0.013
Hardness	mgCaCO	8.92	18.1	12.2	17.7	11.1	17.5	11.5	74.9	21	21.4	17.5
Cu, Total	µg/L	8.58	1.2,	0.97,	4.61	1.4, <RDL	1.4, <RDL	8.26	3.96	15.1	5.05	3.96
Cu, Dissolved	µg/L	1, <RDL,	0.69,	0.48,	3.01, H	0.71,	0.88, <RDL,	3.71, H	3.08, H	3.71, H	1.92	1.00
Calcium, Total	µg/L	2410	5320	3690	5160	3290	5070	3520	22100	5830	6266	5070
Magnesium,	µg/L	705	1170	728	1160	690	1160	649	4810	1560	1404	1160
Zinc, Total	µg/L	58.6	8.37	8.26	8.67	10.5	8.98	37	14.9	60.2	23.9	10.5
Zinc, Dissolved	µg/L	5.29, H	4.75, H	4.62	5.27, H	6.15, H	5.15, H	12.1, H	13.9, H	7.02, H	7.14	5.29
Temperature	deg C	NA	10.5	8.57	3.6	9.68	9.3	11.1	16.2	16	10.62	10.09
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range	mg/L	0.266	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	0.114	0.095
Fecal Coliform[2]	CFU/100	NA	NA	NA	NA	NA	NA	NA	1100	5500	3300	3300

Notes:

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Jan.13.10) did not report on the mean particle size. Full analytical reports from all PSD samples
can be found in Appendix C.

NA = Not analyzed – no sample

Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.

Values reported with "<" indicate target analyte was not detected at reported value.
Values reported with "H" indicate the holding time was exceeded for that analyte.
2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to the program in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains.

Table 5. Sampling Analytical Results for BC_UPOL

Analyte	Units	10/14/09	10/21/09	11/5/09	11/18/09	12/20/09	1/4/10	1/14/10	2/11/10	3/3/10	4/22/10	5/19/10	6/10/10
pH	pH	NA	NA	NA	6.46	6.41	6.47	6.75	6.68	6.73	6.42	6.67	6.53
TSS	mg/L	4.51	2.83	3.4	1.8	2.2	8.98	1.6, <RDL	8	6.6	2.6	7.26	2
PSD (mean size)[1]	µm	6.65	7.37	11.98	7.63	9.45	21.48	8.55	6.22	16.72	7.97	NA	NA
Total Phosphorus	mg/L	0.133	0.0459	0.055	0.0327	0.0359	0.0516	0.0321	0.0626	0.0495	0.0316	0.119	0.0531
Orthophosphate	mg/L	0.0637, H	0.0105	0.00989, H	0.0131, H	0.011, H	0.0098, H	0.0108, H	0.0158, H	0.00936, H	0.00949, H	0.0474, H	0.00834, J
Hardness	$mgCaCO_3/L$	21.5	43.4	47.6	38.3	32	31.2	31.3	39.6	34.9	26.2	48.8	26
Copper, Total	µg/L	2.16	0.77, <RDL	0.63, <RDL	1.2, <RDL	4.36	1.6, <RDL	1.4, <RDL	1.3, <RDL	1.3, <RDL	1.6, <RDL	1.2, <RDL	1.8, <RD
Copper, Dissolved	µg/L	1.9, <RDL,H	0.57, <RDL	0.57, <RDL,H	1.1, <RDL,H	3.33, H	0.94, <RDL,H	1.3, <RDL,H	0.79, <RDL,H	0.97, <RDL,H	1.3, <RDL,H	0.78, <RDL,H	1.3, <RDL
Calcium, Total	µg/L	5980	12200	12800	10900	8850	8630	8900	11100	9550	7480	13800	7330
Magnesium, Total	µg/L	1580	3150	3800	2710	2410	2340	2200	2890	2680	1830	3490	1870
Zinc, Total	µg/L	5.07	1.9, <RDL	2.2, <RDL	3.57	3.53	3.58	4.3	4.49	1.5, <RDL	4.04	4.27	3.55
Zinc, Dissolved	µg/L	4.52, H	1.7, <RDL	1.2, <RDL, H	3.07, H	2.86, H	1.8, <RDL, H	3.47, H	3.29, H	1.1, <RDL, H	4.2, H	2.67, H	2.2, <RDL
Temperature	deg C	NA	NA	NA	7.98	2.4	7.91	8.4	6.6	8.56	11.07	12.4	15.6
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range (>C24)	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
Fecal Coliform[2]	CFU/100ml	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	500	130

Notes:

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Apr.22.10) did not report on the mean particle size. Full analytical reports from all PSD samples can be found in
Appendix C.
NA = Not analyzed – no sample
Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.
Values reported with "<" indicate target analyte was not detected at reported value.

Values reported with “H” indicate the holding time was exceeded for that analyte.
Values reported with “J” indicate an estimated value for that analyte.
2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to sampling in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains.

3.2.3 Boulder Creek Upper Sand Filter Outlet (BC_USFOL)

For the BC_USFOL site, TSS concentrations were below the MDL for seven of the thirteen sampling events (Table 6). Otherwise, conventional and nutrient concentrations were above the MDL for all composite samples. In addition, all samples were above the reporting detection limit (RDL) for all but the following parameters:

- TSS was below the RDL for three samples
- Total phosphorus was below the RDL for one sample
- Total copper was below the RDL for four samples
- Dissolved copper was below the RDL for seven samples
- Total zinc was below the RDL for nine samples
- Dissolved zinc was below the RDL for twelve samples

For the grab samples, lube oil concentrations and diesel range concentrations were below the MDL for all samples. Fecal coliform grab samples were collected during three sampling events with one of the sample concentrations being below the MDL.

3.2.4 Boulder Creek Lower Vault Inlet (BC – LVIN)

For the BC_LVIN site, conventional and nutrient concentrations were above the MDL for all of the three composite samples (Table 7). Orthophosphate phosphorus concentrations were above the MDL, but below the RDL for one of the two samples. For the grab samples, diesel range concentrations were below the MDL for all samples and lube oil concentrations were above MDL for one sample. No fecal coliform grab samples were collected during the sampling events.

3.2.5 Boulder Creek Lower Vault Outlet (BC – LVOL)

With one exception, for the BC_LVOL site, conventional and nutrient concentrations were above the MDL for all composite samples (Table 8). Orthophosphate phosphorus concentrations were below the MDL for one sampling event. Both orthophosphate phosphorus and dissolved copper were above the MDL, but below the RDL for one sampling event. For the grab samples, diesel range concentrations and lube oil concentrations were below the MDL for all samples. Fecal coliform grab samples were collected during three sampling events with one of the sample results below the MDL.

3.2.6 Boulder Creek Lower Sand Filter Outlet (BC – LSFOL)

For the Boulder Creek Lower Sand Filter Outlet site, TSS concentrations were below the MDL for three of the five samples (Table 9). Otherwise, conventional and nutrient concentrations were above the RDL for all composite samples. For the grab samples, diesel range concentrations were below the MDL for all samples and lube oil concentrations were below the MDL for four of the five samples analyzed. Fecal coliform grab samples were collected during three sampling events with all three samples results above the MDL.

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Table 6. Sampling Analytical Results for BC_USFOL

Analyte	Units	10/14/09	10/21/09	11/5/09	11/18/09	12/20/09	1/4/10	1/14/10	2/11/10	3/3/10	4/22/10	5/19/10	6/10/10	9/17/10	Mean	Median
pH	pH	NA	NA	NA	6.52	6.43	6.47	6.59	6.59	6.93	6.49	6.29	6.51	6.86	6.57	6.52
TSS	mg/L	2.2	<1.0	0.8, <RDL	<0.5	<1.0	<1.0	0.25, <MDL	0.25, <MDL	0.3, <MDL	0.71, <RDL	2.2	0.8, <RDL	0.5, <MDL	0.75	0.5
PSD (mean	µm	4.29	3.92	9.35	4.64	5.85	6.42	6.71	4.61	7.18	5.62	NA	NA	NA	5.6	5.7
Total Phosphorus	mg/L	0.048	0.015	0.0211	0.0176	0.0213	0.0178	0.0127	0.0088, <RDL	0.0113	0.0281	0.0753	0.0214	0.0341	0.026	0.21
Orthophosphate	mg/L	0.0161, H	0.00874	0.00771, H	0.00823, H	0.00842, H	0.00712, H	0.00717, H	0.00716, H	0.00624, H	0.00897, H	0.0338, H	0.00723, H	0.0142, H	0.011	0.008
Hardness	mg$CaCO_3$/L	26	31.8	40	32.6	34.8	30.6	30.5	42	33.2	26.6	42.6	32.1	44.7	34.4	32.6
Copper, Total	µg/L	2.76	1.7, <RDL	1.4, <RDL	5.96	1.7, <RDL	1.4, <RDL	1.2, <RDL	2.73	2.07	2.18	3	2.86	4.45	2.57	2.18
Copper,	µg/L	2, <RDL,H	1.6, <RDL	1.5, <RDL,H	5.52, H	1.6, <RDL,H	1.5, <RDL,H	1.3, <RDL,H	2.47, H	2.25, H	2, <RDL,H	2.24, H	2.14, H	3.8, H	2.30	2.0
Calcium, Total	µg/L	7310	9230	11100	9160	9580	8530	8520	11900	9240	7520	12400	9070	12600	9705	9230
Magnesium,	µg/L	1870	2120	2950	2350	2640	2270	2230	2970	2470	1900	2850	2290	3190	2469	2350
Zinc, Total	µg/L	2.65	0.98, <RDL	1.1, <RDL	1.4, <RDL	1, <RDL	1.8, <RDL	1.1, <RDL	1.6, <RDL	0.93, <RDL	3.35	2.5, <RDL	2.2, <RDL	2.3, <RDL	1.8	1.6
Zinc, Dissolved	µg/L	2.4, <RDL,H	1.4, <RDL	0.89, <RDL,H	1.3, <RDL,H	0.8, <RDL,H	1.6, <RDL,H	1.1, <RDL,H	1.6, <RDL,H	1.3, <RDL,H	4.06, H	1.6, <RDL,H	1.4, <RDL,H	1.8, <RDL,H	1.63	1.4
Temperature	deg C	NA	NA	NA	9.32	2.8	8.03	8.4	7.1	9.41	11.4	13.7	16.2	17.2	10.4	9.4
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
Fecal Coliform[2]	CFU/100ml	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	88	14	0.5,<MDL	34.2	14

Notes

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Apr.22.10) did not report on the mean particle size. Full analytical reports from all PSD samples can be found in Appendix C.

NA = Not analyzed – no sample

Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.

Values reported with "<" indicate target analyte was not detected at reported value.

Values reported with "H" indicate the holding time was exceeded for that analyte.

2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to sampling in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains.

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Table 7. Sampling Analytical Results for BC_LVIN

Analyte	Units	1/13/10	2/24/10	Mean	Median
pH	pH	7.19	7.61	7.40	7.40
Total Suspended Solids	mg/L	27.1	24.5	25.8	25.8
PSD (mean size)[1]	µm	15.54	18.89	17.2	17.2
Total Phosphorus	mg/L	0.0363	0.0582	0.047	0.047
Orthophosphate	mg/L	0.0046, <RDL, H	0.00565, H	0.005	0.005
Hardness	mg$CaCO_3$/L	11.5	20.5	16	16
Copper, Total	µg/L	8.38	9.07	8.73	8.73
Copper, Dissolved	µg/L	3.5, H	4.29, H	3.90	3.90
Calcium, Total	µg/L	3330	6350	4840	4840
Magnesium, Total	µg/L	769	1120	945	945
Zinc, Total	µg/L	28.4	47.9	38.2	38.2
Zinc, Dissolved	µg/L	8.79, H	17, H	12.90	12.90
Temperature	deg C	9.8	9.3	9.6	9.6
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range	mg/L	0.574	<0.19	.335	.335
Fecal Coliform[2]	CFU/100ml	NA	NA	NA	NA

Notes:

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Apr.22.10) did not report on the mean particle size. Full analytical reports from all PSD samples can be found in Appendix C.

NA = Not analyzed – no sample

Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.

Values reported with "<" indicate target analyte was not detected at reported value.

Values reported with "H" indicate the holding time was exceeded for that analyte.

2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to sampling in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains.

Table 8. Sampling Analytical Results for BC_LVOL

Analyte	Units	2/11/10	3/3/10	4/22/10	5/19/10	6/10/10	9/17/10	Mean	Median
pH	pH	7.25	7.21	6.71	6.14	6.93	7.42	6.94	7.07
TSS	mg/L	2.6	2.36	2.6	8.12	2.6	16.4	5.8	2.6
PSD (mean size)[1]	µm	5.67	11.77	9.24	NA	NA	NA	8.9	9.2
Total Phosphorus	mg/L	0.0415	0.043	0.0246	0.0367	0.041	0.16	0.058	0.041
Orthophosphate Phosphorus	mg/L	0.0136, H	0.0117, H	0.0046, <RDL, H	<0.006,TA, H	0.0064, H	0.031, H	0.012	0.009
Hardness	$mgCaCO_3/L$	44.5	30.1	11.6	2550	19	63.5	453.1	37.3
Copper, Total	µg/L	3.82	2.9	2.75	4010	11.8	15.1	674.4	7.8
Copper, Dissolved	µg/L	2.7, H	2.56, H	2.04, H	2930, H	6.21, H	1.6, <RDL, H	490.85	2.63
Calcium, Total	µg/L	14700	9820	3830	721000	6120	22300	129628	11260
Magnesium, Total	µg/L	1900	1370	503	183000	913	1900	31598	1635
Zinc, Total	µg/L	16.5	12.5	12.2	1120	15.1	21.4	199.6	15.8
Zinc, Dissolved	µg/L	12.7, H	13.6, H	10.3, H	1090, H	11.8, H	4.76, H	190.53	12.25
Temperature	deg C	8.3	9.27	11.03	11.5	13.7	16.1	11.7	11.3
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
Fecal Coliform[2]	CFU/100ml	NA	NA	NA	<1	250	90	114	32

Notes:

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Apr.22.10) did not report on the mean particle size. Full analytical reports from all PSD samples can be found in Appendix C.

NA = Not analyzed – no sample

Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.

Values reported with "<" indicate target analyte was not detected at reported value.

Values reported with "H" indicate the holding time was exceeded for that analyte

Values reported with "TA" indicate matrix interference. See analytical laboratory report for details.

2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to sampling in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains.

Table 9. Sampling Analytical Results for BC_LSFOL

Analyte	Units	2/11/10	3/3/10	5/19/10	6/10/10	9/17/10	Mean	Median
pH	pH	6.75	6.74	7.15	6.74	7.04	6.88	6.75
TSS	mg/L	0.25, <MDL	0.3, <MDL	2.73	0.45, <MDL	2.12	1.17	0.45
PSD (mean size)[1]	µm	4.6	5.09	NA	NA	NA	4.8	4.8
Total Phosphorus	mg/L	0.0155	0.0136	0.066	0.0209	0.0672	0.037	0.0209
Orthophosphate Phosphorus	mg/L	0.0113, H	0.00933, H	0.0262, H	0.0065, H	0.0355, H	0.018	0.0113
Hardness	mg$CaCO_3$/L	NA	218	145	35.7	181	144.9	163
Copper, Total	µg/L	NA	2.17	11.7	5.98	8.17	7.01	7.075
Copper, Dissolved	µg/L	NA	2.35, H	7.82, H	4.75, H	6.66, H	5.40	5.705
Calcium, Total	µg/L	NA	57200	42900	10500	49400	40000	46150
Magnesium, Total	µg/L	NA	18200	9190	2330	13900	10905	11545
Zinc, Total	µg/L	NA	2.85	10.8	8.37	11.6	8.41	9.585
Zinc, Dissolved	µg/L	NA	3.66, H	8.96, H	5.66, H	10.4, H	7.17	7.31
Temperature	deg C	7.9	8.97	11.8	14.2	15.2	11.6	11.8
NWTPH-Dx Diesel Range	mg/L	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
NWTPH-Dx Lube Oil Range	mg/L	<0.19	<0.19	0.195	<0.19	<0.19	0.115	<0.19
Fecal Coliform[2]	CFU/100ml	NA	NA	42	32	22	32	32

Notes:

[1] PSD data was analyzed by two different laboratories during water year 2010. The second laboratory (sample dates after Apr.22.10) did not report on the mean particle size. Full analytical reports from all PSD samples can be found in Appendix C.
NA = Not analyzed – no sample
Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.
Values reported with "<" indicate target analyte was not detected at reported value.
Values reported with "H" indicate the holding time was exceeded for that analyte
2. Grab samples for fecal coliform are not part of the required sampling for S8.F, however King County staff added this parameter to sampling in May of 2010 to provide information on the removal rates of bacteria by large sand filters treatment trains..

3.2.7 Quality Assurance/Quality Control Report

Field QA/QC Results

For WY2010, field filtration blanks were collected for sixteen sampling events. Field filtration blank samples for each of these sixteen events were analyzed for orthophosphate phosphorus, dissolved copper and dissolved zinc. Results for all samples were below the RDL for all three analytes. With one exception, all field filtration blanks were below the MDL for all three analytes. The field filtration blank collected on May 20, 2010 (associated with samples with a collection date of May 19, 2010) had a dissolved zinc concentration of 0.83 µg/L. The LIMS MDL for dissolved zinc for this sample was 0.5 µg/L while the LIMS RDL was 2.5 µg/L. Concentrations of dissolved zinc in the associated stormwater samples were as follows: BC_UPOL = 2.67 ug/L; BC_USFOL = 1.6 ug/L; BC_LVOL = 1090 ug/L; and BC_LSFOL = 8.96 ug/L. Since the results from the field blank was more than ten times the value of the associated samples from BC_UPOL and BC_USFOL, those samples are considered to be affected by contamination. Since the results from the field blank was less than ten time the values of the associated samples at BC_LVOL and BC_LSFOL, the results are not considered to be affected by contamination.

In addition, the field filtration blank collected on April 22, 2010 did not meet the analytical holding time for orthophosphate phosphorus. The results were therefore qualified. A summary of all the analytical results for the field filtration blanks are presented in Appendix E.

Analytical QA/QC Results

Refer to Appendix F – Analytical Data Quality Assurance/Quality Control Discussion for a discussion of the analytical QA/QC Results.

3.3 Sediment Sampling

Sediment samples were collected from four of the six BMP sites using a Ponar® sampler, at the Boulder Creek Lower Vault Outlet and Boulder Creek Lower Sand Filter Outlet on June 28, 2010, and at the Boulder Creek Upper Pond Outlet and Boulder Creek Lower Vault Inlet on June 29, 2010. No samples were collected from the Boulder Creek Upper Pond Inlet or Boulder Creek Upper Sand Filter Outlet sites as there was no sediment accumulated at these sites. The results of the sediment samples collected from the four locations are summarized in Table 10. The analytical laboratory report is included with the stormwater laboratory reports which is provided electronically on an included cd as Appendix C.

Table 10. Analytical sediment data from BMP monitoring sites (wet weight basis).

Analyte	Units	BC – UPOL	BC – LVIN	BC – LVOL	BC - LSFOL
		6/29/10	6/29/10	6/28/10	6/28/10
Cadmium, Total,	mg/Kg	<0.10	<0.10	0.24, <RDL	<0.10
Copper, Total,	mg/Kg	9.23	8.44, J	33.4	17.1
Lead, Total	mg/Kg	2.8, <RDL	2.7, <RDL	48.6	2.9, <RDL
Zinc, Total	mg/Kg	32.5	31.3	262	31.9
Phosphorus, Total	mg/Kg	446	253, J	364	333
Total Solids	%	13.5	81.7	31.3	58.1
Total Volatile Solids	%	2.89	0.859	7.76	1.65
Gravel	%	8.9	35.6	4.5	25.4
< -2 Phi Gravel	%	6.4, <RDL	8.9	2.4, <RDL	19.8
(-1) - (-2) Phi Gravel	%	1.1, <RDL	4.9	0.6, <RDL	1.7, <RDL
0 - (-1) Phi Gravel	%	1.4, <RDL	21.9	1.5, <RDL	3.9
Sand	%	20.2	72.5	40.9	25.2
0-1 Phi Sand	%	3.1, <RDL	30.2	2.6, <RDL	3.7
1-2 Phi Sand	%	1.4, <RDL	30.4	3.5	3.7
2-3 Phi Sand	%	2.3, <RDL	9.2	24.2	6.3
3-4 Phi Sand	%	8.8	1.9	6.1	8.9
4-5 Phi Sand	%	4.7, <RDL	0.8, <RDL	4.6	2.6
Silt	%	43.6	<0.67	55.4	26
5-6 Phi Silt	%	25.5	<0.67	30.1	5.4
6-7 Phi Silt	%	<3.6	<0.67	11.1	6.5
7-8 Phi Silt	%	7.3, <RDL	<0.67	12.7	8.7
8-9 Phi Silt	%	10.9	<0.67	1.6, <RDL	5.4
Clay	%	32.7	<0.67	3.2, RDL	20.6
9-10 Phi Clay	%	14.5	<0.67	1.6, <RDL	8.7
> 10 Phi Clay	%	18.2	<0.67	1.6, <RDL	11.9
Total Fines	%	76.4	<0.67	58.5	46.6

Notes:

Values reported with "<RDL" indicate the target analyte was above the method detection limit but below the reporting detection limit.

Values reported with "<" indicate target analyte was not detected at reported value.

Values reported with "J" indicate an estimated value for that analyte.

3.4 Performance Evaluation

As part of the BMP performance evaluation, removal efficiencies were calculated for each parameter, except pH, PSD, and temperature, using the following equations:

$$MeanPCR = 1 - \frac{MeanC_{outlet}}{MeanC_{inlet}}$$

Where:

$MeanPCR$ = Mean percent pollutant concentration reduction for BMP.

$MeanC_{outlet}$ = Mean concentration for the grab or composite collected from the outlet of the BMP from all storms.

$MeanC_{inlet}$ = Mean concentration for the grab or composite collected from the inlet of the BMP from all storms.

$$MedianPCR = 1 - \frac{MedianC_{outlet}}{MedianC_{inlet}}$$

Where:

MedianPCR = Median percent pollutant concentration reduction for BMP.

$MedianC_{outlet}$ = Median concentration for the grab or composite collected from the outlet of the BMP from all storms.

$MedianC_{inlet}$ = Median concentration for the grab or composite collected from the inlet of the BMP from all storms.

The mean and median percent pollutant concentration reduction (PCR) for each BMP are included in Table 11 through Table 14. Concentrations reported as less than the method detection limit were included in the analysis by using a value of half the method detection limit as the concentration.

A full statistical analysis of the data along with a discussion of the results will be included in the final report once a complete sample set is obtained and the statistical goals outlined in S8.F of the NPDES Permit have been met.

Table 11. Boulder Creek Upper Pond Pollutant Concentration Reduction

Parameter	Pond Inlet			Pond Outlet			Mean PCR	Median PCR
	n	Mean	Median	*n*	Mean	Median		
pH	8	6.87	6.82	10	6.59	6.6	NA	NA
Total Suspended Solids (mg/L)	9	29.2	6.9	13	4.4	3.4	85%	51%
PSD (mean size, µm)	6	10.6	10.4	10	10.4	8.3	NA	NA
Total Phosphorus (mg/L)	9	0.088	0.037	13	0.059	0.052	33%	-40%
Orthophosphate Phosphorus (mg/L)	9	0.018	0.013	13	0.018	0.011	0%	16%
Hardness (mg CaCO3/L)	9	21.4	17.5	13	36.1	34.9	-69%	-99%
Copper, Total (µg/L)	9	5.05	3.96	13	1.64	1.4	68%	65%
Copper, Dissolved (µg/L)	9	1.92	1.0	13	1.22	1.0	36%	0%
Calcium, Total (µg/L)	9	6266	5070	13	10086	9550	-61%	-88%
Magnesium, Total (µg/L)	9	1404	1160	13	2662	2680	-90%	-131%
Zinc, Total (µg/L)	9	23.9	10.5	13	3.4	3.57	86%	66%
Zinc, Dissolved (µg/L)	9	7.14	5.29	13	2.53	2.67	65%	50%
Temperature (°C)	8	10.62	10.09	10	9.9	8.48	NA	NA
Diesel Range (mg/L)[1]	9	0.095	0.095	13	0.095	0.095	NA	NA
Lube Oil Range (>C24) (mg/L)[2]	9	0.114	0.095	13	0.095	0.095	17%	NA
Fecal Coliform (CFU/100ml)	2	3300	3300	3	216	130	93%	96%

Notes:

PCR = Pollutant concentration reduction

[1] All diesel range concentrations from the pond inlet and pond outlet stations were below the method detection limit of 0.19 mg/L therefore mean and median PCR were not calculated for diesel.

[2] Lube oil concentrations from one pond inlet sample were above the method detection limit of 0.19 mg/L. All other pond inlet samples and all pond outlet samples were below the method detection limit. Since the median concentration for lube oil was below the MDL for the pond inlet and pond outlet samples, no median PCR was calculated.

Table 12. Boulder Creek Upper Sand Filter Pollutant Concentration Reduction

Parameter	Sand Filter Inlet[1]			Sand Filter Outlet			Mean PCR	Median PCR
	n	Mean	Median	*n*	Mean	Median		
pH	10	6.59	6.6	10	6.57	6.515	NA	NA
Total Suspended Solids (mg/L)	13	4.4	3.4	13	0.75	0.5	83%	85%
PSD (mean size, µm)	10	10.4	8.3	10	5.62	5.7	NA	NA
Total Phosphorus (mg/L)	13	0.059	0.052	13	0.026	0.021	56%	59%
Orthophosphate Phosphorus (mg/L)	13	0.018	0.011	13	0.011	0.008	39%	24%
Hardness (mg CaCO3/L)	13	36.1	34.9	13	34.4	32.6	5%	7%
Copper, Total (µg/L)	13	1.64	1.4	13	2.57	2.18	-57%	-56%
Copper, Dissolved (µg/L)	13	1.22	1	13	2.3	2	-89%	-100%
Calcium, Total (µg/L)	13	10086	9550	13	9705	9230	4%	3%
Magnesium, Total (µg/L)	13	2662	2680	13	2469	2350	7%	12%
Zinc, Total (µg/L)	13	3.4	3.57	13	1.8	1.6	47%	55%
Zinc, Dissolved (µg/L)	13	2.53	2.67	13	1.63	1.4	36%	48%
Temperature (°C)	10	9.9	8.5	10	10.4	9.4	NA	NA
Diesel Range (mg/L)[2]	13	0.095	0.095	13	0.095	0.095	NA	NA
Lube Oil Range (>C24) (mg/L)[2]	13	0.095	0.095	13	0.095	0.095	NA	NA
Fecal Coliform (CFU/100ml)	3	216	130	3	34.2	14	84%	89%

Notes:

PCR = Pollutant concentration reduction

[1] Pond outlet station serves as site representing the outlet of the pond and inlet to the sand.

[2] All diesel range and lube oil concentrations from the sand filter inlet and sand filter outlet stations were below the method detection limit of 0.19 mg/L therefore mean and median PCR were not calculated for these analytes.

Table 13. Boulder Creek Lower Vault Pollutant Concentration Reduction

Parameter	Vault Inlet			Vault Outlet			Mean PCR	Median PCR
	n	Mean	Median	*n*	Mean	Median		
pH	2	7.4	7.4	6	6.94	7.07	NA	NA
Total Suspended Solids (mg/L)	2	25.8	25.8	6	5.8	2.6	78%	90%
PSD (mean size, µm)	2	17.2	17.2	3	8.9	9.2	NA	NA
Total Phosphorus (mg/L)	2	0.047	0.047	6	0.058	0.041	-23%	12%
Orthophosphate Phosphorus (mg/L)	2	0.005	0.005	6	0.012	0.009	-140%	-81%
Hardness (mg CaCO3/L)	2	16	16	6	453.1	37.3	-2732%	-133%
Copper, Total (µg/L)	2	8.73	8.73	6	674.4	7.81	-7625%	11%
Copper, Dissolved (µg/L)	2	3.9	3.9	6	490.9	2.63	-12486%	33%
Calcium, Total (µg/L)	2	4840	4840	6	129628	12260	-2578%	-153%
Magnesium, Total (µg/L)	2	945	945	6	31598	1635	-3244%	-73%
Zinc, Total (µg/L)	2	38.2	38.2	6	199.6	15.8	-423%	59%
Zinc, Dissolved (µg/L)	2	12.9	12.9	6	190.53	12.25	-1377%	5%
Temperature (°C)	2	9.6	9.6	6	11.7	11.265	NA	NA
Diesel Range (mg/L)[1]	2	0.095	0.095	6	0.095	0.095	NA	NA
Lube Oil Range (>C24) (mg/L)[2]	2	0.335	0.335	6	0.095	0.095	72%	72%
Fecal Coliform (CFU/100ml)	0	NA	NA	3	114	90	NA	NA

Notes:

PCR = Pollutant concentration reduction

[1] All diesel range concentrations from the vault inlet and vault outlet stations were below the method detection limit of 0.19 mg/L therefore the mean and median PCR were not calculated for diesel.

[2] Lube oil concentrations from one sand filter inlet sample were above the method detection limit of 0.19 mg/L. All sand filter outlet samples were below the method detection limit.

Table 14. Boulder Creek Lower Sand Filter Pollutant Concentration Reduction

Parameter	Sand Filter Inlet[1]			Sand Filter Outlet			Mean PCR	Median PCR
	n	Mean	Median	*n*	Mean	Median		
pH	6	6.94	7.07	5	6.88	6.75	NA	NA
Total Suspended Solids (mg/L)	6	5.8	2.6	5	1.17	0.45	80%	83%
PSD (mean size, µm)	3	8.9	9.2	2	4.8	4.8	NA	48%
Total Phosphorus (mg/L)	6	0.058	0.041	5	0.037	0.021	36%	49%
Orthophosphate Phosphorus (mg/L)	6	0.012	0.009	5	0.018	0.011	-50%	-25%
Hardness (mg CaCO3/L)	6	453.1	37.3	4	144.9	163	68%	-337%
Copper, Total (µg/L)	6	674.4	7.81	4	7.01	7.075	99%	9%
Copper, Dissolved (µg/L)	6	490.85	2.63	4	5.40	5.705	99%	-117%
Calcium, Total (µg/L)	6	129628	12260	4	40000	46150	69%	-276%
Magnesium, Total (µg/L)	6	31598	1635	4	10905	11545	65%	-606%
Zinc, Total (µg/L)	6	199.6	15.8	4	8.41	9.585	96%	39%
Zinc, Dissolved (µg/L)	6	190.53	12.25	4	7.17	7.31	96%	40%
Temperature (°C)	6	11.7	11.265	5	11.6	11.8	NA	-5%
Diesel Range (mg/L)[2]	6	0.095	0.095	5	0.095	0.095	NA	NA
Lube Oil Range (>C24) (mg/L)[3]	6	0.095	0.095	5	0.115	0.095	-21%	NA
Fecal Coliform (CFU/100ml)	3	114	90	3	32	32	72%	64%

Notes:

PCR = Pollutant concentration reduction

[1] Vault outlet station serves as site representing the outlet of the vault and inlet to the sand.

[2] All diesel range concentrations from the sand filter inlet and sand filter outlet stations were below the method detection limit of 0.19 mg/L therefore the mean and median PCR were not calculated for diesel.

[3] Lube oil concentrations from one sand filter outlet sample were above the method detection limit of 0.19 mg/L. All sand filter inlet samples were below the method detection limit. Since the median concentration was below the MDL for both the sand filter inlet and outlet samples, no median PCR was calculated.

3.5 Program/Station Changes

No changes have been made to the sampling program, land use, drainage area, or monitoring stations that could affect the hydrology of the monitoring sites and/or the performance of the monitored BMPs.

4.0. PROJECTED WORK

King County is continuing to sample both BMPs into the 2011 water year, and expects to have collected a total of at least 12 samples at all sites during this water year. Once 12 samples have been collected at all sites, a statistical analyses of the data will be conducted to determine if the statistical requirement outlined in S8.F of the NPDES permit have been met. If the requirements have been met a final BMP report will be produced. If the requirements have not met the sampling will continue until the conditions are met.

5.0. REFERENCES

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