Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Remedial Investigation

QUALITY ASSURANCE PROJECT PLAN: POREWATER SAMPLING OF LOWER DUWAMISH WATERWAY APPENDICES A – D

FINAL

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

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APPENDIX A. HEALTH AND SAFETY PLAN

By their signature, the undersigned certify that this Health and Safety Plan (HSP) is approved and that it will be used to govern health and safety aspects of fieldwork described in the Quality Assurance Project Plan to which it is attached.

Name	Date
Windward Project Manager	

Name	Date
Corporate Health and Safety Manager	

Name	Date
Field Coordinator/Health and Safety Officer	

Acronyms

Acronym	Definition
CPR	cardiopulmonary resuscitation
CSO	combined sewer overflow
EPA	US Environmental Protection Agency
FC	field coordinator
GPS	global positioning system
HSM	Project Health and Safety Manager
HSO	Field Health and Safety Officer
HSP	health and safety plan
LDW	Lower Duwamish Waterway
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PFD	personal flotation device
PPE	personal protective equipment
PM	project manger
QAPP	Quality Assurance Project Plan
RSS	Research Support Services, Inc.
TM	task manager
TBT	tributyltin

A.1.0 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29CFR1910§120. The procedures and guidelines contained in this plan are based on generally recognized health and safety practices. Any changes or revisions to this plan will be made by a written amendment, which will become a permanent part of this plan. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with collection and handling of porewater samples in the Lower Duwamish Waterway (LDW). During site work, this HSP will be implemented by Windward's Field Coordinator (FC), who is also the designated site Health and Safety Officer (HSO), in cooperation with Windward's Corporate Health and Safety Manager (HSM) and Windward's Project Manager (PM).

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of preliminary chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

Observers for the porewater sampling event who are not field personnel will be given a safety briefing by the HSO on physical and chemical hazards. Observers will be advised of chemicals that may be present at the site and where those chemicals may be located. In addition, appropriate attire and any precautions necessary while walking along the shoreline will be discussed.

A.2.0 Site Description and Project Scope

A.2.1 Site Description

The sampling area is in the LDW (see Figure 2-2 in the attached QAPP). The area is affected by tidal fluctuations. The QAPP to which this HSP is attached provides complete details of the sampling program. The following section summarizes the types of work that will be performed during field activities.

A.2.2 Scope and Duration of Work

Porewater samples will be collected with peepers and mini piezometers from select locations for chemical analysis. Sampling with mini piezometers will begin June 6 Deployment of peeper will occur the week of June 13, 2005 and retrieval will occur the week of June 28, 2005. Intertidal porewater sampling locations will be accessed by land or water. Subtidal locations will be accessed by scuba divers.

A.3.0 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HSP.

Task Manager: The task manger (TM) has overall responsibility for the successful outcome of the project. The TM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The TM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the FC and HSO will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP.

The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee shall be present during sampling and operations.

Windward's Corporate Health and Safety Manager: The HSM has overall responsibility for preparation, approval, and revisions of this HSP. The HSM will not necessarily be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew and Dive Team: All field crew and dive team members must be familiar with and comply with the information in this HSP. They also have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately. The dive team members must also adhere to practices in the Diver Safety Manual (RSS).

A.4.0 Hazard Evaluation and Control Measures

This section covers potential physical and chemical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section A.4.3, lists the potential hazards associated with each site activity and the recommended site controls to be used to minimize each potential hazard.

Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

A.4.1 Physical Hazards

For this project, it is anticipated that physical hazards will present a greater risk of injury than chemical hazards. Physical hazards are identified and discussed below.

A.4.1.1 Slips, trips, and falls

As with all fieldwork sites, caution should be exercised to prevent slips, trips, and falls on slick or uneven surfaces. In particular, care should be used in rainy conditions, on the shoreline, and when getting on or off the boat to access the shoreline. Debris, including slick rocks, pieces of wood or pilings, vegetation, and other objects, are found along the shoreline throughout the LDW. Before sampling activities begin, there will be a training session for all field personnel on the physical hazards to be aware of both on the boat and on shore.

Slips can be minimized by wearing boots with good tread, made of material that does not become overly slippery when wet. Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking. Falls may be avoided by working as far from exposed edges as possible, by erecting railings, and by using fall protection when working on elevated platforms. For this project, no work is anticipated that would present a fall hazard.

A.4.1.2 Sampling equipment

Sampling equipment, including GPS, Hydrolab, peepers, piezometers, syringes and digital cameras, may be used onshore or from a boat, depending on whether the location is intertidal or subtidal, respectively. The sampling methodologies are not anticipated to be labor intensive; however, care will be taken to ensure safe use of all equipment. Before field activities begin, there will be a training session for all field personnel in use of sampling equipment. Section A.4.1.8 discusses hazards associated with scuba diving.

A.4.1.3 Falling overboard

Access to some sampling locations will be from a boat. As with any work from a floating platform, there is a chance of falling overboard. Personal flotation devices (PFDs) will be worn by all field personnel in the boat.

A.4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

A.4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress, hypothermia, or frostbite are not anticipated. The sampling will occur during the time of year when extreme weather conditions are not expected to occur.

A.4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

In the event of heavy rain, field team members will not sample near a flowing CSO because of potentially high concentrations of fecal coliform bacteria.

A.4.1.7 Sharp objects

Sampling operations might result in exposure of field personnel to sharp objects on top of or buried within the sediment. If encountered, field personnel should not touch these objects. Also, field personnel should use a shovel or other tool and not dig in the sediment by hand.

A.4.1.8 Scuba diving

Scuba diving presents an array of risks not common to a normal worksite. Therefore, tasks that involve diving will be performed by a professional diver who has been properly trained and certified and is aware of the myriad inherent risks involved with scuba diving in hazardous environments. With proper training, the risk of these potential hazards can be minimized. Commercial divers provided by RSS will adhere to the Diver Safety Manual (RSS).

The diver will dive line-tended, with wireless communication to the surface. A safety diver will tend the line and wear a headset to talk with the diver in the water. The safety diver will also be suited up and ready to don gear if necessary. In the unlikely event that the in-water diver required assistance, he could be retrieved with the tending line or assisted by the safety diver. Emergency oxygen and first aid would be on the boat, as well as a dive plan (Attachment A2) that will list local hospitals and dive-related emergency contact information.

Equipment failure is always a concern. The diver should be familiar with his/her specific type of equipment and check the tank, regulator, BCD, gauges, and any other equipment to make sure everything is in proper working order prior to use. The compressed air supply is filled by a local dive store so an air check is not necessary.

The diver is also equipped with a pony bottle, which is a small emergency (bailout) air tank.

Divers must be careful to avoid pilings and other obstacles that might snag gear or entrap the diver. Having a clear sense of the layout of the area before getting in the water and taking extra caution during times of low visibility will minimize the risk from these hazards.

Hypothermia sets in much more quickly in water than in air. Wearing proper insulation and knowing the symptoms can help prevent this hazard. Warm clothes should be available on board the support boat.

Nitrogen narcosis is a risk of spending too much time at depth. This project will not require diving below approximately 30 ft, so the risk of narcosis is minimal. However, it is still necessary to consult dive tables to create a dive profile for each dive. Strict adherence to the Diver Safety Manual (RSS) should prevent nitrogen narcosis.

If boat traffic is a possibility, a dive flag must be showing in the vicinity of the divers. Divers should surface as close as possible to the flag and/or support boat. Diving will not be done in the channel where shipping activity takes place. The dive tender will continuously monitor channels 13, 14, and 16 for boat traffic near the dive area, advise other vessels of diving operations and warn off boat traffic that may pose a hazard to the divers, if possible.

A.4.2 Vessel Hazards

Because of the high volumes of vessel and barge traffic on the LDW, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. As practical, the field boat will stay out of the navigation channel. Additional potential vessel emergency hazards and responses are listed in Table A-1.

Table A-1. Potential vessel emergency hazards and responses

Potential Emergency Hazard	Response
Fire or Explosion	If manageable, attempt to put out a small fire with a fire extinguisher. Otherwise, call the Coast Guard or 911 and evacuate the area (by rescue boat or swimming) and meet at a designated area. The FC/HSO will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefing.
Medical Emergency/Personal Injury	At least one person with current first aid-CPR training will be on board the vessel at all times. This person will attempt to assess the nature and severity of the injury, call 911 immediately, and apply CPR if necessary. Stop work and wait for medical personnel to arrive. Fill out a site accident report.
Person Overboard	All persons on board the sampling vessel will wear a personal flotation device at all time. Have one person keep an eye on the person and shout the distance (boat lengths) and direction (o'clock) of the person from the vessel. Stop work and use the vessel to retrieve the person in the water.

POTENTIAL EMERGENCY HAZARD	RESPONSE
Sinking Vessel	Call the Coast Guard immediately. If possible, wait for a rescue boat to arrive to evacuate vessel personnel. See fire/explosion section for emergency evacuation procedures. The FC/HSO will take a roll call to make sure everyone is present.
Lack of Visibility	If the navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, stop work immediately. The vessel operator and FC/HSO will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.
Loss of Power	Stop work and call Coast Guard for assistance. Use oars to move vessel towards the shoreline. Vessel personnel should watch for potential collision hazards and notify vessel operator if hazards exist. Secure vessel to a berth, dock, or mooring as soon as possible.
Collision	Stop work and call Coast Guard for assistance. The FC/HSO and vessel operator will assess damage and potential hazards. If necessary, vessel will be evacuated and secured until repairs can be made.

A.4.3 CHEMICAL HAZARDS

Previous investigations have shown that some chemical substances are present at higher-than-background concentrations in the sampling area. Potential exposure to sample media could occur through contact with intertidal sediments and porewater. For the purposes of discussing potential exposure to substances in sediments, the chemicals of concern are metals, tributyltin (TBT), petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). The focus of this sampling is for volatile organic compounds (VOCs), but their anticipated concentrations in porewater or sediment are relatively low. Even though VOCs may volatilize, the fact that all work is being conducted outdoors with good air circulation should minimize any potential for exposure.

A.4.3.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section A.6.

Inhalation —Inhalation is not expected to be an important route of exposure because work is being performed outdoors.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled by the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers on board the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

A.4.3.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned above, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the metals into the body. Field procedures require immediate washing of sediments from exposed skin.

Petroleum hydrocarbons and PAHs — Exposure to petroleum hydrocarbons and PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been seen in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of these compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

Polychlorinated biphenyls — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver, and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

A.4.4 Activity Hazard Analysis

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table A-2 presents the activity hazard analysis for the porewater sampling activities.

Table A-2. Activity hazard analysis

Activity	Hazard	Control
Accessing shoreline and sampling from boat	Slips, trips, or falls Falling overboard	Use care in boarding and departing the vessel. Be cognizant of obstacles on shore. Wear PFD
Porewater sampling	Skin contact with contaminated sediment or porewater; contact with sharp objects	Wear modified Level D PPE or diving suit and gear. Do not dig in sediment with hands. Do not touch sharp objects if found.
Scuba diving	Loss of communication	Dive termination
	Equipment failure	Pre-dive check out, diver tender and/or safety diver present.
	Scrapes, bruises, and entrapment by pilings and other obstacles	Be familiarized with the area before entering the water. Exercise caution when visibility is low.
	Hypothermia	Wear appropriate insulation. Be aware of the symptoms and have warm clothes available.
	Nitrogen narcosis	Consult dive tables for each dive.
	Boat traffic	Fly the dive flag in the vicinity of the divers. Ascend carefully and as close as possible to the support boat. Dive tender will continuously monitor channels 13, 14, and 16 for boat traffic near dive area Dive tender will advise other vessels of diving operations and warn off boat traffic that may pose a hazard to the divers, if possible

A.5.0 Work Zones

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the work zone is to limit the migration of sample material out of the work zone and to restrict access to active work areas by defining work zone boundaries.

A.5.1 Work Zone

The work zones onshore or on the boat will encompass the area where sample collection and handling activities are performed. On the beach, the FC/HSO will delineate the work zone as a particular area. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

A.5.2 Decontamination Station

A decontamination station will be set up at the end of a work day for personnel to clean PPE and equipment. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PFDs, dive gear, or other PPE and equipment. Plastic bags will be provided for expendable and disposable materials.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with LDW water to minimize accumulation of sediment.

A.6.0 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

A.7.0 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working on board the boat. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed below in Sections A.7.1 and A.7.2. Situations requiring PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and an alternative selected.

A.7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- Cotton overalls or laboratory coats
- Chemical-resistant steel-toed boots
- Chemical-resistant gloves
- Safety glasses

A.7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing activities where skin contact with contaminated materials is possible and in which inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- Impermeable outer garb such as rain gear
- Chemical-resistant steel-toed boots
- Chemical-resistant outer gloves

While in the water, the diver will wear a watertight dry suit, watertight gloves, and a positive pressure full face mask to prevent contact with any water or sediment.

A.7.3 SAFETY EQUIPMENT

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment for the field team will include:

- A copy of this HSP
- Diver safety manual
- Dive plan (Attachment A2)
- Emergency oxygen
- First aid kit adequate for the number of personnel
- Emergency eyewash

The FC/HSO will ensure that the safety equipment is on board. Equipment will be checked daily to ensure its readiness for use.

A.8.0 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be maintained. For this project, air, dust, and noise monitoring will not be necessary. The sampled media will be wet and will not pose a dust hazard, and none of the equipment emits high-amplitude (>85 dBA) sound. For this project, the monitoring program will consist of all workers monitoring themselves and their co-workers for signs that might indicate physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Symptoms of heat stress
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Shivering
- Blue lips or fingernails
- Loss of communication with diver

If any of these conditions develop, work shall be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

A.9.0 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- Wash buckets
- Rinse buckets
- Long-handled scrub brushes
- Clean water sprayers

- Paper towels
- Plastic garbage bags
- Alconox® or similar decontamination solution

A.9.1 Minimization of Contamination

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- Do not walk through areas of obvious or known contamination
- Do not handle, touch, or smell contaminated materials directly
- Make sure PPE has no cuts or tears prior to use
- Fasten all closures on outer clothing, covering with tape if necessary
- Protect and cover any skin injuries
- Stay upwind of airborne dusts and vapors
- Do not eat, drink, chew tobacco, or smoke in the work zones

Sampling equipment and boat:

- Place clean equipment on a plastic sheet to avoid direct contact with contaminated media
- Keep contaminated equipment and tools separate from clean equipment and tools
- Rinse boots in LDW water before entering the boat

A.9.2 Personnel Decontamination

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or before leaving the work location. Following is a description of these procedures.

Decontamination procedure:

1. If outer suit is heavily soiled, rinse it off
2. Wash and rinse outer gloves and boots with water
3. Remove outer gloves; inspect and discard if damaged
4. Wash hands if taking a break
5. Don necessary PPE before returning to work
6. Dispose of soiled, expendable PPE before leaving for the day

In addition to the decontamination procedures listed above that apply to all field personnel, divers will also:

7. Thoroughly rinse dive suit and gear after each dive
8. Inspect gear for mud or stains, and re-rinse or scrub with Alconox, if necessary
9. Discard any damaged or heavily soiled gear after the project, if necessary
10. Launder dry suit underwear post project.

A.9.3 SAMPLING EQUIPMENT DECONTAMINATION

All equipment for porewater collection will be decontaminated before each use by rinsing with LDW water, washing with detergent such as Alconox, and then rinsed with LDW water.

A.9.4 VESSEL DECONTAMINATION

Prior to returning to the boat after sampling, personnel will rinse their boots with LDW water to minimize the amount of sediment accumulating in the boat. At the end of each sampling day, the vessel will be rinsed with LDW water to remove sediment from cockpit and crew areas.

A.10.0 Disposal of Contaminated Materials

All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

A.11.0 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

A.11.1 PROJECT-SPECIFIC TRAINING

In addition to HAZWOPER training, as described in Section 2.5 of the QAPP, field personnel will undergo training specifically for this project. Professional divers will also be certified and as per the Diver Safety Manual (RSS). All personnel must read this HSP and be familiar with its contents before beginning work. They shall acknowledge reading the HSP by signing the field team HSP review form contained in

Attachment A1. The form will be kept in the project files as well as a copy of the diver certifications.

The boat captain and FC/HSO will also be required to have the US Coast Guard Auxiliary Boating Safely certification. The Boat captain or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers or agency observers arrive. Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards, and actions to control the hazard
- Ship access control and procedures
- Use and limitations of PPE
- Decontamination procedures
- Emergency procedures
- Use and hazards of sampling equipment
- Location of emergency equipment on the vessel
- Vessel safety practices
- Vessel evacuation and emergency procedures

A.11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

A.11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and cardiopulmonary resuscitation (CPR) training. The diver and dive tender will also be trained in first-aid and CPR as required by the Diver Safety Manual (RSS). Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

A.12.0 Medical Surveillance

A medical surveillance program conforming to the provisions of 29CFR1910§120(f) is not necessary for field team members because they do not meet any of the four criteria outlined in the regulations for implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I)
- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii))
- Employees who are injured or become ill as a result of possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii))
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section A.8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

A.13.0 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment A1). If necessary, accident/incident report forms and Occupational Safety and Health Administration (OSHA) Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all personnel on board
- Weather conditions
- Type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

A.14.0 Emergency Response Plan

As a result of the hazards on board and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use on board to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections identify the on-board individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions to a hospital from any sampling location.

A.14.1 Pre-Emergency Preparation

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the FC/HSO and equipment handlers concerning the emergency procedures in the event that a person is injured.
- A training session given by the FC/HSO informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team.

A.14.2 Project Emergency Coordinator

The FC/HSO will serve as the Project Emergency Coordinator in the event of an emergency. She will designate her replacement for times when she is not on board or is not serving as the Project Emergency Coordinator. The designation will be noted in the logbook. The Project Emergency Coordinator will be notified immediately when an emergency is recognized. The Project Emergency Coordinator will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions on board before the arrival of emergency response units. The Project Emergency Coordinator will notify the HSM and the Windward PM as soon as possible after initiating an emergency response action. The Windward PM will have responsibility for notifying the client.

A.14.3 Emergency Response Contacts

All on-board personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table A-3 lists the names and phone numbers for emergency response services and individuals.

Table A-3. Emergency response contacts

Contact	Telephone Number
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
Emergency Responders	
US Coast Guard	
Emergency General information	(206) 286-5400 (206) 442-5295 UHF Channel 16
National Response Center	(800) 424-8802
EPA	(908) 321-6660
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000
Emergency Contacts	
Project Task Manager	
Berit Bergquist	(206) 577-1291
Corporate Health and Safety Manager	
Tad Deshler	(206) 577-1285
Field Coordinator/ Field Health and Safety Officer	Site cellular telephone:
Joanna Florer	(206) 295-8956

A.14.4 Recognition of Emergency Situations

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

A.14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

A.14.6 FIRE

Field personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

A.14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit
- Notify the Project Emergency Coordinator of the incident, the name of the individual, the location, and the nature of the injury

The Project Emergency Coordinator will immediately do the following:

- Notify the boat captain and the appropriate emergency response organization.
- Assist the injured individual.
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pick-up.
- Designate someone to accompany the injured individual to the hospital.
- If a life-threatening emergency occurs, i.e., injury where death is imminent without immediate treatment, the FC/HSO or boat captain will call 911 and arrange to meet the Medic One unit at the nearest accessible dock. Otherwise, for emergency injuries that are not life-threatening (i.e., broken bones, minor lacerations, etc.) the Project Emergency Coordinator will follow the procedures

outlined above and proceed to the Harbor Island Marina or to an alternative location of her choice if that would be more expedient.

- Notify the HSM and the Windward PM.

If the Project Emergency Coordinator determines that emergency response is not necessary, she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions showing the route to the hospital are in Section A.14.10.

If a worker leaves the boat to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach, and notify the Project Emergency Coordinator.

The Project Emergency Coordinator will have responsibility for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

A.14.8 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

A.14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment on board
- After initial response actions have been taken, seek appropriate medical attention

A.14.8.2 Inhalation

- Move victim to fresh air
- Seek appropriate medical attention

A.14.8.3 Ingestion

- Seek appropriate medical attention

A.14.8.4 Puncture wound or laceration

- Seek appropriate medical attention

A.14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

A.14.10 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 Ninth Ave.
Seattle, WA
(206) 323-3074

Directions from the vicinity of LDW to Harborview Medical Center are as follows:

- Dock the vessel at the 1st Ave S boat launch
- Drive east on S River Street
- Turn left on Occidental Ave S
- Turn left on E Marginal Way S
- Turn right on S Michigan Street
- Look for entrance ramps to I-5 Northbound
- Head north on I-5
- Take the James Street exit
- Head east on James Street to 9th Avenue
- Turn right on 9th Avenue
- Emergency entrance will be two blocks south on the right

A15.0 References

RSS. (no date). Safe practices manual for diving operations. Research Support Services, Inc., Tacoma, WA.

Attachment A1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the LDW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date

Attachment A2. Dive Plan

RSS RESEARCH SUPPORT SERVICES, INC. 206-550-5202
8010 NE LOVGREN ROAD, BAINBRIDGE ISLAND, WA 98110 RESEARCHSUPPORT@EARTHLINK.NET

DIVE SAFETY AND WORK PLAN
Piezometer and Peeper Installation/Retrieval
for Windward Environmental

EMERGENCY RESPONSE INFORMATION

NOTE: Call local 911 first in case of any medical emergency prior to traveling to the emergency medical facility. Call DAN with questions regarding treatment of diving emergencies.

Telephone emergency: 911 and DAN 1-919-684-8111

Coast Guard emergency: 1-206-217-6000 (*CG from any cell phone)

Dive Emergency Gear: First aid kit, emergency oxygen kit, VHF radio, and cellular phones

Field Cellular Phones: 206-550-5202 Parker; 206-799-1470 Stahl, 206-295-8956 Florer

Nearest Dive Emergency Medical Facilities:
Harborview Medical Center, 325 9th Ave., Seattle (206) 731-3074 emergency room

Virginia Mason Hospital, Hyperbaric Medicine Dept., 1202 Terry Ave., Seattle(206) 583-6543 hyperbaric;
(206) 583-6433 emergency room and after hours hyperbaric

U.S. Naval Torpedo Station, Keyport (360) 396-2111 or (360) 396-8111

Nearest Non-dive Emergency Medical Facilities:
Virginia Mason Hospital, Hyperbaric Medicine Dept., 925 Seneca Street, Seattle
(206) 583-6433 emergency room

DIVE PLAN

Project Description: Piezometer and peeper sampling at Great Western and Boeing Plant 2

Project Managers: Eric Parker, RSS; Joanna Florer, Windward Environmental

Dates of operation: June 6-15, 2005: field reconnaissance
June 20-24, 2005: piezometer sampling
July 18-22, 2005: peeper deployment
August 1-5, 2005: peeper retrieval.

Location of Dive: Lower Duwamish River near South Park along east shoreline, and the Myrtle Street Embayment

Staging Location: Mobilize at 1st Avenue South boat launch

Primary Diver: Eric Parker, Research Support Services, Inc.

Backup Diver: Cindy Stahl, Marine Works, Kurt Schwalbe, Mainstay Marine

Dive Supervisor: Eric Parker

Purpose of Work: Install and retrieve subsurface water quality/sediment monitoring instruments (piezometers and peepers)

Number of Dives Anticipated: 15

Maximum depth Anticipated: 20 FSW

Depth for Majority of Work: 10-15 FSW

Breathing Gas: Air

Pre-Dive Procedures:

- The U.S. Coast Guard in Seattle will be provided with an emailed copy of this Dive Plan prior to the dive operations (email hlswatch@pacnorwest.uscg.mil).
- The Coast Guard Marine Safety Unit will be notified at (206) 217-6002 on the day of work prior to commencing diving operations and again when work is finished for the day.
- A pre-dive briefing will be conducted to familiarize divers and surface personnel of site-specific hazards and to ensure readiness to work.

General Work Plan:

- Operations will be conducted from a 14' aluminum work skiff. Since visibility is expected to be low and because of potential contact with contaminated sediment, a single diver (primary diver) will enter the water equipped with wireless communication to the surface. A safety diver and tender will remain on the vessel.
- The primary diver will be line-tended, and the instruments will be transferred to and from the diver using the tending line.

Safety Procedures:

- Diving operations will be conducted in accordance with federal and state health and safety regulations. The Site-Specific Health and Safety Plan (Appendix A) and RSS Dive Safety Plan will apply to this operation and will be reviewed by all participants.
- The Coast Guard will be notified of the operation. No special vessel consideration (such as a no wake zone) is expected to be needed.
- The support vessel will be anchored near the diver's location. A red-and-white diver flag and blue-and-white alpha flag will be flown conspicuously when the diver is in the water.
- The safety diver will stand by ready to assist the primary diver.
- Contamination precautions will include a dry suit with attached latex hood and gloves and positive pressure full-face mask.
- Emergency oxygen will be available on site in case of a pressure-related injury. In addition to administration of oxygen to an injured diver, basic first aid and activation of EMS will apply.

APPENDIX B. FIELD FORMS

FORM 1. PEEPER DEPLOYMENT FORM

Project Name: ______________________ Project Task: ______________________

Date: ______________________ Crew: ______________________

Weather: ______________________

Location ID:	Easting (x):	Northing (y):	Time:
Comments:			
Substrate description (e.g., rock, soil, cobble, gravel, sand, silt, clay)			
Collection location description (e.g., relative to bank or other objects subtidal or intertidal)			

Location ID:	Easting (x):	Northing (y):	Time:
Comments:			
Substrate description (e.g., rock, soil, cobble, gravel, sand, silt, clay)			
Collection location description (e.g,., relative to bank or other objects subtidal or intertidal)			

FORM 2. POREWATER COLLECTION FORM

Project Name: ______________________________ **Project Task:** ______________________________

Date: ______________________________ **Crew:** ______________________________

Weather: ______________________________

Location ID:		**Easting (x):**		**Northing (y):**	**Time:**	
Sample collection method:		___ peeper	___ mini-piezometer	___ other:		
Temp	**SpC**	**DO**	**pH**	**ORP**	**Salinity**	
1	1	1	1	1	1	
2	2	2	2	2	2	
Comments:						

Location ID:		**Easting (x):**		**Northing (y):**	**Time:**	
Sample collection method:		___ peeper	___ mini-piezometer	___ other:		
Temp	**SpC**	**DO**	**pH**	**ORP**	**Salinity**	
1	1	1	1	1	1	
2	2	2	2	2	2	
Comments:						

Location ID:		**Easting (x):**		**Northing (y):**	**Time:**	
Sample collection method:		___ peeper	___ mini-piezometer	___ other:		
Temp	**SpC**	**DO**	**pH**	**ORP**	**Salinity**	
1	1	1	1	1	1	
2	2	2	2	2	2	
Comments:						

FORM 3. PROTOCOL MODIFICATION FORM

Project Name and Number: ______________________________

Material to be Sampled: ______________________________

Measurement Parameter: ______________________________

____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

____

Reason for Change in Field Procedure or Analysis Variation: ______________________________

____

Variation from Field or Analytical Procedure: ______________________________

____

Special Equipment, Materials or Personnel Required: ______________________________

____

____

Initiator's Name: ______________________ Date: ____________

Project Officer: ______________________ Date: ____________

QA Officer: ______________________ Date: ____________

FORM 4. CORRECTIVE ACTION FORM

Project Name and Number: ______________________________

Sample Dates Involved: ______________________________

Measurement Parameter: ______________________________

____

____

Acceptable Data Range: ______________________________

____

____

Problem Areas Requiring Corrective Action: ______________________________

____

____

Measures Required to Correct Problem: ______________________________

____

____

Means of Detecting Problems and Verifying Correction: ______________________________

____

____

Initiator's Name: ______________________ Date: ____________

Project Officer: ______________________ Date: ____________

QA Officer: ______________________ Date: ____________

APPENDIX C. RISK-BASED ANALYTICAL CONCENTRATION GOALS FOR VOCS IN POREWATER

This appendix addresses the following question:

> Are standard analytical methods proposed for VOC analysis of porewater samples sufficiently sensitive to assess risks to benthic organisms from exposure to porewater?

To answer this question, laboratory reporting limits (RLs) were compared to analytical concentration goals (ACGs) for water to ensure that the RLs are sufficiently low. To determine ACGs for this quality assurance project plan (QAPP), risk-based concentrations (RBCs) in water were derived for the protection of benthic invertebrates.

It is not the objective of this appendix to establish toxicity reference values (TRVs) to provide a basis for interpretation of analytical results of porewater samples or to assess risks in the Phase 2 ecological risk assessment (ERA). The TRVs to be used in those assessments will be determined, in consultation with EPA and Ecology, in a separate technical memorandum that will be submitted as a draft to EPA and Ecology on May 26, 2005. The final technical memorandum will be approved by EPA and Ecology no later than July 15, 2005, prior to peeper deployment on July 19, 2005.

There are no federal or state water quality criteria for VOCs for the protection of aquatic organisms (EPA 2002; WAC 173-201A). Thus, individual toxicity study results reported in EPA's ECOTOX database were used to derive chemical-specific RBCs for VOCs that have been detected in groundwater or seeps adjacent to the LDW (see Section 2.2 of this QAPP). Chemical-specific RBCs were derived for growth, mortality (including immobilization), reproductive, or developmental endpoints only. Data for invertebrate species only were searched, but if no invertebrate data were available, then data for fish were included. Toxicity data for both freshwater and marine species were included in the search because of the potential salinity range in the LDW.

Note that the primary literature was not obtained for this screening exercise. For the technical memorandum discussed above, the data and analysis report, and the ERA, the search will be refined and the relevant primary literature will be obtained for derivation of TRVs for any chemicals identified as chemicals of interest based on the porewater results (see Sections 3.1.2.3 and 3.1.3.3 of the QAPP).

Table C-1 present the results of the ECOTOX search. Each row presents the minimum and maximum concentration (if available) reported in ECOTOX for a given chemical for a given species for similar endpoints. No toxicity data were available in ECOTOX for two chemicals—1,1-dichloroethane and chloroethane. The only toxicity data available for vinyl chloride in ECOTOX was for northern pike. Therefore, a detailed literature search was conducted for vinyl chloride and 1,1-dichloroethane, because these two chemicals were previously detected in groundwater or seeps from GWI or Boeing Plant 2/Jorgensen. Chloroethane was not previously detected in seeps or groundwater, so it was not included in the detailed literature search. One fish study was found for 1,1-dichloroethane (Könemann 1981) and one additional fish study was found for vinyl chloride [Groeneveld et al. (1993) as cited in de Rooij et al. (2004)); Table C-1].

The lowest effect or no-effect concentration reported in ECOTOX was selected as the RBC, as shown in bold in Table C-1.

Table C-1. RBCs for freshwater and marine invertebrates from ECOTOX

Analyte	Minimum Reported Concentration [a] (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
1,1,1-Trichloroethane	**1,300**		NOEC (mortality and reproduction), 17 days, *Daphnia magna*
	5,256	137,970	LC50, 24h, *Artemia salina*
	5,400	>1,300,000	LC50, 24h-17d, *Daphnia magna*
	9,850		LC50, 24h, fairy shrimp
	31,200		LC50, 96h, *Americamysis bahia* (opossum shrimp)
	530,000		LC50, 48h, *Daphnia magna*
	4,020,840		LC50, 24h, *Artemia salina*
	6,417,502		LC50, 24h, rotifer
1,1,2-Trichloroethane	**1,000**		NOEC (mortality), 48h, *Daphnia magna*
	10,000		mortality and growth,[b] 16d, great pond snail
	10,000		reproduction,[b] 3 wk, *Artemia bahia*
	15,000		EC50 (reproduction), 3wk, *Artemia salina*
	18,000	190,000	LC50, 24h-7d, *Daphnia magna*
	36,000	72,000	LC50, 48h-3 wk, *Artemia salina*
	18,000	42,000	reproduction,[b] 3-28d, *Daphnia magna*
	<31,000		NOEC (mortality), 48h, *Chironomus*
	36,000		EC50 (mortality and growth), 16d, great pond snail
	41,000	82,000	LC50, 48hr-3wk, amphipod
	42,000	43,000	LC50, 6h-7d, *Crangon crangon*
	43,000		LC50, 6h-7d, *Palaemonetes varians* (shrimp)
	43,000		LC50, 96h, calanoid copepod
	50,000	150,000	mortality, [b] 15d, polychaete
	58,000	170,000	LC50, 96h-16d, great pond snail
	65,000	110,000	LC50, 96h-14d, blue mussel
	140,000	320,000	LC50, 96h-14d, Zebra mussel
	147,000		LC50, 48h, *Chironomus*
	160,000	500,000	LC50, 96h, polychaete
	170,000		LC50, 7d, *Crepidula fornicata* (slipper limpet)
	320,000		100% mortality, 48h, midge
1,1-Dichloroethane	**202,000**		LC50, 7d, *Poecilia reticulate* (guppy)
1,1-Dichloroethene	<**2,400**		NOEC, (mortality), 48h, *Daphnia magna*
	9,000	130,000	LC50, 24-48h, *Daphnia magna*
	80,000		NOEC (mortality), 96h, sheephead minnow
	200,000	340,000	LC50, 24-96h, sheephead minnow
	250,000		LC50, 96h, inland silverside
1,2-Dichloroethane	**6,927**	33,646	LC50, 72h, *Artemia bahia*
	11,000	21,000	reproduction,[b] 28d, *Daphnia magna*
	42,000	72,000	growth,[b] 28d, *Daphnia magna*
	< 68,000		mortality,[b] 48h, *Daphnia magna*
	>100,000		LC50, 24-96h, *Gammarus fasciatus* (scud)
	>100,000		LC50, 24-96h, stonefly
	113,000		LC50, 96h, *Americamysis bahia* (opossum shrimp)
	186,000		LC50, 48h, Australian barnacle
	220,000	1,430,000	LC50, 24-48h, *Daphnia magna*
	200,000	400,000	mortality,[b] 15d, polychaete
	320,000		LC50, 24h, *Artemia bahia*
	400,000	900,000	LC50, 96h, polychaete

Analyte	Minimum Reported Concentration [a] (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Acetone (2-Propanone) [a]	**10,000**		LC50, 24-48h, *Daphnia magna*
	51,000		LC50, 24h, rotifer
	100,000		immobilization,[b] 2-24h, *Daphnia magna*
	>100,000		LC50, 12d, Northern quahog
	>100,000		EC50 (development), 48h, American oyster
	>100,000		LC50, 96h, *Gammarus pulex* (scud)
	>100,000		LC50, 96h, *Lumbriculus variegates* (oligochaete worm)
	>100,000		LC50, 96h, *Helisoma trivolvis* (ramshorn snail)
	>100,000		LC50, 96h, *Dugesia tigrina* (flatworm)
	1,000,000		reproduction,[b] 240d, Great pond snail
	1,101,000[c]		LC50, 192h, Southern king crab
Benzene	>**1,000**	1,000,000	LC50, 24h, rotifer
	1,100		development,[b] 24d, Dungeness crab
	6,700	42,000	LC50, 48-96h, *Gammarus* sp.
	10,000		LC50, 48h, damselfly
	12,860		mortality,[b] 24h, yellow fever mosquito
	<13,000		mortality,[b] 48h, *Daphnia magna*
	15,000	345,000	LC50, 48-96h, *Daphnia pulex*
	16,796	21,216	LC50, 24-96h, *Crangon franciscorum* (shrimp)
	18,400		LC50, 24h, *Ceriodaphnia dubia*
	21,000	66,000	LC50, 24-48h, *Artemia salina*
	27,000	90,800	LC50, 24-96h, *Palaemonetes pugio* (shrimp)
	27,000	43,500	LC50, 24-96h, *Palaemonetes pugio* (shrimp)
	33,587		mortality,[b] 48h, *Daphnia magna*
	34,000		LC50, 48h, mayfly
	48,000		LC50, 48h, water boatman
	58,000	76,000	LC50, 24-120h, *Gammarus fossarum*
	59,600	1,130,000	LC50, 24-48h, *Daphnia magna*
	71,000		LC50, 48h, northern house mosquito
	74,000		LC50, 48h, vortex worm
	88,400	884,000	mortality,[b] 0-7d, copepod
	82,000	111,500	LC50, ≤96h, copepod
	100,000		LC50, 48h, *Chironomus*
	100,000		mortality,[b] 10d, ciliate protozoa
	108,000	>347,000	LC50, 24-96h, Dungeness crab
	111,800		mortality,[b] 0.03-1 h, American lobster
	120,000		LC50, 48h, *Asellus aquaticus* (aquatic sowbug)
	130,000		LC50, 48h, stonefly
	165,000	228,000	mortality,[b] 24-96h, Japanese littleneck clam
	190,000	225,000	LC50, 24-96h, marine bivalve
	200,000		LC50, 24-48h, yellow fever mosquito
	230,000	1,410,000	LC50, 24-120h, great pond snail
	250,000	680,000	LC50, 24-120h, *Asellus aquaticus* (aquatic sowbug)
	>320,000		LC50, 48h, leech
	>320,000		LC50, 48h, oligochaete
	356,000	390,000	LC50, 48h, *Daphnia cucullata*
	377,000		LC50, 48h, Pacific oyster
	590,000	2,550,000	LC50, 24-120h, snail
	710,000		LC50, 96h, copepod
	3,306,160	11,350,560	LC50, 24-96h, crab
Carbon disulfide	**2,100**		LC50, 48h, *Daphnia magna*
	45,000	94,000	LC50, 96h, bleak

ANALYTE	MINIMUM REPORTED CONCENTRATION [a] (µg/L)	MAXIMUM REPORTED CONCENTRATION (µg/L)	STUDY DESCRIPTION
Carbon tetrachloride (tetrachloromethane)	**200**		LC50, 7d, *Dugesia japonica* (flatworm)
	500		abnormal growth,[b] 90 h, hydra
	1,500		EC50, abnormal growth, 7d, *Dugesia japonica* (flatworm),
	2,300		LC50, 3h, *Moina macrocopa*
	35,000	770,000	LC50, 24-48h, *Daphnia magna*
	11,100		LC50, 96h, *Gammarus pseudolimnaeus* (Scud)
	28,000	5,383,805	EC50, 24h, locomotion, immobilization, equilibrium, *Daphnia magna*
	2,153,522		LC50, 24h, *Artemia salina*
	3,520,000		development,[b] 60h, sea urchin
Chlorobenzene	**1,400**	22,000	EC50 (reproduction), 7-10d, *Ceriodaphnia dubia*
	<1,400		NOEC (mortality), 9-11d, *Daphnia magna*
	2,500	19,000	EC50 (reproduction),9-14d, *Daphnia magna*
	3,890		NOEC (mortality), 7-10d, *Ceriodaphnia dubia*
	6,500	11,000	NOEC (reproduction), 9-11d, *Daphnia magna*
	7,600	47,000	LC50, 24-168h, *Ceriodaphnia dubia*
	8,600		LC50, 24-240h, *Daphnia magna*
	10,000		mortality,[b] 48h, *Daphnia magna*
	12,000	19,000	NOEC (reproduction), 7-10d, *Ceriodaphnia dubia*
	16,400		LC50, 96h, *Americamysis bahia* (opossum shrimp)
Chloroethane	na		
Chloroform (trichloromethane)	**2,000**	2,400	LC50, 1h, *Brachionus* sp.(rotifer)
	3,400	200,000	NOEC, 7-10d, mortality, reproduction, *Ceriodaphnia dubia*
	6,300	200,000	NOEC, 9-21d, Equilibrium, reproduction, mortality, *Daphnia magna*
	27,290	34,300	EC50, 24h, Immobilization, *Artemia salina*
	29,000	758,000	LC50, 24-216h, *Daphnia magna*
	32,000		NOEC mortality, 96h, *Penaeus duorarum* (Northern pink shrimp)
	48,000		NOEC (equilibrium), *Daphnia magna*
	54,000		NOEC, mortality, *Tallaperla maria* (stonefly)
	55,670		LC50, 48h, *Chironomus thummi*
	51,571	602,000	EC50, *Daphnia magna*, equilibrium, locomotion, immobilization, reproduction, 24h-11d, *Daphnia magna*
	81,500	134,000	LC50, 24-72h, *Penaeus duorarum* (Northern pink shrimp)
	116,680		LC50, 96h, *Tallaperla maria* (stonefly)
	120,000		near zero mortality, 24h, *Chironomus thummi*
	180,000		near zero mortality, 96h, *Helisoma trivolvis* (ramshorn snail)
	199,200		LC50, 96h, *Gammarus minus* (scud) (change in mortality of unknown significance reported at 100,000 µg/L)
	200,000		near 100% mortality, 48h, *Chironomus thummi*
	232,000		LC50, 96h, *Helisoma trivolvis* (ramshorn snail)
	235,000	368,000	LC50, 48-216h, *Ceriodaphnia dubia*
	250,000		near 100% mortality, *Tallaperla maria* (stonefly)
	300,000		near 100% mortality, 24h, *Helisoma trivolvis* (ramshorn snail)
	311,000	368,000	EC50, reproduction, 7-10d, *Ceriodaphnia dubia*
	6,500,000		mortality,[b] 25min, *Lumbriculus variegatus*
Chloromethane	**270,000**		LC50, 96h, inland silverside
	550,000		LC50, 96h, bluegill
cis- or trans-1,2-dichloroethene	**6,785**	21,329	LC50, 24h, *Artemia salina*
	140,000	165,000	LC50, 24-96h, bluegill

ANALYTE	MINIMUM REPORTED CONCENTRATION [a] (µg/L)	MAXIMUM REPORTED CONCENTRATION (µg/L)	STUDY DESCRIPTION
Ethylbenzene	**30**	3,000	development and reproduction,[b] 2-9d, sponge
	425	1,907	LC50, 24-96h, *Crangon franciscorum* (shrimp)
	1,000		NOEC, 96h, *Americamysis bahia* (opossum shrimp)
	1,940		LC50, 96h, *Gammarus pseudolimnaeus* (scud)
	2,600	87,600	LC50, 24-96h, *Americamysis bahia* (opossum shrimp)
	2,700		LOEC, 96h, *Americamysis bahia* (opossum shrimp)
	6,800		mortality,[b] 48h, *Daphnia magna*
	10,200	22,100	LC50, ≤ 96h, *Palaemonetes pugio* (shrimp)
	13,000	40,000	LC50, 48-96h, Dungeness crab
	13,900	190,000	LC50, 24-48h, *Daphnia magna*
	15,370		LC50 24h *Artemia salina* brine shrimp
	16,000	40,000	LC50, ≤ 96h, copepod
	324,510		LC50, 48h, Pacific oyster
	1,030,080		development,[b] 48h, Pacific oyster
Methylene chloride	**68,000**		mortality,[b] 48h, *Daphnia magna*
	84,478	122,299	LC50, 24h, *Artemia salina*
	108,500		LC50, 48h, grass shrimp
	256,000		LC50, 96h, *Americamysis bahia*
	310,000	2,270,000	LC50, 24-48h, *Daphnia magna*
	500,000		mortality,[b] 2d, *Physa* sp. (pouch snail)
	1,044,639		LC50, 24h, *Artemia salina*
	2,020,620		LC50, 24h, rotifer
Naphthalene	**50**	470	mortality, development and reproduction,[b] 4-14d, midge
	130		development,[b] 13d, Dungeness crab
	600		mortality,[b] 48h, *Daphnia magna*
	750	4,500	mortality, 1-8 wk, sand shrimp
	850	1,280	LC50, 96h, *Neomysis americana* (opossum shrimp)
	971	2,210	LC50, 24-96h, *Pandalus goniurus* (shrimp)
	1,000	3,890	LC50, 48-96h, *Daphnia pulex*
	1,000	2,500	LC50, 96h, dragonfly
	1,000		mortality and reproduction,[b] 24h, copepod
	1,000	20,000	mortality,[b] 24h, , scud
	1,000	2,000	mortality,[b] 24h, copepod
	1,100	2,800	LC50, 8d, *Hemigrapsus nudus* (shore crab)
	1,390		LC50, 96h, shortscale eualid
	2,000	4,000	LC50, 24-96h, shrimp
	>2,000		LC50, 96h, Dungeness crab
	2,160	22,600	LC50, 24-48h, *Daphnia magna*
	2,250	3,120	LC50, 24h, blue crab
	2,350	2,600	LC50, 24-96h, *Palaemonetes pugio* (shrimp)
	2,500		LC50, 96h, *Penaeus azteca* (brown shrimp)
	2,680	3,930	LC50, 24-96h, scud
	2,700	3,070	100% mortality, 2-4d, green sea urchin
	2,810		LC50, 48h, *Chironomus tentans*
	3,780		LC50, 24h, Calanoid copepod
	3,800		LC50, 96h, *Nereis arenaceodentata*
	3,800		LC50, 96h, *Nereis arenaceodentata*
	3,930		LC50, 48h, *Gammarus minus* (scud)
	5,020		LC50, 48h, *Physa gyrina* (pouch snail)
	10,641		LC50, 24h, *Artemia salina*, brine shrimp
	12,200	20,700	LC50, 48h, *Tanytarsus dissimilis* (midge)
	13,000	13,900	LC50, 24-48h, *Chironomus attenuatus* (midge)

Analyte	Minimum Reported Concentration [a] (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Naphthalene, cont'd	16,690		mortality,[b] 96h, *Uca pugilator* (fiddler crab)
	18,537		mortality and reproduction,[b] 10d, copepod
	36,406	43,713	LC50 and development, 24-48h, protozoa
	57,000	74,000	LC50, 24-96h, marine bivalve
	67,800		LC50, 96h, calanoid copepod
	110,000	194,000	LC50 and development, 48h, Pacific oyster
Tetrachloroethene	**331**	18,241	LC50, 24h, *Artemia salina*
	400		NOEC (reproduction), 21d, *Daphnia magna*
	510	1,100	growth,[b] 28d, *Daphnia magna*
	510	1,100	reproduction,[b] 28d, *Daphnia magna*
	900		EC50, (growth), 7d, flatworm
	1,400		LC50, 7d, flatworm
	1,300		LC50, 96h, grass shrimp
	1,300		LC50, 96h, *Nereis arenaceodentata*
	1,800		LC50, 3h, water flea
	2,500		NOEC (mortality), 24h, grass shrimp
	3,600		LC50, 96h, stonefly
	18,850		mortality,[b] 24h, grass shrimp
	3,500		LC50, 48h, Australian barnacle
	9,100	28,600	LC50, 96h, *Gammarus* sp. (scud)
	7,000	54,600	LC50, 24-48h, midge
	9,100		LC50, 48h, *Daphnia magna*
	10,000		mortality,[b] 48h, *Daphnia magna*
	10,200		LC50, 96h, opossum shrimp
	13,200		LC50, 96h, calanoid copepod
	17,400		LC50, 96h, sand shrimp
	21,000	60,000	100% mortality, 24h, *Gammarus* sp. (scud)
	93,400		LC50, 96h, pond snail
Toluene (methylbenzene)	**1,000**	2,000	NOEC (reproduction, equilibrium), 21d, *Daphnia magna*
	2,830	10,400	EC50, 24-96h, development, *Lumbriculus variegatus* (oligochaete worm)
	5,600	64,800	NOEC (mortality), 24-48h, *Chironomus thummi*
	7,600		LC50, 24h, *Ceriodaphnia dubia*
	9,500	38,100	LC50, 24-96h, *Palaemonetes pugio* (daggerblade shrimp)
	14,700	23,920	LC50, 24-96h, *Eualus* sp. (shrimp)
	23,500		LC50, 8d, *Hemigrapsus nudus* (shore crab),
	24,200	74,200	LC50, 96h, *Nitocra spinipes* (harpacticoid copepod)
	28,000		LC50, 96h, *Cancer magister* (Dungeness crab)
	33,000	61,200	LC50, 24h, *Artemia* sp.
	38,900		NOEC (mortality), 96h, *Physa heterostropha* (pond snail)
	47,000	108,660	LC50, 48h, *Chironomus thummi*
	53,000	93,000	NOEC (equilibrium), 24h, *Daphnia magna*
	55,600		LC50, 96h, *Physa heterostropha* (pond snail)
	58,000		LC50, 96h, *Gammarus minus* (scud)
	86,300	470,000	LC50, 24-48h, *Daphnia magna*
	92,140		Locomotion and development,[b] 5-14d, Scyphistomae (common jellyfish)
	113,000	552,600	LC50, 24h, *Brachionus sp.* (rotifer)
	172,000		LC50, 48h, *Crassostrea gigas* (Pacific oyster)
	225,000	250,000	LC50, 24-96h, *Katelysia opima* (marine bivalve)
	447,000		LC50, 96h, *Diaptomus forbesi* (calanoid copepod)
	500,000		EC100, equilibrium, 24h, *Daphnia magna*

Analyte	**Minimum Reported Concentration [a] (µg/L)**	**Maximum Reported Concentration (µg/L)**	**Study Description**
Toluene (methylbenzene), cont'd	790,000		LC50, 96h, chironomid
	1,047,000		EC50 (development), 48h, *Crassostrea gigas* (Pacific oyster)
	1,100,000		LC50, 96h, *Melanoides tuberculata* (snail)
Trichloroethene	**1,700**		LC50 and growth, 7d, flatworm
	2,200		mortality,[b] 48h, *Daphnia magna*
	2,300		LC50, 3h, water flea
	2,300	8,000	LOEC and NOEC (growth), 21d, *Daphnia magna*
	18,000	100,000	LC50, 24-48h, *Daphnia magna*
	14,000	27,000	LC50, 96h, *Americamysis bahia* (opossum shrimp)
	20,000		LC50, 48h, Australian barnacle
	24,000		LC50, 48h, *Gammarus pulex* (scud)
	30,000		LC50, 48h, *Asellus aquaticus* (aquatic sowbug)
	39,000	51,000	LC50, 48h, *Daphnia pulex*
	42,000		LC50, 48h, mayfly
	42,000		LC50, 48h, vortex worm
	48,000		LC50, 24-48h, yellow fever mosquito
	49,000		LC50, 48h, damselfly
	55,000		LC50, 48h, northern house mosquito
	56,000		LC50, 24-48h, great pond snail
	56,000	58,000	LC50, 48h, *Daphnia cucullata*
	64,000		LC50, 48h, *Chironomus* (midge)
	70,000		LC50, 48h, stonefly
	75,000		LC50, 48h, hydra
	75,000		LC50, 48h, leech
	110,000		LC50, 48h, water boatman
	132,000		LC50, 48h, oligochaete
Vinyl chloride (chloroethene)	**128,000**		NOEC (mortality), 96h, *Brachydanio rerio* (zebrafish)
	388,000		100% mortality,10d, Northern pike
Xylene	**7,400**	14,000	LC50, 24-96h, grass shrimp
	7,920		mortality,[b] 24h, yellow fever mosquito
	20,000	40,000	LOEC and NOEC (reproduction), 48-2d, rotifer
	53,000	184,000	LC50, 24-120h, *Gammarus fossarum* (scud)
	87582		LC50, 24h, fairy shrimp
	99,000		EC50, reproduction, 2d, rotifer
	99,500		LC50, 24h, calanoid copepod
	150,000	<1,000,000	LC50, 24h, *Daphnia magna*
	190,000	240,000	LC50, 24-96h, marine bivalve
	190,000	270,000	LC50, 24-120h, *Asellus aquaticus* (aquatic sowbug)
	194,273		LC50, 24h, *Artemia salina*
	350,000	2,070,000	LC50, 24-96h, snail

Bold numbers represent the lowest concentration for each chemical reported in ECOTOX. These concentrations were conservatively selected as RBCs and are the basis of the ACGs identified in Table C-2

na-not available in ECOTOX

[a] If only one concentration was reported in ECOTOX for a particular endpoint and species, it is presented as the minimum concentration

[b] The ECOTOX database did not specify the effect level (e.g., LC50 or NOEC)

[c] Additional higher concentrations were reported in ECOTOX

The ACG for each VOC is equivalent to the RBC derived as described above. These ACGs are compared to ARI's RLs using EPA Method 8260B in Table C-2. A complete list of ARI's MDLs and RLs is presented in Table C-3. For all of the VOCs in

Table C-2, the RL is at least two orders of magnitude lower than the derived ACGs. Thus, the VOC method is sufficiently sensitive to meet the ACGs in Table C-2.

Table C-2. ACGs compared to RLs

Analyte	RL (µg/L)	ACG (µg/L)
1,1,1-Trichloroethane	0.2	1,300
1,1,2-Trichloroethane	0.2	1,000
1,1-Dichloroethane	0.2	202,000
1,1-Dichloroethene	0.2	< 2,400
1,2-Dichloroethane	0.2	6,927
Acetone (2-propanone)	2.0	10,000
Benzene	0.2	> 1,000
Carbon disulfide	0.2	2,100
Carbon tetrachloride (tetrachloromethane)	0.2	200
Chlorobenzene	0.2	1,400
Chloroethane	0.2	na
Chloroform (trichloromethane)	0.2	2,000
Chloromethane	0.2	270,000[a]
cis- or trans-1,2-dichloroethene	0.2	6,785
Ethylbenzene	0.2	30
m,p,-Xylene (xylene)	0.4	7,400[b]
Methylene chloride	0.3	68,000
Naphthalene	0.5	50
o-Xylene (xylene)	0.2	7,400[b]
Tetrachloroethene	0.2	331
Toluene (methylbenzene)	0.2	1000
Trichloroethene	1.0	1,700
Vinyl chloride (chloroethene)	0.2	128,000

[a] Value for fish species because no value was available for invertebrate species

[b] RBC for xylene used because no toxicological data were available for these xylene isomers

Table C-3. List of MDLs and RLs for entire list of VOCs as reported by ARI using EPA Method 8260B

ANALYTE	MDL (µg/L)	RL (µg/L)
1,1,1,2-Tetrachloroethane	0.033	0.2
1,1,1-Trichloroethane	0.044	0.2
1,1,2,2-Tetrachloroethane	0.089	0.2
1,1,2-Trichloro-1,2,2-trifluoroethane	0.030	0.2
1,1,2-Trichloroethane	0.059	0.2
1,1-Dichloroethane	0.071	0.2
1,1-Dichloroethene	0.047	0.2
1,1-Dichloropropene	0.060	0.5
1,2,3-Trichlorobenzene	0.121	0.5
1,2,3-Trichloropropane	0.193	0.5
1,2,4-Trichlorobenzene	0.119	0.5
1,2,4-Trimethylbenzene	0.037	0.2
1,2-Dibromo-3-chloropropane	0.168	0.5
1,2-Dibromoethane	0.107	0.2
1,2-Dichlorobenzene	0.041	0.2
1,2-Dichloroethane	0.097	0.2
1,2-Dichloropropane	0.042	0.2
1,3,5-Trimethylbenzene	0.066	0.2
1,3-Dichlorobenzene	0.058	0.2
1,3-Dichloropropane	0.083	0.2
1,4-Dichlorobenzene	0.053	0.2
2,2-Dichloropropane	0.088	0.2
2-Butanone	0.657	1.0
2-Chloroethyl vinyl ether	0.063	0.5
2-Chlorotoluene	0.058	0.2
2-Hexanone	0.384	1.0
4-Chlorotoluene	0.017	0.2
4-Isopropyl toluene	0.098	0.2
4-Methyl-2-pentanone	0.400	1.0
Acetone (2 propanone)	1.080	2.0
Acrolein	0.319	5.0
Acrylonitrile	0.201	0.2
Benzene	0.041	0.2
Bromobenzene	0.036	0.2
Bromochloromethane	0.077	0.2
Bromodichloromethane	0.049	0.2
Bromoethane	0.072	0.2
Bromoform	0.100	0.2

ANALYTE	MDL (µg/L)	RL (µg/L)
Bromomethane	0.078	0.2
Carbon disulfide	0.071	0.2
Carbon tetrachloride (tetrachloromethane)	0.042	0.2
Chlorobenzene	0.041	0.2
Chlorodibromomethane	0.047	0.2
Chloroethane	0.107	0.2
Chloroform (trichloromethane)	0.047	0.2
Chloromethane	0.045	0.2
cis-1,2-Dichloroethene	0.037	0.2
cis-1,3-Dichloropropene	0.061	0.2
Dibromomethane	0.077	0.2
Dichlorodifluoromethane	0.196	0.2
Ethylbenzene	0.065	0.2
Hexachloro-1,3-butadiene	0.185	0.5
Iodomethane	0.081	0.2
Isopropyl benzene	0.047	0.2
m,p-Xylene	0.078	0.4
Methylene chloride	0.011	0.3
Methyl-t-butyl ether (MTBE)	0.056	0.2
Naphthalene	0.093	0.5
n-Butylbenzene	0.088	0.2
n-Propyl benzene	0.074	0.2
o-Xylene	0.055	0.2
s-Butylbenzene	0.074	0.2
Styrene	0.069	0.2
t-Butylbenzene	0.054	0.2
Tetrachloroethene	0.062	0.2
Toluene (methylbenzene)	0.048	0.2
trans-1,2-Dichloroethene	0.114	0.2
trans-1,3-Dichloropropene	0.054	0.2
trans-1,4-Dichloro-2-butene	0.164	0.2
Trichloroethene	0.071	1.0
Trichlorofluoromethane	0.054	0.2
Vinyl acetate	0.093	0.2
Vinyl chloride (chloroethene)	0.056	0.2

MDL studies are performed in accordance with 40 CFR Part 136, Appendix B, using six degrees of freedom. The MDLs in this table reflect the most recent MDL study conducted by ARI.

MDLs are statistically derived values, and are a measure of short-term precision. True detection at the statistical MDL may not be achievable for all analytes and methods.

Reporting Limit (RL) is defined as the lowest value at which qualitative detection of a given analyte is reported. The RL is based on the MDL, method efficiency, and analyte response. The RL will, at a minimum, equal the MDL (rounded). The RL may exceed the MDL for certain analytes.

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APPENDIX D. PREDICTED TIDES FOR DUWAMISH WATERWAY

Table D-1. Predicted tides for Duwamish Waterway at Eighth Avenue South, June 2005

DATE	DAY	TIME	HEIGHT	STAGE	TIME	HEIGHT	STAGE	TIME	HEIGHT	STAGE	TIME	HEIGHT	STAGE
6/1/2005	Wed	01:22AM	11.6	H	08:17AM	2.4	L	02:12PM	7.8	H	07:29PM	3.6	L
6/2/2005	Thu	02:00AM	11.4	H	09:04AM	0.9	L	03:39PM	8.5	H	08:35PM	4.8	L
6/3/2005	Fri	02:35AM	11.3	H	09:46AM	-0.3	L	04:48PM	9.5	H	09:37PM	5.7	L
6/4/2005	Sat	03:08AM	10.9	H	10:25AM	-1.1	L	05:44PM	10.3	H	10:34PM	6.4	L
6/5/2005	Sun	03:40AM	10.6	H	11:01AM	-1.7	L	06:33PM	10.9	H	11:26PM	6.8	L
6/6/2005	Mon	04:12AM	10.3	H	11:37AM	-2	L	07:16PM	11.2	H			
6/7/2005	Tue	12:13AM	7.1	L	04:44AM	9.9	H	12:12PM	-2	L	07:57PM	11.3	H
6/8/2005	Wed	12:58AM	7.2	L	05:17AM	9.7	H	12:47PM	-1.9	L	08:36PM	11.4	H
6/9/2005	Thu	01:42AM	7.2	L	05:53AM	9.3	H	01:24PM	-1.6	L	09:14PM	11.4	H
6/10/2005	Fri	02:29AM	7.2	L	06:32AM	9	H	02:03PM	-1.2	L	09:52PM	11.3	H
6/11/2005	Sat	03:20AM	6.9	L	07:17AM	8.5	H	02:43PM	-0.7	L	10:29PM	11.3	H
6/12/2005	Sun	04:15AM	6.6	L	08:11AM	8	H	03:25PM	0.2	L	11:04PM	11.2	H
6/13/2005	Mon	05:14AM	5.9	L	09:19AM	7.4	H	04:09PM	1.1	L	11:38PM	11.1	H
6/14/2005	Tue	06:11AM	5	L	10:42AM	6.9	H	04:57PM	2.3	L			
6/15/2005	Wed	12:09AM	11	H	07:01AM	3.9	L	12:13PM	6.8	H	05:49PM	3.5	L
6/16/2005	Thu	12:38AM	10.8	H	07:45AM	2.7	L	01:46PM	7.2	H	06:46PM	4.7	L
6/17/2005	Fri	01:07AM	10.7	H	08:24AM	1.4	L	03:11PM	8.1	H	07:49PM	5.7	L
6/18/2005	Sat	01:37AM	10.6	H	09:03AM	0.1	L	04:20PM	9	H	08:52PM	6.6	L
6/19/2005	Sun	02:09AM	10.6	H	09:42AM	-1.1	L	05:17PM	10	H	09:52PM	7.2	L
6/20/2005	Mon	02:45AM	10.7	H	10:23AM	-2.2	L	06:06PM	10.9	H	10:48PM	7.6	L
6/21/2005	Tue	03:25AM	10.8	H	11:06AM	-3	L	06:52PM	11.5	H	11:42PM	7.8	L
6/22/2005	Wed	04:09AM	10.9	H	11:51AM	-3.6	L	07:37PM	12	H			
6/23/2005	Thu	12:35AM	7.7	L	04:59AM	10.8	H	12:37PM	-3.7	L	08:21PM	12.3	H
6/24/2005	Fri	01:29AM	7.4	L	05:53AM	10.5	H	01:25PM	-3.4	L	09:04PM	12.4	H
6/25/2005	Sat	02:26AM	6.8	L	06:54AM	9.9	H	02:13PM	-2.6	L	09:46PM	12.4	H
6/26/2005	Sun	03:28AM	6	L	08:03AM	9.1	H	03:02PM	-1.2	L	10:27PM	12.3	H
6/27/2005	Mon	04:34AM	4.9	L	09:23AM	8.2	H	03:54PM	0.3	L	11:07PM	12.1	H
6/28/2005	Tue	05:40AM	3.7	L	10:56AM	7.6	H	04:48PM	2.1	L	11:47PM	11.8	H
6/29/2005	Wed	06:43AM	2.3	L	12:40PM	7.5	H	05:49PM	3.8	L			
6/30/2005	Thu	12:26AM	11.5	H	07:41AM	1	L	02:23PM	8.1	H	06:57PM	5.3	L

Reference station: Seattle, corrections applied: Times: High +0 hr. 10 min., Low +0 hr. 11 min., Heights: High 0.97, Low 0.95

All times are listed in Local Daylight Time

All heights are in feet referenced to Mean Lower Low Water

Table D-2. Predicted tides for Duwamish Waterway at Eighth Avenue South, July 2005

Date	Day	Time	Height	Stage	Time	Height	Stage	Time	Height	Stage	Time	Height	Stage
7/1/2005	Fri	01:06AM	11.2	H	08:33AM	0	L	03:47PM	8.9	H	08:12PM	6.5	L
7/2/2005	Sat	01:45AM	10.8	H	09:19AM	-0.8	L	04:53PM	9.8	H	09:25PM	7	L
7/3/2005	Sun	02:24AM	10.4	H	10:02AM	-1.3	L	05:45PM	10.6	H	10:29PM	7.3	L
7/4/2005	Mon	03:03AM	10	H	10:41AM	-1.6	L	06:29PM	11	H	11:22PM	7.4	L
7/5/2005	Tue	03:41AM	9.8	H	11:18AM	-1.8	L	07:08PM	11.3	H			
7/6/2005	Wed	12:07AM	7.4	L	04:20AM	9.6	H	11:54AM	-1.8	L	07:42PM	11.4	H
7/7/2005	Thu	12:47AM	7.2	L	04:59AM	9.4	H	12:28PM	-1.7	L	08:14PM	11.4	H
7/8/2005	Fri	01:25AM	7	L	05:40AM	9.3	H	01:03PM	-1.4	L	08:42PM	11.4	H
7/9/2005	Sat	02:04AM	6.6	L	06:24AM	9	H	01:38PM	-1	L	09:10PM	11.4	H
7/10/2005	Sun	02:46AM	6.2	L	07:12AM	8.6	H	02:14PM	-0.4	L	09:36PM	11.3	H
7/11/2005	Mon	03:30AM	5.5	L	08:07AM	8.1	H	02:51PM	0.6	L	10:03PM	11.3	H
7/12/2005	Tue	04:17AM	4.8	L	09:10AM	7.7	H	03:30PM	1.7	L	10:30PM	11.1	H
7/13/2005	Wed	05:05AM	3.8	L	10:23AM	7.3	H	04:12PM	3	L	10:58PM	10.9	H
7/14/2005	Thu	05:54AM	2.8	L	11:48AM	7.2	H	05:00PM	4.4	L	11:27PM	10.7	H
7/15/2005	Fri	06:43AM	1.7	L	01:22PM	7.6	H	05:57PM	5.7	L			
7/16/2005	Sat	12:00AM	10.6	H	07:33AM	0.6	L	02:57PM	8.4	H	07:07PM	6.8	L
7/17/2005	Sun	12:36AM	10.5	H	08:22AM	-0.6	L	04:13PM	9.4	H	08:23PM	7.6	L
7/18/2005	Mon	01:19AM	10.5	H	09:12AM	-1.6	L	05:10PM	10.4	H	09:34PM	8	L
7/19/2005	Tue	02:08AM	10.6	H	10:01AM	-2.6	L	05:56PM	11.2	H	10:36PM	7.9	L
7/20/2005	Wed	03:03AM	10.7	H	10:49AM	-3.1	L	06:37PM	11.7	H	11:31PM	7.6	L
7/21/2005	Thu	04:00AM	10.8	H	11:37AM	-3.4	L	07:15PM	12	H			
7/22/2005	Fri	12:23AM	7	L	05:00AM	10.7	H	12:23PM	-3.3	L	07:51PM	12.3	H
7/23/2005	Sat	01:14AM	6.2	L	06:02AM	10.4	H	01:09PM	-2.6	L	08:27PM	12.3	H
7/24/2005	Sun	02:06AM	5.2	L	07:06AM	9.9	H	01:55PM	-1.4	L	09:02PM	12.2	H
7/25/2005	Mon	03:00AM	4.1	L	08:16AM	9.2	H	02:42PM	0.1	L	09:37PM	12	H
7/26/2005	Tue	03:57AM	3	L	09:32AM	8.5	H	03:29PM	1.8	L	10:13PM	11.7	H
7/27/2005	Wed	04:56AM	2.1	L	11:00AM	8.1	H	04:21PM	3.6	L	10:51PM	11.3	H
7/28/2005	Thu	05:57AM	1.1	L	12:39PM	8.1	H	05:21PM	5.2	L	11:31PM	10.9	H
7/29/2005	Fri	06:58AM	0.5	L	02:19PM	8.6	H	06:36PM	6.6	L			
7/30/2005	Sat	12:15AM	10.3	H	07:57AM	-0.1	L	03:40PM	9.3	H	08:05PM	7.2	L
7/31/2005	Sun	01:03AM	9.9	H	08:51AM	-0.5	L	04:41PM	10.1	H	09:28PM	7.4	L

Reference station: Seattle, corrections applied: Times: High +0 hr. 10 min., Low +0 hr. 11 min., Heights: High 0.97, Low 0.95

All times are listed in Local Daylight Time

All heights are in feet referenced to Mean Lower Low Water

Table D-3. Predicted tides for Duwamish Waterway at Eighth Avenue South, August 2005

Date	Day	Time	Height	Stage	Time	Height	Stage	Time	Height	Stage	Time	Height	Stage
8/1/2005	Mon	01:53AM	9.5	H	09:39AM	-0.9	L	05:29PM	10.6	H	10:31PM	7.3	L
8/2/2005	Tue	02:44AM	9.3	H	10:22AM	-1	L	06:09PM	11	H	11:17PM	7.1	L
8/3/2005	Wed	03:31AM	9.3	H	11:00AM	-1.1	L	06:42PM	11.2	H	11:53PM	6.8	L
8/4/2005	Thu	04:16AM	9.3	H	11:35AM	-1.1	L	07:10PM	11.2	H			
8/5/2005	Fri	12:25AM	6.5	L	04:59AM	9.3	H	12:08PM	-1	L	07:34PM	11.2	H
8/6/2005	Sat	12:57AM	6	L	05:42AM	9.3	H	12:41PM	-0.8	L	07:54PM	11.2	H
8/7/2005	Sun	01:30AM	5.3	L	06:26AM	9.1	H	01:13PM	-0.2	L	08:14PM	11.2	H
8/8/2005	Mon	02:05AM	4.7	L	07:13AM	8.9	H	01:46PM	0.6	L	08:35PM	11.1	H
8/9/2005	Tue	02:42AM	3.9	L	08:05AM	8.6	H	02:21PM	1.6	L	08:58PM	11	H
8/10/2005	Wed	03:22AM	3	L	09:03AM	8.3	H	02:58PM	2.8	L	09:23PM	10.8	H
8/11/2005	Thu	04:06AM	2.3	L	10:09AM	8.1	H	03:39PM	4.1	L	09:51PM	10.6	H
8/12/2005	Fri	04:54AM	1.5	L	11:28AM	8.1	H	04:27PM	5.4	L	10:22PM	10.4	H
8/13/2005	Sat	05:47AM	0.9	L	01:02PM	8.3	H	05:28PM	6.6	L	11:00PM	10.2	H
8/14/2005	Sun	06:46AM	0.1	L	02:41PM	9	H	06:49PM	7.5	L	11:48PM	10	H
8/15/2005	Mon	07:47AM	-0.8	L	03:55PM	9.9	H	08:16PM	7.9	L			
8/16/2005	Tue	12:48AM	10	H	08:46AM	-1.5	L	04:46PM	10.7	H	09:30PM	7.7	L
8/17/2005	Wed	01:56AM	10.1	H	09:41AM	-2.1	L	05:27PM	11.3	H	10:29PM	7.1	L
8/18/2005	Thu	03:04AM	10.3	H	10:33AM	-2.5	L	06:03PM	11.6	H	11:19PM	6.3	L
8/19/2005	Fri	04:09AM	10.5	H	11:21AM	-2.4	L	06:35PM	11.8	H			
8/20/2005	Sat	12:05AM	5.2	L	05:13AM	10.5	H	12:07PM	-1.8	L	07:07PM	11.9	H
8/21/2005	Sun	12:51AM	4	L	06:15AM	10.4	H	12:51PM	-0.9	L	07:37PM	11.9	H
8/22/2005	Mon	01:38AM	2.8	L	07:18AM	10.1	H	01:35PM	0.5	L	08:09PM	11.7	H
8/23/2005	Tue	02:25AM	1.9	L	08:24AM	9.7	H	02:20PM	2	L	08:41PM	11.4	H
8/24/2005	Wed	03:15AM	1.1	L	09:35AM	9.2	H	03:07PM	3.6	L	09:15PM	11	H
8/25/2005	Thu	04:08AM	0.8	L	10:55AM	8.9	H	03:59PM	5.1	L	09:53PM	10.4	H
8/26/2005	Fri	05:05AM	0.5	L	12:26PM	8.9	H	05:04PM	6.4	L	10:35PM	9.8	H
8/27/2005	Sat	06:08AM	0.5	L	01:59PM	9.2	H	06:31PM	7.1	L	11:27PM	9.2	H
8/28/2005	Sun	07:14AM	0.4	L	03:15PM	9.7	H	08:17PM	7.3	L			
8/29/2005	Mon	12:29AM	8.8	H	08:17AM	0.2	L	04:11PM	10.2	H	09:33PM	7	L
8/30/2005	Tue	01:37AM	8.6	H	09:12AM	0	L	04:55PM	10.6	H	10:23PM	6.6	L
8/31/2005	Wed	02:40AM	8.6	H	09:57AM	-0.1	L	05:30PM	10.8	H	10:58PM	6.2	L

Reference station: Seattle, corrections applied: Times: High +0 hr. 10 min., Low +0 hr. 11 min., Heights: High 0.97, Low 0.95

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