Installation Restoration Program
Final Phase II Feasibility Study Report

143rd Combat Communications Squadron
Seattle Air National Guard Station
Washington Air National Guard
Seattle, Washington

August 1999

Air National Guard
Andrews AFB, Maryland

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Installation Restoration Program
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Seattle Air National Guard Station
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August 1999

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LIST OF ACRONYMS/ABBREVIATIONS

Acronym/ Abbreviation	Definition
AGE	Aerospace Ground Equipment
ANG	Air National Guard
ANG/CEVR	Air National Guard/Installation Restoration Program Branch
ANGS	Air National Guard Station
ARAR	Applicable or relevant and appropriate requirement
bgs	Below ground surface
CCSQ	Combat Communications Squadron
COC	Contaminant of concern
ERM	Environmental Resources Management
FS	Feasibility Study
GAC	Granular activated carbon
IRP	Installation Restoration Program
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
MTCA	Model Toxics Control Act
NFA	No Further Action
PA	Preliminary Assessment
PA/SI	Preliminary Assessment/Site Inspection
POTW	Publicly-owned treatment works
PSG	Project screening goal
RAO	Remedial action objective
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SVE	Soil vapor extraction

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LIST OF ACRONYMS/ABBREVIATIONS

Acronym/ Abbreviation	Definition
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
UST	Underground storage tank
UV	Ultraviolet
VOC	Volatile organic compound
WDOE	Washington Department of Ecology

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EXECUTIVE SUMMARY

As part of the Department of Defense Installation Restoration Program investigating potentially contaminated sites at Air National Guard (ANG) facilities, Environmental Resources Management has conducted a two-part Feasibility Study (FS) for the Washington Air National Guard's Seattle Air National Guard Station (Seattle ANGS). The Seattle ANGS is located on a 7.5-acre parcel of land in the northwest portion of the King County International Airport (Boeing Field) in Seattle, Washington.

The Phase I FS was completed in conjunction with the 1997 Phase I Remedial Investigation (RI). The Phase II FS, presented herein, complements the earlier FS and builds upon data collected during the 1998 Phase II RI. As discussed in the Phase II RI Report (ERM 1999), trichloroethene (TCE) in groundwater is the only contaminant of concern at the Seattle ANGS considered to pose a potential threat to human health or the environment. However, an on-site source of the TCE detected in groundwater has not been identified. The results of the RI suggest that the TCE may originate from an off-site source.

During the Phase I FS, a number of potential remedial alternatives for addressing TCE in groundwater were identified and each was screened with respect to relative effectiveness, implementability, and cost. However, the Phase I FS Report (ERM 1998b) was incomplete due to an incomplete characterization of the subject site. The report recommended further investigation and evaluation of TCE concentrations relative to applicable regulatory criteria, so that the remedial alternatives could be further defined.

Direct-push soil, soil vapor, and groundwater samples were collected and analyzed during the Phase II RI to obtain additional data on VOC concentrations. Additionally, five new monitoring wells were installed and quarterly groundwater monitoring was conducted. TCE was not detected in any of the soil samples. Three direct-push groundwater samples collected in the southern portion of the Station contained TCE; the TCE concentrations in two of the samples exceeded the Washington State Model Toxics Control Act (MTCA) Method A Cleanup Level of 5 micrograms per liter.

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The direct-push groundwater sample results are considered screening-level data. Groundwater samples collected from monitoring wells provide definitive data for groundwater characterization. Although TCE has been detected in several groundwater monitoring wells in the southern portion of the Station, concentrations have generally been below 5 μg/L. However, three samples collected in February and May 1999 contained TCE concentrations above the MTCA Method A Cleanup Level; the maximum concentration detected was 83 μg/L. The results of the Phase II RI suggest that the TCE detected in groundwater at the Seattle ANGS is not site-related. Rather, the TCE appears to be related to groundwater contamination at a Boeing facility immediately south of the Station (ERM 1999).

This Phase II FS Report was originally intended to provide further definition and detailed analysis of the remedial alternatives developed during the Phase I FS. However, because no significant site-related environmental impacts have been identified at the Seattle ANGS, additional evaluation of remedial alternatives is unwarranted at this time. Consequently, the remedial alternatives developed during the Phase I FS are presented again here for the sake of completeness, without further definition. It is recommended that quarterly groundwater monitoring be continued for 1 year (until May or June 2000). If the monitoring results indicate that VOC concentrations in groundwater comply with MTCA Method A Cleanup Levels, remedial actions should be discontinued at the site.

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SECTION 1.0

INTRODUCTION

This Phase II Feasibility Study (FS) Report has been prepared for the Seattle Air National Guard Station (Seattle ANGS) in Seattle, Washington. The Phase II FS was conducted as part of the Air National Guard (ANG) Installation Restoration Program (IRP) under Contract DAHA90-94-0014, Delivery Order 0051. The Air National Guard/Installation Restoration Program Branch (ANG/CEVR) provided technical and project management oversight for this study on behalf of the ANG. This FS Report follows the recommended ANG/CEVR format and contains the basic contents suggested in the United States Environmental Protection Agency (USEPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988).

As discussed in the Phase II Remedial Investigation (RI) Report (ERM 1999), trichloroethene (TCE) in groundwater is the only contaminant of concern (COC) at the Seattle ANGS considered to pose a potential threat to human health or the environment. TCE was detected at concentrations exceeding the Washington State Model Toxics Control Act (MTCA) Method A Cleanup Level of 5 micrograms per liter (µg/L) in three direct-push groundwater samples collected in the southern portion of the Station. The highest concentration detected in these samples was 25 µg/L. TCE also was detected at concentrations of 5.7 to 83 µg/L in three groundwater samples collected in February and May 1999 from monitoring wells near the southern Station boundary. Prior to February 1999, TCE had not been detected above 5 µg/L in any monitoring wells. No on-site sources of TCE have been identified. The Phase II RI results suggest that the TCE may be related to groundwater contamination at the Boeing facility immediately south of the Station (ERM 1999).

In order to simplify the FS process, a modified focused FS format was used for this study (USEPA 1993). The technologies and alternatives evaluated were weighted toward those that are consistent with the Washington State Department of Ecology's (WDOE's) preference for technologies that reduce mass, volume, or toxicity as stated in the MTCA Cleanup Regulation, Washington Administrative Code, Chapter 173-340 (WDOE 1996).

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1.1 Purpose and Organization of Report

The purpose of this Phase II FS Report is to describe the development and screening of remedial alternatives for contaminated media identified at the Seattle ANGS. The remedial alternatives were developed during the Phase I FS, which was prepared in conjunction with the Phase I RI.

The objectives of the FS are to:

- Develop, screen, and evaluate remedial alternatives for addressing TCE-impacted groundwater at the Station that may pose a threat to human health or the environment; and
- Recommend the most cost-effective remedial alternatives that adequately protect human health, welfare, and the environment.

The Phase I Remedial Investigation/Feasibility Study (RI/FS) Work Plan (ERM 1996) indicated that a focused FS approach would be applied if site conditions were favorable, and that the focused FS would contain the elements outlined in the USEPA guidance titled *Presumptive Remedies: Policy and Procedures* (USEPA 1993). The modified focused FS presented herein is more comprehensive than outlined in the USEPA guidance. The reason for this is that USEPA presumptive remedies are currently available only for ex-situ groundwater treatment technologies (USEPA 1996), whereas containment and in-situ treatment technologies are potentially applicable to the Seattle ANGS.

This Phase II FS Report begins with a brief overview of the site history and results of the RI, followed by the development and screening of remedial alternatives as presented in the Phase I FS Report. The contents of the sections are as follows:

- Section 1.0 presents background information for the Seattle ANGS, including site location and history.
- Section 2.0 presents the remedial action objectives and the general response actions to be considered. Remediation technologies applicable to TCE contamination in groundwater are also identified and screened in this section.
- Section 3.0 presents the potential remedial alternatives developed for the Seattle ANGS and describes the screening process that was used to select alternatives for further detailed analysis.

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- Section 4.0 outlines the seven criteria typically used to perform a detailed analysis of remedial alternatives developed during an FS. The remedial alternatives developed during the Phase I FS are not analyzed in detail, because any remedial action beyond continued groundwater monitoring appears to be unwarranted at this time. Consequently, the detailed analysis that normally would be presented in this section is instead replaced by the determination that only limited continuation of groundwater monitoring is justified.

- Section 5.0 presents conclusions.

- Section 6.0 lists references.

Appendices to this report include the following:

- Appendix A: Geologic cross sections from the RI;

- Appendix B: Hydrogeologic data from the RI;

- Appendix C: RI sampling locations and analyses; and

- Appendix D: Tables summarizing the identification of COCs at the Seattle ANGS.

1.2 Background Information

The Seattle ANGS is at 6736 Ellis Avenue South in Seattle, Washington (Figure 1-1). The Station occupies approximately 7.5 acres of land in the northwest portion of the King County International Airport (Boeing Field).

1.2.1 Site Description

One IRP site has been identified at the Seattle ANGS. This site, designated as IRP Site 1 - Burial Site (the IRP site), is in the northeast corner of the Station (Figure 1-2). The IRP site is approximately 175 feet long by 175 feet wide, and is covered with asphalt with the exception of the grass-covered northeast corner. The north and east sides of the IRP site are bounded by a 6-foot-high chain link fence that surrounds the entire Station.

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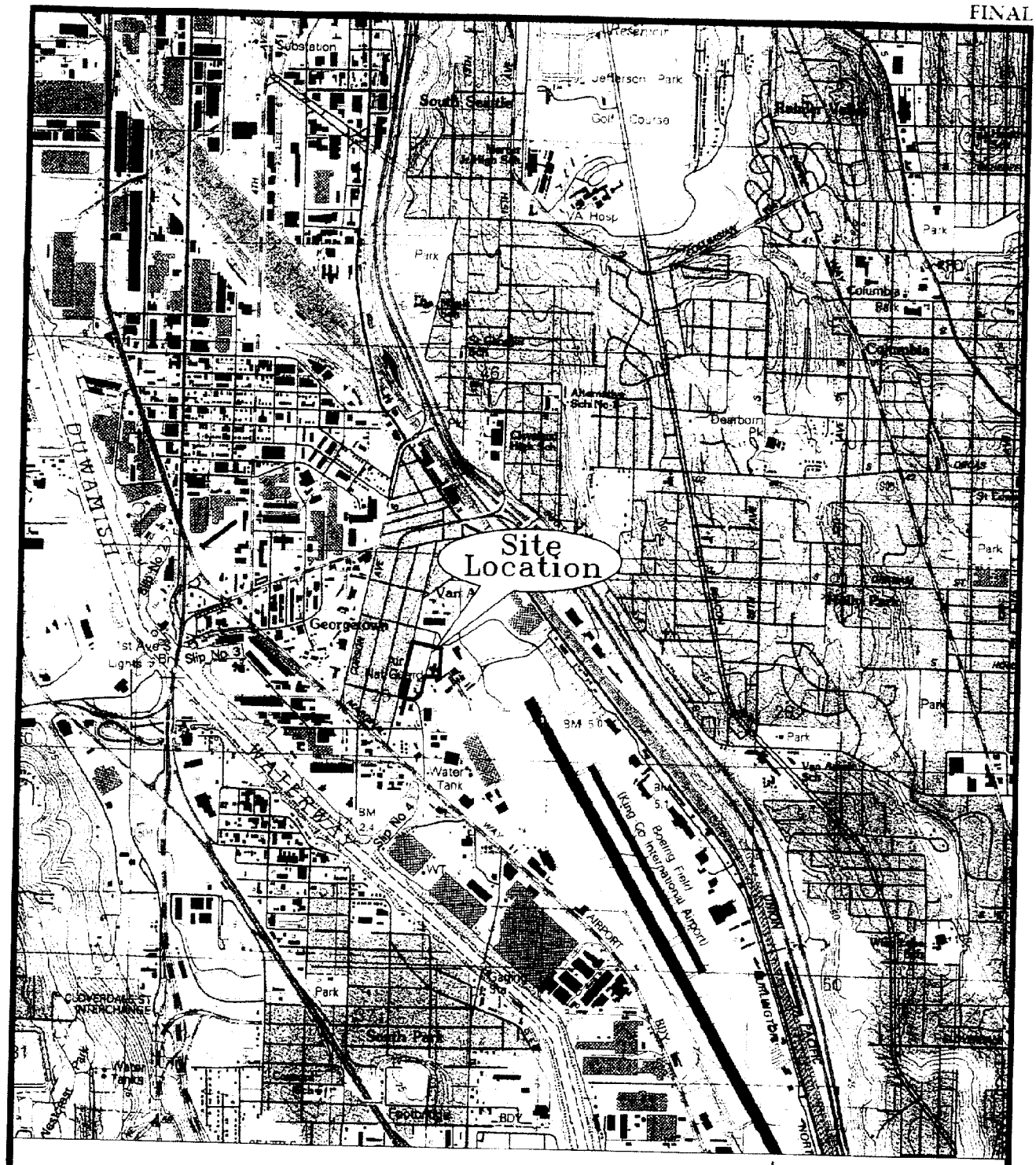

From USGS 7.5 Minute Topographic Map Series. Seattle South, Washington

FIGURE 1-1

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LOCATION MAP OF SEATTLE AIR NATIONAL GUARD STATION SEATTLE, WASHINGTON

143rd CCSQ, Seattle ANGS
Seattle, Washington

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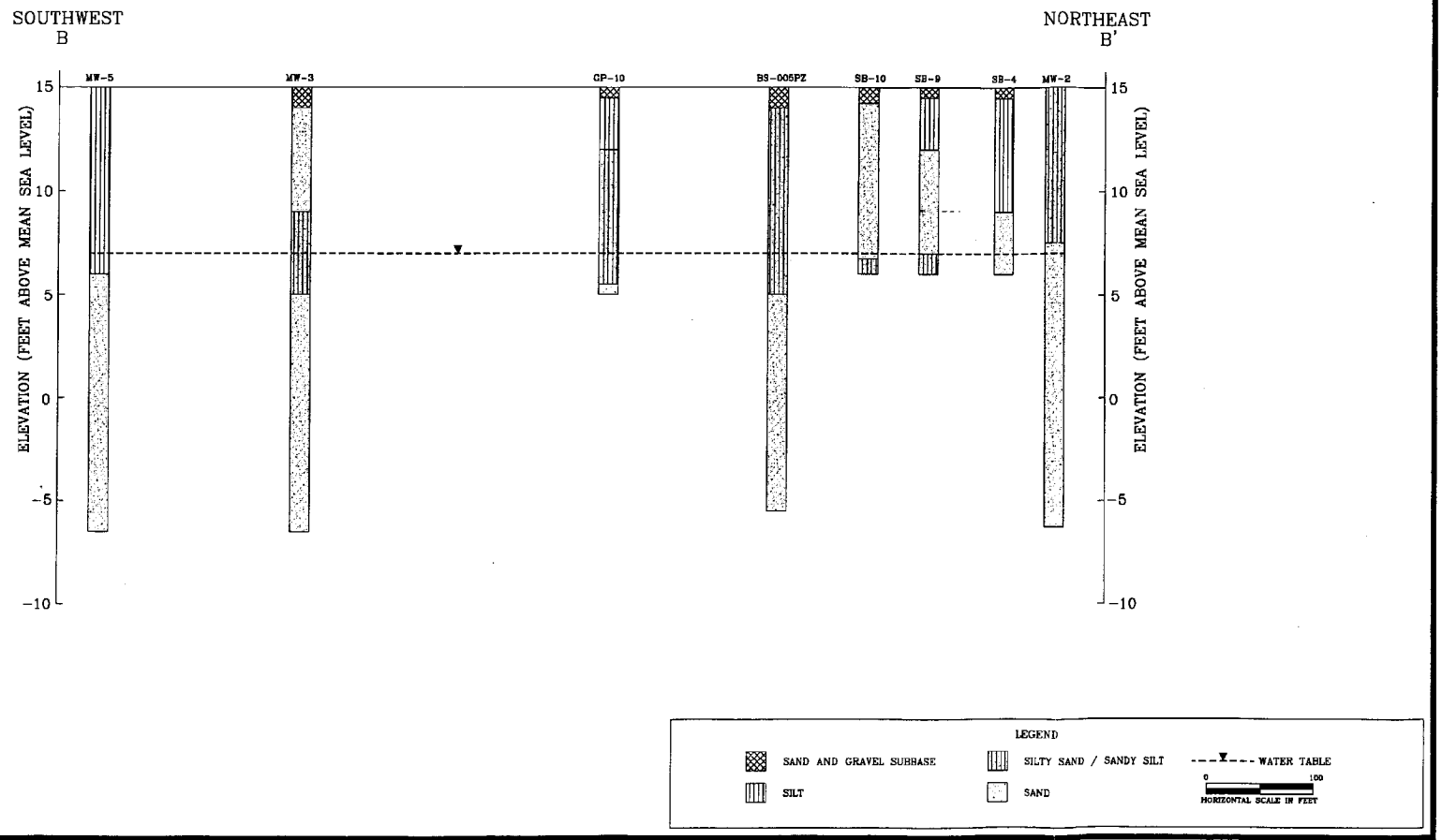

FIGURE A-3

GEOLOGIC CROSS-SECTION B-B'

143rd CCSQ, Seattle ANGS
Seattle, Washington

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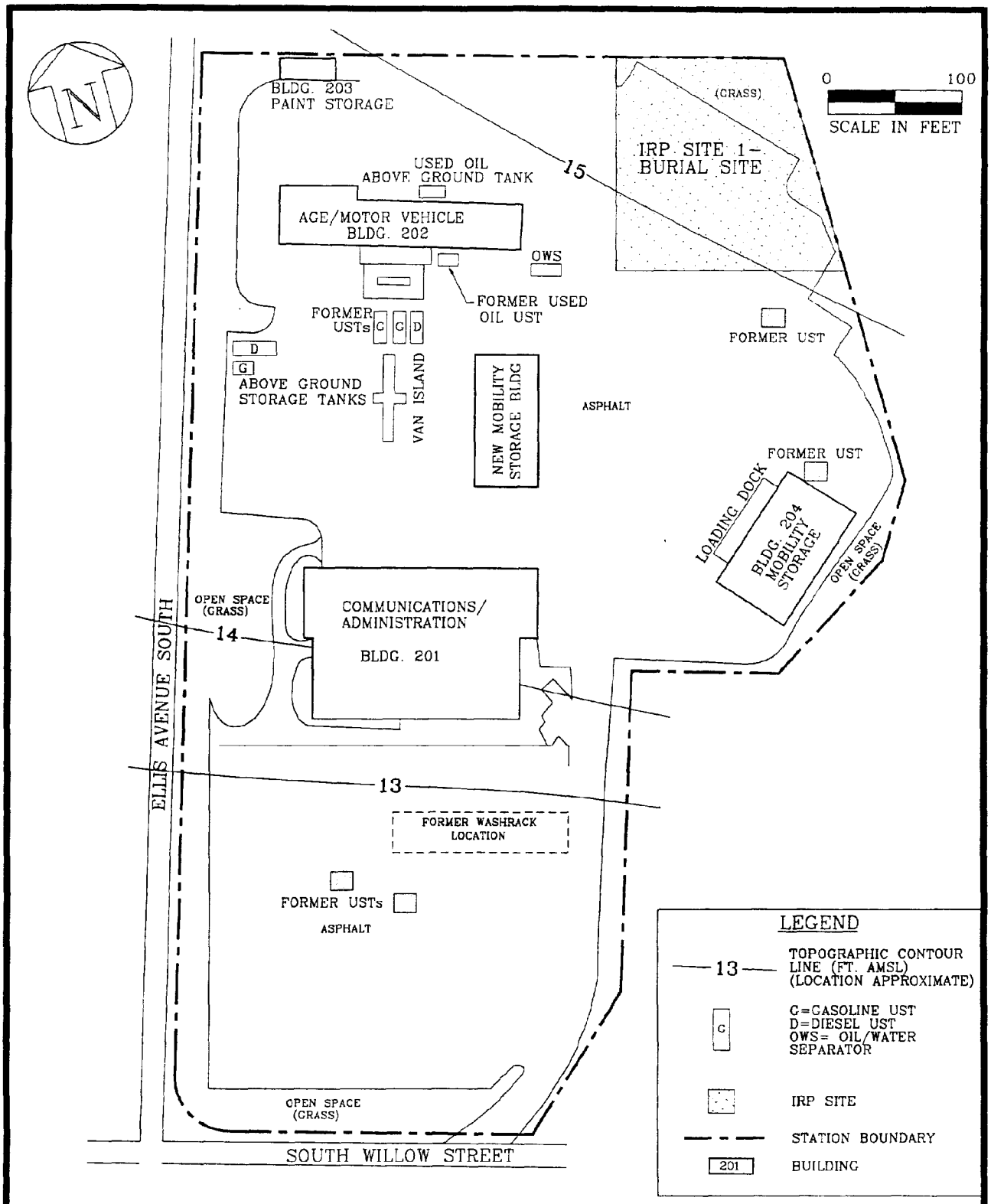

FIGURE 1-2

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SITE MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

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The following text presents selected site information from the Phase II RI Report (ERM 1999). A more detailed description of each topic is found in the RI Report.

1.2.1.1 Land Use

The Seattle ANGS is zoned for industrial use. Properties to the north, east, and south also are zoned for industrial use and have historically been used for industrial purposes. Property to the west of the site (across Ellis Avenue South) is residential.

1.2.1.2 Topography

The Seattle ANGS is located in King County in the Puget Sound Lowlands physiographic province. The Station is on flat, level terrain with a surface elevation of approximately 14 feet above mean sea level.

1.2.1.3 Climate

The climate in the Seattle area is characterized by mild summers and cool winters, with long spring and fall seasons. The average daily temperature ranges from 37 to 47 degrees Fahrenheit (°F) in the winter and from 55 to 72 °F in the summer.

The average annual precipitation is 38.84 inches, including 7.4 inches of snow. The greatest percentage of rainfall occurs from November to January. Free water surface evaporation in the Seattle area is approximately 25 inches per year, resulting in a net precipitation of 13.84 inches per year.

Prevailing wind is from the southwest, and the highest average wind speed of 9.8 miles per hour occurs in March.

1.2.1.4 Sensitive Receptors

There are no City of Seattle Water Department municipal wells within 4 miles of the Seattle ANGS and no private drinking water wells within 1 mile of the Station. The surrounding population obtains drinking water from municipal sources.

There are no critical habitats or endangered or threatened species identified within 4 miles of the Seattle ANGS.

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1.2.1.5 Site Geology

The near-surface geology at the Seattle ANGS is predominantly composed of two units. The first unit is a silty sand fill material present to a depth of approximately 8 feet below ground surface (bgs). The fill material is consistent with the descriptions of the material used to raise the Duwamish Valley for development in the 1910s. The second unit consists primarily of well-sorted, fine-grained sand (river alluvium) and is present from approximately 8 feet bgs to 21.5 feet bgs, the maximum depth explored during the RI. Details regarding site geology are provided in the Phase II RI Report. Geologic cross-sections of the Station are provided in Appendix A.

1.2.1.6 Local Hydrogeology

Groundwater exists in an unconfined aquifer at a depth of 6 to 10 feet bgs, within the upper part of the recent river alluvium and the lower portion of the silty sand fill unit. The inferred groundwater flow direction is south toward the Duwamish Waterway, at an approximate gradient of 0.002 feet per foot. The depth to groundwater is influenced by seasonal precipitation; this influence is illustrated by a 2-foot increase in groundwater elevations between October 1996 and January 1997 (Appendix B).

Slug tests conducted at monitoring well MW-3 generated hydraulic conductivity estimates of 1.25×10^{-4} to 6.09×10^{-4} feet per second, which are consistent with the predominant sand lithology observed in the shallow aquifer. Monitoring well construction data, groundwater elevation data, and representative potentiometric surface maps are provided in Appendix B. A detailed hydrogeologic description is provided in the Phase II RI Report.

1.2.2 Site History

The Seattle ANGS was constructed during World War II by the War Department and used by the Army and Air Force as an "Aircraft Factory School." In 1948, the property was given to King County as surplus property and was subsequently leased to the Washington ANG. The initial property was 17 acres and included 15 buildings, all of which were subsequently demolished. The squadron stationed at the Seattle ANGS went through several name changes and duty assignments. In 1988, the Seattle ANGS squadron acquired its current name, the 143rd Combat

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Communications Squadron (CCSQ). The 143rd CCSQ provides mobile communication equipment and support for airports and airfields.

The Seattle ANGS currently houses five buildings (Figure 1-2): the Paint Storage Building (Building 203), the Aerospace Ground Equipment (AGE)/Motor Vehicle Building (Building 202), the Mobility Storage Building (Building 204), the Communications/Administration Building (Building 201), and the New Mobility Storage Building. Other site features include miscellaneous aboveground storage tanks, a van island, and an oil/water separator. The Station used to have a washrack and several underground storage tanks (USTs); the washrack and USTs are no longer present at the site.

Solid wastes generated from the 1950s through 1968 at the AGE/Motor Vehicle Maintenance Building, Power Production Building, and Communication/Administration Building were reportedly burned and/or buried at the IRP site or disposed of off-site. Wastes generated during this time period included radio tubes, solvents, waste motor oils, kerosene, batteries, brake fluid, spray paints, paint thinners/removers, methyl ethyl ketone, xylene, and naphtha.

Presently, hazardous wastes are collected and disposed of by a licensed contractor or through the Defense Reutilization and Marketing Office at Fort Lewis, Washington.

1.2.3 Previous Investigations

Three IRP investigations have been conducted at the Seattle ANGS:

- A Preliminary Assessment (PA) was conducted by the ANG in December 1993.
- A Preliminary Assessment/Site Inspection (PA/SI) was conducted by Operational Technologies Corporation in 1994.
- A two-part RI was conducted by Environmental Resources Management between 1996 and 1999.

The PA focused on the identification and evaluation of historic and current use, handling, and disposal practices of hazardous materials and hazardous waste at the Seattle ANGS. Based on the results of the PA, one area of concern (subsequently designated IRP Site 1 - Burial Site) was

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identified as being potentially contaminated with hazardous materials and/or waste, thus warranting further IRP investigation.

The focus of the PA/SI was to identify IRP sites and to confirm the presence or absence of soil and groundwater contamination associated with past hazardous material and hazardous waste handling and disposal practices. Field activities for the PA/SI included screening and confirmation activities. The screening activities included a soil vapor survey, a ground-penetrating radar survey, and a magnetometer survey at the IRP site. Confirmation activities included the collection of soil samples from three soil borings and one monitoring well boring, and the installation and sampling of three groundwater monitoring wells. Constituents detected at concentrations above MTCA Cleanup Levels and/or site-specific background concentrations during the PA/SI include total petroleum hydrocarbons (TPH) in soil, gross alpha and gross beta radiation in soil and groundwater, and metals in groundwater.

The focus of the RI was to determine the nature and extent of contamination associated with the IRP site. The RI was conducted in two phases. Field activities for the Phase I RI included screening and confirmation activities. The screening activities included organic vapor screening and TPH screening of soil samples. Confirmation activities included the collection and analysis of 22 direct-push groundwater samples, 10 surface soil samples, 2 storm sewer catch basin samples, and subsurface soil samples from 11 soil borings. Additional Phase I RI activities included the installation of five groundwater monitoring wells, quarterly sampling of the RI and PA/SI monitoring wells for 1 year, and aquifer slug testing to estimate hydraulic conductivity.

Field activities for the Phase II RI included soil vapor sampling at 40 locations across the site, direct-push soil and groundwater sampling at 20 locations, installation of five groundwater monitoring wells, and quarterly groundwater monitoring for 1 year. Sampling location maps and a summary of the samples collected and analyses conducted during the RI are provided in Appendix C. Complete analytical testing results and interpretation of the RI data are presented in the Phase I and II RI Reports (ERM 1998a; ERM 1999).

Numeric project screening goals (PSGs) were developed during the RI for use in identifying COCs in soil and groundwater. The PSGs were derived from State and Federal applicable or relevant and appropriate requirements (ARARs). PSGs for each constituent detected during the RI are listed in Appendix D, along with tables that summarize the screening

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process used to identify COCs. TCE in groundwater is the only COC identified at the Seattle ANGS that is considered to pose a potential threat to human health or the environment.

1.2.4 Nature and Extent of Contamination

TCE has been detected in groundwater samples collected in the southern portion of the Station. The samples were collected from both direct-push (i.e., Geoprobe/StrataProbe) borings and groundwater monitoring wells installed during the RI. The RI results for TCE in groundwater are summarized in Appendix C and depicted on Figure 1-3. TCE was detected in direct-push samples GP-2, GP-4, GP-5, GP-36, GP-37, and GP-38, at concentrations ranging from 1.0 to 25 micrograms per liter (µg/L). TCE also has been detected in groundwater samples collected from monitoring wells MW-4, MW-5, MW-6, MW-7, and MW-8, at concentrations ranging from 2.0 to 83 µg/L.

The direct-push groundwater sample results are considered screening-level data. The groundwater samples collected from monitoring wells, on the other hand, provide definitive data for groundwater characterization. The groundwater sample collected from monitoring well MW-8 in February 1999 (83 µg/L), and the samples collected from wells MW-6 and MW-8 in May 1999 (5.7 and 19 µg/L, respectively), exceeded the MTCA Method A Cleanup Level for TCE of 5 µg/L.

An on-site source area for the TCE detected in groundwater has not been identified at the Station. Out of 27 soil samples analyzed for VOCs during the RI, only one was found to contain TCE. The TCE concentration reported in this sample (0.17 milligrams per kilogram) was below the MTCA Method A Cleanup Level of 0.5 milligrams per kilogram. Furthermore, this soil sample was collected at the depth of the water table in the boring for monitoring well MW-3, and thus may have contained TCE-impacted groundwater that biased the analytical results. Chlorinated VOCs were not detected in any of the other RI soil samples. As discussed in the Phase II RI Report (ERM 1999), it appears that the TCE detected in groundwater at the Seattle ANGS may be related to groundwater contamination at the Boeing facility immediately south of the Station.

1.2.5 Contaminant Fate and Transport

The fate and transport of TCE, as discussed in the Phase II RI Report, is summarized as follows. The primary route of migration for TCE at the

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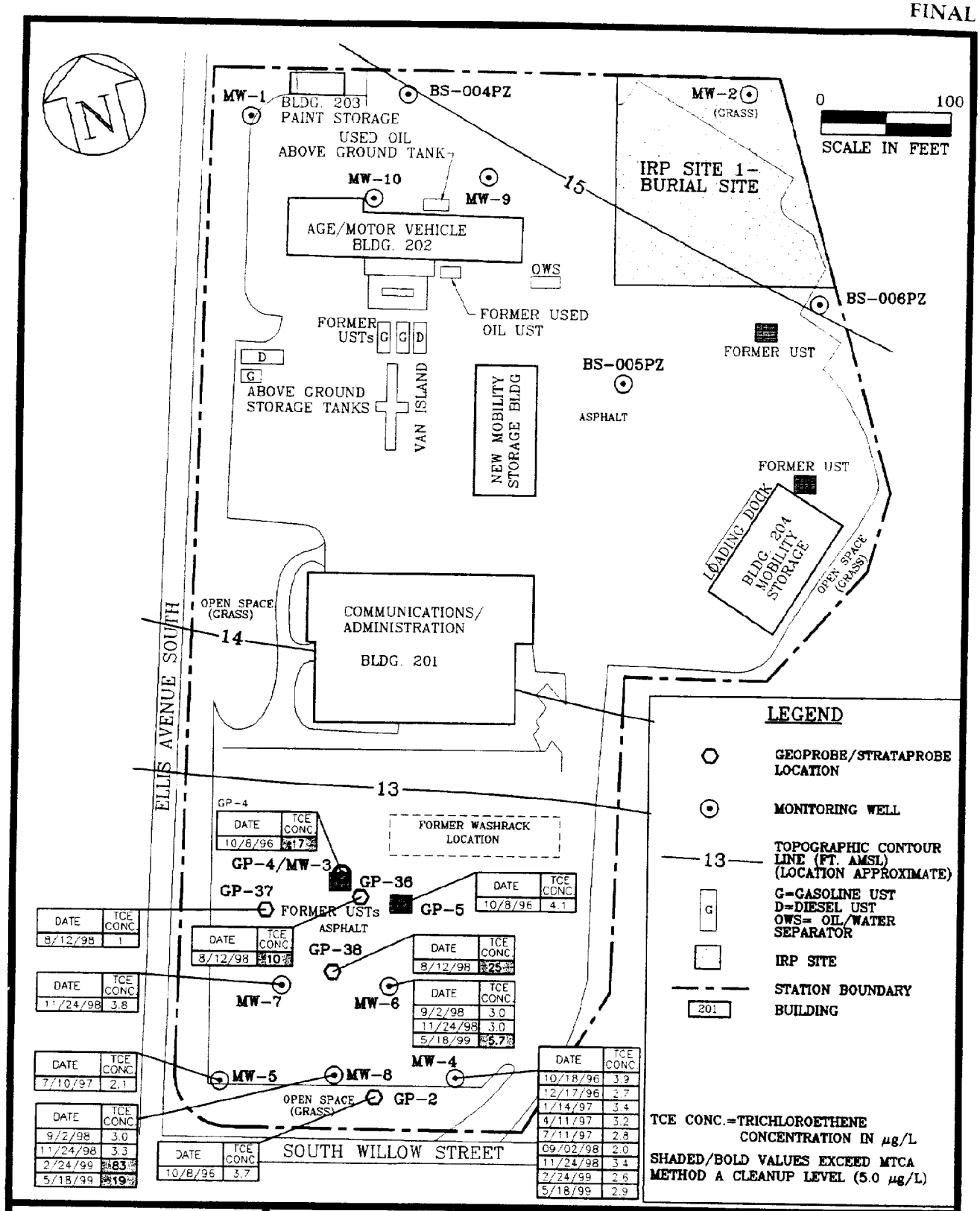

FIGURE 1-3

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TRICHLOROETHENE
IN GROUNDWATER

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

Seattle ANGS is assumed to be transport in groundwater. In general, fate and transport of TCE in groundwater is controlled by its affinity for organic carbon constituents in soil, rates of biodegradation and biokinetic decay, and the solubility-based diffusive dilution of the compound in the saturated zone. Transport of TCE in groundwater can be impeded by its adsorption to organic material in soil and its tendency to volatilize, and to a lesser degree by natural degradation processes. Degradation of TCE through aerobic, anaerobic, or abiotic processes at the Seattle ANGS is difficult to assess because analytical testing conducted to date has not included the full suite of expected degradation products (e.g., ethene, ethane) or the relevant indicator chemicals. Although low levels of an intermediate degradation product (cis-1,2-dichloroethene) have been detected in one monitoring well (MW-5), the data are too sparse to draw any conclusions.

1.2.6 Baseline Risk Assessment

A preliminary baseline risk assessment was conducted as part of the RI to evaluate the potential for TCE in groundwater at the Station to cause adverse health effects in exposed individuals via ingestion of TCE-contaminated drinking water. Using the risk evaluation methods described in ERM (1999), the estimated cancer risk associated with the maximum TCE concentration detected in monitoring wells during the RI (83 μg/L) is 2.09×10^{-5}. This value exceeds the WDOE acceptable cancer risk level of 1×10^{-6} for individual hazardous substances.

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SECTION 2.0

IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 Introduction

This section discusses remedial action objectives (RAOs) and general response actions, and identifies potentially applicable technologies for remediation of TCE in groundwater at the Seattle ANGS. The remediation technologies are then screened using criteria of effectiveness, implementability, and cost. Technologies that are retained at the end of this section are carried over to Section 3.0 for the development and screening of remedial alternatives.

The information presented in this section was developed in conjunction with the Phase I RI, before the additional Phase II data were collected supporting the conclusion that the TCE in groundwater is not site-related. The discussion of RAOs, general response actions, and remediation technologies is included in this Phase II FS Report for the sake of completeness. Except for minor text revisions to reflect the Phase II RI results, the information is presented as it appeared in the Phase I FS Report. The need for further remedial action to address TCE in groundwater at the Station is addressed in Section 4.0.

2.2 Remedial Action Objectives

Section 1.0 summarized the nature and extent of TCE contamination in groundwater at the Seattle ANGS. The RI results suggest that, due to the presence of dissolved TCE at concentrations above the MTCA Method A Cleanup Level, groundwater at the Station could pose an unacceptable risk to human health under the reasonable maximum exposure scenario assumptions of MTCA (i.e., site groundwater used as drinking water). To mitigate these potential health risks and ensure protection of groundwater resources, site-specific RAOs have been developed. These RAOs serve as the performance objectives for groundwater remediation at the Station.

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RAOs are developed from risk-based State and Federal numeric ARARs. RAOs for cleanup actions at the Seattle ANGS are as follows:

- Prevent or eliminate off-site migration of TCE at concentrations exceeding the MTCA Method A Cleanup Level of 5 µg/L; and
- Prevent the ingestion of groundwater exceeding the MTCA Method A Cleanup Level of 5 µg/L.

2.3 General Response Actions

The general response actions developed for remediation of groundwater at the Seattle ANGS are listed on Table 2-1 and include:

- No Action;
- Limited Actions;
- Containment Actions;
- Groundwater Extraction Actions; and
- Ex-Situ or In-Situ Groundwater Treatment Actions.

In addition, Table 2-1 lists possible discharge actions for extracted groundwater. Consideration of the "no action" response is a required component of the FS process as it provides a baseline for comparison. Limited actions include measures taken to limit human exposure to contamination other than remediation. Containment, groundwater extraction, and groundwater treatment actions include measures intended to reduce the toxicity, mobility, mass, and/or volume of TCE-impacted groundwater.

For the purpose of the Phase I FS, the groundwater volume to which response actions may be applied was assumed to be 230,000 gallons. This estimate was derived from the Phase I RI site-characterization data.

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TABLE 2-1

Response Actions and Technology Screening for Trichloroethene in Groundwater
143rd CCSQ, Seattle ANGS, Seattle, Washington

Response Action	Remediation Technology Type	Process Option	Description	Retain?	Reasons	Comments
No Action	No Action	None	No institutional controls or treatment.	Yes	Required	Baseline for comparison.
Limited Actions	Institutional Controls	Property/Water-Use Restrictions or Notifications	Limits future property and/or groundwater use through legal means (e.g., deed restrictions).	Yes	1, 2, 3	Conservative approach - may be unnecessary since site anticipated to be an industrial facility for the long term.
		Fencing	Fencing or other means of limiting site access.	No	B	Perimeter fence already in place; additional fencing unnecessary. Also, limited effectiveness/utility for groundwater contamination.
		Signs	Signs or other means of warning potential trespassers or site users of potential dangers.	No	B	Limited effectiveness/utility for groundwater contamination.
		Groundwater Monitoring	Includes regular monitoring of groundwater to evaluate effectiveness in protecting the environment.	Yes	1, 3	Easy to implement.
	Natural Attenuation	Natural Attenuation Monitoring	Includes monitoring for natural attenuation parameters to evaluate processes such as biodegradation, abiotic transformation, sorption, and dilution that may lead to reductions in groundwater VOC concentrations.	Yes	1, 3	The presence of TCE degradation products in Phase I RI groundwater samples suggests that this is a viable process option for the site.
Containment Actions	Capping	Asphalt/Concrete	Cover source area(s) with asphalt or concrete to limit infiltration of precipitation and contaminant leaching in the vadose zone.	No	See Comments	Site already paved with asphalt; additional capping unnecessary.
	Physical Barrier	Slurry Wall	Placement of a relatively impermeable vertical barrier to restrict groundwater flow and contaminant migration in the downgradient direction.	No	C	Costly and not expected to reduce the mass, volume, or toxicity of TCE.
Groundwater Extraction Actions	Pumping	Extraction Wells	Use of groundwater extraction wells to pump groundwater out of the aquifer for subsequent disposal with or without treatment.	Yes	1, 2, 3	Groundwater extraction can also create a hydraulic barrier to limit migration of contaminants
		Extraction Trench	Use of groundwater extraction trenches to pump groundwater out of the aquifer for subsequent disposal with or without treatment.	No	C	The use of trenches for groundwater extraction is not warranted at this site given the relatively low pumping volumes required.

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TABLE 2-1 (continued...)

Response Actions and Technology Screening for Trichloroethene in Groundwater
143rd CCSQ, Seattle ANGS, Seattle, Washington

Response Action	Remediation Technology Type	Process Option	Description	Retain?	Reasons	Comments
Ex-Situ Groundwater Treatment Actions	Physical	Air Stripping	Water flowing countercurrent to air flow results in the transfer of VOCs from the aqueous phase to the air phase.	No	C	Air stripping expected to be more costly than granular activated carbon.
	Chemical and Physical	Carbon Adsorption	Water is passed through vessels containing granular activated carbon (GAC). Organic compounds with an affinity for carbon are transferred from the aqueous phase to the solid phase by sorption to the GAC.	Yes	1, 2	GAC removal of TCE is a proven technology. This technology is expected to be the most cost effective for the low concentration/low flow conditions anticipated.
	Chemical	Ultraviolet (UV)/Oxidation	UV light and/or oxidizing chemicals (e.g. hydrogen peroxide) can be used to destroy organic constituents.	No	C	UV/oxidation expected to be more costly than GAC.
	Biological	Contact Beds	Water is passed through a reactor vessel that contains a fixed bacterial film. Contaminants are destroyed by the bacteria as the water passes through the reactor vessel.	No	A, C	The retention time for TCE destruction is expected to be on the order of hours.
In-Situ Groundwater Treatment Actions	Physical	Air Sparging/Soil Vapor Extraction	Injection of air to volatilize and/or enhance biodegradation of VOCs. This technology is usually combined with soil vapor extraction for control of injected air and removal of volatiles.	Yes	1, 2	Results in permanent mass reduction of VOCs.
	Biological	Co-Metabolic Bioremediation	Injection of air and methane to enhance methanogenic degradation. TCE is degraded by enzymes produced for oxidation of the methane.	Yes	1, 2	Results in permanent mass reduction of VOCs.
	Chemical	Passive Treatment Wall	A permeable reaction wall is installed across the flow path of a contaminant plume. For TCE, the wall can be filled with iron filings which results in the oxidation of TCE. May also be installed in a "funnel and gate" layout.	No	C	More costly than air sparging or co-metabolic bioremediation.
Discharge Actions	On-Site Discharge	Subsurface Injection/Infiltration	Discharge of treated groundwater back into the subsurface through injection wells or infiltration galleries.	Yes	1, 2, 3	Re-injection of treated groundwater preserves the resource. Can be used to enhance hydraulic containment and/or vadose-zone soil flushing.
	Off-Site Discharge	Publicly-Owned Treatment Works (POTW)	Discharge of treated or untreated extracted groundwater to the sanitary sewer for conveyance to the local POTW.	Yes	1, 2, 3	Expected to be the most cost-effective option if discharge meets POTW requirements.

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TABLE 2-1 (continued)

Response Actions and Technology Screening for Trichloroethene in Groundwater
143rd CCSQ, Seattle ANGS, Seattle, Washington

Response Action	Remediation Technology Type	Process Option	Description	Retain?	Reasons	Comments
Discharge Actions (cont'd)	Off-Site Discharge (cont'd)	Storm Drain	Discharge of treated groundwater to the storm drain.	No	A, C	Requires a National Pollutant Discharge Elimination System permit. Not a "regulatory-friendly" option.

Key to reasons for retaining or rejecting a process option:

1. Implementable/Technically Feasible
2. Effective
3. Cost Effective

A. Not Implementable
B. Not Effective
C. Too Costly

GAC = Granular activated carbon
POTW = Publicly-owned treatment works
TCE = Trichloroethene
UV = Ultraviolet
VOC = Volatile organic compound
RI = Remedial Investigation

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2.4 Identification and Screening of Technology Types and Process Options

The general response actions listed in Section 2.3 are subdivided by remediation technology type and process option on Table 2-1. Technologies and/or process options determined to be inappropriate based on criteria of effectiveness, implementability, and cost are eliminated from further consideration. The rationale for retaining or eliminating particular process options is summarized on Table 2-1.

As shown on Table 2-1, a number of different process options are retained for further consideration. Most of the process options are effective and implementable. Some of the options are eliminated because they are more costly or less effective than others. Based on the screening summarized on Table 2-1, the following process options are retained for the development of remedial alternatives:

- Property/water-use restrictions or notifications;
- Groundwater monitoring;
- Natural attenuation monitoring;
- Groundwater extraction from wells;
- Granular activated carbon (GAC) treatment of extracted groundwater;
- Off-site discharge of untreated or treated extracted groundwater to the sanitary sewer;
- On-site discharge of treated extracted groundwater through underground injection wells or infiltration galleries;
- In-situ treatment by air sparging; and
- In-situ treatment by co-metabolic bioremediation.

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SECTION 3.0

DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, the remediation technologies and process options that remain following the initial screening presented in Section 2.0 are combined to form potential remedial alternatives. Like Section 2.0, the information presented in this section was developed in conjunction with the Phase I RI, before the additional Phase II data were collected supporting the conclusion that the TCE in groundwater is not site-related. The discussion of remedial alternatives is included in this Phase II FS Report for the sake of completeness. Except for minor text revisions, the information is presented as it appeared in the Phase I FS Report. The need for further remedial action to address TCE in groundwater at the Seattle ANGS is addressed in Section 4.0.

The remedial alternatives discussed in this section are designed to address TCE-impacted groundwater at the Seattle ANGS and/or the significant pathways of potential TCE migration. The objective of this step of the FS is to develop remedial alternatives that are protective of human health and the environment and encompass a variety of response options, including:

- Control of potential exposure pathways;
- Reduction of the contaminant mass in groundwater;
- Reduction of risk to an acceptable level and prevention of potential off-site migration; or
- Some combination of the above.

In accordance with USEPA guidance (USEPA 1988), potential remedial alternatives are first developed, and then eliminated from further consideration if they:

1. Do not provide sufficient protection of human health and the environment (effectiveness criterion);

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2. Are problematic with respect to technical or administrative feasibility (implementability criterion); or

3. Are significantly higher in cost than other alternatives without a corresponding increase in benefit, protection, or reliability (cost criterion).

Screening of potential alternatives using the above criteria typically results in a smaller, more manageable set of the most appropriate alternatives which normally would be further evaluated by conducting a detailed analysis of the alternatives. The detailed analysis results in the selection of a preferred remedial alternative for site cleanup. However, because only limited continuation of groundwater monitoring at the Seattle ANGS appears to be warranted at this time, none of the potential remedial alternatives presented in this section were eliminated from further consideration, and a detailed analysis of the alternatives was not performed.

3.1 Development of Alternatives

Five potential alternatives for groundwater remediation were developed using the technologies and process options that remained after the initial screening (Table 2-1). These alternatives are based on the current understanding of the TCE distribution in groundwater at the Seattle ANGS. The five remedial alternatives are outlined below and summarized on Table 3-1.

- Alternative GW-1: No Action. This alternative would leave the site in its present condition. No actions would be taken to monitor groundwater, prevent human contact, prevent contaminant migration, or mitigate the contaminants.

- Alternative GW-2: Limited Action/Institutional Controls/Natural Attenuation. This alternative includes continued groundwater monitoring for VOCs and/or restrictions on future use of the property or groundwater (e.g., deed restrictions). It also includes optional natural attenuation monitoring if necessary to obtain a "No Further Action" (NFA) ruling from the WDOE.

- Alternative GW-3: Groundwater Extraction/Disposal. This alternative includes groundwater monitoring, extraction of groundwater, and appropriate disposal of untreated groundwater.

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TABLE 3-1

Summary of Potential Alternatives for Groundwater Remediation
143rd CCSQ, Seattle ANGS, Seattle, Washington

Response Action	Remediation Technology Type	Process Option	Remedial Alternative*				
			GW-1	GW-2	GW-3	GW-4	GW-5
No Action	No Action	None	X				
Limited Actions	Institutional Controls	Property/Water-Use Restrictions or Notifications		X			
		Groundwater Monitoring		X	X	X	X
	Natural Attenuation	Natural Attenuation Monitoring		X (a)	X (a)	X (a)	X (a)
Groundwater Extraction Actions	Pumping	Extraction Wells			X	X	
Ex-Situ Groundwater Treatment Actions	Chemical and Physical	Carbon Adsorption				X	
In-Situ Groundwater Treatment Actions	Physical	Air Sparging/Soil Vapor Extraction					X
	Biological	Co-Metabolic Bioremediation					X
Discharge Actions	On-Site Discharge	Subsurface Injection/Infiltration				X	
	Off-Site Discharge	Publicly Owned Treatment Works			X	X	

*Remedial Alternatives:
- GW-1 = No Action
- GW-2 = Limited Action/Institutional Controls/Natural Attenuation
- GW-3 = Groundwater Extraction/Disposal
- GW-4 = Groundwater Extraction/Ex-Situ Treatment/Disposal
- GW-5 = In-Situ Treatment

(a) = Natural attenuation monitoring is an optional component of Alternatives GW-2 through GW-5.

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- Alternative GW-4: Groundwater Extraction/Ex-Situ Treatment/ Disposal. This alternative includes groundwater monitoring, extraction of groundwater, aboveground treatment, and appropriate disposal of treated groundwater.

- Alternative GW-5: In-Situ Groundwater Treatment. This alternative includes groundwater monitoring and air sparging with soil vapor extraction and/or co-metabolic bioremediation.

3.2 Screening of Alternatives

This section describes the potential remedial alternatives outlined above and evaluates each alternative with respect to criteria of effectiveness, implementability, and cost. The factors considered in assessing each of these criteria include:

Effectiveness

- Protection of human health and the environment
- Compliance with the RAOs
- Reduction in toxicity, mobility, and volume through treatment

Implementability

- Technical feasibility
- Availability of technology and expertise
- Administrative approval

Cost

- Capital costs
- Operation and maintenance costs

Table 3-2 summarizes the screening evaluation of the potential remedial alternatives.

3.2.1 Alternative GW-1: No Action

Description. The No Action alternative assumes that no site modifications or groundwater monitoring would be required to prevent or eliminate human health and environmental risks associated with TCE in groundwater. An NFA ruling would be pursued for the Seattle ANGS.

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TABLE 3-2

Screening Evaluation of Potential Alternatives for Groundwater Remediation
143rd CCSQ, Seattle ANGS, Seattle, Washington

Alternative	Description	Retain ?	Reasons	Comments
GW-1	No Action	Yes	Required	This alternative is carried through the FS process as a baseline for comparison to other remedial alternatives. It is also retained because concentrations of VOCs requiring response actions may not be confirmed during the Phase II RI.
GW-2	Limited Action/Institutional Controls/Natural Attenuation	Yes	1, 2, 3	This alternative is retained due to the incomplete characterization of VOCs in site soil and groundwater. Based on the Phase II RI results, continued groundwater monitoring, natural attenuation monitoring, and/or deed restrictions may be appropriate.
GW-3	Groundwater Extraction/Disposal	Yes	1, 2, 3	Groundwater extraction and POTW disposal without treatment is expected to reduce the mass of TCE and to limit its migration in groundwater. Implementation of this alternative is dependent on POTW discharge requirements for this site.
GW-4	Groundwater Extraction/Ex-Situ Treatment/Disposal	Yes	1, 2	Groundwater extraction, ex-situ treatment, and reinjection or POTW disposal is expected to reduce the mass of TCE and to limit its migration in groundwater. This alternative is retained in the event treatment is necessary to meet POTW discharge limits.
GW-5	In-Situ Groundwater Treatment	Yes	1, 2, 3	In-situ treatment of groundwater is expected to reduce the mass of TCE and to limit its migration in groundwater. Total treatment time is expected to be less than that for groundwater extraction alternatives.

Key to reasons for retaining an alternative:

1. Implementable/Technically Feasible
2. Effective
3. Cost Effective

FS = Feasibility Study
RI = Remedial Investigation
TCE = Trichloroethene
VOC = Volatile organic compound
POTW = Publicly-owned treatment works

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Evaluation. The No Action alternative is a required component of the FS process. Although this alternative is normally not discussed as a preferred alternative, the results of the RI indicate that an NFA ruling may be appropriate at this site. This alternative meets the criteria of effectiveness, implementability, and cost, and is therefore retained for further evaluation.

3.2.2 Alternative GW-2: Limited Action/Institutional Controls/Natural Attenuation

Description. The Limited Action alternative assumes semiannual groundwater monitoring for VOCs at monitoring wells MW-3, MW-4, and MW-5 for 5 years, with natural attenuation monitoring as necessary.

Monitoring would be discontinued after 2 years if the results of four consecutive sampling events indicate TCE concentrations satisfy the RAOs. In addition, property or water-use restrictions may be utilized to prevent the use of groundwater as drinking water. This alternative also assumes that an NFA ruling would be pursued for the Seattle ANGS.

Natural attenuation monitoring would be included as appropriate depending on the data needs for site closure. Monitored parameters would include, at a minimum, baseline measurements for biodegradation indicators (e.g., dissolved oxygen, redox, methane, carbon dioxide, nitrate, ferrous iron, and sulfate). The VOC intermediate- and end-products of TCE degradation would also be monitored, and their concentrations compared to expected levels based on available stoichiometric and kinetic data for TCE degradation. Monitoring would be conducted on a semiannual or annual basis for 1 to 2 years.

Evaluation. In order to obtain an NFA ruling, it may be necessary to monitor groundwater (with or without natural attenuation parameters) for a limited period of time and/or restrict future use of the shallow groundwater at the Seattle ANGS.

Groundwater monitoring is typically required to determine whether contaminant concentrations are increasing, stable, or decreasing with time. A stable or decreasing trend in contaminant concentrations throughout the area of contamination provides evidence that the contaminants are not migrating in groundwater. Natural attenuation monitoring is typically conducted to determine the efficacy and rates of intrinsic remediation at a

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site, and can include collection of hydrogeologic, dispersion, adsorption, biodegradation, and contaminant source data.

This alternative meets the criteria of effectiveness, implementability, and cost, and is therefore retained for further evaluation.

3.2.3 Alternative GW-3: Groundwater Extraction/Disposal

Description. Alternative GW-3 assumes the installation of two 6-inch diameter groundwater extraction wells to approximately 20 feet bgs in the vicinity of the former washrack; groundwater extraction for a minimum of 2 years with system monitoring; quarterly groundwater monitoring for 2 years followed by semiannual monitoring for 2 years; and discharge of untreated groundwater to the local publicly-owned treatment works (POTW).

The extraction system would consist of submersible pumps placed in the two extraction wells, manual throttling valves or other means of throttling flow, high amperage shut-offs with timed restarts for each pump, flow meters/totalizers, and sample ports. The discharge system would consist of underground piping to the nearest sanitary sewer inlet, and a flow meter/totalizer.

System monitoring would include cumulative and instantaneous flow measurements and the collection of extracted groundwater samples for VOC, pH, and solids analyses. Groundwater monitoring would include depth-to-water measurements and the collection of groundwater samples for VOC analysis at monitoring wells MW-3, MW-4, and MW-5.

Natural attenuation monitoring would be included as appropriate depending on the data needs for site closure. Monitored parameters would include, at a minimum, baseline measurements for biodegradation indicators (e.g., dissolved oxygen, redox, methane, carbon dioxide, nitrate, ferrous iron, and sulfate). The VOC intermediate- and end-products of TCE degradation would also be monitored, and their concentrations compared to expected levels based on available stoichiometric and kinetic data for TCE degradation. Monitoring would be conducted on a semiannual or annual basis during remediation activities and for 1 to 2 years following system shutdown, as appropriate.

The local POTW for the Seattle ANGS is operated by Metro. Metro has a maximum discharge limit for total toxic organics of 2.13 milligrams per liter for sewer system discharges associated with metal finishing and

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electroplating sites. Although other types of sites are evaluated on a case-by-case basis, maximum VOC concentrations detected to date at the Seattle ANGS are considerably lower than Metro's total toxic organics limit, and relatively low discharge rates are anticipated. As such, acceptance of this waste stream by Metro is anticipated.

Evaluation. This alternative meets the criteria of effectiveness, implementability, and cost, and is therefore retained for further evaluation.

3.2.4 Alternative GW-4: Groundwater Extraction/Ex-Situ Treatment/Disposal

Description. Alternative GW-4 assumes the installation of two 6-inch diameter groundwater extraction wells installed to approximately 20 feet bgs in the vicinity of the former washrack; groundwater extraction for a minimum of 2 years with system monitoring; quarterly groundwater monitoring for 2 years followed by semiannual monitoring for 2 years; treatment of extracted groundwater with GAC; and discharge of treated groundwater to the local POTW or to an on-site infiltration trench located upgradient of the former washrack.

The extraction system would consist of submersible pumps placed in the two extraction wells, throttling capability, high amperage shut-offs with timed restarts for each pump, flow meters/totalizers, sample ports, and underground conveyance piping to the treatment system. The treatment system would consist of two GAC vessels in series, preceded by an optional settling/batch tank and cartridge filters for solids removal. The discharge system would consist of underground piping to the sanitary sewer inlet or infiltration trench, and a flow meter/totalizer.

System monitoring would include cumulative and instantaneous flow measurements and the collection of GAC inlet, midpoint, and outlet samples for VOC analysis. Groundwater monitoring would include depth-to-water measurements and the collection of groundwater samples for VOC analysis at monitoring wells MW-3, MW-4, and MW-5.

Natural attenuation monitoring would be included as appropriate depending on the data needs for site closure. Monitored parameters would include, at a minimum, baseline measurements for biodegradation indicators (e.g., dissolved oxygen, redox, methane, carbon dioxide, nitrate, ferrous iron, and sulfate). The VOC intermediate- and end-products of TCE degradation would also be monitored, and their concentrations compared to expected levels based on available stoichiometric and kinetic

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data for TCE degradation. Monitoring would be conducted on a semiannual or annual basis during remediation activities and for 1 to 2 years following system shutdown, as appropriate.

Evaluation. This alternative meets the criteria of effectiveness and implementability. Although this alternative is expected to be more costly than Alternative GW-3, it is uncertain whether Metro will grant permission to discharge untreated groundwater directly to the POTW. Consequently, Alternative GW-4 is retained for further evaluation.

3.2.5 Alternative GW-5: In-Situ Groundwater Treatment

Description. Alternative GW-5 assumes the installation of 24 2-inch diameter air sparge wells installed to approximately 20 feet bgs and 8 soil vapor extraction (SVE) wells installed to approximately 5 to 10 feet bgs in the vicinity of the former washrack; the injection of air and/or methane for a minimum of 1 year with system monitoring; and quarterly groundwater monitoring for 2 years followed by semiannual monitoring for 1 year.

The air/methane injection system would consist of a methane source (e.g., compressed gas cylinders), two air compressors or air sparge blowers, an underground piping/header system to distribute air flow to the sparge wells, and pressure regulators and valves for each well. The SVE system would consist of a blower, a header system to distribute flow among the SVE wells, and valves for each well. In addition, an air emissions treatment system may be required. At the low SVE flows and VOC concentrations anticipated, vapor-phase GAC would likely be the most effective treatment technology for air emissions.

System monitoring would include field measurements of air-sparge and SVE system flows and total organic vapor concentrations (SVE system only). In addition, air samples would be collected from the SVE discharge and, if applicable, upstream of the air emissions treatment system. The air samples would be analyzed for VOCs, oxygen, carbon dioxide, and methane. Groundwater monitoring would include depth-to-water measurements and field testing of dissolved oxygen, pH, temperature, specific conductance and redox. Additionally, groundwater samples collected at monitoring wells MW-3, MW-4, and MW-5 would be analyzed for VOCs.

Natural attenuation monitoring would be included as appropriate depending on the data needs for site closure. Monitored parameters

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would include, at a minimum, baseline measurements for biodegradation indicators (e.g., dissolved oxygen, redox, methane, carbon dioxide, nitrate, ferrous iron, and sulfate). The VOC intermediate- and end-products of TCE degradation would also be monitored, and their concentrations compared to expected levels based on available stoichiometric and kinetic data for TCE degradation. Monitoring would be conducted on a semiannual basis during remediation activities and for 1 to 2 years following system shutdown, as appropriate.

Evaluation. This alternative meets the criteria of effectiveness, implementability, and cost, and is therefore retained for further evaluation.

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SECTION 4.0

DETAILED ANALYSIS OF ALTERNATIVES

4.1 Introduction

It was originally intended that the five remedial alternatives developed during the Phase I FS would be analyzed in detail during the Phase II FS in order to select the most appropriate alternative for groundwater remediation at the Seattle ANGS. The detailed analysis was to be presented in this section, and would have utilized the following assessment criteria:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

These assessment criteria are described further in the Phase I FS Report (ERM 1998b).

As discussed in the Phase II RI Report (ERM 1999), an on-site source of the TCE detected in groundwater at the Seattle ANGS has not been identified. The soil and groundwater data suggest that the TCE may originate from an off-site source. Consequently, a detailed analysis of the remedial alternatives was not performed. However, because TCE has been consistently detected in several monitoring wells at the site, limited continuation of groundwater monitoring is warranted.

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4.2 Selection of Preferred Alternative

The TCE detected in groundwater at the Seattle ANGS does not appear to be related to past or present activities at the Station. The RI results suggest that the TCE may be related to groundwater contamination at the Boeing facility immediately south of the Station (ERM 1999). Consequently, detailed analysis of the remedial alternatives is neither warranted nor required in order to select the most appropriate alternative. The preferred alternative is a variation of Alternative GW-2: Limited Action. Under this alternative, quarterly groundwater monitoring would be continued for 1 year (until May or June 2000). Groundwater samples would be collected from the 13 existing monitoring wells and analyzed for VOCs. If the results of the monitoring indicate that VOC concentrations comply with MTCA Method A Cleanup Levels, an NFA letter would be requested from the WDOE.

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SECTION 5.0

RECOMMENDATIONS

Based on the results of the RI and the FS as discussed herein, continued quarterly groundwater monitoring for 1 year (until May or June 2000) is recommended. Groundwater samples should be collected from the 13 existing monitoring wells and analyzed for VOCs. If the results of the monitoring indicate that VOC concentrations comply with MTCA Method A Cleanup Levels, then the remedial action objectives for the site will be satisfied and no further action should be conducted.

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SECTION 6.0

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APPENDIX A

GEOLOGIC CROSS SECTIONS

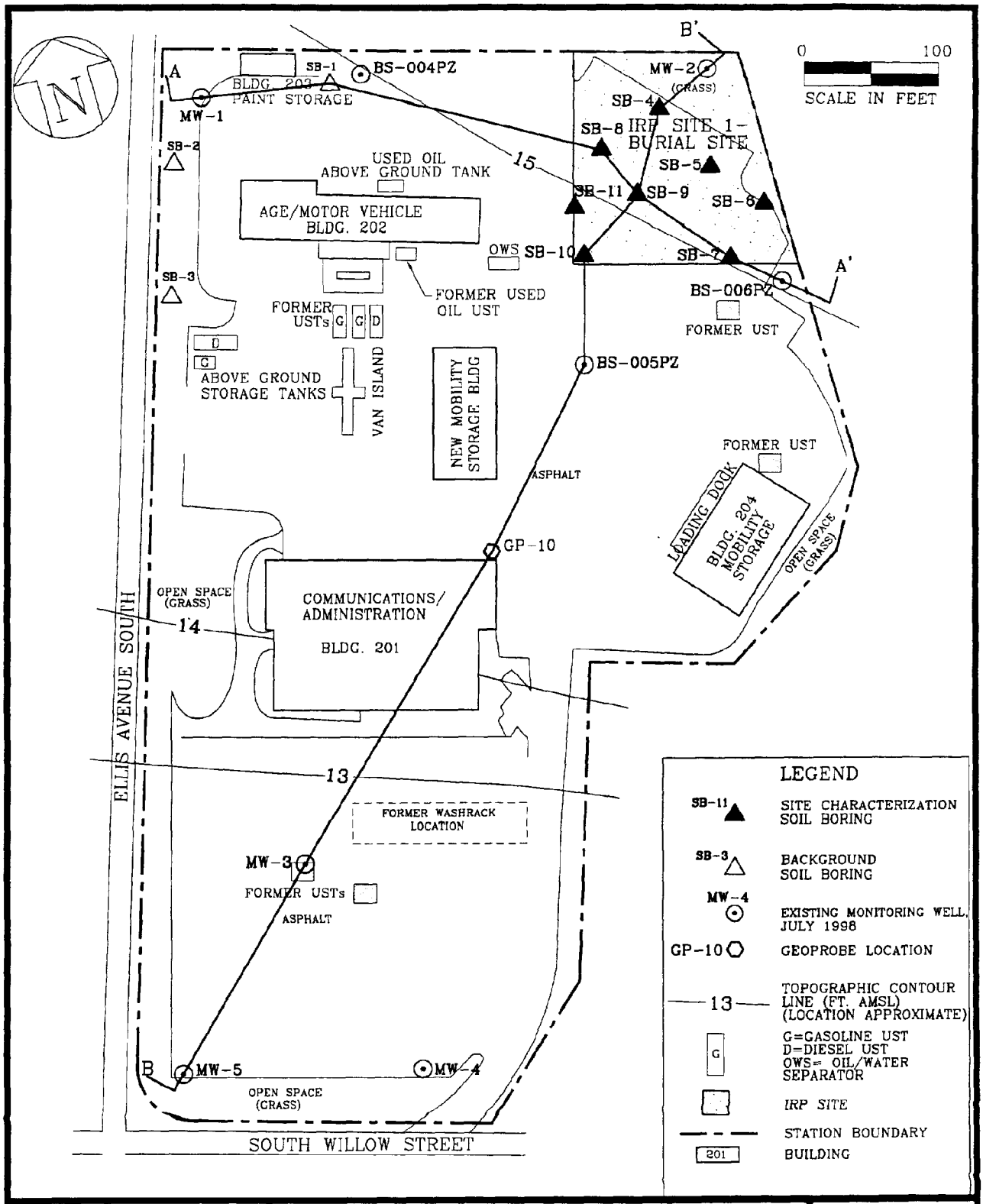

FIGURE A-1

GEOLOGIC CROSS-SECTION
LOCATION MAP

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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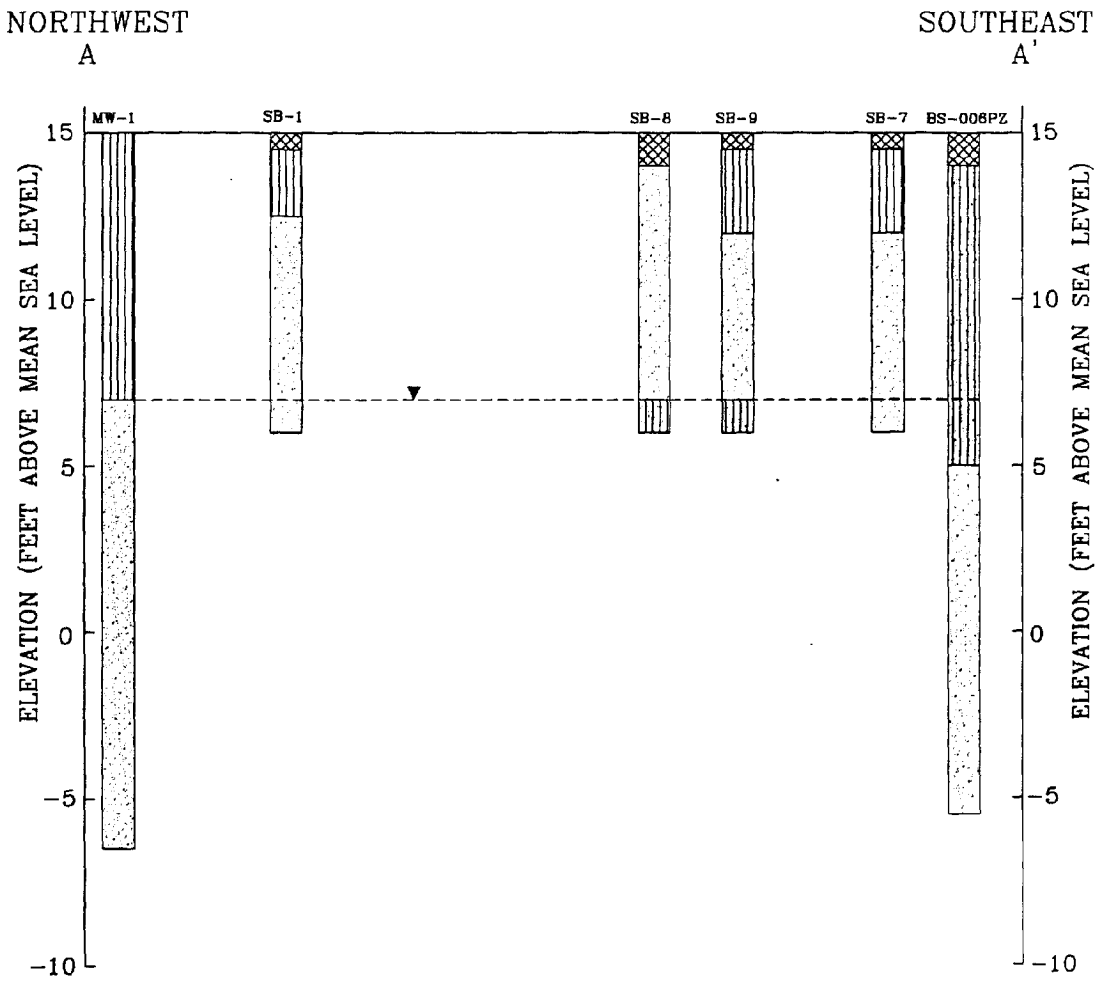

LEGEND

SAND AND GRAVEL SUBBASE

SILT

SILTY SAND / SANDY SILT

SAND

WATER TABLE

0 100

HORIZONTAL SCALE IN FEET

FIGURE A-2

GEOLOGIC CROSS-SECTION A-A'

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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APPENDIX B

HYDROGEOLOGIC DATA

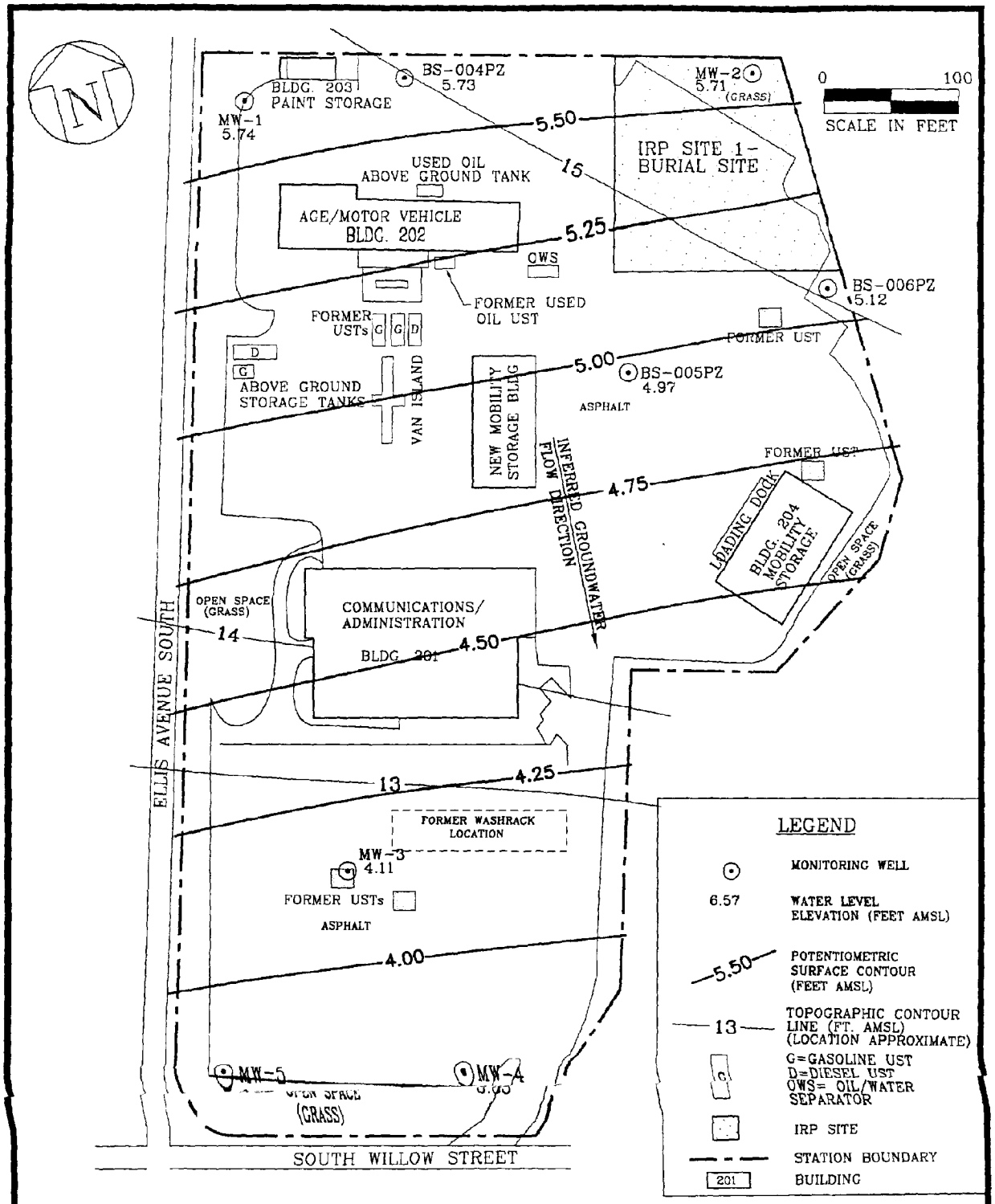

FIGURE B-1

POTENTIOMETRIC SURFACE
22 OCTOBER 1996

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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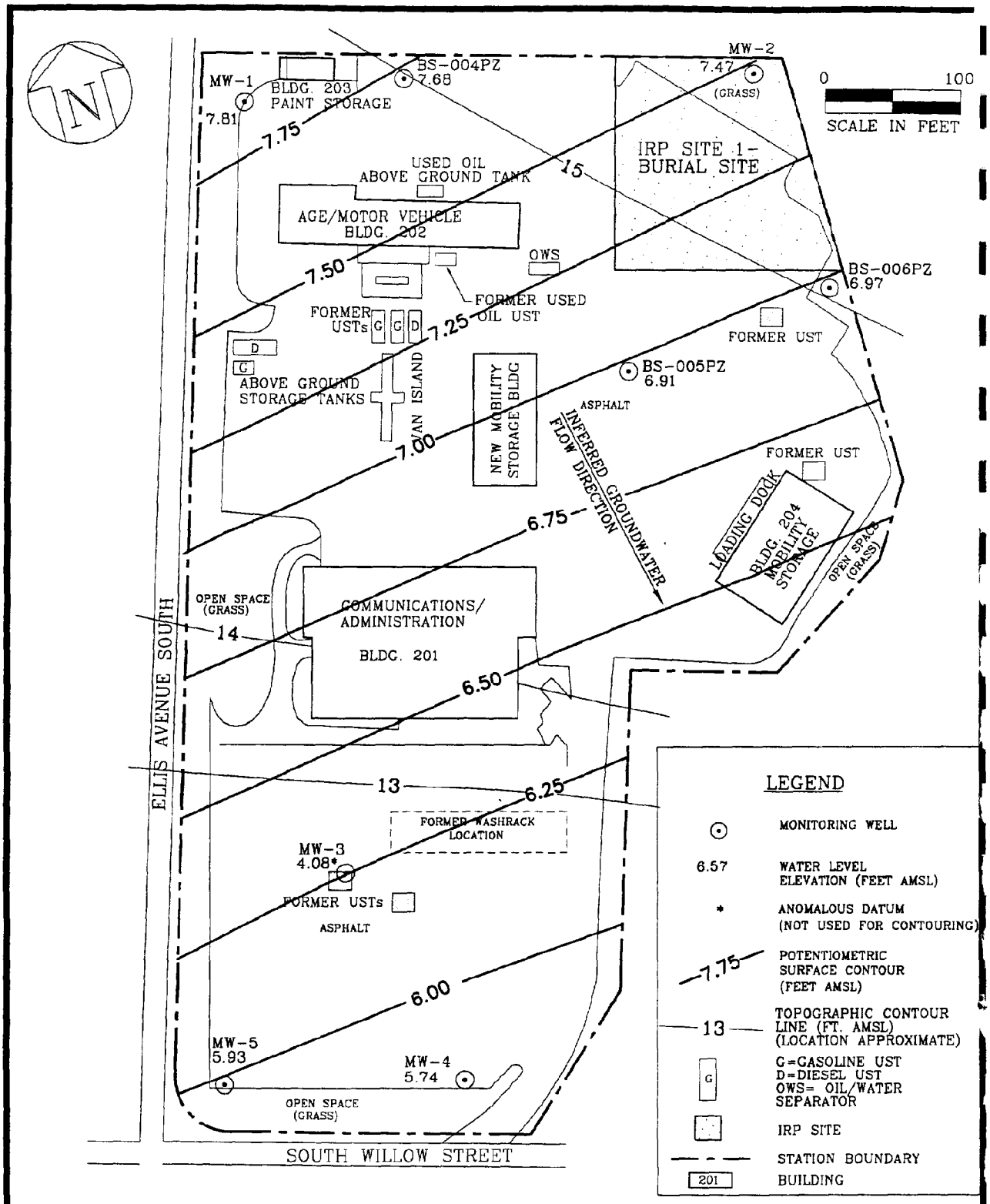

FIGURE B-2

POTENTIOMETRIC SURFACE
14-15 JANUARY 1997

143rd CCSQ, Seattle ANGS
Seattle, Washington

ERM

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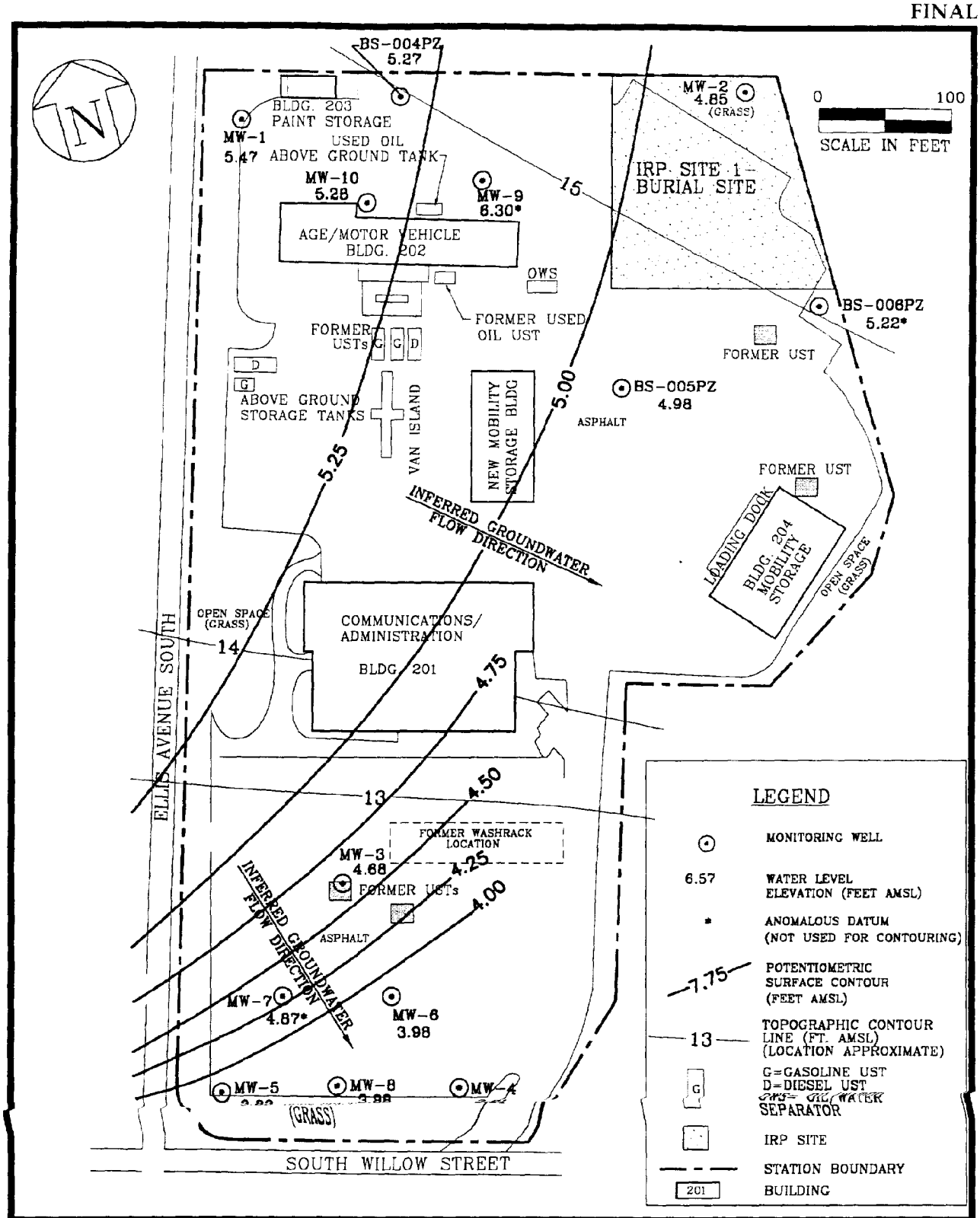

FIGURE B-3

POTENTIOMETRIC SURFACE
24 NOVEMBER 1998

143rd CCS, Seattle ANGS
Seattle, Washington

ERM

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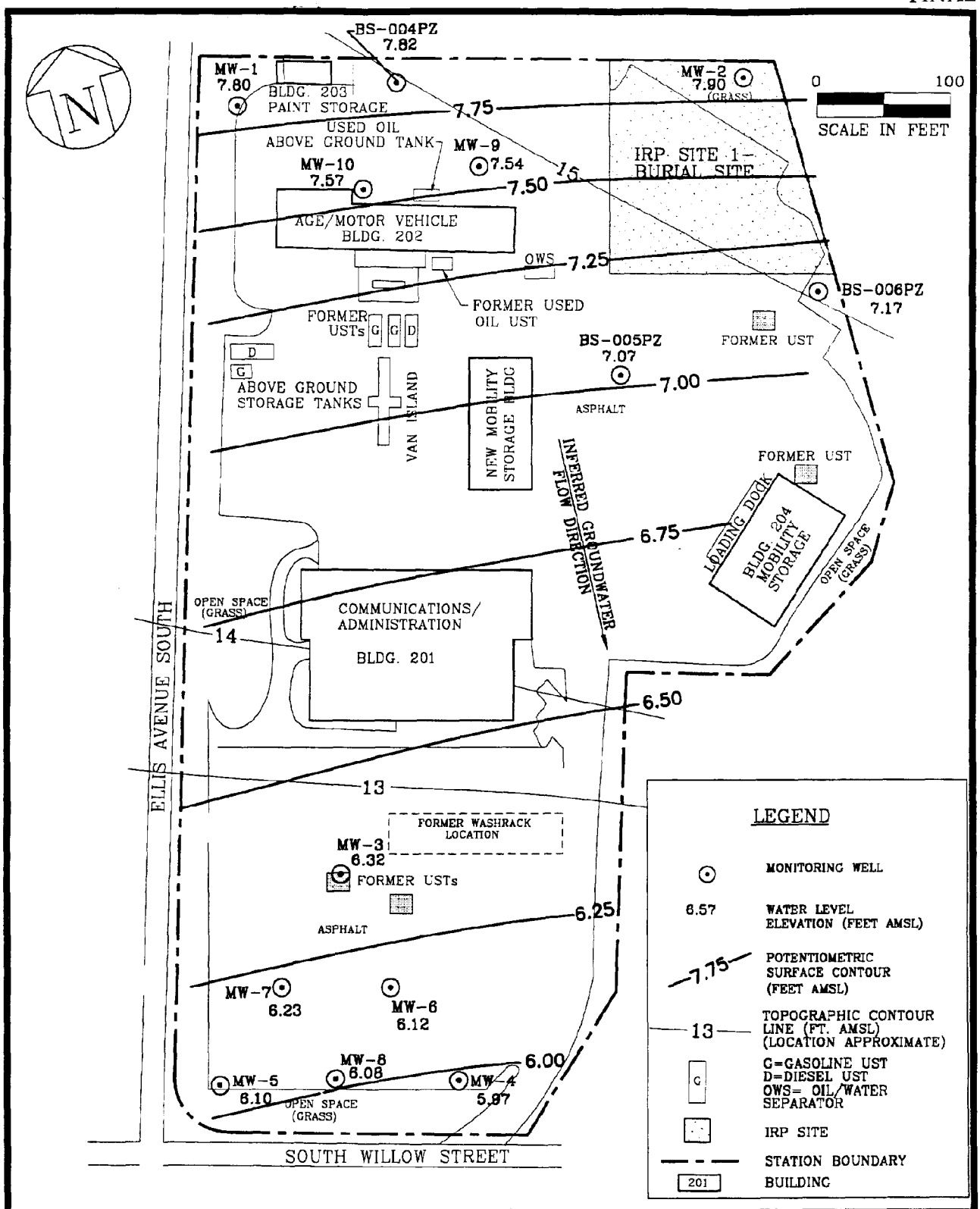

FIGURE B-4

POTENTIOMETRIC SURFACE
24 FEBRUARY 1999

143rd CCS, Seattle ANGS
Seattle, Washington

ERM

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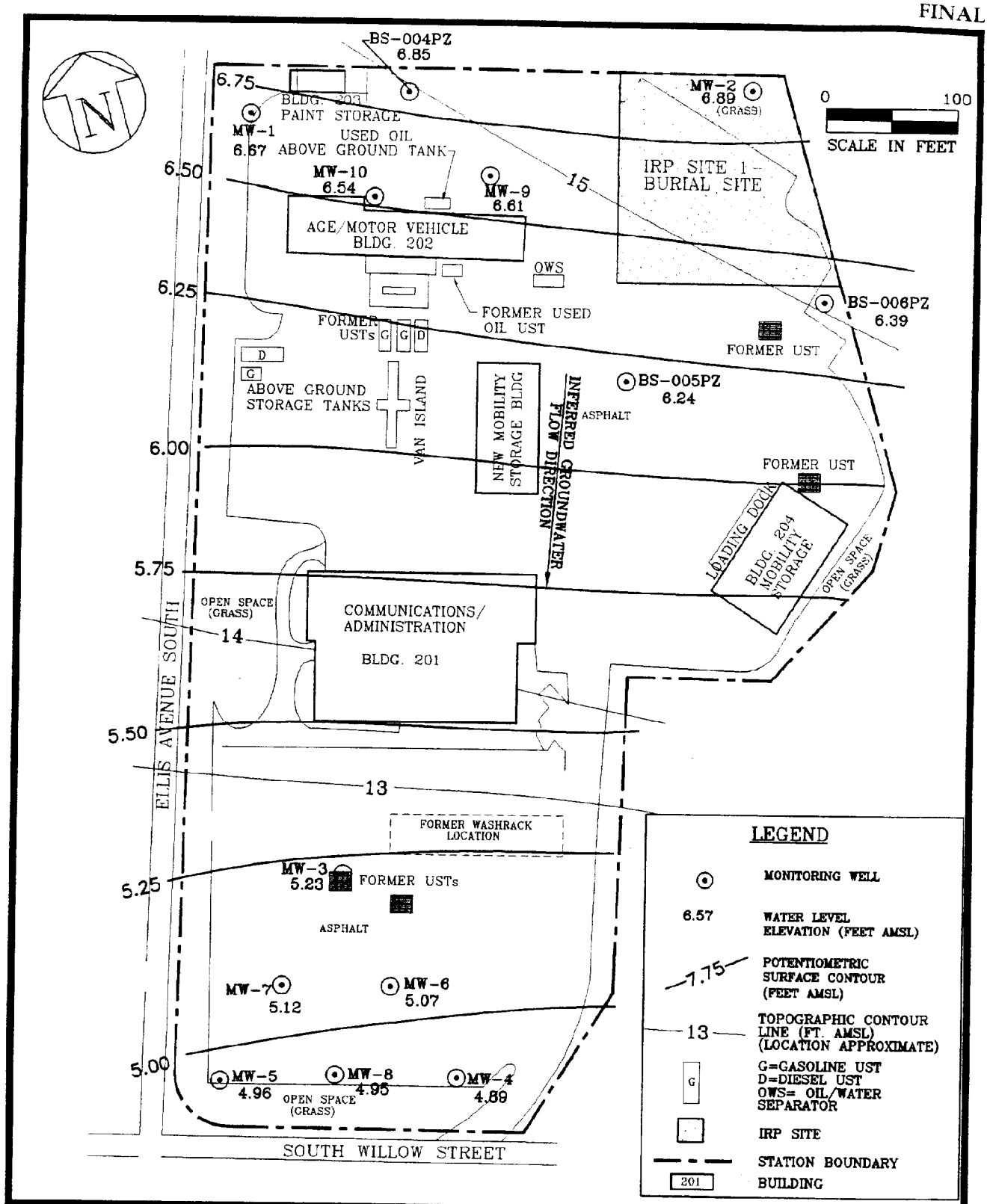

FIGURE B-5

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POTENTIOMETRIC SURFACE
18 MAY 1999

143rd CCS, Seattle ANGS
Seattle, Washington

ERM

TABLE B-1

Monitoring Well Installation Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Location	IRP Investigation	Date Completed	Measuring Point Elevation (ft-amsl)	Total Depth (ft-bgs)	Casing Diameter/ Material	Wellhead Completion	Screen Slot Size (inches)	Annular Seal	Screened Interval (ft-bgs)	Top of Sand Filter Pack (ft-bgs)
BS-004PZ (Background Well)	PA/SI	7/14/94	14.66	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
MW-1 (Background Well)	Phase I RI	10/16/96	14.92	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
BS-005PZ	PA/SI	7/14/94	14.39	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
BS-006PZ	PA/SI	7/14/94	14.59	20.5	2-inch PVC	Flush	0.010	5-feet BC	9.0 - 19.0	7.0
MW-2	Phase I RI	10/16/96	14.60	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-3	Phase I RI	10/17/96	11.88	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-4	Phase I RI	10/17/96	12.05	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-5	Phase I RI	10/17/96	13.94	20.5	2-inch PVC	Flush	0.010	2-feet BC	10.0 - 20.0	7.5
MW-6	Phase II RI	8/27/98	11.62	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-7	Phase II RI	8/27/98	12.17	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-8	Phase II RI	8/27/98	11.90	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-9	Phase II RI	8/27/98	14.30	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0
MW-10	Phase II RI	8/27/98	14.97	20.5	2-inch PVC	Flush	0.010	2-feet BC	5.0 - 20.0	4.0

ft-amsl = Feet above mean sea level
ft-bgs = Feet below ground surface
RI = Remedial Investigation
PA/SI = Preliminary Assessment/Site Inspection
PVC = Polyvinyl chloride
BC = Bentonite chips

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TABLE B-2

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
BS-004PZ (Background Well)	14.66	9/17/96	8.88	5.78
		10/22/96	8.93	5.73
		12/17/96	8.08	6.58
		1/14/97	6.98	7.68
		4/11/97	7.23	7.43
		7/10/97	8.08	6.58
		9/1/98	9.79	4.87
		11/24/98	9.39	5.27
		2/24/99	6.84	7.82
		5/18/99	7.81	6.85
BS-005PZ	14.39	9/17/96	9.16	5.23
		10/22/96	9.42	4.97
		12/17/96	8.51	5.88
		1/15/97	7.48	6.91
		4/10/97	7.65	6.74
		7/11/97	8.47	5.92
		9/1/98	10.12	4.27
		11/24/98	9.41	4.98
		2/24/99	7.32	7.07
		5/18/99	8.15	6.24
BS-006PZ	14.59	9/17/96	9.12	5.47
		10/22/96	9.47	5.12
		12/17/96	8.54	6.05
		1/14/97	7.62	6.97
		4/11/97	7.77	6.82
		7/11/97	8.49	6.10
		9/1/98	10.29	4.30
		11/24/98	9.37	5.22
		2/24/99	7.42	7.17
		5/18/99	8.20	6.39
MW-1 (Background Well)	14.92	10/22/96	9.18	5.74
		12/17/96	8.20	6.72
		1/14/97	7.11	7.81
		4/10/97	7.58	7.34
		7/11/97	8.51	6.41
		9/1/98	10.22	4.70
		11/24/98	9.45	5.47
		2/24/99	7.12	7.80
		5/18/99	8.25	6.67

TABLE B-2

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
MW-2	14.60	10/22/96	8.89	5.71
		12/17/96	8.03	6.57
		1/15/97	7.13	7.47
		4/10/97	7.25	7.35
		7/11/97	7.98	6.62
		9/1/98	9.59	5.01
		11/24/98	9.75	4.85
		2/24/99	6.70	7.90
		5/18/99	7.71	6.89
MW-3	11.88	10/22/96	7.77	4.11
		12/17/96	6.78	5.10
		1/15/97	7.80	4.08
		4/11/97	6.06	5.82
		7/11/97	6.94	4.94
		9/1/98	8.09	3.79
		11/24/98	7.20	4.68
		2/24/99	5.56	6.32
		5/18/99	6.65	5.23
MW-4	12.05	10/22/96	8.20	3.85
		12/17/96	7.21	4.84
		1/14/97	6.31	5.74
		4/11/97	6.65	5.40
		7/11/97	7.43	4.62
		9/1/98	8.21	3.84
		11/24/98	8.14	3.91
		2/24/99	6.08	5.97
		5/18/99	7.16	4.89
MW-5	13.94	10/22/96	10.06	3.88
		12/17/96	9.06	4.88
		1/14/97	8.01	5.93
		4/11/97	8.36	5.58
		7/10/97	9.23	4.71
		9/1/98	10.15	3.79
		11/24/98	10.11	3.83
		2/24/99	7.84	6.10
		5/18/99	8.98	4.96
MW-6	11.62	9/1/98	8.38	3.24
		11/24/98	7.64	3.98
		2/24/99	5.50	6.12
		5/18/99	6.55	5.07

TABLE B-2

Monitoring Well Water Level Summary
143rd CCSQ, Seattle ANGS, Seattle, Washington

Monitoring Well	Measuring Point Elevation (ft amsl)	Date	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
MW-7	12.17	9/1/98	6.75	5.42
		11/24/98	7.30	4.87
		2/24/99	5.94	6.23
		5/18/99	7.05	5.12
MW-8	11.90	9/1/98	8.89	3.01
		11/24/98	8.02	3.88
		2/24/99	5.82	6.08
		5/18/99	6.95	4.95
MW-9	14.30	9/1/98	9.78	4.52
		11/24/98	8.00	6.30
		2/24/99	6.76	7.54
		5/18/99	7.69	6.61
MW-10	14.97	9/1/98	10.42	4.55
		11/24/98	9.69	5.28
		2/24/99	7.40	7.57
		5/18/99	8.43	6.54

ft amsl = Feet above mean sea level
ft bmp = Feet below measuring point

APPENDIX C

REMEDIAL INVESTIGATION SAMPLING LOCATIONS AND ANALYSES

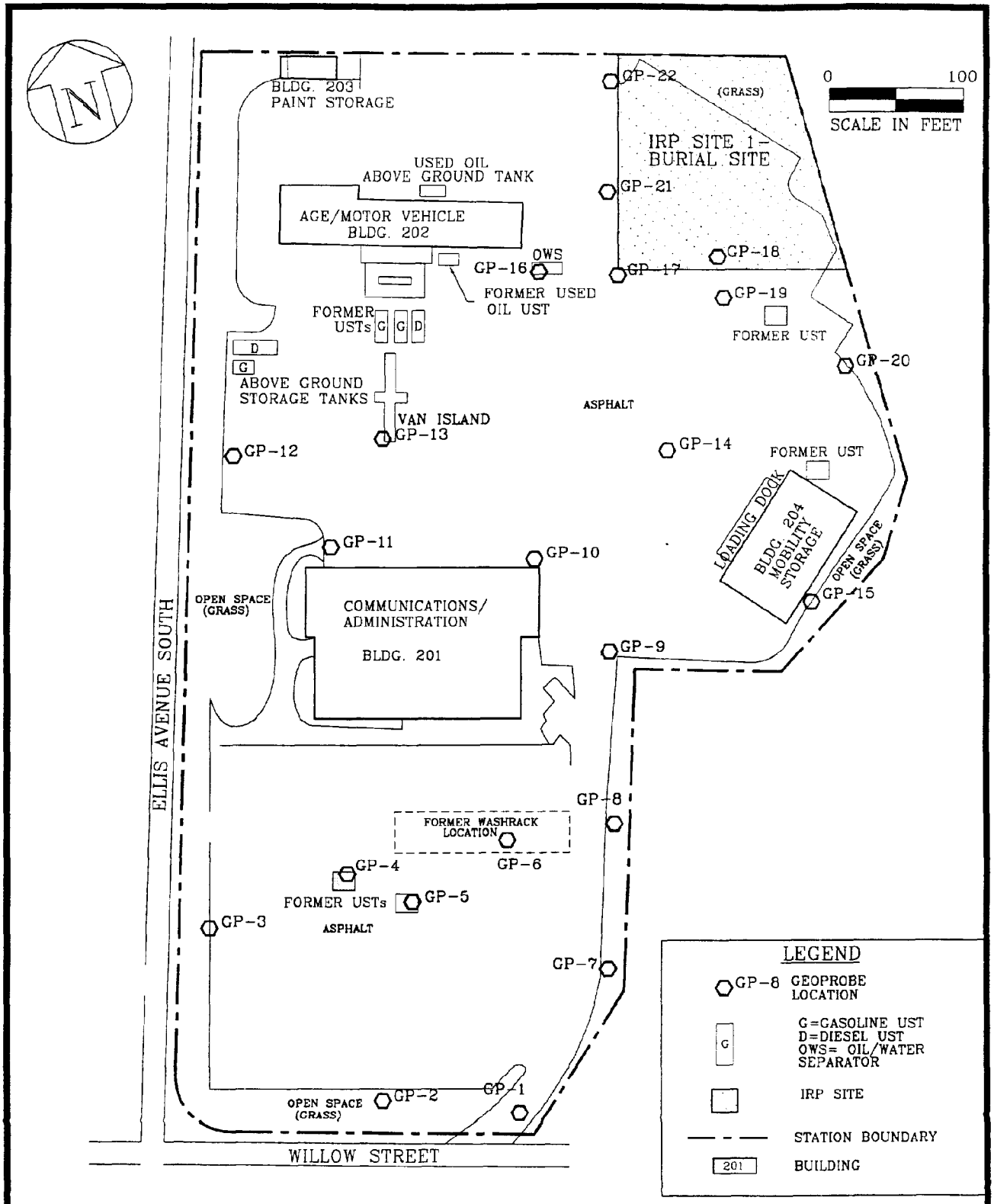

FIGURE C-1

PHASE I RI GEOPROBE
GROUNDWATER SAMPLING LOCATIONS
143rd CCSQ, Seattle ANGS
Seattle, Washington

S:\CAD\DWGS\6061\41\60514131

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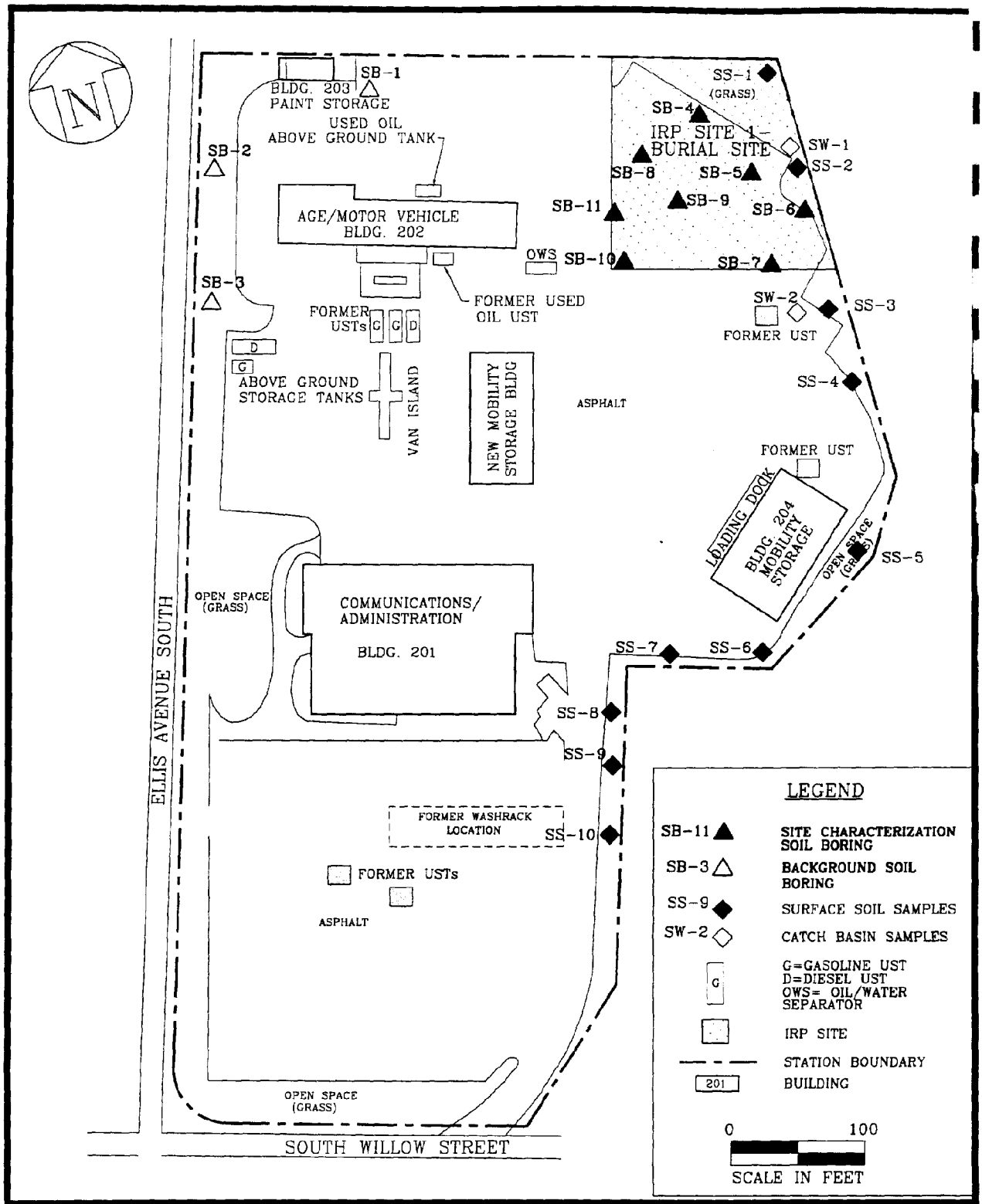

FIGURE C-2

PHASE I RI SOIL SAMPLING LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

S:\cad\dwgs\6051\41\60514133

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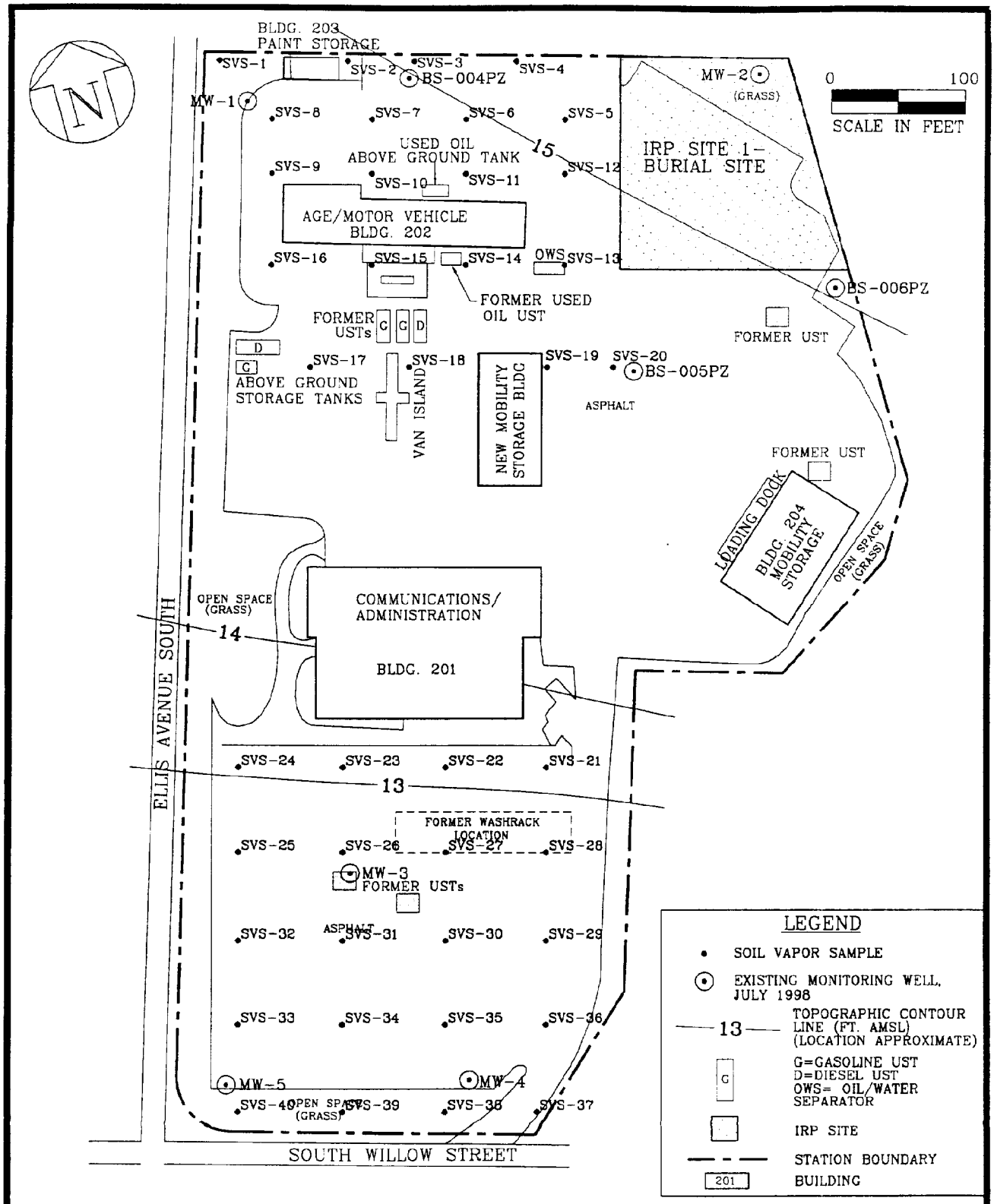

FIGURE C-3

PHASE II RI SOIL VAPOR
SAMPLING LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

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S:\cad\dwgs\6061\41\60514120

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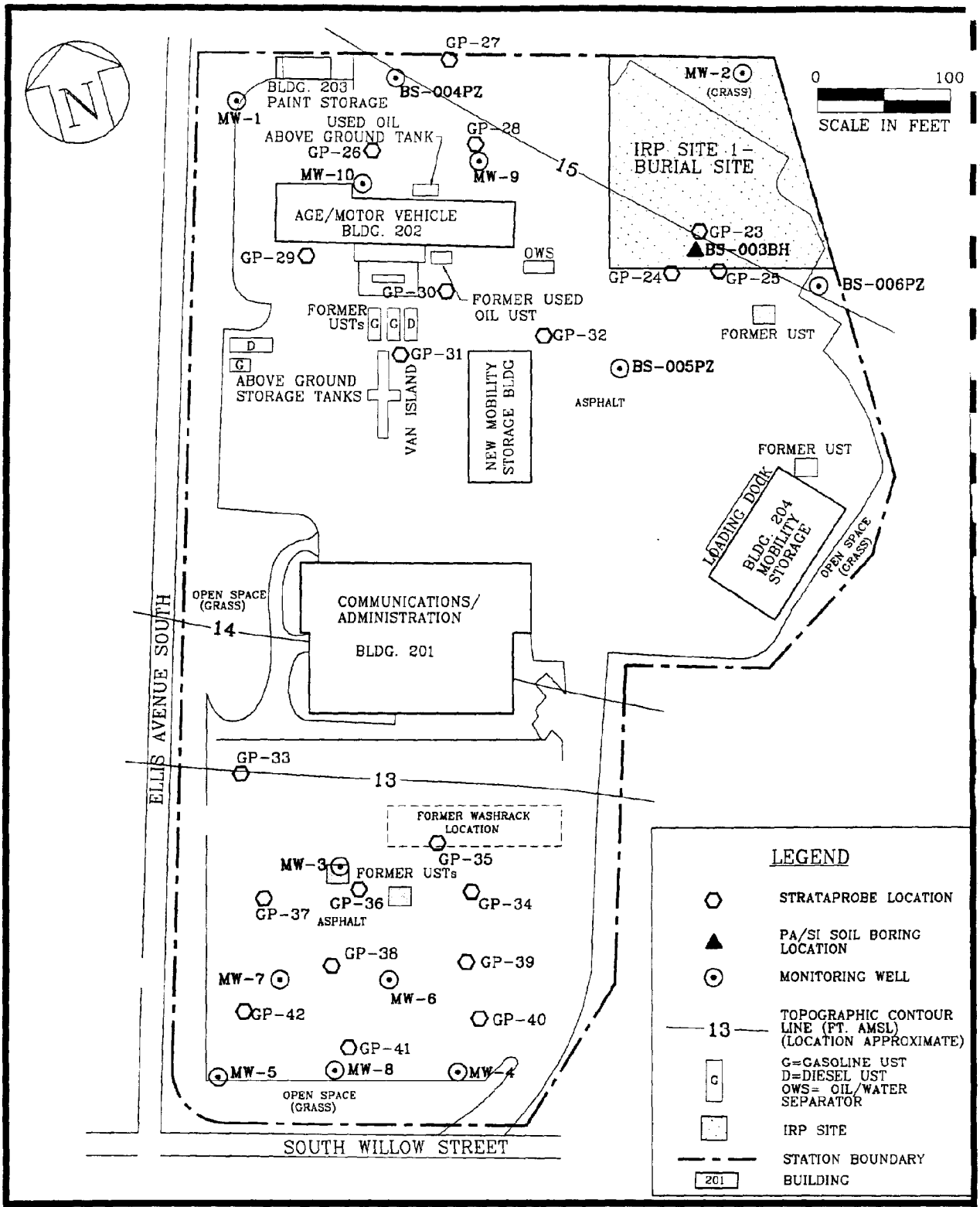

FIGURE C-4

PHASE II RI SOIL AND GROUNDWATER SAMPLING LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

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S:\cad\dwgs\6051\41\60514122

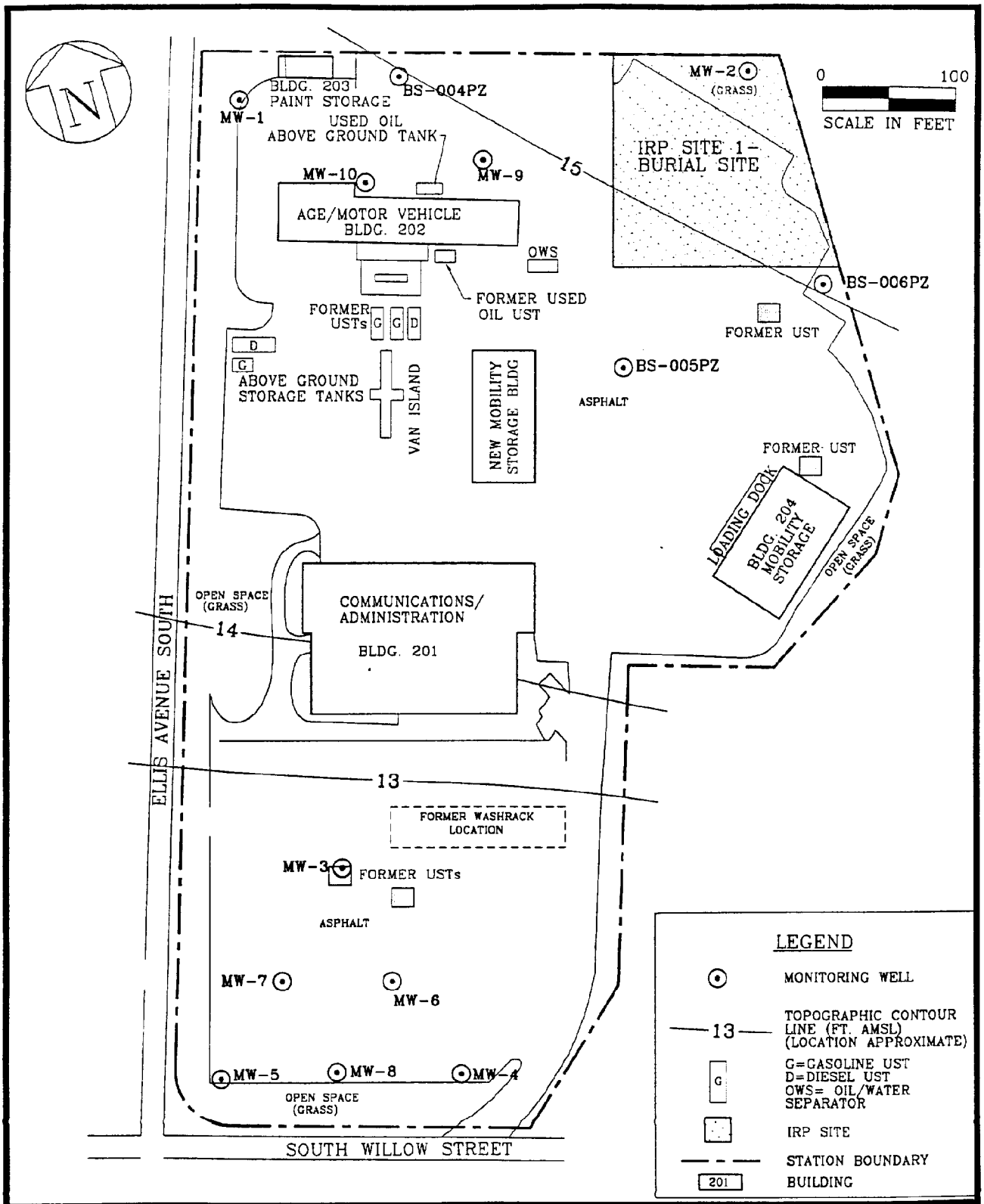

FIGURE C-5

GROUNDWATER MONITORING WELL LOCATIONS

143rd CCSQ, Seattle ANGS
Seattle, Washington

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TABLE C-1

Phase I Remedial Investigation Sampling Program
143rd CCSQ, Seattle ANGS, Seattle, Washington

Site	Matrix	Sampling Method	Field Parameters	Lab Parameters	USEPA Method	Primary Samples	QA/QC Samples					Matrix Total*
							Trip Blank	Rinsate Blank	Field Blank	Field Duplicate	MS/MSD	
Background	Subsurface Soil 3 Locations	Soil Borings	Soil headspace screening using PID/field TPH Soil Classification	PP Metals	3050/6010/6020/7470	9		1		1		10
				SVOCs	3550/8270	9		1		1		10
				TPH	WTPH-HCID (1)	9		1		1		10
				Radionuclides	SM-7110A/B, 903.1, 904.0	9		1		1		10
	Groundwater 1 RI MW 1 PA/SI MW	Monitoring Wells (per round)	Temperature pH Specific conductance Turbidity	PP Metals	6010/6020/7470	2						2
				VOCs	5030/8260	2	1					2
				SVOCs	3550/8270	2						2
				TPH	WTPH-HCID (1)	2						2
				Radionuclides	SM-7110A/B, 903.1, 904.0	2						2
IRP Site No.1	Subsurface Soil 9 Locations	Soil Borings, MW Boring MW-3	Soil headspace screening using PID/field TPH Soil Classification	PP Metals	3050/6010/6020/7470	16		1	1	1	2	19
				TPH	WTPH-HCID (1)	16		1	1	1	2	19
				VOCs	5030/8260	2						2
				SVOCs	3550/8270	16		1	1	1	2	19
				Radionuclides	SM-7110A/B, 903.1, 904.0	16		1	1	1	2	19
	Storm Sewer Catch Basin Sediments 2 Locations	Grab Samples	Headspace screening using PID/field TPH	PP Metals	3050/6010/6020/7470	2						2
				TPH	WTPH-HCID (1)	2						2
				SVOCs	3550/8270	2						2
				VOCs	5030/8260	2						2
				Radionuclides	SM-7110A/B, 903.1, 904.0	2						2

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TABLE C-1

Phase I Remedial Investigation Sampling Program
143rd CCSQ, Seattle ANGS, Seattle, Washington

Site	Matrix	Sampling Method	Field Parameters	Lab Parameters	USEPA Method	Primary Samples	QA/QC Samples					Matrix Total*
							Trip Blank	Rinsate Blank	Field Blank	Field Duplicate	MS/MSD	
IRP Site No. 1 (cont.)	Surface Soil 10 Locations	Surface Sampling	Soil headspace screening using PID/field TPH Soil Classification	TPH	WTPH-HCID (1) WTPH - G/D/HO (2)	10			1	1	1	12
				Radionuclides	SM-7110A/B, 903.1, 904.0	10			1	1	1	12
	Groundwater 4 RI MWs 2 PA/SI MWs	Geoprobe (field lab)	Temperature pH Specific conductance	Selected VOCs	8010/8020	22				2	1	25
				TPH	WTPH-HCID (1)	22				2	1	25
		Monitoring Wells (per round)	Temperature pH Specific conductance Turbidity	PP Metals	6010/6020/7470	6		1	1	1	1	8
				VOCs	5030/8260	6	1	1	1	1	1	8
				SVOCs	3550/8270	6		1	1	1	1	8
				TPH	WTPH-HCID (1)	6		1	1	1	1	8
				Radionuclides	SM-7110A/B, 903.1, 904.0	6		1	1	1	1	8

VOCs = Volatile organic compounds
SVOCs = Semivolatile organic compounds
PP Metals = Priority Pollutant metals
TPH = Total petroleum hydrocarbons
QA/QC = Quality assurance/quality control
MS/MSD = Matrix spike/matrix spike duplicate
USEPA = United States Environmental Protection Agency
PID = Photoionization detector
RI = Remedial Investigation
PA/SI = Preliminary Assessment/Site Inspection
MW = Monitoring Well
* = Blank samples not included in matrix total
(1) = State of Washington TPH analysis - hydrocarbon screening/identification method
(2) = State of Washington TPH analysis - gasoline/diesel/heavy oil quantification method

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TABLE C-2

Phase II Remedial Investigation Sampling Program
143rd CCSQ, Seattle ANGS, Seattle, Washington

Matrix	Sampling Method	Field Parameters	Laboratory Parameters	Analytical Method	Primary Sample Analyses	QA/QC Samples					Total Laboratory Analyses
						Trip Blank	Rinsate Blank	Field Blank	Field DUP	MS/MSD	
Soil Vapor	StrataProbe - 40 locations	None	VOCs	USEPA 8021B	40	2	4	2	4	--	52
Soil	StrataProbe - 20 locations	Organic vapors	VOCs	USEPA 8260	20	1	2	1	2	1	27
			TPH	WTPH-HCID	3	--	1	1	1	--	6
	MW borings - 5 locations	Organic vapors	VOCs	USEPA 8260	5	1	1	--	--	--	7
Groundwater	StrataProbe - 20 locations	None	VOCs	USEPA 8021B	20	1	1	1	2	1	26
	8 existing MWs, 5 new MWs, quarterly for 1 year	S.C., Turbidity, pH, Temperature, D.O., Redox potential	VOCs	USEPA 8260	52	8	5	8	5	3	81

VOCs = Volatile organic compounds
TPH = Total petroleum hydrocarbons
WTPH-HCID = Washington TPH - hydrocarbon identification method
QA/QC = Quality assurance/quality control
DUP = Duplicate sample
S.C. = Specific conductance
D.O. = Dissolved oxygen content
USEPA = United States Environmental Protection Agency
MS/MSD = Matrix spike/matrix spike duplicate
MW = Monitoring well

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FINAL

TABLE C-3

Trichloroethene Detected in
Geoprobe/StrataProbe Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Sample Location	Sample Date	TCE Concentration (ug/L)*
GP-1	10/8/96	ND
GP-2	10/8/96	3.7
GP-3	10/8/96	ND
GP-4	10/8/96	**17**
GP-5	10/8/96	4.1
GP-6	10/8/96	ND
GP-7	10/8/96	ND
GP-8	10/8/96	ND
GP-9	10/8/96	ND
GP-10	10/9/96	ND
GP-11	10/9/96	ND
GP-12	10/9/96	ND
GP-13	10/9/96	ND
GP-14	10/9/96	ND
GP-15	10/9/96	ND
GP-16	10/9/96	ND
GP-17	10/9/96	ND
GP-18	10/9/96	ND
GP-19	10/9/96	ND
GP-20	10/9/96	ND
GP-21	10/9/96	ND
GP-22	10/9/96	ND
GP-23	8/13/98	ND
GP-24	8/13/98	ND
GP-25	8/13/98	ND
GP-26	8/13/98	ND
GP-27	8/13/98	ND
GP-28	8/13/98	ND
GP-29	8/13/98	ND
GP-30	8/13/98	ND
GP-31	8/13/98	ND
GP-32	8/13/98	ND
GP-33	8/12/98	ND
GP-34	8/12/98	ND
GP-35	8/12/98	ND
GP-36	8/12/98	**10**
GP-37	8/12/98	1
GP-38	8/12/98	**25**
GP-39	8/12/98	ND

FINAL

TABLE C-3

Trichloroethene Detected in
Geoprobe/StrataProbe Groundwater Samples
143rd CCSQ, Seattle ANGS, Seattle, Washington

Sample Location	Sample Date	TCE Concentration (ug/L)*
GP-40	8/12/98	ND
GP-41	8/12/98	ND
GP-42	8/12/98	ND

*Geoprobe samples (GP-1 through GP-22) analyzed by USEPA Method 8010; StrataProbe samples (GP-23 through GP-42) analyzed by USEPA Method 8021B.
TCE = Trichloroethene
ug/L = Micrograms per liter
ND = Not detected above method reporting limit
Note: Shaded/bold values exceed the MTCA Method A Cleanup Level (5 ug/L).

FINAL

TABLE C-4

Trichloroethene Detected in Groundwater Monitoring Wells
143rd CCSQ, Seattle ANGS, Seattle, Washington

Date	TCE Concentration in Background Wells (ug/L)*		TCE Concentration (ug/L)*										
	BS-004PZ	MW-1	BS-005PZ	BS-006PZ	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10
9/17/96	ND (ND)	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
10/18/96	NA	ND	NA	NA	ND	ND (ND)	3.9	ND	NA	NA	NA	NA	NA
12/17/96	NA	ND	NA	NA	ND	ND (ND)	2.7	ND	NA	NA	NA	NA	NA
1/14-15/97	ND	ND	ND	ND	ND (ND)	ND	3.4	ND	NA	NA	NA	NA	NA
4/10-11/97	ND	ND	ND	ND	ND	ND	3.2	ND (ND)	NA	NA	NA	NA	NA
7/10-11/97	ND	ND	ND	ND	ND	ND	2.8	2.1 (ND)	NA	NA	NA	NA	NA
9/1-2/98	ND	ND	ND	ND	ND	ND (ND)	2.0	ND	3.0	ND	3.0	ND	ND
11/24-25/98	ND	ND	ND	ND	ND	ND (ND)	3.4	ND	3.0	3.8	3.3	ND	ND
2/24-25/99	ND	ND	ND	ND	ND	ND	2.6 (2.6)	ND	ND	ND	**83 (87)**	ND	ND
5/18-19/99	ND	ND	ND	ND	ND	ND	2.9	ND	**5.7**	ND	**19 (21)**	ND	ND

*Analyzed by USEPA Method 8260
TCE = Trichloroethene
ug/L = Micrograms per liter
NA = Not analyzed
ND = Not detected above method reporting limit
( ) = Duplicate sample results
Note: Shaded/bold values exceed the MTCA Method A Cleanup Level (5 ug/L)
See Table B-1 for monitoring well construction details and installation dates.

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APPENDIX D

IDENTIFICATION OF CONTAMINANTS OF CONCERN

TABLE D-1

Identification of Contaminants of Concern in Soil[1]

143rd CCSQ, Seattle ANGS, Seattle, Washington

Constituent Detected	Project Screening Goal	Units	Confirmed COC? (Y/N)	Reason	Maximum Site-Specific Background Concentration Detected	Maximum Screening Concentration Detected	Maximum Site-Characterization Concentration Detected
Bis(2-ethylhexyl)phthalate	71.4	mg/kg	N	No occurrences above the PSG; suspected lab contaminant.	Not detected.	No field screening for SVOCs.	1 detect: SB-09 @ 9ft bgs on 10/16/96: 3.9 mg/kg.
TPH-Gasoline	100	mg/kg	N	No occurrences above the PSG.	Not detected.	Immunoassay field technique - max TPH > 100 ppm.	2 detects: maximum @ SS-10 @ 0.5 ft bgs on 10/17/96: 35 mg/kg.
TPH-Diesel	200	mg/kg	N	No occurrences above the PSG.	Not detected.	Immunoassay field technique - max TPH > 100 ppm.	3 detects: maximum @ SS-07 @ 0.5 ft bgs on 10/17/96: 70 mg/kg.
TPH-Heavy oil	200	mg/kg	N	No occurrences above the PSG.	Not detected.	Immunoassay field technique - max TPH > 100 ppm.	2 detects: maximum @ SS-09 @ 0.5 ft bgs on 10/17/96: 110 mg/kg.
Trichloroethene	0.5	mg/kg	N	No occurrences above the PSG; presence likely due to VOC impacts to groundwater.	Not detected.	No compound-specific field screening for VOCs.	1 detect: MW-3 @ 9ft bgs on 10/16/96: 0.17 mg/kg.
Gross Alpha Particle Activity	9.96	pCi/g	N	Per letter dated 05/09/97 from the State of Washington Department of Health - Division of Radiation Protection: Radiation in soil is present at background levels.	9 detects - maximum @ SB-3 @ 3 ft bgs on 10/15/96: 12.8 pCi/g.	No field screening for radionuclides.	25 detects: maximum @ SB-05 @ 3 ft bgs on 10/15/96: 16.2 pCi/g.
Gross Beta Particle Activity	16.1	pCi/g	N	Per letter dated 05/09/97 from the State of Washington Department of Health - Division of Radiation Protection: Radiation in soil is present at background levels.	9 detects - maximum @ SB-1 @ 9 ft bgs on 10/15/96: 16.6 pCi/g.	No field screening for radionuclides.	25 detects: maximum @ SB-09 @ 9 ft bgs on 10/16/96: 22.9 pCi/g.
Radium-226	0.77	pCi/g	N	Per letter dated 05/09/97 from the State of Washington Department of Health - Division of Radiation Protection: Radiation in soil is present at background levels.	9 detects - maximum @ SB-2 @ 7 ft bgs on 10/15/96: 0.88 pCi/g.	No field screening for radionuclides.	25 detects: maximum @ SB-07 @ 3 ft bgs on 10/15/96: 1.37 pCi/g.
Radium-228	0.93	pCi/g	N	Per letter dated 05/09/97 from the State of Washington Department of Health - Division of Radiation Protection: Radiation in soil is present at background levels.	9 detects - maximum @ SB-1 @ 7 ft bgs on 10/15/96: 1.34 pCi/g.	No field screening for radionuclides.	25 detects: maximum @ SB-10 & SB-11 @ 9 ft bgs on 10/15/96: 1.29 pCi/g.
Arsenic	20	mg/kg	N	No occurrences above the PSG.	9 detects - maximum @ SB-3 @ 3 ft bgs on 10/15/96: 8.7 mg/kg.	No field screening for metals.	14 detects: maximum @ SB-09 (dup) @ 3ft bgs on 10/16/96: 20 mg/kg.
Cadmium	2	mg/kg	N	No occurrences above the PSG.	Not detected.	No field screening for metals.	1 detect: SB-04 @ 3ft bgs on 10/15/96: 0.8 mg/kg.
Chromium	100	mg/kg	N	No occurrences above the PSG.	9 detects - maximum @ SB-3 @ 3 ft bgs on 10/15/96: 17 mg/kg.	No field screening for metals.	16 detects: maximum @ SB-05 @ 9ft bgs on 10/15/96: 19 mg/kg.
Copper	2,960	mg/kg	N	No occurrences above the PSG.	9 detects - maximum @ SB-2 @ 5 ft bgs on 10/15/96: 20 mg/kg.	No field screening for metals.	16 detects: maximum @ SB-04 @ 3ft bgs on 10/15/96: 35 mg/kg.

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TABLE D-1

Identification of Contaminants of Concern in Soil[1]

143rd CCSQ, Seattle ANGS, Seattle, Washington

Constituent Detected	Project Screening Goal	Units	Confirmed COC? (Y/N)	Reason	Maximum Site-Specific Background Concentration Detected	Maximum Screening Concentration Detected	Maximum Site-Characterization Concentration Detected
Lead	250	mg/kg	N	No occurrences above the PSG.	6 detects - maximum @ SB-2 @ 5 ft bgs on 10/15/96: 33 mg/kg.	No field screening for metals.	16 detects: maximum @ SB-09 (dup) @ 3ft bgs on 10/16/96: 250 mg/kg.
Nickel	1,600	mg/kg	N	No occurrences above the PSG.	9 detects - maximum @ SB-3 @ 3 ft bgs on 10/15/96: 14 mg/kg.	No field screening for metals.	16 detects: maximum @ SB-05 @ 9ft bgs on 10/15/96: 24 mg/kg.
Selenium	400	mg/kg	N	No occurrences above the PSG.	5 detects - maximum @ SB-3 @ 3 ft bgs on 10/15/96: 2.8 mg/kg.	No field screening for metals.	5 detects: maximum @ SB-04 & SB-06 @ 3ft bgs on 10/15/96: 1.5 mg/kg.
Zinc	24,000	mg/kg	N	No occurrences above the PSG.	9 detects - maximum @ SB-2 @ 5 ft bgs on 10/15/96: 45 mg/kg.	No field screening for metals.	16 detects: maximum @ SB-09 (dup) @ 3ft bgs on 10/16/96: 210 mg/kg.

[1]Based on Phase I Remedial Investigation data

Note: Number of detects includes those associated with primary samples only; duplicate samples are not included in this number.
Note: For the radionuclides, the number of detects does not include negative values.

COC = Contaminant of concern
ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
pCi/g = PicoCuries per gram
PSG = Project screening goal
SVOC = Semivolatile organic compound
TPH = Total petroleum hydrocarbons
VOC = Volatile organic compound

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TABLE D-2

Identification of Contaminants of Concern in Groundwater[1]

143rd CCSQ, Seattle ANGS, Seattle, Washington

Constituent Detected	Project Screening Goal	Units	Confirmed COC? (Y/N)	Reason	Maximum Site-Specific Background Concentration Detected	Maximum Screening Concentration Detected	Maximum Site-Characterization Concentration Detected
Acetone	800	µg/L	N	No occurrences above the PSG.	Not detected.	Not detected.	2 detects: maximum @ MW-3 (dup) on 10/18/96: 20 µg/L.
Benzene	5	µg/L	N	Benzene complies with MTCA Method A and Federal MCL criteria based on a statistical screening evaluation of the data.	Not detected.	Geoprobe sample - collected 10/08/96: 2 detects: maximum @ GP-3: 7.6 mg/L.	Not detected.
1,1-Dichloroethane	800	µg/L	N	No occurrences above the PSG.	1 detect @ BS-004PZ on 09/19/96: 0.3 µg/L.	Not detected.	Not detected.
1,2-Dichloroethane	5	µg/L	N	No occurrences above the PSG.	Not detected.	Geoprobe sample - collected 10/08/96: 1 detect @ GP-3: 2.4 mg/L.	Not detected.
cis-1,2-Dichloroethene	70	µg/L	N	No occurrences above the PSG.	Not detected.	Geoprobe sample - collected 10/08/96: 4 detects - maximum @ GP-15: 5 mg/L.	5 detects: maximum @ MW-05 on 10/18/96: 5.6 µg/L.
Ethylbenzene	30	µg/L	N	No occurrences above the PSG.	Not detected.	Geoprobe sample - collected 10/08/96: 1 detect @ GP-5: 9.9 mg/L.	Not detected.
Tetrachloroethene	5	µg/L	N	No occurrences above the PSG.	Not detected.	Not detected.	1 detect: @ BS-005PZ on 07/11/97: 4.7 µg/L.
Toluene	40	µg/L	N	No occurrences above the PSG.	1 detect: @ MW-1 on 01/14/97: 1.1 µg/L.	Geoprobe sample - collected 10/08/96: 1 detect @ GP-5: 1.6 mg/L.	Not detected.
1,1,1-Trichloroethane	200	µg/L	N	No occurrences above the PSG.	5 detects: maximum @ BS-004PZ (dup) on 09/17/96: 3.8 µg/L.	Geoprobe sample - collected 10/08/96: 1 detect @ GP-22: 2 mg/L.	Not detected.
Trichloroethene	5	µg/L	Y	One Geoprobe sample exceeds 2x the MTCA Method A Cleanup Level; does not meet statistical criteria for compliance.	Not detected.	Geoprobe sample - collected 10/08/96: 3 detects - maximum @ GP-4: 17 mg/L.	6 detects: maximum @ MW-4 on 10/18/96: 3.9 µg/L.
1,3,5-Trimethylbenzene	0.507	µg/L	N	No occurrences above the PSG.	Not detected.	Not detected.	2 detects: @ BS-005PZ and BS-006PZ on 09/17/96: 0.3 µg/L.
Xylenes	20	µg/L	N	No occurrences above the PSG.	Not detected.	Geoprobe sample - collected 10/08/96: 1 detect @ GP-22: 7 mg/L.	Not detected.
Gross Alpha Particle Activity	15	pCi/L	N	No occurrences above the PSG; reflects area background.	6 detects - maximum @ MW-1 on 12/17/96: 3.9 pCi/L.	No field screening for radionuclides.	19 detects: maximum @ MW-04 on 10/18/96: 10.8 pCi/L.
Gross Beta Particle Activity	11.3	pCi/L	N	15 detects > PSG; reflects area background.	9 detects - maximum @ BS-004PZ on 12/17/96: 13.2 pCi/L. (3 detects > PSG).	No field screening for radionuclides.	28 detects: maximum @ BS-005PZ on 09/17/96: 20 pCi/L. (15 detects > PSG).
Radium-226	3	pCi/L	N	No occurrences above the PSG; reflects area background.	9 detects - maximum @ MW-1 on 01/14/97: 0.35 pCi/L.	No field screening for radionuclides.	28 detects: maximum @ MW-03 on 01/05/97 and MW-05 on 01/14/97: 0.21 pCi/L.
Radium-226 and 228	5	pCi/L	N	No occurrences above the PSG; reflects area background.	9 detects - maximum @ MW-1 on 01/14/97: 0.66 pCi/L.	No field screening for radionuclides.	28 detects: maximum @ MW-03 (dup) on 10/18/96: 2.03 pCi/L.
Radium-228	2	pCi/L	N	No occurrences above the PSG; reflects area background.	8 detects - maximum @ MW-1 on 01/14/97: 0.31 pCi/L.	No field screening for radionuclides.	24 detects: maximum @ MW-03 (dup) on 10/18/96: 1.88 pCi/L.

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TABLE D-2

Identification of Contaminants of Concern in Groundwater[1]

143rd CCSQ, Seattle ANGS, Seattle, Washington

Constituent Detected	Project Screening Goal	Units	Confirmed COC? (Y/N)	Reason	Maximum Site-Specific Background Concentration Detected	Maximum Screening Concentration Detected	Maximum Site-Characterization Concentration Detected
Arsenic	5	µg/L	N	Suspected anomalous data: 1 low level detect occurred in the first sample collected at MW-5 but has not been repeated.	Not detected.	No field screening for metals.	1 detect: @ MW-05 on 12/17/96: 6 µg/L.
Copper	1000	µg/L	N	No occurrences above the PSG; reflects area background.	3 detects - maximum @ MW-1 on 07/11/97: 19 µg/L.	No field screening for metals.	5 detects: maximum @ MW-02 on 04/10/97: 20 µg/L.
Nickel	100	µg/L	N	No occurrences above the PSG; reflects area background.	4 detects - maximum @ MW-1 on 04/11/97: 13 µg/L.	No field screening for metals.	20 detects: @ MW-02 on 01/05/97: 20 µg/L.
Zinc	5000	µg/L	N	No occurrences above the PSG; reflects area background.	2 detects - maximum @ MW-1& BS-004PZ on 01/04/97: 61 µg/L.	No field screening for metals.	3 detects: @ MW-04 on 01/1497: 270 µg/L.

[1]Based on Phase I Remedial Investigation data

Note: Number of detects includes those associated with primary samples only; duplicate samples are not included in this number.

Note: For the radionuclides, the number of detects does not include negative values.

Note: Monitoring wells were sampled during a total of 4 or 5 groundwater monitoring events, depending on the date of installation:
Wells installed as part of the PA/SI (BS-004PZ through BS-006PZ) were sampled 4 times (9/17/96, 01/14-15/97, 04/9-11/97, and 07/10-11/97).
Wells installed as part of the RI (MW-1 through MW-5) were sampled 5 times (10/15-18/96, 12/17/96, 01/14-15/97, 04/9-11/97, and 07/10-11/97).

COC = Contaminant of concern
ft bgs = Feet below ground surface
pCi/L = PicoCuries per liter
PSG = Project screening goal
SVOC = Semivolatile organic compound
TPH = Total petroleum hydrocarbons
VOC = Volatile organic compound
µg/L = Micrograms per liter
MTCA = Washington State Model Toxics Control Act
MCL = Maximum Contaminant Level

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