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ECOLOGY TOXICS CLEANUP PROGRAM
EPA BROWNFIELDS PROGRAM

SAMPLING AND ANALYSIS PLAN

Little Squalicum Park
Remedial Investigation/Feasibility Study
Bellingham, WA

Prepared for

City of Bellingham

Parks & Recreation Department
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ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
bgs	below ground surface
BNA	base neutral acid
BNSF	Burlington Northern Santa Fe Railway
BTC	Bellingham Technical College
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLARC	cleanup levels and risk calculations
COCs	chemicals of concern
CSL	Cleanup Screening Level
Creek	Little Squalicum Creek
CSM	conceptual site model
DEA	David Evans and Associates
DI	deionized
DRO	diesel-range organic hydrocarbons
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
EDM	Electronic Distance Meter
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
ESI	expanded site inspection
ESL	Ecological Screening Levels
FCR	Field Change Request
GPS	Global Positioning System
GRO	gasoline-range organic hydrocarbons
GW	groundwater samples
HA	site hazard assessment
HASP	health and safety plan
ICP/MS	inductively coupled plasma/mass spectrometry
ICP-OES	inductively coupled plasma-optical emission spectrometry
IHSs	indicator hazardous substance
LAETs	Lowest Apparent Effect Thresholds
LSC	Little Squalicum Creek
LSP	Little Squalicum Park
MCL	maximum contaminant level
MCTA	Model Toxics Control Act

mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NAD	North American Datum
NAPL	nonaqueous phase liquid
NAVD	North American Vertical Datum
NAWQC	National Ambient Water Quality Criteria
NWTPH	Northwest Total Petroleum Hydrocarbons
OCDD	octachlordibenzo-p-dioxin
OCDF	octachlordibenzo-p-furan
OESER	OESER Company
PAHs	polycyclic aromatic hydrocarbons
Park	Little Squalicum Park
PCP	pentachlorophenol
PID	photo-ionization detector
Port	Port of Bellingham
PRGs	Preliminary Remediation Goals
PPE	personal protective equipment
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RI/FS	remedial investigation and feasibility study
SAP	sampling and analysis plan
SHA	site hazard assessment
SI	site inspection prioritization report
SIM	Selective Ion Monitoring
SLs	screening levels
SMS	Washington State Sediment Management Standards
SOPs	standard operating procedures
SOW	Statement of Work
SQLs	Sample Quantitation Limits
SQS	Sediment Quality Standard
STL	Severn Trent Laboratories
SCV	Secondary Chronic Values
SW	surface water
SVOCs	semivolatile organic compounds
TCDD	tetrachlorodibenzo-p-dioxin
TEE	Terrestrial Ecological Evaluation
TEQs	toxicity equivalency quotients
TICs	tentatively identified compounds
TOC	total organic carbon
TP	test pit
TPH	total petroleum hydrocarbons
TSS	total suspended solids

U&I	Utah and Idaho Sugar Company
USCS	Unified Soil Classification System
VOCs	volatile organic compounds
VPH	volatile petroleum hydrocarbon
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act
WQC	water quality criteria

1 INTRODUCTION

This document is the sampling and analysis plan (SAP) for the remedial investigation and feasibility study (RI/FS) of Little Squalicum Park (the Park) located in Bellingham, Washington (Figure 1-1). This SAP describes the sampling strategy and design to meet the data needs of the RI/FS and provides specific guidance for field methodology and quality assurance procedures that will be followed by Integral Consulting, Inc. (Integral) and its subcontractors. Integral is conducting this work under contract No. 2004-014 with the City of Bellingham, Parks and Recreation Department (City), with direction from both the Washington State Department of Ecology Toxics Cleanup program (Ecology) and U.S. Environmental Protection Agency, Region 10 Brownfields program (EPA).[1] This SAP has been prepared for RI sampling and analysis activities in general accordance with Washington Administrative Code (WAC) 173-340-820, WAC 173-204-600, and the Sediment Sampling and Analysis Appendix, as updated (Ecology 2003).

Several documents are cited repeatedly and accompany this SAP. Altogether, these documents are referred to as the Work Plans for the Park RI/FS:

- *Work Plan for the RI/FS of Little Squalicum Park Bellingham, Washington.* The Work Plan describes program objectives, project organization, and project tasks to complete an RI/FS of the Park. This document also provides information on project background, history, and regulatory framework.
- *Quality Assurance Project Plan (QAPP) of Little Squalicum Park RI/FS Bellingham, Washington.* The QAPP describes laboratory methodology and quality assurance/quality control (QA/QC) procedures that will be used to complete a RI/FS for the Park site.
- *Project Health and Safety Plan, Little Squalicum Park RI/FS, Bellingham, Washington. (HASP).* The HASP has been prepared in conformance with Integral's Health and Safety Plan guidelines and in accordance with WAC 173-340-810, applicable Washington Industrial Safety and Health Act (WISHA) regulations, and project requirements. It addresses those activities associated with work to be performed in the Park.
- *Integral Standard Operating Procedures* (SOPs). These numbered documents provide specific, detailed information on conducting routine, repetitive field techniques (e.g., split spoon sampling from a drill rig). These documents are found in Appendix A.

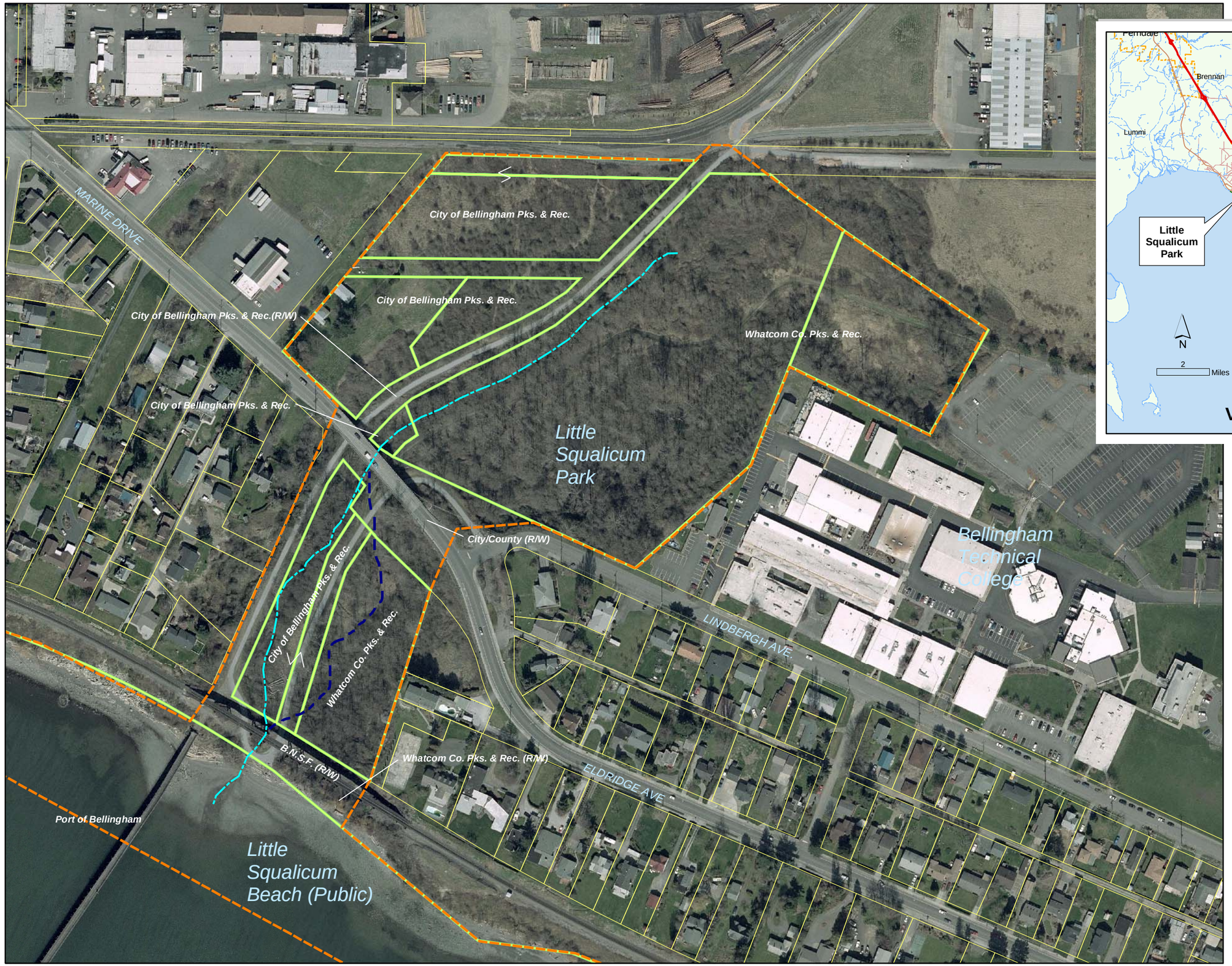
[1] Funding for this work was received by the City of Bellingham (2004) from the EPA Brownfields Program. Additional funding is expected from the Ecology Remedial Action Grant Program (City of Bellingham 2005).

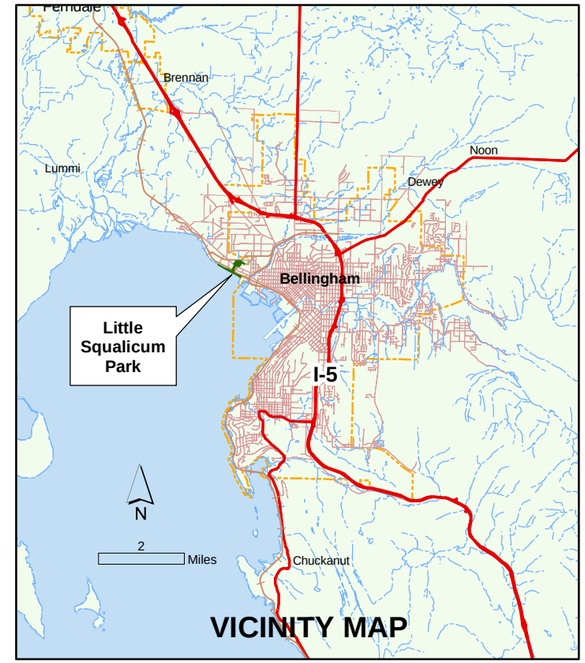
The Whatcom County Health and Human Services completed a site hazard assessment (SHA) of the Park site in February 2004, as required under the Model Toxics Control Act (MTCA). The site's hazard ranking, an estimation of the potential threat to human health and/or the environment relative to other Washington State sites assessed at that time, was determined to be a 1, where 1 represents the highest relative risk and 5 the lowest (Ecology 2004). Based on the results of the SHA, Ecology has determined that a RI/FS should be developed for the Park site pursuant to WAC 173-340-350 and WAC 173-204-560. Ecology has negotiated an *Agreed Order* and Statement of Work (SOW) (dated March 22, 2005) with the City to conduct an RI/FS on the Park site (presented in Attachment A of the Work Plan). The RI/FS is intended to provide sufficient data, analysis, and evaluations to enable Ecology to select a cleanup action alternative for the site.

The primary objectives of the Park RI/FS are to provide critical data necessary to understand the nature and extent of environmental problems at the site, to assess potential risk to human health and the environment, to determine if cleanup actions are required, and to determine how these actions may be accomplished as part of specific wildlife enhancement and park development actions. These objectives will be met by sampling surface water, groundwater, soil and sediments and evaluating the results in concert with other existing data. Other major project objectives are provided in the accompanying Work Plan.

Several historical studies have been completed within the boundaries of the Park. Section 2 presents a review of existing data, including a summary of previous investigations and screening level criteria, a preliminary conceptual site model (CSM), and data gaps. Section 3 presents the sampling design and rationale for a tiered approach to complete the Park RI field and testing investigation. The overall sampling strategy for the Park is to place a greater density of sampling locations in areas for which little or no historical data are available and to limit the analyte list in well-studied areas by applying a tiered sampling and testing approach. An adequate volume of sample will be archived to allow analysis of all analytes for a given medium (including biological toxicity testing), if necessary. Section 4 discusses field methods for sample collection and sample handling methods. References are presented in Section 5. Referenced figures and tables are presented at the end of each section.

Appendix A contains Integral SOPs and field forms, and Appendix B contains the historical biological testing results for the site.





N

0 100 200 Feet

1" = 200'

Parcels

Park Area Ownership

Little Squalicum Park Boundary

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
2002 Aerial Image: City of Bellingham and ADI.

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Current route of creek (approximate)

Possible future re-route of creek

Figure 1-1. Park Area Ownership and Vicinity Map

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2 SITE HISTORY

Site history information was obtained from the OESER Cedar Company RI report (E&E 2002a and references therein) and personal communication with City and Whatcom County personnel. Current property owners within the Park site area are shown on Figure 1-1. The approximate locations of relevant historical activities within the Park boundaries are shown on Figure 2-1.

Recent sampling activities in the Park by Ecology (2004) have uncovered a previously unknown shell midden deposit. The extent of the shell midden deposit, located downstream of the Marine Drive Bridge, is currently unknown. It is also possible that archaeological deposits could be present in other areas of the park.

The first reported development in the area of Little Squalicum Creek (the Creek) was by Edward Eldridge in 1853, under the 320-acre Eldridge Donation Claim. During the late 1800s, most of the area was used by the Eldridge family for dairy farming and ranching. The railway that runs along the shoreline of Bellingham Bay was first developed around 1890. The Eldridge family deeded portions of the uplands and tidelands to Olympic Cement Company in 1911 (now the Tilbury Cement Company). This deed included land for the pier and former rail bed that extends along the west side of the Creek ravine. An old pump house that supplied water from a spring along the creek to the cement plant is located downstream of the Marine Drive Bridge stormwater discharge point. The plant discontinued pumping of spring water for plant use in the 1950s. In 1925, the Eldridge family sold the property now occupied by the OESER Company to the Utah and Idaho Sugar Company (U&I). The sale included an easement for construction of a drain to convey sugar-processing wastes through the creek into the tidelands of Bellingham Bay. The plant remained in operation into the early 1940s, reportedly closing in 1942. During the 1940s and 1950s, a commercial plant nursery was located to the west of the Creek.

In 1932, the Eldridge family granted the Marietta Township mining rights to the gravel within the ravine. Sand and gravel were later mined by the Eiford Company until the late 1960s. In some places within the ravine over 20 ft of native soils were mined for its sand and gravel. Some of the ditches dug to facilitate drainage remain in place today. Much of the creek's original course was diverted into these ditches. The entire ravine was altered substantially from natural conditions with rerouting of the original creek bed and significant changes to the soils and lithology (e.g., backfilling of gravel pit and wash pond excavations, temporary road maintenance, and rail bed and track placement). Temporary basins were dug for gravel washing and reportedly filled with groundwater, both seasonally and, in some cases, year-round. After mining, the land was leased to Mt. Baker Plywood for raw log storage during the early 1970s. Logs were transported to and from the ravine via the beach.

In 1943, the Eldridge family sold a portion of the upper area of the creek ravine to the Tiscornia family who used the land for farming and grazing livestock. The land was obtained by the Bellingham School District in 1955, which subsequently deeded the land in 1993 to the Washington State Board for Community Colleges and Technical Colleges. Bellingham Technical College (BTC), formerly the Bellingham Vocational Technical Institute established here in 1957, is currently located on this 21-acre site. Various portions of the creek, including areas extensively mined for sand and gravel and used for log storage, were deeded to the Whatcom County Park Board by several individuals as well as the school district.

Hugh Eldridge deeded the tidelands onto which the Creek flows to the Port of Bellingham (Port) in 1927. A 60-ft right-of-way west of the Marine Drive Bridge was deeded to the Port in 1956, but was never developed or used by the Port. The fee to this right-of-way was purchased by the City in 2001. In the mid 1960s, construction debris and old furnishings were reportedly dumped in a small area near the east boundary of the ravine, which is now a BTC parking lot. Minor amounts of residential and commercial garbage and refuse may have also been placed in this area based on personal communication with City employees and information provided on a 1963 aerial photo.

In 1977, the City constructed an underground stormwater pipeline through the upper area of the ravine. Stormwater from approximately 3 square miles of the Birchwood neighborhood, including the BTC parking lot, is conveyed through the 36-inch underground pipeline and discharged into the creek. Since 2002, stormwater from the BTC parking lot is directed through a filtering system (reportedly composted leaf media) before discharging into the creek. Although water is diverted directly into the Birchwood neighborhood stormwater pipeline during larger rainstorms (greater than 6-month storm), most runoff (approximately 90%) is treated before discharging to the creek (Hunter 2004, pers. comm.).

The City owns 7.8 acres of the Park and leases 12.3 acres of County-owned property at the site. Currently, an agreement between the City Parks and Recreation Department and Whatcom County Parks Department stipulates that the City must manage and operate the area as a park site for 35 years (to about 2025), with a renewal provision for another 35 years.

The OESER Cedar Company (currently known as the OESER Company) purchased the nearby U&I property in 1943. The OESER Company manufactures poles for utility companies. In records dating back to 1953, the process included segregating poles by length and class, incising some or all of the poles, and subjecting them to "oil treatment" using creosote. Finished poles were shipped offsite by rail. In 1965, the company also started treating wood using 5% pentachlorophenol (PCP) in an oil-based solvent (Diesel No. 2). OESER stopped using creosote to treat wood in the early 1980s but PCP treatment

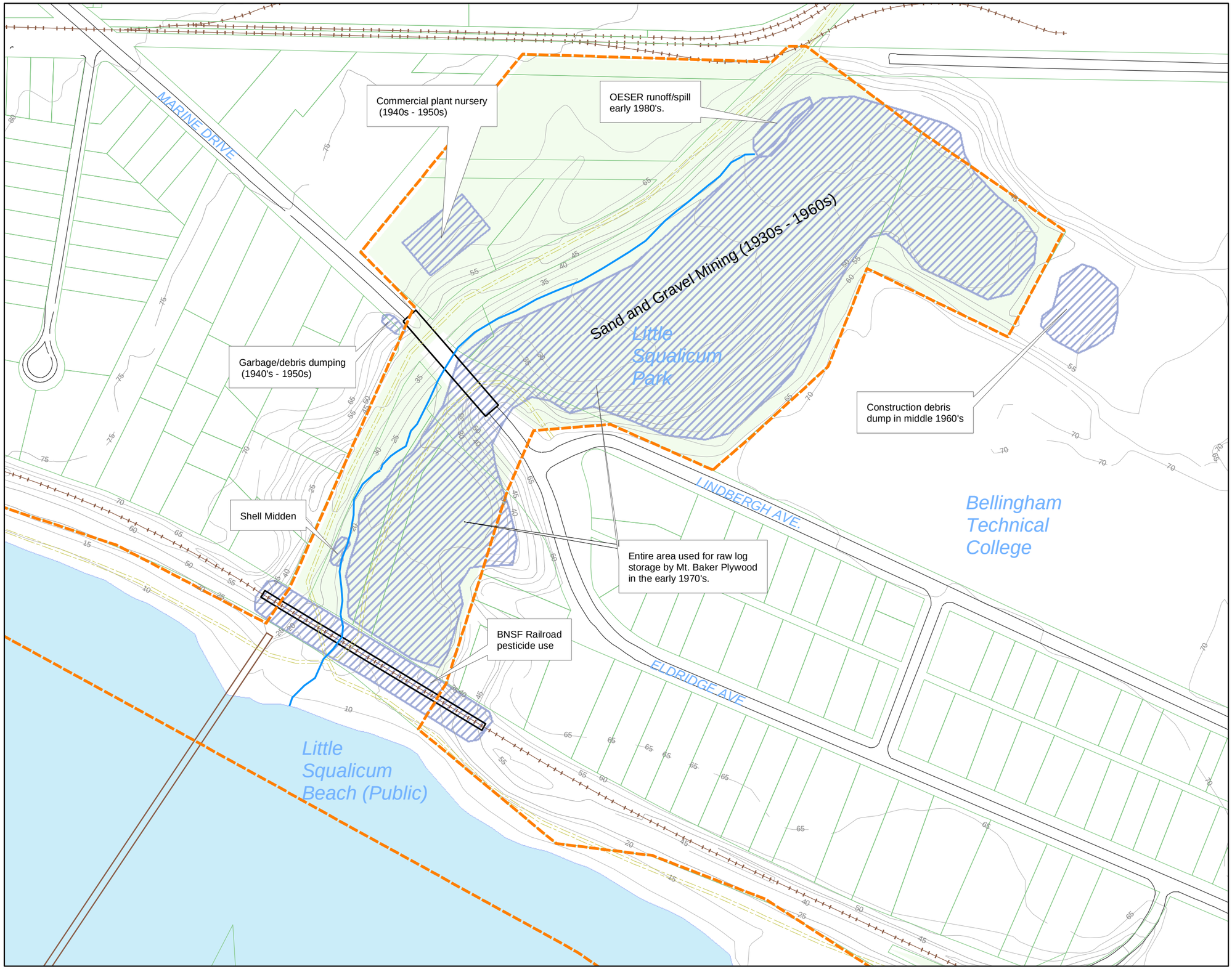
continues to be utilized at the facility. A detailed description of the wood treatment processes used by the OESER Company is presented in the OESER RI (E&E 2002a).

The OESER site has discharged process wastewater or contaminated stormwater to the Creek since start of operations in the late 1940s. The water enters an underground stormwater line originating in the Birchwood neighborhood that crosses the OESER Company property and then discharges into the creek. This OESER/Birchwood neighborhood drainage enters the creek adjacent to the outfall from the Birchwood neighborhood drainage to the east (Figure 2-1). In addition to water, discharges from the OESER Company have been known to contain wastes such as creosote, PCP, dioxins/furans (associated with PCP), diesel fuels, and related oil products. The wastewater/stormwater permit history for the OESER site is also presented in the OESER RI (E&E 2002a). Currently, OESER has a National Pollutant Discharge Elimination System Waste Discharge Permit (NPDES No. WA 003081-3) that allows detectable levels of PCP and petroleum hydrocarbons in effluent discharged to local stormwater.[2]

In addition to the OESER outfall, surface water runoff has been observed originating from the OESER yard and pooling in an area upstream of the "head" of the Creek (Wahl 2004, pers. comm.). The event occurred approximately 15 years ago, and soils and vegetation appeared to be impacted at the time from the contents of the runoff.

Stormwater drainage from the Birchwood neighborhood may also be a source of petroleum hydrocarbons and heavy metals to the Creek. A likely source of these contaminants is from motor vehicle and mixed commercial/residential use throughout this drainage area.

[2] The daily maximum effluent limitation is 9 μg/L for PCP.



Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map Appendix B Map of Brownfield Assessment Area.

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Map Document: (C:\GIS\Projects\LittleSqualicumCr\Historical_Activities.mxd)
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Figure 2-1. Historical Activities

3 REVIEW OF EXISTING DATA

3.1 SUMMARY OF PREVIOUS INVESTIGATIONS

Historical data that were evaluated for possible inclusion in the current RI/FS originated from the following investigations:

- Site Inspection Report (E&E 1987)
- Site Hazard Assessment (Parametrix 1991)
- Wetland Mitigation Plan at Little Squalicum Creek (DEA 1993)
- Site Inspection Prioritization Report (URS 1994)
- Expanded Site Investigation (E&E 1996)
- Removal Assessment, Phase II (E&E 1998a,b)
- OESER Company RI/FS (E&E 2002a,b)
- Little Squalicum Creek Screening Level Assessment (Ecology 2004).

Site sampling locations from these previous investigations are shown on Figures 3-1 through 3-4. A Microsoft Database containing the analytical results for these historical investigations is included on the CD attached to the front cover.

This section briefly summarizes the types of data collected during each of these investigations and the data usability for the current RI/FS. Evaluation of data usability focused on the following five aspects of the data as recommended in *Guidance for Data Usability for Risk Assessment* (USEPA 1992):

1. ***Data Sources***—Evaluate the type of data collected (screening data, fixed laboratory data, etc.) and whether QA/QC samples are available for the data to provide data quality information
2. ***Analytical Methods and Detection Limits***—Evaluate methods for appropriateness and sensitivity and determine if detection limits are low enough for risk-based screening
3. ***Data Quality Indicators***—Review laboratory validation reports for data quality issues
4. ***Background Samples***—Assess whether appropriate quantity and location of background samples were collected
5. ***Consistency of Data Collection Methods***—Evaluate sample collection methods for appropriateness for the chemical, media, and analysis; review field trip notes

to assess quality of sample collection; and determine if differences in sample collection exist between different sampling events and investigations.

In the event that original reports were not available for evaluation of data quality, the data quality evaluation provided in the OESER RI/FS (E&E 2002a,b) was referenced for a summary of the data quality. Regarding data usability for risk assessment purposes, the following assumptions were made:

- Field screening data will not be used for risk assessment purposes.
- Unknown or tentatively identified compounds (TICs) will be excluded from consideration.
- If an analyte is not detected in any sample for a particular medium, then it will be assumed that the chemical is not present and it will be dropped from further consideration in the risk assessment. Note that sample quantitation limits (SQLs) will be compared to screening benchmarks as available, and a list of those compounds with SQLs above screening levels will be provided as part of the risk assessments.
- If an analyte has both detected and non-detect sample results (i.e., any results that include a "U" data qualifier), the assumed concentration in non-detect samples will be one-half of the SQL.
- For non-detect dioxin/furan congeners, two approaches will be followed for the calculation of 2,3,7,8-TCDD toxicity equivalency quotients (TEQs). In the first approach, one-half the SQL will be assumed for non-detects when calculating the TEQ for each sample. Under the second approach, non-detect concentrations will also be assumed to be present at a concentration of one-half the SQL, with the exception that if a congener is never detected in a particular medium, then it will be assumed to not be present, and it will be assigned a concentration of 0 when calculating TEQs (USEPA 2000a).
- For non-detect petroleum fractions, only the second of the above approaches will be used for calculating total volatile petroleum hydrocarbon (VPH)/extractable petroleum hydrocarbon (EPH). If a fraction is never detected in a particular medium, it will be assigned a concentration of 0. Otherwise, it will be assumed to be present at half the detection limit.

3.1.1 Site Inspection Report

Four sediment and two unfiltered surface water samples were collected in the vicinity of the Creek (locations JC-351 through JC-355, and JC-358) as part of the OESER facility investigation performed for EPA (E&E 1987). Semivolatile organic compounds (SVOCs) were analyzed in both media using EPA Method 8270. A data quality summary

presented in the OESER RI indicated that there were only minor problems affecting data usability. However, other factors indicate that while these data can be used to assess data gaps, the data will not be included in the risk evaluation. These factors include: 1) age of the data – these data are approximately 17 years old and do not accurately represent current conditions in the creek, 2) media – sediment and surface water conditions are more likely to change over time than soil conditions, 3) analytes – SVOCs have the potential to volatilize or degrade over time, and 4) depth of sediment collection was not indicated in the database.

3.1.2 Site Hazard Assessment

Seven soil/sediment and five unfiltered groundwater/porewater samples were collected in the vicinity of the Creek (locations PMX-GW-10 through 15, PMX-SD-01 through 03, and PMX-SS-06 through 09) as part of the site hazard assessment (Parametrix 1991). SVOCs (EPA Methods 8270 and 8040) and total petroleum hydrocarbon (TPH) (EPA Methods 8015 and 418.1) were analyzed in both media. A data quality summary presented in the OESER RI indicated that there were several problems that affected data usability: 1) data quality was not addressed in detail, 2) holding times were exceeded, and 3) method blank detection limits were above sample detection limits. While these data will be cautiously used to assess data gaps, the data will not be included in the risk evaluation based on the following considerations: 1) age of the data – these data are approximately 13 years old and do not accurately represent current conditions in the creek, 2) media – sediment and porewater conditions are more likely to change over time than soil conditions, 3) analytes – SVOCs and TPH have the potential to volatilize or degrade over time, and 4) depth of sediment collection was not indicated in the database.

3.1.3 Wetland Mitigation Plan at Little Squalicum Creek

A total of 36 test or hand soil pits were dug within the boundaries of the Park as part of the Wetland Mitigation Plan (DEA 1993). Strata in each pit were classified and described using the Unified Soil Classification System (USCS). A note was made for each pit regarding whether groundwater was encountered and, if so, at what soil depth and relative volume. In 11 of the pits, soils from at least one strata were analyzed for moisture content and percent fines. These data will be carried forward for use in the RI/FS because soil strata and groundwater elevation levels are not likely to have changed since the data were collected. The only limiting factor regarding data interpretation is that location maps were hand drawn, and sample location coordinates were not provided in the report.

3.1.4 Site Inspection Prioritization Report

Eleven sediment samples were collected in the vicinity of the Creek (locations SI-BB01 through 03 and SI-LS01 through 08) as part of the Site Inspection Prioritization Report (URS 1994). SVOCs (EPA Method 8270) were analyzed. A data quality summary

presented in the OESER RI indicated that there were no problems that affected data usability. These data will be used to assess data gaps; however, the data will not be included in the risk evaluation based on the following considerations: 1) age of the data – these data are approximately 10 years old and do not accurately represent current conditions in the creek, 2) media – sediment conditions are more likely to change over time than soil conditions, 3) analytes – SVOCs have the potential to volatilize or degrade over time, and 4) depth of sediment collection was not indicated in the database.

3.1.5 Expanded Site Investigation

Seven sediment, four unfiltered surface water, and three filtered surface water samples were collected in the vicinity of the Creek (locations OS01 through OS07) as part of the Expanded Site Investigation (ESI) (E&E 1996). SVOCs (Method Base Neutral Acid [BNA]) and metals (Methods AA, ICP/MS, and ICP-RAS) were analyzed in all media. A data quality summary presented in the OESER RI indicated that there were no problems that affected data usability. These data will be used to assess data gaps and will be included in the risk evaluation as part of the RI/FS.

3.1.6 Removal Assessment, Phase II

Three unfiltered surface water samples were collected in the vicinity of the Creek (locations 256, 320, and 343) as part of the Phase II Removal Assessment (E&E 1998a,b) conducted at the OESER site. SVOCs (EPA Methods 8270 and 8270 Selective Ion Monitoring [SIM]) and TPH (Method Northwest Total Petroleum Hydrocarbon [NWTPH]) were analyzed. A data quality summary presented in the OESER RI indicated that there were no problems that affected data usability. These data will be used to assess data gaps and will be included in the risk evaluation as part of the RI/FS.

3.1.7 OESER Company Remedial Investigation

The OESER RI (E&E 2002a) was the source for most of the historical data contained within the Park database. Types of data collected in the vicinity of the creek during the RI included groundwater (5 locations), berries (2 locations), seeps (2 locations), springs (1 location), subsurface soil leachate (1 location), surface water (7 locations), sediment (11 locations), bioaccumulation testing (3 locations), surface soil (87 locations), and subsurface soil (12 locations). Most of these media were analyzed for a full suite of analytes, including dioxins, EPA/VPH, TPH, volatile organic compounds (VOCs), SVOCs, metals, and conventionals. The data quality evaluation in the RI report indicated that all precision, accuracy, representativeness, completeness, and comparability goals were achieved for the RI field and analytical investigation. Validated analytical precision and accuracy showed that more than 99% of all target compound and target analyte data were acceptable for use. These data will be used both for data gaps analysis and for risk evaluation in the Park RI.

In addition to conventional and chemical analysis, biological testing was conducted as part of the OESER site RI (E&E 2002a) and included a 10-day toxicity test with the amphipod *Hyalella azteca,* and a 28-day bioaccumulation test with the aquatic oligochaete *Lumbriculus variegates*. Data quality of the biological testing results was deemed acceptable for use in the RI by EPA (refer to Section 3.6.5). These data will also be used both for data gaps analysis and for risk evaluation in the Park RI.

3.1.8 Little Squalicum Creek Screening Level Assessment

Ecology (2004) conducted the most recent investigation and evaluated six surface sediment samples (locations LSC01 through LSC06) and two surface soil samples (LSCS1 and LSCS2) in the vicinity of the Creek. All samples were analyzed for SVOCs using EPA Method 8270, and sediment samples were additionally submitted for bioassay testing. Bioassay tests conducted included a 10-day amphipod (*Hyalella azteca*), 20-day midge (*Chironomus tentans*), and Microtox® sediment porewater tests. The chemical data quality were of acceptable quality; however, some precision was lost in the analysis of SVOCs due to sample dilutions required because of hydrocarbon interference. Bioassay data were also of acceptable quality. These data will be used both for data gaps analysis and for risk evaluation in the Park RI.

3.2 HYDROGEOLOGIC DATA

Groundwater wells (MW-LSC-1 through MW-LSC-4) were installed along the old railroad grade located west of the Creek, and groundwater from these wells was evaluated during the OESER RI (E&E 2002a) (Figure 3-2). Groundwater was observed only a few feet below the ground surface and was characterized as a continuous aquifer with connections to the deeper of two zones identified on the OESER site located upgradient (north) of this Park area. Soils were described as primarily composed of coarse materials (i.e., sands and gravels).

Groundwater was measured over three sampling events in September 1999, December 1999, and February 2000. The data show that groundwater elevations were significantly higher in the middle well (MW-LSC-2), an anomalous mounding of groundwater. MW-LSC-2 appears to be located at the present terminus of the natural overland flow path toward the creek, designated by City staff as "Sugar Waste Gulch" on an old easement description. This area may represent a preferential groundwater flow path, such as a former stream bed to the Creek.

A mass balance of surface and storm drain water flowing into and out of the Creek was also conducted by E&E (2002a). They concluded the following:

- The headwaters of the creek originate with the storm drain outflows from the combined OESER/Birchwood outfall to the west (north) and the Birchwood/BTC outfall from the east.
- The creek terminates with the culvert that empties onto the beach at Bellingham Bay.
- During the dry season, tapped spring flows account for about one-third of the flow from the creek.
- During the rainy season, virtually all flow from the creek can be traced back to stormwater runoff entering the creek through the three storm drain systems that service the surrounding area (including Marine Drive storm drain).

3.3 GEOTECHNICAL AND OTHER PHYSICAL PARAMETERS

As part of the Creek Wetlands Compensation Project, Landau Associates conducted a geotechnical evaluation to assist in wetlands and stream channel design within the Park as compensation for wetlands lost during a planned expansion of the Bellingham International Airport (DEA 1993). Landau was a subconsultant to David Evans and Associates, who was contracted with the Port of Bellingham.

Subsurface conditions were evaluated on the site by excavating 22 backhoe test pits and 6 hand explorations in October 1992 (Figure 3-4). The depth of these excavations ranged from 1 to 6 ft below ground surface (bgs). Selected soil samples were analyzed for grain size and moisture content. The following observations and conclusions were made by Landau:

- Soil conditions were variable and included clean (low silt/clay content) sand and gravel, silty sand and gravel, and occasional silt and clay units.
- Fill materials including wood, metal, glass, and ash debris were encountered at several locations in the northeast to central portion of the site.
- One location, test pit SC-20, contained significant amounts of glass and other household refuse. This location is near the BTC parking lot.
- Groundwater was encountered at six test pit locations in the northeastern portion of the site ranging from approximately 2 to 5-1/2 ft bgs (October 1992).
- Most soil appears to be moderately to highly permeable. As a result, Landau recommended a low permeability liner within the new stream channel location and applicable wetland cells to reduce water loss by infiltration (DEA 1993).

3.4 HABITAT CHARACTERISTICS

The Creek begins at the Birchwood neighborhood outfall (underground pipe from the east) and ends approximately 1,500 ft downstream at Bellingham Bay. The creek channel ranges in width from approximately 5 to 10 ft, with water depths usually less than 1 ft in most places. The creek is fed by three stormwater outfalls (the east Birchwood neighborhood, Birchwood/OESER, and Marine Drive outfalls), two tapped springs, and several small seeps (E&E 2002a). Water flow is observed during the wetter season (October through May), but during the drier season the creek bed may be exposed.

As indicated by E&E (2002a), numerous benthic invertebrate taxa, including caddisfly larvae, midge larvae, amphipods, snails, and aquatic oligochates, were observed in the Creek during the OESER RI fieldwork. These observations suggest that the creek supports reproducing populations of benthic organisms. The Creek, however, does not support fish, although some salmonid fingerlings have been found as far upstream as the Marine Drive Bridge. It is assumed that they swam into this area of the creek during a high tide or storm event and that they remained in this area for only a short time before returning to Bellingham Bay. (An elevated cement culvert near the mouth of the creek provides an obstacle to fish that can only be overcome during such high-water events.)

The creek channel and other areas in the Park are shaded by a well-developed overstory of alder, willow, and black cottonwood trees. Common plant species in the understory include grasses, horsetail, blackberry, hawthorne, holly, and saplings of alder, willow, cottonwood, mountain ash, fir, and cedar (E&E 2002a).

3.5 SCREENING LEVEL CRITERIA

This section presents the ARARs for the purposes of selecting a screening benchmark for evaluating historical data and selecting analytes to carry forward for the RI/FS. Screening benchmarks were compiled based on human health toxicity, ecological toxicity, natural background conditions in Puget Sound, and available site-specific background concentrations. In general, if benchmarks were available from multiple sources for a single analyte, the lowest concentration was selected as the screening benchmark for the purposes of this data gaps analysis. The array of screening benchmarks considered and the selected screening levels for each medium are included with this document.[3] Sources of benchmarks evaluated for each medium are summarized below.

[3] Tables presenting screening benchmarks for soil, groundwater, surface water, and soils are included on the CD attached to the front cover.

3.5.1 Soil

Available historical data for soil include onsite surface and subsurface soil data and background surface soil data. Given that some surface and subsurface soils onsite also have the potential to become sediment in the event that the creek is rerouted, screening benchmarks for sediment were considered in addition to screening benchmarks for soil. There are no human health sediment benchmarks, but there are ecological sediment benchmarks.[4] Screening benchmarks for soil were obtained from the following sources:

- MTCA Method B – Direct Human Contact to Soil, obtained from CLARC Version 3.1 (Ecology 2001a)
- U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for soil leaching to groundwater, obtained from http://www.epa.gov/region09/waste/sfund/prg/index.htm (October 2004)
- MTCA Terrestrial Ecological Evaluation (TEE) Indicator Soil Concentrations for plants, soil invertebrates and wildlife, obtained from MTCA Table 749-3 (Ecology 2001b)
- Freshwater Sediment Lowest Apparent Effect Thresholds (LAETs), obtained from Ecology (2003)[5]
- Marine Sediment Quality Standards, obtained from WAC 173-204 (Ecology 1995)[6]
- Puget Sound regional background soil concentrations (Ecology 1994)
- Site-specific background soil concentrations (surface and subsurface).

The screening levels (SL) were prioritized such that the minimum value of the screening values was used as the SL unless it was less than either of the background concentrations (site-specific or regional), in which case it was adjusted up to the maximum background concentration. For SL values that are normalized to total organic carbon (TOC), but were unavailable for a data set, a TOC value of 1.0% was assumed in normalizing these data. A TOC value of about 1.0% was typically measured in soils and sediments of the Park.

[4] Human health benchmarks are based upon accumulation of all exposure pathways and the affected populations, but not upon strict direct numerical criteria.
[5] Freshwater LAETs are used for guidance only. Sediment bioassays are the definitive tool for evaluation of ecological risk in freshwater systems.
[6] Marine Sediment Quality Standards are screening criteria. Sediment bioassays are the definitive tool for evaluation of ecological risk in marine systems.

3.5.2 Groundwater

Available historical data for groundwater include unfiltered and filtered samples from onsite and background locations. Filtered samples were only analyzed for metals. Screening benchmarks for groundwater came from the following human health and ecological sources:

- Washington State Criteria (WAC 173-201A-040)
- National Ambient Water Quality Criteria – freshwater chronic and human health consumption of water and organisms (USEPA 2002)
- Tier II Secondary Chronic Values (SCV) (Suter and Tsao 1996)
- EPA Region 5 Ecological Screening Levels (USEPA 2003)
- EPA Region 6 Ecological Screening Benchmarks (TNRCC 2001)
- MTCA Method B Surface Water – Ingestion of Fish, obtained from CLARC Version 3.1 (Ecology 2001a)
- Federal MCLs (USEPA 2005)
- State MCLs (WAC 246-290-310)
- MTCA Method B Groundwater.

The preliminary groundwater screening levels were developed in three steps. First, the ecological screening level was identified. The minimum (lower concentration) of the Washington State criterion and the National Ambient Water Quality criterion was selected. If no value was available from either of those sources, the SCV was selected. If no SCV was available, the EPA Region 5 ESL was selected. If no EPA Region 5 ESL was available, the EPA Region 6 benchmark was selected.

Second, the potable groundwater screening level was identified as follows. The state MCL was the preferred screening level. If no state MCL was available, the federal MCL was used. If no federal MCL was available, the MTCA Method B groundwater level was used.

Finally, the ecological and the potable groundwater screening levels were compared with the MTCA Method B surface water level, and the lowest of the three was selected as the risk-based screening level. If the background concentration exceeded the risk-based screening level, the background concentration was used as the final screening level. Background groundwater concentrations were evaluated using well MW-06D, located northeast of the OESER site near Cedarwood Avenue. MW-06D has been sampled on 12 different occasions since 1995, the most recent of which was during the OESER RI conducted by E&E on behalf of EPA (E&E 2002a).

EPA equilibrium partitioning model will be used in the RI to evaluate groundwater concentrations that could re-contaminate sediments.

3.5.3 Surface Water and Porewater

Available historical data include unfiltered water analytical data for surface water, springs, seeps, and porewater, and filtered water analytical data for surface water, springs, and seeps. The sources and hierarchy of screening levels discussed in Section 3.5.2 for groundwater was used for surface water, except no acceptable background data were available for surface water and no screening levels associated with potable water (MCLs and MTCA Method B groundwater) were used. The screening levels for protection of aquatic life and for humans eating fish from the creek are considered at this time sufficiently protective for incidental and occasional consumption of creek water. The creek has insufficient flow to provide a year-round source of drinking water to meet daily needs.

3.5.4 Surface Sediment

Available historical data for sediment includes samples from onsite locations. Given that surface sediments onsite also have the potential to become soil in the event that the creek is rerouted, screening benchmarks for soil were considered in addition to screening benchmarks for sediment. There are no human health sediment benchmarks, but there are ecological sediment benchmarks.[7] Screening benchmarks for sediment were obtained from the following sources:

- MTCA Method B – Direct Human Contact to Soil, obtained from CLARC Version 3.1 (Ecology 2001a)
- U.S. EPA Region 9 PRGs for soil leaching to groundwater, obtained from http://www.epa.gov/region09/waste/sfund/prg/index.htm (October 2004)
- MTCA TE Indicator Soil Concentrations for plants, soil invertebrates and wildlife, obtained from MTCA Table 749-3 (Ecology 2001b)
- Freshwater Sediment LAETs, obtained from Ecology (2003)[8]
- Marine Sediment Quality Standards, obtained from WAC 173-204 (Ecology 1995)[9]

[7] Human health benchmarks are based upon accumulation of all exposure pathways and the affected populations, but not upon strict direct numerical criteria.
[8] Freshwater LAETs are used for guidance only. Sediment bioassays are the definitive tool for evaluation of ecological risk in freshwater systems.
[9] Marine Sediment Quality Standards are screening criteria. Sediment bioassays are the definitive tool for evaluation of ecological risk in marine systems.

- Puget Sound regional background soil concentrations, obtained from Ecology (1994).

The screening levels were prioritized such that the minimum value of the screening values was used as the SL.

3.5.5 Biological Analyses

There are no screening levels associated with the biological analyses that were conducted at the site. Biological testing of site samples followed EPA, Ecology, and American Society for Testing and Materials (ASTM) Methods (USEPA 1994, Ecology 2003, ASTM 1997) and included 10-day toxicity testing of sediment with the freshwater amphipod *Hyalella azteca*, a 20-day test assessing mortality and growth of the midge *Chironomus tentans*, a 28-day sediment bioaccumulation test with the freshwater oligochaete *Lumbriculus variegates*, and the Microtox® sediment porewater test. Testing results are discussed further in Section 3.6.5.

Freshwater sediment biological assessment methods are outlined in Ecology's Sampling Analysis Plan Appendix (Ecology 2003). These include the following:

- 10-day and 20-day sediment toxicity test that assesses mortality and growth of the midge *Chironomus tentans*
- 96-hour sediment toxicity test that assesses mortality and developmental malformations in embryos of the frog *Xenopus laevis*
- Microtox® 100 percent sediment porewater extract test
- 10-day and 28-day sediment toxicity test that assesses mortality and growth of the amphipod *Hyalella azteca*.

3.6 DATA SCREENING

Analytes with detected concentrations exceeding SLs were considered as potential indicator hazardous substances (IHSs). This section summarizes the degree to which detected concentrations exceeded the thresholds presented in Section 3.5 for each medium. Raw analytical data have been assembled from historical reports into the Integral database for this project. The magnitude by which detected concentrations exceeded screening levels is presented for each media in Tables 3-1 through 3-7.

3.6.1 Soil

Both surface soil and subsurface soil data were available for comparison to screening levels. Results are discussed below.

3.6.1.1 Surface Soil

A total of 20 background samples collected during the OESER RI (E&E 2002a) and 102 site samples collected during the OESER RI (100 samples) and the Ecology (2004) investigation were evaluated. Most of the site surface samples (95) only had TPH field screening analysis performed (method used was laser-induced fluorescence or LIF). None of the detected compounds in background soil samples exceeded screening levels. Surface soils from the site, however, had 48 analytes with detected concentrations exceeding screening levels. Exceedances were found for the following analyte classes (number of individual analytes indicated in parentheses): dioxin (1), metals (12), SVOCs including polycyclic aromatic hydrocarbons (PAHs) and PCP (34), and petroleum hydrocarbons (1). The number of samples exceeding screening levels for these analytes is shown in Table 3-1. TPH had the most number of samples (50) exceeding screening levels. Several ubiquitous metals (barium, vanadium, and zinc) had more than 10 exceedances while many SVOCs only had one sample exceeding screening levels.

3.6.1.2 Subsurface Soil

A total of two background samples collected during the OESER ESI (E&E 1996) and 24 site samples collected during the OESER RI were evaluated. None of the detected compounds in background soil samples exceeded screening levels. Site subsurface soils, however, had six analytes (all metals) with detected concentrations exceeding screening levels. These metals included barium, copper, mercury, nickel, vanadium, and zinc. The number of samples exceeding screening levels for these metals is shown in Table 3-2.

3.6.2 Groundwater

Groundwater data available for screening include background data from one well (MW-06D) – 19 unfiltered samples and eight filtered samples, and site data from five wells – 11 unfiltered samples and six unfiltered samples. Filtered groundwater was only analyzed for metals. Background unfiltered groundwater had one analyte with a detected concentration exceeding its screening level – benzo(a)anthracene (Table 3-3). Background filtered groundwater had an exceedance for one metal – thallium (Table 3-4). Site filtered groundwater had exceedances for four metals – barium, cadmium, magnesium, and manganese (Table 3-4). Site unfiltered groundwater had 24 analytes with detected concentrations exceeding screening levels - 21 SVOCs and three metals (Table 3-3). Most of the exceedances for SVOCs occurred only in WP1.[10] Barium and magnesium had more exceedances than the other analytes (4 and 6, respectively).

[10] WP-1 is a shallow well point; hand installed approximately 1 to 2 feet into the center of the creek channel.

3.6.3 Surface Water

A total of 32 site samples provided data for the concentration screening evaluation. These data include samples collected during the ESI (4 surface water samples; E&E 1996), the RA Phase II (3 surface water samples; E&E 1998a,b), the SI (2 surface water samples; E&E 1987), the OESER RI (13 surface water samples, 2 spring samples, and 3 seep samples; E&E 2002a), and the site hazard assessment (5 porewater samples; Parametrix 1991). Both unfiltered and filtered samples were analyzed; filtered samples were only analyzed for metals. Site unfiltered surface water had 23 analytes with detected concentrations exceeding screening levels. Exceedances were found for the following analyte classes (number of individual analytes indicated in parentheses): dioxin (1), metals (8), and SVOCs (14). The number of analytes exceeding screening levels totaled 145, as shown in Table 3-5. Barium, magnesium, and arsenic had the most number of samples (20, 19, 15) exceeding screening levels. Site filtered surface water had exceedances for four metals – aluminum, arsenic, barium, and magnesium (Table 3-6).

3.6.4 Surface Sediment

Data from a total of 54 site surface sediment samples were available for comparison to screening levels; these data were generated as part of several of the historical investigations discussed above. Site samples had 54 analytes with detected concentrations exceeding screening levels. Exceedances were found for the following analyte classes (number of individual analytes indicated in parentheses): dioxins (1), SVOCs (38), petroleum hydrocarbons (1), and metals (14). The number of chemical screening level exceedences within the 54 surface samples totaled 584, as shown in Table 3-7. Eighty percent (471) of the screening level exceedances were for SVOCs and 15% (92) were for metals. Most of the SVOC exceedances (362) were for PAHs. The metals most frequently in exceedance were vanadium (19), zinc (16), and copper (8).

3.6.5 Biological Analyses

This section summarizes results of biological analysis that include sediment toxicity testing, sediment bioaccumulation testing, and berry analysis conducted as part of the OESER Site RI (E&E 2002a) and sediment toxicity testing that was conducted more recently by Ecology (2004). Results are presented in Appendix B.

3.6.5.1 Sediment Toxicity and Bioaccumulation (OESER RI)

Biological analytical results were conducted as part of the OESER site RI (E&E 2002a) and included a 10-day toxicity test with the amphipod *Hyalella azteca* and a 28-day bioaccumulation test with the aquatic oligochaete *Lumbriculus variegates.*[11]

Sediment toxicity testing with *H. azteca* was conducted on samples from eight locations (SD1 through SD8) in the Creek, one location in the channel that leads from the OESER outfall to the creek (SD10), and one location at the Birchwood outfall (SD9), which is considered a site-specific background sample. The Birchwood neighborhood outfall is upstream from the confluence of the OESER outfall channel with the creek. Results are contained in Appendix B, Table B-1.

The two test endpoints evaluated were survival and growth. The average percent survival in samples from the creek and OESER outfall channel ranged from 78 to 93%; average percent survival in the background station was 91%. None of the site survival results differed significantly from the survival results in the background sample. The average dry-weight per organism (amphipod growth) in samples from the creek and OESER outfall channel ranged from 0.13 mg to 0.20 mg; average dry weight per organism in the background station was 0.24 mg. It is not known if the growth results in the site samples are significantly different from the growth in the background sample because it was not reported in the OESER RI, and the raw data are not available to make this comparison. It should be noted, however, that average amphipod growth in the laboratory control was only 0.10 mg per organism.

Sediment bioaccumulation testing with *L. variegatus*, was conducted on sediment from three locations in the Creek (SD2, SD5, and SD6). Results are contained in Appendix B, Table B-2 and B-3. Following the 28-day exposure period, the oligochaetes were removed from the sediment and analyzed for bioaccumulative chemicals of concern (COCs), which included several SVOCs (phenols, PAHs, benzoic acid, and benzyl alcohol), and dioxins/furans. At test termination, the average biomass per replicate in the site samples was 3.7 g, 2.9 g, and 11.2 g, respectively, for samples SD2, SD5, and SD6. The average biomass per replicate in the laboratory control was 8.9 g and biomass at test initiation for all samples was 10 g. These data indicate that growth only occurred in sample SD6, the other two site samples and the control each lost weight during the test. The weight loss in samples SD2 and SD5 was significantly greater than the weight loss in the control, suggesting either a toxic effect at these two locations, or significantly reduced food availability. Over the 28-day test period, the worms are not fed and instead must rely on available organic carbon in the sediment to sustain their dietary requirements. The

[11] It should be noted that the methods and number of tests performed as part of the OESER RI did not follow the requirements of the Washington State Sediment Management Standards, which is an ARAR for this site.

percent TOC in the site samples were 1.3% (SD2), 1.8% (SD5), and 11% (SD6), suggesting that differences in food availability may have contributed to the differences in biomass between the site samples.

The limited biomass obtained from each of the site samples at test termination prevented the analysis of the entire analytical suite at each location, with the exception of the control sample. Rather, analyses were split between the samples: sample SD6 was analyzed for SVOCs, and the biomass from samples SD2 and SD5 was pooled and analyzed for dioxin. Results are summarized in Appendix B along with the corresponding sediment concentrations. Eleven PAHs, six phenols, and two other SVOCs (benzoic acid and benzyl alcohol) were detected in organisms exposed to sediment from location SD6. However, five of these analytes (2,4,6-trichlorophenol, 2-methylphenol, phenol, benzoic acid, and benzyl alcohol) were not detected in sediment from SD6. Seven dioxin/furan congeners were detected in the organisms exposed to sediment from locations SD-02 and SD-05. As compared to sediment dioxin concentrations at these two locations, each of the seven dioxin congeners was also detected in sediment at SD2 and SD5 except for 1,2,3,4,7,8-HxCDD, which was non-detect at both locations.

3.6.5.2 Berry Testing (OESER RI)

Four composite berry samples from Himalayan blackberry (*Rubus discolor*) bushes were collected from the following locations:

- Berry 1: collected by the railroad tracks immediately south of the OESER Company facility
- Berry 2: collected along the old railbed/path above the Creek
- Berry 3: collected from the ravine on the south side of the creek
- Berry 4: collected from a residential background area approximately at the intersection of Squalicum Parkway and Meridian Street in Bellingham, WA.

From all four locations, washed (rinsed with distilled water) and unwashed berries were analyzed for VOCs, SVOCs, and dioxin. Analytes that were detected at least once are presented in Appendix B (Table B-4) and include six PAHs, three other SVOCs (1,2,3-trichlorobenzene, benzoic acid, and benzyl alcohol), two VOCs (p-isopropyltoluene and styrene), and three dioxin/furan congeners (1,2,3,4,6,7,8-HpCDD, OCDD, and OCDF). As expected, in general, concentrations in unwashed berries were greater than concentrations in washed berries. The SVOC 1,2,3-trichlorobenzene was only detected in the washed background sample. All other SVOCs, except from fluoranthene and phenanthrene, were only detected in site samples. Concentrations of fluoranthene and phenanthrene in the berry samples from the site were within the range of concentrations observed in the background sample. The two VOCs were detected in all samples, and concentrations in

berry samples from the site bracketed concentrations observed in the background sample. The compounds p-isopropyl toluene, benzoic acid, and benzyl alcohol are naturally occurring in berries. Of the three dioxin congeners detected, two (1,2,3,4,6,7,8-HpCDD and OCDF) were only detected in the site samples. Octachlordibenzo-p-dioxin (OCDD) was detected in all samples except for the washed berries from the background station; site concentrations bracketed the background concentration. Tetrachlorodibenzo-p-dioxin (TCDD) toxicity equivalency quotients (TEQ) concentrations in unwashed berries consistently exceeded concentrations in washed berries, and site concentrations exceeded background concentrations. Based on these results, the risk assessment in the OESER RI concluded that consumption of berries was not an exposure pathway of concern. No additional sampling of berries is planned for the Park RI.

3.6.5.3 Sediment Toxicity (Ecology)

In September of 2003, Ecology collected six surface sediment samples (locations LSC01 through LSC06) and two surface soil samples (LSCS1 and LSCS2) in the vicinity of the Creek (Ecology 2004). Only the sediment samples were submitted for bioassay analysis; however, all samples were analyzed for SVOCs. Three toxicity tests with three different species conducted on the sediment samples were a 10-day amphipod (*Hyalella azteca*), 20-day midge (*Chironomus tentans*), and Microtox® tests. Sediment toxicity results are presented in Appendix B (Table B-5).

Results indicated that five of the six sediment samples LSC02, LSC03, LSC04, LSC05, and LSC06 showed toxicity as follows:

- LSC02: mean survival was significantly reduced in the 20-day *C. tentans* test as compared to survival in the reference sample. Growth, however, was greater in this sample than in the reference. The bioassay results at this station indicate exceedances of the recommended freshwater Cleanup Screening Level (CSL) endpoint.
- LSC03: mean survival was significantly reduced in the 10-day *H. azteca* test as compared to survival in the reference sample. Mean survival and growth were significantly reduced in the 20-day *C. tentans* test as compared to survival and growth in the reference sample. Microtox® light output was significantly reduced as compared to light output in the reference sample. The bioassay results at this station indicate exceedances of the recommended freshwater CSL endpoint.
- LSC04: mean survival was significantly reduced in the 10-day *H. azteca* test as compared to survival in the reference sample (an exceedance of the freshwater CSL endpoint).
- LSC05: Microtox® light output was significantly reduced as compared to light output in the reference sample (an exceedance of the freshwater SQS endpoint).

- LSC06: mean survival was significantly reduced in the 10-day *H. azteca* test as compared to survival in the reference sample. Microtox® light output was significantly reduced as compared to light output in the reference sample. The results for LSC06 represent a CSL exceedance based on the combined results from the *H. azteca* and Microtox bioassays.

3.7 PRELIMINARY CONCEPTUAL SITE MODEL

At this phase of the RI/FS, the CSM presents a preliminary understanding of site conditions. Integral developed the CSM from the information presented in Section 3.6 and general knowledge of site conditions and contaminant transport behavior. Development of a CSM early in the RI/FS process helps identify data gaps and guide collection of data appropriate for assessing risks and remedial actions. The CSM will be refined throughout the project as additional data are collected and site conditions are better understood. The CSM, illustrated in Figure 3-5 and described in Table 3-8, includes sources of contaminants, transport pathways, and potential exposure pathways for human and ecological receptors.

3.7.1 Sources

Several potential contamination sources have been identified for surface soils and surface waters in the Park. OESER disposed of wood-treating wastes north of the creek near the OESER site boundary. In some cases, discharge of process wastewater or contaminated stormwater may have occurred directly into the creek bed and surrounding areas (refer to Section 2). A stormwater pipe combining discharge from OESER and portions of the Birchwood neighborhood (another potential source) discharges to the creek from the north side. Likely contaminants from these activities include the following:

- PCP, a wood treating chemical
- Diesel-range organic hydrocarbons (DRO), used as a carrier for PCP
- Dioxins and furans, common contaminants of PCP
- PAHs, components of both DRO and the wood treating mixture in creosote
- Gasoline-range organic hydrocarbons (GRO) from vehicular activities.

An outfall conveys nonpoint source runoff from Marine Drive into the Creek at the south end of the bridge. A stormwater pipe combining discharge from the BTC campus and portions of the Birchwood neighborhood discharges to the Creek from the south side. A culvert discharges from the BTC parking lot into the southeast corner of the Park. The petroleum released from Marine Drive and the college could be GRO or DRO. Additional potential contaminants from these facilities include a variety of SVOCs including PAHs

and phthalates, both of which are common in urban runoff, and metals from vehicular activities and general urban runoff.

A gravel pit operated south of the creek, both east and west of Marine Drive. Gravel operations could have been a source of petroleum hydrocarbons (DRO) from the use of motorized equipment (e.g., diesel fuel and motor oil).

Historically, a construction material landfill operated beneath what is now a portion of the BTC parking lot. Based on historical sampling, a debris field was documented in the southeast corner of the Park near BTC. The debris is believed to be primarily construction materials rather than municipal landfill materials.

The BNSF railroad tracks could be a source of pesticides and DRO, including PAHs, to the soils in the vicinity of the tracks. Pesticides and oily products have been reportedly used to treat the wood in the ties and to control vegetation along the tracks.

3.7.2 Transport Pathways

Infiltration from rainfall could cause contaminants in surface soils to leach to subsurface soils and eventually to groundwater. Shallow groundwater might discharge into the creek. The groundwater is also hydraulically connected to Bellingham Bay. Groundwater contaminants could eventually reach surface water and sediments in the creek, the bay, or both.

Soil contaminants could be carried in surface runoff to the surface water in the Creek. Some of the contaminants in surface water could bind to sediments in the creek. Other surface water contaminants could be carried down the creek to the beach and the surface water and sediments of Bellingham Bay.

Many of the contaminants that reach the mouth of the creek are likely to be dispersed into Bellingham Bay because the beach is a highly exposed area with a great deal of erosion. The shallow portions of the beach are primarily cobbles and gravel, with little fine-grained sediments to adsorb chemicals.

Soils in areas not covered by vegetation could become airborne and transported by wind. If GRO is present from urban runoff, some volatilization could occur. The other contaminants of interest are not volatile, so volatilization is not likely to be an important transport pathway for them.

Contaminants in surface and subsurface soil could be taken up by plants and soil-dwelling invertebrates. Contaminants in surface water and sediments of the creek or the bay could be ingested by benthic organisms (animals and plants living in the sediments).

In addition, if the creek were rerouted to another portion of the park, sediment would become soil and soil would become sediment, changing potential pathways for contamination at any given location. If excavation takes place to create a "new" creek bed for the rerouted creek, formerly buried contamination could be exposed and thus potentially transported elsewhere.

3.7.3 Potential Receptor Populations and Exposure Pathways

Potential human receptors include the following:

- Recreational park users
- Maintenance workers working in the park
- Residents near the park
- Workers at BTC, OESER, and other work sites near the park.

Potential ecological receptors include the following:

- Terrestrial and aquatic plants
- Soil-dwelling invertebrates (e.g., worms)
- Terrestrial animals (e.g., birds, mammals, amphibians, and reptiles)
- Domesticated animals (e.g., dogs)
- Various fish species (e.g., salmonids)
- Benthic invertebrates (e.g., snails).

Park users, maintenance and construction workers, and terrestrial animals could be exposed to contaminants in surface soil by direct contact (unintentional ingestion and absorption across the skin) with the soil or by inhalation of airborne particulates. Residents, workers, and terrestrial animals near the park could inhale dust blown out of the park. Terrestrial plants could take up contaminants from surface and shallow subsurface soils and consume contaminated plants or soil-dwelling invertebrates while foraging for food in the park. Park users could be exposed to contaminants by ingesting local plants (e.g., berries).

If park development or maintenance activities uncovered subsurface soil, park users, maintenance workers, and terrestrial animals could be exposed to the subsurface soil through direct contact or inhalation. The subsurface soil would be come available for windblown transport to residents, workers, and terrestrial animals near the park. If the

creek is re-routed, surface and subsurface soils could be converted to sediments with sediment/biota exposure routes.

Ecological receptors are not likely to be exposed directly to groundwater, because groundwater is likely deeper than the active zone for plant roots and burrowing animals (typically 6 ft). Pending future site investigations, the groundwater is assumed to be potable if a well were drilled; though it is unlikely a well will be drilled in the park. If a well were drilled, users could be exposed through ingestion of the water, dermal contact with the water, and inhalation of vapors generated during household activities such as showering. As discussed in Section 3.7.2, groundwater contaminants could be transported from upgradient sources to the Creek, Bellingham Bay, or both.

Park users could be exposed to contaminants in surface water and sediments through direct contact while recreationally using the Creek. Park maintenance workers are unlikely to have much contact with the creek. Terrestrial animals could be exposed to surface water and sediments through direct contact while foraging for prey and through intentionally drinking the water. Terrestrial animals could also be exposed by eating contaminated prey in the creek.

If groundwater or surface water contaminants reach Bellingham Bay, humans could be exposed through direct contact with water and sediments while collecting shellfish or wading recreationally and through ingestion of shellfish caught locally. Birds or animals preying on shellfish and fish migrating into the Creek could also be exposed through direct contact with the surface water and the sediments and through ingestion of the shellfish and fish.

3.8 DATA GAPS

Data gaps can include the following issues:

- Poor data quality
- Inappropriate analytes
- Lack of data for an area or at depth (spatial)
- Lack of current data (temporal)
- Undefined media (sediment vs. soil) and exposure routes.

Section 3.1 discussed the quality of data collected previously at the site. Because of age, data quality problems, or both, this analysis will not use any of the chemical data collected prior to 1996. However, the physical data collected by Landau (DEA 1993) will be used. This eliminates only a small portion of the total data available. Most of the

samples have been analyzed for the contaminants of interest (TPH, SVOCs, PAHs, metals, and dioxins/furans). The discussion of data gaps will focus on spatial and temporal issues, based on a review of available data and locations of site concentrations that exceed SLs (Section 3.6).

3.8.1 Soils

Soil data gaps are primarily spatial. Although soils along the slope north of the Creek near the OESER property have been studied, no recent soil data are available for the old gravel pit areas on the south side of the Creek. Limited data are available in the vicinity of the railroad tracks (BNSF) and the stormwater discharge from BTC. Soil sampling will focus on these three areas southeast of the Creek. A pattern regarding metals contamination in soils was noted during the OESER RI (E&E 2002a). Several metals appear to be elevated in the area of the Park, so metals analyses will be of interest in the Park RI/FS.

Soil sampling at depth in the areas south of the Creek is necessary because of the possibility of rerouting the Creek into these areas. It might be necessary to dig a new streambed or the re-routed stream might erode surface soils, either of which could expose deeper soils. An understanding of the chemical and physical characteristics of soils in these areas is important for completion of the RI.

Temporal issues are not expected to be an important concern for soils. VOCs detected in surface soil samples more than a couple years ago may have volatilized, so they would be present at lower or nondetectable concentrations now (presuming no additional deposition since the earlier sampling events). Risk estimates based on older soil VOC data could be biased high. However, few VOCs have exceeded their SLs in previous investigations. Since VOCs are not expected to be important chemicals of concern, this chemical group is not proposed for further soils testing.[12]

3.8.2 Groundwater

Groundwater does not appear to be a medium of primary concern at the Park based on sampling and testing results in the OESER RI. No additional wells are proposed within the boundaries of the Park. However, additional groundwater sampling of wells located downgradient of the OESER site is warranted to provide current data for evaluating potential risk to humans and the environment. Piezometers may be installed in selected soil sampling locations to monitor seasonal fluctuations in shallow groundwater (refer to Section 4.2.1).

[12] Soil vapors are typically not a concern at levels historically detected at the site. This pathway will be evaluated in the RI pending the results of this sampling event.

3.8.3 Surface Water

Data gaps for surface water are primarily temporal. Contaminant concentrations in the surface water of the Creek are expected to vary over time because of variable inputs from upstream sources and the discharges from Marine Drive, OESER, BTC, and the Birchwood neighborhood. Additional surface water sampling is warranted to provide current data, focusing on discharge areas and identification of sources.

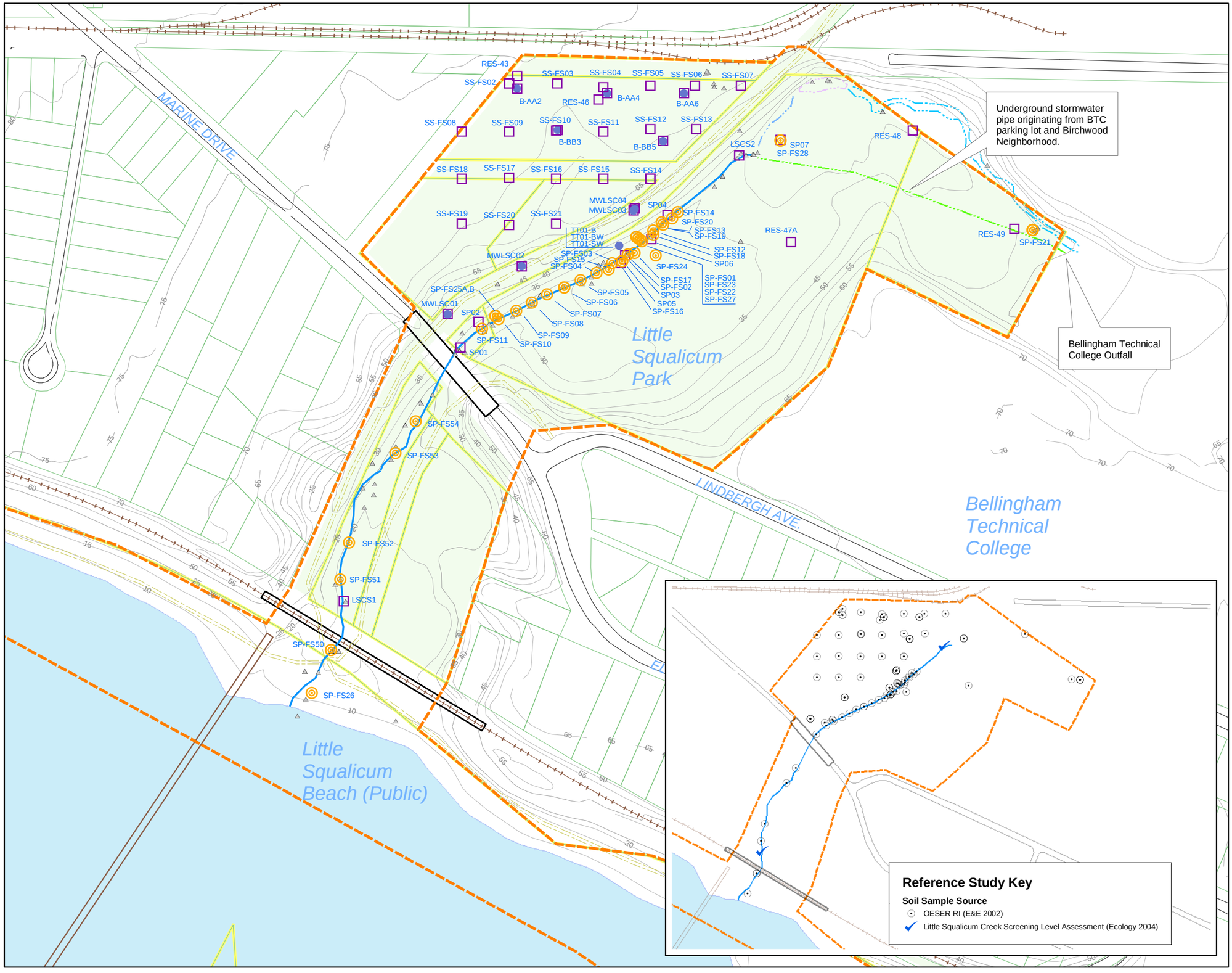
3.8.4 Sediments

Sediment data gaps are both spatial and temporal. Sediment concentrations in the Creek are expected to vary to some extent over time because of interactions with surface water; therefore, older data may not be entirely representative of current sediment conditions. The sediment sampling in the Creek has encompassed most of the length of the creek, but it has not characterized the depth or width of the contaminated sediments. These spatial issues will be important if sediment remediation is warranted.

A round of sediment sampling, at both surface and depth, is warranted to provide current data, focusing on bounding areas of higher concentrations detected in previous sampling efforts and conducting transects across the creek to identify the lateral and vertical extent of sediment contamination.

The highly eroded nature of the beach and the results of previous investigations indicate a low level of concern for the beach located at the mouth of the Creek. Nevertheless, since humans may collect shellfish at the beach, additional beach sediment samples (if sufficient fine-grained sediments can be found within the discharge area of the Creek) will be collected to verify that potential contamination does not pose a health threat.

Sediment in the creek may potentially be reclassified as “soil” if the creek is rerouted to other areas of the Park. Consequently, sediment collected in the creek will be tested as if it will be soil. In addition, soil in the area where the creek could be rerouted will be tested as if it would (later) be sediment.



N

0 100 200 Feet

Soils and Spoil piles

- Spoil Pile or Bank Sample
- Subsurface Soil
- Surface Soil
- Station Locations With Data for Other Media

- Brownfield Assessment Project Area Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

DRAFT

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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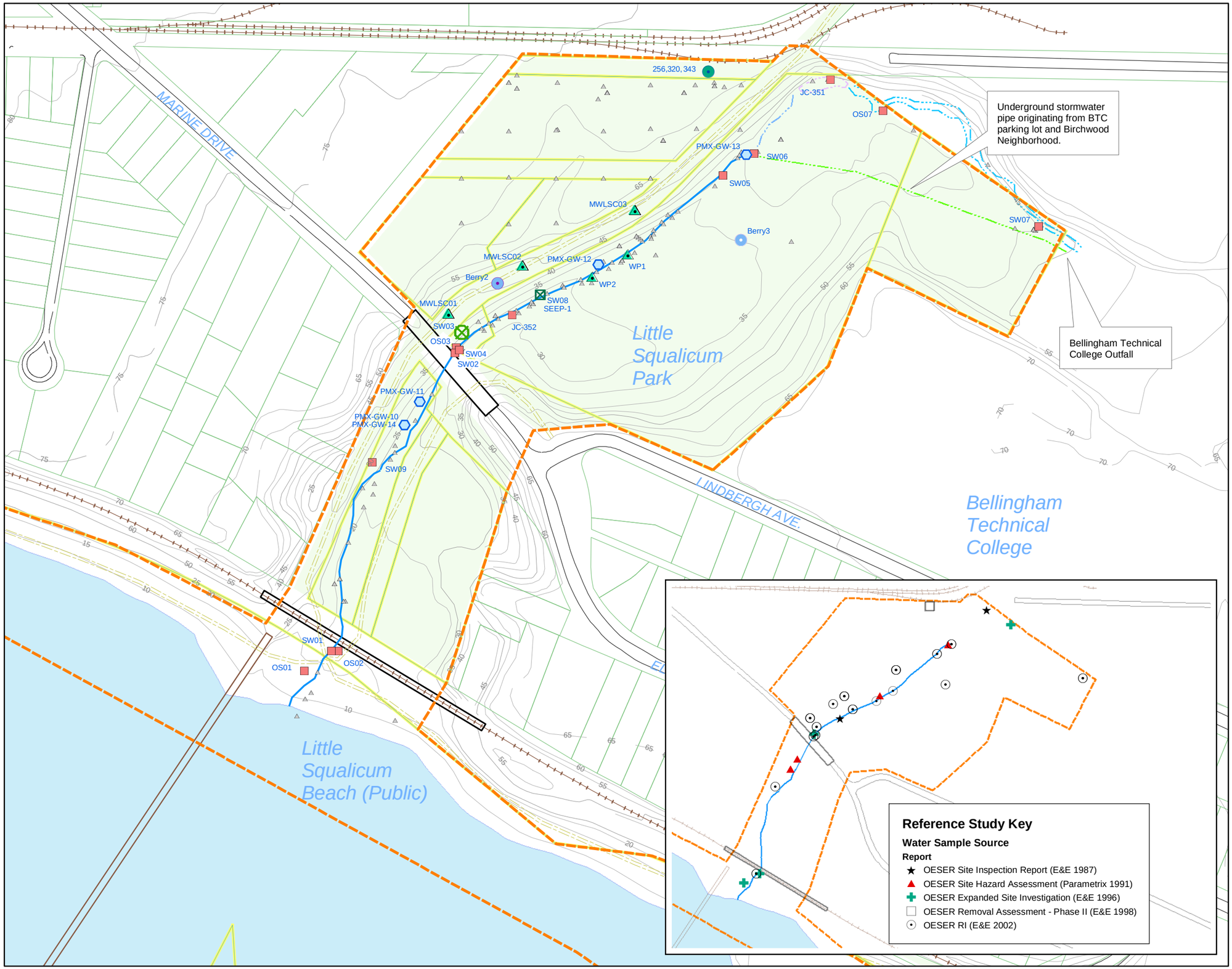
Map Document: (C:\GIS\Projects\LittleSqualicumCr\Sample_Locations_WORKMAP_V4_recov2.mxd)
10/21/2004 -- 8:26:13 AM

Figure 3-1. Historical Soil Sampling Locations



N

0 100 200 Feet

Water, Seeps, and Berries

- Berry Unwashed
- Berry Washed
- Pore Water
- **Outfall Water
- Groundwater
- Spring
- Surface Water
- Seep
- Station Locations With Data for Other Media

- Little Squalicum Park Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

** Three samples at this location

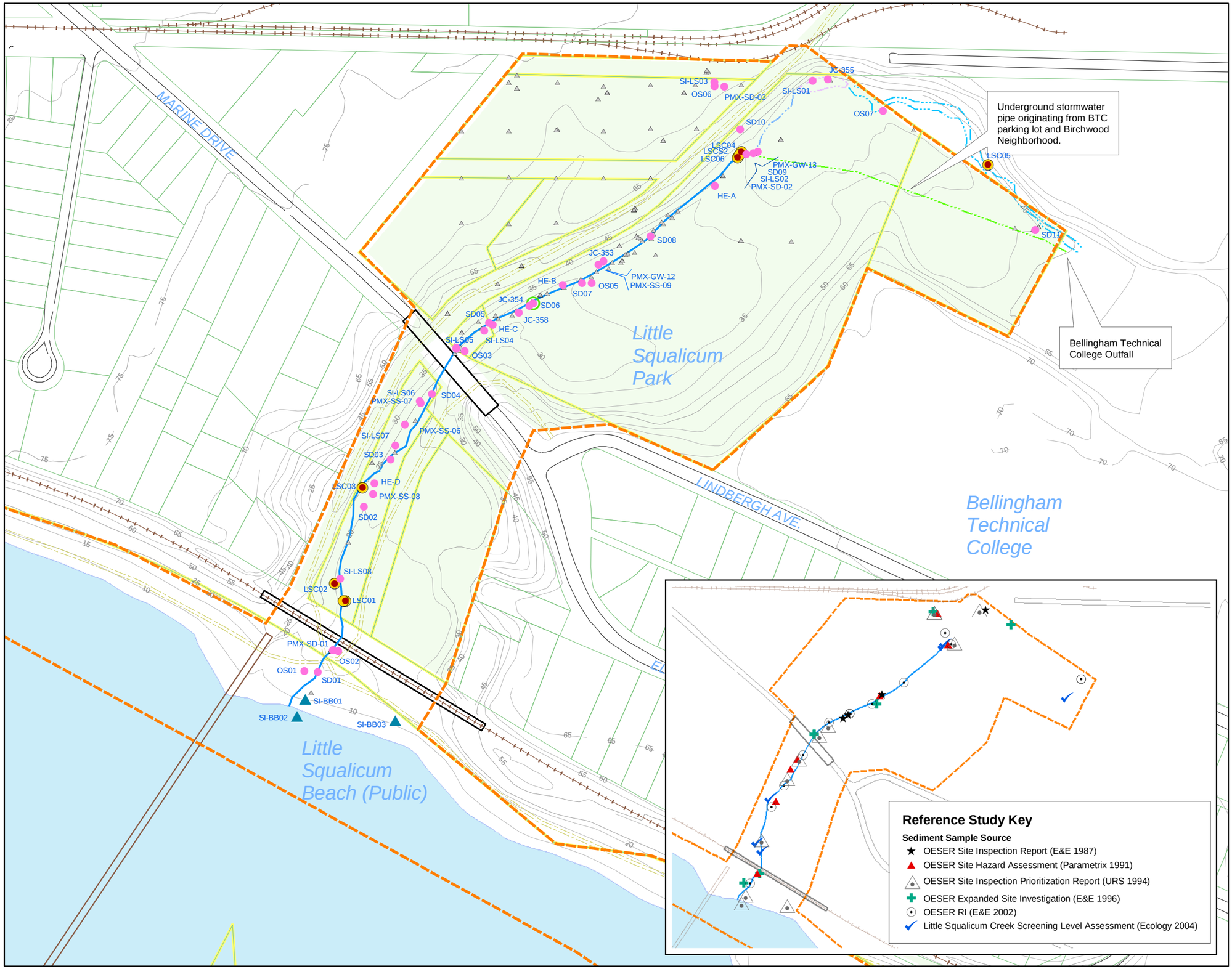
DRAFT

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

integral consulting inc.

Map Document: (C:\GIS\Projects\LittleSqualicumCh1\Sample_Locations_WORK\MAP_V4_recov2.mxd)
10/21/2004 – 8:26:13 AM

Figure 3-2. Historical Water Sampling Locations



N

0 100 200 Feet

Sediment, Bioaccumulation

- Bay Sediment
- (*Surface) Sediment
- Surface Sediment
- Sediment Bioaccumulation
- Ecology Sediment Sample Location
- Station Locations With Data for Other Media

- Little Squalicum Park Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

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Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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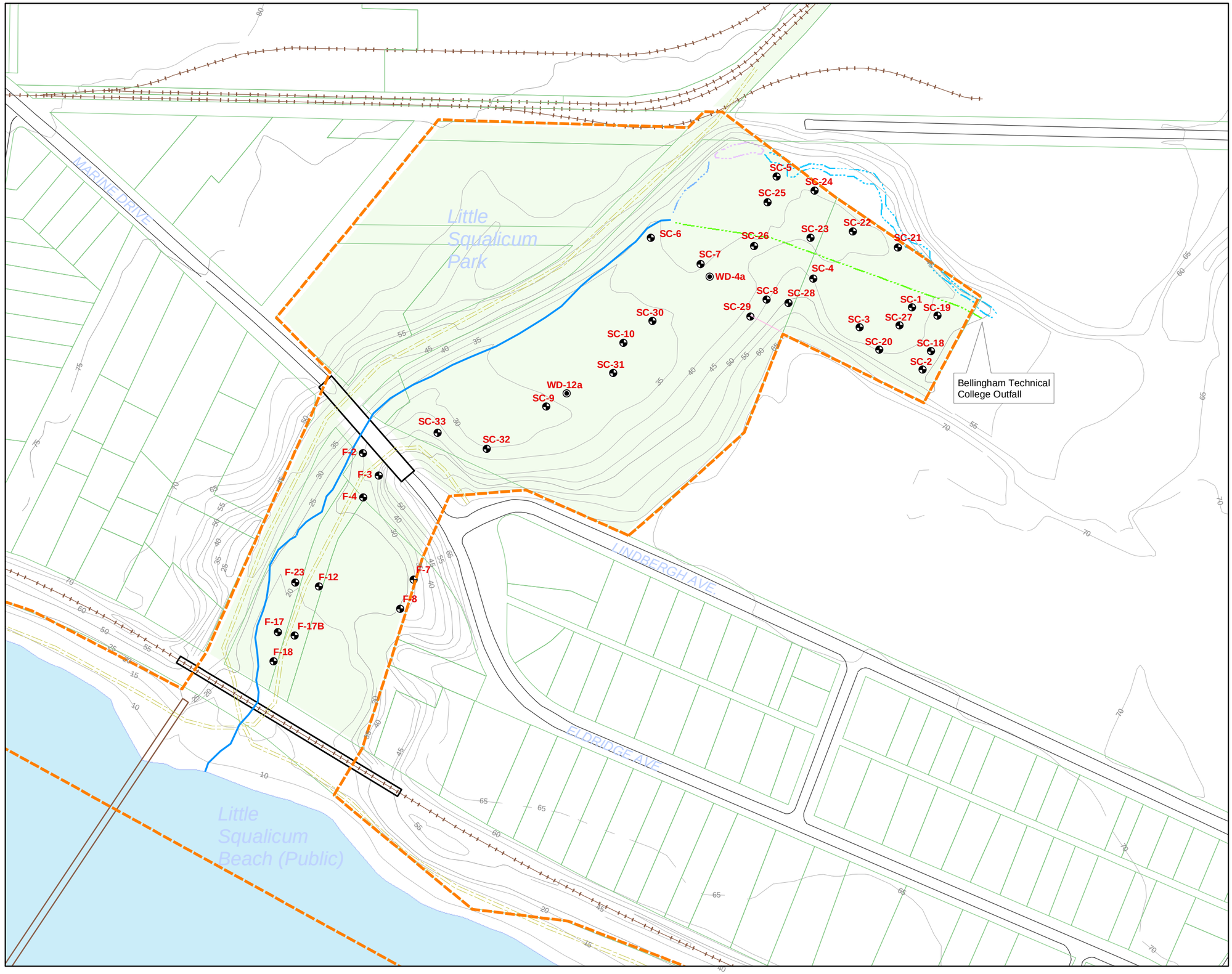
Map Document: (C:\GIS\Projects\LittleSqualicumCr\Sample_Locations_WORKMAP_V4_recov2.mxd)
10/21/2004 -- 8:26:13 AM

Figure 3-3. Historical Sediment Sampling Locations



N

0 100 200 Feet

1993 Wetland Mitigation Plan Station References

- Watershed Dynamics Piezometer Approximate Location and Identification; Water Observed in 10/92.
- Landau Associates Test or Hand Pit Approximate Location and Identification.

- Little Squalicum Park Boundary
- Approximate Parcel Location
- Approx. Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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Map Document: (C:\GIS\Projects\LittleSqualicumCr\Landau_Approx_1993_Test_Locs_BL.mxd)
10/21/2004 -- 8:54:35 AM

Figure 3-4. Historical Geotechnical Sampling Locations[L]

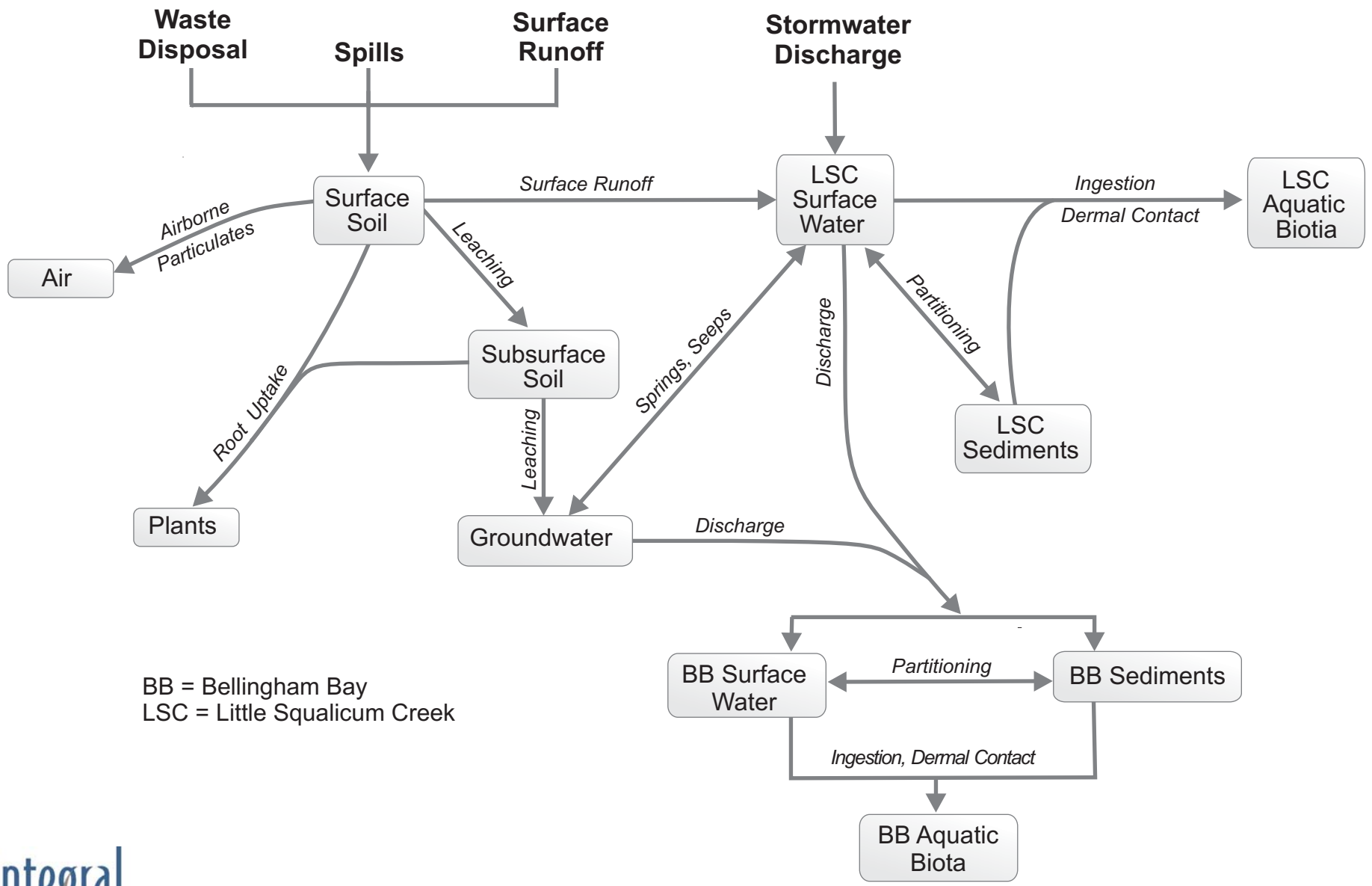


Figure 3-5.
Conceptual Site Model

Table 3-1. Summary of Detected Analytes in Site Surface Soil Exceeding Screening Levels.

Analyte		Units	Screening Level Value	Screening Level Basis	Total Sample Number	Number of Exceedances	Maximum Value	Location of Maximum
Dioxins								
	TEQ (ND=0.5 DL)	ng/Kg	49.77	site-specific background	21	8	2415.97	SP07
SVOCs								
PAHs								
	2-Methylnaphthalene	mg/kg	0.38	Ecology SQS	23	2	11	SP02
	Acenaphthene	mg/kg	0.16	Ecology SQS	23	3	72	SP02
	Acenaphthylene	mg/kg	0.47	Ecology LAET	23	4	1.2	SP02
	Anthracene	mg/kg	1.23	Ecology LAET	23	4	78	SP02
	Fluorene	mg/kg	0.23	Ecology SQS	18	3	57	SP02
	Naphthalene	mg/kg	0.53	Ecology LAET	23	1	5.5	SP02
	Phenanthrene	mg/kg	1	Ecology SQS	23	3	200	SP02
	Total LPAH	mg/kg	3.7	Ecology SQS	23	4	413.7	SP02
	Benz[e]acephenanthrylene	mg/kg	0.14	MTCA Method B	1	1	14	SP02
	Benzo(a)anthracene	mg/kg	0.377	site-specific background	23	6	51	SP02
	Benzo(a)pyrene	mg/kg	0.455	site-specific background	23	8	35	SP02
	Benzo(b)fluoranthene	mg/kg	0.66	site-specific background	23	7	11	SP02
	Benzo(k)fluoranthene	mg/kg	0.24	site-specific background	23	8	11	SP02
	Total Benzo(b,k)fluoranthenes	mg/kg	2.3	Ecology SQS	23	5	22	SP02
	Benzo(g,h,i)perylene	mg/kg	0.422	site-specific background	23	8	7.3	SP02
	Chrysene	mg/kg	0.628	site-specific background	23	8	74	SP02
	Dibenzo(a,h)anthracene	mg/kg	0.376	site specific background	23	6	2.2	SP02
	Fluoranthene	mg/kg	1.6	Ecology SQS	23	3	150	SP02
	Indeno(1,2,3-cd)pyrene	mg/kg	0.612	site-specific background	23	8	9.2	SP02
	Pyrene	mg/kg	8.79	Ecology LAET	23	1	170	SP02
	Total HPAH	mg/kg	9.6	Ecology SQS	23	5	520.7	SP02
Other	2,4-Dimethylphenol	mg/kg	0.029	Ecology SQS	23	4	0.077	LSCS1
	2,4-Dinitrotoluene	mg/kg	0.0008	EPA Region 9 PRG	23	3	0.045	B-BB3
	2,6-Dinitrotoluene	mg/kg	0.0007	EPA Region 9 PRG	23	1	0.022	B-BB3
	2-Methylphenol	mg/kg	0.063	Ecology SQS	23	2	0.065	LSCS2
	Benzoic acid	mg/kg	2.03	Site-specific background	23	2	2.8	LSCS1
	Benzyl alcohol	mg/kg	0.057	Ecology SQS	23	4	1.1	SP03
	bis(2-Ethylhexyl)phthalate	mg/kg	0.47	Ecology SQS	23	4	6.18	LSCS2
	Butylbenzylphthalate	mg/kg	0.049	Ecology SQS	23	4	0.666	LSCS1
	Dibenzofuran	mg/kg	0.15	Ecology SQS	23	2	9.9	SP02
	Dimethylphthalate	mg/kg	0.311	Ecology LAET	23	1	3.13	LSCS1
	Hexachlorobenzene	mg/kg	0.004	Ecology SQS	23	2	0.014	LSCS2
	Pentachlorophenol	mg/kg	0.03	EPA Region 9 PRG	23	8	5.96	LSCS1
	Phenol	mg/kg	0.42	Ecology SQS	23	1	0.429	LSCS2
Petroleum Hydrocarbons								
	TPH Screen or EPH	mg/kg	200.00	MTCA TEE soil	95	50	5533	SP02
Metals								
	Antimony	mg/kg	0.6	Ecology LAET	16	7	36	MWLSC01
	Arsenic	mg/kg	9.09/7	site-specific background	21	4	150	MWLSC01
	Barium	mg/kg	102.00	MTCA TEE wildlife	16	15	510	MWLSC01
	Copper	mg/kg	50.00	MTCA TEE soil	16	3	92	MWLSC01
	Lead	mg/kg	50.00	MTCA TEE plant	16	5	170	MWLSC01
	Manganese	mg/kg	1200.00	Puget Sound Background	16	1	1400	SP05
	Mercury	mg/kg	0.10	MTCA TEE soil	16	9	0.33	SP07
	Nickel	mg/kg	48	Puget Sound Background	16	2	50	SP05
	Selenium	mg/kg	0.30	MTCA TEE wildlife	16	3	3.4	B-AA2
	Silver	mg/kg	0.545	Ecology LAET	16	1	0.7	B-AA2
	Vanadium	mg/kg	2	MTCA TEE plant	16	16	77	B-BB3
	Zinc	mg/kg	86.00	MTCA TEE plant	16	12	610	MWLSC01

Notes:

Ecology SQS - Values normalized to TOC were denormalized by multiplying 0.01 (1% TOC was assumed to be the average for site soils and sediments).

Table 3-2. Summary of Detected Analytes in Site Subsurface Soil Exceeding Screening Levels.

Analyte	Units	Screening Value		Total Sample Number	Number of Exceedances	Maximum Value	Location of Maximum
		Level	Basis				
Barium	mg/kg	102	MTCA TEE wildlife	11	5	260	B-BB5
Copper	mg/kg	50	MTCA TEE soil	11	1	58	B-AA4
Mercury	mg/kg	0.10	MTCA TEE soil	11	3	0.23	B-AA2
Nickel	mg/kg	59.4	Maximum Detected Background	11	1	94	B-AA4
Vanadium	mg/kg	62.5	site-specific background	11	4	83	B-AA4
Zinc	mg/kg	86	MTCA TEE plant	11	1	99	B-AA4

Table 3-3. Summary of Detected Analytes in Unfiltered Groundwater Exceeding Screening Levels.

				Background Unfiltered Groundwater				Site Unfiltered Groundwater			
Analyte	Units	Level	Screening Value Basis	Samples Analyzed	Detections Exceeding SL	Maximum Detected Concentration	Location of Maximum	Samples Analyzed	Detections Exceeding SL	Maximum Detected Concentration	Location of Maximum
SVOCs											
PAHs											
2-Methylnaphthalene	µg/L	329.55	EPA Region 5	--	--	--	--	11	1	340	WP1
Acenaphthene	µg/L	38	Region 5	--	--	--	--	11	1	930	WP1
Anthracene	µg/L	0.73	Tier II	--	--	--	--	11	2	430	WP1
Fluorene	µg/L	3.9	Tier II	--	--	--	--	11	1	940	WP1
Naphthalene	µg/L	12	Tier II	--	--	--	--	11	1	85	WP1
Phenanthrene	µg/L	3.6	EPA Region 5	--	--	--	--	11	1	1700	WP1
Benzo(a)anthracene	µg/L	0.0140	Site-specific background	16	1	0.014	MW06-D	11	3	380	WP1
Benzo(a)pyrene	µg/L	0.0076	Site-specific background	--	--	--	--	11	2	150	WP1
Benzo(b)fluoranthene	µg/L	0.0150	Site-specific background	--	--	--	--	5	2	100	WP1
Benzo(k)fluoranthene	µg/L	0.0120	MTCA GW Method B	--	--	--	--	5	2	100	WP1
Benzo(g,h,i)perylene	µg/L	7.64	Tier II	--	--	--	--	11	1	28	WP1
Chrysene	µg/L	0.0170	Site-specific background	--	--	--	--	11	2	300	WP1
Dibenzo(a,h)anthracene	µg/L	0.0038	EPA NAWQC	--	--	--	--	11	2	12	WP1
Fluoranthene	µg/L	1.9	EPA Region 5	--	--	--	--	11	2	1400	WP1
Indeno(1,2,3-cd)pyrene	µg/L	0.0038	EPA NAWQC	--	--	--	--	11	2	37	WP1
Pyrene	µg/L	0.3	EPA Region 5	--	--	--	--	11	2	1100	WP1
Other											
Benzyl alcohol	µg/L	8.6	Tier II	--	--	--	--	11	1	9.8	WP1
Dibenzofuran	µg/L	3.7	Tier II	--	--	--	--	11	1	490	WP1
Pentachlorophenol	µg/L	0.39	Site-specific background	--	--	--	--	11	1	0.84	WP2
2,4-Dinitrotoluene	µg/L	0.11	EPA NAWQC	--	--	--	--	11	1	25	WP1
3,3'-Dichlorobenzidine	µg/L	0.0210	EPA NAWQC	--	--	--	--	11	1	11	WP1
Metals (Total)											
Barium	µg/L	43.4	Site-specific background	--	--	--	--	6	4	86.8	MWLSC01
Magnesium	µg/L	16200	Site-specific background	--	--	--	--	6	6	21400	MWLSC02
Manganese	µg/L	282	Site-specific background	--	--	--	--	6	3	420	MWLSC01

Table 3-4. Summary of Detected Analytes in Filtered Groundwater Exceeding Screening Levels.

				Background Filtered Groundwater				Site Filtered Groundwater			
Analyte	**Units**	**Level**	**Screening Value Basis**	**Samples Analyzed**	**Detections Exceeding SL**	**Maximum Detected Concentration**	**Location of Maximum**	**Samples Analyzed**	**Detections Exceeding SL**	**Maximum Detected Concentration**	**Location of Maximum**
Metals											
Barium	µg/L	43.4	Site-specific background	--	--	--	--	6	3	89.2	MWLSC01
Cadmium	µg/L	0.25	EPA NAWQC	--	--	--	--	6	1	0.47	MWLSC03
Magnesium	µg/L	16200	Site-specific background	--	--	--	--	6	6	22900	MSLSC02
Manganese	µg/L	282	Site-specific background	--	--	--	--	6	3	400	MWLSC01
Thallium	µg/L	0.24	EPA NAWQC	7	1	2.7	MW06-D	--	--	--	--

Table 3-5. Summary of Detected Analytes in Unfiltered Surface Water Exceeding Screening Levels.

Analyte	Units	Level	Screening Value Basis	Site Unfiltered Surface Water(1) Samples Analyzed	Detections Exceeding SL	Maximum Detected Concentration	Location of Maximum
Dioxins							
TEQ (ND=0.5 DL)	pg/L	0.003	Region 5 ESL	17	13	164.775	SW05
SVOCs							
PAHs							
Anthracene	µg/L	0.73	Tier II SCV (Suter and Tsao 1996)	32	6	25	GW-13
Benzo(a)anthracene	µg/L	0.027	Tier II SCV (Suter and Tsao 1996)	32	5	8	GW-13
Benzo(a)pyrene	µg/L	0.014	Tier II SCV (Suter and Tsao 1996)	32	14	14	GW-13
Benzo(b)fluoranthene	µg/L	0.0296	MTCA Method B	23	5	79	GW-13
Benzo(k)fluoranthene	µg/L	0.0296	MTCA Method B	23	1	0.04	256
Benzo(g,h,i)perylene	µg/L	7.64	EPA Region 5 ESL	32	1	89	GW-13
Chrysene	µg/L	0.0296	MTCA Method B	32	11	86	GW-13
Fluoranthene	µg/L	1.9000	EPA Region 5 ESL	32	4	12	GW-10
Fluorene	µg/L	3.9000	Tier II SCV (Suter and Tsao 1996)	32	1	4	GW-13
Indeno(1,2,3-cd)pyrene	µg/L	0.0296	EPA Region 5 ESL	32	3	0.2	SW08
Phenanthrene	µg/L	3.6000	EPA Region 5 ESL	32	1	7	GW-13
Pyrene	µg/L	0.3000	EPA Region 5 ESL	31	4	32	GW-10
Other							
bis(2-Ethylhexyl)phthalate	µg/L	3	Tier II SCV (Suter and Tsao 1996)	32	5	50	GW-13
Pentachlorophenol	µg/L	4.9102	MTCA Method B	32	6	112	GW-13
Metals (Total)							
Aluminum	µg/L	87	CCC (EPA 2002)	20	6	1610	SW08
Arsenic	µg/L	0.0982	MTCA Method B	20	15	1.1	SW06
Barium	µg/L	4	Tier II SCV (Suter and Tsao 1996)	20	20	112	SW08
Copper	µg/L	9	CCC (EPA 2002) 1	20	1	10.9	SW08
Iron	µg/L	1000	CCC (EPA 2002)	20	1	1530	SW08
Lead	µg/L	2.5	Ecology (WAC 173-201A-040) 1	20	1	4.15	SW05
Magnesium	µg/L	647	EPA Region 6	20	19	26200	OS03
Manganese	µg/L	120	Tier II SCV (Suter and Tsao 1996)	20	2	176	OS07

Notes:
(1) Includes surface water, spring, seep, porewater samples.

Table 3-6. Summary of Detected Analytes in Filtered Surface Water Exceeding Screening Levels.

Analyte	Units	Level	Screening Value Basis	Site Filtered Surface Water(1)			
				Samples Analyzed	Detections Exceeding SL	Maximum Detected Concentration	Location of Maximum
Metals							
Aluminum	µg/L	87	CCC (EPA 2002)	12	2	126	SW06
Arsenic	µg/L	0.0982	MTCA Method B	12	9	0.92	SO01
Barium	µg/L	4	Tier II SCV (Suter and Tsao 1996)	12	12	33.3	SW06
Magnesium	µg/L	647	EPA Region 6	12	12	26800	OS03

Notes:
(1) Includes surface water, spring, seep, porewater samples.

Table 3-7. Summary of Detected Analytes in Site Sediment Exceeding Screening Levels.

Anatyte	Units	Screening Level Value	Screening Level Basis	Total Sample Number	Number of Exceedances	Maximum Value	Location of Maximum
Dioxins							
TEQ (ND=0.5 DL)	ng/Kg	19	Puget Sound Background	12	8	1012.063	SD10
SVOCs							
PAHs							
2-Methylnaphthalene	mg/kg	0.53	Ecology LAET	54	1	2.61	LSC03
Acenaphthene	mg/kg	0.16	Ecology SQS	54	13	12	LSC03
Acenaphthylene	mg/kg	0.47	Ecology LAET	50	1	0.608	SI-BB01
Anthracene	mg/kg	1.23	Ecology LAET	54	15	36.8	LSC03
Fluorene	mg/kg	0.23	Ecology SQS	54	14	17	LSC03
Naphthalene	mg/kg	0.53	Ecology LAET	54	1	3.82	LSC03
Phenanthrene	mg/kg	1	Ecology SQS	54	9	33	LSC03
Total LPAH	mg/kg	3.7	Ecology SQS	54	11	105.23	LSC03
Benzo(a)anthracene	mg/kg	0.137	MTCA Method B	54	33	30.2	LSC03
Benzo(a)pyrene	mg/kg	0.137	MTCA Method B	54	36	20.7	LSC03
Benzo(b)fluoranthene	mg/kg	0.137	MTCA Method B	54	34	21.9	LSC03
Benzo(k)fluoranthene	mg/kg	0.137	MTCA Method B	54	27	13.1	LSC03
Total Benz(bk)fluoranthenes	mg/kg	2.3	Ecology SQS	54	22	47.97	JC-358
Benzo(g,h,i)perylene	mg/kg	0.31	Ecology SQS	54	24	6.75	LSC03
Chrysene	mg/kg	0.137	MTCA Method B	54	36	55.5	LSC03
Dibenzo(a,h)anthracene	mg/kg	0.12	Ecology SQS	54	20	1.7	JC-353
Fluoranthene	mg/kg	1.6	Ecology SQS	54	11	86.3	LSC03
Indeno(1,2,3-cd)pyrene	mg/kg	0.137	MTCA Method B	54	28	10	LSC03
Pyrene	mg/kg	8.79	Ecology LAET	54	3	78	LSC03
Total HPAH	mg/kg	9.6	Ecology SQS	54	23	324.02	LSC03
Other							
2,4-Dimethylphenol	mg/kg	0.029	Ecology SQS	50	9	0.22	OS04
2,4-Dinitrotoluene	mg/kg	0.0008	Region 9 Leaching	50	1	0.038	PMX-SS-08
2,6-Dinitrotoluene	mg/kg	0.0007	Region 9 Leaching	50	1	1.09	PMX-SS-08
2-Methylphenol	mg/kg	0.063	Ecology SQS	50	2	0.198	LSC05
Benzoic acid	mg/kg	0.65	Ecology SQS	42	6	8.24	LSC05
Benzyl alcohol	mg/kg	0.057	Ecology SQS	42	7	6.29	LSC05
bis(2-Ethylhexyl)phthalate	mg/kg	0.47	Ecology SQS	54	13	2.04	PMX-SS-08
Butylbenzylphthalate	mg/kg	0.049	Ecology SQS	54	8	0.508	OS04
Carbazole	mg/kg	0.6	Region 9 Leaching	27	1	4.78	LSC03
Dibenzofuran	mg/kg	0.15	Ecology SQS	54	10	1.1	HE-B
Dimethylphthalate	mg/kg	0.311	Ecology LAET	54	12	4.91	PMX-SS-08
di-n-Butylphthalate	mg/kg	0.103	Ecology LAET	50	1	0.187	PMX-SS-08
di-n-Octylphthalate	mg/kg	0.011	Ecology LAET	50	3	0.142	PMX-SS-08
Hexachlorobenzene	mg/kg	0.004	Ecology LAET	50	1	0.076	LSC06
n-Nitrosodimethylamine	mg/kg	0.0196	MTCA Method B	14	1	0.173	LSC02
N-nitrosodiphenylamine	mg/kg	0.11	Ecology SQS	50	2	0.435	PMX-SD-01
Pentachlorophenol	mg/kg	0.03	Region 9 Leaching	54	29	4.73	PMX-SD-03
Phenol	mg/kg	0.42	Ecology SQS	50	2	2.11	LSC05
Petroleum Hydrocarbons							
TPH	mg/kg	200	MTCA TEE soil	24	13	1393	SD06
Metals							
Antimony	mg/kg	0.6	Ecology LAET	19	6	8.3	OS06
Arsenic	mg/kg	7	Puget Sound Bkgd	19	2	30.9	OS06
Barium	mg/kg	102	MTCA TEE wildlife	19	5	160	SD06
Chromium	mg/kg	48	Puget Sound Bkgd	19	7	249	OS01
Cobalt	mg/kg	20	MTCA TEE plant	19	6	115	OS07
Copper	mg/kg	50	MTCA TEE soil	19	8	104	OS04
Lead	mg/kg	50	MTCA TEE plant	19	3	70	SD06
Mercury	mg/kg	0.1	MTCA TEE soil	19	2	0.198	OS06
Nickel	mg/kg	48	Puget Sound Bkgd	19	7	139	OS01
Silver	mg/kg	0.545	LAET	19	1	30	SD04
Vanadium	mg/kg	2	MTCA TEE plant	19	19	69	SD11
Zinc	mg/kg	86	MTCA TEE plant	19	16	360	SD06
AVS/SEM							
Lead	mg/kg	50	MTCA TEE plant	12	1	58	SD06
Zinc	mg/kg	86	MTCA TEE plant	12	9	445	SD06

Notes:

Ecology SQS - Values normalized to TOC were denormalized by multiplying 0.01 (1% TOC was assumed to be the average for site soils and sediments).

Table 3-8. Receptors and Exposure Pathways, City of Bellingham, Little Squalicum Park.

		Human Receptors				Ecological Receptors		
Medium	**Exposure Pathway**	**Recreational Park User**	**Park Maintenance Worker**	**Offsite Resident**	**Offsite Worker**	**Terrestrial Plant**	**Terrestrial Animal**	**Aquatic Biota**
Surface soil	Ingestion	X	X				X	X
	Dermal contact	X	X				X	X
	Root uptake					X		X
Subsurface soil	Ingestion	(X)	(X)				(X)	
	Dermal contact	(X)	(X)				(X)	
	Root uptake					X		
Groundwater	Ingestion			X	X			
	Dermal contact			X	X			
	Root uptake							
Surface water	Ingestion	X					X	X
	Dermal contact	X					X	X
Sediments	Ingestion	X	X				X	X
	Dermal contact	X	X				X	X
	Root uptake					X		X
Air	Inhalation	O	O	O	O		O	
Terrestrial plants	Ingestion	X					X	
Aquatic biota	Ingestion	X					X	X

X = Pathway exists under normal site conditions.
(X) = Pathway exists only if subsurface soil is brought to the surface.
O = Pathway will be minor unless there are unvegetated areas.

4 FIELD INVESTIGATION APPROACH

This section presents the sampling design and rationale for a tiered approach to complete the Park RI field investigation (Figure 4-1). The design is based on an understanding of historical site data and best professional judgment. Specific issues related to sampling methods and sample handling procedures are addressed in Sections 5. Laboratory methodology and QA/QC procedures are presented in the accompanying QAPP.

Visual, sheen, and headspace screening will be conducted in the field on all soil and sediment samples collected during this investigation. Visual screening will consist of inspecting the soil/sediment for the presence of stains indicative of residual petroleum hydrocarbons. Sheen testing will involve immersion of a portion of the soil/sediment sample in water and observing the water surface for signs of petroleum sheen. Headspace screening will involve the semi-quantitative measurement of total volatile compounds in the air above the sample material using either a flame ionization detector (FID) or photo ionization detector (PID). This field screening approach will assist in selecting samples for laboratory analysis and provide real-time information on whether the proposed sampling program should be expanded to include the collection of additional samples at depth and/or at surrounding locations to further evaluate the nature and extent of contamination at the site.

Metals will be analyzed in all samples because several metals have commonly exceeded their SLs in samples from previous investigations throughout the Park. Chlorinated pesticides and PCBs will be analyzed only in soil samples from the BNSF, because this is the only area where pesticides/PCBs are expected to be present. No samples are proposed for analysis of VOCs because very few VOCs have exceeded their SLs in samples from previous investigations and because historical operations in the Park do not support significant VOC contamination. However, results from the headspace screening in the field may be followed by the laboratory analysis of samples for VOCs if it is deemed warranted.

There are two different laboratory methods of analysis for petroleum hydrocarbons. The NWTPH method provides one result with broad coverage of both aliphatic and aromatic GRO components (NWTPH-Gx) and DRO components (NWTPH-Dx). The petroleum mixture can also be fractionated into smaller carbon chain ranges, treating aliphatics and aromatics separately, to provide more comprehensive information on the composition of the mixture.[13] Fractionation data are necessary to calculate site-specific petroleum cleanup levels, rather than relying on default cleanup levels. GRO mixtures can be fractionated using the VPH analysis. DRO mixtures can be fractionated using the EPH analysis.

[13] For soil and sediment samples, a silica gel cleanup can be used to remove natural organics before analysis.

VPH and EPH analyses are considerably more expensive than the NWTPH analysis. The extra expense of VPH/EPH analyses is unnecessary if the concentrations of petroleum in the sample are low or undetected. The soil and sediment samples will be analyzed initially using the NWTPH method, requesting the GRO analysis, the DRO analysis, or both depending on historical practices in the area. Only those soil and sediment samples that yield detected GRO/DRO results above the SL (100/200 mg/kg for soil and 50 mg/kg for sediment[14]) will be considered for fractionation analyses. In some cases, not all of the samples with GRO/DRO results above the SLs will be submitted for fractionation. Best professional judgment will be used based on the number of samples with GRO/DRO results above the SLs in an area and an understanding of historical practices, which would indicate how heterogeneous or homogeneous the petroleum compositions are likely to be in that area. If homogeneous compositions are expected, fewer samples will be selected for fractionation. When a sample is selected for fractionation, it will be analyzed by VPH if GRO was detected, by EPH if DRO was detected, or by both VPH and EPH if both GRO and DRO were detected above the corresponding SL.

Surface water and groundwater samples will be analyzed initially using the NWTPH method. Best professional judgment will be used in analyzing groundwater and surface water samples for VPH, EPH, or both as appropriate.

A few SVOCs have commonly exceeded their SLs in surface water, soil and sediment samples from previous investigations. The SVOCs of primary concern are PCP (from wood-treating operations), PAHs (components of petroleum and creosote), and phthalates (common in urban runoff). The NWTPH analysis can act as a screen for the SVOCs of concern, because PAHs are components of petroleum and because PCP and phthalates are expected to be co-located with petroleum to some degree. Soil and sediment samples for possible SVOC analyses will be archived, selecting for SVOC analysis those samples with detected GRO or DRO results above their SLs. A minimum of 20% of the soil and sediment samples will be analyzed for SVOCs, even if GRO and DRO are detected (or below the SL) in fewer than 20 percent of the samples. Because of the limited number of surface water and groundwater samples proposed, all of the samples will be analyzed for SVOCs.

Dioxin/furan analyses are substantially more expensive than the other analyses, so only select samples will be analyzed for these chemicals. Surface water samples collected at SW05 (representative of the OESER outfall), SW06 (representative of the Birchwood neighborhood) and background locations will be analyzed for dioxins and furans. No other surface water samples are planned for this testing. All groundwater samples will be

[14] The MTCA Ecology Indicators for Soil Biota of 100 mg/kg (GRO) and 200 mg/kg (DRO) are the proposed SLs for NWTPH in soils in the Park. Based on discussions with Ecology, a lower SL of 50 mg/kg for GRO/DRO will be used for sediments. Samples exceeding 100/200 mg/kg and 50 mg/kg over reference or background levels will be analyzed for SVOCs in soils and sediments, respectively.

analyzed for dioxins and furans. Soil and sediment samples will be archived for possible dioxin/furan analyses, selecting for dioxin/furan analysis those samples with detected concentrations of PCP above its SL (0.360 mg/kg[15]).

The testing program for soils/sediment will consist of four tiers. The first tier is field screening for all collected samples. The second tier is the NWTPH analysis. A GRO or DRO result above its SL invokes the third tier, which is the SVOC analysis, which includes PCP, and possibly also VPH/EPH analyses. A PCP result above the SL invokes the fourth tier, which is the dioxin/furan analysis.

Throughout the tiered approach for analyzing archived samples, best professional judgment and common sense will dictate the choices of analyses. The goal is to improve the understanding of the nature and extent of contamination in the Park with the most cost-effective sampling and analytical strategy possible, not merely to adhere to a strictly proscribed protocol. Any deviations from the protocol described here will be made only with Ecology approval and documented with explanation.

Background or reference samples will be collected for each of the media planned for sampling in the Park (i.e., soils, groundwater, surface water, sediments). The background location for groundwater is a well located northeast of the OESER site near Cedarwood Avenue (MW-06D). The reference location for soils[16], surface water, and sediment is planned for a tributary of Whatcom Creek with similar characteristics as Little Squalicum Creek (an acceptable background location was not identified up-gradient of the project site). Selected reference locations must be upstream of any point sources (including the burn area of Whatcom Creek) and only be impacted by local stormwater runoff. The locations being considered include:

- Fever Creek near Roosevelt Park or north of Alabama Street
- Cemetery Creek near or within Bayview Cemetery.

More than one reference sample may be required to match varied physical characteristics (e.g., grain size) of the Park soil, surface water, and sediment samples.

[15] The Ecology SQS for Marine Sediments is the proposed SL for pentachlorophenol in soils and sediments in the Park. Samples exceeding 0.360 mg/kg pentachlorophenol will be analyzed for dioxins.
[16] A total of 20 background soil samples were collected during the OESER RI. These samples will also be used for comparison to soil samples collected during this RI.

4.1 SOIL INVESTIGATION

4.1.1 Rationale

The primary goal of soil sampling is to fill in spatial data gaps at the gravel pit and BTC areas, which are not suspected of having high contaminant concentrations, and in the BNSF right-of-way. The sampling pattern will be approximately evenly spaced to provide broad coverage of these areas, with an equal likelihood of finding contamination throughout the areas. To make the most efficient use of budget, a tiered analytical approach will be used.

4.1.2 Sampling Strategy

The investigation will include the excavation of 12 test pits (TP), distributed as follows (Figure 4-2):

- TP-1 through TP-3 will be located in the southeast area of the Park near BTC
- TP-4 will be located on the east side of the Creek, north of the area where the underground stormwater pipeline enters the Creek
- TP-5 through TP-8 will be located south(east) of the Creek and east of Marine Drive in the area of the historical gravel pit operations
- TP-9 through TP-12 will be located south(east) of the Creek and west of Marine Drive in the area of the historical gravel pit operations.

The test pits will allow the collection of soil samples at depth in the areas of historical landfill and gravel pit operations, which might have disturbed soils and distributed contamination throughout a depth range up to several feet. Furthermore, TP-9 through TP-12 are located in areas considered for possible re-routing of the Creek (refer to Figure 1-1 in the Work Plan), and it is advisable to have chemical and physical soil data at depth in these locations. In each test pit, all samples will be screened in the field for petroleum hydrocarbons. A sample collected from surface to 1 ft bgs will be submitted for analyses. Additional samples will be collected at 1-2 ft bgs, 2-3 ft bgs, and the bottom of the test pit for archiving. The tiered approach for analyzing these samples is discussed in Section 4.1.3.

Using a hand auger,[17] nine locations will be investigated, as follows (Figure 4-2):

[17] A hand shovel or equivalent may be used if coarse soils are encountered prohibiting the use of the hand auger.

- HA-1 through HA-6 will be located along the BNSF right-of-way
- HA-7 and HA-8 will be located northeast of the Creek in an area suspected to be impacted by a historical OESER spill or contaminated runoff
- Background locations planned for a Whatcom Creek tributary (either Fever Creek near Roosevelt Park or Cemetery Creek near Bayview Cemetery).

Hand augering is proposed for these locations because it is less intrusive than test pits. Samples will be collected at 0-1 ft bgs and 1-2 ft bgs and screened in the field for petroleum hydrocarbons. The tiered approach for analyzing these samples is discussed in Section 4.1.3.

Piezometers will be installed at three test pit locations (TP-3, TP-6, TP-12) to monitor seasonal changes in groundwater levels within the Park. Test pits may have to be excavated deeper, depending on time of year, to observe groundwater seepage at these locations. The depth and seasonal fluctuations in shallow groundwater will be important to understand if the creek is rerouted to other areas of the park.

4.1.3 Analytical Strategy

Reference sample(s) will be analyzed for metals, GRO, DRO, pesticides/PCBs, SVOCs, and dioxins/furans and a sample will be archived for possible VPH/EPH analysis, if necessary.

Field screening results will be considered in the selection of soil samples for analysis. For planning purposes, 0-1 ft site samples from test pit and hand auger locations will be analyzed for the following chemical classes (refer to Table 4-1):

- Metals (all surface samples)
- NWTPH-GRO (some surface samples) and -DRO (all surface samples)
- Pesticides and PCBs (by the BNSF only)
- TOC (all surface samples)
- Physical testing including grain size, moisture content, specific gravity, bulk density, Atterburg Limits (if sample is primarily fine grained) (all surface samples/0-1 ft samples and 2-3 ft samples).

DRO analyses will be requested for all surface soil samples (0-1 ft). GRO analyses will also be requested for the following sample locations, which are most likely to be impacted by urban runoff containing GRO:

- TP-1 through TP-3 near BTC
- TP-9 near the Marine Drive Bridge.

Site surface soil samples (0-1 ft bgs) will be archived for possible VPH, EPH, SVOC, and dioxin/furan analyses, depending on the GRO/DRO results. For each 0-1 ft sample, if the GRO or DRO result exceeds its SL, an archived sample from the same location will be analyzed for SVOCs. If PCP is detected above its SL, the archived sample from the same location will be analyzed for dioxins/furans. If the GRO/DRO result exceeds the SL, an archived sample may be selected for VPH/EPH analysis, depending on the results of other samples from the same area and using the professional judgment discussed previously.

If any chemical exceeding its SL is detected in the 0-1 ft sample of a test pit or hand auger, the lab will be requested to analyze the archived 1-2 ft sample from that location for the appropriate chemical class. If the chemical exceeds its SL in the 1-2 ft sample, the lab will be requested to analyze the archived 2-3 ft sample (test pits only). Finally, if the chemical exceeds its SL in the 2-3 ft test pit sample, the lab will analyze the archived sample from the bottom of the test pit.

If the decision logic described above results in the selection of fewer than 20% of the site surface soil samples for SVOC analyses, additional samples will be selected for SVOCs until a minimum of 20% of the soil samples is reached. The selection of additional samples will rely on best professional judgment, with an effort to select samples from each of the three areas under investigation (BNSF, gravel pit, BTC).

This is a hypothetical example of the tiered soil testing program (all soil samples are screened in the field for petroleum hydrocarbons).

> Lead, cadmium, GRO, and DRO are detected above their SLs in the 0-1 ft sample from TP-6. The lab is requested to analyze an archived 0-1 ft sample from TP-6 for SVOCs and an archived 0-1 ft sample for VPH and EPH. PCP is detected by the SVOC analysis above a concentration of 0.360 mg/kg, so the lab is asked to analyze the archived 0-1 ft sample for dioxins/furans, which are detected.
>
> Based on the results of the 0-1 ft sample, the lab is requested to analyze an archived 1-2 ft sample from TP-6 for metals, GRO, DRO, and SVOCs. Lead and DRO are detected above their SLs in the 1-2 ft sample, but GRO and PCP are not detected above their SLs. The lab is then asked to analyze the archived 1-2 ft sample for EPH, but not VPH. Since PCP was not detected, the lab is not asked to perform a dioxin/furan analysis.
>
> Based on the results of the 1-2 ft sample, the lab is requested to analyze an archived 2-3 ft sample for metals and DRO. Lead is detected above its SL, but DRO is not. The lab is asked to analyze an archived sample from the bottom of the test pit for metals only.

4.2 GROUNDWATER INVESTIGATION

4.2.1 Rationale

The primary goal of groundwater sampling is to update existing data. The sampling pattern will focus on wells located downgradient from the OESER site that are potential sources of contamination to the creek.

4.2.2 Sampling Strategy

Integral will collect two rounds of groundwater samples (GW), one during the wet season and one during the dry season. The wet season samples will be collected between November and May, while the dry season samples will be collected between July and October. The sampling will be conducted at the following times:

- Dry season (September/October 2005)
- Wet season (December 2005/January 2006).

The following four groundwater well locations will be sampled (Figure 4-3):

- MWLSC01 through MWLSC03 (located on the old railroad grade north of the creek and downgradient of the OESER site)
- MW-06D (Background well located northeast of OESER site).

These sampling locations have been sampled previously and are representative of potential sources of contamination to the creek. Sediment/soil sampling (refer to Section 4.4) will also be used to evaluate potential groundwater impacts adjacent to the creek. Results of that evaluation along with this well data will be used to develop a more complete CSM of area groundwater.

4.2.3 Analytical Strategy

All groundwater samples from the site and the background location will be analyzed for hardness, total suspended solids (TSS), TOC, metals (including calcium and magnesium), NWTPH-GRO/DRO, SVOCs, and dioxins/furans, and a sample will be archived for possible VPH/EPH analysis (refer to Table 4-2).

4.3 SURFACE WATER INVESTIGATION

4.3.1 Rationale

The primary goal of surface water sampling is to update existing data. The sampling pattern will focus on the discharge points to the Creek that are potential sources of contamination to the creek. Sampling will focus on the wet season rather than the dry season, since surface water contamination is more likely to be encountered during the wet season based on historical data (E&E 2002a).

4.3.2 Sampling Strategy

Integral will collect two rounds of surface water samples (SW), both during the wet season. The wet season samples will be collected between November and May. The sampling will be conducted at the following times:

- Beginning wet season (November/December 2005)
- Wet season (January/February 2006).

The following seven surface water locations will be sampled (Figure 4-3):

- SW01 (downgradient of all discharge points to the Creek)
- SW04 (potential discharge point from Marine Drive to the Creek)
- SW05 (discharge point from OESER to the Creek)
- SW06 (discharge point from BTC to the Creek)
- SW07 (near BTC)
- SW09 (spatial representation between Marine Drive bridge and BNSF Railroad bridge)
- Reference location planned for a Whatcom Creek tributary (either Fever Creek near Roosevelt Park or Cemetery Creek near Bayview Cemetery).

These sampling locations have been sampled previously and are representative of potential sources of contamination to the creek.

4.3.3 Analytical Strategy

The surface water samples collected from the OESER outfall (SW05), Birchwood neighborhood (SW06), and the reference location will be analyzed for hardness, TSS, TOC, metals (including calcium and magnesium), NWTPH-GRO/DRO, SVOCs, and dioxins/furans, and a sample will be archived for possible VPH/EPH analysis (refer to Table 4-2). Other surface water samples will be analyzed for hardness, TSS, TOC, metals, NWTPH-GRO/DRO, and SVOCs, and samples will be archived for potential VPH/EPH. If GRO/DRO are detected above their SLs, an archived sample from the same location will be analyzed for VPH, EPH, or both as appropriate.

4.4 SEDIMENT INVESTIGATION

4.4.1 Rationale

The primary goal of sediment sampling is to define the extent of hot spots detected during previous investigations (i.e., Ecology study) and to define the width and depth of contamination in the Creek including the identification of SQS and CSL cleanup boundaries. The sampling pattern will focus on bounding contaminated areas identified in previous investigations and performing transects across the creek. To make the most efficient use of budget, Integral will use a tiered analytical approach similar to the one described above for soil.

4.4.2 Sampling Strategy

Integral will collect surface sediment samples (0-4 inches [0-10 cm] bgs) from the following seven locations (Figure 4-4):

- LSC07
- LSC08
- LSC09
- LSC10 through LSC12 on the beach but within the discharge area of the Creek
- Reference location planned for a Whatcom Creek tributary (either Fever Creek near Roosevelt Park or Cemetery Creek near Bayview Cemetery).

These sample locations will assist in defining the boundaries of a hot spot identified upstream of these locations during the Ecology investigation (Ecology 2004) and verifying that the beach does not pose a health threat.

After surface samples have been collected, transects will be performed across the creek bed in the following six locations, evenly spaced over the length of this portion of the creek, using a track-mounted, portable, hollow stem auger to collect samples at depth (Figure 4-4):

- Near LSC04, immediately downstream of the OESER and BTC discharge points
- Near LSC07, midway downstream between the OESER and BTC discharges and the Marine Drive Bridge
- Near LSC08, at the lower end of this creek section
- Near LSC09, downstream of the Marine Drive bridge
- Near LSC03, midway downstream between the Marine Drive bridge and BNSF railroad bridge
- Near LSC01, just upstream of the BNSF railroad bridge.

Transects will allow Integral to investigate the depth and width of sediment contamination in this portion of the creek. Sediment/soil sampling will also be used to evaluate potential groundwater impacts to the creek. For example, borings located upgradient of the creek that show the presence of contamination would support groundwater as a pathway to the creek.

In the event sediment/soil samples are not collected from a proposed location(s) due to refusal (e.g., too gravelly), a temporary well may be installed to evaluate groundwater impacts at this location(s).

For each transect upstream of the Marine Drive bridge, sediment samples will be collected from 0-1 ft bgs, 1-2 ft, 2-3 ft bgs, 3-4 ft bgs, and 4-5 ft bgs at three individual locations as follows:

- A central location midstream
- 5-10 ft south of midstream at or near the stream bank
- 5-10 ft north of midstream at or near the stream bank.

For each transect downstream of the Marine Drive bridge, sediment samples will be collected from 0-1 ft bgs, 1-2 ft, 2-3 ft bgs, 3-4 ft bgs, and 4-5 ft bgs at five individual locations as follows:

- A central location midstream
- 5-10 ft south of midstream at or near the stream bank
- 25-30 ft south of midstream on the stream bank
- 5-10 ft north of midstream at or near the stream bank
- 25-30 ft north of midstream on the stream bank.

Fewer borings are planned for the upstream transects because this area of the creek is confined to a narrower and in some places steeper channel. The channel widens downstream past the Marine Drive Bridge.

Samples may be collected deeper than 5 ft bgs based on observations made in the field (i.e., field screening for visual contamination and headspace analysis).

4.4.3 Analytical Strategy

The analytical strategy for sediment samples will be similar to the analytical strategy for soil samples. The reference sample(s) will be analyzed for TOC, total sulfides, ammonia, metals, DRO, SVOCs, and dioxins/furans, and a sample will be archived for possible EPH analysis. Field screening results will be considered in the selection of site sediment samples for analysis. For planning purposes, all site surface (0-10 cm) and the 0-1 ft and 1-2 ft boring sediment samples will be analyzed for the following chemical classes (refer to Table 4-3):

- TOC
- Metals
- NWTPH-DRO.

Surface sediments (0-10cm) will also be analyzed for total sulfides and ammonia to assist in evaluating the bioassay tests. GRO will not be analyzed, as light end hydrocarbons are not expected to remain in the stream sediments. However, field screening results will be considered in the possible analysis of GRO and VOCs in some samples. Physical testing will also be analyzed for the surface (0-10cm), and 0-1 ft and 2-3 ft samples at depth from selected borings representative of each transect.

Site surface (0-10 cm), 0-1 ft, and 1-2 ft sediment samples will be archived for possible EPH, SVOC, and dioxin/furan analyses, depending on the DRO results. For each site surface or 0-1/1-2 ft sediment sample, if the DRO result exceeds its SL, an archived sample from the same depth will be analyzed for SVOCs. If PCP is detected above its SL, an archived sample from the same location will be analyzed for dioxins/furans. If the DRO result exceeds its SL, an archived sample may be selected for EPH analysis, depending on the results of other samples from the same area and using the professional judgment discussed in Section 4.2.

If any chemical exceeding its SL is detected in the 1-2 ft sediment sample of a transect location, the lab will be requested to analyze the archived 2-3 ft sample from the same

transect location for the appropriate chemical class. If the chemical exceeds its SL in the 2-3 ft sample, the lab will be requested to analyze the archived 3-4 ft sample, and so on. If the decision logic described above results in the selection of fewer than 20% of the site sediment samples for SVOC analyses, additional samples for SVOCs will be selected until a minimum of 20% of the samples for confirmation purposes is reached. The selection of additional samples will rely on best professional judgment, with an effort to select samples throughout the length and breadth of the creek.

Based on the chemical results of the surface sediment samples, toxicity testing will be performed at those locations where concentrations exceed SLs. The proposed tests are:

- Amphipod (*Hyalella azteca*) 10-day mortality test (USEPA 2000b; Test Method 100.1)
- Microtox® Sediment Porewater (*Vibrio fischeri*) (Ecology 2003)
- Midge (*Chironomus tentans*) 20-day mortality and growth test (USEPA 2000b; Test Method 100.2 modified).

Sediment for toxicity testing may be stored in the dark for a maximum of up to eight weeks. Sample bottles will be stored either with no headspace or headspace purged with nitrogen gas.

4.5 SHELL MIDDEN BOUNDARY SURVEY

One prehistoric archaeological site (shell midden) has been identified in the Creek ravine and it is possible that additional sites could also be present (Figure 2-1). The presence of a potentially significant archaeological site requires that cultural resources be addressed before starting any intrusive sampling activities (e.g., test pit excavations). These resources will be addressed using a staged approach. The cultural resource management activities planned for the Park RI/FS may have as many as three stages: 1) inventory of impact areas, 2) evaluation of the identified resources, and 3) development and implementation of a management plan.

The first effort will be to inventory the area by a trained archaeologist/anthropologist. This effort will determine whether, and where, archaeological deposits are present. As noted, at least one site is known to be present. The presence of this site will be confirmed, and its boundaries will be determined and recorded. Other portions of the Park will also be investigated, and, if additional archaeological sites are located, they will also be mapped and recorded. The inventory effort will be accomplished using a combination of background research, and direct archaeological survey inspection, including the use of limited subsurface testing. Once the distribution of archaeological deposits in the project area is determined, it will be possible to assess whether any of these deposits are threatened by the planned environmental assessments and subsequent park developments.

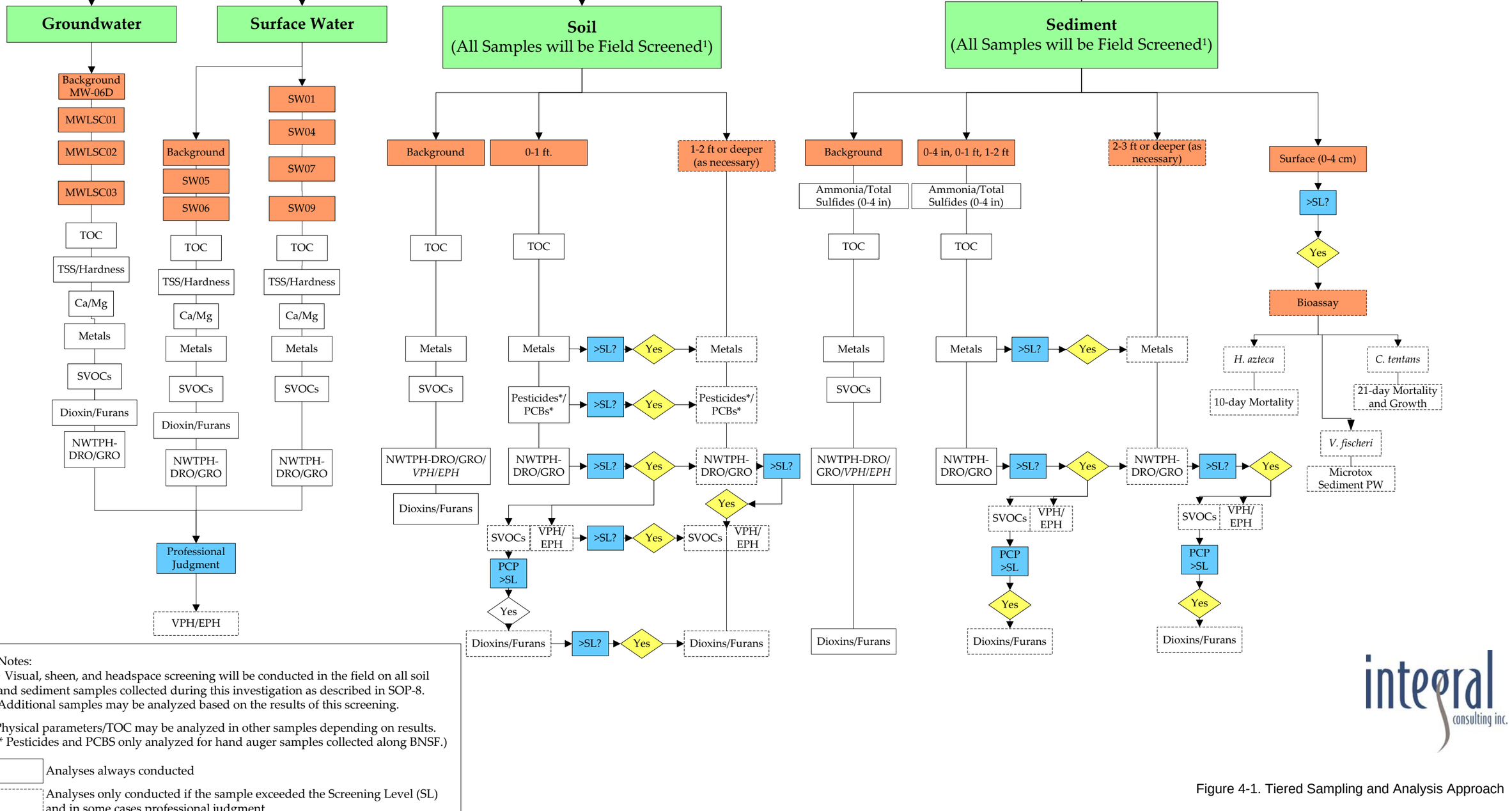
If it appears that an archaeological site is threatened, it will be necessary to determine that site's eligibility for listing with the National Register of Historic Places. A small-scale test excavation will be needed in order to perform this evaluation. If more than one site in the Park is threatened by this project, multiple evaluations will need to be conducted. If a threatened archaeological site is shown to be eligible for listing with the National Register of Historic Places, a management plan will be developed. The plan will seek to avoid or minimize damage to the site. Avoidance is always the preferred protection option, but this is not always possible. If avoiding damage to a site eligible for the National Register is not possible, it may be necessary to undertake data recovery excavations in order to document the cultural deposits that will be destroyed. The management plan could also address protection and interpretation of the site in the future park if this is desirable.

An inventory of the shell midden and other archaeological sites (if found) is planned for fall 2005, before fieldwork for the RI commences. The archaeological inventory will be conducted by Dr. Gary Wessen of Wessen & Associates, Inc., with the assistance of technical support personnel provided by the Lummi Indian Nation's Cultural Contract Services Department. Dr. Wessen will undertake the background literature review and together with the Lummi technical staff, will conduct the fieldwork. The boundaries of each site will be staked and surveyed. All intrusive activities will be avoided within these boundaries.

4.6 FIELD QC SAMPLES

Field duplicates will be collected periodically throughout the sampling program at a frequency of 1 per 20 field samples. Equipment rinse blanks will be collected once for each type of collection method (i.e., surface sediment, groundwater, borings, test pits, surface water). Refer to Section 5 for field QC sampling procedures.

Little Squalicum Park Field Investigation



Notes:
[1] Visual, sheen, and headspace screening will be conducted in the field on all soil and sediment samples collected during this investigation as described in SOP-8. Additional samples may be analyzed based on the results of this screening.

Physical parameters/TOC may be analyzed in other samples depending on results.
(* Pesticides and PCBS only analyzed for hand auger samples collected along BNSF.)

Analyses always conducted

Analyses only conducted if the sample exceeded the Screening Level (SL) and in some cases professional judgment

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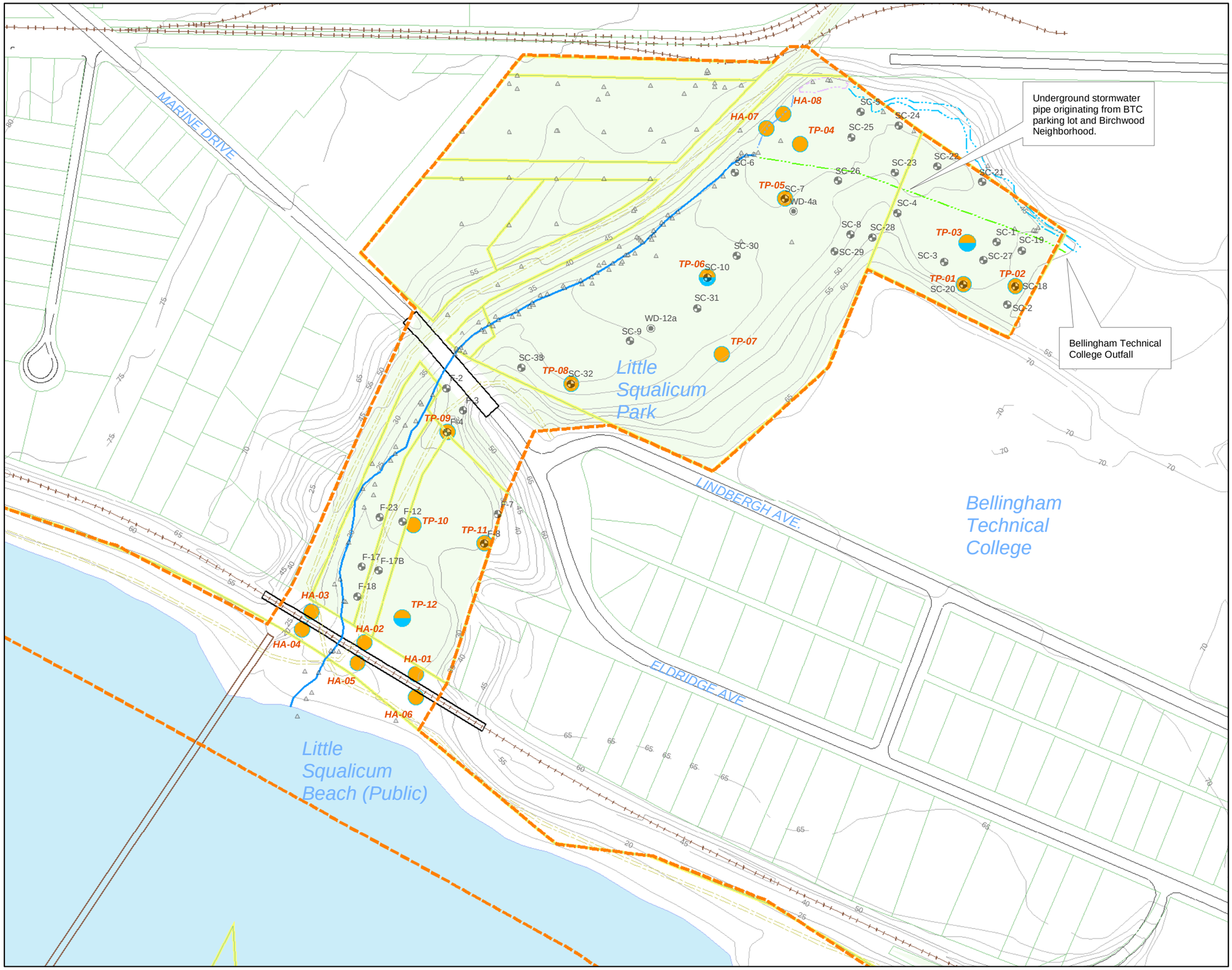
Figure 4-1. Tiered Sampling and Analysis Approach



N

0 100 200 Feet

1993 Wetland Mitigation Plan Station References

- Watershed Dynamics Piezometer Approximate Location and Identification; Water Observed in 10/92.
- Landau Associates Test or Hand Pit Approximate Location and Identification.

Proposed Soil Sample

- Proposed Soil Sample Locations
- Test pit locations with Piezometer Installed
- Station Locations With Data for Other Media

- Little Squalicum Park Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

Note:
Proposed Soil Sample Locations are for Hand Auger (HA) and Test Pits (TP)

A background soil sample(s) will be collected from a Whatcom Creek Tributary (e.g., Fever Creek or Cemetery Creek).

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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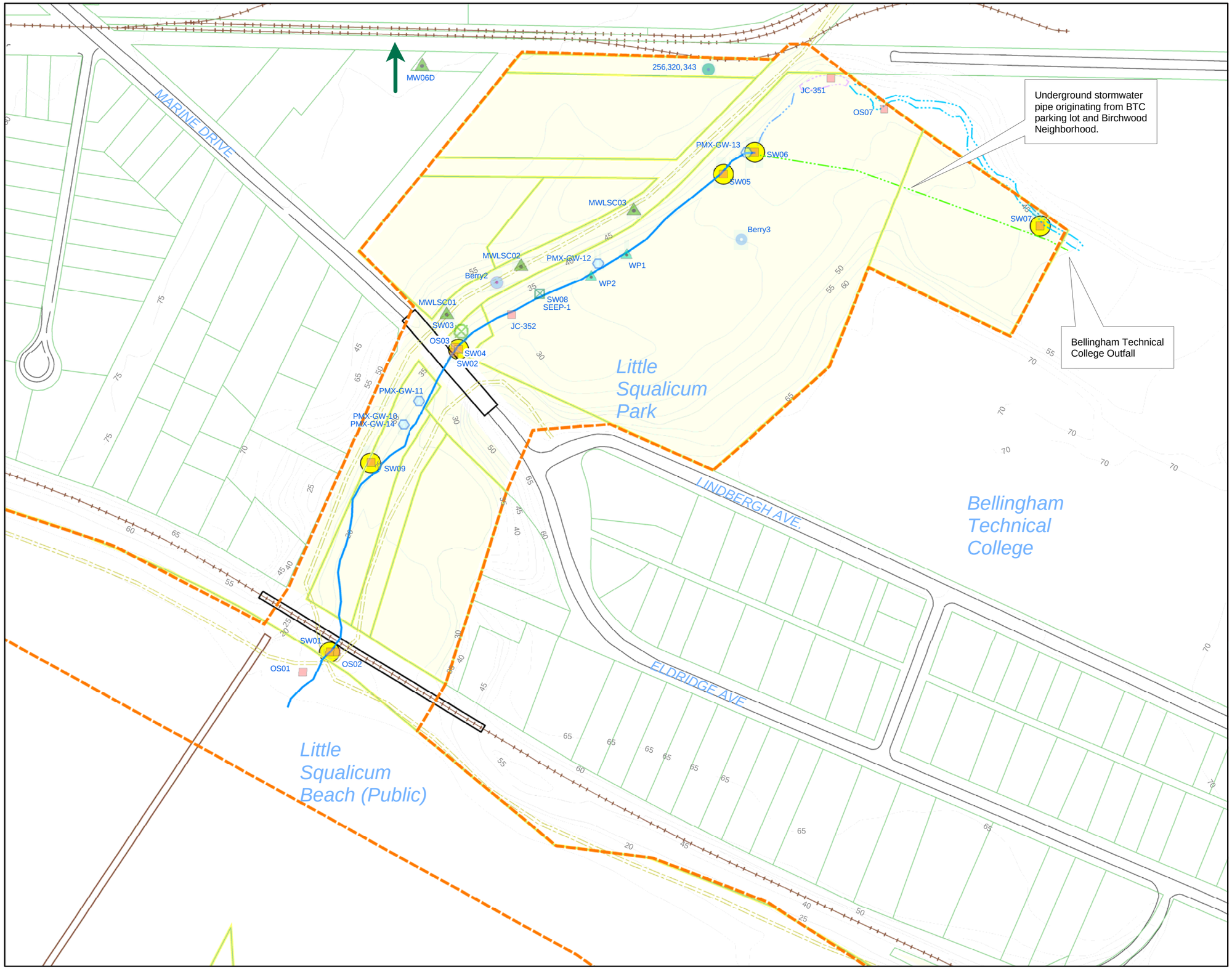
Map Document: (C:\GIS\Projects\LittleSquatcumCr\Sample_Locations_Proposed_Samples_v4.mxd)
10/20/2004 -- 6:13:15 PM

Figure 4-2. Proposed Soil Sampling Locations, Little Squalicum Park Remedial Investigation



N

0 100 200 Feet

- MWLSC01 Proposed Groundwater Sample
- SW04 Proposed Water Sample

Water, Seeps, and Berries

- Berry Unwashed
- Berry Washed
- Pore Water
- **Outfall Water
- Groundwater
- Spring
- Surface Water
- Seep

- Brownfield Assessment Project Area Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

Note:
A background surface water location(s) will be collected from a Whatcom Creek Tributary (e.g., Fever Creek or Cemetery Creek)

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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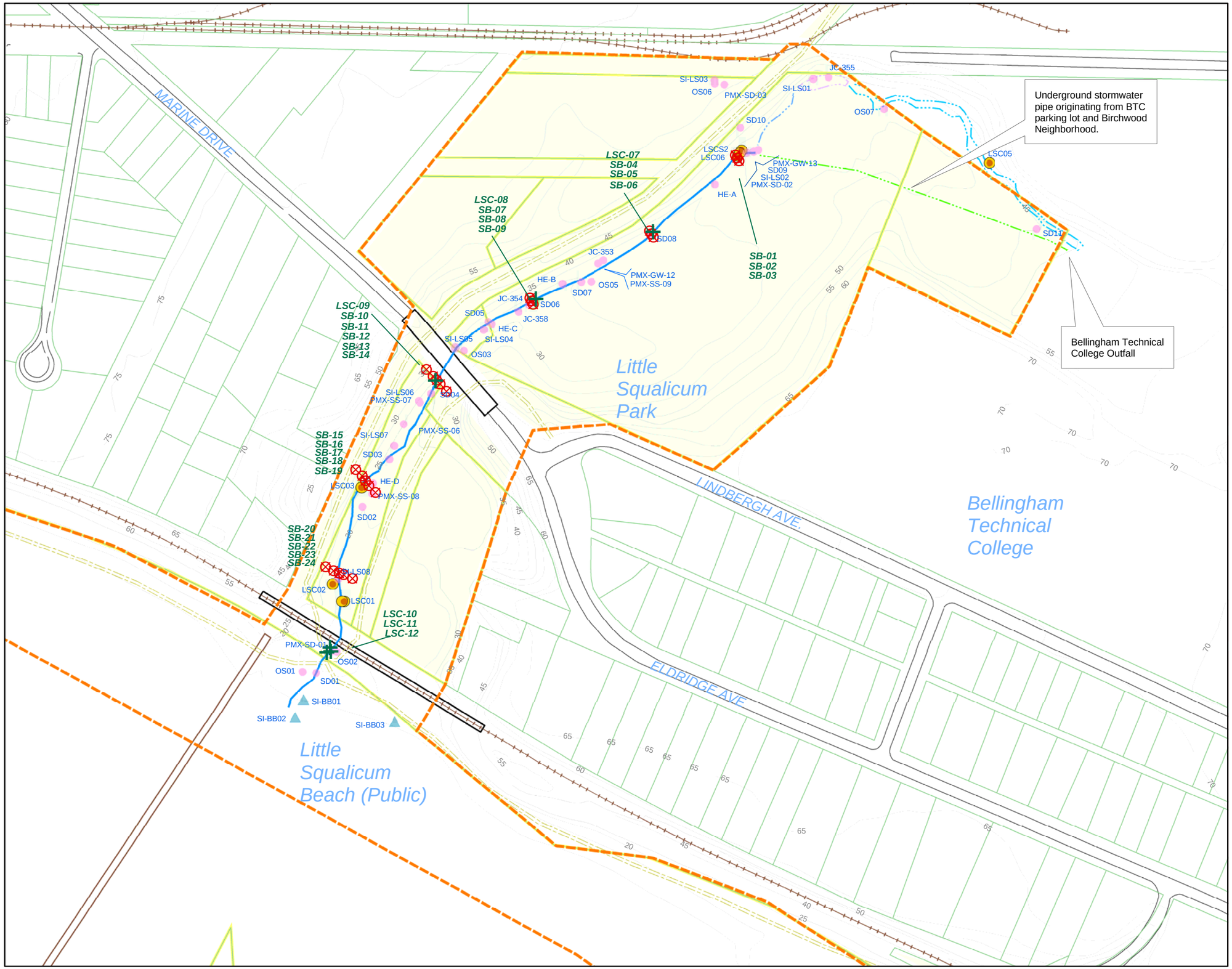
Map Document: (C:\GIS\Projects\LittleSqualicumCrt\Sample_Locations_Proposed_Samples_v4.mxd)
Plot Date: 04/26/2005

Figure 4-3. Proposed Groundwater and Surface Water Sampling Locations, Little Squalicum Park Remedial Investigation



Proposed Sediment Sample

- Sediment Boring Location
- Surface Sediment Location

Historic Sediment, Bioaccumulation

- Bay Sediment
- (*Surface) Sediment
- Sediment Bioaccumulation
- Surface Sediment
- Ecology Sediment Sample Location

- Brownfield Assessment Project Area Boundary
- Park Area Parcels
- Approx. Parcel Location
- Approx Creek Location
- Approx. Depression Location
- Approx. Area of Standing Water
- Approx. Underground Drainage
- Bridge
- Road
- Dock
- Railroad

Note:
A background sediment location(s) will be collected from a Whatcom Creek Tributary (e.g., Fever Creek or Cemetery Creek)

Feature Sources:
Topological features: City of Bellingham web site, source:1998 drawings.
Park area, Brownfield area, Area Trails: Transferred from copy - Site Location Map
Appendix B Map of Brownfield Assessment Area.
Notes:
The locations of Ecology were projected from source Lat./Long. to NAD27 WNZ. OESER station locations were provided in NAD27 WNZ.

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Map Document: (C:\GIS\Projects\LittleSqualicumCt\Sample_Locations_Proposed_Samples_v4.mxd)
Plot Date: 04/26/2005

Figure 4-4. Proposed Sediment Sampling Locations, Little Squalicum Park Remedial Investigation

Table 4-1. Soil Sample Locations and Testing.

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	TOC[1]	Metals[2]	NWTPH[3]	VPH/EPH[4]	SVOCs[5]	Dioxins/ Furans[6]	Pest/ PCBs[7]	Physical Testing[8]	Archive
TP-1	TO BE PROVIDED IN FINAL SAP		0-1	✓	✓	DRO/GRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-2			0-1	✓	✓	DRO/GRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-3			0-1	✓	✓	DRO/GRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-4			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-5			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-6			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓

Table 4-1. Soil Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	TOC[1]	Metals[2]	NWTPH[3]	VPH/EPH[4]	SVOCs[5]	Dioxins/ Furans[6]	Pest/ PCBs[7]	Physical Testing[8]	Archive
TP-7	TO BE PROVIDED IN FINAL SAP		0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-8			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-9			0-1	✓	✓	DRO/GRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-10			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-11			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓
TP-12			0-1	✓	✓	DRO					✓	✓
			1-2									✓
			2-3								✓	✓
			Bottom									✓

Table 4-1. Soil Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	TOC[1]	Metals[2]	NWTPH[3]	VPH/EPH[4]	SVOCs[5]	Dioxins/ Furans[6]	Pest/ PCBs[7]	Physical Testing[8]	Archive
HA-1	TO BE PROVIDED IN FINAL SAP		0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-2			0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-3			0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-4			0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-5			0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-6			0-1	✓	✓	DRO				✓	✓	✓
			1-2									✓
HA-7			0-1	✓	✓	DRO					✓	✓
			1-2									✓
HA-8			0-1	✓	✓	DRO					✓	✓
			1-2									✓
Background	TBD	TBD	0-1	✓	✓	GRO/DRO	✓	✓	✓	✓	✓	✓
Total Samples				**21**	**21**	**21**	**≤21[9]**	**≤21[9]**	**≤21[9]**	**7**	**33**	**65**

[1] Total organic carbon will be analyzed for all 0-1 ft soil samples by EPA Method SW 9060 Modified (Ecology).
[2] Metals analysis will include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc (EPA Methods 6010/7471A).
[3] NWTPH analysis (Ecology 1997) will include both gasoline-range hydrocarbons (GRO) and diesel-range hydrocarbons (DRO) except where indicated.
[4] VPH/EPH petroleum fractionated analysis (Ecology 1997) will be analyzed for selected samples exceeding GRO/DRO SL's or, at a minimum, 20 percent of total samples analyzed.
[5] SVOCs will be analyzed for samples exceeding GRO/DRO SL's or, at a minimum, 20 percent of total samples analyzed for confirmation purposes (EPA Method SW 8270C low levels).
[6] Dioxins/Furans will be analyzed by EPA Method 1613B for samples with PCP concentrations exceeding SL.
[7] Chlorinated Pesticides/PCBs will be analyzed by EPA Method SW 8081/8082 for soil samples collected to evaluate BNSF.
[8] Physical testing will include grain size (ASTM D 422-63 w/hydrometer), Atterburg limits (ASTM D 4318-00), Specific Gravity (ASTM 854-02), and moisture content (ASTM 2216).
[9] Sample total is dependent on the number of samples exceeding SL's, with a minimum of 20 percent site samples analyzed for SVOCs and VPH/EPH.

Note: Field duplicate samples will be collected at a frequency of 1 per 20 field samples. Equipment rinse blank samples will be collected once per sampling method.

Table 4-2. Groundwater Sampling Locations and Testing (Each Sampling Cycle).

Station	Northing (ft)	Easting (ft)	Conventional Testing[1]	Metals[2]	NWTPH [3]	SVOCs[4]	Dioxins/ Furans[5]
MWLSC01	TO BE PROVIDED IN FINAL SAP		✓	✓	GRO/DRO	✓	✓
MWLSC02			✓	✓	GRO/DRO	✓	✓
MWLSC03			✓	✓	GRO/DRO	✓	✓
MW06D			✓	✓	GRO/DRO	✓	✓
Total Samples			**4**	**4**	**4**	**4**	**4**

[1] Conventional testing will include TOC (EPA Method 415.1), TSS (EPA Method 160.2), and Hardness (SM 2340B).
[2] Metals analysis will include arsenic, cadmium, calcium, chromium, copper, lead, magnesium, mercury, nickel, silver, zinc (EPA Methods 200.8/6010B/7470).
[3] NWTPH analysis (Ecology 1997) will include both gasoline-range (GRO) and diesel-range (DRO) hydrocarbons. VPH/EPH petroleum fractionated analysis (Ecology 1997) will be analyzed for all samples exceeding GRO/DRO SLs.
[4] SVOCs will be analyzed by EPA Method SW 8270C low levels for comparison to State Surface Water Quality Criteria.
[5] Dioxins/Furans will be analyzed by EPA Method 1613B.

Note: Field duplicate samples will be collected at a frequency of 1 per 20 field samples. Equipment rinse blank samples will be collected once per sampling method.

Table 4-3. Surface Water Sampling Locations and Testing (Each Sampling Cycle).

Station	Northing (ft)	Easting (ft)	Conventional Testing[1]	Metals[2]	NWTPH [3]	SVOCs[4]	Dioxins/ Furans[5]
SW01	TO BE PROVIDED IN FINAL SAP		✓	✓	GRO/DRO	✓	
SW04			✓	✓	GRO/DRO	✓	
SW05			✓	✓	GRO/DRO	✓	✓
SW06			✓	✓	GRO/DRO	✓	✓
SW07			✓	✓	GRO/DRO	✓	
SW09			✓	✓	GRO/DRO	✓	
Background			✓	✓	GRO/DRO	✓	✓
Total Samples			**7**	**7**	**7**	**7**	**3**

[1] Conventional testing will include TOC (EPA Method 415.1), TSS (EPA Method 160.2), and Hardness (SM 2340B).
[2] Metals analysis will include arsenic, cadmium, calcium, chromium, copper, lead, magnesium, mercury, nickel, silver, zinc (EPA Methods 200.8/6010B/7470).
[3] NWTPH analysis (Ecology 1997) will include both gasoline-range (GRO) and diesel-range (DRO) hydrocarbons. VPH/EPH petroleum fractionated analysis (Ecology 1997) will be analyzed for all samples exceeding GRO/DRO SLs.
[4] SVOCs will be analyzed by EPA Method SW 8270c low levels for comparison to State Surface Water Quality Criteria.
[5] Dioxins/Furans will be analyzed by EPA Method 1613B.

Note: Field duplicate samples will be collected at a frequency of 1 per 20 field samples. Equipment rinse blank samples will be collected once per sampling method.

Table 4-4. Sediment Sample Locations and Testing.

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	Metals[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays[8]	Archive
SB-1	TO BE PROVIDED IN FINAL SAP		0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-2			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-3			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-4			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓

Table 4-4. Sediment Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	Metals[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays[8]	Archive
SB-5	TO BE PROVIDED IN FINAL SAP		0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-6			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-7			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-8			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-9			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓

Table 4-4. Sediment Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	Metals[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays[8]	Archive
SB-10	TO BE PROVIDED IN FINAL SAP		0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-11			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-12			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-13			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-14			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓

Table 4-4. Sediment Sample Locations and Testing. (continued)

Station	Northing (ft)	Eastin g (ft)	Depth (ft bgs)	Metal s[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays [8]	Archive
SB-15	TO B PROVIDED IN FINAL SAP		0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-16			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-17			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-18			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-19			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓

Table 4-4. Sediment Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	Metals[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays[8]	Archive
SB-20	TO BE PROVIDED IN FINAL SAP		0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-21			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-22			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
SB-23			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3									✓
			3-4									✓
			4-5									✓
SB-24			0-1	✓	DRO				✓	✓		✓
			1-2									✓
			2-3							✓		✓
			3-4									✓
			4-5									✓
LSC-07			0-0.3	✓	DRO				✓*	✓		✓

Table 4-4. Sediment Sample Locations and Testing. (continued)

Station	Northing (ft)	Easting (ft)	Depth (ft bgs)	Metals[1]	NWTPH[2]	VPH/EPH[3]	SVOCs[4]	Dioxins/ Furans[5]	Conventional Testing[6]	Physical Testing[7]	Bioassays[8]	Archive
LSC-08			0-0.3	✓	DRO				✓*	✓		✓
LSC-09			0-0.3	✓	DRO				✓*	✓		✓
LSC-10			0-0.3	✓	DRO				✓*	✓		✓
LSC-11			0-0.3	✓	DRO				✓*	✓		✓
LSC-12			0-0.3	✓	DRO				✓*	✓		✓
Background			0-0.3	✓	DRO	✓	✓	✓	✓*	✓		✓
Total Samples				**31**	**31**	**≤31[9]**	**≤31[9]**	**≤31[9]**	**31**	**46**	**≤7[10]**	**127**

[1] Metals analysis will include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc (EPA Methods SW 6010/7471A).
[2] NWTPH analysis (Ecology 1997) will include both gasoline-range (GRO) and diesel-range (DRO) hydrocarbons except where indicated.
[3] VPH/EPH petroleum fractionated analysis (Ecology 1997) will be analyzed for selected samples exceeding GRO/DRO SL's or, at a minimum, 20 percent of total samples analyzed.
[4] SVOCs will be analyzed for samples exceeding GRO/DRO SL's or, at a minimum, 20 percent of total samples analyzed for confirmation purposes (EPA Method SW 8270C low levels).
[5] Dioxins/Furans will be analyzed by EPA Method 1613B for samples with PCP concentrations exceeding SL.
[6] Total organic carbon will be analyzed by EPA Method SW 9060 modified for sediment analysis. Samples (✓*) planned for bioassay testing will also be analyzed for total solids (PSEP 1986), ammonia (Plumb 1981/EPA Method 350.1) and total sulfides (PSEP 1986/EPA 376.2).
[7] Physical testing will include grain size (ASTM D 422-63 w/hydrometer), Atterburg limits (ASTM D 4318-00), Specific Gravity (ASTM 854-02), and moisture content (ASTM 2216).
[8] Bioassay testing will include the 10-day Amphipod (*Hyalella azteca*), Micortox Porewater (*Vibrio fischeri*), and 21-day Midge Larvae (*Chironomus tentans*).
[9] Sample total is dependent on the number of samples exceeding SL's, with a minimum of 20 percent site samples analyzed for SVOCs and EPH.
[10] LSC-07 through LSC-12 will be chemically analyzed first and compared to SL's. If samples exceed chemical SL's, bioassay testing will be conducted on those samples along with appropriate reference sediment.

Note: Field duplicate samples will be collected at a frequency of 1 per 20 field samples. Equipment rinse blank samples will be collected once per sampling method.

5 FIELD SAMPLING METHODS

This section presents the field sampling methods to be used by Integral and its subcontractors for the assessment of the Park. Appendix A contains standard operating procedures (SOPs) for most field methods discussed in this section. In general, field and sample processing methods will follow the Ecology Sediment Sampling and Analysis Appendix and the Puget Sound Estuary Program (PSEP) guidelines for marine and freshwater sediments and surface waters (Ecology 2003, PSEP 1986, 1997a,b,c).

5.1 HORIZONTAL AND VERTICAL CONTROL METHODS

5.1.1 Utility Survey

Proposed sampling locations within the Park will first be marked either by a handheld Global Positioning System (GPS) or contracted land surveyor. A clearly marked stake will be driven into each location. Prior to commencing intrusive field activities, Integral will conduct a utility survey to identify all known underground utilities within the study area. Integral will utilize all information provided by the City and Whatcom County as the baseline for the utilities survey, including the approximate location of the underground stormwater pipe located in the upper area of the park. Integral will also use the regional One-Call service (1-800-424-5555) for locating stations near Marine Drive. If proposed sample locations interfere with utilities, alternate locations will be marked.

5.1.2 Sample Locations

Once the utility survey has been completed, proposed sampling stations will be located by a contracted land surveyor (i.e., David Evans & Asssociates) using a Leica Electronic Distance Meter (EDM) Total Station positioning method. If it is necessary to move a station during the field work, the new location will be marked and staked as described above. At the conclusion of sampling, the land surveyors will survey changed station locations and provide x, y, and z data for all sampling locations. The boundaries of the shell midden and any other archaeological site within the Park will also be surveyed by DEA.

To maintain system accuracy, one or two accessible and recoverable survey control points will be established near or within the Park. Northing and easting coordinates will be provided in both NAD 27 and NAD 83 with 0.1-ft accuracy (City of Bellingham currently uses NAD 27 datum). After sampling is completed, using control points established by the land surveyor, the elevation of each sample point will be determined by differential leveling. Station elevations will be referenced to NAVD 88 and City of Bellingham coordinate system.

The following parameters will be documented at every sample location:

- Horizontal location in state plane coordinates NAD 1927 and 1983
- Depth to mudline (if overlying water)
- Time and date
- Surface elevation referenced to NAVD 88, 2001 Adjustment in U.S. Feet and City of Bellingham coordinate system.

Parameters listed above will be measured using combinations of the following:

- GPS Total Station
- Range-azimuth laser positioning methods
- Sounding lines or poles
- Back-up methods to survey control points (e.g., horizontal triangulation).

5.2 SAMPLING EQUIPMENT

5.2.1 Test Pits

Soil samples will be collected from test pits excavated using a backhoe to a depth of 4 ft bgs. SOP-1 presents the procedures planned for test pit excavations in the Park. Three of the test pits (TP-3, TP-6, TP-12) will be excavated deeper (~6 ft) for the installation of piezometers to monitor groundwater levels in the area (also described in SOP-1).

5.2.2 Hand Augers

Soil samples will be collected using a stainless-steel hand auger or equivalent to a depth of 2 ft bgs. SOP-2 presents the procedures planned for sampling with a hand auger in the Park.

5.2.3 Groundwater Sampling

Groundwater will be collected from each well using either a portable peristaltic pump equipped with Teflon-lined tubing or disposable bailer, as described in SOP-3.

5.2.4 Surface Water Sampling

Surface water will be collected from below the water surface using either a portable peristaltic pump equipped with Teflon-lined tubing or direct filling of sample bottles, as described in SOP-4.

5.2.5 Surface Sediment Sampling

Surface sediment samples (0 to 4 inches) will be collected from the Creek using a stainless-steel shovel, spoon, or trowel following methods described in SOP-5.

5.2.6 Sediment Borings

Sediment borings will be advanced using a portable, track-mounted, hollow-stem auger drill rig as described in SOP-6. A 2-ft long, 3-inch diameter split spoon will be used (or equivalent) to collect sediment samples at each sediment boring location.

5.2.7 Archeological Site Boundaries

The boundaries of archaeological sites (shell midden) will be evaluated within Little Squalicum Park following methods described in SOP-7.

5.3 SAMPLE IDENTIFICATION

Sediment/soil samples will be assigned an individual sample identification number in the following manner:

LSP-TP-## - ##

Where: = Little Squalicum Park (LSP)
Sample Type: TP, HA, SB, LSC = Test pit, Hand Auger, Sediment Boring, and Surface Sediment Sample
Sample Location and Depth Interval: ## - ## = top and bottom depth increment in feet

Sediment/soil sample processing will occur at a processing station as described in the following sections. Sample processing methods are intended to result in high-quality samples that meet the program's quality assurance objectives. Guidelines for sampling handling, and storage are presented in Table 5-1. All samples will be placed immediately in a cooler with ice to preserve them at 4°C and will be kept at this temperature at all times. All samples will be labeled and identified in accordance with Section 5.5.

Surface water samples will be assigned an individual sample identification number in the following manner:

LSP-SW-##
Where: Little Squalicum Park (LSP)
SW-## = Surface Water Sample Number

Groundwater samples will be assigned an individual sample identification number in the following manner:

LSP-GW-##
Where: Little Squalicum Park (LSP)
GW-## = Groundwater Sample Number

Field blank samples (i.e., equipment rinsates) will be assigned an individual sample identification number in the following manner:

LSP-FB-##
Where: Little Squalicum Park (LSP)
FB-## = Field Blank Sample Number

5.4 SOIL/SEDIMENT PROCESSING

Visual, sheen, and headspace screening will be conducted in the field on all soil and sediment samples collected during this investigation as described in SOP-8.

Compositing will only be performed within individual locations to ensure that adequate soil or sediment is available for the required analyses.[18] Split-spoon samples and test pit soils not used for analysis will be managed in accordance with applicable investigation-derived waste requirements as described in Section 5.8.

Soil/sediment composite samples will be processed according to the following step-by-step procedure:

1. Transfer sediment section from split-spoon or soil from test pit to a clean stainless steel bowl and cover with aluminum foil.
2. Stir the composite sample until the sample is of uniform color and texture. If any material (e.g., shells, rocks) has to be removed from the sample, note it in the field logbook or on the sample description sheet.

[18] Compositing and homogenizing is not appropriate for the analysis of volatile organics. Discrete samples will be collected only for analysis of volatile organics in soil and sediments.

3. Fill jars for physical, chemical, and biological analyses.
4. Seal each glass container in a plastic bag in case of breakage. Place in ice chest and pack samples to minimize the chances of breaking.
5. Decontaminate the equipment as described in Section 5.7.
6. Collect excess sediment from the composite and dispose of as investigation derived waste, as discussed in Section 5.8.

5.5 SAMPLE CONTAINERS AND LABELS

Guidelines for sample handling and storage are presented in Table 5-1. All samples will be placed immediately in a cooler with ice to preserve them at 4°C and will be kept at this temperature at all times. All samples will be labeled and identified in accordance with Section 5.5.1.

5.5.1 Sampling Labels

The following sections describe documentation with sampling and handling procedures. Details are outlined in SOP-9 in Appendix A.

5.5.1.1 Sample Labels

Sample containers will be clearly labeled with waterproof black ink at the time of sampling. Sample labels will contain the following information:

- Sample identification numbers
- Sample date
- Sample time
- Preservation used, if any
- Analysis requested
- Initials of samplers.

The sample label will be attached to the sample container prior to, or just after, the container is filled and the lid secured. As an added measure of security, the finished label should be covered with clear packaging tape to protect the ink from moisture and to tightly secure the label to the sample container. Information on the sample label must match the information on the chain-of-custody form and in the site logbook for each sample.

5.5.1.2 Custody Seals

Custody seals will be used on sample shipping containers (coolers) that will either be shipped or sent by messenger to the laboratory. Custody seals will be attached to the lid and body of the coolers to detect any tampering during shipment. The custody seals will be signed and dated by the sampler or sample shipper. Custody seals are not required for samples delivered by hand directly to the lab unless left unattended.

5.5.1.3 Sample Summary Log

Sample summary logs will be maintained by the field team leader and used to keep track of all phases of the sampling and analysis process for all individual samples. The summary sample logs will include sample collection dates, sample delivery dates, dates analytical results are received, laboratory sample delivery group, and laboratory work order number.

5.5.1.4 Sample Custody/Tracking Procedures

The samples collected must be traceable from the time they are collected until they or their derived data are used in the final report. In general, the following provisions apply to sample handling:

- The field team leader, or sampler, will be responsible for the care and custody of the samples collected until they are properly transferred or dispatched to the laboratory.
- All appropriate documentation forms will be used, including sample labels, chain-of-custody forms, sample logs, and any other appropriate forms. Documentation will be completed neatly using waterproof, black ink.
- When transferring possession of samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain of custody form. Containers shipped by common carrier will have the chain-of-custody form enclosed in a watertight container (e.g., plastic resealable bag) and placed in the container prior to sealing.
- Samples will be packaged properly according to the current U.S. Department of Transportation requirements and promptly dispatched to the laboratory for analysis. Sample containers will be packed in coolers (or other shipping containers) with a low-density packing material, such as bubble wrap, and Blue Ice® or its equivalent. The coolers will be securely sealed.
- Each cooler will be accompanied by its own chain of custody form identifying its contents. A copy of the chain of custody form will be retained by the field team leader for inclusion in project records.

- For coolers shipped via express delivery service, custody seals will be affixed to the outside of the coolers (shipping containers). The field team leader, sampler, or shipper will sign and date the custody seals.
- All samples will be shipped via express delivery for overnight delivery or hand delivered to the laboratory.

5.6 FIELD DOCUMENTATION PROCEDURES

The primary types of documentation that will be used for this project include site logbook, photo logs, sample log forms, Field Change Request (FCR) forms, and sample tracking forms. The site logbooks are vital for documenting all onsite activities. Photo documentation will be used to provide an accurate account of the material sampled, sample locations, and environmental conditions. Sample log forms are used to summarize sampling data collected for various sample locations. The FCR forms are used to document any modifications made to the original project plans during field activities. Sample tracking forms include the chain of custody form, sample labels, and custody seals. The chain-of-custody form is used to track sample custody, which is an important aspect of field investigation activities that documents the proper handling and integrity of the samples. Sample labels are used to provide essential information and identification for all samples collected during field activities. Custody seals are used on all sample shipment containers to detect any tampering that may have occurred during transport or shipment. A description of each of these documentation methods is provided in the following sections. Example field forms are presented in Appendix A.

5.6.1 Field Logbooks

The field logbooks will be used to document all field sampling activities performed at the project site. The logbooks will contain the date, time, and description of all field activities performed; names of personnel; weather conditions; the names of visitors to the site; areas where photographs were taken; and any other data pertinent to the project. The site logbooks will also contain all sample collection and identification information and (if appropriate) a drawing of each area sampled, along with the exact location (coordinates) of where the sample was taken. The sampling information will be transferred to sample log forms when the sampler returns to the site office. The logbook is the official, legal record of site activities, and will serve as the key to sample designations and locations, and will include the date, time, site/sample location, sample identification number, sample matrix, how the sample was collected, any comments, and the sampler's name.

Each page of the field logbook will be numbered, dated, and signed by the author. The logbooks will be sturdy, weatherproof, and bound to prevent the removal of pages. All writing will be done in waterproof, black, permanent ink. No pages may be removed from the site logbooks for any reason. Blank pages, if any, will be marked "page

intentionally left blank." Any mistakes will be crossed out with a single line, initialed, and dated. If multiple logbooks are used, they will be numbered sequentially.

5.6.2 Photo Documentation

Photographs will be taken at sampling locations and of selected samples. These photos will help identify the location and will provide an accurate visual record of the material being sampled. All photographs taken will be identified in the field logbooks (preferably in a separate section of the book set aside for that purpose). Photographic logs will contain, at a minimum, the film roll number, the photo number, the date, the time, the initials of the photographer, and a description of the image in the photograph.

5.6.3 Sample Collection Information Form

Sampling logs and collection forms will be used to document site and sample characteristic data, which should agree with the information recorded in the site logbooks. Field personnel are required to fill out one sample log form for each sample collected. A copy of these forms will be stored in the field office or field files, with the original stored in the project file. A copy of these forms will also be included in the final data report and other documents, as appropriate. At a minimum, the log for each sample will contain the sample number, the date and time of sample collection, and a description of the sampling site, as well as the physical characteristics of the sample, the planned analysis, and the initials of the sampler.

5.6.4 Field Change Request Form

The field team leader will be responsible for all environmental sampling activities, and will occasionally be required to adjust the field program, to accommodate site-specific needs after consultation with the project manager and/or QA Coordinator. When it becomes necessary to modify a program or task, the changes will be documented on a FCR form. If a field change is later found to be unacceptable, the action taken during the period of deviation will be evaluated to determine the significance of any departure from the established program practices and appropriate action taken. All field changes will be numbered consecutively starting with the number 001.

5.6.5 Sample Tracking Forms

Sample tracking is an important aspect of field investigation activities, as it documents the proper handling and integrity of the samples. Sample tracking forms to be used for the project will include chain-of-custody forms, sample labels, custody seals, and sample summary logs.

5.6.6 Chain-of-Custody Form

The chain-of-custody form is used to document the history of each sample and its handling from its collection through all transfers of custody until it reaches the analytical laboratory. Internal laboratory records will document custody of the sample from the time it is received in the lab through its final disposition. The chain-of-custody form will be filled out after the samples have been collected and will be double-checked prior to the transport of the samples to the laboratory. At a minimum, the chain-of-custody form will contain the following information:

- Name of project
- Names of samplers
- Sample identification numbers
- Sampling date
- Sampling time
- Number and type of containers per sample
- Sample matrix
- Sample preservation, if any
- Analysis requested.

The completed chain-of-custody form will be placed in a large capacity Ziploc® bag and secured to the sample transport container. If coolers are used to transport samples, the chain-of-custody form will be taped to the underside of the cooler lid.

5.7 DECONTAMINATION PROCEDURES

Equipment decontamination will be performed using procedures outlined below and in SOP-10 (Appendix A). Site personnel will perform decontamination of all equipment prior to removal from the site and between sample locations.

All non-disposable components of the sediment coring equipment (e.g., split spoons), or other equipment used to collect sediment samples that contacts the soils/sediments, will be decontaminated as follows:

- Potable water rinse
- Alconox/Liquinox detergent wash
- Potable water rinse

- Deionized (DI) water rinse
- Air dry.

If non-aqueous phase liquids are encountered in the soils/sediments, the following extra steps may be included in decontaminating equipment:

- Potable water rinse
- Alconox detergent wash
- Methanol to remove water
- Hexane to remove nonaqueous phase liquid (NAPL) film
- DI water rinse.

All sampling equipment that is used in sampling groundwater and surface water will be decontaminated as follows:

- Potable water rinse
- Alconox/Liquinox detergent wash
- Potable water rinse
- DI water rinse
- Air dry.

Rinsate blank samples will be collected as specified in Section 4.6 and SOP-11 (Appendix A) to document the level of decontamination.

All liquids generated as a result of decontamination processes will be containerized and handled as investigation derived wastes, as discussed in Section 5.8.

5.8 INVESTIGATION-DERIVED WASTES

The primary waste streams to be generated during this project and the proposed storage/disposal methods are provided in Table 5-2.

5.8.1 Excess/Rejected Sediment Samples

Sediment/soil samples that are rejected and/or determined to be in excess of what is required to conduct analytical sampling will be returned to the project area that it was collected.

5.8.2 Decontamination and Dewatering Wastewaters

Liquid wastes (i.e., dewatering water and decontamination waters) will be potentially contaminated with petroleum hydrocarbons and PAHs. The presence of any hazardous constituents in the wastewaters is expected to be diluted; therefore, the wastewaters are not expected to be classified as dangerous or hazardous waste. Therefore, the wastewaters are not likely to contain hazardous waste pursuant to the contained-in policy (i.e., environmental media that contain a listed hazardous waste are to be managed as a hazardous waste). Decontamination waters will be disposed of in the project area.

In the use of solvents (e.g., methanol and hexane), decontamination activities will be conducted so as to minimize the potential for spills/releases of wastewaters. Spent decontamination solvents must be stored in leak-proof container(s) with secured lid(s). The lid is to remain closed except when the container is being used for decontamination activities. It is anticipated that liquid wastes be placed in 5-gallon buckets or similar containers for offsite disposal or onsite evaporation (if applicable).

5.8.3 Personal Protective Equipment/Miscellaneous Debris

Personal Protective Equipment (PPE) and miscellaneous debris will be generated during sediment sampling activities. Interim storage of these materials in plastic bags is acceptable. The bags are to be disposed of at an appropriate solid waste facility dumpster after the completion of each sampling event.

Table 5-1. Required Sample Containers, Preservatives, and Holding Times.[1]

Analysis Type	Matrix	Container Size	Holding Time[1]	Preservation
NWTPH-GRO	Soil/Sediment	4 oz glass with Teflon coated/Septum lid	14 days extraction/analysis	Ice (4°C)
NWTPH-DRO	Soil/Sediment	4 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
SVOCs	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Pesticides/PCBs	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Dioxins/Furans	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Metals	Soil/Sediment	4 oz glass	6 months/28 days* 2 years until analysis (except mercury)	Ice (4°C) Frozen (-18°C)
TOC	Soil/Sediment	4 oz glass	14 days 6 months	Ice (4°C) Frozen (-18°C)
Total Sulfides/Ammonia	Soil/Sediment	4 oz glass (zero headspace)	7 days	Ice (4°C)
Grain size	Soil/Sediment	16 oz glass	6 months	Ice (4°C)
Atterburg Limits	Soil/Sediment	Inc.	NA	Ice (4°C)
Specific Gravity	Soil/Sediment	Inc.	NA	Ice (4°C)
Moisture Content/Bulk Density	Soil/Sediment	Inc.	NA	Ice (4°C)
NWTPH-GRO	Water	Two 40-mL glass with Teflon lined Septum lid	14 days extraction/analysis	1+1 HCl to a pH <2 Ice (4°C)
NWTPH-DRO	Water	One 1-liter amber glass	14 days extraction/analysis	1+1 HCl to a pH <2 Ice (4°C)
SVOCs	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Pesticides/PCBs	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Dioxins/Furans	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Metals	Water	One 1-liter HDPE	6 months/28 days*	Ice (4°C), HNO_3 pH<2

Table 5-1. Required Sample Containers, Preservatives, and Holding Times. (continued)

Analysis Type	Matrix	Container Size	Holding Time[1]	Preservation
TOC	Water	One 500-mL HDPE	28 days	Ice (4°C), H_2SO_4 pH<2
TSS	Water	One 1-liter HDPE	--	Ice (4°C)
Hardness	Water	One 1-liter HDPE	--	Ice (4°C)
Bioassays	Sediment	Three 1-liter amber glass	8 weeks	Ice (4°C) No Headspace or Purged with Nitrogen Gas

1 Storage temperatures and maximum holding times for physical/chemical analyses and sediment toxicity tests (PSEP 1997a,b, Ecology 2003)

* Holding time for mercury is 28 days. Holding time for the other metals is 6 months.

Note: All holding times are from the date of sampling. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis without being qualified.

Table 5-2. Primary Waste Streams and Disposal Methods.

Waste Stream	**Estimated Quantity**	**Storage/Disposal Method**
Excess/Rejected Soil/Sediment Samples	*< 1000 lbs*	Returned to test pit location/bank of creek
Excess Surface Water/Groundwater Samples	*<20 gallons*	Returned to creek or poured on ground near location
Purged Groundwater before Sampling	*<200 gallons*	Poured on ground near location
Decontamination Wastewaters (except solvents)	*<100 gallons*	Poured onto ground near processing area
Personal Protective Equipment (PPE)/ Miscellaneous Debris	*<25 cubic ft*	Containerize/offsite disposal by Integral
Decontamination Solvents (methanol and hexane)	*<10 gallons*	Containerize and allow to evaporate/ offsite disposal by Integral if required

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Appendix A

Sampling and Analysis Plan
Standard Operating Procedures
and Field Forms

STANDARD OPERATING PROCEDURE 1

Test Pit Excavation and Sampling/Piezometer Installation/Water Level Measurements

Scope and Application

Test pits will be excavated at 12 locations within the Little Squalicum Park boundaries to further evaluate areas of historical landfill and gravel pit operations, which might have disturbed soils and distributed contamination throughout a depth range up to several feet. Soils will be collected from 1 ft intervals to an approximate depth of 3-4 ft using a stainless steel shovel, trowel, or spoon.

Three test pits (TP-3, TP-6, TP-12) will be excavated deeper (~6 ft) and piezometers will be installed while backfilling the hole to monitor groundwater levels at these locations. The piezometers will be 1-inch in diameter and made of PVC or stainless steel with slotted screens the entire depth of the installation.

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HASP)
- Site logbook and test pit log
- Indelible black-ink pens and markers
- Camera
- Backhoe and operator
- PVC or stainless steel piezometer
- 10-20 Silica sands (if required)
- Well monument, concrete, cap and lock
- Electronic water level indicator
- Stainless steel spoons, trowel, shovel, bowls
- Photoionization detector (PID)
- Plastic sheeting
- Paper towels

- Sample containers
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample labels and appropriate documentation
- Assorted geology supplies (e.g., hand lens, grain size card, scales, etc.)
- Decontamination equipment (SOP-8)

Procedures

Test Pit Excavation

1. Using a backhoe, remove the upper 1-2 ft of soil from an area approximately [5 ft by 5 ft] square, and place to one side of the excavation.

2. Continue the excavation downward using the backhoe, placing the soils on the opposite side of the excavation. Extend the pit vertically and horizontally until the appropriate depth and width are obtained (3-4 ft depth proposed for this project).

3. Collect samples at 1 ft intervals to a depth of 3 feet, and from the bottom of the pit using a stainless steel shovel, trowel or spoon. Personnel shall not enter an excavation if it is more than 4 feet deep. If deeper than 4 ft, use the backhoe bucket to collect a sample.

4. Place soil from desired depth directly into a stainless steel bowl for compositing. Collect soil from all sides of the excavation for each sample depth to provide enough material for analysis.

5. Homogenize soil within bowl/pan with decontaminated stainless steel trowel or spoon. Remove rocks, twigs, leaves and other large debris as appropriate. Fill sample containers for analytical parameters. (Volatiles samples should not be composited but collected from a discrete location within the depth interval.)

6. If groundwater with sheen or odors is encountered, collect a water sample. A sample from less than 4 feet in depth may be obtained by direct fill into bottles (if possible) or by using a decontaminated stainless steel scoop. A sample from a deeper depth should be collected using a stainless steel beaker clamped to a pole (or equivalent). Care should be exercised when pouring the water into the appropriate sample containers as not to aerate the sample. Personnel shall not enter an excavation if it is more than 4 feet deep.

7. Sketch a map of the trench showing the location (horizontally and vertically) of any stained soil layers, samples, buried wastes, etc. in the field notebook and/or on a test pit record form. Describe soil in accordance with ASTM D2488 on the sample log form.

8. Label and manage sample containers in accordance with SOP-7 for shipping and handling of samples.

9. Decontaminate sampling equipment in accordance with SOP-8.

10. Document activities in site logbook.

11. After completion of the trench or at the end of the day, whichever is more frequent, backfill the test trench(es). The soils from the deeper portion of the trench shall be returned to the trench first. If a trench was not completed and is backfilled at the end of a day, it may be restarted the next day from the point at which excavation ceased.

12. Mark the boundaries of the test pits and the ground surface location(s) of any soil/groundwater samples with stakes for subsequent surveying. Perform re-vegetation of the area as necessary and required.

Piezometer Installation

1. Once test pit has been sampled for chemical analysis as described above, excavate pit deeper until groundwater is encountered (~6 ft bgs).

2. Install 1-inch PVC or stainless steel piezometer with pre-packed slotted screen 2-3 feet below groundwater level if possible.

3. Backfill test pit around piezometer (soils are expected to be predominately coarse-grained materials (sands and gravels). If test pit soils are fine-grained, install 10-20 silica sand filter pack from 1 foot below the screen to a maximum of 3 feet above the screen, and then backfill test pit.

4. Cut PVC riser (for surface completions). Record cut length in site logbook.

5. Install concrete pad (minimum 3 feet by 3 feet by 6 inches) and locking protective monument (stand-pipe for each location). Install three bucking posts for standpipe completions, if necessary.

6. A lockable cap will be attached to the top of the casing. A protective cover, level with the ground surface, will be installed with a waterproof seal to prevent the inflow of surface water.

7. Decontaminate all equipment (SOP-8).

8. Document activities in the site logbook.

9. Ground surface at each piezometer will be surveyed to provide horizontal coordinates (northing/easting) and elevation.

Water Level Measurements

1. Rinse water level indicator probe and cable with deionized water and wipe dry with paper towels.

2. Holding cable reel atop casing, lower indicator probe gradually into well until tone and/or light indicates contact with water surface.

3. Grasp cable exactly at the measuring point marked at the top of the well casing with thumb and index finger. Pull cable out of well slowly to read measurement.

4. Record measurement depth to water surface to the nearest 0.01 ft as indicated on graduated cable.

5. Withdraw cable several feet then lower and repeat Steps 2-4. If readings differ by more than 0.2 ft, repeat until readings stabilize.

6. Remove cable and probe from well and rinse with deionized water.

STANDARD OPERATING PROCEDURE 2

Hand Auger Sampling

Scope and Application

Hand augers will be excavated at 8 locations within the Little Squalicum Park boundaries to evaluate soils along the Burlington Northern Santa Fe (BNSF) railroad right-of-way and an area northeast of Little Squalicum Creek suspected to be impacted by a historical OESER spill or contaminated runoff. Soils will be collected from 1 ft intervals to an approximate depth of 2 ft using a stainless steel hand auger or equivalent.

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HASP)
- Site logbook and hand auger log
- Hand auger, drive sampler, or equivalent
- Indelible black-ink pens and markers
- Camera
- Stainless steel spoons, bowls
- Photoionization detector (PID)
- Sample bottles
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample labels and appropriate documentation
- Assorted geology supplies (e.g., hand lens, grain size card, scales, etc.)
- Decontamination equipment (SOP-10)

Procedures

1. Remove vegetation in area of station.
2. Use hand auger/drive sampler to bore into subsurface soil to a depth of 1 ft below ground surface (bgs).

3. Empty soil from hand-auger/drive sampler cuttings directly into a stainless steel bowl for compositing. Collect enough soil from each depth interval for required analysis – this may require compositing up to 3 replicate samples at each station.
4. Describe soil in accordance with ASTM D2488 on the sample log form.
5. Homogenize soil within bowl/pan with decontaminated stainless steel trowel or spoon. Remove rocks, twigs, leaves and other large debris as appropriate. Fill sample containers for chemical parameters. (Volatiles samples should not be composited but collected from a discrete location within the depth interval from one auger sample.)
6. Collect the next depth interval (1-2 ft) and follow the same compositing procedures. Care should be taken in collecting representative soil from each depth interval.
7. Label and manage sample containers in accordance with SOP-9 for shipping and handling of samples.
8. Backfill sampling hole with remaining hand auger/drive sampler cuttings.
9. Decontaminate sampling equipment in accordance with SOP-10.
10. Document activities in site logbook.

STANDARD OPERATING PROCEDURE 3

Groundwater Sample Collection

Scope and Application

Groundwater samples will be collected from three locations within the Little Squalicum Park boundaries and one background location to be determined. There are two sampling rounds planned for this investigation, once in the wet season and once in the dry season. The wet season samples will be collected between October and May the dry season samples between June and September.

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Site logbook
- Indelible black-ink pens and markers
- Sample tags/labels and appropriate documentation
- Appropriate laboratory glassware
- Oil/water interface probe (if necessary)
- Water level meter
- Groundwater parameter multi-meter capable of measuring pH, reduction/oxidation (redox) potential, temperature, specific conductance, turbidity, and dissolved oxygen
- Flow-through cell
- Field alkalinity test kit
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample containers, coolers, and blue ice or equivalent
- Sampling equipment (one or more of the following): Peristaltic pump; disposable, dedicated bailers; Grundfos Redi-Flow submersible pump (or equivalent); Reel E-Z® system including control box; portable generator (5,000 watt minimum)
- Water Sampling Log Forms
- Decontamination equipment (SOP-10)

Typical Procedures

Preparation:

1. Record necessary data in site logbook.
2. Prepare sampling equipment including calibration of field meters prior to use.
3. Move equipment and supplies to sampling location.
4. Decontaminate equipment according to SOP 10.

Purging:

1. Remove well cap.
2. Measure light nonaqueous phase liquid (LNAPL) thickness (if present), measure static water level and total depth of well.
3. Remove the pump from the pump holder and rinse the pump off with distilled water. After consulting the well log to determine depth to the middle of the well screen, slowly lower the pump into the well. Position the pump at the middle of the well screen.
4. Connect the discharge hose and cable for the control box to the Reel E-Z® system. Start the generator and set it to 120 volts. Make sure the generator is kept down-wind from the sampling system.
5. Place the discharge hose in the flow-through box. Place the probes for the calibrated field meters into the flow-through box. Place a bucket beneath the flow-through box to catch purged water.
6. Turn on the pump and adjust flow rate to approximately 2 liters per minute.
7. After approximately 4 liters of water have been purged from the well, adjust the flow rate to 1 liter per minute.
8. Start recording field parameters every 4 liters of water purged. Purging should continue at a constant rate until the selected parameters shown below have stabilized for three consecutive measurements.

Field Parameter	Stabilization Criteria
Temperature	± 1°C
pH	± 0.1 pH units
Specific Conductance	± 5 percent
Dissolved Oxygen	± 10 percent
Redox Potential (Eh)	± 50 mV
Turbidity	± 10 nephelometric turbidity units (NTUs)

Sampling:

1. After specified parameters have stabilized, turn down flow rate on control box so pressure is maintained in the system to stop water from entering well and minimize or stop water from exiting the well.
2. Disconnect discharge hose from Reel E-Z® system.
3. Connect Teflon® sampling tube to Reel E-Z® system. Place bucket beneath sampling tube to catch unsampled water.
4. Turn up flow rate slightly and fill necessary sample bottles. If sampling for volatile organic compounds (VOCs), flow rate should be just enough to create a trickle of water. If sampling for other analytes, adjust flow rate to 1 liter per minute.
5. Samples collected for dissolved metals shall be field filtered by connecting a 0.45 micron in-line filter to the sampling tube. Dispose of filter after each sample.
6. Label and manage sample containers in accordance with SOP 9 for shipping and handling of samples.

Documentation:

1. Fill out one Water Sampling Log Form for each sample collected with all necessary information recorded in the site logbook.

STANDARD OPERATING PROCEDURE 4

Shallow Surface Water Sample Collection

Scope and Application

Surface water samples will be collected from seven locations within the Little Squalicum Park boundaries and a background location to be determined. There are two sampling rounds planned for this investigation, both during the wet season. The wet season samples will be collected between October and May.

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HASP)
- Site logbook and sample log
- Indelible black-ink pens and markers
- Camera
- Any of the following equipment may be used to collect samples:
    - A Teflon/stainless steel scoop with a Teflon/stainless steel handle
    - A stainless steel beaker clamped to a pole
    - Sample bottles (direct fill)
    - Portable peristaltic pump with Teflon tubing
- Water quality meter(s)
- pH paper
- Sample containers
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample labels and appropriate documentation
- Decontamination equipment (SOP-10)

Procedures

Surface water samples shall be collected moving in an upstream direction utilizing the following procedure:

1. Immediately before collecting the sample, record the temperature, dissolved oxygen, pH, turbidity, and specific conductance using a Horiba® water quality meter or equivalent and following the manufacturer's specifications.
2. Submerge the bottle, beaker or scoop and collect a sample. When pouring the water from a beaker or scoop into another bottle container, care should be exercised so as not to aerate the sample. VOC samples will be collected first.
3. A peristaltic pump can also be used if available.
4. Preserve containers as follows:
    a. VOCs - Determine the volume of 1:1 HCl preservative required to adjust the pH of the sample to less than 2 on an extra 40 ml glass vial prior to sampling. Pre-preserve sample bottles with the determined volume of HCl (if possible) and fill with sample. Check the bottle for the presence of trapped air by tapping the bottle when filled and capped.
    b. Other Parameters - Add appropriate volume of preservative (as specified in the SAP) to sample bottle. Verify pH by pouring a minimal portion of the sample onto broad range pH paper.
5. Complete sample logs, labels, custody seals, and chain of custody forms. Record sample information in the field notebook.
6. Place the analytical samples in a cooler for shipment and chill to 4°C (SOP-9).
7. Decontaminate sampling equipment in accordance with SOP-10.

STANDARD OPERATING PROCEDURE SOP-5

Sediment Sampling – Shallow Water

Scope and Application

Surface sediment sampling will be conducted at 6 locations within Little Squalicum Creek to define the extent of hot spots detected during previous investigations (i.e., Ecology 2004 study). A background sediment sample will also be collected at a location(s) to be determined. Surface sediments will be collected using a stainless steel shovel or trowel. Sediment samples will be obtained following the collection of surface water samples at each location, if possible, and will be collected moving in an upstream direction.

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HASP)
- Site logbook and sample log
- Indelible black-ink pens and markers
- Camera
- Stainless steel shovel, trowel, or spoon
- Photoionization detector (PID)
- Ponar grab (or equivalent), in deeper water
- Sample containers
- Sample labels and appropriate documentation
- Assorted geology supplies (e.g., hand lens, grain size card, scales, etc.)
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Decontamination equipment (SOP-10)

Procedures

1. After collection of surface water samples at a location, use a decontaminated stainless steel shovel or trowel to scrape away surficial organic material (grass, leaves, etc.).

2. Obtain sediment for analysis using a stainless steel shovel, trowel or spoon from the surface to 4 inches below sediment surface. Fill sample container for volatile (e.g., H_2S) parameters as discrete grab samples. Then, empty remaining contents of shovel/trowel into a decontaminated stainless steel bowl or pan. Repeat until enough sediment is collected to fill all other required containers.

3. Homogenize sediment within bowl/pan with decontaminated stainless steel trowel or spoon. Remove rocks, twigs, leaves and other large debris as appropriate. Fill sample containers for remaining chemical parameters. (Volatiles samples should not be composited but collected from a discrete location within the depth interval.)

4. Describe soil in accordance with ASTM D2488 on the sample log form.

5. Complete sample logs, labels, custody seals, and chain of custody forms. Record sample information in the field notebook.

6. Place the analytical samples in coolers for shipment and chill to 4°C (SOP-9).

7. Decontaminate sampling equipment in accordance with SOP-10.

STANDARD OPERATING PROCEDURE 6

Hollow-Stem Auger Drilling/Sediment Sampling

Scope and Application

Sediment borings will be advanced at 24 locations to define the width and depth of contamination in Little Squalicum Creek. After surface samples have been collected, sediment borings will be collected along three transects (3-5 borings each) across the creek bed, using a track-mounted, portable, hollow stem auger to collect samples at depth. The drill rig proposed for this work has a small foot-print allowing maneuverability within the creek bed without excessive disturbance of creek sediment, bank soils, and vegetation.

Required Equipment

- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HASP)
- Site logbook and boring log
- Indelible black-ink pens and markers
- Camera
- Hollow-stem auger drill rig
- Driller and helper
- Split-spoon samplers
- Photoionization detector (PID)
- Plastic sheeting
- 55-gallon drums (if required)
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags
- Sample labels and appropriate documentation
- Assorted geology supplies (e.g., hand lens, grain size card, scales, etc.)
- Decontamination equipment (SOP-10)

Typical Procedures

Preparation:

1. Conduct site activity/health and safety briefing.
2. Calibrate field instrumentation.
3. Record necessary data in field logbook.
4. Obtain photograph(s) of site before drilling.
5. Place plastic sheeting and/or drums at drilling location to collect cuttings (if necessary).
6. Move equipment and supplies to drilling location.
7. Set up decontamination and sampling stations.

Construction:

1. Obtain surface soil samples, if required.
2. Drill to first sampling depth, as described in the SAP.
3. Place decontaminated split-spoon sampler on center rods.
4. Drive split-spoon sampler as described in American Society for Testing and Materials (ASTM) Method D-1586. Drive sampler to 18 inches or to refusal (no progress for 50 blows). Record blow counts on boring log form. Retrieve sampler.
5. A larger 3-inch diameter, 2-ft length split-spoon may be used to obtain more sediment from each depth interval.
6. Screen sampler with PID (if required).
7. Describe soil in accordance with ASTM D2488 on the boring log form.
8. Composite soil sample as necessary. If volatile organic compound (VOC) samples are to be collected, collect sample prior to describing soil.
9. Continue drilling to next sample location. Collect samples as outlined above.
10. Label and manage sample containers in accordance with SOP-9 for shipping and handling of samples.
11. Decontaminate sampling equipment in accordance with SOP-10.
12. Document activities in site logbook.

13. Since the total depth of each boring will be only 5 ft below sediment surface, boreholes can be filled with cuttings after hole is complete. No grouting of borehole is required.
14. Move to next location.

STANDARD OPERATING PROCEDURE 7

Archaeological Site Boundaries

Scope and Application

The boundaries of archaeological sites (shell midden) will be evaluated within Little Squalicum Park. There is one known site located upstream of the railroad bridge, in the lower reach of the creek. The following SOP will be followed by Integral and its subcontractor Dr. Gary Wessen during this investigation.

Equipment Required

- Shovel
- Screen box with ¼ inch mesh
- Pin flags
- EDM or 30 meter tape
- Hand-held GPS Receiver
- Camera
- Decontamination equipment (SOP-10)

Procedures

1. Careful visual inspection of all available horizontal and vertical exposures.
2. Establish the extent of the presently visible cultural materials and mark the boundaries of this area with pin flags.
3. Once the latter is done, shovel testing is used to further refine our knowledge of the site's boundaries. (Washington State law forbids the knowing disturbance of an archaeological site - - including any type of sample collection - - without a permit, and so this effort will be conducted without actually impacting the site.)
4. Radial transects will be established out from the marked site boundary. (Depending upon the site's size and shape, four to six transects will be established.)

5. Starting at a point 10 meters beyond the marked site boundary - - on one of the transects - - a small (i.e., 30 centimeter diameter) shovel test pit will be dug.
6. Digging will be done in 10 centimeter arbitrary levels and the sediments recovered from each level will be screened through ¼ inch mesh in order to facilitate the recognition of any cultural materials that might be present.
7. Digging will stop as soon as either potentially intact archaeological deposits or obvious glacial deposits are encountered.
8. Once the first pit is completed, additional pits will be dug at 3 meter intervals on the transect - - moving either toward or away from the site, as appropriate - - until the edge of the buried cultural deposit is located.
9. Steps 5 through 8 will be repeated on each transect.
10. When the shovel testing is completed, additional pin flags marking the extent of the buried cultural deposit will be placed and a map showing the distribution of both the exposed materials and the buried deposits will be prepared.
11. The site are will be photographed and its location recorded with a hand-held GPS receiver in both UTM and State Plane coordinates.
12. At the completion of the effort, all of the shovel test pits will be backfilled and all pin flags will be removed from the area. Wooden stakes or equivalent may be driven along the boundaries of each site for future reference.
13. Decontaminate sampling equipment in accordance with SOP-10.
14. Document activities in site logbook.

STANDARD OPERATING PROCEDURE SOP-8

Hydrocarbon Field Screening for Soil and Sediment

Scope and Application

This SOP presents the qualitative field screening methods for hydrocarbons in soil and sediments.

Equipment and Reagents Required

- Clean stainless steel or plastic pan
- Camera
- Ziploc® bags
- Photo ionization detector (PID) or flame ionization detector (FID)

Procedures

Headspace Field Screening

1. Calibrate PID/FID in accordance with the manufacturer's specifications.
2. Label Ziploc® bag with the sample number.
3. Place representative soil/sediment sample in Ziploc® bag until bag is approximately one-half full. Seal Ziploc® bag and homogenize sample.
4. Allow bag to sit at ambient temperature for approximately 10 minutes. Place PID/FID wand into bag, being careful not to contact soil/sediment with probe.
5. Shake Ziploc® bag and record highest sustained reading in the field logbook.

Visual Screening

Visual screening consists of inspecting the soil/sediment for the presence of stains indicative of residual petroleum hydrocarbons. Visual screening is generally more effective in detecting the presence of heavier petroleum hydrocarbons, such as motor oil, or when hydrocarbon concentrations are high.

1. Visually inspect soil/sediment sample.

2. Indications of the presence of hydrocarbons typically include a mottled appearance or dark discoloration of the soil/sediment.

3. Record observations in logbook. Note: Visual observations do not definitively indicate the presence of hydrocarbons.

Sheen Screening

Sheen testing involves immersion of the soil/sediment sample in water and observing the water surface for signs of sheen.

1. A representative soil/sediment sample is placed into a clean stainless steel or plastic pan filled with deionized water with as little disturbance as possible.

2. Record observations in the logbook. Visual evidence of a sheen forming on the surface of the water is classified as follows:

   No sheen (NS)--No visible sheen on the water surface

   Colorless Sheen (CS)--Light, nearly colorless sheen; spread is irregular, not rapid; film dissipates rapidly (Note: light colorless sheens can be confused with sheens produced by organic content). Note that this sheen may or may not indicate the presence hydrocarbons.

   Heavy Sheen (HS)--Light to heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most or all of water surface is covered with sheen

Note: Samples used for field screening shall not be used for other analyses.

STANDARD OPERATING PROCEDURE SOP-9

Shipping and Handling of Samples

Equipment and Reagents Required

- Sampling and Analysis Plan (SAP)
- Site logbook
- Sample logs
- Sample labels
- Indelible black ink pens
- Ziploc® bags
- Cooler
- Blue Ice® or other ice packs
- Strapping tape or duct tape
- Chain of custody forms
- Custody seals
- Bubble wrap, newspaper, or other packing material

Procedures

NOTE: Before packaging, all samples will be individually labeled and noted in the site logbook by the sampler. Labels will be completed with all required information (refer to SAP). The samples will be assigned individual numbers that describe sample type and sample location. The sample numbers will be used to complete the chain-of-custody forms and track the samples.

Samples to be hand-delivered to the laboratory:

1. Place each sample in a plastic Ziploc® bag and align the label so it can be easily read. Seal the bag.
2. Place individual samples into the cooler so that each container is safely secured.
3. Include enough (four or more) ice packs to maintain a temperature of 4ºC or lower.
4. Complete a chain-of-custody form for the containers and seal in a Ziploc® bag.

5. Tape bag containing the chain-of-custody form to the inside of the cooler lid. Always transport the cooler together with its accompanying chain-of-custody form.
6. Close and latch cooler and affix signed custody seals over the edge of the lid and the top of the cooler body at front and rear.
7. Deliver samples to the laboratory and obtain a signed copy of the chain-of-custody form for tracking purposes.

Samples to be shipped to the laboratory:

1. Place each sample in a plastic Ziploc® bag and align the label so it can be easily read. Seal the bag.
2. Wrap each sample with bubble wrap, newspaper, or other packing material.
3. Place individual samples into the cooler so that the addition of Blue Ice® and/or packing materials will prevent significant movement of samples during shipping. Keep in mind that we cannot predict in what position the cooler will be shipped. Each container has clearance on all sides.
4. Fill the void spaces with ice packs, bubble wrap, newspaper, or other packing material to ensure samples do not break during shipment.
5. Cover the head space inside the cooler with ice packs.
6. Tape bag containing the chain-of-custody form to the inside of the cooler lid. Remember to remove the last copy of the form for tracking purposes.
7. Close and latch cooler, and wrap cooler and lid with at least two turns of strapping, duct, or packaging tape. Affix signed custody seals over the edge of the lid and the top of the cooler body at front and rear.
8. Label coolers with up arrows and information to comply with Department of Transportation requirements.
9. Notify the laboratory approximately when and how many samples will arrive. The samples must be kept under refrigeration (or packed with ice) between sampling and analysis.

Note: If samples are to be stored overnight before shipping, they must be secured in a locked room or other inaccessible area. The cooler should be sealed with a signed and dated custody seal. Before shipping, the Blue Ice® in the cooler should be replaced and the cooler resealed according to the instructions in this SOP. Samples may be shipped in coolers or any other sturdy, water-tight, appropriate container. This SOP refers to coolers for simplicity and because they are the most common type of transport container.

STANDARD OPERATING PROCEDURE SOP-10

Equipment Decontamination

Scope and Application

This SOP describes procedures for decontamination of sampling equipment, drilling equipment and other tools that could come in contact with contaminated media (Ecology 2003, PSEP 1997). Personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific Health and Safety Plan.

Equipment and Reagents Required

- Plastic sheeting
- Steam cleaner and collection basin (if required)
- 55-gallon drums (if required)
- Non-phosphate detergent (e.g., Alconox or Liquinox).
- Acid Rinses (inorganic constituents) shall be reagent grade diluted nitric or hydrochloric acid (if required)
- Solvent Rinses (organic constituents) shall be pesticide grade methanol, hexane, isopropopanol or acetone (if required)
- Deionized or distilled water rinse available from retail stores. Note that distilled water generally contains low levels of organic contaminants and can not be used for field blanks (must receive reagent-grade from laboratory).
- Tap water rinse from local tap water.
- 5-gallon buckets, or other appropriate containers
- Scrub brushes
- Teflon squirt bottles
- Gloves (e.g., nitrile or polyethylene)
- Personal protective clothing

Procedures

Drill Rig or Test Pit Sampling Equipment Decontamination Procedures

1. Decontaminate sampling equipment before use, between samples and stations, and upon completion of sampling operations.

2. Equipment used during drilling/test pit operations should be decontaminated in the Exclusion Zone prior to transport to the Support Zone (refer to HASP).

3. If the steam cleaning location is in an area outside of the Exclusion Zone, remove loose sediment on the drill rig, augers, drill pipe and rods, and other large equipment at the drill site, then move the equipment directly to the steam cleaning decontamination area for more thorough cleaning.

4. To decontaminate a drill rig or backhoe, pressure wash with a steam cleaner using potable water rinse upon mobilization, between drilling locations, and upon demobilization. Cleaning water can be allowed to drain directly on the ground near the station.

5. To decontaminate auger, drill rods, and other downhole tools, pressure wash with a steam cleaner and potable water rinse upon mobilization, between drilling locations, and upon demobilization.

6. To decontaminate split-spoon and hand-auger samplers, wash with laboratory-grade detergent/water solution, rinse with tap water and a final distilled water rinse. If the samplers were exposed to visibly contaminated sediments (e.g. creosote, diesel, etc), include a methanol rinse followed by a hexane rinse. The hexane rinse would be followed by another distilled water rinse. To the extent possible, allow to air dry prior to sampling. If the split-spoon is not used immediately, wrap it in aluminum foil.

Decontamination of Sampling Implements and Processing Materials

1. Decontaminate sampling implements (e.g., spoons and knives) and other processing materials such as mixing bowls and pans, before use, between samples, and upon completion of sampling operations.

2. To decontaminate sampling spoons, mixing bowls and other hand-held tools, wash using a laboratory-grade detergent/water solution, rinse with tap water, followed by distilled water or ASTM Type II Reagent-grade water. As described above, if the sediment is visibly contaminated, a hexane rinse may be necessary

following a methanol rinse to remove water. To the extent possible, allow to air dry. Once decontaminated, this equipment will be wrapped in aluminum foil to prevent contamination by airborne contaminants during transportation to the sampling site.

3. To decontaminate sampling spoons used to collect volatile organics, wash the spoon using a laboratory-grade detergent/water solution, and rinse with distilled water. Wrap the spoon in aluminum foil. The solvent rinses are eliminated in order to avoid interference with the analysis.

4. If necessary, to decontaminate wash buckets, pressure wash with a steam cleaner using a laboratory-grade detergent/water solution and potable water rinse upon mobilization, between station locations, upon demobilization, or as needed during sampling operations.

References

Ecology. 2003. Sediment sampling and analysis plan appendix. Guidance on the development of sediment sampling and analysis plans meeting the requirements of the sediment management standards (Chapter 173-204 WAC). Prepared by Washington State Department of Ecology, Olympia, WA

PSEP. 1997. Recommended guidelines for sampling marine sediment, water columns, and tissue in Puget Sound. Final report. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, WA, and Puget Sound Water Quality Authority, Olympia, WA.

STANDARD OPERATING PROCEDURE SOP-11

Quality Control Sample Preparation

Scope and Application

To establish procedures for preparation of field quality control samples collected during field investigations as described in the Sampling and Analysis Plan (SAP).

Equipment and Reagents Required

- Sample labels
- Indelible ink pens
- Master Sample Log and Chain-of-Custody Record forms
- Sample Bottles with preservatives (if required)

Procedures

The following procedures describe the preparation of various types of field quality control samples. Although general collection frequencies are given below, the type and number of quality control samples collected is dependent upon project specific requirements.

Trip Blanks

Trip blanks are 40-milliliter (40-mL) glass sample bottles (with septum lids) filled in the analytical laboratory with analyte-free water. They are shipped to the field with the empty sample coolers and stored with those bottles until they are used. One set of trip blank samples are enclosed in each sample cooler sent to the analytical laboratory which contains volatile organic compound samples for analysis. The field scientists do not open or otherwise disturb these samples except to label them with a sample number, if required, and prepare them for shipment with environmental samples. Trip blanks are analyzed for volatile organic compounds only.

Equipment Rinsates

Equipment rinsates are collected by capturing the final distilled water rinse from equipment cleaning. Decontamination procedures are detailed in SOP-10. These samples are collected during a sampling event by filling a full suite of environmental sample

containers with rinse water using the same procedures employed for collection of environmental water samples. The results are used to flag analytical data and/or assess the concentrations of analytes in environmental samples during the data validation process. Rinsate samples are analyzed for the same compounds as related environmental samples.

Field Blanks

Field blanks are collected in the field during sampling activities by filling a full suite of environmental sample containers with analyte-free or distilled water, at the field sampling location, by pouring water from analyte-free water containers directly into the sample containers. At a minimum, one field blank will be collected during each sampling event. Field blanks are analyzed for the same compounds as related environmental samples.

Field Duplicates/Splits

Duplicates or splits, except for volatile organic compound analyses, are collected, homogenized, and split at the sampling location. Volatile organic compound sediment samples are collected from the length of the sediment grab or core, and placed immediately into appropriate sample containers for packaging and shipment to the analytical laboratory. Duplicate water samples are collected simultaneously by alternately filling similar sample bottles during the collection procedure. Duplicate samples may either be submitted to the analytical laboratory as a blind sample, or may be identified to the laboratory, depending on project objectives. Duplicate environmental samples are analyzed for the same suite of analytes.

Field Replicate Samples

Field replicate samples are collected as separate samples from the same location as the initial sample collected. Unlike duplicate/split samples, they are not subsamples of one homogenous sample. They are collected and processed according to the same procedures followed for the initial sample. Similar to the field duplicates, they may either be submitted to the analytical laboratory as blind samples, or may be identified as replicate samples, depending on project objectives. Replicate environmental samples are analyzed for the same suite of analytes as the initial sample.

Water Source Blanks

Water source blanks are collected in the field during sampling activities by filling a full suite of environmental sample containers with water from the source used for decontamination and steam cleaning using the same procedures employed for collection

of environmental water samples. At a minimum, one water source blank will be collected during each sampling event (the time frame determined by the arrival of sampling personnel at a sampling area until those personnel leave for more than one day) and from each source of water used in decontamination and steam cleaning. Water source blanks are analyzed for the same compounds as the related environmental samples.

INTEGRAL CONSULTING INC.
SURFACE WATER SAMPLING FORM

PROJECT_____ SAMPLE NO._____
DATE _____ TIME _____ SAMPLED BY_____
WEATHER CONDITIONS_____

SAMPLE LOCATION_____
SAMPLE DEPTH _____
SURFACE WATER FLOW RATE _____
SURFACE WATER TYPE _____
SAMPLE CONDITION (i.e. turbidity, odor, oily)_____
_____

SAMPLE COLLECTION
COLLECTION METHOD _____
COLLECTION TIME____

SAMPLE INFORMATION pH_____ COND._____ T(C) _____ D.OXYGEN _____

ANALYSIS	CONTAINERS	SAMPLE PREP/PRESERVATION

CHAIN OF CUSTODY FORM _____ COC TAPE _____
SHIPPING CONTAINER _____

COMMENTS _____
_____
_____

EQUIPMENT CALIBRATION AND MAINTENANCE FORM (TYPICAL)

INSTRUMENT (NAME / MODEL NO. / SERIAL NO.): _____

MANUFACTURER: _____ DATE PURCHASED or LEASED: _____

CALIBRATION LOGSHEET

Calibration Date	Initial Settings	Standard(s) Used	Procedure	Adjustments Made	Final Settings	Signature of Operator	Comments

MAINTENANCE LOGSHEET

Maintenance Date	Reason for Maintenance	Maintenance Performed	Signature of Operator	Comments

FIELD CHANGE REQUEST (FCR) FORM (TYPICAL)

Project Name: _____ Project No.: _____
Client: _____ Request No.: FCR-_____

To: _____ Date: _____

Field Change Request Title: _____

Description:

_____
_____
_____

Reason for Change:

_____
_____
_____

Recommended Disposition:

_____
_____

_____ _____ _____
Field Operations Lead (or designee) Signature Date

Disposition:

_____
_____

_____ _____ _____
Project Manager Signature Date

Approval:

_____ _____ _____
Project Manager Signature Date

Distribution:

City of Bellingham Project Manager
Integral Project Manager
Field Operations Lead
QA Officer
Project File
Other:

(Additional Field Forms will be provided in Final SAP)

Appendix B

Sampling and Analysis Plan
Biological Results

Table B-1. 10-day Amphipod Sediment Toxicity Test Results.

Sample	***Hyalella azteca***	
	Mean Survival (%)	**Mean Dry Weight per Organism (mg)**
Lab Control	88	0.1
SD9 (Reference)	91	0.24
SD1	88	0.18
SD2	90	0.13
SD3	93	0.15
SD4	78	0.18
SD5	81	0.14
SD6	93	0.2
SD7	83	0.2
SD8	93	0.16
SD10	93	0.15

Table B-2. 28-day Oligochaete Sediment Bioaccumulation Test Results.

	Lumbriculus varietagus			
Sample	**Replicate**	**Tissue Weight (g)**	**Mean Tissue Weight (g)**	**Sediment TOC (%)**
Lab Control	A	9.84	8.89	unknown
	B	9.79		
	C	9.75		
	D	7.99		
	E	7.1		
SD2	A	3.36	3.69	1.3
	B	3.69		
	C	5.24		
	D	3.3		
	E	2.85		
SD5	A	3	2.89	1.8
	B	2.47		
	C	3.08		
	D	4.64		
	E	1.24		
SD6	A	7.98	11.21	11
	B	6.19		
	C	10.26		
	D	14.24		
	E	17.36		

Table B-3. Sediment Oligochaete Tissue Concentrations.

Analyte	Location Study	*Lumbriculus variegatus*			Sediment		
		SD2 & SD5 RI	SD6 RI	Laboratory Control RI	SD2 RI	SD5 RI	SD6 RI
Dioxins							
1,2,3,4,7,8-HxCDD	ng/Kg	**7.394**	NA	0.203 U	3.81	4.95	**16.7**
1,2,3,6,7,8-HxCDD	ng/Kg	**119.97**	NA	0.14 U	**223**	**30**	**79.6**
1,2,3,4,6,7,8-HpCDD	ng/Kg	**1883.7 J**	NA	1.907 UJ	**10100**	**978**	**25100**
1,2,3,4,6,7,8-HpCDF	ng/Kg	**292.16**	NA	0.193 U	**1950**	**163**	**421**
1,2,3,4,7,8,9-HpCDF	ng/Kg	**15.07**	NA	0.275 UJ	**68.3**	**10.7**	**31.6**
OCDD	ng/Kg	**16282.4**	NA	20.121 UJ	**126000**	**60200**	**304000**
OCDF	ng/Kg	**856.7**	NA	0.801 UJ	**11500**	**1210**	**39400**
Total TCDD	ng/Kg	**11.2**	NA	0.128 U	**3.4**	0.345	**2.23**
Total TCDF	ng/Kg	**30.1**	NA	0.182 U	**23**	**0.558**	**1.74**
Total PeCDD	ng/Kg	**6.8**	NA	0.197 U	**5.6**	**1.25**	**9.85**
Total PeCDF	ng/Kg	**231.3**	NA	0.166 U	**337**	**31.9**	**90.9**
Total HxCDD	ng/Kg	**346.8**	NA	0.14 U	**820**	**130**	**381**
Total HxCDF	ng/Kg	**982.5**	NA	0.141 U	**1800**	**175**	**473**
Total HpCDD	ng/Kg	**3346.2**	NA	**1.36**	**18500**	**1780**	**43500**
Total HpCDF	ng/Kg	**307.2**	NA	**1.27**	**1950**	**174**	**453**
TEQ (ND=0.5 DL)	ng/Kg	**36.36**	NA	NA	**320.96**	**81.25**	**624.13**
SVOCs							
2,4,6-Trichlorophenol	mg/kg	NA	**0.74 J**	0.13 U	0.013	0.013	0.031
2-Methylphenol	mg/kg	NA	**1 J**	0.13 U	0.013	0.013	0.031
3&4-Methylphenol	mg/kg	NA	**3.3 J**	**0.27 J**	0.013	**0.012**	**0.1**
Anthracene	mg/kg	NA	**0.37**	0.027 U	**2.2**	**0.061**	**0.56**
Benzo(a)anthracene	mg/kg	NA	**0.17 J**	0.027 U	**3.7**	**0.12**	**1.7**
Benzo(a)pyrene	mg/kg	NA	**0.4**	0.027 U	**2.4**	**0.34**	**1.4**
Benzo(b)fluoranthene	mg/kg	NA	**0.28 J**	0.027 U	**0.82**	**0.15**	**0.7**
Benzo(j)fluoranthene	mg/kg	NA	**0.28 J**	0.27 U			
Benzo(k)fluoranthene	mg/kg	NA	**0.28 J**	0.027 U	**0.82**	**0.15**	**0.7**
Benzoic acid	mg/kg	NA	**5.3 J**	0.27 U	0.026	0.026	0.061
Benzyl alcohol	mg/kg	NA	**13 J**	**1.5 J**	0.013	0.013	0.031
Chrysene	mg/kg	NA	**0.46 J**	0.027 U	**8.3**	**0.23**	**2.2**
Fluoranthene	mg/kg	NA	**1.3**	0.027 U	**0.47**	**0.1**	**3.2**
Naphthalene	mg/kg	NA	**0.11**	0.027 U	**0.024**	**0.0058**	**0.025**
Pentachlorophenol	mg/kg	NA	**2.1 J**	0.13 UJ	**0.033**	**0.056**	**0.46**
Phenanthrene	mg/kg	NA	**0.48**	0.027 U	**0.61**	**0.041**	**0.41**
Phenol	mg/kg	NA	**0.34 J**	0.13 U	0.013	0.013	0.031
Pyrene	mg/kg	NA	**0.43 J**	0.027 U	**0.66**	**0.096**	**2.9**
Tetrachlorophenols	mg/kg	NA	**4 J**	0.13 U	**0.0054**	0.013	**0.079**

NA = not applicable
Bold font indicates detected concentrations

Table B-4. Berry Tissue Concentrations.

Analyte	Sample Location Treatment Study Date	99070520 Berry 1 Washed RI 8/20/1999	99070521 Berry 1 Unwashed RI 8/20/1999	99070522 Berry 2 Washed RI 8/20/1999	99070523 Berry 2 Unwashed RI 8/20/1999	99070524 Berry 3 Washed RI 8/20/1999	99070525 Berry 3 Unwashed RI 8/20/1999	99070524 Berry 4 (Reference) Washed RI 8/20/1999	99070525 Berry 4 (Reference) Unwashed RI 8/20/1999
Dioxins									
1,2,3,4,6,7,8-HpCDD	ng/Kg	1.50 U	3.19 U	1.59 U	**2.7**	2.21 U	**1.07**	0.92 U	0.92 U
OCDD	ng/Kg	**14.47**	**30.42**	**17.84**	**31.07**	**22.02**	**9.45**	10.89 U	**17.72**
OCDF	ng/Kg	1.36 U	**2.72**	1.46 U	**2.91**	1.04 U	2.52 U	0.91 U	0.87 U
Total HpCDD	ng/Kg	1.50 U	0.60 U	1.59 U	**5.04**	1.20 U	**1.07**	0.92 U	0.92 U
TEQ (ND=0.5 DL)	ng/Kg	**0.001**	**0.003**	**0.002**	**0.3**	**0.002**	**0.012**	NA	**0.002**
VOCs									
p-Isopropyltoluene	mg/kg	**0.003**	**0.0067**	**0.013**	**0.015 J**	**0.012 J**	**0.018**	**0.027 J**	**0.013**
Styrene	mg/kg	0.003 U	**0.00034 J**	**0.00018 J**	**0.00022 J**	**0.0013**	**0.0022**	**0.0045**	**0.00061**
SVOCs									
1,2,3-Trichlorobenzene	mg/kg	0.003 U	0.00036 U	0.00036 U	0.00032 UJ	0.00032 UJ	0.00034 U	**0.00033**	0.00035 U
2-Methylnaphthalene	mg/kg	0.0013 U	0.0019 U	**0.0017**	**0.002**	**0.0017**	**0.0011 J**	0.0013 U	0.0013 U
Benzoic acid	mg/kg	0.013 U	**0.032**	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U
Benzyl alcohol	mg/kg	**0.056**	**0.06**	0.0065 U	**0.04**	**0.063**	**0.063**	0.0063 U	0.0065 U
Fluoranthene	mg/kg	**0.0047**	**0.0058**	0.0013 U	0.0027 U	**0.0012 J**	0.0013 U	**0.0041**	0.0013 U
Fluorene	mg/kg	**0.0032**	**0.0033**	0.0013 U	0.0013 U	0.0013 U	0.0013 U	0.0013 U	0.0013 U
Naphthalene	mg/kg	**0.0003**	**0.00036**	0.00036 U	0.00032 UJ	0.00032 UJ	0.00034 U	0.00033 U	0.00035 U
Phenanthrene	mg/kg	**0.015**	**0.016**	**0.0087**	**0.0072**	**0.0053**	**0.0053**	**0.0086**	**0.011**
Phenol	mg/kg	0.0066 U	**0.004 J**	0.0065 U	0.0065 U	0.0065 U	**0.009**	0.0063 U	0.0065 U
Pyrene	mg/kg	0.0013 U	**0.0037**	0.0013 U	0.0013 U	0.0013 U	0.0013 U	0.0013 U	0.0013 U

NA = not applicable

Bold font indicates detected concentrations

Table B-5. Ecology Sediment Toxicity Test Results.

Site	10-day Amphipod (*Hyalella azteca*)			20-day Midge (*Chironomus tentans*)						Microtox	
	Mean % Survival	Mean RPD % Survival	Reference p-values [a] Survival	Mean % Survival	Mean RPD % Survival	Mean Weight per Org (mg)	T/R Mean Weight per Org (mg)	Reference p-values [a] Survival	Reference p-values [a] Growth	Light Reading $I_{(15)}/I_{(0)}$	Mean Change $T_{(15)}/R_{(15)}$
Control	88	NA	NA	96	NA	1.044	NA	NA	NA	0.89/0.93 [b]	NA
LSC-01 (Reference)	80	NA	NA	86	NA	1.564	NA	NA	NA	0.90/0.92 [b]	NA
LSC-02	79	1	0.445	60	36	1.824	1.2	0.006	---	1	1.02
LCS-03	0	200	<0.001	0	200	NA	NA	<0.001	<0.001	0	0.41
LSC-04	70	13	0.107	80	7	2.005	1.3	0.288	---	1	1.04
LCS-05	84	5	---	84	2	1.927	1.2	0.427	---	1	0.79
LSC-06	67	18	0.006	82	5	2.113	1.4	0.370*	---	1	0.79

[a] One-tailed t-test. Survival data arcsine square-root transformation prior to t-test.

[b] Microtox test were run in two batches. Test samples LSC-02 and LSC-03 were run with a control and reference in the first batch and test samples LSC-04, LSC-05, and LSC-06 were run with a control and a reference in the

NA-Not Available or Not Applicable

--- Site response greater than control or reference sediment response.

$I_{(0)}$ is the light reading after the initial five minute incubation period

$I_{(15)}$ is the light reading fifteen minutes after $I_{(0)}$

$C_{(t)}$, $R_{(t)}$, and $T_{(t)}$ are the changes in light readings from the intial reading in each sample container for the control, reference sediment and test sites. $I_{(t)}/I_{(0)}$

T = test sample

R = reference sample

RPD = relative percent difference

RPD = ((T-R)/((T+R)/2))*100

DRAFT FINAL

ECOLOGY TOXICS CLEANUP PROGRAM
EPA BROWNFIELDS PROGRAM

QUALITY ASSURANCE PROJECT PLAN

Little Squalicum Park
Remedial Investigation/Feasibility Study
Bellingham, WA

Prepared for

City of Bellingham
Parks & Recreation Department
3424 Meridian Street
Bellingham, WA 98225

Prepared by

1201 Cornwall Avenue, Suite 208
Bellingham, WA 98225

July 29, 2005

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN
LITTLE SQUALICUM PARK
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BELLINGHAM, WASHINGTON

Quality Assurance Project Plan Approvals

Ecology Project Coordinator:	Mary O'Herron	_____	Date: _____
EPA Project Coordinator:	Ravi Sanga	_____	Date: _____
EPA QA Manager:	Ginna Grepo-Grove	_____	Date: _____
City of Bellingham Project Mgr:	Tim Wahl	_____	Date: _____
Integral Project Manager:	Mark Herrenkohl	_____	Date: _____
Integral Project QA Manager:	Maja Tritt	_____	Date: _____
ARI Project Manager:	Sue Dunnihoo	_____	Date: _____
ARI QA Manager:	Dave Mitchell	_____	Date: _____
STL Project Manager:	Jill Kellmann	_____	Date: _____
STL QA Manager:	Pam Schemmer	_____	Date: _____
NAS Project Manager:	Gerald Irissarri	_____	Date: _____
NAS QA Manager:	Linda Nemeth	_____	Date: _____

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
ARI	Analytical Resources Inc.
BTC	Bellingham Technical College
CFR	Code of Federal Regulations
COC	chain-of-custody
Creek	Little Squalicum Creek
CVAA	cold vapor atomic absorption spectrometry
DQO	data quality objective
DRO	diesel-range organic hydrocarbons
EDD	electronic data deliverable
EIM	electronic information management
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbon screen
EQuIS™	Environmental Quality Information System
FCR	field correction record
FID	flame ionization detector
GC	gas chromatography
GC/ECD	electron capture detector
GC/MS	gas chromatography with mass spectrometry
GPC	gel permeation chromatography
GRO	gasoline-range organic hydrocarbons
HASP	health and safety plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high density polyethylene
HRGC/HRMS	high-resolution gas chromatography with high-resolution mass spectrometry
ICP/MS	inductively coupled plasma/mass spectrometry
ICP/OES	inductively coupled plasma-optical emission spectrometry
LCS	laboratory control sample
LIMS	laboratory information management system
mg/kg	milligrams per kilogram
µg/kg	micrograms per kilogram
MQO	measurement quality objective
MDL	method detection limit
MRL	method reporting limit
MTCA	Model Toxic Control Act
NAS	Northwest Aquatics Sciences, Inc.
NWTPH	Northwest total petroleum hydrocarbons
PARCC	precision, accuracy or bias, representativeness, completeness, and comparability
Park	Little Squalicum Park

PCB	polychlorinated biphenyl
PID	photo-ionization detector
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RPD	relative percent difference
SAP	sampling and analysis plan
SMS	Sediment Management Standards
SOP	standard operating procedure
STL	Severn Trent Laboratories, Inc.
SVOCs	semivolatile organic compounds
TOC	total organic carbon
TSS	total suspended solids
WISHA	Washington Industrial Safety and Health Act
WMG	wide mouth glass

A3 DISTRIBUTION LIST

Ecology Project Coordinator:	Mary O'Herron
EPA Project Coordinator:	Ravi Sanga
EPA QA Manager:	Ginna Grepo-Grove
City of Bellingham Project Manager:	Tim Wahl
Integral Project Manager:	Mark Herrenkohl
Integral Project QA Manager:	Maja Tritt
Integral Field Coordinator:	Eron Dodak
Integral Data Manager:	Tom Schulz
ARI Project Manager:	Sue Dunnihoo
ARI QA Manager:	Dave Mitchell
STL Project Manager:	Jill Kellmann
STL QA Manager:	Pam Schemmer
NAS Project Manager:	Gerald Irissarri
NAS QA Manager:	Linda Nemeth

A4 INTRODUCTION AND PROJECT AND TASK ORGANIZATION

This quality assurance project plan (QAPP) describes quality assurance/quality control (QA/QC) procedures that will be used to complete a remedial investigation/feasibility study (RI/FS) for the Little Squalicum Park (the Park) site located in Bellingham, Washington. This QAPP has been prepared in accordance with EPA guidance for the preparation of QAPPs (USEPA 2002a).

The Park consists of 32 acres located within the Birchwood Neighborhood and lies adjacent to Bellingham Technical College (BTC) and the junction of Marine Drive, Eldridge Avenue and Lindbergh Avenue. Little Squalicum Creek (the Creek) flows through the middle of the park and discharges into Bellingham Bay. The field effort will include collection of surface water, surface sediment, and sediment borings from the Creek. Soil and groundwater samples will also be collected at selected stations within the park boundaries as part of this characterization. Samples from each media will be analyzed for conventional parameters (e.g., total organic carbon, hardness), physical tests (e.g., grain size), heavy metals, petroleum hydrocarbons, semivolatile organic compounds (SVOCs), and dioxins/furans. Selected soil samples will also be analyzed for chlorinated pesticides and PCB Aroclors. Selected surface sediment samples may also be evaluated for toxicity using a suite of freshwater bioassay tests. Details are provided in the *Sampling and Analysis Plan* (SAP) which accompanies this document.

Integral Consulting Inc. (Integral) is conducting this work under contract to the City of Bellingham, Parks and Recreation Department (City), with direction from both the Washington State Department of Ecology (Ecology) and U.S. Environmental Protection Agency, Region 10 Brownfields program (EPA). The organizational structure for this project is illustrated in Figure A-1. Contact information is provided in Table A-1. Project and quality assurance responsibilities are described in detail in Section 4 of the accompanying Work Plan. Responsibilities are included for the following project roles:

- Project managers for Ecology, EPA, the City of Bellingham, Integral, and subcontractor laboratories
- Quality assurance managers for EPA, Integral, and the laboratories
- Task managers for the field effort and subcontractors supporting the sample collection effort.

A5 PROBLEM DEFINITION AND BACKGROUND

The Whatcom County Health and Human Services completed a site hazard assessment (SHA) of the Park site in February 2004, as required under the Model Toxics Control Act (MTCA). The site's hazard ranking, an estimation of the potential threat to human health and/or the environment relative to other Washington State sites assessed at that time, was determined to be a 1, where 1 represents the highest relative risk and 5 the lowest

(Ecology 2004). Based on the results of the SHA, Ecology has determined that a RI/FS should be developed pursuant to WAC 173-340-350 and WAC 173-204-560 for the Park site. Ecology has negotiated an *Agreed Order* (dated March 22, 2005) with the City to conduct an RI/FS on the Park site. The RI/FS is intended to provide sufficient data, analysis, and evaluations to enable Ecology to select a cleanup action alternative for the site.

The primary objective of the Park RI/FS is to provide critical data necessary to understand the nature and magnitude of environmental problems at the site, to determine if cleanup actions are required, and to determine how these actions may be accomplished as part of specific wildlife enhancement and park development actions. This objective will be met by sampling surface water, groundwater, soil and sediments and evaluating the results in concert with other existing data. A complete list of the project objectives are presented in the Work Plan.

Several historical studies of the Park have been completed, as described in Section 3.0 of the SAP. The overall sampling strategy for the Park is to place a greater density of sampling locations in areas for which little or no historical data are available and to limit the analyte list in well-studied areas by applying a tiered sampling and testing approach. An adequate volume of sample will be archived to allow analysis of all analytes for a given medium (including toxicity testing), if necessary. Section 4 of the SAP presents the sampling design and rationale for a tiered approach to complete the Park RI field and testing investigation.

A6 TASK DESCRIPTION

The tasks to be completed for this project include fieldwork, laboratory analyses, data quality evaluation, data management, data analysis, and report preparation. Tasks that will be completed in the field, including related documentation and QA/QC activities, are described in detail in Section 5.0 of the SAP. The following activities are addressed in the SAP:

- Horizontal and vertical control methods
- Sampling equipment and methods
- Sample identification
- Sample processing methods
- Documentation of sample information and field activities
- Sample handling and shipping procedures
- Chain-of-custody (COC) procedures
- Decontamination procedures
- Handling and disposal of investigation-derived wastes.

Integral will collect surface water, groundwater, soil, and sediment and prepare samples for delivery to the laboratories. Eron Dodak or Susan Fitzgerald of Integral will serve as Field Coordinator and will assume custody of samples as they are collected. A list of samples and analyses is provided in Table A-2. Sample locations are provided in Figures 4-1 through 4-4 of the SAP.

Samples will be analyzed by Analytical Resources, Inc. (ARI) of Tukwila, Washington for the following:

- Conventional parameters [total sulfides, ammonia, total solids, total organic carbon (TOC), total suspended solids (TSS), and hardness];
- Physical parameters (grain size, Atterberg limits, specific gravity, and moisture content/bulk density);
- Northwest total petroleum hydrocarbons (NWTPH) – diesel-range organic hydrocarbons (DRO) and gasoline-range organic hydrocarbons (GRO), volatile petroleum hydrocarbon screen (VPH), and extractable petroleum hydrocarbon screen (EPH);
- Total metals;
- SVOCs; and
- Chlorinated pesticides and PCB Aroclors.

ARI will subcontract the dioxins/furans analysis to Severn Trent Laboratories' (STL) facility located in Sacramento, California. A complete analyte list is provided in Tables A-3 through A-6. Analyses will be completed using EPA and Puget Sound Estuary Program (PSEP) methods (USEPA 2005, PSEP 1986, 1997a,b), as indicated in Table A-7. Full laboratory data reports will be provided in hard copy and electronic data deliverables (EDDs) will be provided in spreadsheet format as required for importing into the database. The Environmental Quality Information System (EQuIS™) database application will be used to manage the field and laboratory data. Data will also be submitted electronically to Ecology and EPA in SEDQUAL and EIM formats as required.

Bioassays will be conducted to determine whether anthropogenic contaminants of concern are present at concentrations which are toxic to biota. Biological testing will be conducted on selected sediment samples collected in the Creek based on the chemistry results (tiered sampling approach). The following freshwater sediment toxicity bioassays (2 acute and 1 chronic tests) will be conducted on each selected sample:

- 10-day Amphipod (*Hyalella azteca*)
- Microtox® Sediment Porewater (*Vibrio fischeri*)
- 20-day Midge Larvae (*Chironomus tentans*).

Northwest Aquatics Sciences, Inc. (NAS) of Newport, Oregon, an accredited laboratory by Ecology, will conduct the bioassay testing for this project.[1]

Data verification will be completed by Integral for data generated in the field and by ARI, STL, and NAS for data generated at the laboratories. The completeness of the final database will be verified by Integral. Data validation and data quality assessment will be completed by an independent validation firm, which will be selected at a later date. The validation firm will also complete data verification (i.e., verifying that analytical procedures and calculations were completed correctly and checking transcriptions of the laboratory data) for the first data package for each analysis as part of the full validation that will be completed for these packages. The validation firm will also verify the accuracy of the laboratory EDDs.

The start date for field sampling will be determined following Ecology and EPA approval of the project Work Plans. Currently, it is anticipated that field sampling will begin in October 2005. Sample analysis and data validation are each expected to require 4 to 6 weeks for completion, for a total of 8 to 12 weeks from the time analysis is authorized until finalization of the database. The field and reporting schedules are discussed further in Section 3.3 of the Work Plan.

Samples for conventional analyses, geotechnical, and bioassay testing will be stored under refrigeration (4±2° C). Bioassay samples will also be stored in the dark with sediment bottles either purged with nitrogen gas or with no headspace. Samples for analysis of metals and organic compounds will be stored under refrigeration for immediate analyses, and frozen (-20° C) when initiation of analysis will be delayed or samples archived. Samples will be analyzed or archived according to criteria described in Section 4 of the SAP.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Although data have been collected at the study site during previous investigations, data gaps were identified during a review of existing data (refer to SAP). These data gaps described in Section 3.8 of the SAP will be addressed in this study. A tiered sampling design will be used for the sampling. The sampling design is described in Section 4.0 of the SAP.

Data Quality Objectives (DQOs) were developed for the Park RI/FS using EPA's DQO process (USEPA 2000a) to describe data and data quality needs for the project. Data quality indicators such as the PARCC parameters (i.e., precision, accuracy or bias, representativeness, completeness, comparability) (USEPA 2002a) and analytical sensitivity will be used to assess conformance of data with quality control criteria. DQOs and quality control criteria are described in this section.

[1] Microtox testing will be subcontracted to CH_2M Hill in Corvallis, Oregon, an Ecology accredited lab.

A7.1 The Data Quality Objective Process

As part of the development of the sampling strategy, data needs were evaluated for assessing chemical distributions and developing remedial alternatives for the Park soil and sediments. The seven-step DQO process (USEPA 2000a) was used to identify the adequacy of existing data and the need for additional data, to develop the overall approach to each study element, and ultimately to develop the field sampling plan. The DQO processes for the various aspects of the site characterization are provided in 3 of the SAP.

Reporting limits for this study should ideally be below the screening benchmarks selected for each analyte and sample type. Selection of screening benchmark levels for soil, groundwater, surface water and pore water, and sediment are provided in Section 3.5 of the SAP. Although method reporting limits (MRLs) are below screening levels for most of the analytes, MRLs are above the screening levels in several cases. Screening levels and MRLs for the various sample types are provided in Tables A-3 through A-6. Analytical sensitivity is discussed further in the following section.

A7.2 Data Quality Indicators

The overall DQO for this project is to develop and implement procedures that will ensure the collection of representative data of known and acceptable quality. The QA procedures and measurements that will be used for this project are based on EPA, Ecology, and PSEP guidance (USEPA 2002a, 2005; Ecology 1997, 2003; PSEP 1986, 1997a,b). PARCC parameters are commonly used to assess the quality of environmental data. Measurement quality objectives (MQOs) for the quantitative PARCC parameters, bias, precision, and completeness, are provided in Table A-8.

Bias represents the degree to which a measured concentration conforms to the reference value. The results for matrix spikes, laboratory control samples, field blanks, and method blanks will be reviewed to evaluate bias of the data. The following calculation is used to determine percent recovery for a matrix spike sample:

$$\%R = \frac{M - U}{C} \times 100$$

%R = percent recovery
M = measured concentration in the spiked sample
U = measured concentration in the unspiked sample
C = concentration of the added spike

The following calculation is used to determine percent recovery for a laboratory control sample or reference material:

$$\%R = \frac{M}{C} \times 100$$

%R = percent recovery
M = measured concentration in the reference material
C = established reference concentration

Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Any analytes detected in field or method blanks will be evaluated as potential indicators of bias.

Precision reflects the reproducibility between individual measurements of the same property. Precision will be evaluated using the results of matrix spike duplicates, laboratory duplicates, field splits, and field replicates. Precision is expressed in terms of the relative standard deviation for three or more measurements and the relative percent difference (RPD) for two measurements. The following equation is used to calculate the RPD between measurements:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

C_1 = first measurement
C_2 = second measurement
RPD = relative percent difference

The relative standard deviation is the ratio of the standard deviation of three or more measurements to the average of the measurements, expressed as a percentage.

Completeness will be calculated as the ratio of usable data (i.e., unqualified data and J-qualified data) to requested data, expressed as a percentage.

Additional laboratory QC procedures will be evaluated to provide supplementary information regarding overall quality of the data, performance of instruments and measurement systems, and sample-specific matrix effects.

QC samples and procedures are specified in each method protocol (Table A-7). All QC requirements will be completed by the laboratories as described in the protocols, including the following (as applicable to each analysis):

- Instrument tuning
- Initial calibration

- Initial calibration verification
- Continuing calibration
- Calibration or instrument blanks
- Method blanks
- Laboratory control samples
- Internal standards
- Surrogate spikes
- Serial dilutions
- Matrix spikes
- Matrix spike duplicates or laboratory duplicates.

To alert the data user to possible bias or imprecision, data qualifiers will be applied to reported analyte concentrations when associated QC samples or procedures do not meet control limits. Laboratory control limits for the methods that will be used for this site investigation are provided in Appendix K of ARI's quality assurance plan (Attachment 1 of this QAPP) and, for STL, in Attachment 2 of this QAPP. Data validation criteria and procedures are described in Sections D1 and D2 of this QAPP.

MRLs reflect the sensitivity of the analysis. The methods and modifications selected for this study will incorporate modifications recommended by PSEP (1997a,b) to optimize MRLs. Target MRLs for this study are summarized in Tables A-3 through A-6. Method modifications are described in Section B4.

Method detection limits (MDLs) have been determined by ARI and STL for each analyte, as required by EPA (2003). MDLs are statistically derived and reflect the concentration at which an analyte can be detected in a clean matrix with 99 percent confidence that a false positive result has not been reported. ARI and STL have established MRLs at levels above the MDLs for the project analytes. These values are based on the laboratories' experience analyzing environmental samples and reflect the typical sensitivity obtained by the analytical system. The concentration of the lowest standard in the initial calibration curve for each analysis is at the level of the MRL. This allows reliable quantification of concentrations to the MRL. Analyte concentrations for this site investigation will be reported to the MDL. Analytes detected at concentrations between the MRL and the MDL will be reported with a J qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). Non-detects will be reported at the MRL. The MRL will be adjusted by the laboratory as necessary to reflect sample dilution or matrix interference. For dioxin analyses, STL will determine and report sample-specific detection limits as described in EPA method 1613B.

Representativeness and comparability are qualitative QA/QC parameters. Representativeness is the degree to which data represent a characteristic of an environmental condition. In the field, representativeness will be addressed primarily in the sampling design, by the selection of sampling sites and sample collection procedures. In the laboratory, representativeness will be ensured by the proper handling and storage of samples and initiation of analysis within holding times.

Comparability is the qualitative similarity of one data set to another (i.e., the extent to which different data sets can be combined for use). Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by EPA and PSEP and are commonly used for sediment studies.

The overall quality objective for the toxicity testing is to produce data that meet EPA's and Ecology's acceptability criteria for the 10-day acute *H. azteca*, the Microtox® sediment porewater (*V. fischeri*), and the 20-day chronic *C. tentans* sediment toxicity tests. The toxicity data will be generated to address the objectives listed in Section B1. Acceptance criteria for the bioassay testing methods that will be used for this site investigation are summarized in Section IX of NAS's quality assurance plan (Attachment 3 of this QAPP). Details are provided in each toxicity test method protocol (USEPA 2000b, Ecology 2003).

A8 SPECIAL TRAINING/CERTIFICATION

The City has assembled a project team with the requisite experience and technical skills to successfully complete the RI/FS for the Park. All consultant team personnel involved in sample collection have extensive environmental sampling experience. Minimum training and certification requirements for laboratory personnel are described in the laboratory QA plans (Attachments 1 through 3 to this QAPP).

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations. In response to this requirement, the U.S. Occupational Safety and Health Administration developed regulation 29 CFR§1910.120, the "Hazardous Waste Operations and Emergency Response" standard (HAZWOPER). This standard includes requirements for workers engaged in hazardous waste operations to complete a 40-hour training course and annual 8-hour refresher courses. The training provides employees with knowledge and skills that enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training course and 8-hour refresher courses, as necessary. Training is also consistent with the requirements of the Washington Industrial Safety and Health Act (WISHA). Documentation of course completion will be maintained in personnel files.

A9 DOCUMENTS AND RECORDS

Records will be maintained documenting all activities and data related to field sampling, chemical, and biological analysis at the laboratories. Results of data verification and validation activities will also be documented. Procedures for documentation of these activities are described in this section. The components of field documentation are discussed in Sections 5.5 and 5.6 of the SAP.

The SAP, QAPP, and the health and safety plan (HASP), will be provided to every project participant listed in Section A3. Any revisions or amendments to any of the documents that comprise the SAP will also be provided to these individuals.

A9.1 Field Documentation

The Integral project manager will ensure that the field team receives the final approved version of the SAP (including the HASP and this QAPP) prior to the initiation of field activities. Field records that will be maintained include:

- Field log books
- Photo documentation
- Boring and test pit logs
- Field data and sample collection information forms
- Field change request forms (as needed)
- Sample tracking/chain of custody forms.

The content and use of these documents are described in Section 5.6 of the SAP.

A9.2 Laboratory Documentation

All activities and results related to sample analysis will be documented at each laboratory. Internal laboratory documentation procedures are described in the laboratory QA plans (Attachments 1 through 3 to this QAPP).

The chemistry laboratories will provide a data package for each sample delivery group or analysis batch that is comparable in content to a full Contract Laboratory Program package. It will contain all information required for a complete QA review, including the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- A case narrative referencing or describing the procedures used and discussing any analytical problems and deviations from standard operating procedures (SOPs) and this QAPP
- Chain-of-custody and cooler receipt forms

- A summary of analyte concentrations (to two significant figures, unless otherwise justified), method reporting limits, and method detection limits
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions
- Sample preparation, extraction, dilution, and cleanup logs
- Instrument tuning data
- Initial and continuing calibration data, including instrument printouts and quantification summaries, for all analytes
- Results for method and calibration blanks
- Results for all QA/QC checks, including surrogate spikes, internal standards, laboratory control samples (LCSs), matrix spike samples, matrix spike duplicate samples, and laboratory duplicate or triplicate samples
- Original data quantification reports for all analyses and samples
- All laboratory worksheets and standards preparation logs.

The biological testing laboratory will be responsible for internal checks on sample handling and toxicity data reporting and will correct errors. The laboratory data package will include the following:

- A cover letter or case narrative that identifies the procedures used and discusses any problems encountered and any deviations from the referenced test method, SOPs, and this QAPP
- Chain-of-custody and cooler receipt forms
- A description of the source and composition of water used for the tests
- Detailed information about the test organisms, including source and acclimation or culture conditions
- A description of the experimental design and test chambers
- Data related to water quality measurements and any aeration that may have been required
- Definition of the effect criteria and any other observations
- Responses in the control treatment
- Tabulation and statistical analysis of measured responses
- A description of statistical methods used

- Results associated with the reference toxicant tests.
- Photocopies of all the raw data generated by the laboratory.

Data will be delivered in both hardcopy and electronic format to the Integral laboratory coordinator, who will be responsible for oversight of data verification and validation and for archiving the final data and data quality reports in the project file. Electronic data deliverables will be compatible with Integral's EQuIS™ database.

A9.3 Data Quality Documentation

The first data package generated for each chemical analysis type will be fully validated.[2] If no problems are encountered, validation for the remaining data will be based on review of the summary forms for sample and QC data. Based on the total number of samples to be collected for this investigation (Table A-2), it is anticipated that approximately 25 percent (a minimum of 20 percent) of the data will be fully validated. Data validation reports will be prepared by the contracted validation firm and provided to the Integral laboratory coordinator.

The biological testing laboratory will perform the first data reduction by calculating average survival and biomass for each test sediment and the negative controls. An internal review of the data will be performed by the NAS QA/QC officer. For the external review process the laboratory will provide both the reduced and raw data. The data will be generated in a form amenable to review and evaluation. The raw (replicate) and reduced data will be reviewed and validated by Integral staff.

Results of the validation reports will be summarized in the RI report. Any limitations to the usability of the data will also be discussed in this report.

All database entries provided by the laboratories will be verified against the validated hard-copy data in the data package. All changes to the database will be recorded in the database change log. Any data tables prepared from the database for data users will include all qualifiers that were applied by the laboratories and during data validation.

[2] A copy of the first data package that is fully validated will be provided to the EPA QA managers upon receipt from the laboratory.

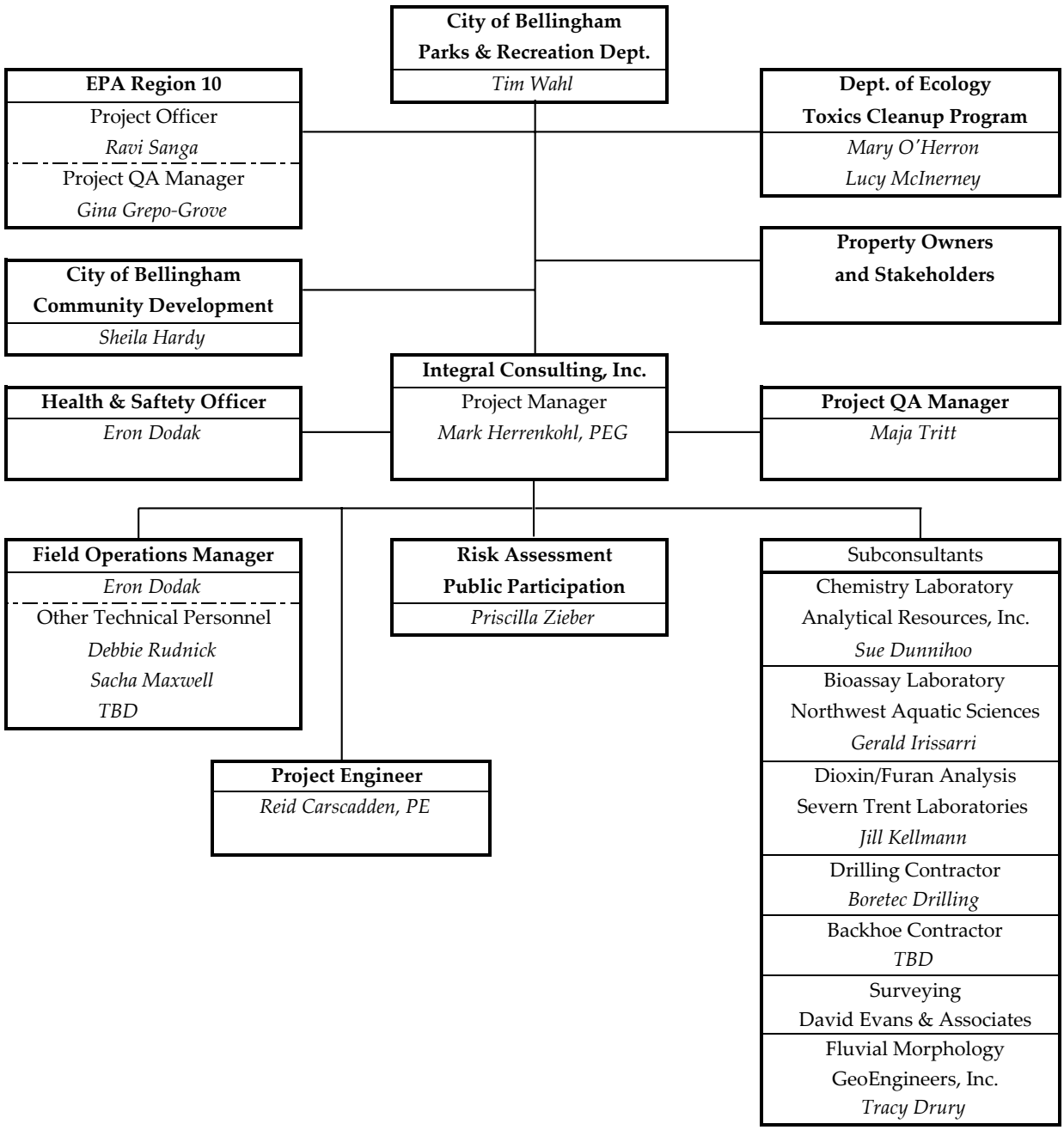

Figure A-1. Program Organization Structure

Table A-1. Project Team Contact Information.

Name	Project Role	Phone	Fax	Email
City of Bellingham				
Tim Wahl	Project Manager	360-676-6985	360-647-6367	twahl@cob.org
Sheila Hardy	Planning & Community Development	360-676-6880	360-738-7431	shardy@cob.org
EPA Region 10				
Ravi Sanga	Project Coordinator	206-553-4092	206-553-0124	Sanga.Ravi@epamail.epa.gov
Ginna Grepo-Grove	Quality Assurance Manager	206-553-1632	206-553-8210	Grepo-Grove.Gina@epamail.epa.gov
Department of Ecology				
Mary O'Herron	Ecology Project Coordinator	360-738-6246	360-738-6253	mohe461@ecy.wa.gov
Lucy McInerney	Toxics Cleanup Program	425-649-7272	na	lpeb461@ecy.wa.gov
Common Consultants				
Mark Herrenkohl (Integral)	Project Manager	360-756-9296 x10	360-756-9296	mherrenkohl@integral-corp.com
Maja Tritt (Integral)	Project QA Coordinator	206-230-9600 x21	206-230-9601	mtritt@integral-corp.com
Eron Dodak (Integral)	Heealth & Safety Officer	503-284-5545 x14	503-284-5755	edodak@integral-corp.com
Susan FitzGerald (Integral)	Field Manager	206-230-9600 x18	206-230-9601	sfitzgerald@integral-corp.com
Priscilla Zieber (Integral)	Risk Assessment/Public Participation	425-820-1739		pzieber@integral-corp.com
Reid Carscadden (Integral)	Project Engineer	206-230-9600 x29	206-230-9601	rcarscadden@integral-corp.com
Chemical Laboratories				
Sue Dunnihoo (Analytical Resources, Inc.)	Laboratory Project Manager	206-695-6207	206-695-6201	sued@arilabs.com
Dave Mitchell (Analytical Resources, Inc.)	Laboratory QA Manager	206-695-6205	206-695-6201	davem@arilabs.com
Jill Kellmann (STL/Sacramento)	Laboratory Project Manager	916-374-4402	916-372-1059	jkellmann@stl-inc.com
Pam Schemmer (STL/Sacramento)	Laboratory QA Manager	916-374-4441	916-372-1059	pschemmer@stl-inc.com
Bioassay Laboratory				
Gerald Irissarri (Northwest Aquatic Service	Laboratory Project Manager	541-265-7225	541-265-2799	girissarri@nwaquatic.com
Linda Nemeth (Northwest Aquatic Services	Laboratory QA Manager	541-265-7225	541-265-2799	lnemeth@intew.net

Table A-2. Summary of Samples and Analyses.

Analysis	Number of Samples			
	Field Samples	Field Replicates[1]	Equipment Rinse Blanks[2]	Total
Soil Samples				
TOC	21	2	2	25
Metals	21	2	2	25
NWTPH-Gx	5	1	1	7
VPH[3]	≤5	≤1	0	≤6
NWTPH-Dx	21	2	2	25
EPH[4]	≤21	≤2	0	≤23
Physical testing	33	2	0	35
Pesticides	7	1	1	9
PCB Aroclors	7	1	1	9
SVOCs[5]	≤21	≤2	≤2	≤25
Dioxins/Furans	≤21	≤2	≤2	≤25
Archive (total)	65	0	0	65
Groundwater Samples				
Round 1				
Hardness	4	1	1	6
TSS	4	1	1	6
TOC	4	1	1	6
Metals (unfiltered)	4	1	1	6
Metals (filtered)	4	1	1	6
NWTPH-Gx	4	1	1	6
VPH[3]	≤4	≤1	0	≤5
NWTPH-Dx	4	1	1	6
EPH[4]	≤4	≤1	0	≤5
SVOCs	4	1	1	6
Dioxins/Furans	4	1	1	6
Round 2				
Hardness	4	1	1	6
TSS	4	1	1	6
TOC	4	1	1	6
Metals (unfiltered)	4	1	1	6
Metals (filtered)	4	1	1	6
NWTPH-Gx	4	1	1	6
VPH[3]	≤4	≤1	0	≤5
NWTPH-Dx	4	1	1	6
EPH[4]	≤4	≤1	0	≤5

Table A-2. Summary of Samples and Analyses. (continued)

Analysis	Number of Samples			
	Field Samples	Field Replicates[1]	Equipment Rinse Blanks[2]	Total
Ground water Samples				
Round 1				
SVOCs	4	1	1	6
Dioxins/Furans	4	1	1	6
Surface Water Samples				
Round 1				
Hardness	7	1	1	9
TSS	7	1	1	9
TOC	7	1	1	9
Metals (unfiltered)	7	1	1	9
NWTPH-Gx	7	1	1	9
VPH[3]	≤7	≤1	0	≤8
NWTPH-Dx	7	1	1	9
EPH[4]	≤7	≤1	0	≤8
SVOCs	7	1	1	9
Dioxins/Furans	3	1	1	5
Round 2				
Hardness	7	1	1	9
TSS	7	1	1	9
TOC	7	1	1	9
Metals (unfiltered)	7	1	1	9
NWTPH-Gx	7	1	1	9
VPH[3]	≤7	≤1	0	≤8
NWTPH-Dx	7	1	1	9
EPH[4]	≤7	≤1	0	≤8
SVOCs	7	1	1	9
Dioxins/Furans	3	1	1	5
Sediment Samples				
Chemical Analysis				
TOC	31	2	2	35
TS, Sulfides, Ammonia	7	1	1	9
Metals	31	2	2	35
NWTPH-Dx	31	2	2	35

Table A-2. Summary of Samples and Analyses. (continued)

Analysis	Number of Samples			
	Field Samples	Field Replicates[1]	Equipment Rinse Blanks[2]	Total
Sediment Samples				
Chemical Analysis				
EPH[4]	≤31	≤2	0	≤33
Physical testing	46	3	0	49
SVOCs	≤31	≤2	2	≤35
Dioxins/Furans	≤31	≤2	2	≤35
Archive (total)	127	3	0	130
Toxicity testing[7]				
10-day Amphipod Mortality	≤7	NA	NA	≤7
21-Day Midge Mortality and Growth	≤7	NA	NA	≤7
Pore Water Microtox®	≤7	NA	NA	≤7

Notes:

[1] The collection frequency for field replicates and splits is 5% of natural samples.

[2] A field rinsate blank will be collected once for each sampling method.

[3] VPH analyses will be complete if screening levels are exceeded for TPH-GRO or, at a minimum, 20 percent of total samples will be analyzed.

[4] EPH analyses will be complete if screening levels are exceeded for TPH-DRO or, at a minimum, 20 percent of total samples will be analyzed.

[5] SVOCs will be analyzed for samples exceeding GRO/DRO SL's or, at a minimum, 20 percent of total samples will be analyzed.

[6] Dioxins/Furans will be analyzed in samples with pentachlorophenol concentrations exceeding SL.

[7] Toxicity tests will be completed on samples where concentrations exceed SLs.

Table A-3. Screening Benchmarks and MRLs for Soil Analytes.

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark [a]	Method Reporting Limit[b]	Method Detection Limit[c]
Dioxins					
1,2,3,4,6,7,8-HpCDD	ng/Kg	--	NV	50	--
1,2,3,4,6,7,8-HpCDF	ng/Kg	--	NV	50	--
1,2,3,4,7,8,9-HpCDF	ng/Kg	--	NV	50	--
1,2,3,4,7,8-HxCDD	ng/Kg	--	NV	50	--
1,2,3,4,7,8-HxCDF	ng/Kg	--	NV	50	--
1,2,3,6,7,8-HxCDD	ng/Kg	--	NV	50	--
1,2,3,6,7,8-HxCDF	ng/Kg	--	NV	50	--
1,2,3,7,8,9-HxCDD	ng/Kg	--	NV	50	--
1,2,3,7,8,9-HxCDF	ng/Kg	--	NV	50	--
1,2,3,7,8-PeCDD	ng/Kg	--	NV	50	--
1,2,3,7,8-PeCDF	ng/Kg	--	NV	50	--
2,3,4,6,7,8-HxCDF	ng/Kg	--	NV	50	--
2,3,4,7,8-PeCDF	ng/Kg	--	NV	50	--
2,3,7,8-TCDD	ng/Kg	--	NV	10	--
2,3,7,8-TCDF	ng/Kg	--	NV	10	--
OCDD	ng/Kg	--	NV	100	--
OCDF	ng/Kg	--	NV	100	--
Total HpCDD	ng/Kg	--	NV	--	--
Total HpCDF	ng/Kg	--	NV	--	--
Total HxCDD	ng/Kg	--	NV	--	--
Total HxCDF	ng/Kg	--	NV	--	--
Total PeCDD	ng/Kg	--	NV	--	--
Total PeCDF	ng/Kg	--	NV	--	--
Total TCDD	ng/Kg	--	NV	--	--
Total TCDF	ng/Kg	--	NV	--	--
TEQ (ND=0.5 DL)	ng/Kg	site-specific background/Puget Sound Background	49.77/19	--	--
SVOCs					
PAHs					
2-Methylnaphthalene	mg/kg	Ecology SQS	0.38	0.02	--
Acenaphthene	mg/kg	Ecology SQS	0.16	0.02	--
Acenaphthylene	mg/kg	Ecology LAET	0.47	0.02	--
Anthracene	mg/kg	Ecology LAET	1.23	0.02	--
Benzo(a)anthracene	mg/kg	site-specific background/MTCA Method B	0.377/0.137	0.02	--
Benzo(a)pyrene	mg/kg	site-specific background/MTCA Method B	0.455/0.137	0.02	--
Benzo(b)fluoranthene	mg/kg	site-specific background/MTCA Method B	0.663/0.137	0.02	--
Benz[e]acephenanthrylene	mg/kg	MTCA Method B	0.14	0.02	--
Benzo(g,h,i)perylene	mg/kg	site-specific background/Ecology SQS	0.422/0.31	0.02	--
Benzo(k)fluoranthene	mg/kg	site-specific background/MTCA Method B	0.241/0.137	0.02	--
Chrysene	mg/kg	site-specific background/MTCA Method B	0.628/0.137	0.02	--
Dibenzo(a,h)anthracene	mg/kg	site specific background/Ecology SQS	0.376/0.12	0.02	--
Fluoranthene	mg/kg	Ecology SQS	1.6	0.02	--
Fluorene	mg/kg	Ecology SQS	0.23	0.02	--
Indeno(1,2,3-cd)pyrene	mg/kg	site-specific background/MTCA Method B	0.612/0.137	0.02	--
Naphthalene	mg/kg	Ecology LAET	0.53	0.02	--
Phenanthrene	mg/kg	Ecology SQS	1	0.02	--
Pyrene	mg/kg	Ecology LAET	8.79	0.02	--
Other					--
1,2,3-Trichlorobenzene	mg/kg	MTCA TEE soil	20.00	0.02	--
1,2,4-Trichlorobenzene	mg/kg	Ecology SQS	0.81	0.02	--
1,2-Dichlorobenzene	mg/kg	Ecology SQS	0.02	0.02	--
1,3-Dichlorobenzene	mg/kg	MTCA Method B	16.00	0.02	--

Table A-3. Screening Benchmarks and MRLs for Soil Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark [a]	Method Reporting Limit[b]	Method Detection Limit[c]
Other					
1,4-Benzenediamine	mg/kg	MTCA Method B	15200.00	20 (estimated)	--
1,4-Dichlorobenzene	mg/kg	Ecology SQS	0.03	0.02	--
2,4,5-Trichlorophenol	mg/kg	MTCA TEE plant	4.00	0.1	--
2,4,6-Trichlorophenol	mg/kg	EPA Region 9 PRG	0.20	0.1	--
2,4-Dichlorophenol	mg/kg	EPA Region 9 PRG	1.00	0.1	--
2,4-Dimethylphenol	mg/kg	Ecology SQS	0.029	0.02	--
2,4-Dinitrophenol	mg/kg	EPA Region 9 PRG	0.30	0.2	--
2,4-Dinitrotoluene	mg/kg	EPA Region 9 PRG	0.0008	0.1	0.00386
2,6-Dinitrotoluene	mg/kg	EPA Region 9 PRG	0.0007	0.1	0.00666
2-Chloronaphthalene	mg/kg	MTCA Method B	4900.00	0.02	--
2-Chlorophenol	mg/kg	EPA Region 9 PRG	4.00	0.2	--
2-Methylphenol	mg/kg	Ecology SQS	0.063	0.02	--
2-Nitroaniline	mg/kg	MTCA Method B	1.70	0.1	--
3,3'-Dichlorobenzidine	mg/kg	EPA Region 9 PRG	0.007	0.1	0.0236
4-Chloroaniline	mg/kg	EPA Region 9 PRG	0.70	0.1	--
4-Methylphenol	mg/kg	Ecology SQS	0.67	0.02	--
4-Nitrophenol	mg/kg	MTCA TEE soil	7.00	0.1	--
Aniline	mg/kg	MTCA Method B	175.00	0.02	--
Benzidine	mg/kg	MTCA Method B	0.00435	0.2	tbd
Benzoic acid	mg/kg	Site-specific background/Ecology SQS	2.03/0.65	0.2	--
Benzyl alcohol	mg/kg	Ecology SQS	0.057	0.02	--
bis(2-chloroisopropyl)ether	mg/kg	MTCA Method B	3200.00	0.02	--
bis(2-Chloroethyl)ether	mg/kg	EPA Region 9 PRG	0.0004	0.02	0.00599
bis(2-Ethylhexyl)phthalate	mg/kg	Ecology SQS	0.47	0.02	--
Butylbenzylphthalate	mg/kg	Ecology SQS	0.049	0.02	--
Carbazole	mg/kg	EPA Region 9 PRG	0.60	0.02	--
Dibenzofuran	mg/kg	Ecology SQS	0.15	0.02	--
Diethylphthalate	mg/kg	Ecology SQS	0.61	0.02	--
Dimethylphthalate	mg/kg	Ecology LAET	0.311	0.02	--
di-n-Butylphthalate	mg/kg	Ecology LAET	0.1	0.02	--
di-n-Octylphthalate	mg/kg	Ecology LAET	0.01	0.02	0.00392
Hexachlorobenzene	mg/kg	Ecology SQS	0.004	0.2	0.00604
Hexachlorobutadiene	mg/kg	Ecology SQS	0.04	0.02	--
Hexachlorocyclopentadiene	mg/kg	MTCA TEE plant	10.00	0.1	--
Hexachloroethane	mg/kg	EPA Region 9 PRG	0.50	0.02	--
Isophorone	mg/kg	EPA Region 9 PRG	0.50	0.02	--
Nitrobenzene	mg/kg	EPA Region 9 PRG	0.10	0.02	--
n-Nitrosodimethylamine	mg/kg	MTCA Method B	0.0196	0.1	0.0338
n-Nitroso-di-n-propylamine	mg/kg	EPA Region 9 PRG	0.00005	0.1	0.00838
N-nitrosodiphenylamine	mg/kg	Ecology SQS	0.11	0.02	--
Pentachlorophenol	mg/kg	EPA Region 9 PRG	0.03	0.1	0.01925
Phenol	mg/kg	Ecology SQS	0.42	0.02	--
Pyridine	mg/kg	MTCA Method B	80.00	0.1	--
Retene	mg/kg	Ecology LAET	6.02	0.04 (estimated)	--
Tetrachlorophenols	mg/kg	MTCA TEE soil	20	0.1	--
VPH					
C10-C12 Aliphatics	mg/kg	--	NV	5	--
C10-C12 Aromatics	mg/kg	--	NV	5	--
C12-C13 Aromatics	mg/kg	--	NV	5	--
C5-C6 Aliphatics	mg/kg	--	NV	5	--
C6-C8 Aliphatics	mg/kg	--	NV	5	--
C8-C10 Aliphatics	mg/kg	--	NV	5	--
C8-C10 Aromatics	mg/kg	--	NV	5	--

Table A-3. Screening Benchmarks and MRLs for Soil Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark [a]	Method Reporting Limit[b]	Method Detection Limit[c]
EPH					
C10-C12 Aliphatics	mg/kg	--	NV	5	--
C10-C12 Aromatics	mg/kg	--	NV	5	--
C12-C16 Aliphatics	mg/kg	--	NV	2	--
C12-C16 Aromatics	mg/kg	--	NV	2	--
C16-C18 Aliphatics	mg/kg	--	NV	2	--
C16-C18 Aromatics	mg/kg	--	NV	2	--
C18-C21 Aliphatics	mg/kg	--	NV	2	--
C18-C21 Aromatics	mg/kg	--	NV	2	--
C21-C28 Aliphatics	mg/kg	--	NV	2	--
C21-C28 Aromatics	mg/kg	--	NV	2	--
C28-C36 Aliphatics	mg/kg	--	NV	2	--
C28-C36 Aromatics	mg/kg	--	NV	2	--
Estimated Total EPH+VPH	mg/kg	MTCA TEE soil	200.00	59	--
TPH Screen					
TPH	mg/kg	MTCA TEE soil	200.00	20	--
Pesticides					
4,4'-DDD	ug/kg	MTCA TEE	0.75	2	0.095
4,4'-DDE	ug/kg	MTCA TEE	0.75	2	0.125
4,4'-DDT	ug/kg	MTCA TEE	0.75	2	0.199
Aldrin	ug/kg	MTCA Method B direct contact	0.06	1	0.044
alpha-BHC	ug/kg	MTCA Method B direct contact	0.16	2	0.051
alpha-Chlordane	ug/kg	MTCA TEE	1.00	1	--
beta-BHC	ug/kg	MTCA Method B direct contact	0.56	1	0.091
delta-BHC	ug/kg	MTCA TEE	6.00	1	--
Dieldrin	ug/kg	MTCA Method B direct contact	0.06	2	0.085
Endosulfan I	ug/kg	MTCA Method B direct contact	480.00	1	--
Endosulfan II	ug/kg	MTCA Method B direct contact	480.00	2	--
Endosulfan Sulfate	ug/kg	MTCA Method B direct contact	480.00	2	--
Endrin	ug/kg	MTCA TEE	0.20	2	0.082
Pesticides					
Endrin Aldehyde	ug/kg	MTCA TEE	0.20	2	0.184
Endrin Ketone	ug/kg	MTCA TEE	0.20	2	0.187
gamma-BHC (Lindane)	ug/kg	MTCA Method B direct contact	0.77	2	0.09
gamma-Chlordane	ug/kg	MTCA TEE	1.00	1	--

Table A-3. Screening Benchmarks and MRLs for Soil Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark [a]	Method Reporting Limit[b]	Method Detection Limit[c]
Pesticides					
Heptachlor	ug/kg	MTCA Method B direct contact	0.22	1	0.073
Heptachlor Epoxide	ug/kg	MTCA Method B direct contact	0.11	1	0.054
Methoxychlor	ug/kg	MTCA Method B direct contact	400.00	10	--
Toxaphene	ug/kg	MTCA Method B direct contact	0.91	100	tbd
PCBs					
Aroclor 1016	ug/kg	MTCA Method B direct contact	5.6	33	NV
Aroclor 1221	ug/kg		NV	33	--
Aroclor 1232	ug/kg		NV	33	--
Aroclor 1242	ug/kg		NV	33	--
Aroclor 1248	ug/kg		NV	33	--
Aroclor 1254	ug/kg	MTCA Method B direct contact	1.6	33	NV
Aroclor 1260	ug/kg		NV	33	--
Total PCBs	ug/kg	MTCA TEE	0.65	--	--
Metals					
Arsenic	mg/kg	Sound Background	9.09/7	5	--
Cadmium	mg/kg	Ecology LAET	2.39	0.2	--
Chromium	mg/kg	site-specific background	98.2/83	0.5	--
Copper	mg/kg	MTCA TEE soil	50.00	0.2	--
Lead	mg/kg	MTCA TEE plant	50.00	2	--
Mercury	mg/kg	MTCA TEE soil	0.10	0.05	--
Silver	mg/kg	Ecology LAET	0.545	0.3	--
Zinc	mg/kg	MTCA TEE plant	86.00	0.6	--
Conventionals					
<Sieve 200	percent	--	NV	0.1	--
Sieve 0.25	percent	--	NV	0.1	--
Sieve 0.5	percent	--	NV	0.1	--
Sieve 004	percent	--	NV	0.1	--
Sieve 010	percent	--	NV	0.1	--
Sieve 020	percent	--	NV	0.1	--
Sieve 040	percent	--	NV	0.1	--
Sieve 060	percent	--	NV	0.1	--
Sieve 140	percent	--	NV	0.1	--
Sieve 200	percent	--	NV	0.1	--
TOC	mg/kg	Ecology LAET	98200	100	--

[a] When a "/" is used to separate two values, the first value is for surface soil and the second is for subsurface soil.

[b] Detected COIs will be reported to the MDL with J qualifiers applied below the MRL.

[c] The MDL will be used as the reporting limit for non-detects when the MRL is above the screening benchmark. The MDL is below the screening benchmark for the following analytes: 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 3,3'-Dichlorobenzidine, bis(2-Chloroethyl)ether, Hexachlorobenzene, n-Nitrosodimethylamine, n-Nitroso-di-n-propylamine, and Dieldrin. The MDLs for benzidine and toxaphene are also expected to be greater than the screening benchmark.

Ecology SQS - Values normalized to TOC were denormalized by multiplying 0.01 (1% TOC was assumed to be the average for site soils and sediments).

NV = no value

tbd = to be determined

-- = not applicable

Table A-4. Screening Benchmarks and MRLs for Groundwater Analytes.

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
Dioxins					
1,2,3,4,6,7,8-HpCDD	pg/L	--	NV	50	--
1,2,3,4,6,7,8-HpCDF	pg/L	--	NV	50	--
1,2,3,4,7,8,9-HpCDF	pg/L	--	NV	50	--
1,2,3,4,7,8-HxCDD	pg/L	--	NV	50	--
1,2,3,4,7,8-HxCDF	pg/L	--	NV	50	--
1,2,3,6,7,8-HxCDD	pg/L	--	NV	50	--
1,2,3,6,7,8-HxCDF	pg/L	--	NV	50	--
1,2,3,7,8,9-HxCDD	pg/L	--	NV	50	--
1,2,3,7,8,9-HxCDF	pg/L	--	NV	50	--
1,2,3,7,8-PeCDD	pg/L	--	NV	50	--
1,2,3,7,8-PeCDF	pg/L	--	NV	50	--
2,3,4,6,7,8-HxCDF	pg/L	--	NV	50	--
2,3,4,7,8-PeCDF	pg/L	--	NV	50	--
2,3,7,8-TCDD	pg/L	EPA Region 5 ESL	0.003	10	--
2,3,7,8-TCDF	pg/L	--	NV	10	--
OCDD	pg/L	--	NV	100	--
OCDF	pg/L	--	NV	100	--
Total HpCDD	pg/L	--	NV	--	--
Total HpCDF	pg/L	--	NV	--	--
Total HxCDD	pg/L	--	NV	--	--
Total HxCDF	pg/L	--	NV	--	--
Total PeCDD	pg/L	--	NV	--	--
Total PeCDF	pg/L	--	NV	--	--
Total TCDD	pg/L	--	NV	--	--
Total TCDF	pg/L	--	NV	--	--
TEQ (ND=0.5 DL)	pg/L	Site-specific background	18.26	--	--
VPH					--
C5-C6 Aliphatics	ug/L	--	NV	50	--
C6-C8 Aliphatics	ug/L	--	NV	50	--
C8-C10 Aliphatics	ug/L	--	NV	50	--
C8-C10 Aromatics	ug/L	Site-specific background	36	50	NV[d]
Methyl tert-Butyl Ether	ug/L	EPA Region 6	11070	5	--
Benzene	ug/L	MTCA GW Method B	0.80	5	--
Ethylbenzene	ug/L	Tier II	7.30	5	--
m&p-Xylene	ug/L	Tier II	13	5	--
o-Xylene	ug/L	Tier II	13	5	--
Toluene	ug/L	Tier II	9.80	5	--
EPH					
C10-C12 Aliphatics	ug/L	Site-specific background	24	40	NV[d]
C10-C12 Aromatics	ug/L	Site-specific background	36	40	NV[d]
C12-C16 Aliphatics	ug/L	Site-specific background	24	40	NV[d]
C12-C16 Aromatics	ug/L	Site-specific background	24	40	NV[d]
C16-C21 Aliphatics	ug/L	--	NV	40	--
C16-C21 Aromatics	ug/L	Site-specific background	47	40	--
C21-C34 Aliphatics	ug/L	--	NV	40	--
C21-C34 Aromatics	ug/L	Site-specific background	47	40	--
C8-C10 Aliphatics	ug/L	--	NV	50	--
C8-C10 Aliphatics	ug/L	--	NV	50	--
SVOCs					
Routine and Detected					
2,4-Dimethylphenol	ug/L	EPA Region 5	100.17	1	--
2-Methylnaphthalene	ug/L	EPA Region 5	329.55	1	--
2-Methylphenol	ug/L	Tier II	13	1	--
Benzoic acid	ug/L	Tier II	42	10	--

Table A-4. Screening Benchmarks and MRLs for Groundwater Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
Benzyl alcohol	ug/L	Tier II	8.6	5	--
Dibenzofuran	ug/L	Tier II	3.70	1	--
Diethylphthalate	ug/L	Tier II	210	1	--
di-n-Octylphthalate	ug/L	EPA Region 6	22	1	--
Pentachlorophenol	ug/L	Site-specific background	0.39	5	0.3
Other					
1,2,4-Trichlorobenzene	ug/L	MTCA GW Method B	35	1	--
1,2-Dichlorobenzene	ug/L	Tier II	14	1	--
1,2-Diphenylhydrazine[c]	ug/L	EPA NAWQC	0.036	1	0.395
1,3-Dichlorobenzene	ug/L	Tier II	71	1	--
1,4-Dichlorobenzene	ug/L	MTCA GW Method B	1.82	1	--
1-Methylnaphthalene	ug/L	Tier II	2.1	1	--
2,4,5-Trichlorophenol	ug/L	EPA Region 6	64	5	--
2,4,6-Trichlorophenol	ug/L	EPA NAWQC	1.4	5	0.202
2,4-Dichlorophenol	ug/L	EPA Region 5	11	5	--
2,4-Dinitrophenol	ug/L	EPA Region 5	19	10	--
2,4-Dinitrotoluene	ug/L	EPA NAWQC	0.11	5	--
2,6-Dinitrotoluene	ug/L	MTCA GW Method B	16	5	--
2-Chloronaphthalene	ug/L	EPA Region 5	0.396	1	0.396
2-Chlorophenol	ug/L	EPA Region 5	24	1	--
2-Nitrophenol	ug/L	EPA Region 6	1920	5	--
3,3'-Dichlorobenzidine	ug/L	EPA NAWQC	0.021	5	0.897
4-Bromophenyl-phenylether	ug/L	Tier II	1.5	1	--
4-Methylphenol	ug/L	EPA Region 6	543	1	--
4-Nitrophenol	ug/L	Tier II	300	5	--
7,12-Dimethylbenz(a)anthracer	ug/L	EPA Region 5	0.55	2 (estimated)	NV
Aniline	ug/L	EPA Region 5	4.1	1	--
Benzidine	ug/L	MTCA Method B	0.00032	10	4.22
bis(2-Chloroethyl)ether	ug/L	EPA NAWQC	0.03	1	0.440
bis(2-chloroisopropyl)ether	ug/L	MTCA GW Method B	320	1	--
bis(2-Ethylhexyl)phthalate	ug/L	Site-specific background	16.60	1	--
Butylbenzylphthalate	ug/L	Tier II	19	1	--
Dimethylphthalate	ug/L	EPA Region 6	330	1	--
di-n-Butylphthalate	ug/L	Tier II	35	1	--
di-n-Octylphthalate	ug/L	EPA Region 5	30	1	--
Hexachlorobenzene	ug/L	Region 5	0.0003	1	0.209
Hexachlorobutadiene	ug/L	Region 5	0.053	1	0.540
Hexachlorocyclopentadiene	ug/L	EPA MCL	50	5	--
Hexachloroethane	ug/L	EPA NAWQC	1.4	1	--
Isophorone	ug/L	EPA NAWQC	35	1	--
Nitrobenzene	ug/L	MTCA GW Method B	8	1	--
n-Nitrosodimethylamine	ug/L	EPA NAWQC	0.00069	5	0.245
n-Nitroso-di-n-propylamine	ug/L	EPA NAWQC	0.0005	5	0.410
N-nitrosodiphenylamine	ug/L	EPA NAWQC	3.3	1	--
Phenol	ug/L	EPA Region 5	180	1	--
Pyridine	ug/L	MTCA GW Method B	16	2	--
Tetrachlorophenols	ug/L	EPA Region 5	1.2	10	tbd
Acenaphthene	ug/L	Region 5	38	1	--
Acenaphthylene	ug/L	EPA Region 5	4840	1	--

Table A-4. Screening Benchmarks and MRLs for Groundwater Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
Anthracene	ug/L	Tier II	0.73	1	0.297
Fluorene	ug/L	Tier II	3.9	1	--
Naphthalene	ug/L	Tier II	12	1	--
Phenanthrene	ug/L	EPA Region 5	3.6	1	--
Benzo(a)anthracene	ug/L	Site-specific background	0.014	1	0.331
Benzo(a)pyrene	ug/L	Site-specific background	0.0076	1	0.303
Benzo(b)fluoranthene	ug/L	Site-specific background	0.015	1	0.252
Benzo(k)fluoranthene	ug/L	MTCA GW Method B	0.01	1	0.475
Benzo(g,h,i)perylene	ug/L	Tier II	7.64	1	--
Chrysene	ug/L	Site-specific background	0.017	1	0.398
Dibenzo(a,h)anthracene	ug/L	EPA NAWQC	0.0038	1	0.219
Fluoranthene	ug/L	EPA Region 5	1.9	1	--
Indeno(1,2,3-cd)pyrene	ug/L	EPA NAWQC	0.0038	1	0.257
Pyrene	ug/L	EPA Region 5	0.3	1	0.341
Petroleum Hydrocarbons					
Diesel	ug/L	--	NV	250	--
Gasoline	ug/L	--	NV	250	--
Motor Oil	ug/L	--	NV	500	--
Metals					
Arsenic	ug/L	Site-specific background	3.5	0.5	--
Cadmium	ug/L	EPA NAWQC	0.25	0.2	--
Calcium	ug/L	--	NV	50	--
Chromium	ug/L	EPA NAWQC	74	0.5	--
Copper	ug/L	Site-specific background	9.7	0.5	--
Lead	ug/L	Site-specific background	2.53	1	--
Magnesium	ug/L	Site-specific background	16200	50	--
Mercury	ug/L	WA State	0.012	0.1	--[e]
Silver	ug/L	Tier II	0.36	0.5	--[e]
Zinc	ug/L	WA State	104.5	4	--
Conventionals					
Hardness	mg/L	--	NV	-	--
TOC	mg/L	--	NV	1.5	--
TSS	mg/L	--	NV	0.1	--

[a] Detected COIs will be reported to the MDL with J qualifiers applied below the MRL.

[b] The MDL will be used as the reporting limit for non-detects when the MRL is above the screening benchmark. The MDL is at or below the screening benchmark for the following analytes: anthracene, pentachlorophenol, 2,4,6-Trichlorophenol, 2-Chloronaphthalene, and Pyrene. The MDL for the tetrachlorophenols is also expected to be greater than the screening benchmark.

[c] 1,2-Diphenylhydrazine cannot be separated from azobenzene.

[d] Determination of MDLs is not required for VPH and EPH methodology. However, the methodology is expected to be sufficiently sensitive to allow detection of the hydrocarbon series if the analytes are present at the level of the screening benchmark.

[e] The reporting limits for metals were established by ARI based on their experience with these analyses. The reporting limits for mercury and silver are greater than the screening benchmarks.

NV = no value

tbd = to be determined

-- = not applicable

Table A-5. Screening Benchmarks and MRLs for Surface Water Analytes.

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
Dioxins					
1,2,3,4,6,7,8-HpCDD	pg/L		NV	50	
1,2,3,4,6,7,8-HpCDF	pg/L		NV	50	
1,2,3,4,7,8,9-HpCDF	pg/L		NV	50	--
1,2,3,4,7,8-HxCDD	pg/L		NV	50	--
1,2,3,4,7,8-HxCDF	pg/L		NV	50	--
1,2,3,6,7,8-HxCDD	pg/L		NV	50	--
1,2,3,6,7,8-HxCDF	pg/L		NV	50	--
1,2,3,7,8,9-HxCDD	pg/L		NV	50	--
1,2,3,7,8,9-HxCDF	pg/L		NV	50	--
1,2,3,7,8-PeCDD	pg/L		NV	50	--
1,2,3,7,8-PeCDF	pg/L		NV	50	--
2,3,4,6,7,8-HxCDF	pg/L		NV	50	--
2,3,4,7,8-PeCDF	pg/L		NV	50	--
2,3,7,8-TCDD	pg/L	Region 5 ESL	0.003	10	--
2,3,7,8-TCDF	pg/L		NV	10	--
OCDD	pg/L		NV	100	--
OCDF	pg/L		NV	100	--
Total HpCDD	pg/L		NV	--	--
Total HpCDF	pg/L		NV	--	--
Total HxCDD	pg/L		NV	--	--
Total HxCDF	pg/L		NV	--	--
Total PeCDD	pg/L		NV	--	--
Total PeCDF	pg/L		NV	--	--
Total TCDD	pg/L		NV	--	--
Total TCDF	pg/L		NV	--	--
TEQ (ND=0.5 DL)	pg/L	Region 5 ESL	0.003	--	--
SVOCs					
PAHs					
2-Methylnaphthalene	ug/L	EPA Region 5 ESL	330	1	--
Acenaphthene	ug/L	EPA Region 5 ESL	38	1	--
Acenaphthylene	ug/L	EPA Region 5 ESL	4840	1	--
Anthracene	ug/L	Tier II SCV (Suter and Tsao 1996)	0.73	1	0.297
Benzo(a)anthracene	ug/L	Tier II SCV (Suter and Tsao 1996)	0.027	1	0.331
Benzo(a)pyrene	ug/L	Tier II SCV (Suter and Tsao 1996)	0.014	1	0.303
Benzo(b)fluoranthene	ug/L	MTCA Method B	2.96E-02	1	0.252
Benzo(k)fluoranthene	ug/L	MTCA Method B	2.96E-02	1	0.475
Benzo(g,h,i)perylene	ug/L	EPA Region 5 ESL	7.64	1	--
Chrysene	ug/L	MTCA Method B	2.96E-02	1	0.398
Dibenzo(a,h)anthracene	ug/L	EPA Region 6	5	1	--
Fluoranthene	ug/L	EPA Region 5 ESL	1.9	1	--
Fluorene	ug/L	Tier II SCV (Suter and Tsao 1996)	3.9	1	--
Indeno(1,2,3-cd)pyrene	ug/L	EPA Region 5 ESL	2.96E-02	1	0.257
Naphthalene	ug/L	Tier II SCV (Suter and Tsao 1996)	12	1	--
Phenanthrene	ug/L	EPA Region 5 ESL	3.6	1	--
Pyrene	ug/L	EPA Region 5 ESL	0.3	1	0.341
Other					
1,2,4-Trichlorobenzene	ug/L	Tier II SCV (Suter and Tsao 1996)	110	1	--
1,2-Dichlorobenzene	ug/L	MTCA Method B	14	1	--
1,2-Diphenylhydrazine[c]	ug/L	MTCA Method B	0.325	1	0.395
1,3-Dichlorobenzene	ug/L	Tier II SCV (Suter and Tsao 1996)	71	1	--
1,4-Dichlorobenzene	ug/L	MTCA Method B	4.86	1	--
2,4,5-Trichlorophenol	ug/L	EPA Region 6	64	1	--

Table A-5. Screening Benchmarks and MRLs for Surface Water Analytes. (continued)

Analyte		Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
	2,4,6-Trichlorophenol	ug/L	EPA Region 5 ESL	4.9	5	0.202
	2,4-Dichlorophenol	ug/L	EPA Region 5 ESL	11	5	--
	2,4-Dimethylphenol	ug/L	EPA Region 5 ESL	100.17	1	--
	2,4-Dinitrophenol	ug/L	EPA Region 5 ESL	19	10	--
	2,4-Dinitrotoluene	ug/L	EPA Region 5 ESL	44	5	--
	2,6-Dinitrotoluene	ug/L	EPA Region 5 ESL	81	5	--
	2-Chloronaphthalene	ug/L	EPA Region 5 ESL	0.396	1	0.433
	2-Chlorophenol	ug/L	EPA Region 5 ESL	24	1	--
	2-Methylphenol	ug/L	Tier II SCV (Suter and Tsao 1996)	13	1	--
	2-Nitrophenol	ug/L	EPA Region 6	1920	5	--
	3,3'-Dichlorobenzidine	ug/L	EPA Region 5 ESL	4.5	5	0.897
	4-Bromophenyl-phenylether	ug/L	Tier II SCV (Suter and Tsao 1996)	1.5	1	--
	4-Chloroaniline	ug/L	EPA Region 5 ESL	231.97	5	--
	4-Methylphenol	ug/L	EPA Region 6	543	1	--
	4-Nitrophenol	ug/L	Tier II SCV (Suter and Tsao 1996)	300	5	--
	Dimethylbenz(a)anthracene	ug/L	EPA Region 5 ESL	0.548	2 (estimated)	NV
	Aniline	ug/L	EPA Region 5 ESL	4.1	1	--
	Benzidine	ug/L	MTCA Method B	3.22E-04	10	4.22
	Benzoic acid	ug/L	Tier II SCV (Suter and Tsao 1996)	42	10	--
	Benzyl alcohol	ug/L	Tier II SCV (Suter and Tsao 1996)	8.6	5	--
	bis(2-Chloroethyl)ether	ug/L	MTCA Method B	8.54E-01	1	0.440
	bis(2-Ethylhexyl)phthalate	ug/L	Tier II SCV (Suter and Tsao 1996)	3	1	--
	Butylbenzylphthalate	ug/L	Tier II SCV (Suter and Tsao 1996)	19	1	--
	Dibenzofuran	ug/L	Tier II SCV (Suter and Tsao 1996)	3.7	1	--
	Diethylphthalate	ug/L	Tier II SCV (Suter and Tsao 1996)	210	1	--
	Dimethylphthalate	ug/L	EPA Region 5 ESL	73	1	--
	di-n-Butylphthalate	ug/L	Tier II SCV (Suter and Tsao 1996)	35	1	--
	di-n-Octylphthalate	ug/L	EPA Region 5 ESL	30	1	--
	Hexachlorobenzene	ug/L	EPA Region 5 ESL	0.0003	1	0.209
	Hexachlorobutadiene	ug/L	EPA Region 5 ESL	0.053	1	0.540
	Hexachlorocyclopentadiene	ug/L	EPA Region 5 ESL	77.04	5	--
	Hexachloroethane	ug/L	MTCA Method B	5.33	1	--
	Isophorone	ug/L	EPA Region 5 ESL	920	1	--
	Nitrobenzene	ug/L	EPA Region 5 ESL	220	1	--
	n-Nitrosodimethylamine	ug/L	EPA Region 5 ESL	4.89	5	0.245
	n-Nitroso-di-n-propylamine	ug/L	MTCA Method B	0.82	5	0.410
	N-nitrosodiphenylamine	ug/L	MTCA Method B	9.73	1	--
	Pentachlorophenol	ug/L	MTCA Method B	4.91	5	0.914
	Phenol	ug/L	EPA Region 5 ESL	180	1	--
	Pyridine	ug/L	EPA Region 5 ESL	2380	0	--
	Tetrachlorophenols	ug/L	EPA Region 5 ESL	1.2	10 (estimated)	tbd
Petroleum Hydrocarbons						
	Gas-Range	mg/L		NV	0.25	--
	Diesel-Range	mg/L		NV	0.5	--
VPH						
	C5-C6 Aliphatics	ug/L		NV	50	--
	C6-C8 Aliphatics	ug/L		NV	50	--

Table A-5. Screening Benchmarks and MRLs for Surface Water Analytes. (continued)

Analyte		Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
	C8-C10 Aliphatics	ug/L		NV	50	--
	C8-C10 Aromatics	ug/L		NV	50	--
EPH						
	C8-C10 Aliphatics	ug/L		NV	50	--
	C10-C12 Aliphatics	ug/L		NV	40	--
	C10-C12 Aromatics	ug/L		NV	40	--
	C12-C16 Aliphatics	ug/L		NV	40	--
	C12-C16 Aromatics	ug/L		NV	40	--
	C16-C21 Aliphatics	ug/L		NV	40	--
	C16-C21 Aromatics	ug/L		NV	40	--
	C21-C34 Aliphatics	ug/L		NV	40	--
	C21-C34 Aromatics	ug/L		NV	40	--
Metals						
	Arsenic	ug/L	MTCA Method B	9.82E-02	0.5	--[e]
	Cadmium	ug/L	CCC (EPA 2002)	0.25	0.2	--
	Calcium		--	NV	50	--
	Chromium	ug/L	CCC (EPA 2002)	74	0.5	--
	Copper	ug/L	CCC (EPA 2002)	9.00	0.5	--
	Lead	ug/L	Ecology (WAC 173-201A-040)	2.50	1	--
	Magnesium	ug/L	EPA Region 6	647	50	--
	Mercury	ug/L	Ecology (WAC 173-201A-040)	0.012	0.1	--[e]
	Silver	ug/L	Tier II SCV (Suter and Tsao 1996)	0.36	0.5	--[e]
	Zinc	ug/L	Ecology (WAC 173-201A-040)	104.50	4	--
Conventionals						
	Hardness	mg/L	--	NV	-	--
	TOC	mg/L	--	NV	1.5	--
	TSS	mg/L	--	NV	0.1	--

[a] Detected COIs will be reported to the MDL with J qualifiers applied below the MRL.

[b] The MDL will be used as the reporting limit for non-detects when the MRL is above the screening benchmark. The MDL is below the screening benchmark for the following analytes: Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Indeno(1,2,3-cd)pyrene, Pyrene, 1,2-Diphenylhydrazine, 2-Chloronaphthalene, Benzidine, Hexachlorobenzene, and Hexachlorobutadiene. The MDL for the tetrachlorophenols is also expected to be greater than the screening benchmark.

[c] 1,2-Diphenylhydrazine cannot be separated from azobenzene.

[d] Determination of MDLs is not required for VPH and EPH methodology. However, the methodology is expected to be sufficiently sensitive to allow detection of the hydrocarbon series if the analytes are present at the level of the screening benchmark.

[e] The reporting limits for metals were established by ARI based on their experience with these analyses. The reporting limits for arsenic, mercury, and silver are greater than the screening benchmarks.

NV = no value

tbd = to be determined

-- = not applicable

Table A-6. Screening Benchmarks and MRLs for Sediment Analytes.

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
Dioxins					
1,2,3,4,6,7,8-HpCDD	ng/Kg	--	NV	50	--
1,2,3,4,6,7,8-HpCDF	ng/Kg	--	NV	50	--
1,2,3,4,7,8,9-HpCDF	ng/Kg	--	NV	50	--
1,2,3,4,7,8-HxCDD	ng/Kg	--	NV	50	--
1,2,3,4,7,8-HxCDF	ng/Kg	--	NV	50	--
1,2,3,6,7,8-HxCDD	ng/Kg	--	NV	50	--
1,2,3,6,7,8-HxCDF	ng/Kg	--	NV	50	--
1,2,3,7,8,9-HxCDD	ng/Kg	--	NV	50	--
1,2,3,7,8,9-HxCDF	ng/Kg	--	NV	50	--
1,2,3,7,8-PeCDD	ng/Kg	--	NV	50	--
1,2,3,7,8-PeCDF	ng/Kg	--	NV	50	--
2,3,4,6,7,8-HxCDF	ng/Kg	--	NV	50	--
2,3,4,7,8-PeCDF	ng/Kg	--	NV	50	--
2,3,7,8-TCDD	ng/Kg	--	NV	10	--
2,3,7,8-TCDF	ng/Kg	--	NV	10	--
OCDD	ng/Kg	--	NV	100	--
OCDF	ng/Kg	--	NV	100	--
Total HpCDD	ng/Kg	--	NV	--	--
Total HpCDF	ng/Kg	--	NV	--	--
Total HxCDD	ng/Kg	--	NV	--	--
Total HxCDF	ng/Kg	--	NV	--	--
Total PeCDD	ng/Kg	--	NV	--	--
Total PeCDF	ng/Kg	--	NV	--	--
Total TCDD	ng/Kg	--	NV	--	--
Total TCDF	ng/Kg	--	NV	--	--
TEQ (ND=0.5 DL)	ng/Kg	Puget Sound Background	19	--	--
SVOCs					
PAHs					
2-Methylnaphthalene	mg/kg	Ecology SQS	0.38	0.02	--
Acenaphthene	mg/kg	Ecology SQS	0.16	0.02	--
Acenaphthylene	mg/kg	Ecology LAET	0.47	0.02	--
Anthracene	mg/kg	Ecology LAET	1.23	0.02	--
Benzo(a)anthracene	mg/kg	MTCA Method B	0.137	0.02	--
Benzo(a)pyrene	mg/kg	MTCA Method B	0.137	0.02	--
Benzo(b)fluoranthene	mg/kg	MTCA Method B	0.137	0.02	--
Benzo(g,h,i)perylene	mg/kg	Ecology SQS	0.31	0.02	--
Benzo(j)fluoranthene	mg/kg	--	NV	0.02	--
Benzo(k)fluoranthene	mg/kg	MTCA Method B	0.137	0.02	--
Chrysene	mg/kg	MTCA Method B	0.137	0.02	--
Dibenzo(a,h)anthracene	mg/kg	Ecology SQS	0.12	0.02	--
Fluoranthene	mg/kg	Ecology SQS	1.6	0.02	--
Fluorene	mg/kg	Ecology SQS	0.23	0.02	--
Indeno(1,2,3-cd)pyrene	mg/kg	MTCA Method B	0.137	0.02	--
Naphthalene	mg/kg	Ecology LAET	0.529	0.02	--
Phenanthrene	mg/kg	Ecology SQS	1	0.02	--
Pyrene	mg/kg	Ecology LAET	8.79	0.02	--
Other					
1,2,4-Trichlorobenzene	mg/kg	Ecology SQS	0.0081	0.02	0.00626
1,2-Dichlorobenzene	mg/kg	Ecology SQS	0.023	0.02	--
1,2-Diphenylhydrazine	mg/kg	MTCA Method B	1.25	0.02	--
1,3-Dichlorobenzene	mg/kg	MTCA Method B	16	0.02	--

Table A-6. Screening Benchmarks and MRLs for Sediment Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
1,4-Dichlorobenzene	mg/kg	Ecology SQS	*0.031*	0.02	--
2,4,5-Trichlorophenol	mg/kg	MTCA TEE plant	4	0.1	--
2,4,6-Trichlorophenol	mg/kg	Region 9 Leaching	0.2	0.1	--
2,4-Dichlorophenol	mg/kg	Region 9 Leaching	1	0.1	--
2,4-Dimethylphenol	mg/kg	Ecology SQS	0.029	0.02	--
2,4-Dinitrophenol	mg/kg	Region 9 Leaching	0.3	0.2	--
2,4-Dinitrotoluene	mg/kg	Region 9 Leaching	0.0008	0.1	0.00386
2,6-Dinitrotoluene	mg/kg	Region 9 Leaching	0.0007	0.1	0.00666
2-Chloronaphthalene	mg/kg	MTCA Method B	4900	0.02	--
2-Chlorophenol	mg/kg	Region 9 Leaching	4	0.2	--
2-Methylphenol	mg/kg	Ecology SQS	0.063	0.02	--
2-Nitroaniline	mg/kg	MTCA Method B	1.7	0.1	--
3&4-Methylphenol	mg/kg	MTCA Method B	310	0.02	--
3,3'-Dichlorobenzidine	mg/kg	Region 9 Leaching	0.007	0.1	0.02362
4-Chloroaniline	mg/kg	Region 9 Leaching	0.7	0.1	--
4-Methylphenol	mg/kg	Ecology SQS	0.67	0.02	--
4-Nitrophenol	mg/kg	MTCA TEE soil	7	0.1	--
Aniline	mg/kg	MTCA Method B	175	0.02	--
Benz[e]acephenanthrylene	mg/kg	MTCA Method B	0.137	0.02	--
Benzidine	mg/kg	MTCA Method B	0.00435	0.2	tbd
Benzoic acid	mg/kg	Ecology SQS	0.65	0.2	--
Benzyl alcohol	mg/kg	Ecology SQS	0.057	0.04	--
bis(2-Chloroethyl)ether	mg/kg	Region 9 Leaching	0.0004	0.02	0.00599
bis(2-chloroisopropyl)ether	mg/kg	MTCA Method B	3200	0.02	--
bis(2-Ethylhexyl)phthalate	mg/kg	Ecology SQS	0.47	0.02	--
Butylbenzylphthalate	mg/kg	Ecology SQS	0.049	0.02	--
Carbazole	mg/kg	Region 9 Leaching	0.6	0.02	--
Dibenzofuran	mg/kg	Ecology SQS	0.15	0.02	--
Diethylphthalate	mg/kg	Ecology SQS	0.61	0.02	--
Dimethylphthalate	mg/kg	Ecology LAET	0.311	0.02	--
di-n-Butylphthalate	mg/kg	Ecology LAET	0.103	0.02	--
di-n-Octylphthalate	mg/kg	Ecology LAET	0.011	0.02	0.00392
Hexachlorobenzene	mg/kg	Ecology LAET	0.004	0.02	0.00604
Hexachlorobutadiene	mg/kg	Ecology LAET	0.039	0.02	--
Hexachlorocyclopentadiene	mg/kg	MTCA TEE plant	10	0.1	--
Hexachloroethane	mg/kg	Region 9 Leaching	0.5	0.02	--
Isophorone	mg/kg	Region 9 Leaching	0.5	0.02	--
Nitrobenzene	mg/kg	Region 9 Leaching	0.1	0.02	--
n-Nitrosodimethylamine	mg/kg	MTCA Method B	0.0196	0.02	0.0338
n-Nitroso-di-n-propylamine	mg/kg	Region 9 Leaching	0.00005	0.1	0.00838
N-nitrosodiphenylamine	mg/kg	Ecology SQS	0.11	0.02	--
Pentachlorophenol[a]	mg/kg	Region 9 Leaching	0.03	0.1	0.01925
Phenol	mg/kg	Ecology SQS	0.42	0.02	--
Pyridine	mg/kg	MTCA Method B	80	0.1	--
Retene	mg/kg	Ecology LAET	6.02	0.04 (estimated)	--
Tetrachlorophenols	mg/kg	MTCA TEE soil	20	0.1	--

Table A-6. Screening Benchmarks and MRLs for Sediment Analytes. (continued)

Analyte	Units	Screening Benchmark Source	Selected Screening Benchmark	Method Reporting Limit[a]	Method Detection Limit[b]
EPH					
C10-C12 Aliphatics	mg/kg	--	NV	5	--
C10-C12 Aromatics	mg/kg	--	NV	5	--
C12-C16 Aliphatics	mg/kg	--	NV	2	--
C12-C16 Aromatics	mg/kg	--	NV	2	--
C16-C18 Aliphatics	mg/kg	--	NV	2	--
C16-C18 Aromatics	mg/kg	--	NV	2	--
C18-C21 Aliphatics	mg/kg	--	NV	2	--
C18-C21 Aromatics	mg/kg	--	NV	2	--
C21-C28 Aliphatics	mg/kg	--	NV	2	--
C21-C28 Aromatics	mg/kg	--	NV	2	--
C28-C36 Aliphatics	mg/kg	--	NV	2	--
C28-C36 Aromatics	mg/kg	--	NV	2	--
Petroleum Hydrocarbons					
TPH	mg/kg	MTCA TEE soil	200	20	--
Metals					
Arsenic	mg/kg	Puget Sound Bkgd	7	0.2	--
Cadmium	mg/kg	LAET	2.39	0.2	--
Chromium	mg/kg	Puget Sound Bkgd	48	0.5	--
Copper	mg/kg	MTCA TEE soil	50	0.2	--
Lead	mg/kg	MTCA TEE plant	50	2	--
Mercury	mg/kg	MTCA TEE soil	0.1	0.05	--
Silver	mg/kg	LAET	0.545	0.3	--
Zinc	mg/kg	MTCA TEE plant	86	0.6	--
Conventionals			NV		
<Sieve 200	percent	--	NV	0.1	--
Sieve 0.25	percent	--	NV	0.1	--
Sieve 0.5	percent	--	NV	0.1	--
Sieve 004	percent	--	NV	0.1	--
Sieve 010	percent	--	NV	0.1	--
Sieve 020	percent	--	NV	0.1	--
Sieve 040	percent	--	NV	0.1	--
Sieve 060	percent	--	NV	0.1	--
Sieve 140	percent	--	NV	0.1	--
Sieve 200	percent	--	NV	0.1	--
TOC	mg/kg	LAET	98200	100	--

[a] Detected COIs will be reported to the MDL with J qualifiers applied below the MRL.

[b] The MDL will be used as the reporting limit for non-detects when the MRL is above the screening benchmark. The MDL is below the screening benchmark for the following analytes: 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 3,3'-Dichlorobenzidine, bis(2-Chloroethyl)ether, Hexachlorobenzene, n-Nitrosodimethylamine, and n-Nitroso-di-n-propylamine. The MDL for benzidine is also expected to be greater than the screening benchmark.

Ecology SQS - Values normalized to TOC were denormalized by multiplying 0.01 (1% TOC was assumed to be the average for site soils and sediments).

NV = no value

tbd = to be determined

-- = not applicable

Table A-7. Laboratory Methods.

Analytes	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure
Soil and sediment samples					
Conventional Analyses	ARI				
Total sulfides[a]		EPA 376.2	Distillation	EPA 376.2	Colorimetry
Ammonia[a]		EPA 350.1 (Plumb)	KCl extraction	EPA 350.1	Colorimetry
Total organic carbon		Plumb 1981	Acid pretreatment	Plumb 1981	Combustion
Metals	ARI				
Arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc		EPA 3050	Strong acid digestion	EPA SW 6010	ICP
Mercury		EPA 7471A	Acid digestion/oxidation	EPA 7471A	CVAA
Petroleum hydrocarbons	ARI				
Gasoline-range hydrocarbons[b]		NWTPH-Gx	Methanol extraction	NWTPH-Gx	GC/FID
			Purge and trap		
Diesel- and oil-range hydrocarbons		EPA 3545B or 3550B	ASE or Sonication	NWTPH-Dx	GC/FID
			Acid and Silica gel cleanup		
Volatile petroleum hydrocarbons[b]		WDOE VPH	Methanol extraction	WDOE VPH	GC/PID and FID
			Purge and trap		
Extractable petroleum hydrocarbons		WDOE EPH	Sonication	WDOE EPH	GC/FID
			Silica gel fractionation		
Organochlorine pesticides[b]	ARI	EPA 3550B	Sonication	EPA 8081A	Dual column GC/ECD
		EPA 3630C	Silica Gel Cleanup		
		EPA 3660B	Sulfur cleanup		
PCB Aroclors[b]	ARI	EPA 3550B	Sonication	EPA 8082	Dual column GC/ECD
		EPA 3665A	Sulfuric acid cleanup		
		EPA 3630C	Silica Gel Cleanup		
		EPA 3660B	Sulfur cleanup		
Semivolatile organic compounds	ARI	EPA 3550B	Sonication	EPA 8270C	GC/MS
		EPA 3640A	Gel permeation chromatography		

Table A-7. Laboratory Methods. (continued)

Analytes	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure
Chlorinated dioxins and furans	STL	EPA 1613B	Soxhlet/Dean Stark extraction	EPA 1613B	HRGC/HRMS
			Sulfuric acid cleanup		
			Silica/carbon column cleanup		
Toxicity tests [a]	NAS				
Microtox® test of sediment pore water		Ecology 2003	Pore water extraction	Ecology 2003	*V. fisheri* luminescence
Amphipod 10-day bioassay (*Hyalella azteca*)		Ecology 2003	--	ASTM 2000	10-d mortality
Midge 21-day bioassay (*Chironomus tentans*)		Ecology 2003	--	ASTM 2000	21-d mortality and growth
Geotechnical characteristics	ARI				
Grain Size		NA	--	ASTM-D422-63	Sieve/Hydrometer
Atterberg Limits		NA	--	ASTM-D4318-00	Wet method; moisture determination
Specific Gravity		NA	--	ASTM-D854-02	Water pycnometer
Moisture Content		NA	--	ASTM-D-2216	Gravimetric
Groundwater and surface water samples					
Conventional Analyses	ARI				
Total organic carbon		EPA 415.1	Acid pretreatment	EPA 415.1	Combustion
Total Suspended Solids		EPA 160.2	Filtration and drying	EPA 160.2	Gravimetric
Hardness (Ca, Mg)		--	--	SM 2340B	Calculation
Metals	ARI				
Cadmium, chromium, copper, lead, nickel, silver, zinc		EPA 3005	Acid digestion	EPA 200.8	ICP/MS
Calcium, magnesium		EPA 3005	Acid digestion	EPA 6010B	ICP/OES
Mercury		EPA 7470	Acid digestion/oxidation	EPA 7470	CVAA
Petroleum hydrocarbons	ARI				
Gasoline-range hydrocarbons		NWTPH-Gx	Purge and trap	NWTPH-Gx	GC/FID

Table A-7. Laboratory Methods. (continued)

Analytes	Laboratory	Sample Preparation		Quantitative Analysis	
		Protocol	Procedure	Protocol	Procedure
Diesel- and oil-range hydrocarbons		EPA 3520C	Liquid-Liquid	NWTPH-Dx	GC/FID
Volatile petroleum hydrocarbons		WDOE VPH	Purge and trap	WDOE VPH	GC/PID and FID
Extractable petroleum hydrocarbons		WDOE EPH	Separatory Funnel or Liquid-Liquid	WDOE EPH	GC/FID
			Silica gel fractionation		
Semivolatile Organic Compounds	ARI	EPA 3510C	Separatory Funnel	EPA 8270C	GC/MS
Chlorinated dioxins and furans	STL	EPA 1613B	Extraction	EPA 1613B	HRGC/HRMS
			Sulfuric acid cleanup		
			Silica/carbon column cleanup		

a Will be analyzed in sediment samples only.

b Will be analyzed in selected soil samples only.

Table A-8. Measurement Quality Objectives.

Analysis	Bias (percent)	Precision (RPD)	Completeness (percent)
Soil and sediment samples			
Conventional analytes	75–125	±35	95
Physical charactersitics	NA	±35	95
Metals	75–125	±35	95
Organic compounds			
Petroleum hydrocarbons	50–150	±50	95
Semivolatile organic compounds	30-150	±50	95
Pesticides	30-150	±50	95
PCB Aroclors	30-150	±50	95
Dioxins and furans	50–150	±50	95
Groundwater and surface water samples			
Conventional analytes	75–125	±35	95
Metals	75–125	±35	95
Organic compounds			
Petroleum hydrocarbons	50–150	±50	95
Semivolatile organic compounds	30–150	±50	95
Dioxins and furans	50–150	±50	95

NA - not applicable
RPD - relative percent difference

SECTION B: DATA GENERATION AND ACQUISITION

B1 SAMPLING PROCESS DESIGN

This section presents the sampling design for a tiered approach to complete the Park RI field investigation (Section 4.0 in the SAP). The design is based on Integral's understanding of historical site data and professional judgment. Specific issues related to sampling methods and sample handling procedures are addressed in Section 5.0 of the SAP.

A total of 12 test pits are planned for excavation within the Park site boundary. The test pits will allow collection of soil samples at depth in the areas of historical landfill and gravel mining operations, which might have disturbed soils and distributed contamination throughout a depth range up to several feet. In each test pit, a sample collected from surface to 1 ft below ground surface (bgs) will be submitted for analyses. Additional samples will be collected at 1-2 ft bgs, 2-3 ft bgs, and the bottom of the test pit for archiving. Selected soil samples will be analyzed for TOC, grain size, Atterberg limits, specific gravity, moisture content/bulk density, metals, and NWTPH-DRO and -GRO. Depending on the results, archive samples may be analyzed for VPH/EPH, SVOCs and dioxins/furans.

Soil samples will also be collected at 9 locations using a hand auger. Hand augering is proposed for these locations because it is less intrusive than test pits. Soil samples will be collected at 0-1 ft bgs and 1-2 ft bgs. Selected soil samples will be analyzed for TOC, grain size, Atterberg limits, specific gravity, moisture content/bulk density, metals, chlorinated pesticides, PCBs, and NWTPH-DRO. Depending on the results, archive samples may be analyzed for EPH, SVOCs and dioxins/furans.

Surface water samples will be collected at 7 designated locations (including one background location) using either a peristaltic pump or grab sampling equipment (e.g., sampled directly into bottles). Integral will collect two rounds of surface water samples, both during the wet season. Surface water samples will be analyzed for hardness, total suspended solids (TSS), TOC, metals (including calcium and magnesium), NWTPH-GRO/DRO, and SVOCs. Selected surface water samples may also be analyzed for VPH/EPH and dioxins/furans.

Surface sediment samples will be collected from 7 locations at a depth of 0 to 10 cm using a stainless steel, hand-held coring device or large spoon. After surface samples have been collected, sediment borings will be drilled along transects across the creek bed at six locations, evenly spaced over the length of the creek. The borings will be advanced using a track-mounted, portable, hollow stem auger to collect samples at depth. For each transect of 3 to 5 borings, sediment samples will be collected from 0-1 ft bgs, 1-2 ft, 2-3 ft bgs, 3-4 ft bgs, and 4-5 ft bgs. Site surface (0-10 cm) and the 0-1 ft and 1-

2 ft boring sediment samples will be analyzed for TOC, metals, and NWTPH-DRO. Surface sediments (0-10 cm) will also be analyzed for total sulfides and ammonia to assist in evaluating the bioassay tests, if required. Physical testing (grain size, Atterberg limits, specific gravity, moisture/bulk density) will also be analyzed for the surface (0-10 cm – grain size only), and 0-1 ft and 2-3 ft samples at depth from selected borings representative of each transect. Site surface (0-10 cm), 0-1 ft, and 1-2 ft sediment samples will be archived for possible EPH, SVOC, and dioxin/furan analyses, depending on the DRO results. Additional samples collected at depth may be analyzed for these chemical groups pending the results of shallow sediment samples.

Based on the chemical results of the surface sediment samples we will perform toxicity testing at those locations where concentrations exceed corresponding SLs. The proposed tests are:

- Amphipod (*Hyalella azteca*) 10-day mortality test (USEPA 2000b; Test Method 100.1)
- Microtox® Sediment Porewater (*Vibrio fischeri*) (Ecology 2003)
- Midge (*Chironomus tentans*) 20-day mortality and growth test (USEPA 2000b; Test Method 100.2 modified).

Groundwater samples will be collected at three wells in the Park and a background location (MW-06D[3]) using either a peristaltic pump or bailer. Integral will collect two rounds of groundwater samples, one during the dry season and the other during the wet season. Groundwater samples will be analyzed for hardness, TSS, TOC, metals (including calcium and magnesium), NWTPH-GRO/DRO, SVOCs, and dioxins/furans. Depending on the results of the NWTPH method, VPH/EPH may be analyzed.

Field replicates will be collected and analyzed at a frequency of 5 percent of samples. Equipment rinse blanks will be collected and analyzed once per sampling method. Field QC samples are described in Section 4.6 of the SAP.

B2 SAMPLING METHODS

Field sampling methods are described in Section 5.0 of the SAP and include the following activities:

- Horizontal and vertical control methods (utility survey and sample locations)
- Sampling equipment (test pits, hand augers, surface water sampling, surface sediment sampling, sediment borings, and groundwater sampling)

[3] MW-06D is a background well located northeast of the OESER site near Cedarwood Avenue.

- Sample identification
- Sample containers and labels (sample labels, custody seals, sample summary log, sample custody/tracking procedures)
- Field documentation and procedures (field logbooks, photo documentation, sample collection form, field change request form, sample tracking form, chain-of-custody form)
- Decontamination procedures
- Investigation-derived wastes.

Standard operating procedures (SOPs) for each sampling method are provided in Appendix A of the SAP.

Soil samples will be collected from test pits excavated using a backhoe to a depth of 4 ft bgs. SOP-1 presents the procedures planned for test pit excavations in the Park.

Soil samples will be collected using a stainless steel hand auger or equivalent to a depth of 2 ft bgs. SOP-2 presents the procedures planned for sampling with a hand auger in the Park.

Groundwater will be collected from each well using either a portable peristaltic pump equipped with Teflon-lined tubing or disposable bailer. Refer to SOP-3 in the SAP.

Surface water will be collected from below the water surface using either a portable peristaltic pump equipped with Teflon-lined tubing or direct filling of sample bottles. See SOP-4.

Surface sediment samples (0 to 10 cm) will be collected from the Creek using a stainless steel shovel, spoon or trowel following methods described in SOP-5.

Sediment borings will be advanced using a portable, track-mounted, hollow-stem auger drill rig as described in SOP-6. A 2-ft long, 3-inch diameter split spoon will be used (or equivalent) to collect sediment samples at each sediment boring location.

Requirements for sample containers, sample preservation, storage temperature, and holding times are summarized in Table B-1. All sample containers will have screw-type lids to ensure adequate sealing of the bottles. Lids of the glass containers will have Teflon inserts to prevent sample reaction with the plastic lid and to improve the quality of the seal. When required, preservative will be added to containers at the laboratory prior to shipment to the sampling site.

Commercially available, pre-cleaned jars will be used, and the laboratory will maintain a record of certification from the suppliers. The bottle shipment documentation will record batch numbers for the bottles. With this documentation, bottles can be traced to

the supplier, and bottle rinse blank results can be reviewed. The bottle documentation from the laboratory will be included in the Integral project file.

B3 SAMPLE HANDLING AND CUSTODY

The principal documents used to identify samples and to document possession will be field logbooks and chain-of-custody (COC) records. Custody will be documented for all samples at all stages of the analytical or transfer process. COC procedures for core and sample handling prior to delivery to the laboratories are outlined in Section 5.5 of the SAP.

Upon receipt of samples at each laboratory, the sample manager will check for physical integrity of the containers and seals and inventory the samples by comparing sample labels to those on the COC forms. The laboratory will include the COC and cooler receipt forms in the data package. Any breaks in the COC or non-conformances will be noted and reported in writing to the Integral laboratory coordinator within 24 hours of receipt of the samples. Each laboratory QA plan (Attachments 1 through 3 to this QAPP) includes procedures used for accepting custody of samples and documenting samples at the laboratory. The laboratory project manager will ensure that a sample-tracking record is maintained that follows each sample through all stages of sample processing at the laboratory.

All samples submitted to ARI for archival will be stored at -20° C. Sediment for toxicity testing will be stored in the dark for a maximum of 8 weeks. Sample bottles for toxicity testing will be stored either with no headspace or headspace purged with nitrogen gas. Each laboratory will maintain COC documentation and documentation of proper storage conditions for the entire time that the samples are in its possession. The chemical laboratories will store the excess samples for a minimum of 6 months following completion of data validation.

The laboratories will not dispose of the samples for this project until authorized to do so by the Integral laboratory coordinator. The laboratories will dispose of samples, as appropriate, based on matrix, analytical results, and information received from the client. If determined to be hazardous, remaining samples will enter the appropriate laboratory waste streams.

B4 ANALYTICAL METHODS

Samples of all matrix types collected for this study will be analyzed for chemical constituents. Toxicity tests will additionally be conducted for selected sediment and sediment pore water samples. Sediment and soil samples will also be tested for geotechnical characteristics. The laboratory methods that will be used to complete the chemical, biological, and geotechnical testing are described below.

B4.1 Chemical Analyses

Soil, groundwater, surface water, and sediment samples will be analyzed for metals, organic compounds, and conventional analytes. Detailed analyte lists and method reporting limits are provided in Tables A-3 through A-6, respectively, for each sample type. Method reporting limits are equivalent to the concentration of the lowest calibration standard (i.e., the practical quantitation limit) and represent the low end of the calibration range. Analytes that are detected at concentrations below the reporting limit will be reported, but will be qualified as estimated (a "J" qualifier will be applied to the result by the laboratory).

ARI will complete analyses for metals, organic compounds (except dioxins and furans), conventional analytes, and geotechnical characteristics. STL will complete analyses for dioxins and furans. Laboratory methods for sample preparation and analysis are summarized in Table A-7 and described in the following sections. Sample containers, preservation, and holding times are provided in Table B-1.

B4.1.1 Metals

Sediment and soil samples will be analyzed for metals by EPA Method 6010 and for mercury by EPA Method 7471A. Strong acid digestion with nitric acid and hydrogen peroxide will be used to prepare samples for analysis of metals other than mercury. Analysis will be completed by inductively coupled plasma/mass spectrometry (ICP/MS). Mercury samples will be digested with aqua regia and oxidized using potassium permanganate. Analysis will be completed by cold vapor atomic absorption spectrometry (CVAA).

Three methods will be used to analyze groundwater and surface water samples for total metals. Digestion with nitric and hydrochloric acids will be used to prepare samples for analysis of metals other than mercury. Analysis for these metals will be completed by ICP/MS. Calcium and magnesium analyses will be completed by inductively coupled plasma-optical emission spectrometry (ICP-OES). Calcium and magnesium concentrations will be used to calculate water hardness. Mercury samples will be digested with aqua regia, oxidized using potassium permanganate, and analyzed by CVAA.

B4.1.2 Petroleum Hydrocarbons

Soil, groundwater, sediment, and surface water samples will be analyzed for diesel- and oil- range petroleum hydrocarbons. These samples will additionally be analyzed for EPH if screening levels are exceeded. Soil, groundwater, surface water samples will also be analyzed for gasoline-range petroleum hydrocarbons (GRO). These samples will be analyzed for VPH if screening levels are exceeded. Details regarding the decision to analyze samples for VPH or EPH are provided in Section 4.0 of the SAP.

GRO and VPH will be extracted from soil samples using methanol, followed by purge and trap with a carbon-based trap. Groundwater and surface water samples will be

purged directly without prior extraction. The contents of the trap will be analyzed by gas chromatography (GC) with a flame ionization detector (FID) for NWTPH-GRO. Samples for VPH will be analyzed using both FID and a photo-ionization detector (PID). The FID detects both aliphatic and aromatic hydrocarbons, whereas the PID detects only the aromatic hydrocarbons. The aliphatic hydrocarbons are calculated as the difference between the FID and PID responses.

For diesel- and oil-range petroleum hydrocarbons, samples will be extracted with methylene chloride and solvent-exchanged into hexane. Silica gel chromatography will be used to separate the aliphatic and aromatic hydrocarbons in the samples. The fractions will be analyzed separately by GC/FID.

B4.1.3 Semivolatile Organic Compounds

SVOCs in sediment and soil samples will be analyzed by EPA SW-846 Method 8270C, with modifications recommended by PSEP (1997a,b) to allow lower reporting limits. Modifications will include the use of a larger sample volume, corresponding to 50 g of dry sediment and a final extract volume of 0.5 mL. Samples will be extracted by sonication. Gel permeation chromatography will be used to clean up the sample extracts. Samples will be analyzed by gas chromatography with mass spectrometry (GC/MS).

Continuous liquid-liquid extraction will be used to extract SVOCs from groundwater and surface water samples. SVOCs will be analyzed by GC/MS with a large-volume injector to enhance sensitivity. TICs will not be reported for this study.

B4.1.4 Dioxins and Furans

Chlorinated dioxins and furans in sediment and soil samples will be extracted with toluene in a Soxhlet/Dean Stark extractor. Water samples will be extracted with methylene chloride. Cleanup procedures will include sulfuric acid cleanup and silica/carbon column cleanup. Additional cleanup procedures will be used if necessary to remove interferences. Samples will be analyzed by high-resolution gas chromatography with high-resolution mass spectrometry (HRGC/HRMS). EPA Method 1613B requires isotopically labeled analogs of target analytes to be spiked into each sample before extraction. Target analytes are quantified relative to the labeled analog and therefore their calculated concentration compensates for extraction and cleanup efficiencies.

As described in EPA Method 1613B, detection limits are calculated on an individual compound and sample basis and depend on the signal-to-background ratio for the specific labeled isomer. Concentrations will be reported to the sample-specific MDLs.

B4.1.5 Pesticides

Chlorinated pesticides in soil samples will be analyzed using EPA SW-846 Method 8081A. Samples will be extracted by sonication extraction. Gel permeation

chromatography (GPC) will be used to remove large organic interferents, and sulfur cleanup will be completed if necessary using tetrabutylammonium sulfite. Samples will be analyzed by gas chromatography with an electron capture detector (GC/ECD).

B4.1.6 PCBs

PCB Aroclors in soil samples will be analyzed using EPA SW-846 Method 8082 with modifications recommended by PSEP (1997a) to allow lower reporting limits. Modifications will include the use of a larger sample volume, corresponding to 25 g of dry sediment, and a final extract volume of 5 mL. Samples will be extracted by sonication. Extracts will be cleaned using sulfuric acid cleanup, silica gel cleanup, and sulfur cleanup. Samples will be analyzed by GC/ECD.

B4.1.7 Conventional Analyses

Conventional analyses of sediment samples will include total solids, total sulfides, ammonia, and TOC. Soil samples will be analyzed for total solids and TOC. EPA and PSEP methods will be used as shown in Table A-7.

Total solids in soil and sediment samples will be determined according to PSEP (1986). These results will be used to calculate analyte concentrations on a dry-weight basis and will also be reported in the database.

Total sulfide analysis in sediment samples will include distillation of the sulfide into a sodium hydroxide trap and analysis by colorimetry (EPA 376.2).

Ammonia in sediment samples will be analyzed by EPA Method 350.1. The method, originally developed for use in water samples, will be modified for sediment samples by adding an extraction with a potassium chloride solution. Colorimetry will be used to determine ammonia concentrations.

TOC in sediment and soil samples will be analyzed as described in EPA Method SW 9060 (Ecology modified). Samples will be pretreated with hydrochloric acid to remove inorganic carbon, dried at 70° C, and analyzed by combustion in an induction furnace.

Conventional analyses of surface water samples will include total suspended solids, total organic carbon, and hardness. EPA methods will be used as shown in Table A-7.

For TSS determination, water samples will be filtered through a pre-weighed glass fiber filter. The filter will be dried and weighed and the TSS determined by difference.

Total organic carbon in surface water samples will be analyzed by EPA Method 415.1. Organic carbon in the samples will be oxidized and the evolved CO_2 will be analyzed using an infrared detector. Samples will be pretreated with hydrochloric acid to remove inorganic carbon.

The hardness of the water samples will be calculated using the results for calcium and magnesium which will be obtained by ICP/OES as described for metals.

B4.2 Biological Testing

Bioassays will be conducted on selected sediment samples to determine whether anthropogenic contaminants of concern are present at concentrations which are toxic to biota. The following freshwater sediment toxicity bioassays (2 acute tests and 1 chronic test) will be conducted:

- 10-day Amphipod (*Hyalella azteca*)
- Microtox® Sediment Porewater (*Vibrio fischeri*)
- 20-day Midge Larvae (*Chironomus tentans*).

Biological testing will be in compliance with *Methods for Measuring the Toxicity and Bioaccumulation of Sediment Associated Contaminants with Freshwater Invertebrates* (USEPA 2000b), ASTM Guideline E 1706-95b (ASTM 1997, 2000), and the *Sediment Sampling and Analysis Plan Appendix – Subappendicies C and D* (Ecology 2003) following requirements presented in the *Phase 1 Freshwater Sediment Quality Values in Washington State* (Ecology 2002). NAS, an accredited laboratory by Ecology, will conduct the bioassay testing for this project.

All samples for bioassay testing will be stored in 1-liter amber jars, at 4°C, with no headspace (or headspace purged with nitrogen gas) until analysis by the laboratory. Toxicity tests will be initiated within 8 weeks of sample collection.

B4.3 Geotechnical Testing

A suite of physical tests are used to evaluate excavation, filling and capping methods, and capacity of existing soils and sediments to provide foundation support for filling/capping material. The following tests will be completed for selected samples collected in the cores (Table A-2).

B4.3.1 Grain Size

Grain size will be analyzed by the hydrometer and sieve method following ASTM Method D422-63 (ASTM 2003), and will provide information on site geologic character and engineering properties of soil/sediment proposed for remediation.

B4.3.2 Atterberg Limits

Atterberg limits will be determined for selected samples of soil and sediment samples in accordance with ASTM D4318-00 (includes organic determination). Atterberg limits, which include the liquid limit, plastic limit, and the plasticity index, are used to define plasticity characteristics of clays and other cohesive sediments.

B4.3.3 Specific Gravity

Specific gravity will be measured on samples selected for engineering properties in accordance with ASTM D854-02. The specific gravity of soil/sediment samples is used to determine sediment removal and the bed consolidation after filling/capping.

B4.3.4 Moisture Content

Moisture content will be measured on selected samples analyzed for engineering properties in accordance with ASTM D-2216. Moisture content is used to determine the initial *in situ* void ratio of the soil/sediment and to estimate the short-term bulking (or increase in volume) during excavation activities.

B5 QUALITY CONTROL

Quality control samples will be prepared in the field and at the laboratories to monitor the bias and precision of the sample collection and analysis procedures.

B5.1 Field Quality Control Samples

Field QC samples for this study will include field replicates and equipment rinse blanks. These field QC samples will minimally be collected for each type of sample at a frequency of 5 percent of the sample total. The procedures for preparing field duplicates and rinse blanks are presented in Section 4.6 and Appendix A of the SAP. Validation criteria and procedures for field QC samples are described in Sections D1 and D2 of this QAPP.

B5.2 Laboratory Quality Control

Extensive and detailed requirements for laboratory QC procedures are provided in the EPA and PSEP protocols that will be used for this study (Table A-8). Every method protocol includes descriptions of QC procedures, and many incorporate additional QC requirements by reference to separate QC chapters. QC requirements include control limits and requirements for corrective action in many cases. QC procedures will be completed by the laboratories, as required in each protocol and as indicated in this QAPP.

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicates or laboratory duplicates, and method blanks will be one for every 20 samples or one per extraction batch, whichever is more frequent. Surrogate spikes and internal standards will be added to every field sample and QC sample, as required. Calibration procedures will be completed at the frequency specified in each method description. As required for EPA SW-846 methods, performance-based control limits have been established by the laboratories. These and all other control limits specified in the method descriptions will be used by the laboratories to establish the acceptability of the data or the need for reanalysis of the samples. Laboratory control limits for recoveries of surrogate compounds, matrix spikes, and laboratory control samples, and

for relative percent difference of matrix spike duplicates and laboratory duplicates, are provided in Appendix K of ARI's QA manual (Attachment 1 to this QAPP) and in Appendix 2 for STL.

Test acceptability for bioassays is based on the source and sensitivity of the test organisms and on the control of physical and chemical conditions in the culture chambers while the test is in progress. Quality control procedures will include negative and positive controls for the toxicity tests; acceptance conditions for the test organisms; and chemical monitoring of the overlying water in the culture chambers. Water quality monitoring for the various toxicity tests will include ammonia, hardness, alkalinity, conductivity, dissolved oxygen, pH, and temperature. Control criteria and procedures are described in Section IX of the QA/QC Manual for NAS (Appendix 3 of this QAPP). Details are provided in each testing protocol (Table A-7).

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Analytical instrument testing, inspection, maintenance, setup, and calibration will be conducted by the laboratories in accordance with the requirements identified in the laboratories' SOPs and manufacturer instructions. In addition, each of the specified analytical methods provides protocols for proper instrument setup and tuning, and critical operating parameters. Instrument maintenance and repair will be documented in maintenance log or record books.

B7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Laboratory instruments will be properly calibrated, and the calibration will be verified with appropriate check standards and calibration blanks for each parameter before beginning each analysis. Instrument calibration procedures and schedules will conform to analytical protocol requirements and descriptions provided in the laboratories' QA plans.

All calibration standards will be obtained from either the EPA repository or a commercial vendor, and the laboratories will maintain traceability back to the National Institute of Standards and Technology. Stock standards will be used to make intermediate standards and calibration standards. Special attention will be given to expiration dating, proper labeling, proper refrigeration, and prevention of contamination. Documentation relating to the receipt, mixing, and use of standards will be recorded in a laboratory logbook. All calibration and spiking standards will be checked against standards from another source.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The quality of supplies and consumables used during sample collection and laboratory analysis can affect the quality of the project data. All equipment that comes into contact with the samples and extracts must be sufficiently clean to prevent detectable contamination, and the analyte concentrations must be accurate in all standards used for calibration and quality control purposes.

During sample collection, solvents of appropriate, documented purity will be used for decontamination. Solvent containers will be dated and initialed when they are opened. The quality of laboratory water used for decontamination will be documented at the laboratory. As discussed in Section B2, cleaned and documented sample containers will be provided by the laboratory. All containers will be visually inspected prior to use, and any suspect containers will be discarded.

Reagents of appropriate purity and suitably cleaned laboratory equipment will also be used for all stages of laboratory analyses. Details for acceptance requirements for supplies and consumables at the laboratories are provided in the laboratory SOPs and QA plans. All supplies will be obtained from reputable suppliers with appropriate documentation or certification. Supplies will be inspected to confirm that they meet use requirements, and certification records will be retained by Integral (i.e., for supplies used in the field) or the laboratory.

B9 NON-DIRECT MEASUREMENTS

Existing chemical data from previous investigations in the Park will be used for this investigation. All historical data were reviewed for quality assurance. Details are provided in section 3.1 of the SAP.

B10 DATA MANAGEMENT

Data for this project will be generated in the field and at the laboratories. The final repository for sample information for the sample collection efforts described in the SAP will be an EQuIS™ database. Procedures to be used to transfer data from the point of generation to the EQuIS™ database are described in this section. Final data will be combined with historical data and summary tables will be created using EQuIS™.

B10.1 Field Data

Data that are generated during sediment collection and sample preparation will be manually entered into the field logbook, core logs, and COC forms. Data from these sources will be entered into the EQuIS™ database directly from the field logbook and core logs. These data include station location coordinates, station names, sampling dates, sample identification codes, and additional station and sample information (e.g., water depth, sample type, field replicate number). All entries will be reviewed for

accuracy and completeness by a second individual, and any errors will be corrected before the data are approved for release to data users.

B10.2 Laboratory Data

A variety of manually entered and electronic instrument data are generated at the laboratories. Data are manually entered into:

- Standard logbooks
- Storage temperature logs
- Balance calibration logs
- Instrument logs
- Sample preparation and analysis worksheets
- Maintenance logs
- Individual laboratory notebooks
- Results tables for conventional analyses (e.g., grain-size distribution, total solids).

All manual data entry into the laboratory information management system (LIMS) is proofed at the laboratory. All data collected from each laboratory instrument, either manually or electronically, are reviewed and confirmed by analysts before reporting. At ARI, the sample information is electronically loaded to temporary files in LIMS and submitted for further review. Forms IV-X for validated data packages are generated in the laboratory and reviewed for correctness in interpretation, conformance with QA requirements, and completeness. Once the data have been accepted, the final results are released to the LIMS for reporting. The LIMS is used to generate the EDD as well as Forms I-III for the data package, providing a single source for reporting of chemical data. The EDD is further spot-checked against the hard copy to ensure that the correct data set is reported for both. A detailed description of procedures for laboratory data management and data review and verification are provided in the laboratory QA plans (Attachments 1 through 3).

Laboratory data will be entered directly into the EQuIS™ database from the EDD. A database printout will be used to verify database entries against the hard-copy laboratory data packages. Electronic data will also be provided to Ecology and EPA in SEDQUAL and EIM import formats, as required.

Table B-1. Required Sample Containers, Preservatives, and Holding Times.[1]

Analysis Type	Matrix	Container Size	Holding Time[1]	Preservation
NWTPH-GRO	Soil/Sediment	4 oz glass with Teflon coated/Septum lid	14 days extraction/analysis	Ice (4°C)
NWTPH-DRO	Soil/Sediment	4 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
SVOCs	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Pesticides/PCBs	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Dioxins/Furans	Soil/Sediment	8 oz glass	14 days extraction/40 days analysis 1 year until analysis	Ice (4°C) Frozen (-18°C)
Metals	Soil/Sediment	4 oz glass	6 months/28 days* 2 years until analysis (except mercury)	Ice (4°C) Frozen (-18°C)
TOC	Soil/Sediment	4 oz glass	14 days 6 months	Ice (4°C) Frozen (-18°C)
Total Sulfides/Ammonia	Soil/Sediment	4 oz glass (zero headspace)	7 days	Ice (4°C)
Grain size	Soil/Sediment	16 oz glass	6 months	Ice (4°C)
Atterburg Limits	Soil/Sediment	Inc.	NA	Ice (4°C)
Specific Gravity	Soil/Sediment	Inc.	NA	Ice (4°C)
Moisture Content/Bulk Density	Soil/Sediment	Inc.	NA	Ice (4°C)
NWTPH-GRO	Water	Two 40-mL glass with Teflon lined Septum lid	14 days extraction/analysis	1+1 HCl to a pH <2 Ice (4°C)
NWTPH-DRO	Water	One 1-liter amber glass	14 days extraction/analysis	1+1 HCl to a pH <2 Ice (4°C)
SVOCs	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Pesticides/PCBs	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Dioxins/Furans	Water	Two 1-liter amber glass	7 days extraction/40 days analysis	Ice (4°C)
Metals	Water	One 1-liter HDPE	6 months/28 days*	Ice (4°C), HNO_3 pH<2

Table B-1. Required Sample Containers, Preservatives, and Holding Times. (continued)

Analysis Type	Matrix	Container Size	Holding Time[1]	Preservation
TOC	Water	One 500-mL HDPE	28 days	Ice (4°C), H_2SO_4 pH<2
TSS	Water	One 1-liter HDPE	--	Ice (4°C)
Hardness	Water	One 1-liter HDPE	--	Ice (4°C)
Bioassays	Sediment	Three 1-liter amber glass	8 weeks	Ice (4°C) No Headspace or Purged with Nitrogen Gas

[1] Storage temperatures and maximum holding times for physical/chemical analyses and sediment toxicity tests (PSEP 1997a,b, Ecology 2003)

* Holding time for mercury is 28 days. Holding time for the other metals is 6 months.

Note: All holding times are from the date of sampling. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis without being qualified.

SECTION C: ASSESSMENT AND OVERSIGHT

This project will rely heavily on the knowledge and experience of the project team. The field team and laboratories will stay in close verbal contact with the Integral project manager and QA manager during all phases of the project. This level of communication will serve to keep the management team appraised of activities and events, and will allow for informal but continuous project oversight. Few scheduled assessment activities are planned for this project because the scope of the sampling and analysis effort and the size of the project team are relatively small.

C1 ASSESSMENTS AND RESPONSE ACTIONS

Assessment activities will include readiness reviews prior to sampling and prior to release of the final data to the data users, and internal review while work is in progress. An informal technical systems audit may be conducted if problems are encountered during any phase of this project.

Readiness reviews are conducted to ensure that all necessary preparations have been made for efficient and effective completion of each critical phase of project work. The first readiness review will be conducted prior to field sampling. The field coordinator will verify that all field equipment is ready for transfer to the site. The field coordinator will also verify that the field team and subcontractor have been scheduled and briefed and that the contract for the subcontractor has been signed by both parties. Any deficiencies noted during this readiness review will be corrected prior to initiation of sampling activities.

The second readiness review will be completed before final data are released for use. The data manager will verify that all results have been received from the laboratories, data validation and data quality assessment have been completed for all of the data, and data qualifiers have been entered into the database and verified. Any deficiencies noted during this review will be corrected by the data manager, the Integral QA manager, or their designee. Data will not be released for final use until all data have been verified and validated. No report will be prepared in conjunction with the readiness reviews. However, the project manager and data users will be notified when the data are ready for use.

Technical review of intermediate and final work products generated for this project will be completed throughout the course of all sampling, laboratory, data validation, data management, and data interpretation activities to ensure that every phase of work is accurate and complete and follows the QA procedures outlined in this QAPP. Any problems that are encountered will be resolved between the reviewer and the person completing the work. Any problems that cannot be easily resolved or that affect the final quality of the work product will be brought to the attention of the Integral and City

of Bellingham project managers. Ecology and EPA will be notified of any problems that may affect the final outcome of the project.

The laboratories have implemented a review system that serves as a formal surveillance mechanism for all laboratory activities. Each phase of work is reviewed by a supervisor before it is approved for release. Details are provided in the laboratory QA plans (Attachments 1 through 3 to this QAPP).

Technical system audits may be conducted if serious problems are encountered during sampling or analysis operations. If completed, these audits will be conducted by the Integral QA manager or designee or by the ARI, STL, or NAS QA manager. These audits may consist of onsite reviews of any phase of field or laboratory activities or data management. Results of any audits will be provided in the RI report.

Any project team member who discovers or suspects a non-conformance is responsible for reporting the non-conformance to the project manager, the Integral QA manager, or the laboratory project or QA manager, as applicable. The project manager will ensure that no additional work dependent on the non-conforming activity is performed until a confirmed non-conformance is corrected.

C2 REPORTS TO MANAGEMENT

Corrective actions will be required if deviations from the methods or QA requirements established in the SAP or this QAPP are encountered. When a non-conformance is identified, corrective action will be taken immediately, if possible. The project manager will be contacted and, if necessary, will provide assistance in resolving the issue. A formal corrective action plan is not likely to be required for a project of this limited scope. However, any non-conformance issue that ultimately affects the quality of the data or results in a change of scope in the work described in the SAP, including this QAPP, will be documented in the field log or field correction record (FCR) to the project manager. This documentation will serve as a Corrective Action Report. A description of the non-conformance issue, the attempted resolution, and any effects on data quality or usability will be provided in the RI report.

The laboratories have implemented routine systems of reporting non-conformance issues and their resolution. These procedures are described in the laboratory QA plans (Attachment 1 through 3 to this QAPP). Laboratory non-conformance issues will also be described in the RI report if they affect the quality of the project data.

SECTION D: DATA VALIDATION AND USABILITY

Data generated in the field and at the laboratories will be verified and validated according to criteria and procedures described in this section. Data quality and usability will be evaluated, and a discussion will be included in the RI report.

D1 CRITERIA FOR DATA REVIEW, VERIFICATION, AND VALIDATION

Field and laboratory data for this project will undergo a formal verification and validation process. All entries into the database will be verified. All errors found during the verification of field data, laboratory data, and the database will be corrected prior to release of the final data.

Data verification and validation for organic compounds and metals will be completed according to methods described in the EPA Region 10 SOP for validation of dioxins and furans (USEPA 1996) and in the functional guidelines for organic and inorganic data review (USEPA 1999, 2002b). Data will be qualified as estimated as necessary if results for laboratory control samples, matrix spike samples, and matrix spike or laboratory duplicates do not meet measurement quality objectives provided in Table A-8 or if control limits for any other QC sample or procedure do not meet performance-based control limits. Performance-based control limits are established periodically by the laboratories. Current values are provided in Appendix K of the laboratory QA plan (Attachment 1 to this QAPP) and, for STL, in Attachment 2 of this QAPP.

No guidelines are available for validation of data for TOC, grain size, Atterberg limits, and specific gravity. These data will be validated using procedures described in the functional guidelines for inorganic data review (USEPA 2002b), as applicable. The MQOs for accuracy (Table A-8) will be used as control limits for matrix spike recovery, and the MQO for precision will be used as the control limit for laboratory duplicate or triplicate analyses. Performance-based control limits will be used to qualify these data if results for other quality control samples do not meet control limits.

Results for field duplicates will be evaluated using the MQOs provided in Table A-8. Data will not be qualified as estimated if the MQOs are exceeded, but RPD results will be tabulated, and any exceedances will be discussed in the RI report. Equipment rinse blanks will be evaluated and data qualifiers will be applied in the same manner as method blanks, as described in the functional guidelines for data review (USEPA 1996, 1999, 2002b).

Data will be rejected if control limits for acceptance of data are not met, as described in EPA (1996, 1999, 2002b).

D2 VERIFICATION AND VALIDATION METHODS

Field data will be verified during preparation of samples and COCs. Field data and COCs will be reviewed by the field coordinator after the field effort is complete. After field data are entered into the project database, 100 percent verification of the entries will be completed to ensure the accuracy and completeness of the database. Any discrepancies will be resolved before the final database is released for use.

Procedures for verification and validation of laboratory data and field QC samples will be completed as described in the functional guidelines and SOP for data validation (USEPA 1996, 1999, 2002b) and summarized in Section D1, above. The accuracy and completeness of the database will be verified at the laboratory when the EDDs are prepared and again as part of data validation. All entries to the database from the laboratory EDDs will be checked against the hard-copy data packages. Data validation will be completed by a subcontracted data validation firm.

In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use.

Method reporting limit goals for this project are provided in Tables A-3 through A-7. Reporting limits for non-detects will be compared to the method reporting limit goals to evaluate method sensitivity for each sample. Any exceedance of actual MRLs over the target MRLs will be discussed in the RI report.

D3 RECONCILIATION WITH USER REQUIREMENTS

The goal of data validation is to determine the quality of each data point and to identify data points that do not meet the project MQOs. Nonconforming data may be qualified as estimated or rejected as unusable during data validation if criteria for data quality are not met. Rejected data will not be used for any purpose. An explanation of the rejected data will be included in the RI report.

Data qualified as estimated will be used to evaluate the site and will be appropriately qualified in the final project database. These data are less precise or less accurate than unqualified data. The data users, in cooperation with the Integral project manager and QA manager, are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses for this study. The data quality discussion in the RI report will include all available information regarding the direction or magnitude of bias or the degree of imprecision for qualified data to facilitate the assessment of data usability. The RI report will also include a discussion of data limitations and their effect on data interpretation activities.

SECTION E: REFERENCES

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ATTACHMENTS 1 - 3

Analytical Resources, Inc.
Quality Assurance Plan

Severn Trent Laboratories, Inc.
Quality Assurance Plan

Northwest Aquatic Sciences, Inc.
Quality Assurance Plan

(Attached CD)

Preliminary Screening Benchmarks for All Sediment Analytes

Analyte	Units	MTCA Method B Direct Human Contact [a]	MTCA Ecological Indicator Plants Conc. [b]	MTCA Ecological Indicator Soil biota Conc. [b]	MTCA Ecological Indicator Wildlife Conc. [b]	Washington State (Ecol. 95 Marine) Normalized SQS [c]	Washington State (Ecol. 95 Marine) Normalized CSL [c]	Washington State (Ecol. 95 Marine) Denormalized SQS [d]	Washington State (Ecol. 95 Marine) Denormalized CSL [d]	Washington State (Ecol. 03 FW) LAET	Washington State (Ecol. 03 FW) 2LAET	USEPA Region 9 PRG Leaching [e]	Preliminary Screening Benchmark	Puget Sound Background f	Selected Screening Benchmark	Screening Benchmark Source
Dioxins																
1,2,3,4,6,7,8-HpCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,4,6,7,8-HpCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,4,7,8,9-HpCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,4,7,8-HxCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,4,7,8-HxCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,6,7,8-HxCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,6,7,8-HxCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,7,8,9-HxCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,7,8,9-HxCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,7,8-PeCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,3,7,8-PeCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2,3,4,6,7,8-HxCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2,3,4,7,8-PeCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2,3,7,8-TCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2,3,7,8-TCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
OCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
OCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total HpCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total HpCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total HxCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total HxCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total PeCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total PeCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total TCDD	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Total TCDF	ng/Kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
TEQ (ND=0.5 DL)	ng/Kg	6.67	NV	NV	2	NV	NV			NV	NV	NV	2	19	19	Puget Sound Background
SVOCs																
PAHs																
2-Methylnaphthalene	mg/kg	1600	NV	NV	NV	*38*	*64*	*0.380*	*0.640*	0.469	0.555	NV	0.38	NV	0.38	Ecology SQS
Acenaphthene	mg/kg	4800	20	NV	NV	*16*	*57*	*0.160*	*0.570*	1.06	1.32	570	0.16	NV	0.16	Ecology SQS
Acenaphthylene	mg/kg	NV	NV	NV	NV	*66*	*66*	*0.660*	*0.660*	0.47	0.64	NV	0.47	NV	0.47	Ecology LAET
Anthracene	mg/kg	24000	NV	NV	NV	*220*	*1200*	*2.200*	*12.000*	1.23	1.58	12000	1.23	NV	1.23	Ecology LAET
Benzo(a)anthracene	mg/kg	0.137	NV	NV	NV	*110*	*270*	*1.100*	*2.700*	4.26	5.8	2	0.137	NV	0.137	MTCA Method B
Benzo(a)pyrene	mg/kg	0.137	NV	NV	12	*99*	*210*	*0.990*	*2.100*	3.3	4.81	8	0.137	NV	0.137	MTCA Method B
Benzo(b)fluoranthene	mg/kg	0.137	NV	NV	NV	NV	NV			NV	NV	5	0.137	NV	0.137	MTCA Method B
Benzo(g,h,i)perylene	mg/kg	NV	NV	NV	NV	*31*	*78*	*0.310*	*0.780*	4.02	5.2	NV	0.31	NV	0.31	Ecology SQS
Benzo(j)fluoranthene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo(k)fluoranthene	mg/kg	0.137	NV	NV	NV	NV	NV			NV	NV	49	0.137	NV	0.137	MTCA Method B
Chrysene	mg/kg	0.137	NV	NV	NV	*110*	*460*	*1.100*	*4.600*	5.94	6.4	160	0.137	NV	0.137	MTCA Method B
Dibenzo(a,h)anthracene	mg/kg	0.137	NV	NV	NV	*12*	*33*	*0.120*	*0.330*	0.8	0.839	2	0.12	NV	0.12	Ecology SQS
Fluoranthene	mg/kg	3200	NV	NV	NV	*160*	*1200*	*1.600*	*12.000*	11.1	15	4300	1.6	NV	1.6	Ecology SQS
Fluorene	mg/kg	3200	NV	30	NV	*23*	*79*	*0.230*	*0.790*	1.07	3.85	560	0.23	NV	0.23	Ecology SQS
Indeno(1,2,3-cd)pyrene	mg/kg	0.137	NV	NV	NV	*34*	*88*	*0.340*	*0.880*	4.12	5.3	14	0.137	NV	0.137	MTCA Method B
Naphthalene	mg/kg	1600	NV	NV	NV	*99*	*170*	*0.990*	*1.700*	0.529	1.31	84	0.529	NV	0.529	Ecology LAET

Preliminary Screening Benchmarks for All Sediment Analytes

Analyte	Units	MTCA Method B Direct Human Contact [a]	MTCA Ecological Indicator Plants Conc. [b]	MTCA Ecological Indicator Soil biota Conc. [b]	MTCA Ecological Indicator Wildlife Conc. [b]	Washington State (Ecol. 95 Marine) Normalized SQS [c]	Washington State (Ecol. 95 Marine) Normalized CSL [c]	Washington State (Ecol. 95 Marine) Denormalized SQS [d]	Washington State (Ecol. 95 Marine) Denormalized CSL [d]	Washington State (Ecol. 03 FW) LAET	Washington State (Ecol. 03 FW) 2LAET	USEPA Region 9 PRG Leaching [e]	Preliminary Screening Benchmark	Puget Sound Background f	Selected Screening Benchmark	Screening Benchmark Source
Phenanthrene	mg/kg	NV	NV	NV	NV	*100*	*480*	*1.000*	*4.800*	6.1	7.57	NV	1	NV	1	Ecology SQS
Pyrene	mg/kg	2400	NV	NV	NV	*1000*	*1400*	*10.000*	*14.000*	8.79	16	4200	8.79	NV	8.79	Ecology LAET
Total Benz(bk)fluoranthenes	mg/kg	NV	NV	NV	NV	*230*	*450*	*2.300*	*4.500*	11	13.8	NV	2.3	NV	2.3	Ecology SQS
Total HPAH	mg/kg	NV	NV	NV	NV	*960*	*5300*	*9.600*	*53.000*	31.64	54.8	NV	9.6	NV	9.6	Ecology SQS
Total LPAH	mg/kg	NV	NV	NV	NV	*370*	*780*	*3.700*	*7.800*	6.59	9.2	NV	3.7	NV	3.7	Ecology SQS
Other																
(Z)6-Pentadecen-1-ol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,1'-Biphenyl, 2,3'-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,1'-Biphenyl, 2,4'-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,1'-Biphenyl, 2-ethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2,4-Trichlorobenzene	mg/kg	800	NV	20	NV	*0.81*	*1.8*	*0.008*	*0.018*	NV	NV	5	0.0081	NV	0.0081	Ecology SQS
1,2:7,8-Dibenzphenanthrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,2-Dichlorobenzene	mg/kg	7200	NV	NV	NV	*2.3*	*2.3*	*0.023*	*0.023*	NV	NV	17	0.023	NV	0.023	Ecology SQS
1,2-Diphenylhydrazine	mg/kg	1.25	NV	NV	NV	NV	NV			NV	NV	NV	1.25	NV	1.25	MTCA Method B
1,3,5-Tribromophenol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,3,6,10-Cyclotetradecatetraene, 3,7,11-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,3,6-Octatriene, 3,7-dimethyl-, (Z)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,3,7-Octatriene, 3,7-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1,3-Dichlorobenzene	mg/kg	16	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	16	MTCA Method B
1,4-Dichlorobenzene	mg/kg	41.7	NV	20	NV	*3.1*	*9*	*0.031*	*0.090*	NV	NV	2	0.031	NV	0.031	Ecology SQS
11H-Benzo[b]fluorene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
13-Docosenoic acid, methyl ester, (Z)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
19-Norpregn-4-ene-3,20-dione, 10-vinyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1'H-Cholest-2-eno[3,2-b]indole, 5'-chloro	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1H-Indene, 1-ethylidene-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1H-Indene, 5-butyl-6-hexyloctahydro-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1H-Indene, octahydro-2,2,4,4,7,7-hexam	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1H-Indene, octahydro-2,3a,4-trimethyl-2-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1-Methylnaphthalene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1-Nonene, 4,6,8-trimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
1-Phenanthrenecarboxaldehyde, 1,2,3,4,	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2(1H)-Naphthalenone, octahydro-1,4a-di	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2,4,5-Trichlorophenol	mg/kg	8000	4	9	NV	NV	NV			NV	NV	270	4	NV	4	MTCA TEE plant
2,4,6-Trichlorophenol	mg/kg	90.9	NV	10	NV	NV	NV			NV	NV	0.2	0.2	NV	0.2	Region 9 Leaching
2,4-Dichlorophenol	mg/kg	240	NV	NV	NV	NV	NV			NV	NV	1	1	NV	1	Region 9 Leaching
2,4-Dimethylphenol	mg/kg	1600	NV	NV	NV	0.029	0.029			NV	NV	9	0.029	NV	0.029	Ecology SQS
2,4-Dinitrophenol	mg/kg	160	20	NV	NV	NV	NV			NV	NV	0.3	0.3	NV	0.3	Region 9 Leaching
2,4-Dinitrotoluene	mg/kg	160	NV	NV	NV	NV	NV			NV	NV	0.0008	0.0008	NV	0.0008	Region 9 Leaching
2,6-Dinitrotoluene	mg/kg	80	NV	NV	NV	NV	NV			NV	NV	0.0007	0.0007	NV	0.0007	Region 9 Leaching
2-Aminodiphenylsulphone	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2-Chloronaphthalene	mg/kg	4900	NV	NV	NV	NV	NV			NV	NV	NV	4900	NV	4900	MTCA Method B
2-Chlorophenol	mg/kg	400	NV	NV	NV	NV	NV			NV	NV	4	4	NV	4	Region 9 Leaching
2-Methylphenol	mg/kg	4000	NV	NV	NV	0.063	0.063			NV	NV	15	0.063	NV	0.063	Ecology SQS
2-Nitroaniline	mg/kg	1.7	NV	NV	NV	NV	NV			NV	NV	NV	1.7	NV	1.7	MTCA Method B

Preliminary Screening Benchmarks for All Sediment Analytes

Analyte	Units	MTCA Method B Direct Human Contact [a]	MTCA Ecological Indicator Plants Conc. [b]	MTCA Ecological Indicator Soil biota Conc. [b]	MTCA Ecological Indicator Wildlife Conc. [b]	Washington State (Ecol. 95 Marine) Normalized SQS [c]	Washington State (Ecol. 95 Marine) Normalized CSL [c]	Washington State (Ecol. 95 Marine) Denormalized SQS [d]	Washington State (Ecol. 95 Marine) Denormalized CSL [d]	Washington State (Ecol. 03 FW) LAET	Washington State (Ecol. 03 FW) 2LAET	USEPA Region 9 PRG Leaching [e]	Preliminary Screening Benchmark	Puget Sound Background f	Selected Screening Benchmark	Screening Benchmark Source
2-Nitrophenol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2-Phenylnaphthalene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
2-Propenoic acid, 3-(4-methoxyphenyl)-,	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3&4-Methylphenol	mg/kg	310	NV	NV	NV	NV	NV			NV	NV	NV	310	NV	310	MTCA Method B
3,3'-Dichlorobenzidine	mg/kg	2.22	NV	NV	NV	NV	NV			NV	NV	0.007	0.007	NV	0.007	Region 9 Leaching
3,4-Dihydro-2,5,8-trimethyl-2-(4,8,12-trim	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3,4-Dihydroxy-5-methoxybenzaldehyde	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3,4-Dihydroxy-5-methoxybenzaldehyde (2	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3,4-Octadiene, 7-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3-Fluoranthenamine	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
3-Nitroaniline	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4,6-Dinitro-2-methylphenol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Aminodiphenylsulphone	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Bromophenyl-phenylether	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Chloro-3-Methylphenol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Chloroaniline	mg/kg	320	NV	NV	NV	NV	NV			NV	NV	0.7	0.7	NV	0.7	Region 9 Leaching
4-Chlorophenyl-phenylether	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Methylphenol	mg/kg	400	NV	NV	NV	0.67	0.67			0.76	2.36	NV	0.67	NV	0.67	Ecology SQS
4-Nitroaniline	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
4-Nitrophenol	mg/kg	NV	NV	7	NV	NV	NV			NV	NV	NV	7	NV	7	MTCA TEE soil
5H-Dibenzo[a,d]cyclohepten-5-ol, 10,11-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
5H-Dibenzo[a,d]cycloheptene, 5-methyle	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
7,12-Dimethylbenz(a)anthracene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
7,9-Di-t-butyl-1-oxaspiro[4,5]deca-6,9-die	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
7H-Dibenzo(c,g)carbazole	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9,19-Cyclolanost-23-ene-3,25-diol, (3.bet	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9,9'-Biphenanthrene, octacosahydro-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9-Eicosyne	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9-Eicosyne (2)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9-Eicosyne (3)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
9H-Fluorene, 9-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Acetamide, N-methyl-N-[4-[4-methoxy-1-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Androst-5-en-17-one, 3-(acetyloxy)-, cycl	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
A'-Neogammacer-22(29)-en-3-one	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
A'-Neogammacer-22(29)-en-3-one (2)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
A'-Neogammacer-22(29)-en-3-one (3)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Aniline	mg/kg	175	NV	NV	NV	NV	NV			NV	NV	NV	175	NV	175	MTCA Method B
Anthracene, 1-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Anthracene, 9-butyltetradecahydro-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benz[a]anthracene, 1-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benz[a]anthracene, 9-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benz[e]acephenanthrylene	mg/kg	0.137	NV	NV	NV	NV	NV			NV	NV	NV	0.137	NV	0.137	MTCA Method B
Benz[j]aceanthrylene, 3-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzene, 1,2,3,4-tetramethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzene, 2-methoxy-1,3,5-trimethyl-4-nit	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--

Preliminary Screening Benchmarks for All Sediment Analytes

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Benzenesulfonamide, N,4-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzidine	mg/kg	0.00435	NV	NV	NV	NV	NV			NV	NV	NV	0.00435	NV	0.00435	MTCA Method B
Benzo[b]chrysene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[b]naphtho[2,1-d]thiophene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[b]naphtho[2,3-d]furan	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[b]triphenylene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[b]triphenylene (2)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[c]phenanthrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzo[e]pyrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzoic acid	mg/kg	320000	NV	NV	NV	0.65	0.65			2.91	3.79	400	0.65	NV	0.65	Ecology SQS
Benzothiazole, 2-(methylthio)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzoylformic acid	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Benzyl alcohol	mg/kg	24000	NV	NV	NV	0.057	0.073			NV	NV	NV	0.057	NV	0.057	Ecology SQS
Bicyclo[4.1.0]heptane, 3,7,7-trimethyl-, [1	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
bis(2-Chloroethoxy)methane	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
bis(2-Chloroethyl)ether	mg/kg	0.909	NV	NV	NV	NV	NV			NV	NV	0.0004	0.0004	NV	0.0004	Region 9 Leaching
bis(2-chloroisopropyl)ether	mg/kg	3200	NV	NV	NV	NV	NV			NV	NV	NV	3200	NV	3200	MTCA Method B
bis(2-Ethylhexyl)phthalate	mg/kg	71.4	NV	NV	NV	*47*	*78*	*0.470*	*0.780*	2.52	6.38	NV	0.47	NV	0.47	Ecology SQS
Butylbenzylphthalate	mg/kg	16000	NV	NV	NV	*4.9*	*64*	*0.049*	*0.640*	0.26	0.366	930	0.049	NV	0.049	Ecology SQS
Carbazole	mg/kg	50	NV	NV	NV	NV	NV			0.923	NV	0.6	0.6	NV	0.6	Region 9 Leaching
Cholest-7-ene, (5.alpha.,14.beta.)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Cyclopentane, 1,1'-[3-(2-cyclopentylethyl	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
D:A-Friedoolean-6-ene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Decane 3-cyclohexyl-, 3-cyclohexyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
d-Homoandrostane, (5.alpha.)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
D-Homoandrostane, (5.alpha.,13.alpha.)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,e)pyrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,h)acridine	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,h)pyrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,i)pyrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,j)acridine	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzo(a,l)pyrene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dibenzofuran	mg/kg	290	NV	NV	NV	*15*	*58*	*0.150*	*0.580*	0.399	0.443	NV	0.15	NV	0.15	Ecology SQS
Diethylphthalate	mg/kg	64000	100	NV	NV	*61*	*110*	*0.610*	*1.100*	NV	NV	NV	0.61	NV	0.61	Ecology SQS
Dimethylphthalate	mg/kg	80000	NV	200	NV	*53*	*53*	*0.530*	*0.530*	0.311	0.436	NV	0.311	NV	0.311	Ecology LAET
di-n-Butylphthalate	mg/kg	8000	200	NV	NV	*220*	*1700*	*2.200*	*17.000*	0.103	NV	2300	0.103	NV	0.103	Ecology LAET
di-n-Octylphthalate	mg/kg	1600	NV	NV	NV	*58*	*4500*	*0.580*	*45.000*	0.011	0.201	10000	0.011	NV	0.011	Ecology LAET
Dodecanamide, N,N-bis(2-hydroxyethyl)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dodecane, 1-cyclopentyl-4-(3-cyclopenty	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Dotriacontane	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Eicosane, 7-hexyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Formamide, N,N'-2,6-piperazinediylidene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Germacrene B	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Germanicol	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Hexachlorobenzene	mg/kg	0.625	NV	NV	17	*0.38*	*2.3*	*0.004*	*0.023*	NV	NV	2	0.0038	NV	0.004	Ecology LAET

Preliminary Screening Benchmarks for All Sediment Analytes

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Hexachlorobutadiene	mg/kg	12.8	NV	NV	NV	*3.9*	*6.2*	*0.039*	*0.062*	NV	NV	2	0.039	NV	0.039	Ecology LAET
Hexachlorocyclopentadiene	mg/kg	480	10	NV	NV	NV	NV			NV	NV	400	10	NV	10	MTCA TEE plant
Hexachloroethane	mg/kg	71.4	NV	NV	NV	NV	NV			NV	NV	0.5	0.5	NV	0.5	Region 9 Leaching
Hexadecane, 2,6,11,15-tetramethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Hexanedioic acid, bis(2-ethylhexyl) ester	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Isophorone	mg/kg	1050	NV	NV	NV	NV	NV			NV	NV	0.5	0.5	NV	0.5	Region 9 Leaching
m-Nitroaniline	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
N,N'-Bis(pentamethylene)thiuramtetrasul	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 1-(2-propenyl)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 1,2-dihydro-4-phenyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 1,2-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 1,4-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 1,7-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, 2,6-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphthalene, decahydro-2,6-dimethyl-3-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Nitrobenzene	mg/kg	40	NV	40	NV	NV	NV			NV	NV	0.1	0.1	NV	0.1	Region 9 Leaching
n-Nitrosodimethylamine	mg/kg	0.0196	NV	NV	NV	NV	NV			NV	NV	NV	0.0196	NV	0.0196	MTCA Method B
n-Nitroso-di-n-propylamine	mg/kg	0.143	NV	NV	NV	NV	NV			NV	NV	0.00005	0.00005	NV	0.00005	Region 9 Leaching
N-nitrosodiphenylamine	mg/kg	204	NV	20	NV	*11*	*11*	*0.110*	*0.001*	NV	NV	1	0.0011	NV	0.11	Ecology SQS
Nonadecane	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Nonadecane, 2-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Olean-13(18)-ene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Olean-18-ene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pentachlorophenol	mg/kg	8.33	3	6	4.5	0.36	0.69			NV	NV	0.03	0.03	NV	0.03	Region 9 Leaching
Pentalene, octahydro-1-(2-octyldecyl)-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenanthrene, 2,3-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenanthrene, 2-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenanthrene, 4-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenanthrene, 5,6-dihydro-5-azido-6-hyd	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenanthrene, 9,10-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Phenol	mg/kg	48000	70	30	NV	0.42	1.2			NV	NV	100	0.42	NV	0.42	Ecology SQS
Phenol, 2,2'-methylenebis[6-(1,1-dimethy	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pregnane-3,20-dione, 11-hydroxy-, (5.alp	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pyrene, 1,3-dimethyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pyrene, 1-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pyrene, 2-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Pyridine	mg/kg	80	NV	NV	NV	NV	NV			NV	NV	NV	80	NV	80	MTCA Method B
Retene	mg/kg	NV	NV	NV	NV	NV	NV			6.02	NV	NV	6.02	NV	6.02	Ecology LAET
Squalene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Tetrachlorophenols	mg/kg	2400	NV	20	NV	NV	NV			NV	NV	NV	20	NV	20	MTCA TEE soil
Tetradecane	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Tetratriacontane, 17-hexadecyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Triphenylene	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Triphenylene, 2-methyl-	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--

Preliminary Screening Benchmarks for All Sediment Analytes

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Unknown Alkane Hydrocarbon	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Unknown Alkene Hydrocarbon	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Unknown Alkene Hydrocarbon (2)	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Unknown Alkyl Aromatic Hydrocarbon	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Unknown PAH	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Vitamin E	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
EPH												NV	NV	NV		
C10-C12 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C10-C12 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C12-C16 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C12-C16 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C16-C18 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C16-C18 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C18-C21 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C18-C21 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C21-C28 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C21-C28 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C28-C36 Aliphatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
C28-C36 Aromatics	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Petroleum Hydrocarbons																
TPH	mg/kg	2000	NV	200	NV	NV	NV			NV	NV	NV	200	NV	200	MTCA TEE soil
Metals																
Aluminum	mg/kg	76000	50	NV	NV	NV	NV			NV	NV	NV	50	32600	32600	Puget Sound Bkgd
Antimony	mg/kg	32	5	NV	NV	NV	NV			0.6	1.9	5	0.6	NV	0.6	Ecology LAET
Arsenic	mg/kg	0.667	10	60	132	57	93			31.4	50.9	29	0.667	7	7	Puget Sound Bkgd
Barium	mg/kg	5600	500	NV	102	NV	NV			NV	NV	1600	102	NV	102	MTCA TEE wildlife
Beryllium	mg/kg	160	10	NV	NV	NV	NV			0.46	NV	63	0.46	0.6	0.6	Puget Sound Bkgd
Cadmium	mg/kg	80	4	20	14	5.1	6.7			2.39	2.9	8	2.39	1	2.39	LAET
Calcium	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Chromium	mg/kg	240	42	42	67	260	270			95	133	38	38	48	48	Puget Sound Bkgd
Cobalt	mg/kg	NV	20	NV	NV	NV	NV			NV	NV	NV	20	NV	20	MTCA TEE plant
Copper	mg/kg	2960	100	50	217	390	390			619	829	NV	50	36	50	MTCA TEE soil
Iron	mg/kg	23000	NV	NV	NV	NV	NV			NV	NV	NV	23000	58700	58700	Puget Sound Bkgd
Lead	mg/kg	250	50	500	118	450	530			335	431	NV	50	24	50	MTCA TEE plant
Magnesium	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Manganese	mg/kg	11200	1100	NV	1500	NV	NV			NV	NV	NV	1100	1200	1200	Puget Sound Bkgd
Mercury	mg/kg	24	0.3	0.1	5.5	0.41	0.59			0.8	3.04	NV	0.1	0.07	0.1	MTCA TEE soil
Nickel	mg/kg	1600	30	200	980	NV	NV			53.1	113	130	30	48	48	Puget Sound Bkgd
Potassium	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Selenium	mg/kg	400	1	70	0.3	NV	NV			NV	NV	5	0.3	NV	0.3	MTCA TEE wildlife
Silver	mg/kg	400	2	NV	NV	6.1	6.1			0.545	3.5	34	0.545	NV	0.545	LAET
Sodium	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Thallium	mg/kg	5.6	1	NV	NV	NV	NV			NV	NV	NV	1	NV	1	MTCA TEE plant
Vanadium	mg/kg	560	2	NV	NV	NV	NV			NV	NV	6000	2	NV	2	MTCA TEE plant
Zinc	mg/kg	24000	86	200	360	410	960			683	1080	12000	86	85	86	MTCA TEE plant

Preliminary Screening Benchmarks for All Sediment Analytes

Analyte	Units	MTCA Method B Direct Human Contact [a]	MTCA Ecological Indicator Plants Conc. [b]	MTCA Ecological Indicator Soil biota Conc. [b]	MTCA Ecological Indicator Wildlife Conc. [b]	Washington State (Ecol. 95 Marine) Normalized SQS [c]	Washington State (Ecol. 95 Marine) Normalized CSL [c]	Washington State (Ecol. 95 Marine) Denormalized SQS [d]	Washington State (Ecol. 95 Marine) Denormalized CSL [d]	Washington State (Ecol. 03 FW) LAET	Washington State (Ecol. 03 FW) 2LAET	USEPA Region 9 PRG Leaching [e]	Preliminary Screening Benchmark	Puget Sound Background f	Selected Screening Benchmark	Screening Benchmark Source
Conventionals												NV	NV	NV	NV	
<Sieve 200	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 0.25	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 0.5	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 004	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 010	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 020	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 040	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 060	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 140	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Sieve 200	percent	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
TOC	mg/kg	NV	NV	NV	NV	NV	NV			98200	NV	NV	98200	NV	98200	LAET
AVS/SEM																
Cadmium	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Copper	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Lead	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Mercury	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Nickel	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--
Zinc	mg/kg	NV	NV	NV	NV	NV	NV			NV	NV	NV	NV	NV	NV	--

a: Obtained from CLARC 3.1 or, if missing in CLARC 3.1, from USEPA Region 9 PRGs: http://www.epa.gov/region09/waste/sfund/prg/index.htm. Toxicity data were not checked to see of they had been updated since November 2001.
b: Obtained from MTCA Table 749-3.
c: Obtained from WAC 173-204 (Ecology 1995).
d: Italicized values were originally normalized; values have been denormalized for consistency with soil screening values
e: Obtained from USEPA Region 9 PRGs. Dilution attenuation factor of 20 selected for the unsaturated zone.
f: Obtained from Ecology 94-115. Dioxin TEQ background obtained from Ecology 00-03-045 and 99-333.

DRAFT FINAL

ECOLOGY TOXICS CLEANUP PROGRAM
EPA BROWNFIELDS PROGRAM

HEALTH AND SAFETY PLAN

Little Squalicum Park
Remedial Investigation/Feasibility Study
Bellingham, WA

Prepared for

City of Bellingham

Parks & Recreation Department
3424 Meridian Street
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July 29, 2005

The Health and Safety Plan (HASP) will be provided with the final Work Plans.