Quality Assurance Project Plan

Metals Concentrations from Stormwater Runoff in an Industrial Area Creek

by
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September 2005

303(d) Listing 2004 Submittals:
Mill Creek at Orillia – Dissolved Oxygen and Fecal Coliform

Waterbody Number: WA-09-1015

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Approvals

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Abstract

Industrial stormwater self-monitoring reports in Washington State have shown generally elevated levels of zinc, and to a lesser extent copper, in stormwater discharges. A plan is described for studying the impacts of industrial stormwater on zinc and copper concentrations in Mill Creek, a tributary of Springbrook Creek. The creek drainage area, which traverses a predominately industrial area in Kent, lies predominately in an industrial area. The unusually high density of industrial facilities provides an opportunity to assess the potential for stormwater runoff from industrial areas to impact receiving waters. Ambient creek water samples will be collected during “first flush” summer and fall storms following periods of no precipitation. Results will be compared with water quality standards. Clean sampling techniques and low-level metals analyses will be used.

Background

High levels of zinc, and to a lesser extent copper, in stormwater samples have been reported by some industries in self-monitoring reports to the Washington State Department of Ecology (Ecology). These reports, first required in 2003 under the Industrial Stormwater General Permit (ISGP), show that greater than 60% of industrial stormwater samples exceed the benchmark value for zinc of 117 µg/L, with over 20% exceeding 500µg/L. Benchmark values, which appear in the ISGP, are stormwater discharge concentrations below which it is presumed that water quality standards will not be exceeded. A study of a number of facilities under the ISGP in the vicinity of Kent, Washington, found that common sources of zinc in stormwater discharge include outdoor galvanized materials and motor oil and hydraulic fluid from operations on paved areas (Golding, 2005).

While benchmarks are presumptive, actual impacts on Washington State receiving waters from metals, particularly zinc and copper from industrial stormwater discharges, are not known. By monitoring zinc and copper concentrations at two sampling sites along Mill Creek, the potential for exceeding water quality standards will be investigated. The most current data, for a tributary of Mill Creek, shows elevated levels of zinc.

Springbrook Creek and its tributary, Mill Creek, traverse an industrialized area in Kent, Washington. Fifty-six facilities with Ecology permits under the ISGP are located within an 11.5 square mile portion of the Springbrook Creek/Mill Creek watershed. Mill Creek has been selected for study because of the particularly high density of industrial development in its drainage area and its small size and correspondingly low flow. The results of this case study may provide an indication of the potential for zinc and copper in the stormwater runoff from industrial facilities under the ISGP to cause an impairment of receiving water quality. An impairment of water quality from zinc and/or copper in the creek would serve as an indication that the impact of industrial stormwater runoff on receiving water, with respect to these metals, should be considered. A finding of no water quality standards exceedances in Mill Creek would provide an indication that zinc and copper impacts on receiving waters from industrial stormwater may not be a generalized problem.

Previous Sampling Results

The 1996 and 1998 section 303(d) list of impaired waterbodies included the following parameters for Springbrook (Mill) Creek: fecal coliform, temperature, dissolved oxygen, sediment bioassay, cadmium, copper, mercury, and zinc. In addition, chromium was included in the 1998 list, having been incorrectly assigned to another segment in the 1996 list. Zinc was listed for two segments of Springbrook and Mill creeks, based on two excursions from water quality standards in 1984.

The listings for cadmium, copper, mercury, zinc, and chromium were based on data from 1990 and earlier, before the superfund cleanup of Western Processing Co., Inc. This company's activities had included recycling, reclaiming, treating, and disposing of industrial wastes, including electroplating wastes. Based on a review of more recent receiving water data from King County and Landau and Associates, Johnson and Golding (2002) concluded that Mill Creek is meeting standards for cadmium, chromium, copper, and zinc and recommended that the listings be removed from the 2002/2004 list. They also sampled for mercury, which had been high in the creek before a superfund cleanup at Western Processing Co., Inc. along Mill Creek. Mercury was found at levels well below the chronic freshwater quality standard.

The finding that a majority of industries under the ISGP were self-reporting high concentrations of zinc, and to a lesser extent copper, in stormwater in western Washington suggested that receiving waters of industrialized areas may experience inputs of metals from these sources during storm events. This was not confirmed by the data reviewed by Johnson and Golding because data collected prior to a 2001 to 2003 King County study did not concentrate on the effects of stormwater during storm conditions and failed to find elevated metals concentrations.

From 2001-2003, Herrera Environmental Consultants sampled Springbrook Creek near its mouth as well as at a tributary of Mill Creek. The sampling was part of a King County water quality study of the Green/Duwamish watershed (WRIA 9). The study was conducted to develop and prioritize management actions for a salmon habitat plan (King County, 2004).

In the King County study, samples were collected during periods of base flow and stormwater events. Samples taken on a tributary of Mill Creek in an industrialized area showed four excursions from freshwater criteria for dissolved zinc (Table 1). All of these excursions occurred during storm events.

Table 1. King County (3004) Study – Excursions from Water Quality Standards, Sampling Site B-317

Date	Zinc Dissolved	Hardness	Water Quality Criterion
7 November 2002	52 μg/L	38.3	50.8 μg/L
21 January 2003	35.3 μg/L	23.8	33.9 μg/L
22 January 2003	34.6 μg/L	24.1	34.3 μg/L
17 November 2003	29.6 μg/L	19.3	28.4 μg/L

Project Description

This project will evaluate the impact of stormwater discharges from industrial areas on zinc and copper levels in Mill Creek. Sampling is to take place during three storm events during summer and fall under “first flush” conditions for which the storm events have been preceded by periods of relatively dry weather. Samples will be collected at two sites on Mill Creek: one at the location of King County sampling site B-317 and one at the mouth of Mill Creek.

Sequential auto-samplers will be used to collect samples for three storm events, each sampled for up to a 24-hour period. Four subsamples will be collected to comprise each hourly sample. The resulting metals data will be used to assess metals concentrations in comparisons to water quality standards.

Objectives

The objective of this study is to demonstrate, through a case study, the possibility that stormwater discharges from industrial facilities under the ISGP may cause an impairment of receiving waters. A secondary objective is to use the data collected to verify current section (303d) listings for Mill Creek.

King County data from a sampling site along a tributary of Mill Creek (sampling site B-317) shows that the worst case for zinc occurs during storm events, with water quality criteria exceeded on four occasions during 2002-2003 sampling events.

This study will focus on finding exceedances of water quality criteria for zinc and copper. It will differ from the King County data in three principal ways:

1. Receiving water samples will be taken during presumed worst case “first flush” conditions, during storm events in summer or fall, preceded by relatively long periods of dry conditions. The King County study included storm events throughout the wet season.

2. Hourly samples will be collected, consisting of four subsamples (one every 15 minutes) in order to compare metals concentrations with water quality criteria. This way, hourly data can be compared with water quality criteria, which are based on hourly data. This will have more efficacy for this purpose than the collection of single samples during storm events, as was done in the King County study.

3. Sampling sites along Mill Creek will include a site at the mouth of Mill Creek (where it joins Springbrook Creek). The drainage area has a more dense concentration of industrial facilities than the King County sampling site B-317.

A site map is shown as Figure 1. The figure shows water courses, USGS flow gage stations, industrial facilities with stormwater discharge permits, and sampling sites for this project.

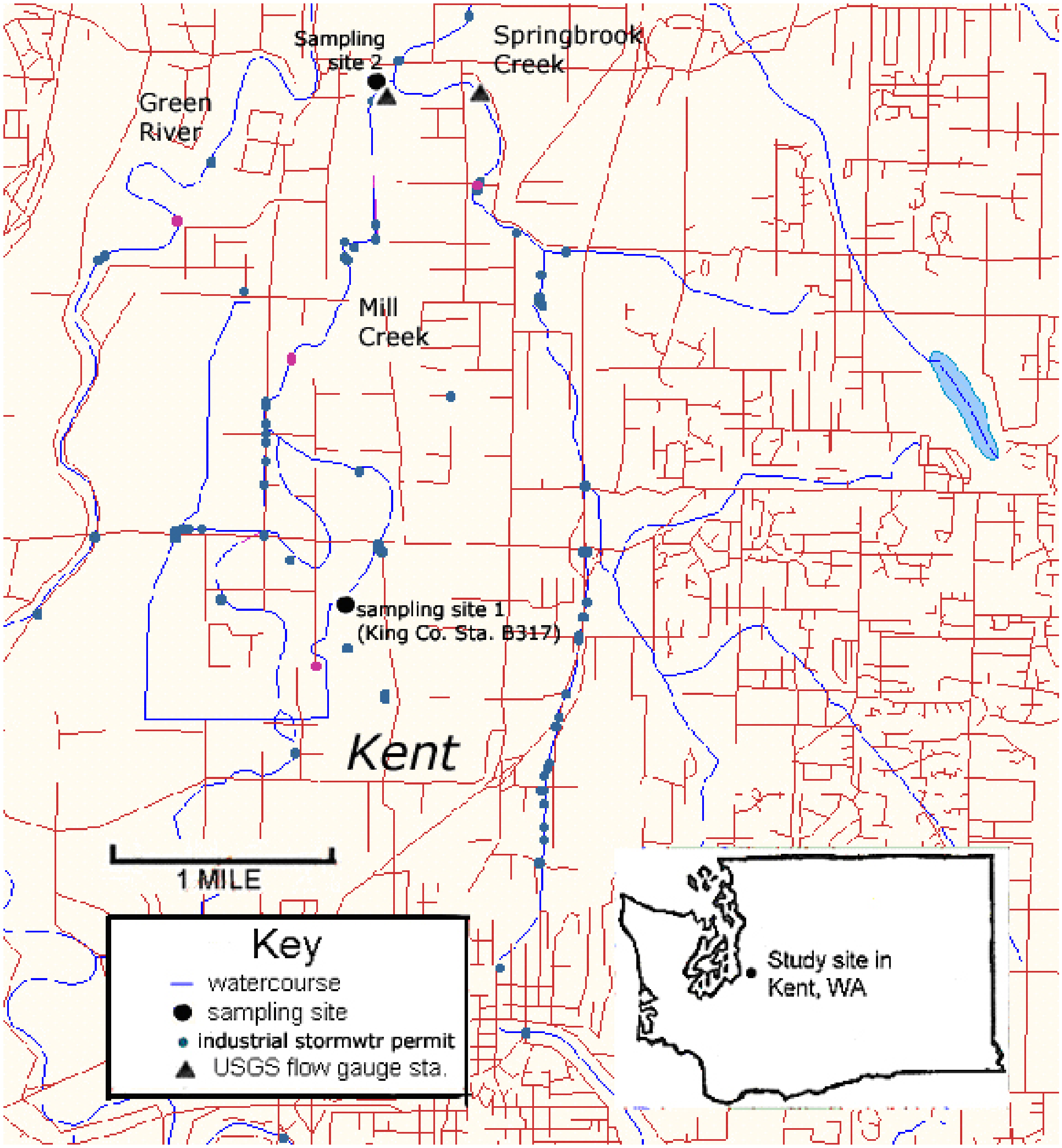

Figure 1. Study Area

Organization and Schedule

Organization

Environmental Assessment (EA) Program Project Manager – Steven Golding (360- 407-6701)
Prepare Quality Assurance (QA) Project Plan, collect data, draft and final report.

WQ Client – Ed O'Brien (360-407-6438)
Provide input for QA Project Plan, review QA Project Plan, final report.

EA Program Toxics Studies Unit Supervisor – Dale Norton (360-407-6765)
Review QA Project Plan and report.

Manchester Environmental Laboratory Director – Stuart Magoon (360-871-8801)
Manager, laboratory analyses and QA.

Ecology Quality Assurance Officer – Cliff Kirchmer (360-407-6455)
Review QA Project Plan.

EA Program – Carolyn Lee (360-407-6430)
EIM data entry.

Deliverables and Schedule

Field Work:	August 15 – October 31, 2005
Laboratory Analysis:	August 2005 – December, 2005
EIM Data Engineer:	Carolyn Lee
EIM Study Area ID:	SGOL008
EIM Study Name:	Metals in Receiving Waters from Stormwater
EIM Data Entry Completed:	April 2006
Report Lead Author:	Steven Golding
Report Draft to Supervisor:	January 2006
Report Draft to Client:	February 2006
Report Draft out for External Review:	Not Applicable
Final Investigative Report:	April 2006

Cost Estimate

The laboratory cost for this project is estimated to be $17,108 (50% discounted price at Manchester Environmental Laboratory). A cost breakdown is shown in Table 2.

Table 2. Estimated Laboratory Costs

Parameter	# Samples	Cost Per Sample	Total Cost
Low-level Zn and Cu (dissolved)	78	$55 + $24 filter	$6,162
Low-level Zn and Cu (dissolved), QA	16	$55 + $24 filter	$1,264
Low-level Zn and Cu (Total Recoverable)	78	$55 + $28 prep	$6,474
Low-level Zn and Cu (Total Recoverable), QA	16	$55 + $28 prep	$1,328
Hardness	78	$20	$1,560
Hardness, QA	16	$20	$320
Total			$17,108

Quality Objectives

The quality objectives for metals analyses for this project specify the lowest concentrations of interest to be at least 10 times lower than the applicable water quality criteria. Table 3 shows applicable water quality criteria for zinc and copper based on a hardness of 19 mg/L, a low hardness from 2004 King County data for station B317 on a tributary of Mill Creek. Because storm events and the resulting stormwater are relatively short in duration, acute criteria, rather than chronic, are generally applied and will be used to establish quality objectives for this study.

Table 3. Applicable Water Quality Criteria for Zinc and Copper

	Fresh Water Criteria	
	Acute	Chronic
Zinc	28.0 µg/L	25.6 µg/L
Copper	3.6 µg/L	2.8 µg/L

To meet the freshwater criteria of Table 3, low-level metals analysis is required. The lowest quantitation limits can be obtained by using Teflon sample bottles but this is not necessary for this project. By using standard HDPE metals collections bottles, low enough quantitation limits can be attained to evaluate compliance with water quality criteria. Reporting limits are more than an order of magnitude below the criteria, easily permitting the identification of excursions from water quality criteria. Because of the low reporting limits, a performance based approach is followed for defining measurement quality objectives (MQOs) for this project (Table 4). The MQOs are Manchester Environmental Laboratory's QC limits for the parameters/methods shown in the table.

Table 4. Measurement Quality Objectives

Parameter	Check Standards/ LCS (Recovery)	Duplicate Samples (RPD*)	Matrix Spikes (Recovery)	Matrix Spike Duplicates (RPD*)	Lowest Concentration of Interest
Zinc	85-115%	20%	75-125%	20%	28.0 µg/L
Copper	85-115%	20%	75-125%	20%	3.6 µg/L
Hardness	85-115%	20%	75-125%	20%	1 mg/L

*RPD – Relative Percent Difference (the difference between samples and duplicates divided by their mean value, expressed as a percentage).

Sampling Process Design (Experimental Design)

Samples will be collected during what are expected to be worst-case conditions for metals concentration: storm events in summer or fall, for which there have been relatively long periods of dry conditions.

Figure 2 shows 2002 dissolved zinc concentrations at King County station B317 near the Tukwila Parkway plotted against flow recorded at USGS gauging station 12113349 at Mill Creek near its mouth at Orillia. Zinc concentrations shown in Figure 2 are expressed as percent of acute criteria.

The figure also shows that high concentrations of zinc occurred during storm events rather than during drier periods of base flow (< 5 cfs). The four King County samples exceeding water criteria are shown above the 100% line.

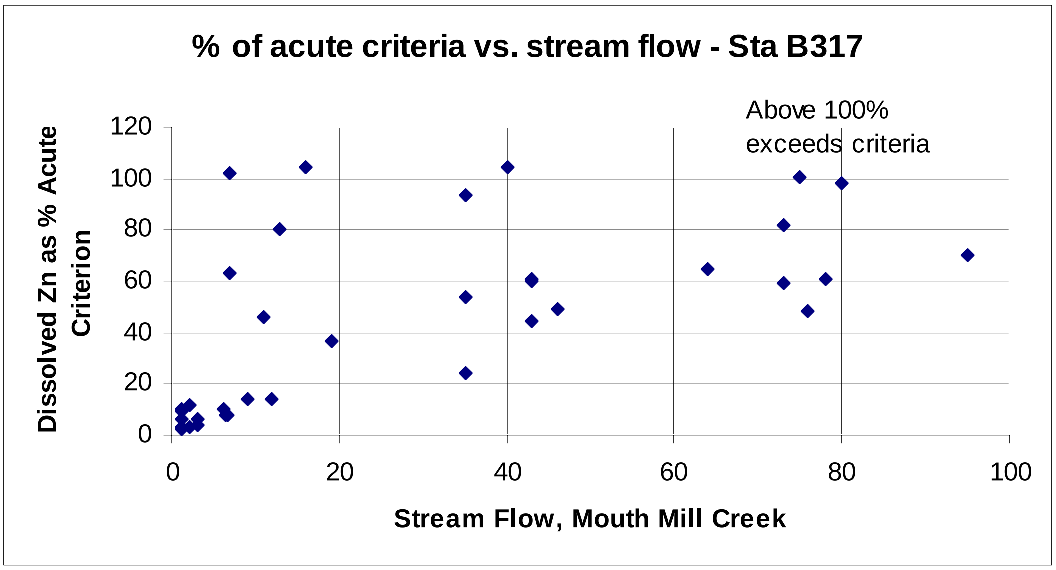

Figure 2. Dissolved Zinc vs Flow, Station B317, King County Data

Figure 2 also shows that above base flow, the relationship between data points and acute criteria do not correlate well with flow. This suggests that other factors, such as extent of antecedent dry period, may be more closely linked to exceedances of acute water quality criteria than is flow alone.

Conditions of highest metals concentrations and potential exceedances of water quality criteria can be expected during early portions of stormwater runoff from storm events preceded by periods of relatively dry conditions. The sampling design for this project calls for sampling during such storm events.

Dissolved and total recoverable zinc and copper, as well as hardness and turbidity, will be analyzed. Sampling will be opportunistic, dependent on the occurrence of storm events. Sampling will be timed to coincide with summer and fall storm events.

To aid in planning sampling deployment, delineating storm events, and determining number of preceding dry days, real-time flow and stage data for USGS gauge station 1211349 (Mill Creek near the mouth at Orillia) will be accessed at http://waterdata.usgs.gov/wa/nwis/uv?station=12113349. The station is proximal to sampling site 2 of this study.

A storm event will be defined for this study as a period of precipitation accompanied by a significant increase in flow at USGS station 1211346. "First flush" conditions, the subject of this study, may be associated with even a minor increase in stream flow. The King County study, which included not only "first flush," but storm events throughout the wet season, defined storm events as 20% increase from base flow.

The two sampling locations for this project are shown in Figure 1. Sampling site 1 is to be located at King County station B-317 (2004 study), where exceedances for zinc were found. In this way, data will be comparable to that collected for the King County study. Sampling site 2 is to be located at the mouth of Mill Creek, where it joins Springbrook Creek. This location is associated with a high density of industrial facilities in its drainage area, higher than that of site B-317. Sampling site 1 is downstream of 6 facilities with industrial stormwater permits. Sampling site 2 is downstream of 24 such facilities.

Two sequential auto samplers will be used simultaneously, one at each sampling site. Receiving water subsamples will be composited automatically at a rate of four subsamples per hour, to form hourly samples. The following sampling scheme has been devised to maximize temporal resolution at the beginning of a storm period, while sampling for a 24-hour period. A total of 13 discrete hourly samples will be collected for a 24-hour, or longer, storm.

- Discrete samples for each of the first 3 hours of storm event: 4 subsamples/hour.
- Discrete samples for every other (odd-numbered) hour, for hours 5-23.

The basis for this sampling scheme is that most temporal variability can be expected during the beginning of a storm event, with reduced variability in pollutant concentrations as the storm event continues.

Sampling by the sequential samplers will be initiated manually. Weather forecasts and radar information will form the basis of deployment of samplers at the sampling sites.

The sampling sites are within one hour of the Ecology headquarters workplace in Lacey, Washington. It is common practice in the field of stormwater sampling to deploy auto-samplers and initiate sampling manually, even when several hours are required for personnel to reach a sampling site.

Consideration was given to automatic initiation of sampling triggered by float switches set up at the receiving water sites, or by precipitation actuation. These triggering methods were ruled out for the following reasons:

- The time of unattended sampler presence would be considerably extended, presenting security risks.

- Sluggish or stagnant base-flow conditions and poorly defined, highly vegetated channels at the sampling sites during dry weather conditions would present obstacles to setting up for auto-sampling.

- Travel time in the drainage areas for the sampling sites favors direct observation of receiving water flows to determine time to actuate samplers.

- There is no provision for visual verification that stormwater discharge is occurring.

Samples will be analyzed for dissolved and total recoverable zinc and copper as well as hardness. Turbidity will be measured in the field using a ratio-type turbidimeter (nephelometer).

Table 5 shows the sampling schedule for this project. Actual sampling will be opportunistic, with dates dependent upon the occurrence of storm events.

Table 5 – Sampling Schedule for Opportunistic Sampling, August 15 – October 31, 2005

	Storm Event 1	Storm Event 2	Storm Event 3	Total
# of 1-hr samples per site	13	13	13	39
# of sites	2	2	2	
# samples, both sites	26	26	26	78
# QA samples	6	5	5	16
Total # samples	32	31	31	94
Parameters	Zn & Cu, diss. Zn & Cu, TR Hardness	Zn & Cu, diss. Zn & Cu, TR Hardness	Zn & Cu, diss. Zn & Cu, TR Hardness	94 analyses 94 analyses 94 analyses

In order to plan sampling to include flow from all industries in the drainage areas, stormwater travel time from the farthest industry from the sampling site to each sampling site has been estimated. The flow velocity in Mill Creek at USGS gauging station 12113349 near the mouth of Mill Creek was found to vary from 1.03 fps to 1.41 fps at flows varying from 19.3 cfs to 112 cfs. Based on an estimated flow velocity of 1 fps, and an approximate distance of 2 miles, the longest creek-mile distance from a permitted industry to sampling point 1 (King County sampling site B-317), a travel time to the mouth of Mill Creek is estimated to be 3 hours. The estimated travel time for the 5 miles from sampling site 2 (mouth of Mill Creek) to the farthest industry, is estimated to be 7 hours. These estimated travel times will serve as guides for the time of sampler activation from the onset of a storm event, supported by observed stream flows.

Worst case, “first flush” conditions may be anticipated to occur at some time between the travel time from the nearest source of industrial runoff to that from the farthest. Therefore, the planned sampling duration of 24 hours is expected to include worst-case conditions.

Table 6 lists sample sizes, containers, preservation, and holding times for the study parameters.

Table 6. Sample Size, Container, Preservation, and Holding Time by Parameter

Parameter (Analyte)	Sample Size	Container	Preservation	Holding Time
Dissolved Cu, Zn	500 mL	1 L HDPE bottle	Filter, HNO_3 to pH<2	6 months
TR Cu, Zn	500 mL	1 L HDPE bottle	HNO_3 to pH<2	6 months
Hardness	100 mL	125 mL n/m poly	HNO_3 to pH<2	6 months
Turbidity (field)	500 mL	500 mL w/m poly	Cool to 4º C	48 hours

Sampling Procedures

Metals sampling procedures will be based on the guidance in EPA Method 1669, *Sampling Ambient Water for Trace Metals at EPA Water Quality Levels.*

Battery operated ISCO sequential auto-samplers will be used to collect samples for metals and hardness analysis. A pre-cleaned stainless steel strainer will be attached at the intake opening of a sampler's Teflon® sampling hose. The strainer will be suspended in a well-mixed portion of the creek, well above the creek bed to prevent the collection of sediments.

The samplers, bottles, and stainless steel strainers will be precleaned by rinsing with 10% nitric acid followed by three rinses with deionized water. The silastic tubing used in the peristaltic pumps of the auto samplers will be replaced with new silastic tubing before each storm event to prevent metals contamination.

Each sequential sampler holds 24 HDPE bottles on ice. Thirteen bottles will be pre-cleaned with 10% nitric acid, followed by three deionized water rinses. During sampling, the bottles will be automatically filled one at a time, with subsamples timed at 15 minutes, for a total of 4 subsamples in each bottle, to represent each one-hour period of sampling. After the first four hours of collection, sampling frequency will be reduced to every other hour. The final sample (hour 23) will be collected four hours from the sample before it (hour 19).

A pre-cleaned stainless steel strainer will be attached at the opening of the Teflon sampling hose and the strainer will be suspended above the bed of the creek to be sampled in order not to pick up sediment. The strainer will be placed in a well-mixed portion of the receiving water.

At the end of the sampling period, the bottles will be removed from the auto sampler and each of the 13 bottles filled will form a sample representing one hour of storm.

Samples for total recoverable metals analysis and hardness will be poured into 1-liter HDPE bottles provided by Manchester Environmental Laboratory (MEL) for metals samples. Dissolved metals samples will first be filtered in the field with pre-cleaned 0.45 µm Nalgene disposable filter units (#450-0045, type S). Filtering will be done in a glove box constructed of a PVC frame and polyethelene cover. Powder-free nitrile gloves will be worn to prevent sample contamination.

All metals samples will be acidified in the field with HNO_3 from ultra-cleaned Teflon® vials supplied by the MEL.

Field activities will be recorded in a notebook on waterproof paper. A hand-held GPS will be used to record sampling locations. All samples will be held on ice for transport to Ecology headquarters. All samples will be kept in a secure cooler and transported to MEL within one-to-two days of collection. Chain-of-custody procedures (Manchester Environmental Laboratory, 2003) will be followed.

Measurement Procedures

Receiving water turbidity will be measured at each sampling site at least three times per storm event. Turbidity samples will be collected as grab samples, the samples shaken and immediately poured into the sampling cell of a portable ratio-type nephelometer.

Table 7 shows the analytical methods for this study.

Table 7. Measurement Method

Analyte	Samples {Number/ Arrival Date]	Expected Range of Results	Reporting Limit	Sample Preparation Sample Preparation Method	Analytical Method
TR Zinc in water	32/ Aug - Oct (opportunistic)	50 – 1000 µg/L	5 µg/L	Digested with mixture of NO_2 and HCL	EPA 200.8 ICP-MS
Diss. Zinc in water	32/ Aug – Oct (opportunistic)	10 – 700 µg/L	1 µg/L	--	EPA 200.8 ICP-MS
TR Copper in water	32/ Aug - Oct (opportunistic)	1 – 100 µg/L	0.1 µg/L	Digested with mixture of NO_2 and HCL	EPA 200.8 ICP-MS
Diss. Copper in water	32/ Aug - Oct (opportunistic)	1 – 100 µg/L	0.1 µg/L	--	EPA 200.8 ICP-MS
Hardness	32/ Aug-Oct (opportunistic)	1-150 µg/L	1 mg/L	Hardness by calculation	EPA 200.7 ICP
Turbidity	32/ Aug - Oct (opportunistic)	2 – 100 NTU	0.02 NTU	--	Std. Method 2130

Quality Control Procedures

Field

Calibration of the portable nephelometer will be performed prior to the field season with known formazin standards. Additionally, the meter will be verified with each use by measuring the turbidity of know portable Gel-ex secondary standards.

Two filter blanks and two total recoverable metals blanks will be analyzed to detect potential contamination from sample containers, the filtration procedure, preservative, or sample handling. The transfer blanks will be prepared by pumping deionized water through the auto-sampler to be collected in one of the auto-sampler's collection bottles. Before use, the deionized water will be stored in organics-free bottles with Teflon lids. Filtration blanks will be prepared using the same procedure, with blank water poured from auto-sampler bottles into the filter apparatus. Two hardness field blanks will also be prepared by pouring deionized water into hardness collection bottles.

Laboratory

Laboratory QC samples will include check standards/laboratory control samples, method blanks, analytical duplicates, matrix spikes, and matrix spike duplicates.

Duplicates for metals and hardness analyses will be selected by MEL, following their standard practice. Samples for spike and spike duplicate analysis will be identified on the sample tags and the Laboratory Analysis Required form.

Data Management Procedures

The field and laboratory data will be entered into Excel spreadsheets and into Ecology's EIM system. Hardness results will be used to calculate the water quality criteria corresponding to each sample, using the Ecology spreadsheet tsdalc11.xls (www.ecy.wa.gov/programs/eap/pwspread/pwspread.html). Excursions from the criteria will be identified.

Audits and Reports

The project lead will prepare a draft report of findings February 2006 or before. A final report will be published April 2006 or before. The report will include:

- Map of the area showing sampling sites.
- Description of field and laboratory methods.
- List of dates of sampling and corresponding USGS flow data for Mill Creek.
- Discussion of data quality and the significance of any problems encountered in the analysis.
- Summary table of field and laboratory data.
- Results from data analysis.
- Comparison of results with water quality standards.
- Conclusions and recommendations.

Data Verification and Validation

Data Verification

MEL will conduct a review of all laboratory data and case narratives. MEL will verify that methods and protocols specified in the QA Project Plan were followed; that all calibrations, checks on quality control, and intermediate calculations were performed for all samples; and that the data are consistent, correct, and complete, with no errors or omissions. Evaluation criteria will include the acceptability of holding times, instrument calibration, procedural blanks, spike sample analyses, precision data, laboratory control sample analyses, and appropriateness of data qualifiers assigned. Manchester will prepare written data verification reports based on the results of their data review. A case summary can meet the requirements for a data verification report.

Data Validation

To determine if MQOs have been met, check sample, duplicate sample, matrix spike, and spike duplicate results will be compared with the MQOs for this project (Manchester Environmental Laboratory's QC limits for this project – Figure 3).

To evaluate whether the targets for reporting limits have been met, the results will be examined for "non-detects" and to determine if any values exceed the lowest concentration of interest.

Data Quality (Usability) Assessment

Data quality will be assessed to determine if the data can be used to meet the project objectives. If there are cases for which MQOs have not been met, these will be evaluated in terms of whether corresponding project objectives can still be met.

A determination of whether sufficient data were obtained to meet project objectives will be made. If the project outcome finds significant exceedances of water quality criteria, data quantity and kind will be deemed sufficient. If not, an assessment will be made as to the adequacy of data and its kind (whether worst-case storms were represented).

It is the nature of the objective of this project that a positive finding of exceedances in one-hour representative samples will indicate that that project objectives have been met. A negative finding, on the other hand, may lead to an inconclusive assessment of whether the extent of data collected was adequate. The extent of data collected for this project is, at the outset, known to be limited to a single season of antecedent dry storms at only two locations. The finding by King County (2004) of single grabs exceeding water quality criteria has supported the project goal of finding exceedances of water quality criteria.

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