Union Station/SITE 4

File Copy

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July 2, 1996

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Michael J. Gallagher
Section Supervisor
Toxics Cleanup Program
Washington Department of Ecology
3160 160th Avenue S.E.
Bellevue, WA 98008-5452

RE: Detailed Application for Prospective Purchaser Agreement

Dear Mr. Gallagher:

Enclosed is the Detailed Application for a Prospective Purchaser Agreement for Nitze-Stagen & Company, Inc. This Detailed Application supplements the Initial Application submitted on March 29, 1996.

We will forward the appendices to the remedial investigation and feasibility study to you first thing tomorrow morning.

We look forward to working with you to realize the tremendous potential this site holds.

Sincerely,

Bradley M. Marten

BMM/kk

Enclosures

cc: Mary Sue Wilson, Attorney General's Office
Kevin Daniels, Nitze-Stagen & Company, Inc.
David South, Department of Ecology

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DETAILED APPLICATION

for a Prospective Purchaser Agreement for the Union Station Project

Submitted on behalf of

NITZE-STAGEN & COMPANY, INC.

VOLUME ONE

July 2, 1996

DETAILED APPLICATION[1]

1. A remedial investigation/feasibility study sufficient to meet the demonstrations necessary in the statute and to select a remedy under WAC 173-340-360.

See Exhibit 1.

2. A proposed plan for cleanup of the site complying with WAC 173-340-360.

See Exhibits 1 and 2.

3. Identification of the applicant's proposed share of the cleanup, including a detailed description of the substantial new resources to be provided to facilitate cleanup.

The Union Station Redevelopment Project (the "Project") represents a final cleanup action plan for the Union Station Property (the "Property"). Nitze-Stagen & Co., Inc. ("Nitze-Stagen") will bear the cost of this cleanup. Currently, the Property has a hazard ranking of 3, but no investigation or remediation is planned by Ecology or Union Pacific, the current owner. Nitze-Stagen will spend over $ 1.2 Million on environmental enhancements that are not currently planned by Union Pacific or required by the Department of Ecology.

These improvements include:

- testing, evaluation, removal and disposal of contaminated soil encountered during construction;
- a complete covering of the Property with a combination of asphalt-concrete paving and building structures to limit the potential for direct human contact with any remaining contaminated soil;
- monitoring to confirm continued compliance with groundwater cleanup standards; and

[1] These requirements are taken from Department of Ecology Policy 520A, "Interim Policy - - Prospective Purchaser Agreements" (August 26, 1994).

- institutional controls to prevent exposure to contaminated soil, and potentially contaminated groundwater, and to conduct periodic review of the status of the Property.

Please see sections 12.1, 11.4.3, and 11.3.2 of the Feasibility Study, located at Exhibit 1, and section 3.0 of the Cleanup Action Plan, located at Exhibit 2, for a complete description and cost breakdown of the substantial new resources Nitze-Stagen will provide to effectuate these improvements.

4. Information describing the applicant's ability to conduct or finance the proposed remedial actions and the purchase, redevelopment, or reuse proposal. This information shall include written authorization for Ecology to contact persons financing the proposal.

See Exhibit 3, a letter from Seafirst Bank, indicating Nitze-Stagen's financial qualifications. Any further questions regarding Nitze-Stagen's ability to conduct or finance the proposed remedial actions and the purchase and development of the Property should be directed to Kevin Daniels, Chief Financial Officer, Nitze-Stagen & Co., Inc., 2401 Utah Avenue South, Suite 305, Seattle, WA 98134-1431. A letter authorizing him to provide Ecology with any necessary information regarding financial arrangements for the Project is also included in Exhibit 3.

5. A detailed description of (including a plan), and an updated schedule for the purchase, redevelopment, or reuse of the site. The application should also include a legal commitment to the proposal in the form of a purchase option or contract or equivalent. The applicant should include information demonstrating the proposal is consistent with current comprehensive plans and zoning and identify any pending changes to these plans or zoning that could affect this consistency. Copies of any correspondence with any local, state, or federal agencies with land use jurisdiction or permitting authority for the proposal should be included.

A detailed plan for the Project is outlined in Exhibits 1 and 2, as well as the Initial Application. A copy of the May 23, 1996, Option Agreement between Union Pacific and Nitze-Stagen for the Project Property is attached as Exhibit 4. As described in the Initial Application, and the Economic Report attached as Exhibit 9, the Project Property is in a zone in which mixed commercial/retail is a specifically permitted use. As Ecology requested, we have attached the relevant zoning code provisions as Exhibit 5. In fact, the City of Seattle has already issued a Property Use and Development Agreement on the Project Property. A copy of this permit is attached as Exhibit 6.

6. A notarized document from the current owners and operators of the site authorizing Ecology to access the site to verify the information submitted and oversee the cleanup, including conducting verification testing, if deemed necessary by Ecology.

See Exhibit 4 (Article II).

7. Notarized documents from the applicant and the seller indicating they have fully disclosed all information in their possession which relates in any way to the proposal.

See Exhibits 7 and 4 (Article II and Exhibit E).

8. Information demonstrating the proposed use for the site will not contribute to the existing release or threatened release or interfere with remedial actions that may be needed at the site.

The planned development will not interfere with cleanup actions at the Property, will not contribute to any existing or threatened release, and is compatible with the preferred cleanup alternative. The extent of existing contamination and the preferred cleanup alternative are described in the attached Remedial Investigation/Feasibility Study, attached as Exhibit 1. The preferred alternative incorporates the planned development and includes covering all exposed soil with either building structures or asphalt-concrete paving to prevent direct human contact with contaminated soil; testing and properly disposing of contaminated soil excavated during construction activities; monitoring of groundwater for one year after the initial phase of development; and institutional controls. Groundwater monitoring wells will be accessible for the needed period of monitoring.

Development tenants are unlikely to use or discharge hazardous substances similar to those currently found at the Property and thus will not contribute to any existing or threatened release.

See also section 12.1 in the Feasibility Study, attached as Exhibit 1, and section 4.0 in the Cleanup Action Plan, attached as Exhibit 2.

9. Information demonstrating the proposed use for the site will not likely increase health risks to persons at or in the vicinity of the site. To make this demonstration requires: a. Identification of the hazardous substances present at the site and their concentrations; b. Activities in the potentially affected vicinity during

and after remediation, along with identification of potential exposure pathways for persons on-site and off-site; c. The remedial action proposed for the site; and d. Estimates of exposures of persons in the potentially affected vicinity during and after site purchase/redevelopment.

See Appendix I to the Feasibility Study, located at Exhibit 1, for a human health risk evaluation for future exposure conditions demonstrating that the proposed use for the Property will not likely increase health risks to persons at or in the vicinity of the Property.

10. A detailed description of the substantial public benefits of the project.

As set forth in the Initial Application, the Project will provide numerous public benefits. These benefits will include environmental enhancements, economic benefits, community benefits and improved aesthetics. The following discussion expands upon the discussion in the Initial Application on two key public benefits: environmental and economic.

Environmental Benefits:

The environmental benefits of the Project will occur as a direct result of the proposed cleanup action. The selected action's components are discussed at length in both the Feasibility Study and the Cleanup Action Plan. Nitze-Stagen is pleased to present a cleanup action to Ecology that is both practicable and protects human health and the environment through the permanent control of potential exposure to contaminated soil. All potential exposure pathways are cut off using these methods. In addition, the selected action complies with MTCA threshold requirements, including protection of human health and the environment. Thus, the remedial action effectively and permanently protects human health and the environment. These environmental benefits are discussed at length in Exhibits 1 and 2.

Economic Benefits:

Redevelopment of the Property will create substantial new tax revenues for state and local governments. These projections are summarized in a detailed economic study, attached as Exhibit 8.

As discussed in the report, this development is extremely important to the growth of the City of Seattle. The Project will provide considerable space for employment and will expand the potential for the Seattle downtown business center to accommodate future

employment. Specifically, the Project will provide 1,200,000 square feet of economic employment space, and produce 3,980 permanent jobs and 2,140 construction jobs, for a total job creation of 6,120. In addition, the Project will provide $216,000,000 of private investment, and $460,000,000 of business activity per year. The Project will produce a minimum of $13,600,000 in annual tax revenues.

Also as discussed in the report and the Initial Application, this Project provides numerous other benefits to the community and the local economics. It will be the first high-rise office building complex completed since 1991 in downtown Seattle. It will positively influence surrounding land uses and create a much-desired bridge between the International District and Pioneer Square. Development sites that are ready-to-build, with permits in place, are rare in the central business district in Seattle. Thus, this Project is well-located and well-positioned in the local real estate market to help the economic center of the region accommodate more economic energy.

11. A proposed schedule for negotiations of the prospective purchaser agreement and a contact person for the negotiations.

As Ecology is aware, Nitze-Stagen currently has construction time constraints that dictate obtaining an Agreement by September. We are aware that Ecology also has time constraints concerning the review of this application. We believe that the following schedule would accommodate our September deadline:

Initial Meeting with Ecology to review detailed application	July 10, 1996
Initial Draft of Prospective Purchaser Consent Decree circulated	July 12, 1996
Finalize Prospective Purchaser Consent Decree	August 12, 1996
Public Comment Period Begins	August 12, 1996
Complete Responsiveness Survey	September 23, 1996
Lodge Consent with Court	September 30, 1996

However, we would like to work with Ecology to determine a suitable schedule.

Bradley M. Marten, Esq., Marten & Brown LLP, 1191 2nd Ave., Suite 2200, Seattle, WA 98101, phone number (206) 292-2604, is the person to contact regarding Prospective Purchaser Agreement negotiations.

12. For proposals for a less than complete cleanup indicating the current owners are expected to pay for part of the cleanup, a notarized letter from the current owner accepting status as a PLP and indicating a willingness to negotiate cleanup.

The Project represents a complete remedial action.

13. Any additional and updated information that has become known since submittal of the initial application.

Other than the additional PLP, economic, environmental, and other information provided herein, Nitze-Stagen does not have any other revisions or additions to its initial submittal.

14. Additional information as requested by Ecology based on the information in the initial application or other information necessary to process the application.

As requested by Ecology, Nitze-Stagen has conducted a thorough search for other potential PLPs. Please see Exhibit 9 for a summary of our findings. We have also included a thorough economic report in response to Ecology's questions regarding the economic impact of the Project. Also as you requested, we are working with Susan Lee to further develop the public participation plan.

Nitze-Stagen will be happy to provide Ecology with any additional information it may request.

Report

Focused Remedial Investigation and Feasibility Study Union Station Seattle, Washington

July 1, 1996

Prepared for

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and

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1.0 EXECUTIVE SUMMARY

This report summarizes the results of a remedial investigation (RI) and feasibility study (FS) for the Union Station property (property) under the Washington State Model Toxics Control Act (MTCA) Prospective Purchaser Agreement (PPA) program (in accordance with August 29, 1994, guidance) administered by the Washington State Department of Ecology (Ecology). The property is located at the south end of downtown Seattle, between the Pioneer Square and International Districts (Figure 1-1). The property, totaling approximately 7.5 acres, consists of the historic Union Station building on the northern portion of the property, the METRO bus tunnel on the eastern portion of the property, and undeveloped areas. As shown on Figure 1-1, the property is discussed as three parcels, the North, Main, and South, for clarity in this RI.

Planned Future Use. Nitze-Stagen seeks to purchase the property to build a commercial office development that will serve as a link between the downtown business district and the international district. Rehabilitation of the historic Union Station building is also included in the development plans. Currently, approximately 60 percent of the property surface is covered by the Union Station building and the METRO bus tunnel and International District Station. The intended redevelopment will effectively cover the property with impervious surfaces associated with the new buildings, parking areas, and pedestrian walkways. In addition, the planned redevelopment will minimize the disturbance of subsurface soils.

Objectives. The objectives of the RI were to:

- Compile soil quality data from previous investigations
- Identify the presence/absence of environmental impacts (soils/waters) in the areas identified as potentially contaminated based on the property history review by evaluating constituent concentrations relative to standards protective of human health and the environment
- Identify the general nature and approximate extent of contamination based on statistical exceedance of protective standards
- Summarize physical conditions of soil and hydrogeology
- Evaluate potential data gaps
- Develop information to support a feasibility study.

Property History. In the course of studies that have been completed over the last 10 years, a detailed history of the property was conducted including an extensive review of property records, and a review of historical operational activities and practices. Relative to potential environmental concerns, the following two primary historical property activities were identified:

- The former coal gasification plant in the northern portion of the Main Parcel
- The former Vulcan Ironworks in the southern portion of the Main Parcel.

The results of the historical review formed the basis for scoping of the previous environmental investigation work and more recent RI work plan (Hart Crowser 1996) for this RI, which is briefly summarized below.

Evaluation of Data Gaps. The existing data for soil and groundwater were reviewed in the context of a preliminary conceptual model for the property which is provided in Section 6. Based on this review, the following data gaps were identified and the justification for including them or excluding them from additional investigation during this RI are provided:

- **Deep Groundwater Data.** Historical activities that resulted in the release of coal tar residuals or iron works residuals occurred at and above the interface between the former tideflat surface and the bottom of what is currently the fill layer. As a result of this, constituents were likely influenced by lateral tidal action more than from any potential vertical transport component. In addition, regional groundwater data indicate upward or horizontal gradients dominate in this vicinity because of the discharge to Elliott Bay. For these reasons, evaluation of the shallow groundwater is believed to be sufficient for the purposes of this RI/FS which focused on the collection of current low turbidity groundwater data in the downgradient portions of the shallow groundwater beneath the property.

- **Key Chemicals Associated with Historical Use.** The historical information on coal gasification plants and iron works (as described in more detail in Section 2) was reviewed relative to the likelihood of the presence of key chemicals after 80 or more years in the environment. These were further evaluated to determine if any additional chemicals were not evaluated in previous sampling activities. The outcome of this review indicated that the chemicals that are predominant in these historical activities and are also persistent in the environment over long periods of time are metals and PAH and that these should be the focus of this RI.

- **TPH/Oils.** Although use of lubricating oils may have occurred at either of the historical facilities, the TPH analytical method is not representative of the predominant contaminant coal tar residuals. Evaluation of PAH better characterizes coal tars as indicted by the composition delineated in Section 2. PAH also better represent the potential for risk from exposure (carcinogenic PAH) and better characterize the more mobile fraction of coal tar residuals, naphthalene. In addition, because the residual materials from property activities have been present for over 80 years (and thus are in approximate equilibrium conditions), it was determined that the focus for the TPH investigation should be in the groundwater (as opposed to in the soil). Thus, groundwater samples were collected and analyzed for TPH at the three new downgradient and two upgradient off-property wells.

- **Cyanide.** Although cyanide may be found in conjunction with coal gasification plants, it is a relatively mobile constituent (e.g., it has high solubility). In addition, the analytical method for analysis of cyanide often results in false positives. The combined relative mobility, lack of persistence, and complexities of the analytical method did not warrant additional characterization for this constituent since there was already previous characterization results available for this constituent.

1.1 Property Soils and Hydrogeology

In general, soils in the property vicinity consist of fill, recent native alluvial and tidal soils, and glacially overridden soils.

Property Soils. Prior to the turn of the century, a marine embayment (the Duwamish Embayment) existed between the West Seattle highland on the west and First and Beacon Hills on the east. According to Coast and Geodetic Survey charts, water depths within the embayment ranged from 5 to 12 ft during the late 1800s with a shallowing toward the shoreline which existed at the foot of Beacon and First Hill and the downtown area. Modification and filling of this embayment began around the turn of the century and was essentially finished between 1907 and 1912. The native soils, which directly underlie the surficial fill soils at the property, are the result of a complex sequence involving non-glacial, glacial, and marine deposition.

Historical Operations. Thus, residual materials resulting from historical activities (from the Coal Gasification Plant and Iron Works which were established on piers over the marine embayment on the property) occurred above the surface of the former tideland area. It is likely that residuals were influenced by tidal flushing prior to the filling activity at the turn of the century, and since operations in both facilities ceased by 1907, there were relatively few years of

contribution of residuals within the new surficial fill soils. Fill material eventually covered nearly the entire property to depths of as much as 25 ft.

Hydrogeology. Regional groundwater flow in the vicinity of the Union Station property is generally westward toward Elliott Bay. On the property, flow in the fill groundwater zone is in a northwesterly direction, with eventual discharge to Elliott Bay. Downward movement of groundwater to deeper marine and glacial zones is not expected because of regionally and locally upward gradients.

1.2 Soil Characterization

The evaluation of soil quality at the Union Station property is based primarily on ten years of studies completed by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Samples from various explorations including soil borings, surface soil samples, and groundwater monitoring wells were collected and analyzed in the vicinity of the property.

Sampling Locations. The majority of explorations were placed on the northeastern portion of the Main Parcel to evaluate soil quality conditions at the former coal storage houses, retorts, coke house, shop, and plant rail line loading and off-loading areas. These areas were identified as the most likely to contain the highest concentrations of residual wastes associated with the former gas plant. Although some other areas for byproduct handling (including the tar paper manufacturing area and associated tar pit, the crude oil tank, and the pipe cutting and storage area) were identified in the northwestern portion of the parcel, these areas are currently covered (and will remain covered) by the Union Station building. An additional focus of the characterization work was to place explorations in the vicinity of the wharf perimeters of the Vulcan Iron Works formerly located in the southern portion of the property.

Analytical Testing. Soil and groundwater samples from the property were analyzed for a suite of chemicals that would be typical of the wastes associated with both the former coal gasification plant and a metals manufacturing facility. Soil analyses performed included semivolatile organics, pesticides/herbicides, total petroleum hydrocarbons, volatile organics, total metals, total cyanide, and extraction procedure toxicity (EP Tox) metals (Table 4-1).

1.3 Summary of Soil Quality

Eighty-two soil samples were collected on and off the property. The analytical results from soils between 0 and 15 feet below ground surface were compared with the MTCA Method B cleanup levels (residential direct contact screening levels). Although there is no MTCA Method B cleanup level for TPH, TPH results were compared to the Method A cleanup level.

Constituents of Potential Concern. Based on a statistical analysis of the soil data for the property, we have identified selected metals, PAH, and TPH as constituents of potential concern for the property soils as shown in Table 1-1. None of the constituents in Table 1-1 meet the MTCA three-fold statistical criteria. The constituents of concern were further evaluated by comparing analytical results from soil samples collected at all depths to concentrations that are protective of surface water (groundwater protection screening levels).

Extent of Elevated Constituents in Soil. Concentrations of PAH and metals above the screening levels were encountered in soils collected on and immediately adjacent to the property. In the southwest portion of the Main Parcel, with the exception of arsenic and beryllium (which had maximum concentrations generally within 4 ft of ground surface), the maximum exceedances of the direct contact screening levels for metals and PAH occurred between 8 and 13 ft below ground surface.

Metals exceedances were within 10 times the screening level and confined to within the upper 20 ft of soil. The metals exceedances are generally distributed across the property at fairly uniform concentrations, which does not indicate a particular source. Potential sources include both the Vulcan Iron Works operations conducted within the southern portion of the main parcel and the fill material that was placed throughout the property.

In the northeast portion of the Main Parcel, substantially higher concentrations and magnitude of exceedance were encountered for PAH ranging from depths of 18 to 50 ft below the existing ground surface. The observed elevated PAH in subsurface soils appear to be derived from the former gas plant operations. The highest concentrations occur along the northeastern portion of the Main Parcel, although there is an area of elevated PAH in apparent South Jackson Street regrade fill material that may have contained gas plant residuals in the southwestern portion of the Main Parcel.

Potential Impact to Groundwater. Soils in the property area do not appear to be significantly impacting shallow groundwater quality. Although a number of soil PAH and soil metal concentrations are above the conservative surface water protection screening levels these constituents generally were not encountered in groundwater samples collected during the May 1996 sampling event (see next subsection) at concentrations exceeding marine criteria protective of Elliott Bay.

1.4 Groundwater Characterization

Groundwater samples have previously been collected in association with a number of investigations conducted on or adjacent to the Union Station property between 1985 and 1993. Groundwater samples collected during the previous investigations were analyzed for a number of parameters including volatile and semivolatile organics, metals, and cyanide.

As part of this RI, three new downgradient monitoring wells were installed. The wells were screened in the upper fill deposits. Groundwater samples were collected from the three new wells and existing upgradient wells B-4 and B-6. Groundwater samples were analyzed for volatile and semivolatile organics, dissolved metals, total petroleum hydrocarbons (TPH), total dissolved soils (TDS), and total suspended solids (TSS). Groundwater samples collected from this event are more representative of groundwater quality than previous samples since they meet current practical quantitation limits and sample collection methods minimized turbidity.

1.5 Summary of Groundwater Quality

Thirty groundwater samples were collected on and off the property. The analytical results from the groundwater samples were compared with water quality criteria protective of the eventual marine receptor Elliott Bay (groundwater screening levels). This comparison was made because property groundwater is extremely unlikely to be used as a drinking water source in the future. The purpose of this comparison was to identify chemicals of potential concern in groundwater.

Previous Groundwater Data. Previous groundwater sampling data show that several upgradient wells had exceedances of the groundwater screening levels. These exceedances included arsenic, copper, nickel, zinc, PAH, benzene, bis(2-ethylhexyl)phthalate, and cyanide.

Benzene exceedances were present beneath South Jackson Street north of the Main Parcel. On-property groundwater sampling also showed exceedances of arsenic, PAH, TPH, and bis(2-ethylhexyl)phthalate.

May 1996 Groundwater. The May 1996 groundwater sampling data had a single relatively small exceedance of the screening level for arsenic, in the downgradient well HC-101. Arsenic exceedances of similar concentrations were also observed in upgradient wells B-4 and B-6. Notably, no PAH concentrations in any of the five wells sampled during this round exceeded screening levels, indicating a high likelihood that previous sample results were biased high from high turbidity. No other exceedances were observed in either upgradient or downgradient wells.

Groundwater Modeling. Although there were no PAH exceedances observed in the downgradient May 1996 groundwater sampling event, we conducted groundwater modeling using the highest concentrations from the previous data to provide additional information. The modeling indicates that substantial concentration reductions of PAH occur within short distances (well before groundwater discharges to Elliott Bay), as a result of dilution and dispersion (not accounting for attenuation caused by biological degradation or by sorption to soil particles).

Together, the recent groundwater sample analytical results along with the modeling results indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

1.6 Summary of Exposure Pathway Interpretation for Current Property Use

The analytical results discussed above were evaluated in the context of potential current exposure pathways to determine whether there is the potential for exposure to elevated constituents in property media. Because there is no current population using the unpaved portion of the property and access to the property is restricted by chain-link with barbed wire fence, there is a limited potential for complete exposure pathways to the soil to be present. For groundwater, there is no current use of shallow groundwater beneath the property for drinking water, thus, the primary potential pathway for the property is the eventual groundwater discharge to the marine receptor of Elliott Bay.

Direct Contact with Soils. The only constituents identified above direct contact screening levels were metals and cPAH in on-property soil samples at depths between 1.5 and 12 ft below

ground surface. Since the property is currently fenced and has no current residential or industrial property uses in areas where there is exposed soil, there is no potential for direct contact exposure.

Inhalation Pathway. Generally the areas on the property not covered by buildings, the bus tunnel, or above-ground roadways are vegetated. Since there is no current property use and no disturbance of the property soil (which could lead to transport off the property), and no current property users, the inhalation pathway appears to be incomplete.

Impact to Groundwater and Downgradient Receptor. The best indicator of this potential is the actual downgradient groundwater monitoring results. This is because the historical constituents at the property have been there for over 80 years and are, therefore, weathered and represent approximate equilibrium conditions. Property soils do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations from previous sampling events were reported at concentrations above the screening levels, these constituents generally were encountered in area groundwater during the May 1996 sampling event at concentrations below the marine criteria protective of Elliott Bay. In the 1996 sampling, the only constituents in property wells that exceeded groundwater screening levels (cyanide and arsenic) were found at similar concentrations in upgradient wells.

Together, the modeling results discussed above, along with the recent groundwater sample analytical results, indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

1.7 Conclusions

Based on the RI data, the constituents of concern are PAH and metals in subsurface soils in the areas of the property identified above. The affected areas observed from the data are consistent with the historical activities identified from the detailed history review of the property. In addition, although PAH and metals above screening levels are found in subsurface soils, and were detected in property groundwater, the only current exposure pathway identified (groundwater transport to Elliott Bay) is not impacted by releases from the property. The sufficiency of current property data is summarized below:

- The historical operations ceased at the property well over 80 years ago, and thus property conditions (and residual contaminants) should approximate equilibrium conditions

- Constituents detected at the property compare well with those expected based on historical property activities and locations

- There has been a large number of on-property and off-property soil and groundwater samples collected and analyzed for a wide variety of constituents

- Constituents detected in off-property soils and upgradient wells are similar and of similar order-of-magnitude as those on the property

- Recent more representative groundwater results, especially those downgradient, indicate no exceedances of screening levels from releases at the property

- There is only one complete exposure pathway (discharge of groundwater to Elliott Bay) that does not appear to be impacted.

Based on our review of the property data for soils and groundwater, we believe the above factors indicate the property has been adequately characterized for the purposes of this RI and that sufficient data are presented herein to form the basis of alternative selection in the FS (considering the historical property uses and future planned uses).

1.8 Feasibility Study Introduction

Based on the results of the remedial investigation portion of this document, this feasibility study has been prepared to fulfill state requirements and to recommend a remedial alternative for the property to assist Ecology in preparing a cleanup action plan. This feasibility study develops four remedial alternatives to address contamination older than 80 years at three parcels of Union Station property in Seattle and provides a preferred alternative.

The components of the feasibility study include:

- Defining cleanup standards and remedial action objectives for the property

- Identifying and screening potential cleanup response actions, technologies, and process options

- Developing and evaluating potential cleanup action alternatives based on MTCA criteria

- Identifying a preferred cleanup action alternative that adequately protects human health and the environment from risks associated with the constituents of concern at the property.

The sections that follow address these components.

1.9 Cleanup Standards And Remedial Action Objectives

Cleanup standards and remedial action objectives are established for property cleanup actions in conformance with MTCA regulations. Based on the analysis conducted in the feasibility study, the remedial action objectives are established for the property as follows:

- Prevent ingestion or direct contact with affected soil containing metals and cPAH above respective cleanup levels within the point of compliance.

- Prevent transfer of constituents of concern from the soil at the property that would result in future groundwater concentrations above the groundwater cleanup levels, at the downgradient point of compliance.

- Prevent direct contact with or ingestion of groundwater.

Soil cleanup levels are conservatively based on residential property use conditions. The property is zoned international district mixed and nearby uses include residential and commercial. Groundwater cleanup standards are based on the assumption that groundwater is extremely unlikely to be used as a future source of drinking water but would have its highest use in discharging to the marine aquatic environment located approximately 2,000 ft to the west. Consequently, groundwater remedial action objectives were developed for monitoring of continued compliance with cleanup standards at the downgradient point of compliance, rather than the use of property groundwater as a drinking water source.

Points of compliance are established for soil and groundwater. The point of compliance for direct contact with soil is from the ground surface to a depth of 15 ft. The point of compliance to protect groundwater is throughout the soil column. The point of compliance for groundwater with a potential to discharge to surface water is at the property boundary; groundwater compliance would be monitored at three downgradient wells located on the west side of the central parcel.

An assessment of additional regulatory requirements that could apply to property cleanup actions was conducted, and several requirements were identified. Applicable regulations were considered in preparing the remedial action objectives and evaluating the alternatives.

1.10 Evaluation of General Response Actions, Technologies, and Process Options

General response actions, cleanup technologies, and process options were screened and evaluated to develop a list of functional actions that could be taken at the property to achieve remedial action objectives. A wide range of cleanup processes was screened based on applicability and technical implementability for contaminants associated with hydrocarbon and manufactured gas plant sites. Cleanup processes found to be applicable to the characteristics identified in the remedial investigation portion of this document were further evaluated based on effectiveness, implementability, and cost to develop a list of processes from which to assemble cleanup action alternatives. Based on the screening and evaluations, the following soil and groundwater cleanup process options were reviewed and retained for further consideration:

- Restrictive covenants and access control (institutional controls)
- Sampling and analysis (monitoring)
- Paving (capping)
- Air sparging (*in situ* soil treatment)
- Construction soil excavation/disposal (soil excavation)
- Accessible soil excavation/disposal (soil excavation).

These cleanup process options were considered potentially applicable to property conditions and serve as the basis for development of cleanup action alternatives.

The retained *in situ* treatment process option (air sparging) is considered potentially applicable for reduction of contaminant volume and toxicity, but it is not capable of achieving MTCA soil cleanup levels throughout the property. Air sparging and related technologies are demonstrated processes for diesel, jet fuel, and other relatively light-end hydrocarbons, but less information is available regarding the effectiveness of the processes for biodegrading heavy hydrocarbon constituents such as carcinogenic polycyclic aromatic hydrocarbons (cPAH).

Consequently, the process would require an assessment of effectiveness and practicability if implemented.

1.11 Development of Cleanup Action Alternatives

The development of candidate cleanup action alternatives takes into account the remedial action objectives, characteristics of the property and constituents of concern, and applicable process options. Key assumptions that affected the development of cleanup action alternatives for the property are listed below:

- **Avoiding impacts to existing property structures** - No cleanup action would be undertaken that results in damage to existing property structures (e.g., bus tunnel or Union Station) or structures adjacent to the property (e.g., public street viaducts).

- **Impracticability of complete soil removal** - Due to the location of the majority of contaminated soil beneath major property features (e.g., the bus tunnel, street viaducts, Union Station), complete removal of contaminated soil is considered impracticable and is not retained as a cleanup option.

- **Limitations of soil remediation** - Due to access restrictions, remediation of all the contaminated soil to achieve regulatory cleanup levels throughout the property is not practicable; accordingly, some constituents of concern would remain on-property for all cleanup action alternatives. The concentration of organic material in soil is too low to support the use of some thermal technologies.

- **Limitations of future property groundwater use** - It is extremely unlikely that shallow property groundwater would be used as a future source of drinking water.

Four cleanup action alternatives were developed incorporating combinations of the retained cleanup process options presented above. These alternatives provide a technical and economic range for the detailed evaluation and comparison of cleanup action alternatives.

- **Alternative 1: Limited Action**. Monitoring; institutional controls; and shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 2: Paving**. Paving (for isolation); monitoring; institutional controls; and shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 3: Air Sparging**. *In situ* air sparging; paving; monitoring; institutional controls; shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 4: Deep Soil Excavation**. Testing and disposal of the accessible portion of the Main Parcel, paving, monitoring, and institutional controls.

A summary of each alternative and its estimated cost is presented below. The estimated cost of the alternative includes the capital construction cost and the operation and maintenance cost for the duration of the action.

Alternative 1 - Monitoring, institutional controls, and construction soil excavation would maintain the limited potential for direct contact. Monitoring would be conducted using existing property wells to confirm continued compliance with groundwater cleanup standards. Due to the age of the contaminants at the property, no future exceedances are anticipated; therefore, no active contingent remedy is included. Contaminated soil encountered during construction activities would be removed and managed off-property in accordance with applicable waste management regulations. Institutional controls would be implemented to control access and potential exposure to contaminated soil, or property groundwater and to conduct periodic review of the status of the property. This alternative is estimated to cost about $700,000.

Alternative 2 - Paving, monitoring, institutional controls, and construction soil excavation would permanently isolate the contaminated soil through paving and construction of building structures to further reduce the limited potential for direct contact. Contaminated soil encountered during construction activities would be removed and managed off-property in accordance with applicable waste management regulations. Monitoring would be conducted using wells to confirm continued compliance with groundwater cleanup standards. Due to the age of the contaminants at the property, no future exceedances are anticipated; therefore, no active contingent remedy is included. Institutional controls would be implemented to control access and potential exposure to contaminated soil, or property groundwater and to conduct periodic review of the status of the property. This alternative is estimated to cost about $1,200,000.

Alternative 3 - Air sparging, paving, monitoring, institutional controls, and construction soil excavation (as needed) would implement the cleanup measures associated with Alternative 2 and would add *in situ* air sparging in an attempt to reduce the volume of constituents of concern in the property soil. Air sparging uses low pressure subsurface air injection through a system of injection wells to stimulate *in situ* aerobic biodegradation of the constituents of concern present in contaminated soil. Air sparging could potentially achieve some small reduction

of the volume of cPAH in the contaminated soil; however, this process is still considered experimental, is not expected to significantly enhance long-term effectiveness, and is not capable of achieving soil cleanup standards. Certain PAH compounds strongly adsorb to the organic soil matrix and would not be degraded by biological activity. The monitoring program for this alternative would add subsurface air analyses to monitor the air sparging operations. The estimated present worth cost for this alternative is $3,800,000.

Alternative 4 - Accessible soil excavation, air sparging, paving, monitoring, institutional controls, and construction soil excavation would implement the cleanup measures associated with Alternative 3, and would also add excavation of accessible soil (soil not located beneath existing property structures) to permanently remove this portion of the contaminated soil from the property. Less than 30 percent of the contaminated soil is accessible, and all of this contaminated soil would be removed under this alternative. Areas of the property beneath the bus tunnel, street viaducts, and Union Station building would not be excavated because of the high potential for damage and disruption. Portions of 4th Avenue South and South Airport Way would require temporary shoring and/or temporary closure to facilitate soil excavation. Selected areas within the exposed soil would be difficult to excavate due to the presence of battered piles (installed at an angle and extending outward) used to support the parking lid structure. Supplemental cleanup measures for the contaminated soil remaining on-property would include modified versions of the air sparging, paving, institutional controls, and monitoring measures associated with Alternative 3. The estimated present worth cost for this alternative is $22,600,000.

1.12 Evaluation of Alternatives

The cleanup action alternatives are individually and comparatively assessed according to threshold and primary balancing criteria defined in MTCA (WAC 173-340), including 1) protection of human health and the environment; 2) compliance with cleanup standards; 3) compliance with applicable state and federal laws; 4) provision for compliance monitoring; 5) use of permanent solutions to the maximum extent practicable; 6) provision for a reasonable restoration time frame; and 7) consideration of public concerns. Alternatives 1, 2, 3 and 4 were all effective in accomplishing the remedial action objectives. Alternatives 1 and 2 were effective

and had the lowest estimated cost. The air sparging step of Alternative 3 was not clearly effective for high molecular weight aromatic hydrocarbons such as cPAH and, due to the additional cost, this alternative was eliminated. Alternative 4 was eliminated because the benefit from its excavation component was considered disproportionate to the substantial additional cost.

1.13 Preferred Cleanup Action

Based on the evaluation and comparison of cleanup action alternatives, Alternatives 1 and 2 satisfy the remedial action objectives. Because the paving component of Alternative 2 is beneficial in reducing the risk of exposure and the cost is not disproportionate to the benefit, Alternative 2 is the preferred alternative. The preferred cleanup action effectively protects human health and the environment by: 1) effectively preventing any potential direct contact with contaminated soil; 2) managing contaminated soil encountered during construction in compliance with applicable regulatory requirements; and 3) providing for institutional controls and monitoring to identify and prevent potential exposure to contaminated media.

The primary potential risk associated with the property (direct exposure to contaminated soil) would be effectively controlled through paving, property development, and institutional controls. It is extremely unlikely that property groundwater would be used as a drinking water source, given the availability of municipal water supply and regulations discouraging development of water wells in this area. The low migration potential and the low solubility in groundwater cause the constituents of concern in the contaminated soil to be relatively immobile, as evidenced by the fact that there are no exceedances of groundwater quality standards caused by releases from the property. Consequently, there is little potential for impacts to groundwater quality.

In summary, the preferred cleanup action would effectively achieve the cleanup standards and remedial action objectives and would provide protection of human health and the environment from potential risks.

Vicinity Map

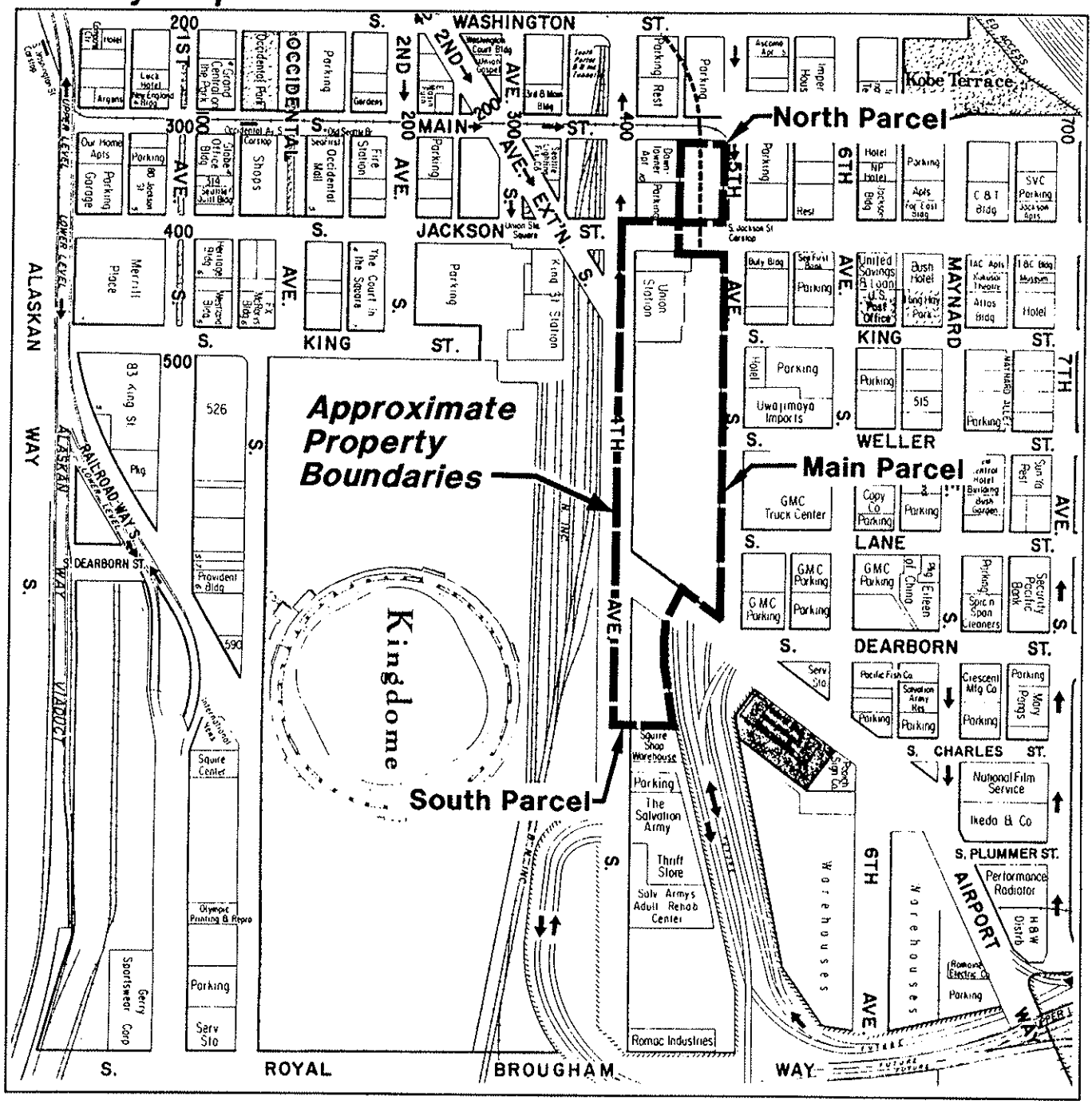

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Figure 1–1

TABLE 1-1

SUMMARY OF POTENTIAL CONSTITUENTS OF CONCERN
ON THE PROPERTY BY MEDIA

Analyte	Soil[a]	Groundwater Previous	Groundwater May 1996
Metals			
Arsenic	X	X	X
Beryllium	X		
Lead	X		
TPH	X[b]	X[b]	
Semivolatiles			
Bis(2-ethylhexyl)phthalate		X	
Benzo(a)anthracene	X	X	
Benzo(a)pyrene	X	X	
Benzo(b)fluoranthene	X		
Benzo(bk)fluoranthene	X		
Benzo(k)fluoranthene	X	X	
Chrysene	X	X	
Dibenz(a,h)anthracene	X	X	
Indeno(1,2,3-cd)pyrene	X	X	
Fluoranthene		X	
Acenaphthene		X	

(a) Based on direct contact.
(b) Although there is no TPH Method B cleanup level, it is included as a constituent of concern because it exceeded the corresponding Method A cleanup level.

2.0 INTRODUCTION

This section of the Remedial Investigation (RI) summarizes the property background information and provides an overview of the scope and technical approach of this work, the RI organization, a general description of the property, the history of the property, and a synopsis of previous investigations.

2.1 RI Scope

The purpose of this report is to summarize the results of the work conducted in accordance with the work plan (Hart Crowser, 1996) to conduct a Remedial Investigation (RI) at the Union Station property (property) located in Seattle, Washington. It also compiles and summarizes the extensive previous investigations conducted at the property over the past decade. The subsection below briefly summarizes the technical scope of our remedial investigation activities.

2.1.1 Project Objectives

This RI was conducted to support a PPA with Ecology under MTCA. The objectives for the RI study include:

- Compile soil quality data from previous investigations;
- Summarize physical conditions of soil and hydrogeology;
- Evaluation potential data gaps;
- Identify the presence/absence of environmental impacts (soils/waters) in the areas identified as potentially contaminated based on the property history review by

evaluating constituent concentrations relative to standards protective of human health;

- Identify the general nature and approximate extent of contamination based on statistical exceedence of protective standards; and

- Develop information to support a feasibility study.

2.1.2 Technical Approach

The following briefly summarizes the technical approach for the soil and groundwater investigation at the property.

Soils. The primary focus of the soils evaluation is to review and compile the existing analytical data of eighty-two soil samples and determine if key chemicals of potential concern are present above appropriate MTCA cleanup levels.

We used the existing soil sample analytical data to prepare a comprehensive database. Sample results for soils within 15 feet of existing grade are compared with the MTCA Method B cleanup levels for direct contact. Those sample results that exceed the cleanup level are mapped to show concentration and distribution with depth.

Sample results from surface depths to greater than 15 feet were evaluated relative to their protectiveness of the highest beneficial use of the groundwater (i.e., eventual discharge to Elliott Bay).

No additional soil sampling was conducted because based on our review of the compiled existing data, we believe that the property soils are adequately characterized. We reviewed the compiled existing data with respect to historical property use, and current property conditions

(e.g., the cover over the property areas comprised by the Union Station Building and the Metro bus tunnel).

Groundwater. The objective of the groundwater evaluation effort is to obtain representative data for PAHs and metals that meet current standards for sampling procedures and detection limits. These results will allow comparison of current groundwater conditions with those reported earlier (i.e., 1987 sampling). In addition, these results compiled with the previous twenty-five groundwater sample results form the basis for evaluating potential impacts to the eventual downgradient receptor of Elliott Bay.

Because property groundwater will not be used as a drinking water source, groundwater data were compared with criteria protective of marine organisms in Elliott Bay.

The current RI field effort included:

- Installation of three off-property downgradient monitoring wells (HC-101 through HC-103) screened (at depths of approximately 5 to 15 feet below ground surface;

- Collection of groundwater samples and water level measurements in the three newly installed wells and existing wells B-4 and B-6;

- Sampling using methods such as proper well design, development, and low-flow sampling to minimize possible false-positive sample results associated with turbidity;

- Analyzing groundwater samples by North Creek Analytical Laboratory for PAHs/semivolatiles (EPA Method 8270), volatiles (EPA Method 8260), benzene, toluene, ethylbenzene, and xylene (BTEX-EPA Method 8020), WTPH-G,

WTPH-D extended, nine dissolved metals (As, Be, Cd, Cr, Cu, Pb, Ni, Ag, and Zn - EPA Method 6000/7000), TSS (EPA Method 160.2), and TDS;

- Measuring water levels, pH, conductivity, temperature, and dissolved oxygen in the field; and

- Summarizing analytical results and groundwater flow directions in a concise RI text which focuses on the data presented in the summary figures and tables.

Exposure Pathway Interpretation for Current Property Use. This evaluation was conducted to include:

- A conceptual model diagram of potential exposure pathways for current property use including the potential marine impacts of groundwater discharge to Elliott Bay; and

- A brief summary of the conceptual model and the findings regarding concentrations above the appropriate MTCA cleanup levels.

2.2 Limitations

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Nitze-Stagen for specific application to the referenced property. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

Based on the age of the previous investigations, some of the detection limits for the analyses are above more recently established screening levels. However, these analyses were

conducted in accordance with accepted methods for their time and are deemed acceptable for the purposes of this RI.

Data from other consultants are included. Hart Crowser is not responsible for completeness nor accuracy of that data.

2.3 RI Report Organization

Subsequent sections of the RI report are organized as follows:

- The remainder of Section 2.0 summarizes the property location, property history, and previous property investigations.

- Section 3.0 summarizes the property hydrogeology including the regional geology, groundwater occurrence, surface and subsurface conditions, and groundwater levels and flow.

- Sections 4.0 and 5.0 describe the media characterization activities, the comparative screening methods, and the quality of the media relative to the selected screening criteria for soil and groundwater, respectively.

- Section 6.0 provides an evaluation of potential exposure pathways at the property which discusses the property conceptual model in the context of the findings described in the preceding sections.

- Section 7.0 summarizes the findings of the RI.

- Section 8.0 lists the references for the report.

Tables and figures relevant to each section are numbered to correspond to their respective section and are included at the end of each section.

Eight appendices follow the references:

- Appendix A presents the specific methods followed for soil and groundwater explorations and sample collection during field activities at the property;
- Appendix B presents the logs of explorations conducted at the property;
- Appendix C summarizes the results of the data quality review conducted for soil and groundwater samples;
- Appendix D provides a complete set of data tables for all samples and analytical results at the property;
- Appendix E provides a listing of the groundwater model input assumption and the modeling results;
- Appendix F provides TPH Laboratory Chromatograms for May 1996 groundwater samples;
- Appendix G provides letters from EPA, Ecology, and Department of Health; and
- Appendix H provides supplemental information from previous reports.

2.4 General Property Description

The approximately 7.5-acre property is located at the south end of downtown Seattle, near the Kingdome, between the Pioneer Square and International Districts as shown on Figure 1-1. It is bounded by Main Street to the north, Airport Way to the south, Fourth Avenue to the west, and Fifth Avenue to the east. The property consists of the historic Union Station building on the northern portion of the property, the Metro bus tunnel on the eastern portion of the property, and undeveloped areas.

Note that this investigation was limited to identification of potential impacts to environmental media (soil and groundwater) associated with the property. This assessment did not include any investigation of existing buildings (e.g., Union Station), underground utilities, or other structures (e.g., Metro bus tunnel).

Based on information compiled for the stadium EIS (Shapiro and Associates, 1996), the property is currently zoned as International District Mixed use (IDM). Existing land use is recorded as retail/office on the northern portion of the property and commercial/parking lot on the southern portion of the property. Existing zoning to the north and east of the property is also IDM. The area located west of the property is zoned Pioneer Square Mixed (PSM). The area south of the property, comprises the Duwamish Industrial Corridor and is designated predominantly for General Industrial (IG2) with some Commercial (C2) land uses. Specific features pertinent to evaluating environmental issues are:

- The property is currently comprised of vacant land, the Union Station building, and the Metro bus tunnel;

- Adjacent properties are being used for commercial, office, hotel, and parking purposes;

- The property is located within the downtown Seattle core, immediately north of the Duwamish Industrial Corridor; and

- Future office building/parking/commercial uses and public plaza (open space that consists of concrete pavers with contained raised landscaping) are part of property planning considerations.

2.5 Historical Summary

In 1874, the Seattle Gaslight Company constructed a coal gasification plant on the property on pilings over the mudflats of Duwamish Bay. The area surrounding the pile-supported facility was filled in over the years. Around the turn of the century the Vulcan Iron Works manufactured iron, brass, and steel on the southern portion of the Main Parcel.

In 1907, the gas plant was razed and the property was leveled for construction of the existing Union Station. Vulcan Iron Works was subsequently relocated in 1910 to make room for the new tracks leading to the Union Station. The Union Station served passengers until 1971 when Union Pacific discontinued passenger operations at the property.

The Downtown Seattle Transit Project bus tunnel, which has its southern terminus at Union Station, was constructed in 1990. The southernmost bus station is located on the eastern side of the property along 5th Avenue South. The tunnel boarding platforms are below grade at the grade of the former railroad tracks on the property. Metro constructed the tunnel and the terminal at the Union Station property and the pedestrian platform lid to the north. Union Pacific Realty constructed the pedestrian platform lid which extends above the station to the south.

This brief historical summary of the property is discussed in more detail below.

2.5.1 Historical Information

From the mid-1800s until the 1950s, manufactured gas plants produced gas from coal and oil for lighting, heating, and cooking needs throughout the country. Gas plant wastes and byproducts were often sold or recycled for various purposes. Excess gas plant wastes and byproducts were commonly stored in the vicinity of the gas plant properties and this is the source of wastes that may still remain around many of these facilities.

The Union Station property was formerly at the edge of the tidal shoreline south of the developing town of Seattle. Prior to about 1890, development in the property vicinity was limited to a coal gasification plant at the shoreline margin (currently the location of Union Station) and trestled railroad tracks that curved through the area around King Street. Use of the tidelands areas expanded in the late 1880s and early 1890s. Buildings supported on piled platforms were constructed in the area adjacent to the mainline rail tracks that followed what is now Airport Way. Meanwhile, in the late 1890s, programs were developed to fill the tidelands area to promote additional industrial expansion. Composite information on the location of former structures and shoreline for the property is provided on Figure 2-1.

The following subsections provide a detailed chronology of property history with a focus on the coal gasification facility.

2.5.2 Early Development in the Area

The Seattle Gaslight Company was founded in the Spring of 1873. The original plant, which fronted the south side of South Jackson Street between 4th and 5th Avenues South, was completed in January 1874. The plant was located at the edge of the tideline and most of the facility was built on a piled and planked wharf extending out into the Duwamish Bay. Only the buildings at the northeast corner of the plant were constructed on land.

By the late 1870s, plant expansion and improvement began. The original gasholder (a cylindrical above-ground gas-storage unit), located at the western end of the plant, was apparently relocated around that time; a new tank was built on the North Parcel immediately north of South Jackson Street near 5th Avenue South.

Plant expansion continued throughout the next decade, and by the late 1880s the planked wharf had been extended to cover over 75 percent of the block between South Jackson and South King Streets. Also, two new gasholders were built on the North Parcel north of the main plant. Although the buildings on the main plant property imply that this area was used exclusively for gas generation at this time, byproduct refining was part of the overall operation. This is indicated by the locations of the refining works including tar paper manufacturing in the northwest corner of the property (Figure 2-1).

The plant again went through a major building phase around 1900. It appears that both gas manufacturing and byproduct refinement were consolidated within the main plant. The latter included manufacture of water gas, ammonia, and tar roofing paper. Most of the plant was still built on the pile and plank platform, although by this time the tideland area surrounding the plant had been filled; it is not known whether fill was placed only around the platform structure, or if it was also placed underneath the structures.

The gasification plant continued in operation until 1907, when the property was leveled in preparation for the construction of Union Station.

A series of structures raised on piles to the level of the railroad tracks that ran along what is now Airport Way South were built between 1888 and 1894. Some of these were associated with railroad operations, although some appear to be commercial or warehouse buildings that relied on railroad shipment for goods.

New industrial facilities with brick construction replaced the older frame buildings in the southern end of the parcel between Airport Way South and South Weller Street by 1900. The major industry in the southern end of the Main Parcel was the Vulcan Iron Works plant located between South Dearborn and South Lane Streets north of Airport Way South. The iron works was built before 1900 and expanded in 1902 to cover the entire portion of the block north of Airport Way South. Along with the residues from the iron, brass, and steel manufacturing processes, it is likely that a variety of lubricants were used on property for servicing machinery and products typical of industrial facility procedures at this time. The plant was relocated to 4th Avenue South and South Royal Brougham Way around 1910 to make room for the new tracks leading to Union Station.

2.5.3 Relationship between Historical Property Use and Potential Contaminant Release

Derivation of Typical Gas Plant Wastes. Gas plant wastes consist mostly of tar, lampblack, and tarry sludges. Coal tar is a complex chemical mixture (containing more than 250 individual compounds), similar to creosote, that is derived from the destructive distillation of coal in coke ovens and retorts. During the process, coal is heated to 450 to 900 degrees centigrade for approximately 16 hours. Coal vapors generated from this process are then condensed to produce liquid, and the coal tars can then be separated out because they sink. The resulting coal tars are then distilled to yield various fractions including: about 5% light oil, 17% middle oil, 7% heavy oil, 9% anthracene oil, and 62% pitch.

Typical Coal Tar Chemical Composition. Major classes of chemicals and relative percent composition associated with gas plant wastes are approximately 85% polycyclic aromatic hydrocarbons (PAHs). The PAHs associated with coal tars have a distinctive composition dominated by naphthalenes (11 to 14%), and phenanthrene (3 to 7%). Other chemical classes include: 10% phenolics (e.g., phenols, cresols, napthals), 5% various inorganic sulfur and nitrogen compounds (e.g., acridenes, cyanide, ammonia, thiodenes, sulphite), less than 5% light aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene [BTEX]), and trace metals

(e.g., aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, sodium, and vanadium). All of these chemicals are common constituents in the environment.

2.5.4 Tidelands, Shoreline, and Fill

The original shoreline of the tidelands in the gasification plant area crossed the Main Parcel in a northwest-southeast slant leaving over 80 percent of the block submerged during high tide. Grade changes in the tideflats were gradual, and it is likely that the whole block was mudflats during low tide. The North Parcel, north of South Jackson Street was uplands (Figure 2-1).

It appears that the shoreline remained essentially the same until around 1895 to 1897. A tidal lagoon that extended from Occidental Avenue South to 3rd Avenue South between South Main Street and Yesler Way had been the scene of dumping and filling throughout the 1860s and 1870s. Beyond that area, however, tideland reclamation was limited and focused on extension along the southern end of 1st Avenue South and Occidental Avenue South.

In 1895, work began on construction of a ship canal to Lake Washington through Beacon Hill and the Rainier Valley, including dredging of associated waterways. It appears that the land north of the Oregon and Washington Railway Company tracks, which ran east-west just south of King Street, was filled as part of this dredging operation. Presumably, the materials came from excavation of the East and West Channel Waterways of the Duwamish River near Harbor Island. It is estimated that the fill was placed about 1897.

It appears that the area from the gasification plant to Airport Way South was filled or at least partially filled between 1905 and 1909, presumably by the railroads. During 1908-1909, the city had instituted a massive regrading of South Jackson Street immediately east of the coal gasification plant block, which was under construction at that time for the Union Station

facilities. It is possible that much of the fill material placed at this time south of the new station came from the regrade.

During the period 1909 to 1912, Oregon and Washington Railway and Navigation Co. (Union Pacific) and the Great Northern Railway constructed the reinforced concrete viaducts on South Jackson Street from 4th Avenue South to 5th Avenue South, on 4th Avenue South from Jackson Street to Seattle Boulevard (Airport Way South), and on Seattle Boulevard from 4th Avenue South to 5th Avenue South; and a retaining wall on 5th Avenue South from South Main Street to Seattle Boulevard. These viaducts and retaining walls are still in-place and are used for traffic flow in the study area.

Union Station was constructed in 1911 by the Oregon and Washington Railway and Navigation Co. (Union Pacific) and the Chicago Milwaukee and St. Paul Line.

2.5.5 Recent Developments

Union Station served passengers until 1971, when Union Pacific discontinued railroad operations at the property. Based on the existence of a rail yard and a roundhouse located south of the station, only limited routine maintenance activities were conducted at the station with most of the heavy maintenance activities occurring off of the property. Union Pacific continued to use some of the building space for offices until 1978, and in 1984 they removed the railroad tracks from the station area. The depot building is currently being used as leased space for various social functions.

Since the abandonment of its original purpose, the Union Station area has been the target of a variety of proposals for new uses, most of which feature the distinguished old depot as the historic centerpiece for a larger development. The station building's historic significance is recognized by its inclusion in the National Register of Historic Places.

The DSTP Bus Tunnel, which has its southern terminus at Union Station, was completed in 1990. Refer to the FS for information on soil removal during bus tunnel construction. The station for the southernmost bus terminal is immediately east of the Union Station building, along 5th Avenue South. The boarding platforms for the station are below street level and at grade with the former railroad tracks, with access to the boarding platform from entrances at South King Street and South Jackson Street. Metro constructed the tunnel and the terminal at the Union Station property. Union Pacific Realty constructed the lid which extends the grade level plaza above the bus terminal southward along 5th Avenue South. Union Pacific Realty granted an easement to Metro for the area needed for the terminal but retains development rights associated with the land area.

2.6 Previous Property Investigations

Evaluation of environmental quality at the Union Station property is based primarily on work completed previously by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Figure 2-2 presents locations of explorations from these previous investigations as well as the current RI. In addition to the three new downgradient wells (HC-101 through HC-103), we have included the locations and sampling results from the nearby King Street Station property to provide additional off-property downgradient groundwater quality information. Other documents such as memoranda and records of meetings or telephone conversations have been reviewed for supplemental information.

2.7 Chronology of Significant Events

Listed below is a chronology of selected events relating to assessment of soil and groundwater quality near the Union Station property. The information summarized in this section is provided in detail in each of the report/technical memo products indicated below.

Date	Event
1982	Hydrocarbons are noted during drilling associated with the South Jackson Street bridge.
Fall 1984	Preliminary Engineering Study for Downtown Seattle Transit Project (DSTP) indicates the presence of black tar-like substance near the intersection of 5th Avenue South and South Jackson Street. Historical coal gasification plant is identified as the source.
January 1985	Analysis of three soil samples indicates the presence of hydrocarbons.
September 1985	Additional soil samples confirm previous test results.
February 1986	Union Pacific Realty Company (then Upland Industries) authorizes Hart Crowser to conduct soil and groundwater quality and hydrogeologic assessment of the Union Station property.
	Union Pacific Realty, Hart Crowser, and Metro meet with Washington State Department of Ecology (Ecology) to discuss the property.
	Shannon & Wilson, Inc., produces draft report summarizing soil and groundwater quality data collected in conjunction with DSTP.
May 1986	Hart Crowser produces report titled "Soil and Groundwater Quality Analyses and Preliminary Hydrogeologic Assessment."
June 1986	Union Pacific Realty and Hart Crowser meet with Ecology (Gary Brugger and John Conroy) to discuss the May 1986 report.

March 1987	Hart Crowser reports on soil quality in the North Parcel.
August 1987	Hart Crowser reports on soil quality in the South Parcel.
September 1987	Hart Crowser reports on surface soil quality.
November 1988	Ecology designates the Union Station property as a hazardous waste property, using the former ranking system under Chapter 70.105B RCW, prior to the current WARM process used to rank contaminated properties for cleanup.
1990	Completion of Metro bus tunnel.
June 1991	SAIC Inc. and DPRA Inc., contractors for Ecology, conduct a Site Hazard Assessment (SHA). No sampling and analysis were conducted.
June 1991	Ecology ranks the Union Station property as a "5" based on Ecology's Washington Ranking Method (WARM) ranking matrix. (The WARM ranking is from "1" to "5" with "5" being of lowest priority for cleanup.)
July 1993	The Washington State Department of Health (DOH) conducts a health investigation at the Union Station property. DOH concludes that the Union Station property does not present a significant hazard to public health.
June 1994	Roy F. Weston, contractor of the U.S. Environmental Protection Agency (EPA) conducts a non-sampling inspection to determine if any further action is appropriate at the property.

August 1994	Ecology reranks the Union Station property to a "3" from a "5" based on a revision of the WARM ranking matrix (no new information was used to perform the ranking).
September 1994	EPA listed the Union Station property as a "No Further Action" property based on the assessment performed by Roy F. Weston in June 1994.

Composite Plan of Former Structures and Shoreline

Curb
Curb
Curb
Paved
Airport Way S.
Filled - 1905-1909
Jackson Regrade?
1903 Addition
Pre-1900
Pre-1900
Building Complex
on Piles, 1900
Buildings 1900
Vulcan Iron Works
Ca. 1900-1909 (on piles)
Edge of Plank
Platform, 1900
Piled
Cause
1900
Resurfaced Area
Conc
S. Dearborn St.
S. Lane St.
Paved
Gate
CB
Conc
CB
CB
BB

Notes: 1. Basic Site plan including topography and existing features from Washington State Department of Transportation drawing entitled ' SR-90 Alaska Way to Vicinity 23rd Ave. S., Sheets 2 and 3, dated December, 1980.

2. X 9.2 Elevation in Feet (City Datum)

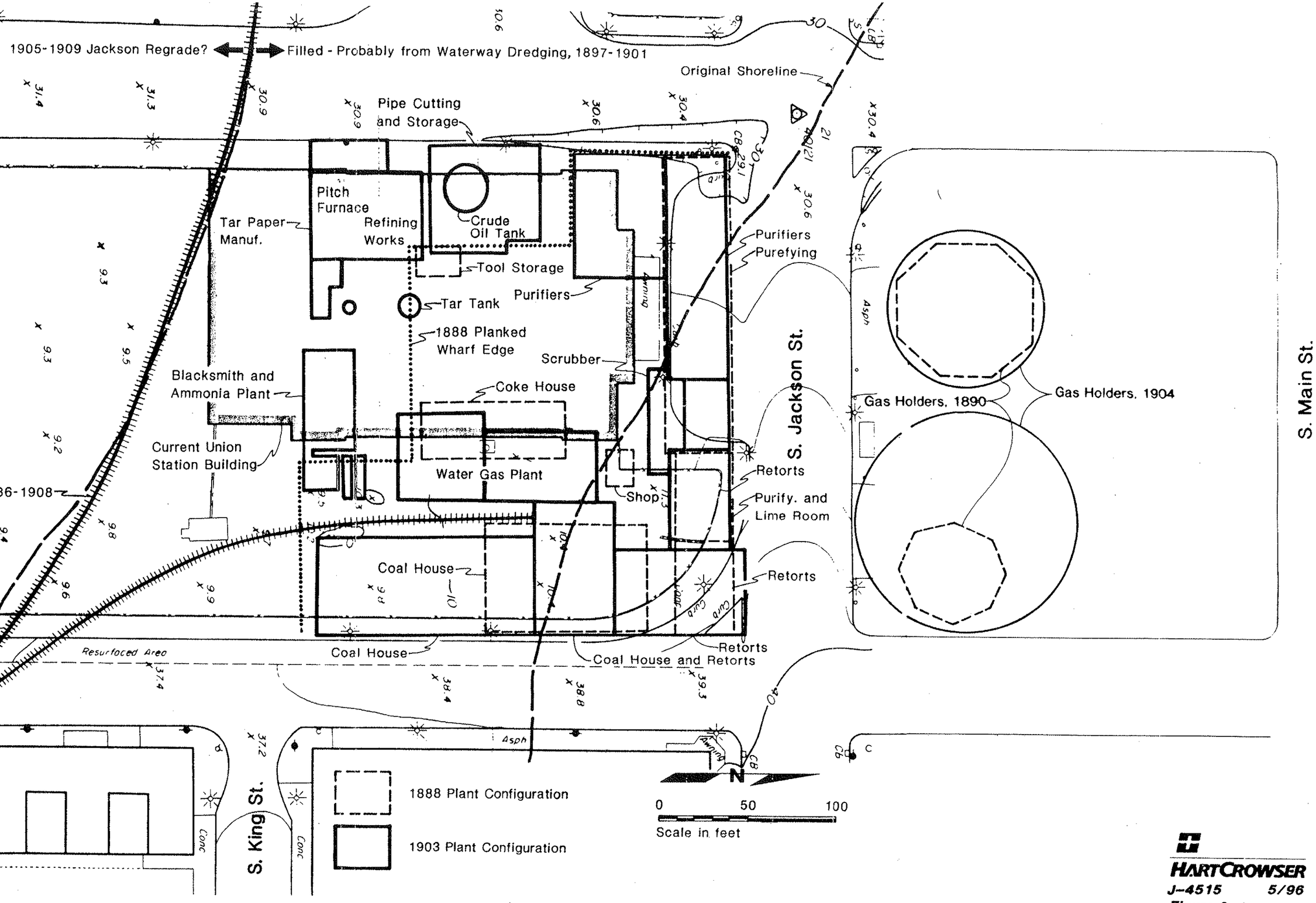

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Figure 2-1

Property and Vicinity Map Showing Previous Explorations and Recently Installed Groundwater Monitoring Wells

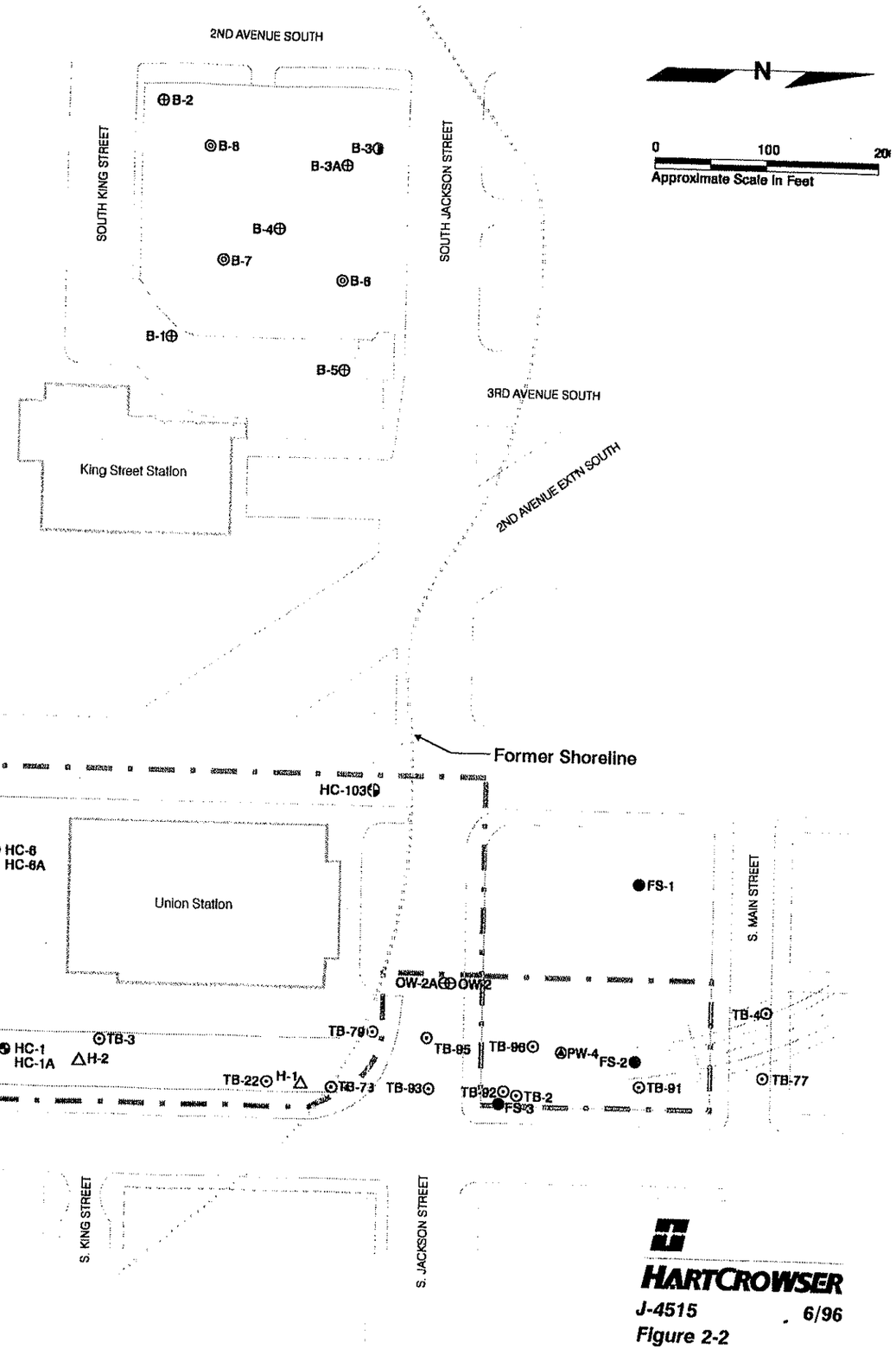
⊕HC-101	Recently Installed Monitoring Well Location and Number
◎	Resampling of Existing Well

Existing Exploration Location and Number (Hart Crowser)

⊕B-5	Monitoring Well (January 1993, J-3711)
◎B-7	Soil Boring (January 1993, J-3711)
◑B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
●FS-3	Chemical Boring (January 1987, J-1636-03)
◎BP-3	Boring (August 1987, J-1636-05)
◆G-1	Shallow Geochemical Boring (August 1987, J-1636-04)
◑HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
⊕B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5

Exploration Location and Number (Others)

⊙TB-82	Boring/Well (January 1986)
⊖OW-2A	Boring/Well (July 1996)
ⓐPW-4	Boring (January 1987)
△H-3	Approximate Location of Surface Soil Sample (January 1987)
	Former Shoreline
	Approximate Property Boundary



coreldrw\jobs\4515\siteplan

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J-4515 6/96

Figure 2-2

3.0 PROPERTY HYDROGEOLOGY AND SUBSURFACE CONDITIONS

This section compiles information from previous reports and current property explorations, including:

- **Regional Geology and Groundwater Occurrence.** Discusses the historical regional geology and regional groundwater flow and sources;

- **Property Subsurface Conditions.** Discusses property subsurface conditions on the Main Parcel, South Parcel, and North Parcel with respect to the fill layer, tidal soils, and glacial soils, using subsurface cross sections for illustration; and

- **Groundwater Levels and Flow.** Describes local groundwater elevations and flow direction.

Selected subsurface explorations and cross section locations are shown on Figure 3-1. Subsurface cross sections are presented on Figures 3-2, 3-3, and 3-4. A groundwater elevation contour map is presented on Figure 3-5, and Table 3-1 presents groundwater elevation data.

3.1 Regional Geology and Groundwater Occurrence

Prior to the turn of the century, a marine embayment (the Duwamish Embayment) existed between the West Seattle highland on the west and First and Beacon Hills on the east. According to Coast and Geodetic Survey charts, water depths within the embayment ranged from 5 to 12 feet during the late 1800s with a shallowing toward the shoreline which existed at the foot of Beacon and First Hill and the downtown area (Figure 3-1). Modification and filling of this embayment began around the turn of the century and was essentially finished between 1907 and 1912. The native soils which directly underlie the surficial fill soils at the property are the result of a complex sequence involving non-glacial, glacial, and marine deposition.

The regional groundwater flow system is characterized primarily by recharge in the upland areas of Beacon and First Hills to the east of the property, and discharge into Elliott Bay. Three potentially water-bearing geologic units occur in the vicinity of the Union Station property, as follows:

- **Fill Material.** Consisting of a heterogenous mixture of silt, sand, clay, and gravel with layers and pockets of scattered debris;

- **Tideland Soils.** Consisting of fine-grained silts and clays with occasional sand layers; and

- **Glacial Deposits.** Consisting of interbedded layers of more permeable sands and gravels, till deposits, and hard silt deposits.

Groundwater from these units is not used for drinking water.

3.2 Property Subsurface Conditions

In general, soils in the property vicinity consist of fill, recent native alluvial and bay tideland soils and glacially overridden soils as shown on the generalized subsurface cross sections on Figures 3-2, 3-3, and 3-4. Figure 3-1 shows the exploration and cross section locations. Only those explorations for which chemical data were derived are presented on Figure 3-1. The soil units are described below.

3.2.1 Fill Varies in Thickness and Characteristics

Fill soils are those soils which have been placed over native soils during the latter part of the coal gasification plant operational period (refer to Figure 3-2). As with most fills, the

soils vary considerably in thickness and characteristics. As a result of the variable soil types, the fill materials will have a variable capacity to transmit water (permeability).

At the North Parcel, the fill consists of loose to medium dense, silty sand to depths of 7 to 20 feet below ground surface. The ground surface was modified somewhat during the Metro tunnel construction, with grading and subsequent placement of fill.

At the Main Parcel, the fill includes sand and gravel, silty sandy gravel, and clay and sand to depths of about 25 feet. The fill ranges from very loose to medium dense.

At the South Parcel, the fill includes 2 to 3 feet of medium dense, sand and gravel underlain by about 20 feet of soft, clayey, hydraulic fill.

3.2.2 Native Tideland Soils Underlie Fill

Prior to historical filling, natural deposition of tideland soils occurred in the tidal zone. These tideland soils typically include interlayered loose sands and soft silts.

At the North Parcel, tideland soils are not present because the original shoreline was further southwest, approximately at South Jackson Street (Figure 3-1). At this parcel, the fill directly overlies older glacial soils.

At the Main Parcel, the tideland soils occur beneath the fill to depths ranging from about 35 to 90 feet below ground surface. The tideland soils are fine-grained, consisting of clayey silt, organic silty clay, peaty silty sand, and silty gravelly sand.

At the South Parcel, tideland soils are present beneath the fill to depths of about 35 to 50 feet below ground surface.

The tideland soils are generally finer-grained, and thus less permeable, than the overlying fill materials. However, like the fill, the native tideland soils exhibit considerable interlayering (sands and silts), and groundwater flow will depend on interconnection of the more permeable zones.

3.2.3 Deeper Glacial Soils Present at Each Parcel

Glacial soils occur beneath the fill or beneath the tideland soils where present. The glacial soils were deposited by glaciers and subsequently subjected to the weight of the glacial ice, resulting in dense or hard soils. Cobbles or boulders were occasionally noted (from drill action) during explorations within the glacial soils.

At the North Parcel, glacial soils, consisting of sand, silty sand, gravelly silty sand (till-like), and sandy silt are first encountered at depths of about 8 to 30 feet below ground surface.

At the Main Parcel, glacial soils, consisting of sand, silty sand, gravelly, silty sand (till-like), and clayey silt are first encountered at depths ranging from 40 to 110 feet below ground surface.

At the South Parcel, glacial soils, primarily sandy silt and sand, are first encountered at depths of about 35 to 50 feet below ground surface.

Glacial soils extend to the depth of exploration at the property (to depths of 130 feet; elevation -120 feet). Regional information indicates that up to 3,600 feet of glacial soils are present beneath downtown Seattle (Hall and Othberg, 1974).

3.3 Upper Fill Zone Groundwater Levels and Flow

During the May 1996 groundwater sampling, groundwater was encountered within the fill unit at the property from depths of 4.5 to 6.5 feet below ground surface at the downgradient (west) side of the property (near Fourth Avenue), and at depths of about 35 feet on the upgradient (east) side of the property (near Fifth Avenue) where the ground surface is 20 to 25 feet higher.

Regional information indicates that shallow groundwater in the area ultimately discharges to Elliott Bay. Based on past and present water level elevations measured in monitoring wells, groundwater flows from southeast to northwest across the property toward 4th Avenue South and South Jackson Street. Table 3-1 summarizes the groundwater elevation data for the property. Figure 3-5 illustrates the general direction of groundwater flow in the fill beneath the property (Hart Crowser, 1986). This groundwater flow map is based on data from numerous monitoring wells, many of which have since been decommissioned during construction of the Metro bus tunnel.

To confirm regional groundwater flow information, we also briefly reviewed regional information (including the downgradient King Street Station and the upgradient or cross-gradient stadium EIS work). However, an in-depth review of that information was beyond the scope of this work. Groundwater elevation data from the May 1996 sampling (four wells) indicate flow in the same general northwestern direction consistent with that determined from the 1986 measurements. Although the majority of the bus tunnel in the immediate property vicinity is constructed above the water table, drainage around the foundation of the bus tunnel may at times influence the local groundwater elevations. Groundwater flow velocity within the fill aquifer on the property was previously estimated to be about 0.2 to 2 feet per month (Hart Crowser, 1986).

The groundwater elevation in well B-6 was approximately 13 feet, considerably above the groundwater elevation in the other fill zone wells. Well B-6 is screened near the bottom of the fill zone, near the contact with the tideland soils. Beneath the tideland soil layer, significant artesian pressures are present in the deep glacial zone (e.g., wells TB-23 and TB-80 are flowing artesian wells—see Table 3-1). Higher groundwater elevations observed in well B-6 indicate that it is potentially in hydraulic connection with the higher hydraulic head conditions in the deeper zones.

In summary, groundwater elevation data indicate that groundwater flow is generally westward with eventual discharge to Elliott Bay, and that regional upward hydraulic gradients would prevent downward groundwater flow from the fill to deeper marine or glacial units.

3.3.1 Utility Corridor

Underground utility corridors can sometimes provide a preferential pathway for shallow groundwater flow, because the utility conduits are commonly bedded in highly permeable gravel. Thus, a limited evaluation of the potential for preferential utility corridor transport at the downgradient perimeter of the property was conducted as part of this RI.

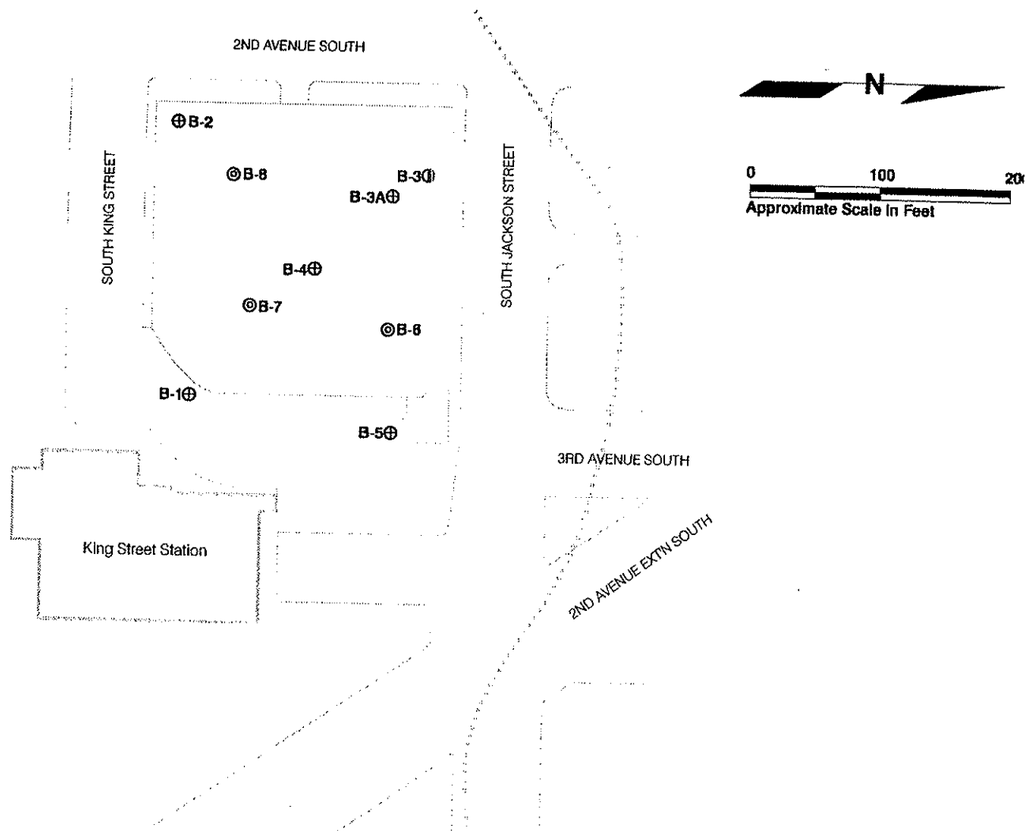
Based on a review of City of Seattle utility maps, two primary utilities were identified downgradient of the property. Beneath Fourth Avenue, there is a 4-foot-diameter sewer main buried approximately 14 to 15 feet below ground with a slope toward the south, and a water main is present at a depth of 2 to 3 feet below ground. The water line is above the groundwater table and consequently does not pose a potential groundwater flow pathway; however, the sewer main may provide a preferential flow pathway.

Site and Exploration Plan Showing Cross Section Locations

HC-101	Recently Installed Monitoring Well Location and Number
	Resampling of Existing Well
	Existing Exploration Location and Number (Hart Crowser)
B-5	Monitoring Well (January 1993, J-3711)
B-7	Soil Boring (January 1993, J-3711)
B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
FS-3	Chemical Boring (January 1987, J-1636-03)
BP-3	Boring (August 1987, J-1636-05)
G-1	Shallow Geochemical Boring (August 1987, J-1636-04)
HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5

	Exploration Location and Number (Others)
TB-82	Boring/Well (January 1986)
OW-2A	Boring/Well (July 1996)
PW-4	Boring (January 1987)
H-3	Approximate Location of Surface Soil Sample (January 1987)
	Former Shoreline
	Approximate Property Boundary
A A'	Cross Section Location and Designation (April 1986, J-1636-01)

Note: Exploration locations are only shown where chemical data were collected.



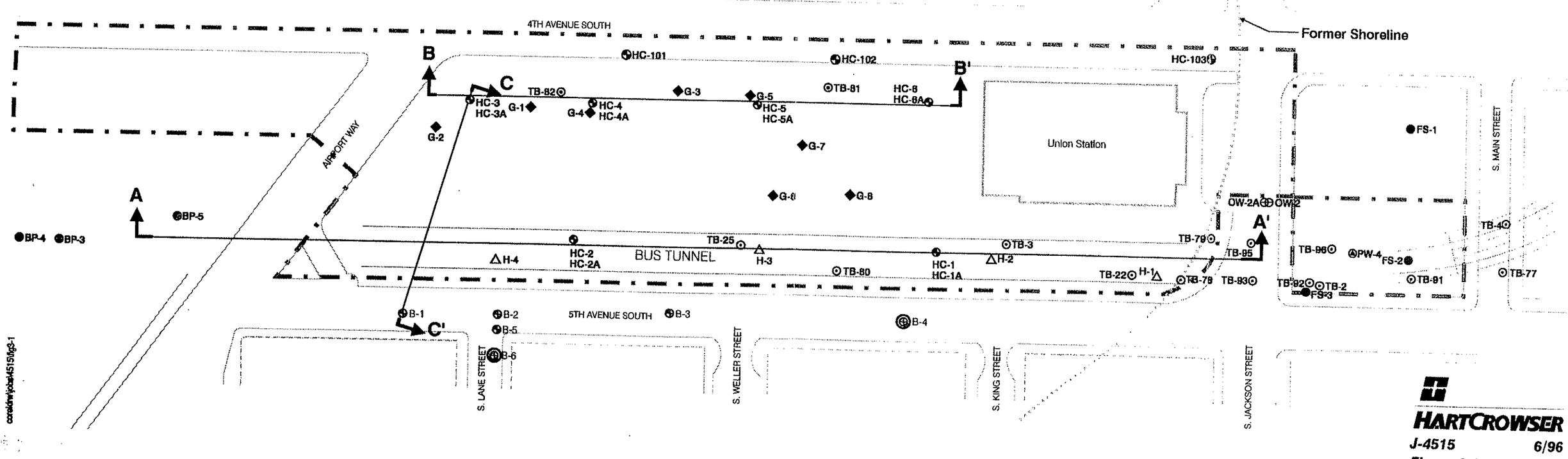


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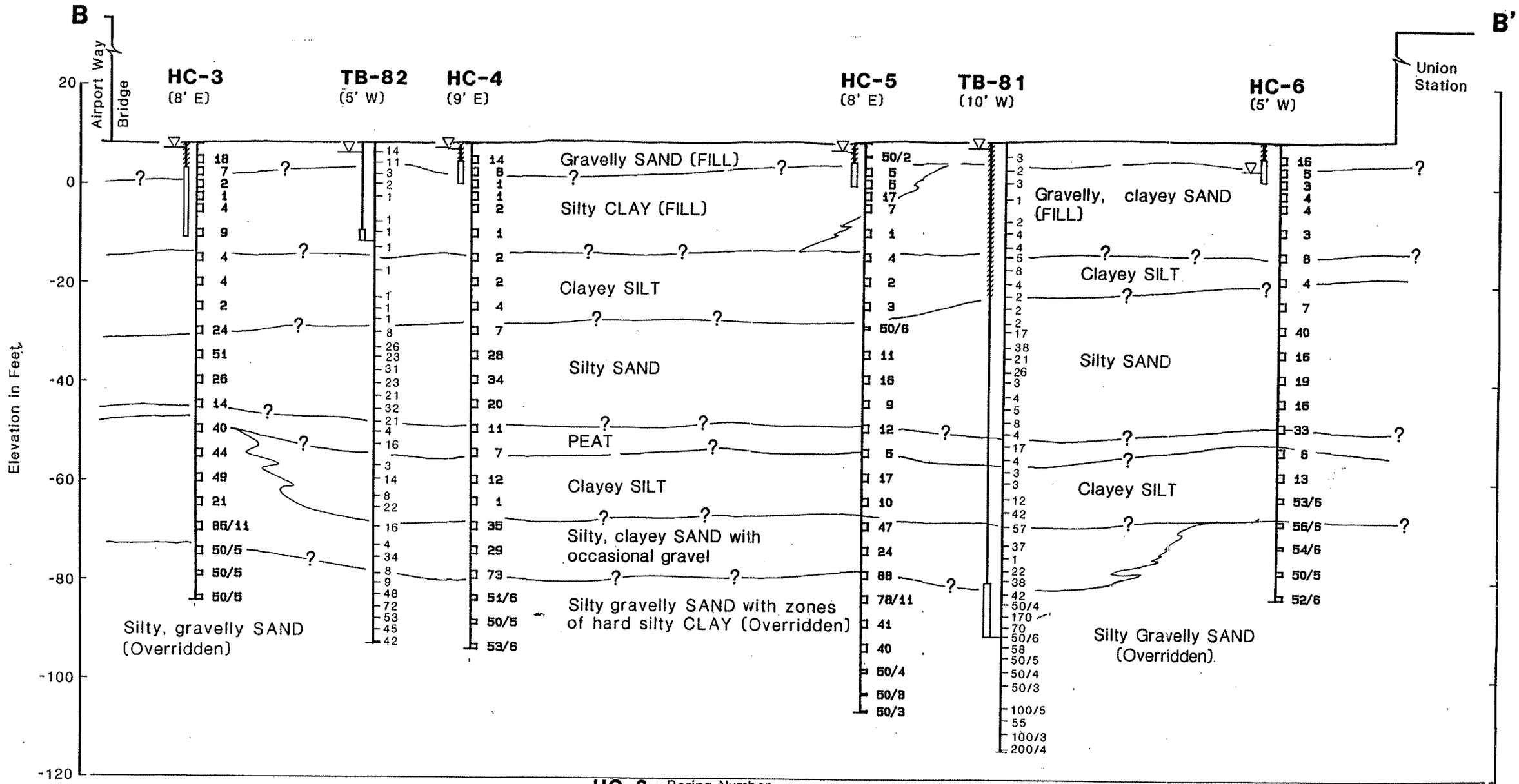
Figure 3-1

corel/dmw/jobs/4515/fig3-1

Generalized Subsurface Cross Section B–B'

Union Station Development SE



Notes: 1. **The stratum lines are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.**
2. See Figure 3–1 for explanation of boring numbers.

Observation Well Installation
Water Level
Seal
Screen Section

HC-3 (10' W)
44

Boring Number
Offset Distance and Direction
Boring Location
Standard Penetration Resistance in Blows per Foot

Horizontal Scale in Feet
0 50 100
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

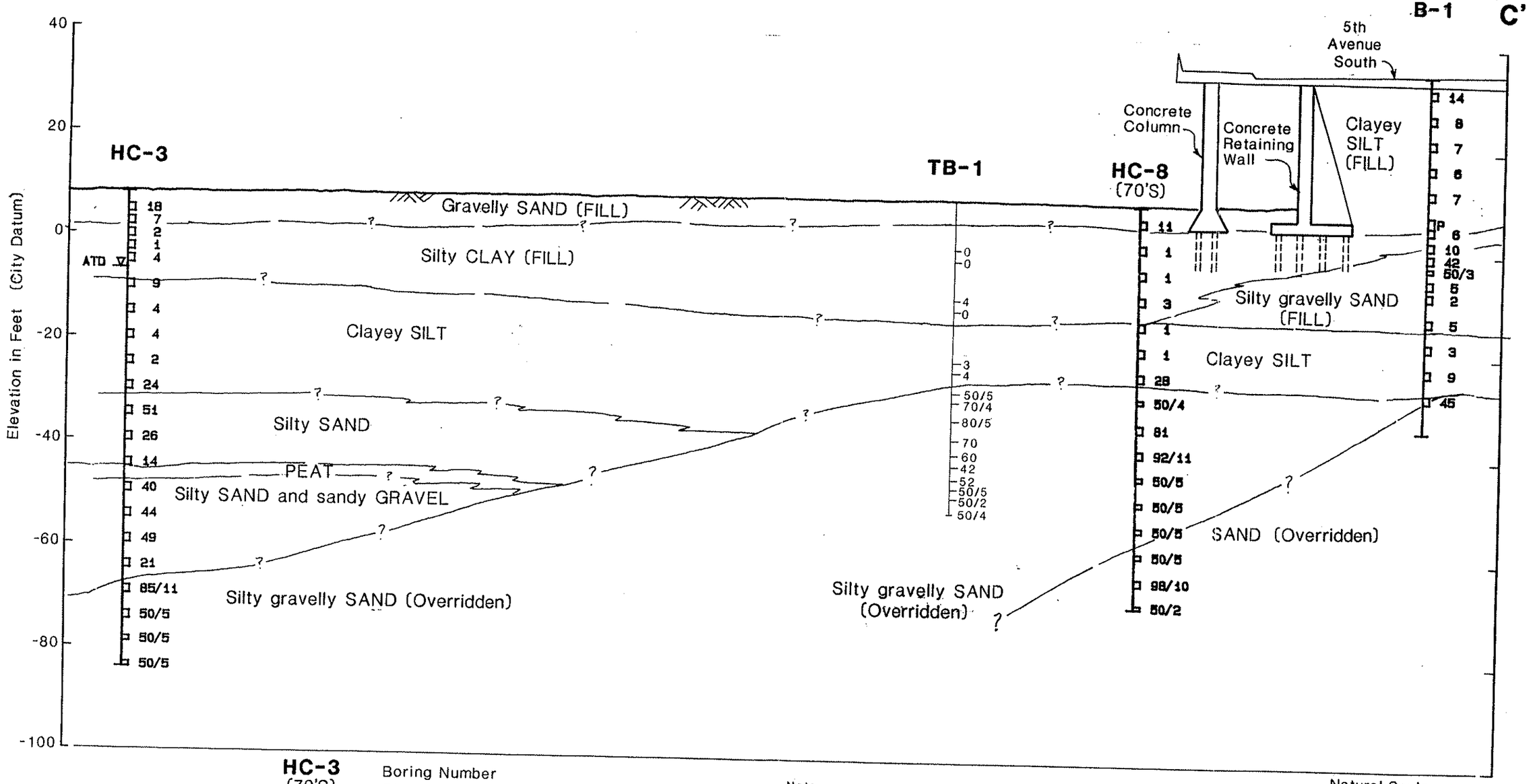
J–4515	April	1996
J-1636-02	February	1987
J-1636	January	1986

HART-CROWSER & associates inc.

Figure 3–3

Generalized Subsurface Cross Section C–C'

Union Station Development SE



HC-3
(70'S)

Boring Number
Distance Offset and Direction
Boring Location

11 Standard Penetration Resistance

Note:

1. The stratum lines are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 3-1 for explanation of boring numbers.
3. Logs for explorations with chemical data are presented in Appendix H.

Natural Scale

0 20 40
Scale in Feet

J-4515 April 1996
J-1636-02 February 1987
HART-CROWSER & associates inc.
Figure 3-4

Table 3-1. Groundwater Elevation Data

Well Number	Fill Zone	Deep Glacial Zone	Other
February 21, 1986			
HC-1A (1)	2.95	--	--
HC-2A	7.90	--	--
HC-3A	7.31	--	--
HC-4A	7.29	--	--
HC-5A	6.90	--	--
HC-6A	3.38	--	--
B-1	8.10	--	--
B-2	--	--	9.38
B-3	7.85	--	--
B-4	3.94	--	--
B-6	14.20	--	--
B-119	--	8.66	--
TB-3	--	--	9.82
TB-23	--	*	--
TB-78	3.64	--	--
TB-80	4.09	*	--
TB-82	--	--	7.82
May 2, 1996			
HC-101	2.84	--	--
HC-102	2.98	--	--
HC-103	2.29	--	--
B-4	2.8 ±0.5 (2)	--	--
B-6	13.01	--	--

NOTES:
(1) Very slow recovery
(2) Estimated using approximate ground surface elevation
NA = No piezo installation or broken
* = Artesian conditions, water overflows.
-- = Not relevant

4.0 SOIL CHARACTERIZATION

This section presents the findings of our review and compilation of the last 10 years of soil characterization efforts at the Union Station property. No additional soil samples were collected because the existing data were deemed adequate for supporting a RI. The objective of this soil characterization summary is to evaluate constituent concentrations in soil and compare them to current MTCA screening levels to identify chemicals of potential concern.

The following sections present the soil characterization summary, which includes:

- **Soil Quality Investigations/Soil Quality Exploration and Chemical Analysis Programs.** These sections summarize previous soils investigations that were used for this RI.

- **Soil Screening Criteria.** Discusses the basis for selection and use of MTCA numerical criteria for screening soil chemical data to determine chemicals of potential concern and provides an evaluation of the sufficiency of the data.

- **Evaluation of Soil Quality Relative to Screening Criteria.** This section discusses the results of on- and off-property soil quality testing relative to MTCA direct contact and groundwater protection screening levels.

- **Summary of Soil Quality.** Summarizes the major findings of the soil quality investigation.

Previous soil sampling collection methods are referenced in Appendix A. The sample boring logs from previous and current investigations are presented in Appendix B. A summary database for all data used in this RI is presented in Appendix D.

4.1 Soil Quality Investigations

The evaluation of soil quality at the Union Station property is based primarily on work completed in the last 10 years by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Data were compiled from eight previously completed documents including:

- **Hart Crowser, 1986.** Soil and Groundwater Quality Analyses and Preliminary Hydrogeologic Assessment, Proposed Union Station Development property, Seattle, Washington.

- **Hart Crowser, 1987a.** Results of Chemical Analysis of Soil Samples, Union Station North Development, Seattle, Washington.

- **Hart Crowser, 1987b.** Results of Soil Sampling and Analysis, Union Station Development South, Seattle, Washington.

- **Hart Crowser, 1987c.** Geotechnical and Environmental Site Feasibility Assessment, Proposed King Street Station Project, Seattle, Washington.

- **Hart Crowser, 1993.** Supplemental Soil and Ground water Quality Assessment. Glacier Park Company Property, King Street Station, Seattle, Washington.

- **Hart Crowser, 1994.** Summary Report Environmental and Geotechnical Engineering Issues, Union Station Property, Seattle, Washington.

- **Shannon & Wilson, 1986a.** Geotechnical Report Field and Laboratory Test Results. Metro Downtown Seattle Transit Project.

- **Shannon & Wilson, 1986b.** Geotechnical Report and Aquifer Testing and Dewatering Requirements South Tunnel Portal and International District Station. Metro Downtown Seattle Transit Project.

Other documents such as memoranda and records of meetings/telephone conversations have been reviewed for supplemental information.

4.2 Soil Quality Exploration and Chemical Analysis Programs

4.2.1 Soil Explorations

The previous exploration locations including soil borings, surface soil samples, and groundwater monitoring wells are shown on Figure 4-1. The locations of property characterization explorations were focused on those areas of the property which indicated the highest potential for residual wastes based on historical property uses. An additional consideration was access to the subsurface. For example, samples were not collected under the existing Union Station building. Note also that a number of previous explorations have been covered by the new Metro bus tunnel as shown on Figure 4-1.

Most of the explorations installed at the property were borings because the residual materials from historical property use are located at the former ground or tidal surface approximately 10 to 15 feet below current ground surface (i.e., below the majority of the 10 to 15 feet of fill material placed circa 1900). Borings were generally installed through the upper fill material, tideflat deposits, and into the dense underlying glacial soils (Figure 3-2, 3-3, and 3-4).

The majority of explorations were placed on the northeastern portion of the Main Parcel to evaluate soil quality conditions at the former coal storage houses, retorts, coke house, shop, and plant rail line loading and off-loading areas. These areas were identified as the most likely

to contain the highest concentrations of residual materials associated with the former gas plant. Although some other areas for byproduct handling (including the tar paper manufacturing area and associated tar pit, the crude oil tank, and the pipe cutting and storage area) were identified in the northwestern portion of the property, these areas are currently covered by the Union Station building.

An additional focus of the characterization work was to place explorations in the vicinity of the wharf perimeters of the Vulcan Iron Works formerly located in the southern portion of the property.

Boring chemical and relevant geological information is represented on all figures, and logs are presented in Appendix B.

4.2.2 Chemical Analysis Program

Soil and groundwater samples from the property were analyzed for a suite of chemicals that would be typical of the residual materials associated with both the former coal gasification plant and a metals manufacturing facility. Previous on-property soil sample analyses included semivolatiles organics, pesticides/herbicides, total petroleum hydrocarbons, volatile organics, total metals, total cyanide, and EP Tox metals (Table 4-1). Previous off-property soil sample analyses consisted of semivolatile organics, total petroleum hydrocarbons, volatile organics, and total metals (Table 4-1). Chemical analyses were performed by Laucks Testing Laboratories and Analytical Technologies, Inc., for the Hart Crowser and Shannon & Wilson investigations, respectively.

4.3 Soil Screening Criteria

Soil quality results were screened relative to Model Toxics Control Act (MTCA) (Chapter 173-340 WAC, February 1991) screening levels developed in the FS in an effort to identify

chemicals of potential concern and assess whether remedial actions may be required at the property.

4.3.2 Screening and Statistical Analysis of Soil Data

As discussed in the FS, soil quality data were compared to MTCA Method B residential cleanup levels and Ecology's soil concentration that is protective of surface water (the default groundwater protection criteria of 100 times the applicable screening level). The default water protection criteria are conservative, particularly for hydrophobic compounds, such as high molecular weight PAHs, that are essentially non-leachable under typical environmental conditions. Thus, for PAHs, a more realistic equilibrium partitioning-based screening criteria was developed for alternative comparative purposes (refer to Section 4.4.3 and Table 4-6).

Statistical summary tables (Tables 4-2 through 4-5) present summary statistics including detection frequencies, range of concentrations, maximum detected concentration, and mean concentrations. In addition, these summary tables present the MTCA three-fold statistical criteria including the magnitude of exceedence, the percent exceedence, and the 95 percent upper confidence limits (UCL) on the arithmetic mean.

Sample concentrations above the MTCA screening levels developed in the FS do not necessarily indicate that remedial actions are required. This screening approach helps identify areas and constituents which require further evaluation.

4.4 Evaluation of Soil Quality Relative to Screening Criteria

Eighty-two soil samples were collected on and adjacent to the property. Elevated concentrations of PAHs and metals have been encountered in soils sampled on and adjacent to the property. The highest concentrations of PAHs and metals were encountered in the lower portion of the fill unit and at the historical tideflat surface at an approximate depth ranging from

15 to 25 feet. Much of the observed affected soil appears to be derived from the former gas plant operations conducted along the northern portion of the property. In addition, Vulcan Iron Works operations conducted within the southern portion of the property may have also acted as a source of metals and PAHs to property soils.

The evaluation of soil quality presented in this section has been subdivided into assessment of direct contact risks posed by on- and off-property surface soils (upper 15 feet) and potential soil impacts to shallow groundwater quality. Summaries of the soil (both surface and subsurface) analytical results including detection frequencies, statistics, and number of samples exceeding regulatory criteria are presented in Tables 4-2 through 4-5. Tables 4-2 and 4-3 provide a summary of exceedences relative to the MTCA B residential screening levels for on- and off-property soils, respectively. Compounds that exceed MTCA Method B residential screening levels are plotted on Figure 4-1. A complete summary of sample-specific results is presented in Appendix D.

Soil analytical results generated by the previous Hart Crowser and Shannon and Wilson investigations were reviewed by an environmental chemist to evaluate the general quality of the data. In general, data quality for all analyses is acceptable for the purposes of this RI. No data were rejected based on data deficiencies. Data qualifiers were assigned to the existing soils data based on blank contamination, low spike recoveries, and headspace in the volatile organic analysis (VOA) samples. A summary of this review is provided in Appendix C.

4.4.1 Comparative Screening of On-Property Surface Soils for Direct Contact

Surface Soils. Surface soil samples (at depths of 0 to 15 feet) were collected from soil borings and surface samples within the Union Station property and were compared to MTCA Method B residential screening levels (screening level). Table 4-2 presents a statistical summary of those samples above the screening level for on-property soils. Figure 4-1 presents a distribution plot for samples that exceeded the screening levels.

- **Semivolatiles/PAHs.** Selected soil samples were submitted for semivolatile analysis. Surface soil concentrations for cPAHs exceeded the screening level (0.66 mg/kg) at six locations (HC-3, HC-4, HC-5, HC-6, TB-22, and TB-91). Concentrations above the screening level ranged from 0.76 to 43.0 mg/kg. Field observations indicated that there were relatively strong odors between the 8- to 9-foot-depth interval for HC-3 and between the 5- to 21-foot-depth interval for HC-5. Wood chips and coal pieces were observed at the 17.5- to 19.0-foot-depth interval for HC-3. Historical information indicates that the source of the fill material for the southern portion of the property was from the South Jackson Street regrade, located just east of the coal gasification plant. Therefore, these detections of cPAHs may be attributed to placed fill material. Location HC-4 and TB-91 did not have any visually observed material that may have been attributed to the detections of cPAHs; however, it is likely that these detections are associated with the placed fill material as well.

  One soil sample collected at a depth of 12.5 feet below ground surface from boring TB-22 contained benzo(a)anthracene at a concentration (16 mg/kg) above the screening level. The Shannon & Wilson boring log (1986a) for this exploration describes the soils in this depth interval to be "oil soaked." The former coal gasification plant was located in the TB-22 area and is likely the source of this material.

- **Total Petroleum Hydrocarbons.** Because PAHs more accurately reflect the residual materials associated with historical site use, limited TPH analyses were conducted in site soils. One soil sample collected at a depth of 12.5 feet from boring TB-22 was submitted for TPH-D analyses in 1985 and had a reported concentration of 145,000 mg/kg. Visual field observations indicated that there was high oil content in the soil. There is no MTCA Method B residential

screening level for TPH; however, the result is above the MTCA Method A screening level of 200 mg/kg.

- **Metals.** Various metals (As, Be, and Pb) exceeded the Method B screening levels at various locations (HC-1, HC-2, HC-3, HC-4, HC-5, HC-6, and TB-92) (Figure 4-1). Locations HC-1, HC-2, HC-3, HC-4, HC-5, HC-6, and TB-92 had exceedences for arsenic and beryllium that were within the Puget Sound Background ranges (Ecology, 1994). Lead was detected at a concentration of 290 mg/kg for location HC-5 which exceeds the screening level of 250 mg/kg.

- The other concentrations for soil samples were below the screening levels for all other chemical constituents (conventionals, pesticides/ herbicides, EP Tox metals, and volatile organics) for surface soils within the Union Station property.

4.4.3 Comparative Screening of On-Property Soils for Groundwater Protection

To evaluate the protectiveness of on-property soil concentrations relative to potential impacts to shallow groundwater and the eventual groundwater discharge to Elliott Bay, the conservative 100-fold default factor for marine surface water protection was used as a screening level for the soil samples.

In addition, marine surface water protection levels for cPAH compounds were evaluated using a literature partition-based approach to provide more realistic values for these hydrophobic compounds. Property-specific leaching factors using soil and groundwater quality collected at the Union Station property were not developed because of limitations in the groundwater quality data in the probable source areas. The turbid nature of the historical groundwater samples collected in the probable source areas do not provide realistic estimates of mobile or dissolved constituent concentrations and the most recent groundwater samples collected using low flow sampling techniques were collected upgradient or downgradient of the probable source areas.

PAHs and metals are the primary constituents that are above the screening level for soil samples collected on the property (Table 4-4). However, many of these constituents were not detected in actual property groundwater during the most recent groundwater sampling event conducted in May 1996 (see Section 5) consequently, although conservative estimates using the default 100-fold criteria indicate the potential for impact, actual groundwater measurements do not indicate a significant impact to shallow groundwater quality on the property. A more detailed discussion of the results follows:

- **Carcinogenic PAHs.** Most of the PAHs that exceed the default groundwater protection screening levels for soils are cPAHs derived primarily from coal and coal tar-like materials. Exposure of cPAH-containing soils to water will not likely result in any significant impacts. The cPAHs were not detected in property groundwater during the May 1996 sampling event (see Section 5). These high molecular weight hydrocarbons are relatively insoluble in water, have a high affinity for soil and organic matter, and are relatively immobile under normal environmental conditions. The cPAHs rarely present a groundwater concern except in situations where they are in contact with free-phase organic solvents that can act as carriers. No free-phase organic solvents were encountered at the Union Station property.

- **Non-carcinogenic PAHs.** Non-carcinogenic PAH concentrations in Union Station soils do not appear to significantly impact shallow groundwater quality. Acenaphthene and fluoranthene were the most frequently detected ncPAH in on-property soils and are most likely associated with occurrences of coal and coal tar-like materials.

  The highest concentrations of acenaphthene (100 mg/kg) and fluoranthene (100 mg/kg) were detected at location HC-3. More recent low turbidity groundwater data (May 1996) had very low concentrations of acenaphthene and fluoranthene (0.06 and 0.0026 mg/L, respectively) at HC-101, located close to HC-3. Therefore, based on the soil and groundwater data collected to date, it does not appear that ncPAH concentrations in property soils significantly impact shallow groundwater quality. As discussed in Section 5, dilution and attenuation will significantly reduce ncPAH concentrations in shallow groundwater before it discharges to Elliott Bay.

- **Metals.** Although total metal concentrations detected in on-property soils frequently exceed the conservative screening levels for metals, dissolved metal concentrations detected in the May 1996 low turbidity groundwater samples were below concentrations protective of marine surface water, with the exception of arsenic which slightly exceeded the screening levels at location HC-101. Since most of calculated soil screening levels protective of groundwater (using the conservative default of 100 times the surface water criteria) are below typical background concentrations for metals, many of the screening levels reverted to Puget Sound background levels established by Ecology (Ecology, 1994). The detected arsenic concentrations are below typical background concentrations for metals.

Consistent with these results, EP Tox leachability testing (the standard test at the time) performed on composite samples collected from borings FS-1, FS-2, FS-3 (on North Parcel), and G-1 through G-8 (Main Parcel) did not contain detectable concentrations of metals except for zinc (0.1 to 0.8 mg/L) and barium (0.1 to 0.5 mg/L)(Table D-1). It was concluded in previous investigations that the EP Tox results for G-1 through G-8 classified the material as non-dangerous waste material (Hart Crowser, 1987b).

Based on the soil and groundwater quality data collected to date, it does not appear that total metal concentrations in property soils significantly impact shallow groundwater quality.

4.4.4 Comparative Screening of Off-Site Soils for Groundwater Protection

PAHs and metals are the primary constituents that exceed the conservative marine surface water protection screening levels in the soil samples collected adjacent to the property (Table 4-5). The type and concentrations of constituents encountered in off-property soils were fairly consistent with on-property soils. As discussed in the previous section, many of these constituents were not detected in property groundwater during the most recent low turbidity groundwater sampling event conducted in May 1996 (see Section 5) and do not appear to be significantly impacting shallow groundwater quality on the property.

4.5 Summary of Soil Quality

Based on our review of the soil data for the property, we have identified selected metals and PAHs as constituents of potential concern for the property.

Elevated concentrations of PAHs and metals were encountered in soils collected on and immediately adjacent to the property. The highest concentrations of PAHs and metals were

encountered in the lower portion of the fill unit and at the historical tideflat surface at depths ranging from 15 to 25 feet below ground surface. Much of the observed affected soil appears to be derived from the former gas plant operations conducted along the northern portion of the property as well as the Vulcan Iron Works operations conducted within the southern portion of the property.

The only constituents identified above direct contact MTCA Method B screening levels were cPAHs and metals in on-property soil samples at depths between 0 and 12.5 feet below ground surface.

Soils on and off the property also do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations are above the conservative surface water protection screening levels, these constituents generally were encountered in groundwater during the May 1996 sampling event at concentrations below the marine criteria protective of Elliott Bay.

MTCA Method B Residential (Direct Contact) Soil Screening Level Exceedences for On-Property Samples between 0 to 15 Feet Depth

HC-101	Recently Installed Monitoring Well Location and Number
	Resampling of Existing Well
	Existing Exploration Location and Number (Hart Crowser)
B-5	Monitoring Well (January 1993, J-3711)
B-7	Soil Boring (January 1993, J-3711)
B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
FS-3	Chemical Boring (January 1987, J-1636-03)
BP-3	Boring (August 1987, J-1636-05)
G-1	Shallow Geochemical Boring (August 1987, J-1639-04)
HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5
	Exploration Location and Number (Others)
TB-82	Boring/Well (January 1986)
OW-2A	Boring/Well (July 1996)
PW-4	Boring (January 1987)
H-3	Approximate Location of Surface Soil Sample (January 1987)
	Former Shoreline
	Approximate Property Boundary

Exploration Number	Sample Depth in Feet
Constituent	Concentration in mg/kg

HC-3	8.0 to 9.0
cPAHs	5.0 - 43.0
Arsenic	5.2
Beryllium	0.7

HC-4	7.5 to 9.0
cPAHs	1.7 - 4.5
Arsenic	8.2
Beryllium	0.7

HC-5	7.5 to 9.0
cPAHs	6.0 - 7.0
Arsenic	6.0
Beryllium	0.6
Lead	290

HC-6	10.0 to 11.5
cPAHs	2.2 - 3.9
Arsenic	4.6
Beryllium	0.5

HC-2	10.0 to 11.5
Arsenic	6.9
Beryllium	0.6

HC-1	10.0 to 11.5
Arsenic	9.0
Beryllium	0.5

TB-22	12.5
cPAHs	3.0 - 16.0

TB-92	2.5 to 4.0
Arsenic	11.0
Beryllium	2.2

TB-91	2.5 to 4.0
cPAHs	1.0

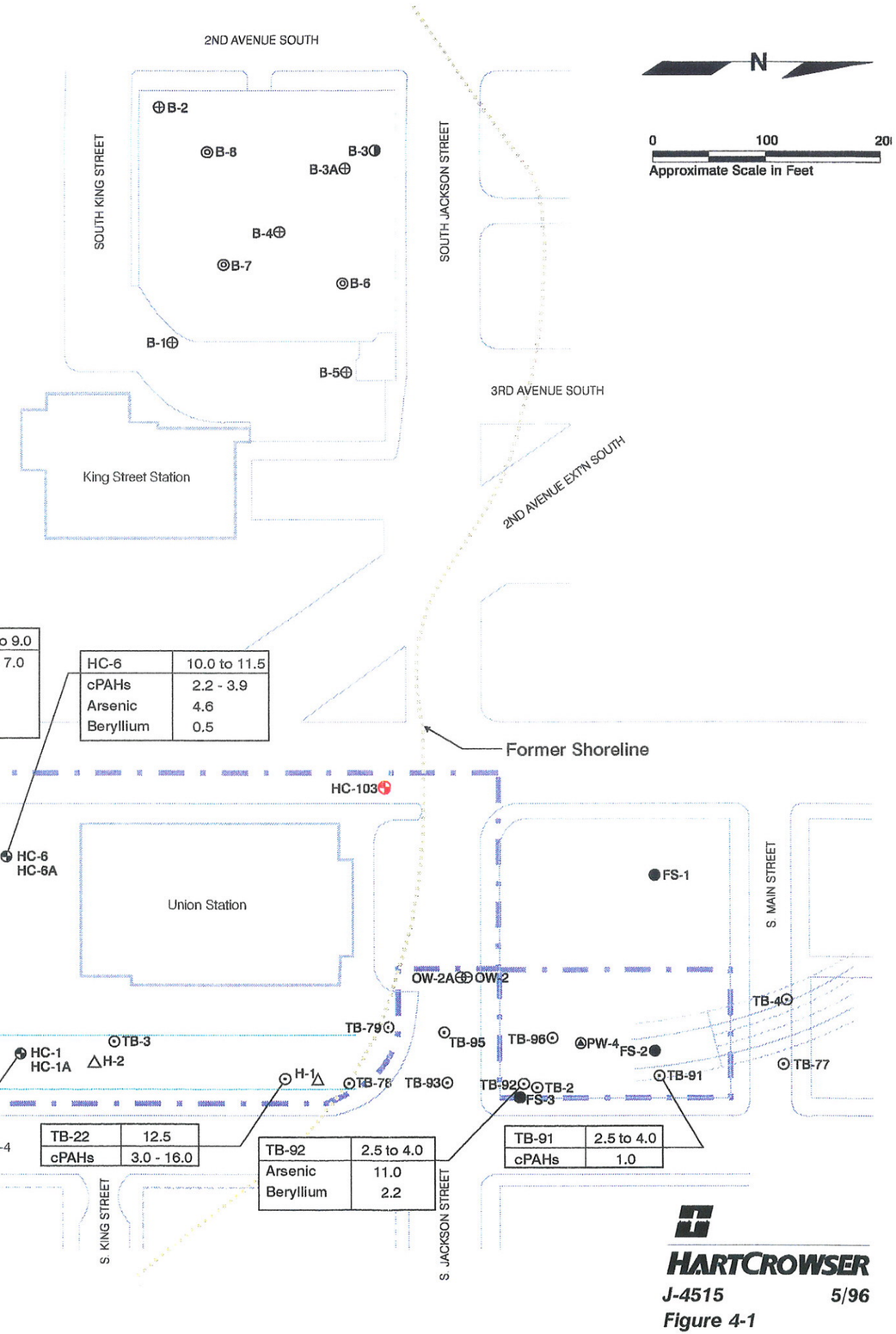


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Figure 4-1

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Table 4-1 - Union Station Sample Information Table (Soil)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
On-Property										
Comp 1000	G-1 Composite	6/24/87				X				
Comp 1001	G-2 Composite	6/24/87				X				
Comp 1002	G-3 Composite	6/24/87				X				
Comp 1003	G-5 Composite	6/24/87				X				
Comp 1004	G-7 Composite	6/25/87				X				
Comp 1005	G-8 Composite	6/25/87				X				
G-2 S-1	0 to 1.5	6/24/87				X				
G-3 S-3	5.0 to 6.5	6/24/87				X				
G-4 S-1	0 to 1.5	6/24/87				X				
G-4 S-3	4.0 to 5.5	6/24/87				X				
G-5 S-3	4.0 to 5.5	6/24/87				X				
G-6 S-1	0 to 1.5	6/25/87				X				
G-6 S-3	4.0 to 5.5	6/25/87				X				
G-7 S-1	0 to 1.5	6/25/87				X				
G-8 S-1	0 to 1.5	6/25/87				X				
FS-1 Comp	2.5 to 9	1/16/87				X	X		X	
FS-2 Comp	2.5 to 14	1/17/87				X	X		X	
FS-3 Comp	2.5 to 10.9	1/17/87				X	X		X	
H-1	1	12/6/85						X		
H-2	1	12/6/85						X		
H-3	1	12/6/85						X		
H-4	1	12/6/85						X		
HC-1	10 to 11.5	12/10/85	X	X				X		
HC-1	17.5 to 19	12/10/85	X	X				X		
HC-2	10 to 11.5	12/12/85	X	X				X		
HC-2	15.8 to 16.5	12/12/85	X	X				X		
HC-3	17.5 to 19	12/11/85	X	X				X		
HC-3	8 to 9	12/11/85	X	X				X		
HC-4	22.5 to 24	12/17/85	X	X				X		
HC-4	7.5 to 9	12/17/85	X	X				X		
HC-5	22.5 to 24	12/13/85	X	X				X		
HC-5	7.5 to 9	12/13/85	X	X				X		
HC-6	10 to 11.5	12/12/85	X	X				X		
HC-6	22.5 to 23.5	12/12/85	X	X				X		
TB-22	12.5	9/13/84						X		X
TB-25	18 to 19	10/10/84						X		X
TB-3	18 to 19.5	10/12/84						X		X
TB-78	19 to 20.5	11/11/85						X		X
TB-78	21.5 to 23	11/11/85						X		X
TB-78 Comp	19 to 23	11/11/85	X	X				X	X	
TB-79	17.5 to 19	9/5/85	X	X				X	X	
TB-91	12.5 to 14	12/10/85						X		
TB-91	2.5 to 4	12/9/85						X		
TB-91	31 to 32.5	12/11/85						X		
TB-92	13 to 14.5	12/12/85						X		
TB-92	2.5 to 4	12/11/85	X	X				X	X	
TB-92	33 to 34.5	12/12/85	X	X				X	X	

Table 4-1 - Union Station Sample Information Table (Soil)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
Off-Property										
B-1	35 to 36.5	12/16/85	X	X				X		
B-1	40 to 41.5	12/16/85	X	X				X		
B-1	47.5 to 49	12/16/85	X	X				X		
B-2	35 to 36.5	12/18/85	X	X				X		
B-2	47.5 to 49	12/18/85	X	X				X		
B-3	33.5 to 34	12/19/85	X	X				X		
B-3	52.5 to 54	12/19/85	X	X				X		
B-4	32.5 to 34	12/18/85	X	X				X		
B-4	40 to 41.5	12/18/85	X	X				X		
B-4	47.5 to 48.5	12/18/85	X	X				X		
B-6	29.5 to 31	12/23/85	X	X				X		
B-6	39.5 to 41	12/23/85	X	X				X		
B3A-COMP	5 to 14	1/21/93		X						
B3A-S1	2.5 to 4	1/21/93								X
B3A-S5	12.5 to 14	1/21/93								X
B6-S1	2.4 to 4	1/21/93		X						X
B6-S4	10 to 11.5	1/21/93								X
B7-COMP	7.5 to 14	1/21/93		X						
B7-S1	2.5 to 4	1/21/93								X
B7-S2	5 to 6.5	1/21/93								X
B8-COMP	2.5 to 9	1/21/93		X						
B8-S2	5 to 6.5	1/21/93								X
B8-S3	7.5 to 9	1/21/93								X
BP-3	0 to 4	6/22/87		X				X	X	
BP-3	5 to 9	6/22/87		X				X	X	
BP-4	0 to 1.5	6/24/87		X				X	X	
BP-4	6 to 9	6/24/87		X				X	X	
BP-5	2.5 to 3	6/24/87		X				X	X	
BP-5	5 to 6.5	6/24/87		X				X	X	
TB-4	12.5 to 14	7/17/84						X		
TB-77	15	8/29/84						X		
TB-93	15 to 16.5	12/3/85						X		
TB-93	2.5 to 4	12/13/85	X	X				X	X	
TB-93	35 to 36.5	12/14/85						X		
TB-93	52.5 to 54	12/14/85						X		

Table 4-2 - Statistical Summary of On-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	6/6	64.4 to 87.2	87.2	HC-6/10 - 11.5	71.47	87.2				
Semivolatiles in mg/kg										
2-Methylnaphthalene	4/14	0.05 U to 150	150	HC-3/8 - 9	11.26	150				
Acenaphthene	6/15	0.05 U to 100	100	HC-3/8 - 9	12.89	100	4800	0/15	0	
Acenaphthylene	5/15	0.05 U to 55	55	HC-3/8 - 9	6.20	55				
Anthracene	7/15	0.05 U to 84	84	HC-3/8 - 9	7.60	84	24000	0/15	0	
Benzo(a)anthracene	8/15	0.05 U to 43	43	HC-3/8 - 9	4.95	43	0.66	5/15	33.33	65.15
Benzo(a)pyrene	9/15	0.05 U to 41	41	HC-3/8 - 9	4.19	41	0.66	5/15	33.33	62.12
Benzo(b)fluoranthene	3/8	0.05 U to 3	3	TB-22/12.5	0.42	3	0.66	1/8	12.5	4.55
Benzo(bk)fluoranthene	4/7	0.05 U to 34	34	HC-3/8 - 9	5.96	34	0.66	4/6	66.67	51.52
Benzo(g,h,i)perylene	6/15	0.05 U to 17	17	HC-3/8 - 9	1.57	17				
Benzo(k)fluoranthene	2/8	0.05 U to 3	3	TB-22/12.5	0.42	3	0.66	1/8	12.5	4.55
Bis(2-ethylhexyl)phthalate	2/14	0.05 U to 11	11	H-4	1.05	11	71.4	0/14	0	
Butylbenzylphthalate	1/8	0.05 U to 0.1	0.1	TB-92/2.5-4	0.04	0.1				
Chrysene	7/14	0.05 U to 36	36	HC-3/8 - 9	3.61	36	0.66	4/14	28.57	54.55
Di-n-octylphthalate	1/14	0.05 U to 3 U	1.3	H-4	0.34	1.3	1600	0/14	0	
Dibenzo(ah)anthracene	4/15	0.05 U to 5	5	HC-3/8 - 9	0.43	5	0.66	1/13	7.69	7.58
Dibenzofuran	4/14	0.05 U to 13	13	HC-3/8 - 9	1.16	13				
Fluoranthene	10/15	0.05 U to 100	100	HC-3/8 - 9	9.23	100	3200	0/15	0	
Fluorene	6/15	0.05 U to 84	84	HC-3/8 - 9	7.97	84	3200	0/15	0	
Indeno(1,2,3-cd)pyrene	6/15	0.05 U to 18	18	HC-3/8 - 9	1.52	18	0.66	3/13	23.08	27.27
Naphthalene	8/15	0.05 U to 150	150	HC-3/8 - 9	16.88	150	3200	0/15	0	
Phenanthrene	10/15	0.05 U to 250	250	HC-3/8 - 9	23.05	250				
Pyrene	9/15	0.05 U to 93	93	HC-3/8 - 9	13.02	93	2400	0/15	0	
Total cPAHs	9/15	0.05 U to 177	177	HC-3/8 - 9	17.62	177				
Volatiles in mg/kg										
Acetone	1/1	0.03 to 0.03	0.03	TB-92/2.5-4	0.03	0.03	8000	0/1	0	

Table 4-2 - Statistical Summary of On-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Total Metals in mg/kg										
Arsenic	7/7	4.6 to 11	11	TB-92/2.5-4	7.27	11	1.67	7/7	100	6.59
Beryllium	7/7	0.5 to 2.2	2.2	TB-92/2.5-4	0.83	2.2	0.233	7/7	100	9.44
Cadmium	2/7	0.5 U to 2.3	2.3	HC-5/7.5 - 9	0.59	2.3	80	0/7	0	
Chromium	7/7	11 to 62	62	HC-3/8 - 9	39.29	62	400	0/7	0	
Copper	7/7	28 to 77	77	HC-5/7.5 - 9	50.57	77	2690	0/7	0	
Lead	7/7	6 to 290	290	HC-5/7.5 - 9	79	290	250	1/7	14.29	1.16
Mercury	6/6	0.1 to .8	0.8	HC-4/7.5 - 9	0.30	0.8	24	0/6	0	
Nickel	7/7	13 to 72	72	HC-3/8 - 9	47.43	72	1600	0/7	0	
				HC-4/7.5 - 9					0	
Silver	6/7	0.1 U to 0.7	0.7	HC-4/7.5 - 9	0.46	0.7	400	0/7	0	
Zinc	7/7	44 to 1100	1100	HC-5/7.5 - 9	227	1100	24000	0/7	0	
EP Tox Metals in mg/L										
Barium	18/18	0.1 to 0.5	0.5	Comp 1002	0.25	0.322				
				Comp 1005						
Zinc	15/15	0.1 to 0.8	0.8	G-8 S-1	0.31	0.462				
TPH in mg/kg										
Diesel	1/1	145000 to 14500	145000	TB-22/12.5	145000	145000				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 4-3 - Statistical Summary of Off-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Semivolatiles in mg/kg										
2-Methylnaphthalene	3/9	0.021 to 0.15	0.15	BP-3/0 - 4	0.05	0.15				
Acenaphthene	5/9	0.008 to 0.39	0.39	BP-3/0 - 4	0.07	0.39	4800	0/9	0	
Acenaphthylene	4/9	0.014 to 0.17	0.17	TB-4/12.5-14	0.04	0.17				
Anthracene	5/9	0.019 to 0.41	0.41	BP-3/0 - 4	0.10	0.41	24000	0/9	0	
Benzo(a)anthracene	7/9	0.035 to 0.68	0.68	TB-4/12.5-14	0.22	0.68	0.66	1/9	11.11	1.03
Benzo(a)pyrene	5/9	0.05 U to 1	1	TB-4/12.5-14	0.32	1	0.66	2/9	22.22	1.52
Benzo(b)fluoranthene	3/7	0.05 U to 1.2	1.2	BP-5/5 - 6.5	0.36	1.2	0.66	1/7	14.29	1.82
Benzo(bk)fluoranthene	2/2	0.16 to 0.17	0.17	TB-77/15	0.17	0.17	0.66	0/2	0	
Benzo(g,h,i)perylene	4/9	0.05 U to 1.8	1.8	BP-5/5 - 6.5	0.36	1.8				
Benzo(k)fluoranthene	3/7	0.05 U to 0.8	0.8	BP-5/5 - 6.5	0.29	0.8	0.66	1/7	14.29	1.21
Chrysene	7/9	0.036 to 0.81	0.81	BP-3/0 - 4	0.27	0.81	0.66	2/9	22.22	1.23
Di-n-octylphthalate	1/3	0.05 U to 0.1	0.052	TB-77/15	0.04	0.052	1600	0/3	0	
Dibenzo(ah)anthracene	5/9	0.046 to 0.2	0.2	BP-5/5 - 6.5	0.08	0.2	0.66	0/9	0	
Fluoranthene	5/9	0.023 to 1.6	1.6	TB-4/12.5-14	0.35	1.6	3200	0/9	0	
Fluorene	5/9	0.007 to 0.3	0.3	BP-3/0 - 4	0.06	0.3	3200	0/9	0	
Indeno(1,2,3-cd)pyrene	5/9	0.05 U to 1.8	1.8	BP-5/5 - 6.5	0.36	1.8	0.66	2/9	22.22	2.73
Naphthalene	5/9	0.007 to 0.12	0.12	BP-3/0 - 4	0.05	0.12	3200	0/9	0	
Phenanthrene	8/9	0.025 to 1.3	1.3	BP-3/0 - 4	0.29	1.3				
Pyrene	5/9	0.016 to 1.5	1.5	TB-4/12.5-14	0.30	1.5	2400	0/9	0	
Total cPAHs	8/9	0.046 to 5.67	5.67	BP-5/5 - 6.5	1.73	5.67				
Volatiles in mg/kg										
Acetone	1/1	0.28 to 0.28	0.28	TB-93/2.5-4	0.28	0.28	8000	0/1	0	

Table 4-3 - Statistical Summary of Off-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Total Metals in mg/kg										
Arsenic	11/11	2 to 110	110	BP-4/0 - 1.5	19.02	67.53	1.67	11/11	100	65.87
Beryllium	1/1	0.5 to 0.5	0.5	TB-93/2.5-4	0.50	0.5	0.233	1/1	100	2.15
Cadmium	3/11	0.3 U to 1.1	1.1	BP-3/0 - 4	0.42	1.1	80	0/11	0	
Cadmium	3/11	0.3 U to 1.1	1.1	BP-5/5 - 6.5	0.42	1.1	80	0/11	0	
Chromium	11/11	19 to 57	57	BP-3/5 - 9	34.73	44.503	400	0/11	0	
Copper	11/11	11 to 96	96	BP-5/5 - 6.5	39.36	69.883	2690	0/11	0	
Lead	10/11	2.7 to 160	160	BP-5/5 - 6.5	34.36	160	250	0/11	0	
Nickel	11/11	25 to 63	63	BP-3/5 - 9	41.82	50.74	1600	0/11	0	
Zinc	11/11	28 to 210	210	BP-3/0 - 4	78.45	122.3	24000	0/11	0	
TPH in mg/kg										
Diesel	1/8	16 J to 20 U	16 J	B7-S1	10.75	16				
Oil	2/8	50 U to 92	92	B8-S2	39.63	92				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 4-4 - Statistical Summary of On-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	12/12	37 to 87.2	87.2	HC-6/10 - 11.5	68.12	74.3				
Total Cyanide	2/4	0.5 U to 0.8	0.8	TB-79/17.5-19	0.48	0.8	5	0/4	0	
Total Metals in mg/kg										
Arsenic	16/16	3.4 to 11	11	TB-92/2.5-4	6.48	7.68	0.5	16/16	100	22
Beryllium	16/16	0.3 to 2.2	2.2	TB-92/2.5-4	0.68	.869	0.1	16/16	100	22
Cadmium	4/16	0.5 U to 2.3	2.3	HC-5/7.5 - 9	0.46	2.3	0.8	1/16	6.25	2.875
Chromium	16/16	11 to 62	62	HC-3/8 - 9	31.38	42.17	5	16/16	100	12.4
Copper	16/16	16 to 77	77	HC-5/7.5 - 9	40.31	53.4	0.5	16/16	100	154
Lead	15/16	1.8 to 290	290	HC-5/7.5 - 9	55.31	290	0.58	15/15	100	500
Mercury	12/12	0.1 to 1.3	1.3	HC-2/15.8 - 16.	0.38	0.614	0.0025	12/12	100	520
Nickel	16/16	13 to 72	72	HC-3/8 - 9 HC-4/7.5 - 9	36.81	51.1	20	12/16	75	3.6
Selenium	2/16	0.5 U to 1.5	1.5	TB-78 Comp	0.38	1.5	7.1	0/16	0	
Silver	13/16	0.1 to 1.2	1.2	TB-79/17.5-19	0.43	0.571	0.12	12/16	75	10
Zinc	16/16	39 to 1100	1100	HC-5/7.5 - 9	131.81	1100	7.7	16/16	100	142.86
EP Tox Metals in mg/L										
Barium	18/18	0.1 to 0.5	0.5	Comp 1002 Comp 1005	0.25	0.322				
Zinc	15/15	0.1 to 0.8	0.8	G-8 S-1	0.31	0.462				
Semivolatiles in mg/kg										
2-Methylnaphthalene	13/25	0.05 U to 650	650	HC-1/17.5 - 19	42.80	650				
Acenaphthene	15/28	0.05 U to 530	530	HC-1/17.5 - 19	30.88	530	22.5	5/28	17.86	23.56
Acenaphthylene	12/28	0.05 U to 59	59	HC-1/17.5 - 19	8.60	59				
Anthracene	17/28	0.05 U to 275	275	HC-1/17.5 - 19	22.23	275	2590	0/28	0	
Benzo(a)anthracene	20/28	0.05 U to 220	220	HC-1/17.5 - 19	17.61	220	0.66	16/28	57.14	333.33
Benzo(a)pyrene	19/28	0.05 U to 220	220	HC-1/17.5 - 19	14.48	220	0.66	14/26	53.85	333.33
Benzo(b)fluoranthene	7/15	0.05 U to 45	45	TB-79/17.5-19	5.73	45	0.66	4/13	30.77	68.18
Benzo(bk)fluoranthene	10/13	0.05 U to 250	250	HC-1/17.5 - 19	26.89	250	0.66	10/12	83.33	378.79
Benzo(g,h,i)perylene	14/28	0.05 U to 110	110	HC-1/17.5 - 19	6.16	110				
Benzo(k)fluoranthene	6/15	0.05 U to 29	29	TB-3/18-19.5	3.31	29	0.66	4/13	30.77	43.94

Table 4-4 - Statistical Summary of On-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Bis(2-ethylhexyl)phthalate	4/25	0.05 U to 20 U	11	H-4	0.55	11	0.66	2/18	11.11	16.67
Butylbenzylphthalate	1/13	0.05 U to 4 U	0.1	TB-92/2.5-4	0.26	0.1				
Chrysene	17/25	0.05 U to 175	175	HC-1/17.5 - 19	12.81	175	0.66	13/25	52	265.15
Di-n-butylphthalate	2/13	0.05 U to 10	10	TB-78/21.5-23	0.88	10	291	0/13	0	
Di-n-octylphthalate	3/25	0.05 U to 20 U	1.3	H-4	0.80	1.3				
Dibenzo(ah)anthracene	10/28	0.05 U to 24	24	HC-1/17.5 - 19	1.27	24	0.66	5/21	23.81	36.36
Dibenzofuran	12/25	0.05 U to 120	120	HC-1/17.5 - 19	7.89	120				
Fluoranthene	21/28	0.05 U to 560	560	HC-1/17.5 - 19	52.16	560	2.7	14/28	50	207.41
Fluorene	17/28	0.05 U to 384	384	TB-3/18-19.5	31.76	384	242	2/28	7.14	1.59
Indeno(1,2,3-cd)pyrene	14/28	0.05 U to 110	110	HC-1/17.5 - 19	6.21	110	0.66	9/22	40.91	166.67
Naphthalene	18/28	0.05 U to 1600	1600	HC-1/17.5 - 19	141.47	1600	988	2/28	7.14	1.62
Phenanthrene	20/28	0.05 U to 1030	1030	HC-1/17.5 - 19	79.94	1030				
Phenol	1/15	0.05 U to 5000	0.5	TB-78 Comp	166.87	0.5	110000	0/15	0	
Pyrene	20/28	0.05 U to 752	752	TB-3/18-19.5	55.79	752	77.7	3/28	10.71	9.68
Total cPAHs	21/28	0.05 U to 999	999	HC-1/17.5 - 19	68.29	999				
Volatiles in mg/kg										
Acetone	3/4	0.03 to 18	18	TB-79/17.5-19	4.55	18				
Ethylbenzene	1/4	0.005 U to 18	18	TB-79/17.5-19	4.52	18	27.6	0/4	0	
Methylene Chloride	1/4	0.005 U to 8.4	8.4	TB-79/17.5-19	2.12	8.4	160	0/4	0	
Toluene	1/4	0.005 U to 5	5	TB-79/17.5-19	1.27	5	48.5	0/4	0	
Xylene (total)	1/4	0.005 U to 30	30	TB-79/17.5-19	7.52	30				
TPH in mg/kg										
Diesel	3/5	50 U to 145000	145000	TB-22/12.5	30536	145000				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 4-5 - Statistical Summary of Off-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Dimethylphthalate	1/12	0.05 U to 65 U	2.1	B-4/40 - 41.5	2.92	2.1	7200	0/12	0	
Fluoranthene	13/24	0.023 to 3400	3400	B-4/47.5 - 48.	142.53	3400	2.7	3/24	12.5	1259.26
Fluorene	11/24	0.007 to 2800	2800	B-4/47.5 - 48.	117.20	2800	242	1/24	4.17	11.57
Indeno(1,2,3-cd)pyrene	10/24	0.05 U to 730	730	B-4/47.5 - 48.	30.88	730	0.66	6/24	25	1106.06
Naphthalene	14/24	0.007 to 1500	15000	B-4/47.5 - 48.	627.86	15000	988	1/24	4.17	15.18
Phenanthrene	16/24	0.025 to 8400	8400	B-4/47.5 - 48.	351.49	8400				
Pyrene	13/24	0.016 to 2800	2800	B-4/47.5 - 48.	117.34	2800	77.7	1/24	4.17	36.04
Total cPAHs	15/24	0.046 to 7126	7126	B-4/47.5 - 48.	299.69	7126				
Volatiles in mg/kg										
Acetone	1/1	0.28 to 0.28	0.28	TB-93/2.5-4	0.28	0.28				
TPH in mg/kg										
Diesel	1/8	16 J to 20 U	16 J	B7-S1	10.75	16				
Oil	2/8	50 U to 92	92	B8-S2	39.63	92				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

J Estimated value.

Table 4-5 - Statistical Summary of Off-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	12/12	55 to 81	81	B-4/47.5 - 48.	72.70	77.03				
Total Metals in mg/kg										
Arsenic	23/23	2 to 110	110	BP-4/0 - 1.5	14.37	21.69	0.5	23/23	100	220
Beryllium	13/13	0.4 to 1.2	1.2	B-4/40 - 41.5	0.66	0.793	0.1	13/13	100	12
Cadmium	4/23	0.3 U to 1.1	1.1	BP-3/0 - 4 BP-5/5 - 6.5	0.36	1.1	0.8	3/23	13.04	1.375
Chromium	23/23	9 to 83	83	B-2/35 - 36.5	34.83	46.512	5	23/23	100	16.6
Copper	23/23	11 to 98	98	B-1/47.5 - 49	42.35	56.368	0.5	23/23	100	196
Lead	18/23	2 U to 340	340	B-2/47.5 - 49	42.35	229.341	0.58	18/18	100	586.21
Mercury	11/18	0.1 to 0.6	0.6	B-1/47.5 - 49	0.13	0.6	0.0025	11/11	100	240
Nickel	23/23	8 to 94	94	B-2/35 - 36.5	40.78	55.32	20	19/23	82.61	4.7
Silver	10/19	0.1 U to 1 U	0.6	B-2/35 - 36.5	0.20	0.6	0.12	10/13	76.92	5
Zinc	23/23	17 to 210	210	BP-3/0 - 4	73.48	96.742	7.7	23/23	100	27.27
Semivolatiles in mg/kg										
2,4-Dinitrotoluene	1/12	0.05 U to 65 U	1.2	B-4/40 - 41.5	0.13	1.2	0.91	1/11	9.09	1.32
2-Methylnaphthalene	7/24	0.021 to 4500	4500	B-4/47.5 - 48.	187.74	4500				
Acenaphthene	11/24	0.008 to 4700	4700	B-4/47.5 - 48.	197.59	4700	22.5	2/24	8.33	208.89
Acenaphthylene	7/24	0.014 to 1200	1200	B-4/47.5 - 48.	50.09	1200				
Anthracene	13/24	0.019 to 2700	2700	B-4/47.5 - 48.	112.91	2700	2590	1/24	4.17	1.04
Benzo(a)anthracene	13/24	0.035 to 1600	1600	B-4/47.5 - 48.	67.12	1600	0.66	4/24	16.67	2424.24
Benzo(a)pyrene	12/24	0.05 U to 1700	1700	B-4/47.5 - 48.	71.43	1700	0.66	6/24	25	2575.76
Benzo(b)fluoranthene	3/10	0.05 U to 1.2	1.2	BP-5/5 - 6.5	0.26	1.2	0.66	1/10	10	1.82
Benzo(bk)fluoranthene	7/14	0.05 U to 1400	1400	B-4/47.5 - 48.	100.76	1400	0.66	3/14	21.43	2121.21
Benzo(g,h,i)perylene	9/24	0.05 U to 410	410	B-4/47.5 - 48.	17.41	410				
Benzo(k)fluoranthene	3/10	0.05 U to 0.8	0.8	BP-5/5 - 6.5	0.21	0.8	0.66	1/10	10	1.21
Bis(2-ethylhexyl)phthalate	5/18	0.05 U to 65 U	1.3	B-2/47.5 - 49	0.21	1.3	0.66	2/16	12.5	1.97
Chrysene	13/24	0.036 to 1600	1600	B-4/47.5 - 48.	67.28	1600	0.66	7/24	29.17	2424.24
Di-n-octylphthalate	1/18	0.05 U to 65 U	0.052	TB-77/15	1.85	0.052				
Dibenzo(ah)anthracene	8/24	0.046 to 96	96	B-4/47.5 - 48.	4.10	96	0.66	2/24	8.33	145.45
Dibenzofuran	4/18	0.05 U to 600	600	B-4/47.5 - 48.	33.59	600				

5.0 SUMMARY OF GROUNDWATER CHARACTERIZATION

This section presents specific information on groundwater sampling and analysis, including:

- **Previous On-Property and Off-Property Groundwater Sampling Investigations.** These subsections summarize available groundwater sampling data for on-property and off-property investigations;

- **Scope of Current Groundwater Sampling Program.** Discusses the current groundwater sampling program;

- **Groundwater Screening Levels.** Discusses the criteria to be used to screen the previous and new groundwater sampling data;

- **On-Property and Off-Property Groundwater Quality.** These sections discuss on-property and off-property groundwater quality data;

- **Local Groundwater Not Used as a Drinking Water Source.** Discusses groundwater conditions relative to drinking water source;

- **Potential Impacts to Elliott Bay.** Discusses why groundwater from the Union Station property poses limited, if any, potential risk to Elliott Bay; and

- **Summary of Groundwater Quality.** Summarizes the major findings of the groundwater quality investigation.

5.1 Previous On-Property Groundwater Sampling Investigations

Groundwater samples have previously been collected in association with several investigations on the Union Station property. These groundwater sampling events include:

- **September 1985.** A sample was collected from TB-78, in the northeast corner of the Main Parcel (Figure 3-1);

- **November 1985.** A sample was collected from TB-80, on the east edge of the Main Parcel;

- **February 1986.** Samples were collected from HC-1A, HC-2A, HC-3A, HC-4A, HC-5A, and HC-6A on the Main Parcel, and from PW-4 and TB-96 on the North Parcel; and

- **March 1986.** Another sample was collected from PW-4, on the North Parcel.

5.2 Previous Off-Property Groundwater Sampling Investigations

Groundwater samples have previously been collected off-property near the Union Station property in association with investigative sampling events including:

- **February 1986.** Samples were collected from B-1, B-2, B-3, B-4, and B-6, in 5th Avenue South, located to the east of the Union Station property. Samples were also collected from TB-95, OW-2, and OW-2A on South Jackson Street, located north of the Main Parcel (Figure 3-1);

- **March 1986.** Another set of samples were collected from TB-95 and OW-2; and

- **January 1993.** Samples were collected from B-1, B-2, B-3A, and B-5 on the King Street Station property, which is located downgradient of the Union Station property.

A summary of on- and off-property sampling and analyses is presented in Table 5-1.

5.3 Scope of Current Groundwater Sampling Program

The objective of the current groundwater evaluation effort was to confirm the previously collected groundwater quality data. These results allow for comparison of current groundwater conditions with those reported earlier (i.e., 1986 sampling), which in turn, can be used as a basis for evaluating potential impacts to Elliott Bay. The groundwater sampling program scope included:

- Installing three downgradient monitoring wells screened in the upper fill deposits at depths ranging from 5 to 15 feet below ground surface;

- Collecting groundwater samples and measuring water levels in existing upgradient wells B-4 and B-6 and the three new downgradient wells;

- Using low-flow sampling to minimize possible false-positive sample results associated with turbidity;

- Analyzing the groundwater samples for semivolatile organics (Method 8270 GC/MS SIMS), Volatile Organics (Method 8240 GC/MS), ten dissolved metals (As, Be, Cd, Cr, Cu, Hg, Pb, Ni, Ag, and Zn), total suspended solids (TSS), total dissolved solids (TDS), and TPH (WTPH-G and WTPH-D extended); and

- Measuring water levels, pH, electrical conductivity, temperature, and dissolved oxygen in the field.

5.4 Groundwater Screening Levels

As discussed in Section 5.8 below, the primary receptor of potential concern is marine organisms in Elliott Bay. The screening level we used to evaluate groundwater quality are summarized in the FS.

5.5 On-Property Groundwater Quality

Tables 5-2 and 5-3 summarizes the on-property groundwater analytical data, for each of the locations with exceedences of the screening level for previous and current sampling events, respectively. Tables 5-4 and 5-5 summarize the constituents detected, detection frequency, highest and lowest detected concentration, location of highest detection, the screening level for the constituents detected, and exceedences of the screening level for previous and current on-property groundwater data, respectively. The complete chemical data for groundwater samples are presented in Table D-2 in Appendix D.

It should be noted that the groundwater quality results reported by the previous investigation may be significantly positively biased (particularly for high molecular weight PAHs) because of the turbid nature of the samples. Groundwater samples collected during the most recent sampling event were collected using low flow sampling techniques that significantly reduced turbidity and provided more representative groundwater quality data.

5.5.1 Previous Data

Exceedences of screening levels in on-property wells from these high turbidity samples includes cPAHs, ncPAHs, and arsenic in HC-3A and TB-78. Note that PAHs were also detected upgradient of the property (see Section 5.6).

- **Conventionals.** Measured values for conventional water quality parameters (chloride, sodium, conductivity, temperature, pH, and hardness) were all within typical ranges for groundwater in the downtown area. No exceedences of conventional parameters were observed.

- **Total Metals.** Total metals concentrations were observed to be consistently higher than dissolved metals concentrations in data from previous investigations (dissolved metals are defined by whatever passes through a 0.45 um filter). This indicates that the total metals concentrations are associated with particulate matter within the groundwater samples rather than dissolved in the groundwater, i.e., that the total concentrations are higher as a result of well installation, development, and sampling methods which provide turbid samples. The monitoring wells were installed in accordance with Chapter 174-160 WAC, yet cannot necessarily be developed sufficiently to provide low turbidity samples consistently across the property. Therefore, in accordance with MTCA (WAC 173-340-720 8(a)), dissolved metals concentrations are a more representative measure of groundwater quality at the property. Dissolved metals analytical results are discussed below and in all subsequent groundwater quality sections.

- **Dissolved Metals.** Dissolved metals analyses showed that only arsenic exceeded its screening level of 0.004 mg/L. Arsenic exceedence concentrations range from 0.006 to 0.009 mg/L. Note that these arsenic concentrations are within the range

of background levels for Western Washington groundwater that are thought to be the result of natural conditions (USGS, 1994).

- **Semivolatile Organics (PAHs).** Exceedences of the screening level occurred for two ncPAHs (acenaphthene and fluoranthene) in TB-78 and HC-3A. Note that TB-78 is essentially an upgradient well, since it is located at the northeast corner of the property. The cPAH exceedences occurred at locations HC-3, HC-5, and TB-78 and range from 0.001 to 0.17 mg/L. Bis(2-ethylhexyl)phthalate was detected at a concentration of 0.012 mg/L at TB-96. Though this compound was not detected in the laboratory blank, it is possible that this detection is associated with laboratory contamination.

- **Volatile Organics.** No detections were observed above screening levels.

- **Total Petroleum Hydrocarbons.** No total petroleum hydrocarbons analyses were performed for previous on-property groundwater samples.

5.5.2 May 1996 Data

In May 1996, three new downgradient wells (HC-101, HC-102, and HC-103) were sampled. An exceedence of screening levels was observed for dissolved arsenic in HC-101 (Table 5-5). Results for naphthalene and BTEX were reported in more than one analytical method. However, the analytical methods more specific to these compounds were used for the purposes of this report (for BTEX, EPA Method 8020, and for naphthalene, EPA Method 8270). The complete chemical data for the May 1996 groundwater samples (both on- and off-property) are presented in Table D-3 in Appendix D.

- **Conventionals.** Measured values for conventional water quality parameters (total dissolved solids, conductivity, temperature, and pH) were all within typical ranges for groundwater in the downtown area.

- **Dissolved Metals.** Dissolved metals showed that only arsenic exceeded its screening level (0.004 mg/L) at a concentration of 0.0091. This concentration is similar to the exceedence observed in the previous on-property groundwater sampling results which are comparable to arsenic concentrations observed in Western Washington groundwater (USGS, 1994). In addition, this concentration is lower than the maximum concentrations observed in off-property dissolved arsenic samples.

- **Other Constituents except TPH.** No exceedences of screening criteria were observed for any other constituents.

- **Total Petroleum Hydrocarbons.** TPH as gasoline was detected in HC-101 at 3.6 mg/L and in HC-102 at 0.074 mg/L. TPH as diesel was also detected in HC-101 at 2.5 mg/L. Although there is not MTCA Method B cleanup level for TPH in groundwater, the MTCA Method A cleanup level is 1 mg/L. However, the chromatograms of these samples do not contain a hydrocarbon pattern indicative of gasoline or diesel (Appendix F). The compounds that eluted in the gasoline and diesel ranges appear to be mostly aromatic compounds derived from a coal tar- or creosote-like source.

5.6 Off-Property Groundwater Quality

Tables 5-6 and 5-7 summarize the off-property groundwater analytical data for each of the locations with exceedences of the screening criteria for previous and current sampling events, respectively. Tables 5-8 and 5-9 summarize the constituents detected, detection frequency,

highest and lowest detected concentration, location of highest detection, the screening levels for the constituents detected, and exceedences of the screening levels for previous and current off-property groundwater data, respectively. The complete chemical data for previous groundwater samples are presented in Table D-2 in Appendix D.

5.6.1 Previous Data

Upgradient of the property, several wells had exceedences of the screening levels. The ncPAH concentrations exceeded the screening level in B-4, and the arsenic concentration in B-6 exceeded its screening levels. Total cyanide also exceeded the screening level in B-4. It should be noted that the turbid nature of the groundwater sample collected from well B-4 in 1986 may have positively biased the observed PAH concentrations.

Downgradient of the property, no constituents were detected in samples from the King Street Station property above their respective detection limits.

Well OW-2A, located in South Jackson Street north of the Main Parcel, had exceedences in benzene, toluene, and ethylbenzene, as well as several ncPAHs.

- **Conventionals.** Measured values for conventional water quality parameters (chloride, sodium, conductivity, temperature, pH, and hardness) were all within typical ranges for groundwater in the downtown area, except for a fairly high conductivity value of 6,200 umhos/cm in B-2, located just east (upgradient) of the Union Station Site. Total cyanide was detected at 0.081 mg/L in B-4, which is located in 5th Avenue just east (upgradient) of the Union Station property. Cyanide was not detected at any of the other five off-site sampling locations.

- **Total Metals.** Dissolved metals, as discussed below, are considered to be more representative of property and area groundwater quality, as discussed in Section 5.5.1.

- **Dissolved Metals.** Dissolved metals analysis results indicated that arsenic, copper, and nickel exceed their screening levels. Arsenic exceeded the screening level in two locations (B-1 and B-6) and ranged from 0.005 to 0.11 mg/L. B-1 and B-6 is located upgradient of the south end of the Main Parcel. Copper exceedence concentrations range from 0.003 to 0.004 mg/L. Nickel exceedence concentrations range from 0.014 to 0.13 mg/L.

- **Semivolatile Organics.** Exceedences of the screening level occurred for ncPAHs (acenaphthene and fluoranthene) and cPAHs. These exceedences occurred primarily in B-4, which is located upgradient (east) of the Union Station property, and in OW-2A, located on South Jackson Street between the Main Parcel and the North Parcel. Bis(2-ethylhexyl)phthalate was detected at low concentrations in two locations (B-1 and TB-95) and ranged from 0.01 to 0.02 mg/L. Though this compound wasn't detected in the laboratory blank, it is a common lab contaminant which may be the source of these two detections.

- **Volatile Organics.** BTEX were detected at two locations, B-4 and OW-2A. Benzene, toluene, and ethylbenzene concentrations were detected at concentrations above the screening levels in OW-2A. Monitoring well OW-2A is located in South Jackson Street to the north of the Main Parcel. These exceedences may be associated with a former gas station that operated upgradient of the property.

- **Total Petroleum Hydrocarbons.** TPH analyses as diesel and as oil were conducted on samples from B-1, B-2, and B-3A on the King Street Station

property, located downgradient of the Union Station property. There were no TPH detections in these samples.

5.6.2 May 1996 Data

In May 1996, two upgradient wells (B-4 and B-6) were sampled.

- **Conventionals.** Measured values for conventional water quality parameters (total dissolved solids, conductivity, temperature, and pH) were all within typical ranges for groundwater in the downtown area. Cyanide exceeded the screening level at upgradient well B-4.

- **Dissolved Metals.** Dissolved metals analyses showed that only arsenic and nickel exceeded the screening levels in B-6.

- **Semivolatile Organics (PAHs).** Semivolatiles were detected at concentrations exceeding the screening levels in well B-4.

- **Volatile Organics.** There was an exceedence of screening levels for benzene in well B-4 indicating an off-property upgradient source of BTEX compounds.

- **Total Petroleum Hydrocarbons.** TPH was not detected in either upgradient well.

5.6.3 Utility Corridor

Underground utility corridors can sometimes provide a preferential pathway for shallow groundwater flow, because the utility conduits are commonly bedded in highly permeable gravel.

Thus, a limited evaluation of the potential for preferential utility corridor transport at the downgradient perimeter of the property was conducted as part of this RI.

Based on a review of City of Seattle utility maps, two primary utilities were identified downgradient of the property. Beneath Fourth Avenue, there is a 4-foot-diameter sewer main buried approximately 14 to 15 feet below ground with a slope toward the south, and a water main is present at a depth of 2 to 3 feet below ground. The water line is above the groundwater table and consequently does not pose a potential groundwater flow pathway; however, the sewer main may provide a preferential flow pathway.

5.7 Local Groundwater Not Used as a Drinking Water Source

MTCA (WAC 173-340-720) assumes that all groundwater is a current or future potential drinking water source unless one of the following three conditions is met:

- Groundwater does not have sufficient yield (i.e., less than 0.5 gallon/minute on a sustained basis);

- Groundwater contains naturally occurring constituents that cause the water to be non-potable, (e.g., total dissolved solids greater than 10,000 mg/L); or

- Groundwater exists at such great depths or in a location that makes it technically infeasible to recover.

Ecology has also reserved the right to designate certain aquifers that do not meet one or more of the exemptions as nonpotable on a case-by-case basis (e.g., Harbor Island, and shallow aquifers in the Commencement Bay nearshore area). This property is within an industrial/commercial area with no hydraulically downgradient areas to the west and northwest

that have any potential to be future drinking water sources based on the relatively high total dissolved solids.

Ecology has determined that the groundwater pathway is the only pathway of potential concern at the Union Station property, based on published information associated with the recent reranking of the former property (Hart Crowser, 1994). In 1994, Roy F. Weston (with concurrence from EPA) concluded the waters under the property would not be used as a drinking water source and stated that there were no drinking water wells within 5 miles of the property (Appendix G).

In 1991, SAIC under contract to Ecology concluded no further remedial action for the property based, in part, on the lack of use of the groundwater for drinking water (Appendix G). However, groundwater is not currently used for drinking water in the vicinity of downtown Seattle. Municipal drinking water for the City of Seattle comes from the protected surface water sources of the Tolt and Cedar Rivers. Furthermore, there is no reason to believe that property groundwater will be a drinking water source in the future. Groundwater quality in the downtown Seattle area is generally poor because it has been impacted by a number of historical industrial/commercial sources. For example, groundwater in the area of the Union Station property has total dissolved solids (TDS) concentrations of 300 to 500 mg/L., although the MTCA standard is 10,000 mg/L, the Washington State standard is 250 mg/L for groundwater to be used as drinking water.

5.8 Modeling of PAH Transport in Groundwater

Groundwater monitoring data collected from shallow wells (HC-101, HC-102, and HC-103) in the fill groundwater zone downgradient of the property indicate that the PAHs detected in groundwater beneath the Union Station property are reduced substantially within a short distance downgradient of the property (all PAH detections were below screening levels). These results indicate that the detected PAHs do not pose an adverse impact to Elliott Bay.

Although there were no PAH exceedences in the May 1996 sampling, to further support reductions in PAH concentrations attributable to natural dispersion and dilution in the aquifer, groundwater modeling was performed using the EPA Exposure Assessment Multimedia Model Multimed (Salhotra et al., 1990). Multimed is a repackaged version of the contaminant transport model used by EPA to calculate dilution/attenuation factors (DAFs) in development of the TCLP regulations. The DAF is equivalent to the concentration reduction occurring between the property and a downgradient location. Only the saturated zone (aquifer) module of the model was used for this evaluation. To provide conservatism for this evaluation, only physical dispersion and dilution in the aquifer were considered. Chemical and biological attenuation process (e.g., sorption and degradation) were not considered. Consequently, DAFs estimated by this modeling are both conservative and constituent-independent (i.e., applicable to any constituent).

PAHs are the principal chemicals of potential concern at the Union Station property. Our conceptual model indicates (refer to Section 6.0) that shallow groundwater at the Union Station property flows beneath the King Street property on its way to Elliott Bay. Groundwater quality data from the King Street property showed no detections of PAHs, indicating that PAHs are not readily transported in the aquifer from the Union Station property. The objective of the modeling was to evaluate whether natural dispersion/dilution processes in the aquifer could be expected to reduce concentrations of PAHs sufficiently to produce nondetectable concentrations by the time groundwater reached the King Street property, thus providing a verification of the empirical data. Naphthalene was the PAH with the highest detected concentration at the Union Station property. Thus, naphthalene was the focus of the modeling effort. (Coincidentally, naphthalene is the most mobile, or least attenuated, of the PAHs based on partition coefficients from the literature; however, as discussed above, the modeling did not consider attenuation processes). Naphthalene also represents a conservative basis for evaluation of phenanthrene the only constituent detected in the May 1996 downgradient well sampling (because it is more mobile than phenanthrene).

The steady state modeling used property-specific information for hydraulic parameters (e.g., hydraulic conductivity of 1 x 10^{-3} cm/sec, and gradient of 0.002) available from previous work at the property (Hart Crowser, 1986). Aquifer thickness was assumed to be only 10 feet for this evaluation, and porosity was assumed to be 0.3 based on literature values. Infiltration within the property and recharge downgradient of it were assumed to be 10 percent of precipitation (or 4.4 inches/year) based on runoff estimates for commercial/industrial areas (Linsley and Franzini, 1979) and an average precipitation of 44 inches/year at Sea-Tac airport. Longitudinal, transverse, and vertical dispersion were calculated by the model using the model default relationships based on distance from the source to the receptor well (refer to Salhotra et al., 1990). The initial concentration at the property was set at 1.0 mg/L, such that the modeled downgradient concentration will be the inverse of the DAF. Appendix E provides a listing of model input assumptions and the modeling results.

The results of the highly conservative modeling indicate that naphthalene (and consequently phenanthrene) should be at concentrations below detection limits by the time groundwater reaches the King Street property, approximately 400 meters away. A DAF of about 10,000 was estimated by this modeling (Appendix E). The highest naphthalene concentration detected on property was 2,300 μg/L. Reducing this by 10,000 times produces an estimated concentration at the King Street property of about 0.2 μg/L, which is below the detection limit of 1 μg/L. By inference, the other PAHs, detected at lower concentrations on the property than naphthalene, should also be below detection limits at the King Street property. This also applies to phenanthrene detected in the downgradient well. Since the PAHs are reduced to concentrations below surface water screening levels by the time they reach the King Street property, the PAHs at the Union Station property pose negligible risk to marine organisms in Elliott Bay. Even if preferential flow pathways exist, substantial reductions in concentration would still be expected within a relatively short distance, thereby posing little risk to Elliott Bay.

5.9 Summary of Groundwater Quality

Regional groundwater flow in the vicinity of the Union Station property is generally westward toward Elliott Bay. On the property, flow in the fill groundwater zone is in a northwesterly direction, with eventual discharge to Elliott Bay. Downward movement of groundwater to deeper marine and glacial zones is not expected because of regionally and locally upward gradients. Groundwater in the area is not used for drinking water; therefore, the primary receptor of concern is marine organisms in Elliott Bay.

Previous groundwater sampling data show that several upgradient wells had exceedences of the screening levels. These exceedences included ncPAHs, cyanide, and arsenic. Benzene, toluene, and ethylbenzene exceedences were present beneath South Jackson Street north of the Main Parcel. On-property groundwater sampling also showed no exceedences of ncPAHs and cPAHs.

The May 1996 groundwater sampling data showed no exceedences of PAHs or any other constituents in the downgradient wells. Only arsenic exceedences at concentrations similar to western Washington background were observed in both upgradient and downgradient wells.

Marine Surface Water Quality Criteria Exceedences for Groundwater

HC-101	Recently Installed Monitoring Well Location and Number
	Resampling of Existing Well
	Existing Exploration Location and Number (Hart Crowser)
B-5	Monitoring Well (January 1993, J-3711)
B-7	Soil Boring (January 1993, J-3711)
B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
FS-3	Chemical Boring (January 1987, J-1636-03)
BP-3	Boring (August 1987, J-1636-05)
G-1	Shallow Geochemical Boring (August 1987, J-1636-04)
HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5

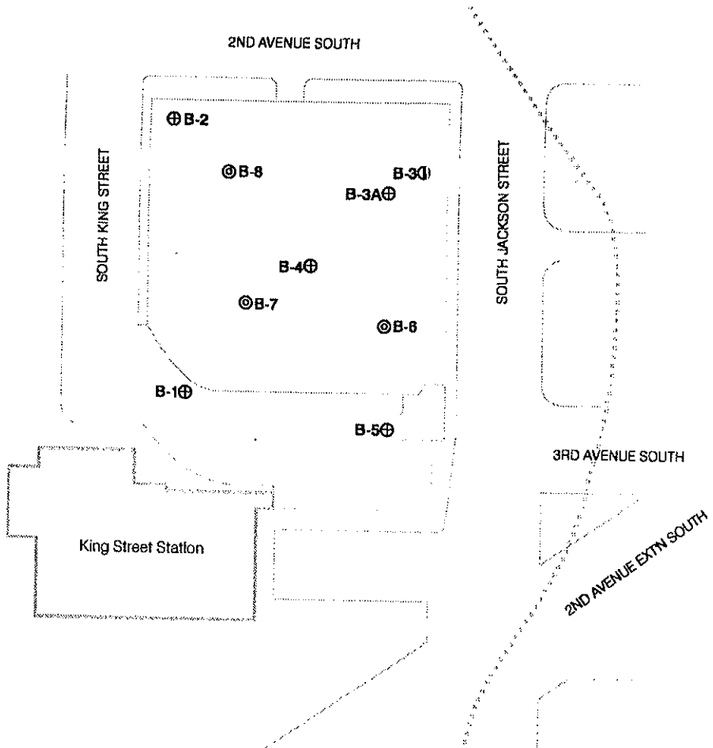
	Exploration Location and Number (Others)
TB-82	Boring/Well (January 1986)
OW-2A	Boring/Well (July 1996)
PW-4	Boring (January 1987)
H-3	Approximate Location of Surface Soil Sample (January 1987)
	Former Shoreline
	Approximate Property Boundary

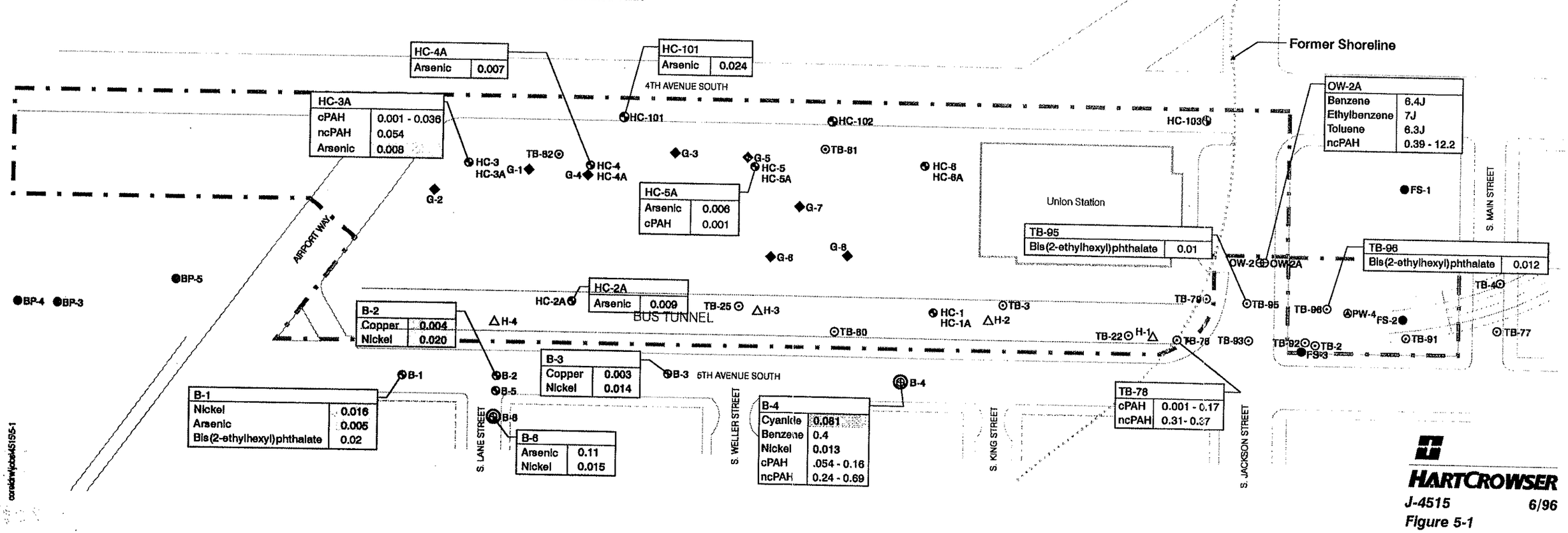
Exploration Number	
Constituent	Concentration in mg/L

Total Cyanide

Dissolved Metals

J Estimated Value





HARTCROWSER

J-4515 6/96

Figure 5-1

Table 5-1 - Union Station Sample Information Table (Groundwater)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
On-Property										
HC-101		5/3/96	X		X			X	X	X
HC-102		5/3/96	X		X			X	X	X
HC-103		5/3/96	X		X			X	X	X
HC-1A		2/18/86	X		X			X	X	
HC-2A		2/18/86	X		X			X	X	
HC-3A		2/18/86	X		X			X	X	
HC-4A		2/18/86	X		X			X	X	
HC-5A		2/18/86	X		X			X	X	
HC-6A		2/18/86	X		X			X	X	
HC-B-4		5/1/96	X		X			X	X	X
HC-B-6		5/3/96	X		X			X	X	X
PW4		2/20/86	X	X				X	X	
PW4		3/20/86						X	X	
TB-78	5 to 25	9/16/85	X	X				X	X	
TB-80	15 to 25	11/11/85	X	X				X	X	
TB96		2/20/86	X	X				X	X	
Off-Property										
B-1		2/19/86	X		X			X	X	
B-1		1/22/93						X	X	X
B-2		2/19/86	X		X			X	X	
B-2		1/22/93						X	X	X
B-3		2/19/86	X		X			X	X	
B-3A		1/22/93						X	X	X
B-4		2/19/86	X		X			X	X	
B-5		1/22/93						X	X	X
B-6		2/19/86	X		X			X	X	
OW2		2/21/86	X	X				X	X	
OW2		3/20/86	X	X				X	X	
OW2A		2/21/86	X	X				X	X	
TB95		2/20/86	X	X				X	X	
TB95		3/20/86						X	X	

Table 5-2 - Screening Criteria Exceedences in Previous On-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-2A	2/18/86	Arsenic, Dissolved	0.009	0.004
HC-3A	2/18/86	Arsenic, Dissolved	0.008	0.004
HC-3A	2/18/86	Benzo(a)anthracene	0.028	0.0001
HC-3A	2/18/86	Benzo(a)pyrene	0.036	0.0002
HC-3A	2/18/86	Chrysene	0.029	0.0001
HC-3A	2/18/86	Dibenzo(ah)anthracene	0.001	0.0002
HC-3A	2/18/86	Fluoranthene	0.054	0.0271
HC-3A	2/18/86	Indeno(1,2,3-cd)pyrene	0.013	0.0002
HC-4A	2/18/86	Arsenic, Dissolved	0.007	0.004
HC-5A	2/18/86	Arsenic, Dissolved	0.006	0.004
HC-5A	2/18/86	Benzo(a)pyrene	0.001	0.0002
HC-5A	2/18/86	Indeno(1,2,3-cd)pyrene	0.001	0.0002
TB-78	9/16/85	Acenaphthene	0.37	0.225
TB-78	9/16/85	Benzo(a)anthracene	0.14	0.0001
TB-78	9/16/85	Benzo(a)pyrene	0.17	0.0002
TB-78	9/16/85	Benzo(k)fluoranthene	0.12	0.0002
TB-78	9/16/85	Chrysene	0.16	0.0001
TB-78	9/16/85	Fluoranthene	0.31	0.0271
TB-78	9/16/85	Indeno(1,2,3-cd)pyrene	0.001	0.0002
TB96	2/20/86	Bis(2-ethylhexyl)phthalate	0.012	0.0059

Table 5-3 - Screening Criteria Exceedences in May 1996 On-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-101	5/3/96	Arsenic, Dissolved	0.0091	0.004

Table 5-4 - Statistical Summary of Previous On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Chloride in mg/L	2/2	18 to 28	28	PW4-2-86	23	28				
Conductivity in µmhos/c	8/8	65 to 620	620	HC-1A	333.88	620				
Sodium in mg/L	2/2	38 to 53	53	PW4-2-86	45.5	53				
Temperature in °C	6/6	3.8 to 6.5	6.5	HC-1A	4.97	6.5				
Total Cyanide in mg/L	3/8	0.005 to 0.047	0.047	HC-1A	0.01	0.047	0.05	0/8	0	
Total Hardness as CaCO3 in mg/L	2/2	250 to 270	270	TB96-2-86	260	270				
pH	6/6	6.3 to 6.6	6.6	HC-1A HC-2A HC-6A	6.5	6.6				
Dissolved Metals in mg/L										
Arsenic	4/6	0.005 U to 0.009	0.009	HC-2A	0.005	0.009	0.004	4/4	100	2.25
Cadmium	4/6	0.001 to 0.003	0.003	HC-2A	0.002	0.003	0.008	0/6	0	
Chromium	6/6	0.004 to 0.005	0.005	HC-4A HC-5A	0.0043	0.005	0.05	0/6	0	
Copper	3/6	0.001 to 0.002	0.002	HC-2A HC-3A	0.0011	0.002	0.0029	0/6	0	
Nickel	6/6	0.004 to 0.01	0.01	HC-2A	0.0063	0.01	0.01	0/6	0	
Silver	2/6	0.001 to 0.001	0.001	HC-2A HC-5A	0.0007	0.001	0.02	0/6	0	
Zinc	6/6	0.012 to 0.063	0.063	HC-5A	0.030	0.063	0.0766	0/6	0	
Semivolatiles in mg/L										
2-Methylnaphthalene	2/11	0.001 U to 0.6	0.6	TB-78/5-25	0.056	0.6				
Acenaphthene	2/11	0.001 U to 0.37	0.37	TB-78/5-25	0.040	0.37	0.225	1/11	9.09	1.64
Acenaphthylene	2/11	0.001 U to 0.13	0.13	TB-78/5-25	0.015	0.13				
Anthracene	2/11	0.001 U to 0.24	0.24	TB-78/5-25	0.026	0.24	25.9	0/11	0	
Benzo(a)anthracene	2/11	0.001 U to 0.14	0.14	TB-78/5-25	0.015	0.14	0.0001	2/2	100	1400
Benzo(a)pyrene	3/11	0.001 to 0.17	0.17	TB-78/5-25	0.019	0.17	0.0002	3/3	100	850
Benzo(bk)fluoranthene	2/6	0.001 to 0.026	0.026	HC-3A	0.005	0.026				
Benzo(g,h,i)perylene	1/11	0.001 U to 0.012	0.012	HC-3A	0.002	0.012				

Table 5-4 - Statistical Summary of Previous On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Benzo(k)fluoranthene	1/5	0.001 U to 0.12	0.12	TB-78/5-25	0.024	0.12	0.0002	1/1	100	600
Bis(2-ethylhexyl)phthalat	2/11	0.001 to 0.029 U	0.012	TB96-2-86	0.002	0.012	0.0059	1/9	11.11	2.03
Chrysene	2/11	0.001 U to 0.16	0.16	TB-78/5-25	0.017	0.16	0.0001	2/2	100	1600
Dibenzo(ah)anthracene	1/11	0.001 to 0.01 U	0.001	HC-3A	0.000	0.001	0.0002	1/1	100	5
Dibenzofuran	1/10	0.001 U to 0.12	0.12	TB-78/5-25	0.013	0.12				
Fluoranthene	2/11	0.001 U to 0.31	0.31	TB-78/5-25	0.034	0.31	0.0271	2/11	18.18	11.44
Fluorene	2/11	0.001 U to 0.2	0.2	TB-78/5-25	0.022	0.2	2.422	0/11	0	
Indeno(1,2,3-cd)pyrene	3/11	0.001 to 0.013	0.013	HC-3A	0.001	0.013	0.0002	3/3	100	65
Naphthalene	3/11	0.001 U to 2.3	2.3	TB-78/5-25	0.212	2.3	9.8	0/11	0	
Phenanthrene	2/11	0.001 U to 0.6	0.6	TB-78/5-25	0.064	0.6				
Phenol	2/2	0.016 to 0.029	0.029	TB-80/15-25	0.023	0.029	1100	0/2	0	
Pyrene	2/11	0.001 U to 0.27	0.27	TB-78/5-25	0.030	0.27	0.777	0/11	0	
Total cPAHs	2/11	0.001 U to 0.59	0.59	TB-78/5-25	0.066	0.59				
Volatiles in mg/L										
Acetone	7/9	0.001 U to 0.016	0.012	HC-6A	0.008	0.012				
Total Organic Halogens	1/1	0.02 to 0.02	0.02	PW4-2-86	0.02	0.02				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 5-5 - Statistical Summary of May 1996 On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals in mg/L										
Total Dissolved Solids	3/3	430 to 960	960	HC-101	633.33	960				
Total Suspended Solids	3/3	9 to 35	35	HC-101	24.33	35				
Dissolved Metals in mg/L										
Arsenic	1/3	0.004 U to 0.0091	0.0091	HC-101	0.004	0.0091	0.004	1/3	33.33	2.28
Nickel	1/3	0.0058 to 0.01 U	0.0058	HC-103	0.005	0.0058	0.01	0/3	0	
Semivolatiles in mg/L										
Acenaphthene	3/3	0.0012 to 0.06	0.06	HC-101	0.023	0.06	0.225	0/3	0	
Acenaphthylene	2/3	0.0001 U to 0.016	0.016	HC-101	0.005	0.016				
Anthracene	3/3	0.0002 to 0.0028	0.0028	HC-101	0.001	0.0028	25.9	0/3	0	
Fluoranthene	3/3	0.00018 to 0.0026	0.0026	HC-101	0.001	0.0026	0.0271	0/3	0	
Fluorene	3/3	0.00037 to 0.02	0.02	HC-101	0.007	0.02	2.422	0/3	0	
Naphthalene	3/3	0.00022 to 0.53	0.53	HC-101	0.177	0.53	9.8	0/3	0	
Phenanthrene	3/3	0.00087 to 0.024	0.024	HC-101	0.009	0.024				
Pyrene	3/3	0.00019 to 0.0023	0.0023	HC-101	0.001	0.0023	0.777	0/3	0	
Volatiles (EPA 8260) in mg/L										
1,2,4-Trimethylbenzene	1/3	0.001 U to 0.018	0.018	HC-101	0.006	0.018				
1,2,5-Trimethylbenzene	1/3	0.001 U to 0.0074	0.0074	HC-101	0.003	0.0074				
Benzene	1/3	0.001 U to 0.037	0.037	HC-101	0.013	0.037	0.071	0/3	0	
Isopropylbenzene	1/3	0.001 U to 0.0065	0.0065	HC-101	0.003	0.0065				
Naphthalene	1/3	0.001 U to 1	1	HC-101	0.334	1				
P-Isopropyltoluene	1/3	0.001 U to 0.0056	0.0056	HC-101	0.002	0.0056				
m & p-Xylene	1/3	0.001 U to 0.044	0.044	HC-101	0.015	0.044				
o-Xylene	1/3	0.001 U to 0.025	0.025	HC-101	0.009	0.025				
BTEX (EPA 8020) in mg/L										
Benzene	1/3	0.0005 U to 0.004	0.0043	HC-101	0.002	0.0043				
Ethylbenzene	1/3	0.0005 U to 0.077	0.077	HC-101	0.026	0.077				
Toluene	1/3	0.0005 U to 0.007	0.0077	HC-101	0.003	0.0077				
Xylene (total)	1/3	0.001 U to 0.064	0.064	HC-101	0.022	0.064				
TPH in mg/L										
Diesel	1/3	0.25 U to 2.5	2.5	HC-101	0.917	2.5				
Gasoline	2/3	0.05 U to 3.6	3.6	HC-101	1.233	3.6				

Table 5-6 - Screening Criteria Exceedences in Previous Off-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L		Screening Level in mg/L
B-1	2/19/86	Arsenic, Dissolved	0.005		0.004
B-1	2/19/86	Nickel, Dissolved	0.016		0.01
B-1	1/22/93	Bis(2-ethylhexyl)phthalate	0.02		0.0059
B-2	2/19/86	Copper, Dissolved	0.004		0.0029
B-2	2/19/86	Nickel, Dissolved	0.02		0.01
B-3	2/19/86	Copper, Dissolved	0.003		0.0029
B-3	2/19/86	Nickel, Dissolved	0.014		0.01
B-4	2/19/86	Total Cyanide	0.081		0.05
B-4	2/19/86	Nickel, Dissolved	0.013		0.01
B-4	2/19/86	Acenaphthene	0.69		0.225
B-4	2/19/86	Benzo(a)anthracene	0.11		0.0001
B-4	2/19/86	Benzo(a)pyrene	0.16		0.0002
B-4	2/19/86	Chrysene	0.097		0.0001
B-4	2/19/86	Fluoranthene	0.24		0.0271
B-4	2/19/86	Indeno(1,2,3-cd)pyrene	0.054		0.0002
B-4	2/19/86	Benzene	0.4		0.071
B-6	2/19/86	Arsenic, Dissolved	0.11		0.004
B-6	2/19/86	Nickel, Dissolved	0.015		0.01
OW2A	2/21/86	Acenaphthene	0.39		0.225
OW2A	2/21/86	Naphthalene	12.2		9.8
OW2A	2/21/86	Benzene	6.4	J	0.071
OW2A	2/21/86	Ethylbenzene	7	J	0.276
OW2A	2/21/86	Toluene	6.3	J	0.485
TB95	3/20/86	Bis(2-ethylhexyl)phthalate	0.01		0.0059

Table 5-7 - Screening Criteria Exceedences in May 1996
Off-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-B-4	5/1/96	Arsenic, Dissolved	0.0099	0.004
HC-B-6	5/3/96	Arsenic, Dissolved	0.013	0.004

Table 5-8 - Statistical Summary of Previous Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Chloride in mg/L	4/4	1 to 22	22	TB95-2-86	8.25	22				
Conductivity in µmhos/cm	9/9	160 to 6200	6200	B-2	1348	6200				
Sodium in mg/L	4/4	25 to 75	75	OW2A-2-86	44.5	75				
Temperature in °C	5/5	8.4 to 10.8	10.8	B-1	9.54	10.8				
Total Cyanide in mg/L	1/6	0.005 U to 0.081	0.081	B-4	0.016	0.081	0.05	1/6	16.67	1.62
Total Hardness as CaCO3 in mg/L	4/4	54 to 340	340	OW2A-2-86	163.5	340				
pH	5/5	6.7 to 7.6	7.6	B-4	7.24	7.6				
Dissolved Metals in mg/L										
Antimony	1/5	0.005 U to 0.02	0.02	B-2	0.006	0.02	4.3	0/5	0	
Arsenic	2/5	0.005 to 0.11	0.11	B-6	0.023	0.11	0.004	2/2	100	27.5
Cadmium	5/5	0.003 to 0.005	0.005	B-2	0.004	0.005	0.008	0/5	0	
Chromium	5/5	0.003 to 0.005	0.005	B-3 B-4	0.004	0.005	0.05	0/5	0	
Copper	2/5	0.001 U to 0.004	0.004	B-2	0.002	0.004	0.0029	2/5	40	1.38
Nickel	5/5	0.013 to 0.02	0.02	B-2	0.016	0.02	0.01	5/5	100	2
Silver	5/5	0.002 to 0.003	0.003	B-1	0.002	0.003	0.02	0/5	0	
Silver	5/5	0.002 to 0.003	0.003	B-6	0.002	0.003	0.02	0/5	0	
Zinc	5/5	0.012 to 0.03	0.03	B-2	0.019	0.03	0.0766	0/5	0	
Semivolatiles in mg/L										
2-Methylnaphthalene	2/14	0.001 U to 1.63	1.63	B-4	0.190	1.63				
Acenaphthene	2/14	0.001 U to 0.69	0.69	B-4	0.079	0.69	0.225	2/14	14.29	3.07
Acenaphthylene	1/14	0.001 U to 0.94	0.94	B-4	0.069	0.94				
Anthracene	2/14	0.001 U to 0.22	0.22	B-4	0.020	0.22	25.9	0/14	0	
Benzo(a)anthracene	1/14	0.001 U to 0.11	0.11	B-4	0.008	0.11	0.0001	1/1	100	1100
Benzo(a)pyrene	1/14	0.001 U to 0.16	0.16	B-4	0.011	0.16	0.0002	1/1	100	800
Benzo(bk)fluoranthene	1/5	0.001 U to 0.12	0.12	B-4	0.025	0.12				
Benzo(g,h,i)perylene	1/14	0.001 U to 0.053	0.053	B-4	0.006	0.053				
Benzoic Acid	1/4	0.001 J to 0.05 U	0.001 J	B-3A	0.019	0.001				

Table 5-8 - Statistical Summary of Previous Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect		Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Bis(2-ethylhexyl)phthalate	4/14	0.001 U to 0.027 U	0.02		B-1-1-22-93	0.003	0.02	0.0059	2/10	20	3.39
Chrysene	1/14	0.001 U to 0.097	0.097		B-4	0.007	0.097	0.0001	1/1	100	970
Dibenzofuran	1/14	0.001 U to 0.078	0.078		B-4	0.008	0.078				
Fluoranthene	1/14	0.001 U to 0.24	0.24		B-4	0.019	0.24	0.0271	1/14	7.14	8.86
Fluorene	2/14	0.001 U to 0.3	0.3		B-4	0.028	0.3	2.422	0/14	0	
Indeno(1,2,3-cd)pyrene	1/14	0.001 U to 0.054	0.054		B-4	0.004	0.054	0.0002	1/1	100	270
Naphthalene	2/14	0.001 U to 12.2	12.2		OW2A-2-86	1.487	12.2	9.8	1/14	7.14	1.24
Phenanthrene	2/14	0.001 U to 0.64	0.64		B-4	0.054	0.64				
Pyrene	1/14	0.001 U to 0.24	0.24		B-4	0.019	0.24	0.777	0/14	0	
Total cPAHs	1/14	0.001 U to 0.541	0.541		B-4	0.041	0.541				
Volatiles in mg/L											
Acetone	6/10	0.001 U to 0.076	0.076		B-2	0.017	0.076				
Benzene	2/14	0.001 U to 6.4 J	6.4	J	OW2A-2-86	0.486	6.4	0.071	2/14	14.29	90.14
Chloroform	1/10	0.001 to 0.001	0.001		B-4	0.0006	0.001				
Ethylbenzene	2/14	0.001 U to 7 J	7	J	OW2A-2-86	0.510	7	0.276	1/14	7.14	25.36
Methylene Chloride	1/10	0.001 U to 0.019 U	0.006		B-6	0.003	0.006				
Toluene	2/14	0.001 U to 6.3 J	6.3	J	OW2A-2-86	0.461	6.3	0.485	1/14	7.14	12.99
o-Xylene	2/10	0.001 U to 3.4 J	3.4	J	OW2A-2-86	0.356	3.4				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 5-9 - Statistical Summary of May 1996 Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UC (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals in mg/L										
Total Dissolved Solids	2/2	840 to 940	940	HC-B-4	890	940				
Total Suspended Solids	2/2	21 to 24	24	HC-B-4	22.5	24				
Dissolved Metals in mg/L										
Arsenic	2/2	0.0099 to 0.013	0.013	HC-B-6	0.01145	0.013	0.004	2/2	100	3.25
Zinc	2/2	0.021 to 0.022	0.022	HC-B-4	0.0215	0.022	0.0766	0/2	0	
Semivolatiles in mg/L										
Acenaphthene	1/2	0.0001 U to 0.0002	0.00027	HC-B-4	0.00016	0.00027	0.225	0/2	0	
Fluoranthene	1/2	0.0001 U to 0.0001	0.00013	HC-B-4	0.00009	0.00013	0.0271	0/2	0	
Fluorene	1/2	0.0001 U to 0.0001	0.00016	HC-B-4	0.000105	0.00016	2.422	0/2	0	
Phenanthrene	1/2	0.0001 U to 0.0004	0.0004	HC-B-4	0.000225	0.0004				
Pyrene	1/2	0.0001 U to 0.0001	0.00014	HC-B-4	0.000095	0.00014	0.777	0/2	0	

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.