

Water Quality Study Design Quality Assurance Project Plan

for

Swamp Creek
Fecal Coliform Bacteria
Total Maximum Daily Loads

Swamp Creek Assessment Sampling
City of Kenmore

August 2008

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Approvals

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Table of Contents

Abstract	1
Introduction.....	2
Applicable Water Quality Standards	3
Basin Descriptions	4
Swamp Creek	4
Pollution Sources	4
Impaired Areas.....	5
Swamp Creek	5
Existing Monitoring Programs.....	6
King County.....	6
Snohomish County.....	6
Project Description.....	7
Relationship of this Monitoring with Existing Programs	7
Organization and Schedule	8
Project Budget.....	8
Data Quality Objectives.....	9
Upstream/Downstream Differences.....	10
Trends Over Time.....	10
Sampling Process Design.....	10
Sampling Procedures	11
Overview.....	11
Planning	11
Field Procedures.....	11
Fecal Coliform Sampling.....	11
Sampling procedure	12
Field Quality Control	13
Measurement Procedures	15
Field	15
Station Information	15
Discharge Measurements	16
Office	17
Stream Discharge Data	17
Lab	17
Fecal Coliform - Membrane Filtration Method	17
Quality Control	18
Field	18
Station Information	18
Field Notes	18
Fecal Coliform Bacteria.....	19
Laboratory.....	19
Fecal Coliform	19
Data Qualifiers	19
Data Management Procedures	20
Recording Field Measurements	20

Audits and Reports.....	21
Data Verification, Validation, and Review.....	21
Verification.....	21
Validation.....	22
Review.....	22
Data Quality (Usability) Assessment.....	22
References.....	23

List of Figures and Tables

Figure 1. Swamp Creek Watershed	3
Table 1. Current Water Quality Statistics in Swamp Creek	6
Table 2. Roles and Responsibilities for TMDL-related monitoring	8
Table 3. Projected Monitoring Budget for a typical year	9
Table 4. Quantitative Data Quality Objectives	10
Table 5. Summary of Field and Laboratory Quality Control Procedures.....	18
Table 6. Data Qualifiers by Ecology’s MEL	20

Appendices

- Appendix A— Letter from Ecology—July 5, 2007 Re: QAPP Extension Request
- Appendix B— Discharge Measurement Practices, Snohomish County Surface Water Management
- Appendix C—Year #1 Monitoring Stations Map
- Appendix D—Chain of Custody Form

Abstract

Swamp Creek is located in WRIA 8 and flows south, from north of Everett to its terminus in the City of Kenmore, where it discharges into the Sammamish River, just up stream of the river's union with Lake Washington. This stream was listed by the State of Washington under Section 303(d) of the federal Clean Water Act for failing to meet the U.S. Environmental Protection Agency (EPA) human health criteria for fecal coliform. A Total Maximum Daily Load (TMDL) Report and Implementation Plan for Swamp Creek was submitted by Ecology and approved by EPA in August 2006. This Quality Assurance Project Plan (QAPP) describes the procedure that will be used to track fecal coliform levels and assess major drainage areas for potentially elevated coliform levels within the City of Kenmore.

The objective of this five year monitoring plan is to provide information to track and ultimately identify potential drainage areas that may contain major fecal coliform sources in that portion of the Swamp Creek Basin lying within the City of Kenmore. Long-term monitoring stations previously established and routinely maintained by King and Snohomish Counties, provide information on baseline levels of bacteria in lower Swamp Creek and track the levels of coliforms entering and leaving the City.

The City of Kenmore will conduct an assessment of surface water runoff within its jurisdiction to augment these baseline studies in order to determine potential sources and assess if any additional long-term monitoring is warranted. This plan presents an approach to collect and analyze monthly coliform grab samples at five sampling stations on an annual basis, as well as monitor flow at the 73 Avenue Bridge (King County Flow Site 56b), per the requirements of p.11 of Appendix 2 of the City of Kenmore NPDES Phase II Permit.

Introduction

Swamp Creek is polluted by bacterial pollution from a variety of sources throughout the watershed. Although the specific sources have not been identified, many of the potential sources are believed to come from humans and/or human activities, including pet wastes, failing septic tanks and illegal discharges. As a result of the bacterial pollution problem, the Department of Ecology (Ecology) developed the Swamp Creek Fecal Coliform Total Maximum Daily Load Detailed Implementation Plan, (Svrjcek 2006). In this plan, Ecology established water quality monitoring requirements for local municipalities that collect, treat, and convey stormwater.

The sources of bacterial pollution affecting Swamp Creek are not clearly understood at this time. Monitoring may help with source identification, while providing a record of results needed to observe long-term trends. The TMDL Submittal Report documented that bacterial pollution was a significant problem in the main stem of Swamp Creek. Additional monitoring, conducted by Snohomish County, established that a number of upper watershed areas are polluted as well and contribute to the elevated levels passing through the City of Kenmore. Data collected to date by the two counties, shows coliform concentrations increasing within the creek as it passes through the City of Kenmore prior to discharge into Lake Washington.

Currently, three of the six sampling sites within the Swamp Creek watershed are located within the City of Kenmore. The current water quality monitoring program for Swamp Creek is shown in Figure 1. Within the City of Kenmore, coliforms are being monitored as the creek flows into and out of the City. A flow station is located approximately mid-way between the two water quality monitoring stations.

This Quality Assurance Project Plan (QAPP) is designed to meet Ecology requirements for water quality monitoring related to the Swamp Creek TMDL. The City of Kenmore understands the need to identify the local bacterial pollution problems and reduce coliform concentrations within Swamp Creek. The City also understands the importance of working together with other local municipalities including Everett, Lynnwood, Mountlake Terrace, Brier, and Bothell to achieve water quality objectives within the watershed. The water quality monitoring activities for the City of Kenmore to support those efforts are detailed in this document. The existing King and Snohomish County monitoring programs satisfy the TMDL-related permit requirements of identifying baseline concentrations. The City of Kenmore has proposed an assessment program to track coliform levels and monitor major drainage areas (for elevated concentrations) within the City.

The City of Kenmore's surface and stormwater management program began in 1998 when the City was formed from within unincorporated King County. Kenmore has a stormwater utility and a citywide comprehensive stormwater management plan. This plan is currently being updated for compliance with the Department of Ecology NPDES Phase II Municipal Stormwater Permit.

Applicable Water Quality Standards

Federal and State water quality standards for Swamp Creek are designed to protect Lake Washington—one of the most important recreational waterbodies in Washington State. State Water Quality Standards (Washington Administrative Code 173-201A) establish the use of primary recreational contact for both Swamp Creek and Lake Washington. The Standard requires that water quality in these receiving waters meet a geometric mean of 50 cfu/100mL, and an upper 10th percentile value not to exceed 100 cfu/100 mL.

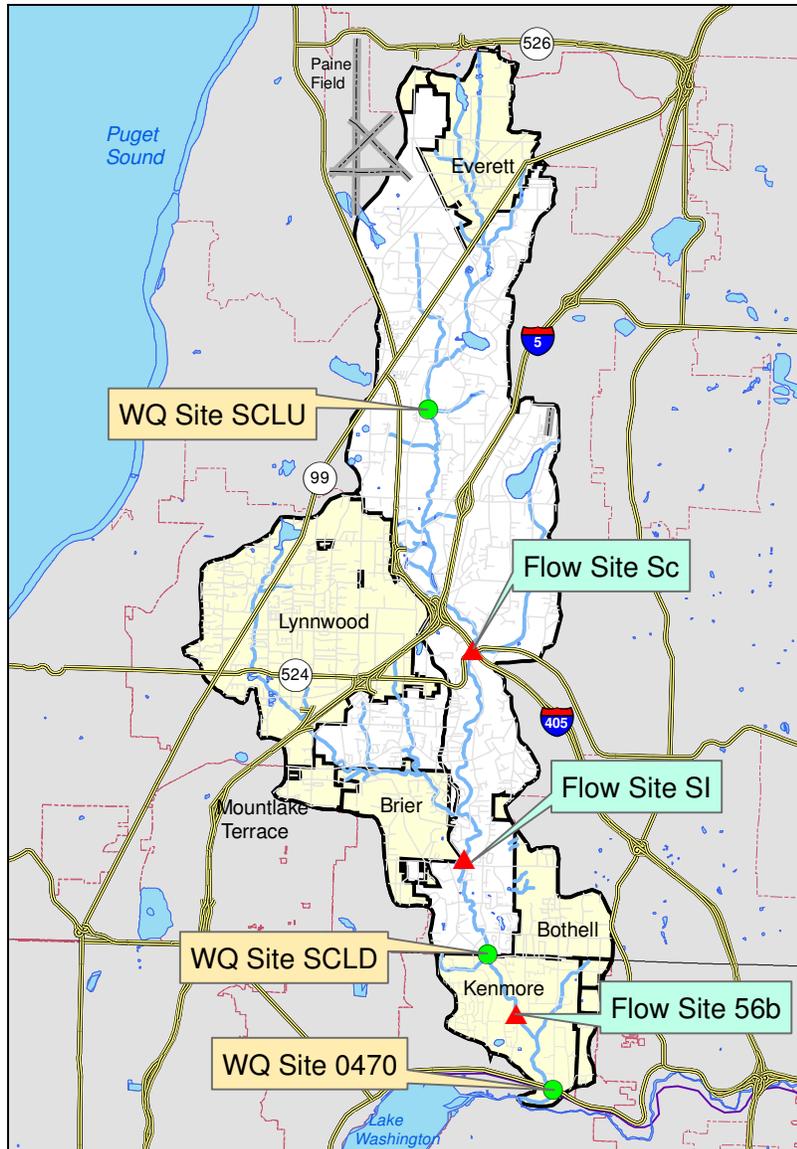


Figure 1. Swamp Creek Watershed. Current long-term monitoring sites are indicated by green dots. Flow gauging sites shown by red triangles.

Basin Descriptions

Swamp Creek

Swamp Creek is typical of Puget Sound lowland watersheds. In the gently sloping upper basin, Swamp Creek flows through a narrow valley which gradually broadens to a floodplain almost $\frac{3}{4}$ of a mile wide in the lower basin. The middle basin contains a narrow valley with steep slopes in excess of 15 percent just south of the I-405 and I-5 crossing. Elevation in the headwaters is approximately 520 feet, while the elevation at the mouth is about 20 feet above sea level. The stream gradient is flat, decreasing from about 50 feet per mile in the upper basin to less than 20 feet per mile near the mouth. Scriber Creek, Little Swamp Creek, and Martha Creek are the largest of the 19 streams tributary to Swamp Creek. Major lakes in the Swamp Creek watershed are Scriber Lake, Martha Lake, and Stickney Lake (SWM 1994, 2000).

Most of Swamp Creek and its tributaries are shallow and unsuitable for full-immersion swimming activities. However, several noteworthy exceptions are Wallace Park in the City of Kenmore, Lake Martha, and Lake Stickney. Scriber Lake in Lynnwood is large enough and deep enough for swimming but this activity is not encouraged by the city. Although public access to the creek is largely limited to road crossings and a few parks, Swamp Creek is fully accessible to adjacent landowners, their children, and in some cases their neighbors. Limited boating opportunities exist where Swamp Creek meets the Sammamish River. The watershed is located within the US Census Defined Urbanized Area; therefore, it is expected that population growth and urban development will be concentrated in this area. Road density is highest in the Scriber Creek subbasin (Svrjcek 2006).

Kenmore has a population of about 19,000 and is primarily a residential community, with small commercial area along State Highway 522. The City is located in King County, just upstream of the confluence of the Sammamish River and Lake Washington. Swamp Creek flows through the middle of the City and joins the Sammamish River at the southernmost boundary of the city. The City comprises about eight percent of the Swamp Creek watershed. It is located at the terminus of the Swamp Creek watershed and, consequently, all pollution generated upstream flows through the City of Kenmore.

Pollution Sources

Coliform pollution usually comes from a combination of both point and non-point sources. Nationally, one of the major non-point source contributions is urban stormwater runoff, which includes municipal stormwater discharges currently covered by National Pollutant Discharge Elimination System (NPDES) stormwater permits¹.

Non-point water pollution most commonly results from land use related activities, such as inadequate agricultural practices, failing onsite septic systems, and untreated stormwater

¹ See the following website for more information: <http://www.epa.gov/ow/regs/permit.html>

runoff that does not come from municipal separate storm sewer systems (MS4s). Where stormwater comes from rural areas it may carry wastes from domesticated animals. Stormwater from the more urban areas is likely to carry pet wastes directly into nearby streams. Hobby farms are common on larger parcels within the Swamp Creek watershed. Urban and suburban development is continuing in the Swamp Creek watershed, increasing the water quality impacts from stormwater runoff.

Current non-point source pollution controls within the City of Kenmore, as currently practiced by the City, include:

- Public Education and involvement
- Management and maintenance of the City's storm sewer system
- Legal authorities and ordinances (i.e., pet wastes, illegal discharges, etc.)
- Pet waste management
- Proposed assessment monitoring (as proposed in this QAPP)
- Interagency coordination

Impaired Areas

Swamp Creek

Swamp Creek was included on Washington's 1996 303(d) list because of numerous exceedances of fecal coliform bacteria standards, as monitored and documented by Ecology. Since the year 2000, a consistent pattern of bacterial pollution has been observed in Swamp Creek at each of the three long-term stations (Figure 1). All areas exceed state criteria for bacteria at all times of the year (Table 1). During the dry summer months when stream flows are low, bacteria levels rise far beyond both the geometric mean criterion of 50 cfu/100 mL and the 90th percentile criterion 100 cfu/100 mL. During the wetter months of the year, bacteria concentrations improve at each site (possibly due to dilution from increased runoff conditions), but not enough to meet state standards. For these reasons, Ecology established a TMDL for Swamp Creek.

Snohomish County performed water quality studies in Swamp Creek in the early 1990s. One study was conducted above station SCLU and the other was done as part of a larger one-year urban monitoring program. The purpose of the study was to examine the quality of water coming from residential, mixed, or small farmland uses. Although it turned out to be difficult to clearly show the effect of each type of land use, none of the five locations monitored met state bacteria standards. Fourteen Swamp Creek sites were tested as part of the urban monitoring study—11 out of the 14 sites exceeded state bacteria thresholds.

Table 1. Current Water Quality Statistics in Swamp Creek Watershed.

(Data from 2000 through 2004 show that all state criteria for bacteria are exceeded for wet and dry seasons. Bacteria levels are much higher in dry weather months.)

Monitoring Location	Dry Season			Wet Season			State Standards	
	# of Samples	GMV	90 th percentile	# of Samples	GMV	90 th percentile	GMV	90 th percentile
SCLU (upper Swamp Creek)	16	343	2,688	34	66	636	50	100
KC BB470/ SCLD (county line)	25	176	459	70	86	310	50	100
KC 0470 (mouth)	28	300	1,260	47	131	674	50	100

GMV refers to the geometric mean value criterion and 90th percentile refers to the 90th percentile criterion.

Existing Monitoring Programs

As noted in Table 1, Snohomish County and King County have conducted either local characterization monitoring or they have an ongoing monitoring program in place now. A discussion of monitoring conducted by these entities is provided below.

King County

King County performs water quality monitoring and flow gauging in the Swamp Creek basins as shown in Figure 1. Water quality monitoring is done for temperature, pH, dissolved oxygen, turbidity, conductivity, total suspended solids, total phosphorus, total nitrogen, ortho phosphate, ammonia, nitrate/nitrite, fecal coliform, and sometimes metals. King County has also performed selected characterization monitoring at various times since the 1970s. The County is committed to continuing this monitoring effort for the foreseeable future (personal communication Bob Brenner, Water Quality Planner, King County, September 2007).

(Note that this monitoring by King County satisfies some of the base line sampling that would normally need to be performed by the City of Kenmore. Should the County decided to discontinue this monitoring; the City may need to assume similar monitoring on an annual basis. It is our understanding that the County has discontinued flow monitoring at Flow Site 56b in 2001, but has continued coliform monitoring at WQ Site 0470. The City has included flow monitoring at the 73rd Avenue Bridge (King County Flow Site 56b) and additional coliform monitoring at Site 0470 in this QAPP, in addition to coliform monitoring and flow measurements at four additional sites.)

Snohomish County

Snohomish County performs regular water quality monitoring and flow gauging in the Swamp Creek basin as shown in Figure 1. Water quality monitoring is done for temperature, pH, DO, turbidity, conductivity, TSS, total phosphorus, total nitrogen, ortho phosphate, ammonia, nitrate/nitrite, fecal coliform, and sometimes metals. Snohomish County has also performed selected characterization monitoring at various times in previous years. They will continue this monitoring and also plan to add additional parameters to determine sources of bacterial contamination in the coming year (2008) (personal communication Steve Britch, Water Quality specialist, Snohomish County, September 2007).

Project Description

There are two goals associated with this City of Kenmore QAPP. The first goal is to comply with the requirements of the Swamp Creek TMDL. This goal will be met by monitoring stream flow at a reconstructed stream gage below the 73rd Avenue Bridge (King County Flow Site 56b), and by continued monitoring of stream flow and coliform concentration at the USGS Gaging station near the intersection of Bothell Way (SR 522) and 80th Avenue North (Site 0470; See Figure 1). Analysis from data collected at these sites will allow City scientists to document trends in flow duration, and coliform concentration after five years of monitoring.

The second goal is to collect samples to track and monitor major drainage areas for potential sources of coliforms within the City of Kenmore. Sample collection at five sites per year is being proposed in order to identify coliform sources within the lower Swamp Creek Drainage network. Locations for the five sites have been included in Appendix C. The sampling locations will be positioned along the main channel and three major tributaries in the Swamp Creek drainage network.

Relationship of this Monitoring with Existing Programs

Long-term monitoring currently performed by King and Snohomish Counties is important. Flow gauging stations operated by these entities are critical for establishing when stream flow is dominated by stormwater runoff. (Note that flow monitoring by King County at Site 56b was discontinued in 2001.) Water quality assessments to be performed by the City of Kenmore will compliment this long term trend monitoring, by attempting to track coliform levels and monitoring potential elevated concentrations from major drainage areas within the City.

In addition to the long-term monitoring stations that have been established and will continue to be monitored by King and Snohomish Counties, the City of Kenmore will conduct a long-term monitoring within the City limits to track coliform levels. This monitoring program will consist of sampling fecal coliform bacteria at five sites located between the Snohomish County monitoring station to the north and includes the King County monitoring station to the south (King County Flow Site 56b). Sampling includes the selection of monthly grab

samples and flow measurements at each of the five sites, in addition to monthly flow monitoring at 73rd Avenue Bridge (King County Flow Site 56b).

Organization and Schedule

Table 2 below describes the roles and responsibilities of staff involved in this project.

Table 2. Roles and Responsibilities for TMDL-related monitoring.		
Name/Address	Title	Responsibilities
Kent Vaughan	City of Kenmore Senior Engineer	Responsible for overall project supervision
Consultant (TBD)		Responsible for preparation of QAPP, project design, collecting and analyzing data, developing graphs and writing final report for the Bacterial Pollution Remediation Plan (BPRP).

The following schedule is proposed for this QAPP:

Prepare Draft QAPP for internal review:	July 2008
Submittal QAPP to Ecology for approval	August 2008
Begin assessment of Swamp Creek potential sources	August 2008
Conduct Year #1 sampling	September-December 2008
Prepare Year #1 report and submit to Ecology (w. NPDES II Annual Rpt)	March 2009
Prepare annual report for Bacterial Pollution Remediation Plan	August 2011
Data analysis near end of permit cycle	August 2012

Limitations: There are no known limitations imposed on the proposed schedule by factors such as weather, seasonal conditions, and equipment availability. However, such limitations will be addressed accordingly if they occur. Flows in Swamp Creek are known to get very high at times and only the most dramatic conditions are expected to have any potential effect on the sampling program. Should problems develop they will be reported through annual BPRP/SWMP reporting.

Project Budget

Field Labor Costs

Coliform sampling and flow measurements will be performed monthly at each of the five sites, with flow sampling occurring at the 73rd Avenue Bridge site (King County Flow Site 56b). Stream discharge measurements will be performed during each visit as coliform samples are collected. This approach will generate the required 60 samples per year, plus 12 QA/QC samples.

The approach will be to collect samples and flow measurements from all five stations and the flow measurement at the 73rd bridge (King County Flow Site 56b) on a single day. (Note that no additional costs have been included to recalibrate the flow gauge at the 73rd Avenue Bridge.) (Budget estimate: 16hrs=\$1,250/day; \$15,000annually.)

Analysis and Reporting

Analysis and Reporting includes three main tasks: 1) the initial reduction and interpretation of the field data, 2) the preparation of client reports, 2) the coordination and management of monitoring, analyses, and report writing, and 3) the production of the annual Ecology report. (Budget estimate: \$7,500/year.)

Laboratory Costs

Sixty coliform samples plus twelve QA samples (a total of 72 vials of water) will be collected each year. All of these samples will be analyzed for fecal coliforms. (Budget estimate: \$2,000.)

Summary of Projected Monitoring Budget

Expenditure Type	2008 4 mo @ Monthly	2009 12 mo @ Monthly
<i>Field Work</i>	\$ 3,800	\$ 15,000
<i>Laboratory Costs</i>	400	2,000
<i>Analysis and Reporting</i>	7,500	7,500
<i>Project Management</i>	500	2,500
<i>Direct Expenses*</i>	250	1,500
<i>Annual Total</i>	\$ 12,150	\$ 28,500

Data Quality Objectives

Data quality objectives are qualitative and quantitative statements of the precision, bias, representativeness, completeness, and comparability necessary in order for the data to address project objectives. The primary indicators of data quality are precision and bias, which, together, express the data's accuracy.

Precision, expressed as the standard deviation of replicate sample analyses, is a measure of data scatter due to random error, while bias is a measure of the difference between the result for a parameter and the true value due to systematic errors. Potential sources of errors include sample collection, physical and chemical instability of samples, interference effects,

instrument calibration, and contamination. Random error affects the determination of bias; thus bias estimation may be problematic. Consequently, dedication to established protocols is one method used to reduce concern over sources of bias (Lombard and Kirchmer, 2001).

Fecal coliform bacteria levels are highly influenced by the biological component in the aquatic environment and can be subject to sample contamination problems. Table 4 below summarizes the laboratory accuracy and analytical reporting limits for parameters that can reliably be used for decision-making. Seasonal sampling and other sampling design features will be used to better evaluate critical conditions on which to determine water quality compliance with state bacteria standards.

The goals for evaluating the impacts to water quality require the ability to detect “differences.” These differences can be based on: (1) a simple comparison of upstream and downstream locations (e.g., “bracketing” and BMP effectiveness evaluations), or (2) determining a trend over time at points on a stream in the absence of changes to upstream land-use activities.

Table 4. Quantitative Data Quality Objectives				
Analysis	Accuracy % deviation from true value	Precision Relative Standard Deviation	Bias % deviation from true value	Required Reporting Limits (concentration)
Laboratory Analysis				
Fecal Coliform (MF)¹	N/A	RSD \pm30%	N/A	1 colony forming unit per 100 mL

¹ Using Standard Method 9222D

Upstream/Downstream Differences

Sources of very high fecal coliform concentrations, such as failing septic systems or leaking sewer lines, can have severe effects on overall stream concentrations even when the volume discharged is low. However, when the concentration upstream of a source is high the change due to the source can be difficult to separate and quantify.

Trends Over Time

The ability to detect changes in water quality (trends) is the objective of a long-term sampling design. A historical perspective, which only long-term records can provide, is necessary in order to make informed decisions regarding water quality assessments. These long-term needs are currently satisfied by the stations maintained by King and Snohomish Counties, as Swamp Creek passes through the City of Kenmore.

Sampling Process Design

In order to determine if and where a long-term monitoring station is needed, beyond the information being provided by King and Snohomish Counties, an assessment of possible contributing sites will be conducted.

Sampling related to the TMDL is limited to bacterial pollution measured using fecal coliform testing. Although Ecology encourages monitoring of temperature and dissolved oxygen levels as well, these additional parameters will not be taken at this time.

The frequency of the assessment monitoring for the Swamp Creek will be 60 grab samples collected per year over the next five years, as determined by the City and Ecology.

Sampling Procedures

Overview

Ambient level of fecal coliform bacteria is the preferred indicator of disease-causing microorganisms in Washington State. There are two standard methods for the detection of coliform bacteria, the Membrane Filter (MF) technique and the Most Probable Number (MPN) index. The MF and MPN methods are frequently not comparable. The US Environmental Protection Agency (EPA) currently recommends the MF procedure because it is faster and more precise than the MPN technique (EPA, 2001). However, MPN is better for use in chlorinated effluents, highly turbid waters, and salt or brackish waters. Ecology requires all partners in this program to have samples analyzed by state-accredited laboratories using the Membrane Filter technique SM9222D. Samples collected for this project will be analyzed by AmTest Laboratories in Redmond, Washington <http://www.amtestlab.com>.

Planning

Bacteria samples must be collected in sterilized bottles. Because there is a relatively short holding time and culture medium must be prepared ahead of time, it is important to prearrange sampling with the laboratory.

A Sampling Checklist, Field Work Plan, and sample label template is provided in Appendix F. A chain-of-custody form from AmTest Laboratories is also provided in Appendix E.

Ecology recommends that data be collected in a format consistent with the Ecology Environmental Information Management (EIM) database. To accomplish this, each station will need a user location ID that is unique within EIM. Ecology will assist Kenmore in developing these. Guidance on the use of EIM is found on Ecology's website at <https://fortress.wa.gov/ecy/eimimport/submit.htm>.

Field Procedures

Fecal Coliform Sampling

Ambient water quality samples collected as part of this QAPP will generally use the “dipping method.” The dipping method is intended to collect the most representative sample taken at a single point in time (also called a grab sample). Field personnel will avoid collecting water from near the surface and will collect samples from the center of flow (thalweg) when possible.

Field measurements and comments are recorded on either a form prepared prior to sampling, ideally in a notebook of water resistant paper, or loose-leaf water resistant paper. All notes should be photocopied and stored in a safe location after a sampling run. Project name, station location, date and time of sample collection, and sample number should be recorded, at a minimum. Other useful information may include staff gauge or tape down measurements, estimates of discharge, field quality control information, field meter measurements if applicable, weather conditions, and comments about turbidity, color and odor.

A word about safety: Safety is a primary concern whenever working in or near waterbodies. In addition, many sampling locations are sited close to roadway crossings to facilitate access in right-of-ways and to reduce travel times to the actual sample site. The need for life vests, reflective clothing, orange marking cones, and flashing lights should be considered to protect field personnel in the event of a fall into the water, and to alert drivers to workers’ presence on the roadside.

The general procedures for taking a proper fecal coliform sample are discussed below.

Sampling Procedure

1. A sterilized sample container provided by the accredited laboratory will be used. The minimum sample size is 250 mL. Both polypropylene and glass bottles are considered acceptable.
2. A sample pole may be used for reaching the thalweg quickly and conveniently. (Such as a boat hook fashioned with a burette clamp or two hose clamps fastened to the end of the pole.) Caution will be taken not to contaminate the pole with sediments or other substances that increase the likelihood of contaminating the sampling process.
3. For sites that may require entering the stream, care will be taken to not stir up sediment. Approaching sites from downstream will be done in all possible cases. Where this is not possible, allow the flow to dissipate any stirred up sediment before proceeding to sample. Face upstream, preferably in the portion of the channel with predominant flow.
4. Uncap the sample bottle, leaving the aluminum foil on the cap. Be careful not to contaminate the inside of the bottle, cap, or aluminum foil with your fingers, dirt, water dripping from bridges or other sources.
5. Invert the bottle and plunge it mouth down through the surface to a depth of 15 to 30 cm (6 to 12 inches, mid-depth of stream where feasible). While under water, rotate the mouth of the bottle into the current. Bring the upright sample bottle back through the surface. Pour off enough water until the water level is at the shoulder of the bottle. This allows room for mixing the sample before analysis at the lab.

6. Recap the bottle. Attach the appropriate label and place the bottle on ice upon reaching shore or your vehicle.
7. Other notes:
 - Do not rinse the bottle.
 - Do not pour water into the fecal bottle from another container.

Field Quality Control

Field Replicates

Total variability (precision) for field sampling and laboratory analysis will be assessed by collecting field replicates. In some cases field duplicates, field blanks, and field splits may also be appropriate. *(Note that 10% field blanks are proposed to be used in this QAPP.)*

Field replicates are two samples collected from the same location at the same time. A second bottle is plunged side-by-side with the regular sample. Field replicates will be collected at the rate of ten percent, with a minimum of one field replicate per sampling run. If using a pole to collect samples it may not be possible to collect the samples side-by-side. In this case the field replicate should be collected as soon as possible after the regular sample. Make a comment in the field notes if the samples are not collected side-by-side.

Replicate results that are “non-detects” cannot be used to estimate precision. Similarly, the variability found at low concentrations cannot be used to estimate the variability at higher concentrations, and vice versa. Variability, or precision, is estimated as the standard deviation of a number of results. The standard deviation varies with the magnitude of the results. Separate estimates of standard deviation will be determined for each range of concentration. By collecting field replicates often over a long time period we should be able to calculate standard deviations for a wide range of concentrations.

There is no advantage to randomly selecting samples for replication, so field personnel should use all available information and professional judgment to select samples likely to yield positive results representing a range of concentrations. To simplify matters, replicates could be collected randomly at the beginning of the program and then adjust to collecting replicates at stations with anticipated concentration ranges.

Field replicates may be marked as such before they are sent to the laboratory or they can be labeled in such a way as to give the impression that they are completely separate samples. The latter are referred to as “blind” field replicates, since the laboratory analysts are not made aware of the fact that they are field replicates.

Other Field QC Samples

At this time, field replicates are required but field duplicates, field splits, and field blanks are not. The need for additional quality control samples will be determined as the project develops. Quality control sample types are described below:

1. Field duplicates are useful for estimating variability due to laboratory analysis. Field duplicates are collected by obtaining a sample in a sterilized container large enough

- for two regular samples. The sample is shaken and then partitioned into two regular sterilized bottles, which are assigned different sample numbers and analyzed as two distinct samples.
2. Field splits are like field duplicates but the two samples are sent to different laboratories. Laboratories may require different amounts of water for analysis so the size of the common bottle will need to be adjusted accordingly.
 3. Field blanks are used to measure the presence of contamination due to sample collection and handling procedures. Two types of field blanks exist. Both types require bottles filled with sterile, non-chlorinated water prior to a sampling run. Transport blanks are left unopened but otherwise handled and transported in the same way as other samples. Transfer blanks are sterile water transferred to another sterile empty container during the sampling run, but otherwise handled and transported normally.

An impromptu field blank may become necessary if a field person suspects that the bottles have become contaminated. A bottle should be filled with clean, non-chlorinated water and analyzed as a regular sample. Obtaining such water can be difficult however, as bottled water may have some fecal coliform present. City tap water would be a better choice if the chlorination level were sufficiently low. Field personnel may also elect to stop sampling until new bottles are obtained.

Sample container

A sterile glass or polypropylene bottle will be used for all samples collected. When working with laboratories associated with wastewater treatment plants, it should be specified that the bottle be empty, with no sodium thiosulfate or other dechlorinating agents. Sample bottles should be autoclaved with caps covered in aluminum foil or otherwise sterilized supplied by an accredited laboratory.

Select a bottle according to the following criteria:

- Use the 500 ml bottle when sampling for enterococci in addition to fecal coliform.
- Use bottles with EDTA added if high metal concentrations are suspected.

At Ecology, empty bottles have a holding time; three months for bottles without thiosulfate or EDTA, and one month for bottles with thiosulfate or EDTA. Your laboratory may have different recommendations.

Field processing

No field processing is required.

Sample storage

All samples will be placed in an ice chest with crushed or cube ice immediately. The temperature should be between 0°C and 4°C. Samples will be stored in the dark. For chain-of-custody procedures, the vehicle must be locked whenever it is not in view of sampling personnel.

Holding Time Before Testing

The culturing of samples will take place as soon as possible. Standard Methods (APHA, AWWA, and WEF, 1998) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for water tested for compliance purposes. When compliance is not an issue, a maximum of 24 hours is allowed for refrigerated samples. Samples under this program will be subject to the 24-hour maximum hold time.

Chain-of-Custody and Labels

Chain-of-custody is a series of procedures designed to document a sample or set of samples from the moment of collection, through transport, analysis and reporting. Chain-of-custody requires that each sample be properly identified, and that a record be kept of the names of all persons who handle the sample. The person with custody must have full and verifiable control of the samples at all times.

A sample is considered to be under a person's custody if it is:

- In the individual's physical possession
- In the individual's sight
- Secured in a tamper-proof way by that person, or
- Secured by the person in an area that is restricted to authorized personnel

Elements of chain-of-custody include:

- Sample identification
- Security seals and locks
- Security procedures
- Chain-of-custody record
- Field log book

Proper labeling requires using waterproof paper and waterproof inks. Some laboratories used gummed labels and others use tags, both of which can come off. One way to help prevent this is to place samples in plastic bags that are then submerged in the ice. The plastic bags prevent direct contact between the ice and labels and make it more likely to be able to reassign a label if it does come off.

Labels should include the time of collection since the holding time for fecal coliform analyses are limited.

Sample seals and custody tape are usually not necessary if the samples are transported to the laboratory immediately after collection by the personnel who collected the sample. If samples are transferred or stored in an unsecured area then custody seals or tape should be used.

Measurement Procedures

Field

Station Information

After the network of long term monitoring stations has been determined it will be necessary to obtain location information for each station. A Geographic Positioning System (GPS) receiver is the recommended method for obtaining coordinates. Coordinates can also be estimated by computer programs with aerial photos and topographic maps but this method is less accurate and some of these are based on an outdated coordinate referencing system. GPS measurements are not required for source identification monitoring projects.

Station location information:

- Coordinate Reference System: NAD83
- Latitude: 47° 47' 57"
(from Microsoft Terraserver)
- Longitude: 122° 15' 21"
(from Microsoft Terraserver)
- Altitude: 200 feet

Coordinates should be obtained whenever stations are added to the long term monitoring program. Even if there is no intention to include the data in EIM coordinate information is useful for data archival and presentations.

Discharge Measurements

Discharge will be determined using Price Type current meters. The Price Type current meter is the primary version used by the USGS for stream gaging, and will be used for all measurements of flow velocity. The Price Type meter has six conical shaped cups that rotate on a vertical axis. When the meter is in use, the cups trap air in them and keep water and silt away from the bearing surfaces, reducing friction so that the wheel can spin freely in very low velocity currents. Inside the chamber, a wire makes contact with the bucket wheel shaft once during every revolution to record velocities in slow currents, and a second makes contact once during every five revolutions to record velocities in faster currents.

The pygmy model is supported by a top-setting wading rod for work in shallow and moderate-depth streams. The top-setting wading rod permits all settings to be made in-the-dry, and has a main column of $\frac{1}{2}$ -inch hexagonal stock and a meter positioning rod of $\frac{3}{8}$ -inch-diameter stock. When the setting rod is adjusted to read the depth of water, the meter is positioned automatically for the six-tenths-depth method (described below). The main rod attaches to a base plate and allows the rod to rest on the streambed of the flow channel. The main rod is graduated in 0.1-foot intervals so depths of flow can be measured accurately. (U.S. Bureau of Reclamation, 1984).

Velocity and depth measurements are made along a cross section of the stream at vertical intervals (or stations). Typically, a tag line is stretched across the stream, perpendicular to the

direction of stream flow. The tag line is used to determine the width of the stream and the distance of each measurement interval from a cross-section boundary (edge of water). Ideally, five percent of the discharge is measured at each of twenty vertical intervals, with no more than ten percent measured at any one interval. In the case of very small streams, a smaller number of verticals intervals may be used (U.S. Bureau of Reclamation, 1984).

One of two methods is typically used to determine mean velocities in a vertical line with a current meter; they include the six-tenths-depth method and the two-point method. The six-tenths method consists of measuring the velocity at 0.6 of the depth from the water surface when the depth of flow is less than 2.5 feet. Here, the measured velocity is taken as the mean velocity for the vertical. When the depth of flow is greater than 2.5 feet, the two-point method is used. It consists of measuring the velocity at 0.2 and then at 0.8 of the depth from the water surface with the mean velocity taken as the average of the two measurements (Rantz et al., 1982).

Before leaving the site, the magnitude of the widths, depths, and velocities for each vertical interval or station will be reviewed for gross errors. The Aqua-Calc Open Channel Flow Computer automatically determines the total stream discharge for the cross section measured. Using a local reference point or staff gage, the stream stage will be noted and later used to construct a rating curve. The stage may be used to estimate discharge when a sufficient number of discharge measurements have been made.

Office

Stream Discharge Data

Bacteria concentration data collected as part of this QAPP will be evaluated using flow duration or similar analyses in the future. To accomplish that, high quality flow data collected on a daily, or more frequent, basis is needed at representative locations in the watershed. Currently, stream gauging networks provided by Snohomish County and King County are well suited for this purpose. At present, three stream gauges are functioning on Swamp Creek.

A new stage-discharge relationship is currently being assembled for a gage that was installed upstream from the new 73rd Avenue bridge near Wallace Park (King County Flow Site 56b). This gage was installed to replace the Flow Site 56b that had been maintained by King County (See Figure 1.). The automated sensor within the gage housing records stream stage and water temperature in 15 minute intervals. During monthly visits, this information will be downloaded, and flow velocity measurements will be made so that the stream stage data can be converted to stream discharge data.

Note: Discharge measurements will be performed at the 73rd Avenue Bridge following USGS approved techniques. Discharge measurements will initially be made over a range of hydrologic conditions (including peak flow events) to define the relation between stage and discharge. Subsequent measurements will be made at periodic intervals to verify the stage-discharge relation established. A continuous record of stage will be obtained by installing

instruments that sense and record the water-surface elevation in Swamp Creek. The discharge rating established at the site and the gage-height record will be reduced to mean values for selected time periods. The mean discharge for each day (average daily discharge) and extremes of discharge (peak flow events) for the year will be computed. The computation of continuous records of streamflow will follow approved USGS guidelines.

Snohomish County maintains two stream gauges on Swamp Creek. One station is Swamp Creek near 228th and the other is Swamp Creek at I-405. Discharge and water temperature data is available at both stations in numerous formats. This data is available at http://web5.co.snohomish.wa.us/spw_swhydro/hydrology-find-site.asp.

Lab

Fecal Coliform - Membrane Filtration Method

Laboratory analyses for fecal coliform bacteria will be performed by laboratories accredited by the Washington State Department of Ecology. The analytical method to be used is described by Standard Methods for the Examination of Water and Wastewater, No: 9222 D, 24 hour Membrane Filter (MF) procedure. This method will be used for this study with the following exceptions:

Holding temperature is to be between zero and four degrees Celsius (Standard Methods allows up to ten degrees Celsius).

Holding time is not to exceed 24 hours (Standard Methods recommends no more than eight hours but allows up to 24 hours).

The detection limit and the precision for this method are both 1 colony per 100 mL. Densities are to be reported as fecal coliform bacteria per 100 mL.

In this method, samples are filtered using varying volumes to establish fecal coliform plate densities in the range of 20 and 60 colonies. The filtered samples are incubated for 24 ± 2 hours at $44.5 \pm 0.2^{\circ}\text{C}$. The colonies produced by fecal coliform bacteria are various shades of blue. The colonies are counted with a low power microscope or other optical device.

Quality Control

Quality control procedures used during field sampling and laboratory analysis will provide estimates of the precision of the monitoring data. Bacteria samples will be analyzed using Standard Method SM 9222D, membrane filtration method. Field replicates will help to determine compliance with measurement quality objectives. Total variation for field sampling and analytical variation will be assessed by collecting replicate samples and performing lab replicates as discussed below.

Table 5. Summary of Field and Laboratory Quality Control Procedures						
Analysis	Field Blanks	Field Replicates	Lab Check Standard	Lab Method Blank	Lab Replicates	Matrix Spikes
Fecal Coliform (MF)	1/10 samples	1/10 samples	N/A	1/run	1/10 samples	N/A

Field

Station Information

Station coordinates obtained by GPS, or descriptions will be accurately recorded. If GIS resources are available they will be plotted on a Geographic Information System (GIS) map and compared to the expected location and features. The need for adjustments or new coordinates will be made on a case-by-case basis.

Field Notes

The notes from each field run will be tabulated and compared to chain-of-custody forms and laboratory results for completeness and accuracy. Any problems and associated corrective actions will be recorded. Any unresolved problems should be flagged and discussed in the data report.

Fecal Coliform Bacteria

Total variability for field sampling and laboratory analysis will be assessed by collecting replicate samples at the rate of ten percent of regular samples collected, and a minimum of one replicate per sampling run. Bacteria samples tend to have a high relative standard deviation between replicates compared to other water quality analyses. The standard deviation also varies based on the order of magnitude of the results.

Laboratory

Fecal Coliform

Routine laboratory quality control procedures will be followed. Laboratories should perform at least one analytical duplicate per sampling run. Duplicate laboratory analysis refers to analyzing duplicate aliquots from a single sample container. Each sample is carried through all steps of sample preparation and analysis. The results for laboratory duplicates provide an estimate of analytical precision, including the homogeneity of the sample matrix.

Field personnel may want to request that the analytical duplicate be performed on the same sample that accompanies the field replicate, as this allows an estimate total and analytical variability from results for the same sample. There is no advantage to randomly selecting samples for duplicate analysis.

If the samples selected for duplicate analyses do not contain measurable amounts of fecal coliform, the results provide no information on precision. Similarly, if the laboratory selects samples from another study with significantly different levels of fecal coliform or different matrices, the estimate of precision may not be applicable to these samples.

The laboratory must report the results of their analytical duplicates.

The laboratory may have additional quality control procedures and they may report those results. For example, Ecology’s Manchester Environmental Laboratory (MEL) reports whether procedural blanks and laboratory control samples are within acceptable limits. Procedural blanks and laboratory control samples ensure that the media, buffers, reagents, glassware, filters and other laboratory apparatus are sterile.

Data Qualifiers

Each laboratory will have its own list of data qualifiers. Table 6 lists the data qualifiers used by Ecology’s MEL. At some time during the study each laboratory will be expected to provide a list of relevant qualifiers and supporting documentation so that a cross-reference list can be developed.

Table 6. Data Qualifiers Used by Ecology’s MEL	
Code	Definition
E	Reported result is an estimate because it exceeds the calibration range.
G	Value is likely greater than result reported; result is an estimated minimum value.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
N	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a “tentative identification”.
NJ	The analysis indicates the presence of an analyte that has been “tentatively identified” and the associated numerical value represents its approximate concentration.
NAF	Not analyzed for.
NC	Not calculated.
R {REJ}	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
U	The analyte was not detected at or above the reported sample quantitation limit.
UJ	The analyte was not detected at or above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately measure the analyte in the sample.

The same qualifier may be used for several unrelated problems. For example, the “J” qualifier is used when samples exceed the 24-hour holding time, when there are too many colonies on a plate to make a precise determination, and when non-fecal colonies that may interfere with fecal colonies are observed on the plates. For this reason, laboratory reports should include a narrative that describes why data qualifiers are assigned. The project manager will review the data qualifiers promptly to ensure that proper modifications are made as needed to field or lab procedures. Laboratory quality control will be regularly assessed by the project manager.

Data Management Procedures

Recording Field Measurements

Time, location, weather conditions, and other observations and environmental factors will be recorded at the time of sampling and maintained for public record purposes. Data will be transferred no less than quarterly to a computer spreadsheet to provide a backup copy of hard data and to facilitate information sharing with Ecology and other agencies. At that time, the hard data will be checked for errors. Laboratory reports, worksheets, and chain-of-custody records will be filed together and stored in a binder or other organized form.

Staff will be responsible for internal quality control validation and for properly transferring and reporting data to the project manager throughout the project. The project manager may approve data that does not meet data quality objectives above for use with appropriate qualification and consultation.

Data will be summarized annually and reported as part of the Bacterial Pollution Remediation Plan section of the Stormwater Management Plan. Data qualifiers will be explained in all reports as needed. Data will be explained in tabular and graphical format. Tables will track seasonal compliance with water quality standards using a dry season period of May through September.

Audits and Reports

The accredited laboratory will submit data reports to the project lead. Any problems with the analyses, corrective actions taken, or changes to the referenced method will be reported to the project manager for correction or action as needed. Reports will also be prepared no less than annually for permit reporting purposes as noted above.

Specific Quality Assurance information that will be noted in the reports includes the following:

- Changes in monitoring, i.e., divergence from the QA project plan
- Results of performance and/or system audits
- Significant QA problems and recommended solutions
- Data quality assessment in terms of precision, accuracy, representativeness, completeness, comparability, and reporting limits
- Sample estimates and rejections
- Discussion of whether the QA objectives were met, and the resulting impact on decision making
- Limitation on use of the measurement data

Data Verification, Validation, and Review

Verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Once measurement results have been recorded, they are verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions
- Results for QC samples accompany the sample results
- Established criteria for QC results were met
- Data qualifiers are properly assigned where necessary
- Data specified in Sampling Process Design were obtained
- Methods and protocols specified in the QA Project Plan were followed

Qualified and experienced laboratory staff will examine lab results for errors, omissions, and compliance with QC acceptance criteria. Findings will be documented in each case narrative.

Note on additional field measurements taken in addition to TMDL-required samples:

When field measurements are taken, field results should also be verified, whenever possible before leaving the site where the measurements are made. The field lead is responsible for checking to be sure that field data entries are complete, and to check for errors if field measurements are taken. The field lead should be on the lookout for any entries that do not seem consistent with expected values; verification measurements may need to be made. Field duplicate measurements that can be easily repeated (e.g. gauge) should be checked against each other.

Measurements that differ by more than the acceptable error limit should be repeated and the new value(s) recorded and evaluated. If the difference is not a result of reading error, but is a result of rapidly changing conditions; e.g. a rapidly rising or falling stream, or a great deal of turbulence, a note should be made to that effect, and both values should be recorded for potential averaging.

Validation

Data validation will follow verification. Validation is parameter-specific, and involves a detailed examination of the data package, using professional judgment to determine whether the method quality objectives (MQOs) (Table 5) have been met. The project lead will examine the complete data package in detail to determine whether the procedures in the methods and procedures specified in this QA Project Plan were followed.

Validation will entail evaluation of relative percent differences between field duplicates and lab splits. Acceptable precision is outlined in Table 5. Bias is unknown, and will be addressed in the context of the sampling regimen. Laboratory duplicates will yield estimates of laboratory precision. Field duplicates will indicate overall variability (environmental + sampling + laboratory) in the case of bacteria or (environment + instrumentation + sampling) in the case of flow and stream gauge.

Review

It is vital that results be transferred accurately at each stage of this project. The individual tasked with that data entry is responsible for reviewing the data to be sure it is complete, consistent, and correct.

Data Quality (Usability) Assessment

This QAPP follows Ecology's requirements to collect approximately 60 samples annually to ensure data usability at long-term monitoring sites. If values of zero are obtained during the study, a value of 1 should be used for computations because geometric means cannot be calculated using zero values.

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The City Of Kenmore

P.O. Box 82607 • Kenmore, Washington 98028-0607

August 18, 2008

Sarah Davenport-Smith
Washington State Department of Ecology
3190 160th Avenue SE
Bellevue, WA 98008-5452

**Re: *Revised Water Quality Study Design Quality Assurance Project Plan (QAPP)
for Swamp Creek Fecal Coliform Total Maximum Daily Load (TMDL),
Western Washington Phase II Municipal Permit #WAR04-5519***

Dear Ms. Davenport-Smith:

Thank you very much for your comments in the letter dated January 15, 2008. We have revised the QAPP according to each of Ecology's comments, making this QAPP consistent with the Department of Ecology's recommendations. (Please see Attachment A for a copy of the revised QAPP and Attachment B for a tabular summary that addresses each of Ecology's comments.)

The revised QAPP, also shown in Attachment A, includes significant changes in the sampling strategy for the water quality monitoring program. According to this revised QAPP, samples will be collected at five locations instead of twelve, and the City will now collect twelve samples per year at each of the five stations, at the rate of approximately one per month, totaling about 60 per year. We also propose to monitor the discharge continuously at the 73rd Avenue Bridge location (King County Flow Site 56b), and perform stream discharge measurements using staff gauges at each of the five sampling locations on the same days that coliform samples are collected. The sampling stations have been strategically located to measure fecal coliforms within each of the major tributaries and the main stem of Swamp Creek that pass through the City of Kenmore to assess major drainage areas for potentially elevated coliform levels.

In response to specific Ecology comments, our changes have included the following:

- We have added your name to our QAPP as final reviewer.
- We have added a distribution list to the front of the document.
- We have reduced the number of monitoring stations, and increased the sampling frequency to be consistent with Ecology's recommendations.

August 18, 2008
Sarah Davenport-Smith
Page 2 of 2

- We have included a plan to monitor flow at each station to estimate fecal coliform loadings and to determine if sampling events are influenced by storm hydrology.
- We have selected an accredited laboratory from Ecology's website and included a chain-of-custody form from their website in Appendix D of our QAPP.
- And we have added text to the Quality Control section of the QAPP to further define the role of the project manager in overseeing laboratory quality control.

Thank you again for your comments. Please feel free to contact us if you have any questions regarding our revised QAPP and monitoring plan. Upon your approval of this revised QAPP, we have a team and lab standing by to initiate sampling in September.

Sincerely,



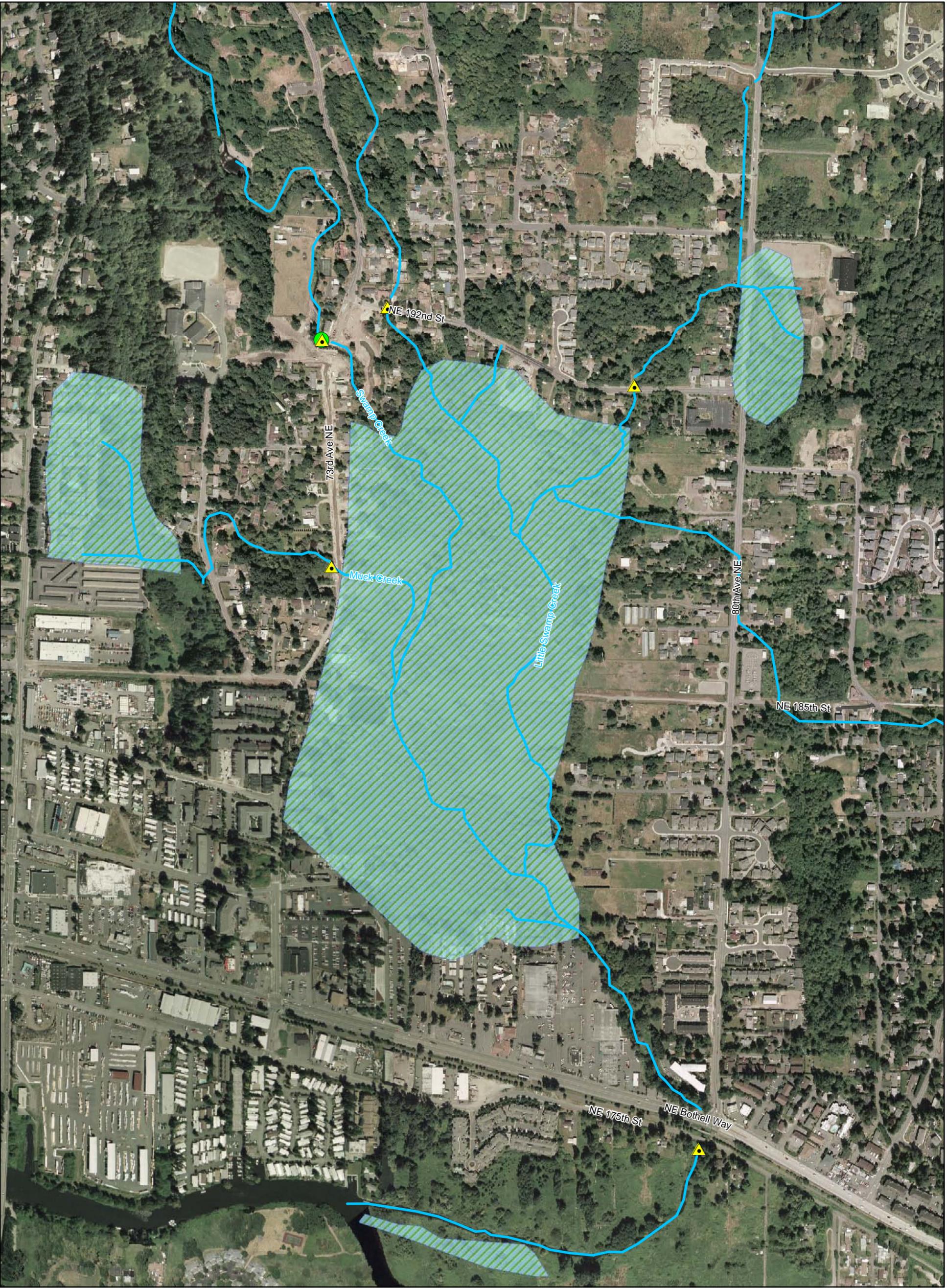
Ron Loewen, PE
Interim City Engineer

Attachment A—Revised QAPP

Attachment B—Tabular Summary of Responses to Ecology's January 15, 2008 Comments

Attachment C—Ecology's QAPP Review Letter dated January 15, 2008.

Swamp Creek Coliform Sampling Stations



Legend

-  Fecal Coliform Sampling Stations
-  Continuous Flow Monitoring Station
-  Swamp Creek Stream Network
-  Wetlands



SCALE = 1:6,000

