Final Comprehensive
Remedial Investigation Report
Part I of IV
Volume 1 of 7

For Philip Services Corporation's
Georgetown Facility
734 S. Lucile Street,
Seattle, Washington
WAD 00081 2909

Submitted to:
Washington State Department of Ecology

By: Philip Services Corporation
955 Powell Avenue SW
Renton, Washington 98055

In coordination with:

Pioneer Technologies Corporation
2612 Yelm Highway SE
Suite B
Olympia, WA 98501-4826

Geomatrix Consultants, Inc
One Union Square
600 - University Street, Suite 1020
Seattle, WA 98101

Farallon Consulting, L.L.C.
320 Third Avenue NE
Issaquah, Washington 98027

Exponent®, Environmental Group
4000 Kruse Way Place
Building 2, Suite 285
Lake Oswego, Oregon 97035

November 14, 2003

This report has been prepared under the responsible charge of a State of Washington Licensed Hydrogeologist.

1367

John A. Maloy

John A. Maloy
Philip Services Corporation
955 Powell Avenue SW
Renton, WA 98055

11/14/03

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LIST OF ACRONYMS

µg/l	Micrograms per liter
1,1-DCE	1,1-dichloroethene
1,2-DCE	Cis- and trans-1,2-dichloroethene
ASTDR	Agency for Toxic Substances and Disease Registry
ASTM	American Society for Testing Materials
Bp	Boiling point
BEI	Burlington Environmental, Inc.
Bgs	Below the ground surface
BNA	Base neutral acids
BTEX	Benzene, toluene, ethylbenzene and xylenes
CAP	Cleanup Action Plan
CATOX	Catalytic oxidation unit
CD	Compact disk
CERCLA	Comprehensive Environmental Response, Liability and Compensation Act
CFCs	Chlorofluorocarbons
Cfm	Cubic feet per minute
CFR	Code of Federal Regulations
Cfs	Cubic feet per second
Chempro	Chemical Processors, Inc.
CLs	Cleanup levels
Cm/s	Centimeters per second
CO_2	Carbon dioxide
COC	Chain of custody
COPC	Chemicals of potential concern
COSD	City of Seattle Datum
DCA	Dichloroethane
DNAPL	Dense nonaqueous phase liquids
DOH	Washington State Department of Health
DQI	Data quality indicator
DQO	Data quality objective
Draft HHERA	Draft Human Health and Ecological Risk Assessment
Draft RF	Draft Comprehensive RCRA Facility Investigation Report
DTW	Depth to water
Ecology	Washington State Department of Ecology
EDD	Electronic data deliverable
EI	Environmental indicator

EP	Extraction procedure (toxicity test)
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPH	Extractable petroleum hydrocarbons
Facility	PSC Georgetown Facility
FS	Feasibility Study
GAC	Granular-activated carbon
Gc	Gas chromatograph
GC/MS	Gas chromatrography/mass spectrometry
GIVF	Groundwater to Indoor Air Volatilization Factor
Gpm	Gallons per minute
GRO	Gasoline-range organics
HCIM	Hydraulic Control Interim Measure
HPAH	Heavy polycyclic aromatic hydrocarbons
HSWA	Hazardous and Solid Waste Amendments
IMIPAL	Inhalation Pathway Interim Measure Action Levels
IPIM	Inhalation Pathway Interim Measure
L/min	Liter per minute
LCS	Laboratory control spike
LNAPL	Light nonaqueous-phase liquid
LPAH	Light polycyclic aromatic hydrocarbons
LRO	Lube oil range organics
MCL	Maximum contaminant level
MDL	Method detection limit
Mg/kg	Milligram per kilogram
Mg/L	Milligrams per liter
MIBK	Methyl isobutyl ketone
ML/min	Milliliters per minute
MLLW	Mean low low water
MP	Measuring point
MQO	Method quality objective
MRL	Method reporting limit
MS/MSD	Matrix spike/matrix spike duplicate
MSL	Mean sea level
MTCA	Model Toxics control Act
MV	Millivolts
NAPL	Nonaqueous phase liquid
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOV	Notice of Violation

O&M	Operation and maintenance
ORP	Oxidation reduction potential
PAH	Polycyclic aromatic hydrocarbons
PCAMP	Pre-Corrective Action Monitoring Plan
PCB	Polychlorinated biphenyls
PCE	Tetrachloroethene
PID	Photoionization detector
Ppb	Parts per billion
Ppbv	Parts per billion by volume
PPC	Preservative Paint Company
PPE	Personal protective equipment
Ppm	Parts per million
PRALs	Preliminary remedial action levels
PRAQs	Preliminary remedial objectives
PSC	Philip Services Corporation
PVC	Poly vinyl chloride
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
Redox	Reduction/oxidation
RFI	RCRA Facility Investigation
RFO	RCRA Facility Assessment
RI	Remedial Investigation
RO	Reverse osmosis
RPD	Relative percent difference
SAD	SAD Properties LLC
SAP	Sampling and Analysis Plan
SCFM	Standard cubic feet per minute
SFD	Seattle Fire Department
SIM	Selective ion mode
SOP	Standard operating procedure
SPU	Seattle Public Utilities
SVE	Soil vapor extraction
SVOC	Semi-volatile organic compounds
SWMU	Solid Waste Management Unit
TASCO	The Amalgamated Sugar Company
TCA	Trichloroethane
TCE	Trichloroethene
TCLP	Toxicity characteristic leaching procedure
THC	Total hydrocarbons
TMB	Trimethylbenzene
TPH	Total petroleum hydrocarbon
TSA	Technical System Audit
TSCA	Toxic Substances Control Act

TSD	Treatment, storage or disposal
UCL	Upper confidence limit
USC	United States Code
USDA	United States Drug Administration
USGS	U.S. Geological Survey
UST	Underground storage tank
UV	Ultraviolet
VOC	Volatile organic compound
WAC	Washington Administrative Code
VPH	Volatile petroleum hydrocarbons

1.0 INTRODUCTION

Philip Services Corporation (PSC) has conducted a Remedial Investigation (RI) pursuant to the Resource Conservation and Recovery Act (RCRA) and the Model Toxics Control Act (MTCA) at its Georgetown Facility (facility) located at 734 South Lucile Street, Seattle, Washington. In August 2001, PSC completed a Draft Comprehensive RCRA Facility Investigation Report (Draft RFI), which included a Draft Human Health and Ecological Risk Assessment (Draft HHERA). In response to comments on that document from the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), PSC has conducted numerous field activities to address data gaps identified in the Draft RFI and Draft HHERA. The field activities included:

- Installation of 56 new monitoring wells,
- Quarterly sampling of more than 70 wells, along with two additional sampling events at selected permanent monitoring wells,
- Installation and sampling of 33 direct push groundwater reconnaissance borings,
- Multi-media sampling of more than 10 locations for the indoor air pathway,
- Tidal studies, and
- Slug testing.

The property at 734 South Lucile Street was a permitted RCRA hazardous waste treatment, storage, or disposal facility (hereby referred to as "facility") under 40 CFR 260-299 until December 2002, when the facility stopped accepting waste. On August 15, 2003, the Ecology approved PSC's July 2003 certification of RCRA above-ground closure for the facility. However, PSC is still responsible for subsurface closure per Section VII, Corrective Actions, of the facility's operating permit. A comprehensive description of the facility's former operations is provided in Section 2.0.

The Hazardous and Solid Waste Amendments (HSWA) to RCRA require both interim status and RCRA Part B permitted TSD facility operators to implement corrective action for releases of hazardous waste or hazardous constituents from Solid Waste Management Units (SWMUs) at their facilities.[1] The corrective action program at the facility began in 1988, when the EPA issued a 3008(h) order for corrective action (EPA, 1988) to the facility while it had interim status. In August 1991, the facility received a RCRA Part B operating permit (EPA, 1991), which included requirements for a corrective action program. Part VII of the facility's current RCRA Part B permit contains the specific requirements for corrective action at the facility (Ecology, 2002). The US EPA Region 10 office enforced the corrective action requirements of the permit until March 11, 2002, when the facility was transferred to Ecology's Hazardous Waste and Toxics Cleanup Program. Ecology has authority for the RCRA Corrective Action program in Washington and is using the State of Washington's MTCA statute and the dangerous waste regulations as the primary enforcement regulations for meeting RCRA corrective action requirements.[2]

In 1988, PSC conducted initial RI activities at the facility under the 3008(h) order and subsequently under the RCRA Part B permit. The scope of the RI work is described in the current RCRA permit (Ecology, 2002). This Comprehensive RI report presents the results of the RI activities performed under the permit, and includes the RI Report (Part I), a Human Health and Ecological Risk Assessment (Part II), the revised Public Participation Plan (Part III), and a

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[1] Section 3008(h) of RCRA requires corrective action at interim status TSD facilities; Section 3004(u) and (v) require corrective action at fully permitted TSD facilities, as well as beyond the boundary of the facility.

[2] On November 4, 1994, the Washington State Department of Ecology received final authorization from the US Environmental Protection Agency, Region 10 to implement the state corrective action program in lieu of the federal corrective action program. The state corrective action rules and regulations authorized by the Agency include: Chapter 70.105 RCW (Hazardous Waste Management); Chapter 173-303 WAC (Dangerous Waste Regulations); Chapter 70.105D RCW (Model Toxics Control Act); and Chapter 173-340 WAC (The Model Toxics Control Act Cleanup Regulation). These rules and regulations meet the requirements of Section 3004(u) and (v) of RCRA (Section 206 of HSWA), 42 USC Section 6924(u), and regulations codified at 40 CFR 264.101 such that these regulations are no less stringent than applicable Federal requirements.

Feasibility Study (FS) Scope of Work Technical Memorandum (Part IV). Upon approval of this RI, PSC will proceed to the next phase of the corrective action process, the FS, which will evaluate the practicable options for the final remedy. Ecology will determine the final remedy and, following appropriate public participation and comment, a Cleanup Action Plan (CAP) will be prepared for the facility.

1.1 *Facility Location and Description*

The facility is located at 734 South Lucile Street, Seattle, King County, Washington in the Georgetown neighborhood of south Seattle, as shown in Figure 1-1. In the Public Land Survey System, the facility is located in the SW¼, of the NE¼, of Section 20, T.24.N, R.4.E. This location is approximately 47° 33' N. Latitude, 122° 19' W. Longitude.

Land use in the vicinity of the facility is mixed residential, commercial, and industrial. Figure 1-2 shows the zoned land use in the immediate vicinity of the facility. The facility is bordered on the east and north by Union Pacific Railroad property and rail lines. The Preservative Paint Company operates a facility to the east of the rail lines across Airport Way South. The "Bertholdi Building, " which is used as office space, is located to the southeast of the facility, on the southeast corner of Airport Way South and Lucile Street. Western Trailer Repair Inc. is located south of the facility across South Lucile Street. Immediately to the west of the southern part of PSC's facility is Stone-Drew/Ashe & Jones, Inc, a plumbing supply warehouse, which is owned by SAD Properties LLC (SAD). PSC owns the adjacent property west of the North Field formerly owned by The Amalgamated Sugar Company (also known as White Satin Sugar, but herein referred to as TASCO).[3] Directly northwest of the North Field, to the northwest of the Amalgamated Sugar property, is the property owned by Aronson Investment Company (Aronson), which is leased as a warehouse with office space. Three residences are located southwest of the facility on the west side of Denver Avenue South. These properties are identified in Figure 1-3. Several commercial and industrial businesses are located to the southwest or downgradient (as groundwater flows) from the facility. These businesses have had known releases or the potential for releases, or conducted environmental cleanup activities

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[3] At this time, the building on the Amalgamated Sugar property is vacant. PSC is using the property to install an interim measure, as described in Section 2.0.

resulting from the use and/or storage of hazardous materials or hazardous waste on their properties. These businesses are identified and described in Appendix 1A.

The former facility plan, presented in Figure 1-4, shows all the former operating units described in the Part B permit. The primary operating units at the facility were the process containment building, main warehouse, container check-in area (West Field), drum storage area, railroad loading area, a second container storage area and the processing area. The process containment building was used for paint can crushing, processing of aerosol containers and processing of household hazardous waste. The warehouse was used for container storage. The West Field was used for container check-in. The North Field was used for drum storage with a railroad car loading and unloading pad along the northern edge of the property. Another container storage area was located in the South Field. The processing area, located to the east of the warehouse, consisted of an above-ground storage tank system. During operation, the entire perimeter of the facility was secured by an eight-foot chainlink fence topped with barbed wire.

PSC completed closure of the operating units at the facility in 2003 in accordance with applicable RCRA and state requirements and requirements under the Toxics Substances Control Act. PSC currently conducts no waste operations at the facility although corrective action activities continue at the site. All former facility buildings, including the process containment building and large warehouse with office space, have been decontaminated and will be demolished by the end of 2003. The property is completely paved with concrete or asphalt.[4] Figure 1-5 shows the existing facility includes structures or equipment associated with two on-site interim measures, as described in Section 2.0.

1.2 *Objectives of Remedial Investigation Report*

The objectives of this report include summarizing and interpreting the data collected during investigations conducted at the facility under Part VII of the Part B permit, defining the nature and extent of surface and subsurface contamination that originated on the facility property, and describing the risks associated with that contamination. The requirements for this report are

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[4] The entire site is "capped" by concrete, except in areas where the hydraulic control interim measure barrier wall is installed and asphalt will be used to patch the trenched area.

outlined in Section VII.A.3. and Section VII.A.4. of the Part B permit (Ecology, 2002) and MTCA (Ecology, 2001), and are provided below.

RI report requirements:

- Discuss the finding and conclusions of the investigations performed to characterize the nature and extent of hazardous constituents in soil, soil gas, groundwater, and air
- Explain the subsurface stratigraphy and hydrogeologic parameters
- Provide results of a groundwater beneficial use analysis
- Describe the groundwater point of compliance
- Identify the preliminary cleanup levels and objectives
- Determine whether the Environmental Indicators for protecting current human receptors from unacceptable exposures, and for stopping the downgradient movement of contaminated groundwater, have been met
- Provide the results of quality assurance activities and a data usability analysis
- Prepare a revised Public Participation Plan
- Submit a quantitative Human Health and Ecological Risk Assessment that assesses current and future exposure pathways and develops risk based cleanup levels and proposed points of compliance
- Prepare an FS Scope of Work Technical Memorandum proposing the focus and format of the FS based on predictions of future groundwater movement, the risks to receptors

potentially exposed to the contaminated media, and considering the post-implementation of interim measures and final remedial action alternatives

This information is provided in the following sections of the report, which include:

Section 2 – Facility History
Section 3 – Physical Description and Setting
Section 4 – Description of Investigative Activities
Section 5 – Data Quality and Usability Assessment
Section 6 – Groundwater Beneficial Use and Point of Compliance
Section 7 – Sources Areas and Chemicals of Potential Concern
Section 8 – Nature and Extent of Impacted Soil
Section 9 – Nature and Extent of Impacted Groundwater
Section 10 – Description of Soil Gas and Indoor Air Results
Section 11 – Environmental Indicator Status
Section 12 – Comparison of Site Concentrations to Cleanup Levels and Preliminary Remedial Action Objectives
Section 13 – Summary and Conclusions

1.3 *References*

Department of Ecology (Ecology). 2001. *Model Toxics Control Act (MTCA). WAC 173–340.* 2001 proposed updates. Washington State Department of Ecology, Olympia Washington.

Department of Ecology (Ecology). 2002. *Final Resource Conservation Act (RCRA) Permit Modification (GTMOD 38-3)– Transfer of Corrective Action Lead Agency.* March 11, 2002.

United States Environmental Protection Agency (EPA). 1991. RCRA Part B Permit for the BEI Georgetown Facility at 734 S. Lucile Street, Seattle, WA.

United States Environmental Protection Agency (EPA). 1988. RCRA Section 3008(h) Agreed Order for Chemical Processors Incorporated, 734 South Lucile Street, Seattle Washington.

Note: The image was photographed on 10 Jul 1990 by the National Aerial Photography Program and digitized by the USGS DOQ Program on 26 Apr 1996

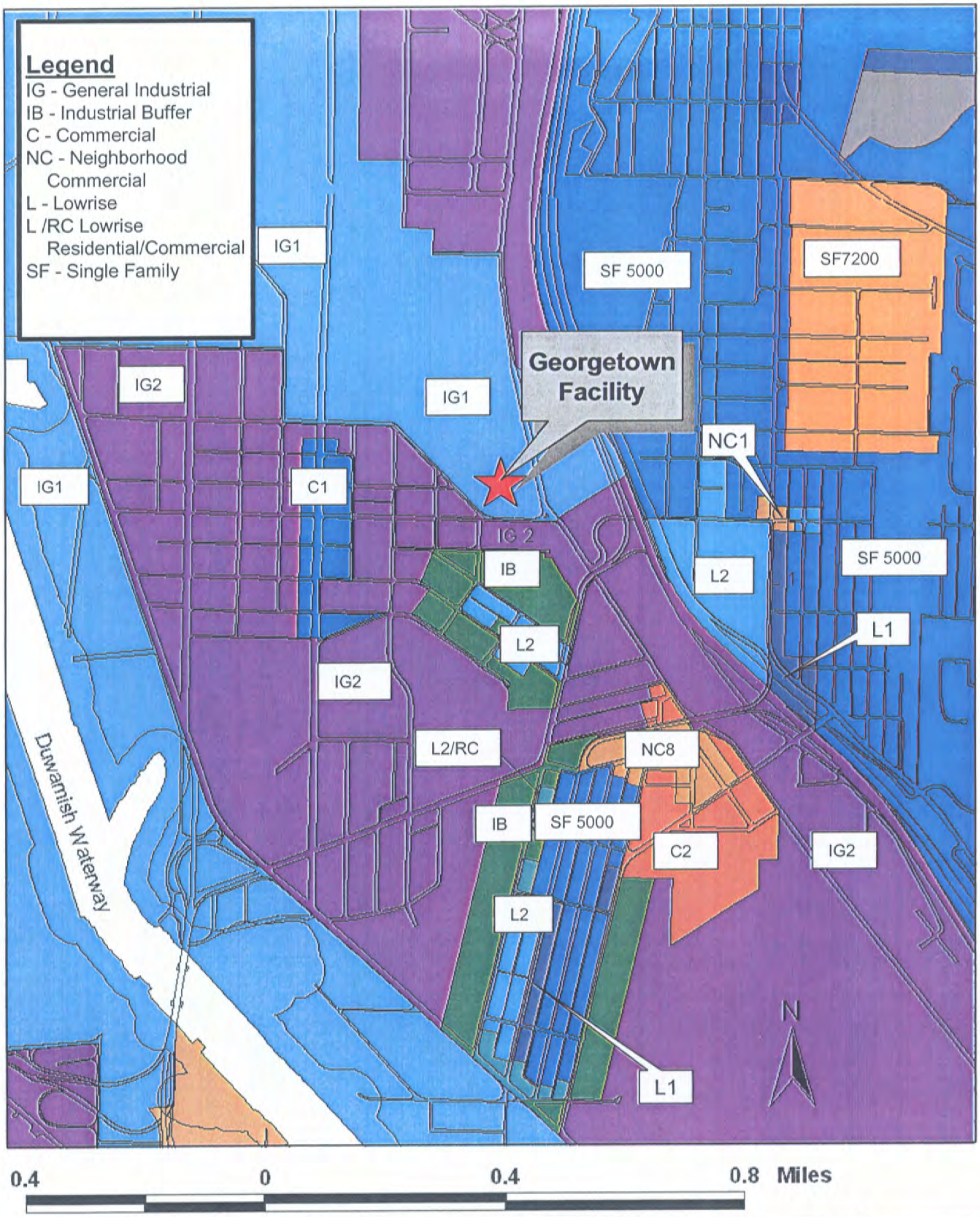
PSC

Facility Location-Aerial View
PSC Georgetown Facility
Seattle, Washington

Figure 1-1

5/02

p:\projects_2002\philips_aerial_utm83_8x11.mxd
Date: May 2002



PSC

City of Seattle Land Use Zoning
Georgetown Area
Seattle, Washington

Source: City of Seattle, 1998

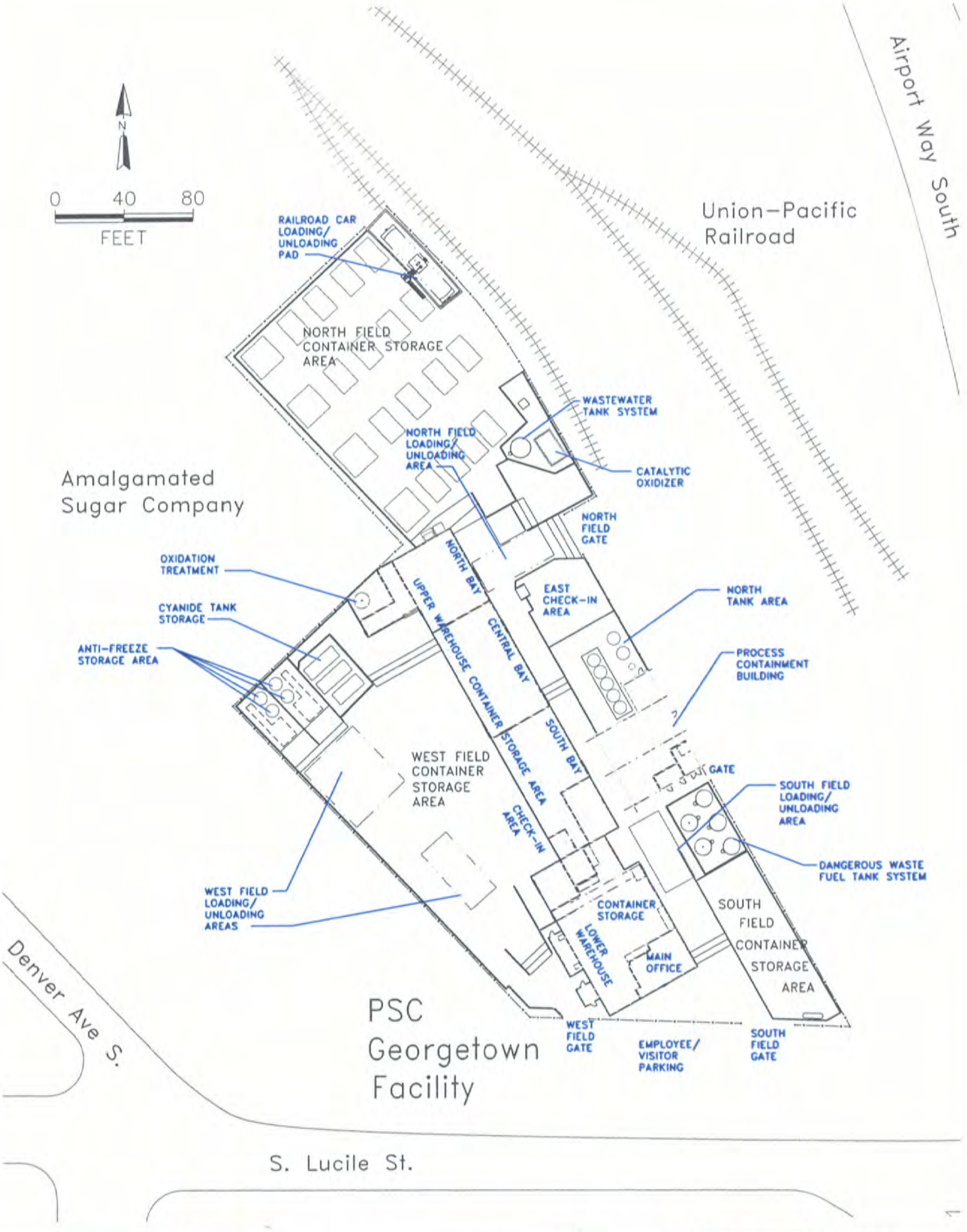
dtb

RI2003

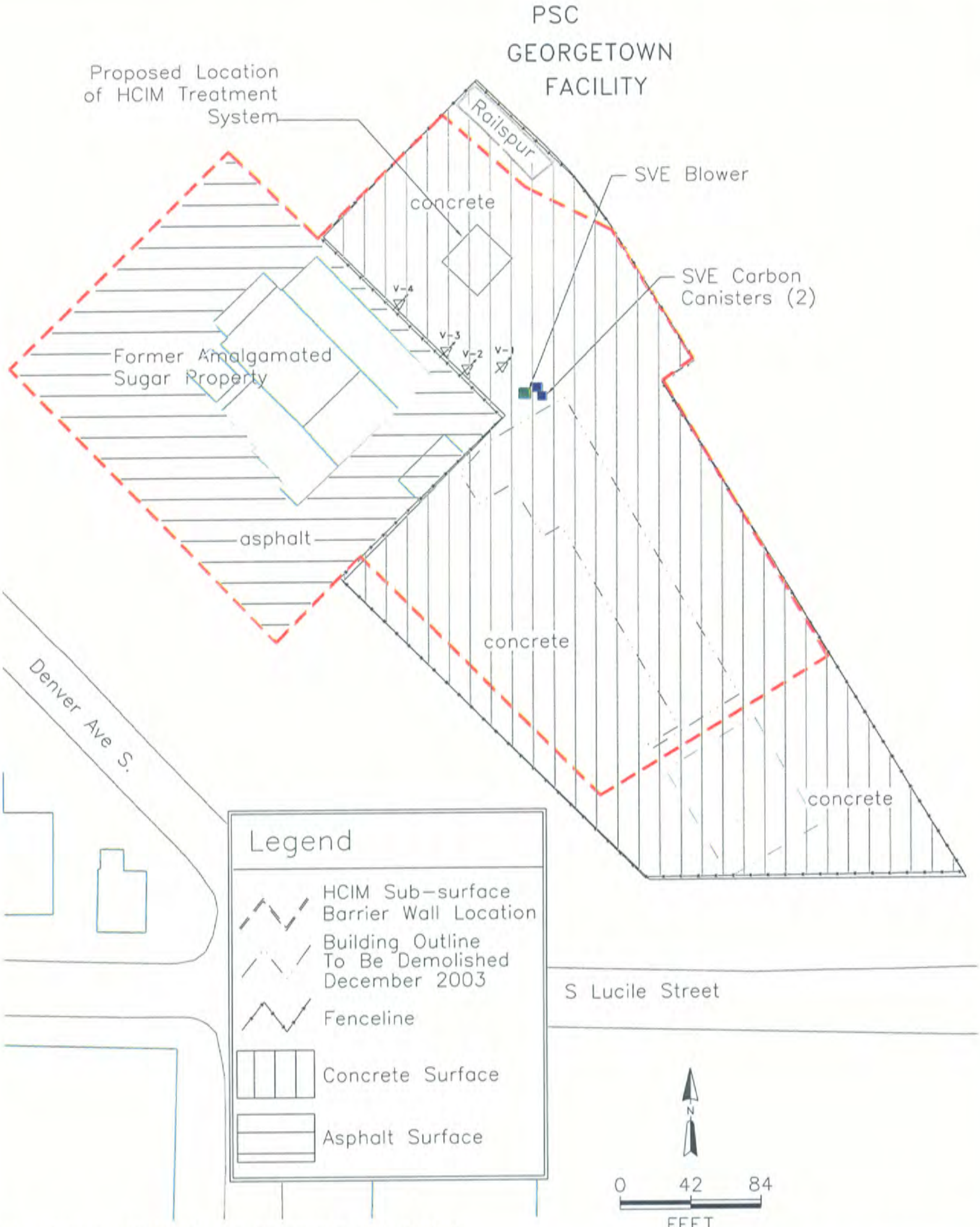
7/23/2003

1-2

TITLE: Properties Adjacent to PSC Georgetown Facility PSC Georgetown	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD:	APPD:	
	DATE: 8/25/03	REV.: 1	FIGURE NO.: 1-3



PSC	TITLE: Former Facility Plan	DWN: dtb	DES.:	PROJECT NO.: RI2003
		CHKD:	APPD:	
	Georgetown Facility	DATE: 11/6/03	REV.: 1	FIGURE NO.: 1-4



Note: Barrier wall trench will be capped with asphalt.

TITLE: Current Facility Plan Georgetown Facility	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD:	APPD:	
	DATE: 11/6/03	REV.: 2	FIGURE NO.: 1-5

2.0 FACILITY HISTORY

2.1 *Ownership History*

There is no available information concerning the owners or operators of the property at 734 S. Lucile Street prior to the late 1950's (Chempro, 1988a). The Preservative Paint Company (PPC), currently located across Airport Way to the east of the facility, owned and operated the property from 1958 to approximately 1986. Chemical Processors Inc. (Chempro) acquired the PPC solvent recovery and distillation operations in August 1970 and later purchased the real property for the facility from the West family, owners of Preservative Paint Company. In 1986, David Sabey purchased all of the capital stock in Chempro. In March 1988, Glacier Park Company, a wholly-owned real estate subsidiary of Burlington Northern Inc. bought a majority interest in Chempro and its subsidiaries from David Sabey. In late 1988, Burlington Northern Inc. spun off its natural resources subsidiaries, including Glacier Park Company and Chemical Processors, Inc., into a new publicly traded company, Burlington Resources Inc. At this time, as a majority owned subsidiary of Burlington Resources, Chempro changed its corporate name to Burlington Environmental Inc. (BEI). In December 1993, Philip Environmental Inc., a Canadian company, purchased BEI. In August 1997, Philip Environmental merged with two other publicly traded companies to form Philip Services Corp. In 1999, Philip Services Corp. reorganized under Chapter 11 bankruptcy and emerged from the financial restructuring in 2000 as Philip Services Corporation. Philip Services Corporation filed Chapter 11 bankruptcy on June 2, 2003 in Houston, Texas. The bankruptcy is still pending finalization.

BEI continues to be the legal owner of the facility and a wholly owned subsidiary of Philip Services Corporation. To simplify the text for the reader, PSC is used throughout the text regardless of the legal owner of the property or the legal permit holder, except for Section 2.2, which discusses the operational history of the facility.

2.2 *Operational History*

2.2.1 Pre-1950s

The facility is located in the Duwamish River Valley, an area that was originally part of the Duwamish River Estuary before the US Army Corps of Engineers dredged a channel for the river between approximately 1900 and 1910. The Duwamish Waterway channel is now located approximately 0.8 miles west of the facility.

A review of historical aerial photographs and topographic maps was conducted to gain a better understanding of general historical uses of the facility property. Historical aerial photos and topographic maps are presented in Appendix 2A. Based on 1936 and 1946 aerial photos, it appears that three warehouse buildings were situated on the facility property prior to the mid-1940's. By 1946, the three warehouses had been replaced by a single structure in the approximate location of the present main facility warehouse. In a 1956 aerial photo, what is considered the processing area and north field appear vacant, although the west field storage area shows some activity. The 1956 aerial photo also shows the present warehouse building with an extension to the north and a room added along the west/southwest side, which PSC believes was a paint mix tank room (Chempro, 1988a).

2.2.2 1950s to 1970s

The former owner, PPC, used the facility property as a distillation plant for reclaiming waste solvents and manufacturing paints, as well as alkyd and latex resins, from approximately 1958 to 1970. The process still area, which was located along the eastern property boundary, was constructed by approximately 1959. Between 1958 and 1965, PPC installed 22 underground storage tanks (USTs) in north field and two USTs in an area to the south and east of the warehouse, respectively. PPC used these tanks for the storage of substances such as thinners, solvents, and mineral spirits until 1970. A 1969 aerial photo shows the process still area and north and west fields in use, with boundaries very similar to those of the facility's present configuration. For an unknown period of time between 1958 and 1970, another company, Wood Beautifiers Inc.[1], also used the west field for staining wood shakes and shingles and for storage of wood stains, thinners, solvents, and mineral spirits (Chempro, 1988a).

2.2.3 1970 to 1990

From 1970 to approximately 1986, the facility was used for storage, solvent recycling, and treatment of dangerous wastes by processes including, but not limited to, electrolytic destruction of cyanide, distillation, and blending of dangerous waste fuel. Alkyd resins were also manufactured at the facility until the early 1980's. Until approximately 1980, portions of the facility's warehouse were subleased for product storage by other companies such as PPC, Loomis Chemical, and Cargill. In addition, PPC also used the USTs and other outdoor container storage areas on the east side of the facility until approximately 1980 (Chempro, 1988a).

According to facility records, the west field apparently was inactive from 1970 to 1975. In 1975, the west field was covered with surface soil and gravel rock fill then the area was used for drum storage. In 1980, this area became the staging area for incoming and outgoing drums and for bulk liquid waste storage. In 1982, the west field was paved with asphalt (Chempro, 1988a). Between 1970 and 1981, the north field was used for drum storage. The north field was partially paved with concrete between 1974 and 1981, and was fully paved in 1982.

Between 1970 and 1987, the 24 on-site USTs were used to store solvents, cyanides and other materials. In 1987, all 24 USTs were removed in accordance with applicable regulations. Documents associated with tank removal activities, including a removal work plan, tightness certification, laboratory analytical results and photos of the tank removal, are presented in Appendix 2B. Prior to the tank removal in the autumn of 1987, 22 (A-O, 1-7) of the 24 tanks at the facility were tested for tightness. All tanks with the exception of Tank B, which held

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[1] Wood Beautifiers Inc. may have been an affiliate of PPC, but this relationship has yet to be confirmed.

solvent, and Tank N, which held cyanide waste, were certified tight. During the excavation of Tank N, fill lines were severed and approximately one-quarter gallon of liquid containing 500-1000 parts per million (ppm) cyanide leaked from the lines onto surrounding soil. The impacted soil was excavated during the removal of Tank N, and drummed for proper disposal. Samples of visibly impacted soil from the excavation of Tank N were analyzed for volatile organic compounds (VOCs) and cyanide. 1,1-Dichloroethane, trans-1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, toluene, ethylbenzene, styrene, and xylenes were detected in soil and groundwater samples, while 1,2-dichloroethane and 4-methyl-2-pentanone were also detected in groundwater in the area of the excavation. Detected cyanide concentrations in groundwater ranged between 8 and 13 ppm. Less than one cubic yard of soil contaminated with a "tar-like" substance was also excavated during the removal of Tank N and drummed for proper disposal. Soil samples collected during the removal of Tanks 8 and 9 showed toluene, ethylbenzene and xylene concentrations ranging between 1,500 and 3,500 ppm and chlorinated VOC concentrations less than 10 ppm. Several soil samples were also collected from the excavation for Tanks 1-7. Acetone, 1,1,1-trichloroethane, tetrachloroethene, 4-methyl-2-pentanone, trichloroethene and trans-1,2-dichloroethene were detected in soil from this excavation. Excavated tanks were brushed clean, inerted with carbon dioxide (CO_2) and sent to the PSC Tacoma facility for proper decommissioning.

2.2.4 1990 to present

In 1991, the facility was issued a RCRA Part B Permit to manage hazardous waste. EPA and Ecology issued the permit jointly. As a part of this Part B Permit, the facility was required to complete upgrades to facility process units and containment to prevent releases to the environment. The company completed these upgrades by 1993, which included a microsilica concrete cap on the entire facility, concrete berms around all containers and a self-contained stormwater management system.

Over the years, the number of processes occurring at the facility decreased substantially. Some processes are not well documented because they were phased out or closed prior to the issuance of the facility's final permit. However, changes that occurred while the facility had a RCRA permit have been documented. The distillation process was shut down in February 1996 and cyanide treatment was discontinued at the facility in March 2000. Oxidation treatment and fuel blending were the only two processing operations at the facility from March 2000 to December 2002. In December 2002, PSC provided Ecology with a notice of intent to close the facility and the facility ceased all operations and hazardous waste processing activity. The facility completed above-ground closure requirements in 2003. Ecology accepted and approved PSC's above-ground clean closure certification in August 2003.

2.3 *Regulatory History*

The facility was regulated by RCRA for both operations and cleanup. RCRA is the primary federal legislation that applies to prospective or future hazardous waste management and addresses historical contamination from hazardous waste operations. An amendment to the 1965 Solid Waste Disposal Act, RCRA was promulgated in 1976 to ensure the safe management and disposal of huge volumes of municipal and industrial solid waste generated nationwide. RCRA has undergone multiple amendments including the HSWA of 1984 that expanded the scope and requirements of RCRA. Subtitle C of RCRA established a program for handling wastes from "cradle to grave." Under Subtitle C, owners or operators of hazardous waste management facilities are required to submit a permit application covering all aspects of the design, operation, maintenance, and closure of the facility. The permit application has two parts, the first of which, Part A, covers general information about the facility. The second part, Part B, includes highly detailed and technical information about facility operations and outlines the requirements of the cleanup process at the RCRA facility.

The corrective action regulatory history of the facility can be summarized as follows.[2]

- August 1980: A notification of hazardous waste activity, identifying the company as a generator and owner/operator of a treatment, storage or disposal (TSD) facility, was submitted to EPA, as an initial requirement for the subsequent "interim status" filing under RCRA.

- November 1980: A RCRA Part A permit application, identifying wastes handled at the facility to include solvents, cyanides, acids and alkaline materials, waste fuel oils, and polychlorinated biphenyls (PCBs), was submitted to EPA. The facility was automatically grandfathered into the RCRA Program, giving the facility Interim Status under RCRA Part 265.

- Early 1988: the company initiated meetings with EPA to begin the process of meeting the requirements of the Revised Off-Site Policy under the Comprehensive Environmental Response, Liability and Compensation Act (CERCLA), which required that facilities receiving CERCLA remediation waste must undergo a RCRA Facility Assessment (RFA) or be subject to a corrective action order under RCRA §§ 3008(h) or 3013, before receiving waste from a Superfund site. As a result of these meetings, an RFA was scheduled for the facility, and the company commenced negotiations with EPA for a corrective action order under § 3008(h), which required the company to submit the initial proposals for sampling and analysis of environmental media at the facility.

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[2] As noted previously, the name PSC or the "company" will be used in reference to the company regardless of the time period referenced in this historical summary to avoid confusion. Although the name of the company has changed from time to time with ownership by different parent companies, i.e., Burlington Resources, Philip Environmental Inc., Philip Services Corporation, the legal entity has not been modified or merged out of its original legal existence, nor has the facility itself changed ownership.

- September 1988: EPA issued a 3008(h) order for the facility. This order formalized the company's interim status corrective action responsibilities under RCRA. This corrective action order required the company to complete an initial RCRA Facility Investigation (RFI). The company completed the RFI and the results of this study were summarized in the Phase II Hydrogeologic Investigation Report (SE/E, 1989b).

- October 1988: The company submitted its completed RCRA Part B permit application to EPA for review and comment (Chempro, 1988b).

- August 1991: A RCRA Part B permit (Permit No. WAD000812909) was issued jointly by EPA and Ecology, which contained HSWA 3004(u) and (v) corrective action requirements. This permit required an off-site RFI and interim measures, and provided steps for cleanup and compliance monitoring. PSC installed the first interim measure at the facility in 1994 and RFI activities have been ongoing since 1991.

- June 1994: PSC requested a permit modification to the corrective action portion of the Part B permit GT-MOD 5-4 (BEI, 1994b). The approved modification changed the groundwater monitoring program as presented in Section VII.B.1. of the RCRA Part B Permit.[3]

- February 1995: PSC requested a permit modification for groundwater monitoring at the facility GTMOD 29-2 (BEI, 1995). This approved modification changed the groundwater monitoring program as presented in Section VII.B.1. of the RCRA Part B Permit, and reduced the number of analytes, the number of wells, and the frequency at which wells are sampled as described in the July 1992 Pre-Corrective Action Groundwater Monitoring Plan (BEI, 1992a).

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[3] Modifications that are not discussed here, such as 1-4 and 6-28, were operational permit modifications.

- May 2000: PSC requested a permit modification, GTMOD-38-3, related to corrective action (PSC, 2000d). The permit modification included revised RCRA permit language, an updated schedule for corrective actions, more refined RFI/ Corrective Measures Feasibility Study processes, and a framework for considering new remediation technologies. EPA redrafted the Draft Permit Modification in January 2001 and this document was eventually finalized as the revised Section VII of the Permit (EPA, 2001a).

- August 2001: PSC submitted groundwater monitoring permit modification request GTMOD-43-2 to EPA (PSC, 2001h). This permit modification proposed to remove some wells from the permit-required monitoring well network, add some monitoring wells to the network, modify the analytical requirements, and change the frequency of sampling and water level elevation measurements. This modification was approved by EPA on November 27, 2001 (EPA, 2001b).

- February 2002: PSC submitted permit modification request GTMOD-45-1 to EPA (PSC, 2002a). This permit modification request proposed to address data gaps from the Draft Comprehensive RCRA Facility Investigation Report (PSC, 2001f) by gathering more chemical and hydrogeological data, analyzing the data, validating the data, and interpreting the data to characterize the facility and surrounding area according to RCRA and MTCA guidelines and to support a well documented risk assessment. As such, PSC also requested that the Final Comprehensive RFI Report be submitted to the agency on October 31, 2003. This permit modification was merely allowed sufficient time for PSC to submit a Class 2 permit modification for this schedule extension and was proceeded by permit modifications GTMOD-47-1 and GTMOD-48-2.

- February 2002: PSC submitted an Ecology pre-approved permit modification request GTMOD-46-1 to EPA (PSC, 2002b). This permit modification request proposed to modify the permit-specified schedule for the Final Groundwater Interim Measure Work Plan, specifically related to the revision of the Draft Groundwater Interim Measures Work Plan requested by EPA in a letter dated June 28, 2001. The Draft Interim Measures Work Plan (PSC, 2001g) included three different groundwater interim measures: a groundwater beneficial use study, an interim measure protective of the groundwater to indoor air pathway (inhalation pathway), and a hydraulic control interim measure. Each of these interim measures required more detailed work plans or reports under separate cover. This permit modification request proposed the schedule for the next deliverable for each of these interim measures.

- March 2002: EPA delegated to Ecology the authorization under RCRA section 3006(b), 42U.S.C. 6926(b) to implement RCRA requirements at RCRA facilities in the State of Washington, including HSWA requirements for corrective action. EPA and Ecology agreed to establish a transition schedule for lead agency authority for corrective actions at the facility from EPA to Ecology. EPA retained corrective action authority for the facility until 2001 when final authority was delegated to Ecology for administration under MTCA. This permit language and subsequent modifications are provided in Appendix 2C.

- April 2002: PSC submitted a permit modification request GTMOD-47-1 to Ecology (PSC, 2002f). This permit modification was pre-approved by Ecology on April 8, 2002 (via email). This permit modification request proposed a 60-day extension on the due date of the Revised Draft RI report. During the 60-day extension, PSC would submit a Class 2 permit modification request for an extension on the due date of the Final Comprehensive RI Report. The Class 2 permit modification would include a detailed rationale for the time required to fill the identified data gaps.

- April 2002: PSC submitted a permit modification request GTMOD-48-2 to Ecology (PSC, 2002g). This permit modification request proposed to modify the time required to submit quality-assured data to Ecology under the quarterly corrective action progress reports. In addition, this modification request proposed to modify the permit-specified schedule for the Final Comprehensive Remedial Investigation Report, because of data gaps identified by PSC, EPA, and Ecology, that are required to be filled prior to finalizing this document. This permit modification was approved with conditions on August 23, 2002. Ecology's conditions included adding interim measure language and due dates for the Hydraulic Control Interim Measure and the Inhalation Pathway Interim Measure to the corrective action section of the permit along with the revised due date for the RI of October 31, 2003.

- April 2002: PSC submitted a permit modification request GTMOD-49-1 to Ecology (PSC, 2002h). This permit modification request proposed to modify the permit-specified schedule for providing financial assurance for corrective action until June 30, 2002 because of economic conditions. This permit modification was pre-approved by Ecology on April 15, 2002.

- June 2002: PSC revised the Pre-Corrective Action Monitoring Plan (PCAMP) (PSC, 2002). This plan provided a sampling and analysis plan for the Pre-Corrective Action Groundwater Monitoring Program, which is required under Permit Condition VII.B. The plan was updated to include 55 new monitoring wells installed in 2002 and to update the analytical requirements and sampling frequency. This plan also included an updated Quality Assurance Project Plan. Ecology approved this permit modification in August 2002.

- June 2002: PSC submitted a permit modification request GTMOD-50-1 to Ecology (PSC, 2002i). This permit modification was pre-approved by Ecology on April 19, 2002. This permit modification request proposed to modify the PCAMP by abandoning monitoring well CG-7-S1. The well integrity of well CG-7-S1 was poor and was not in compliance with state well maintenance regulations. Permit condition VII.H.4. assumes that a new well will replace the abandoned well. However, no well was installed to replace CG-7-S1 because EPA and Ecology already approved the discontinuation of chemical sampling at CG-7-S1.

- June 2002: PSC submitted a permit modification request GTMOD-51-1 to Ecology (PSC, 2002k). This permit modification was pre-approved by Ecology on June 27, 2002 (via email). This permit modification request proposed to modify the PCAMP after PSC implemented permit modification GTMOD-43-2, which added 54 new monitoring wells to the PCAMP. However, seven of the proposed wells in GTMOD 43-2 were unable to be installed at that time because of access problems. In addition, Sections VII.B.2 and VII.G.4 and VII.G.5 were modified to make the requirements for Appendix IX sampling consistent throughout the permit.

- June 2002: PSC submitted a permit modification request GTMOD-53-1 to Ecology (PSC, 2002l). In April 2002, PSC requested an extension on the due date of the Final RI report to June 23, 2002 in permit modification GTMOD-47-1[1]. The purpose of that extension request was to allow PSC time to submit a Class 2 permit modification, GTMOD-48-2, to formally submit this extension request to the public for comment and to allow for a public meeting and agency review. On June 20, 2002, PSC received a request from Ecology to request an extension on the due date of the Final RI Report to August 2, 2002 to allow Ecology more time to review public comments on this Class 2 GTMOD-48-2. Therefore, PSC submitted that request as permit modification GTMOD 53-1[1].

- July 2002: EPA terminated the 3008(h) Order for the facility (EPA, 2002).

- August 2002: PSC submitted a permit modification request GTMOD-52-1 to Ecology (PSC, 2002m). This permit modification request proposed a revision of the Financial Assurance for Corrective Action Language in Section VII.J of the permit. This permit modification was pre-approved by Ecology on June 27, 2002. However, Ecology later made comments on the permit modification and the modification was re-submitted to Ecology in May 2003.

- November 2002: PSC submitted a permit modification request GTMOD-57-1 to Ecology (PSC, 2002o). This permit modification was pre-approved by Ecology on November 8, 2002. This permit modification request proposed a change to the PCAMP by changing all Total Petroleum Hydrocarbon – Diesel Extended Range (TPH-Dx) and Total Petroleum Hydrocarbon – Gasoline Extended Range (TPH-Gx) analyses to Extractable Petroleum Hydrocarbon (EPH) and Volatile Petroleum Hydrocarbon (VPH) analysis at all wells where TPH analysis were required. EPA and Ecology requested that PSC implement this change, because a risk evaluation can use EPH/VPH data but not TPH data.

- December 2002: PSC notified Ecology of its intent to close RCRA permitted operations at its Georgetown Facility. The facility then followed its approved Closure Plan to comply with RCRA above-ground closure requirements. PSC received the last waste shipment into the facility in December 2002.

- December 2002: PSC notified EPA of its intent to close Toxics Substances Control Act (TSCA) permitted operations at the facility. The facility also submitted a revised Closure Plan, because new TSCA regulations had been instituted since the original Closure Plan was prepared (PSC, 2002p and 2002q).

- January 2003: PSC submitted permit modification request GTMOD-58-1 to Ecology (PSC, 2003a). This permit modification request proposed to revise the date for Inhalation

Pathway Interim Measure (IPIM) Technical Memorandum #2, due December 31, 2002. PSC requested the modification because IPIM Technical Memorandum #1, submitted on time in November 2002, was still under review by Ecology at that time, and it would be preferable for the Ecology to comment on the first memorandum prior to PSC's submittal of the second. Ecology pre-approved this modification in a letter dated December 31, 2002. The new due date was established for a date twenty-one (21) days after the due date of PSC's revised IPIM Technical Memorandum #1. This permit modification was pre-approved by Ecology on December 31, 2002.

- February 2003: The revised TSCA Closure Plan was approved by EPA and PSC mobilized to begin field work in March (EPA, 2003a).

- May 2003: PSC re-submitted permit modification request GTMOD-52-1 to Ecology (PSC, 2003d), after incorporating Ecology's comments on the initial submittal. This permit modification request proposed a revision of the Financial Assurance for Corrective Action Language in Section VII.J of the permit. This permit modification was pre-approved by Ecology on April 29, 2003 (via email).

- June 2003: PSC submitted permit modification request GTMOD-59-1 to Ecology. This permit modification request proposed to revise the analyte list, the wells sampled for each analyte, and the sampling frequency described in the PCAMP (PSC, 2002i). The PCAMP proposed a fixed sampling and analysis schedule for one year beginning in May 2002, after which time the required analytes and sampling locations would be re-evaluated. On April 28, 2003, PSC re-evaluated the sampling and analysis schedule and proposed changes to Ecology. On May 8, 2003, Ecology pre-approved changes to the PCAMP sampling and analysis schedule.

- July 2003: PSC submitted permit modification request GTMOD-60-1 to Ecology (PSC, 2003g). This permit modification was pre-approved by Ecology on July 29, 2003. This permit modification request proposed to abandon some wells because they were either within the HCIM subsurface barrier wall alignment or so close to the proposed wall alignment that they would be damaged by the construction of the wall. In addition, based on Ecology's recommendations, PSC replaced well CG-140-WT with a new well CG-140-30. Well CG-140-WT will only be used for water levels and well CG-140-30 will be used for groundwater chemical sampling and water levels. PSC has also added well CG-151-25 for hydrological uses only.

- July 2003: PSC submitted RCRA certification of clean above-ground closure at the Georgetown Facility to Ecology meeting the requirements in the approved Closure Plan (PSC, 2003h).

- July 2003: PSC submitted TSCA certification of clean above-ground closure at the Georgetown Facility to EPA meeting the requirements in the approved Closure Plan (PSC, 2003k).

- August 2003: PSC submitted permit modification request GTMOD-61-1 to Ecology (PSC, 2003i). This permit modification was pre-approved by Ecology on May 19, 2003. This permit modification request proposed to replace the SVE system blower type and air treatment method from that described in the July 2, 1993 Interim Measures Design and Implementation Work Plan. It also replaces that work plan with a revised SVE Operation and Maintenance/Sampling and Analysis Plan dated July 25, 2003.

- August 2003: Ecology approved PSC's certification of clean RCRA above-ground closure for the facility (Ecology, 2003).

- September 2003: EPA approved PSC's certification of clean TSCA above-ground closure for the facility (EPA, 2003b).

2.4 *Corrective Action History*

Corrective actions have been implemented at the facility under the conditions of the 3008(h) order issued in 1988 and the facility's Part B permit. Under the current permit corrective action requirements, PSC is obligated to conduct an RI, FS, and implement a remedy or combination of remedies that address contamination at the facility and other related impacted areas. This section describes the corrective action activities that have occurred to date.

2.4.1 Solid Waste Management Unit Report (RCRA Facility Assessment)

A SWMU Report prepared for EPA in July 1988 (Chempro, 1988a) identified 37 SWMUs that were closed prior to 1988. Table 2-1 lists the SWMUs identified in the 1988 report and includes the period of use and all of the types of waste found within each unit. Figure 2-1 shows the location of all 37 SWMUs. Other chemical storage and handling areas that were not identified in the SWMU Report include the former cyanide treatment area, closed in 2000, the former acid/base storage area and the former distillation area, closed in 1996. These areas are also shown in Figure 2-1.

2.4.2 Documented and Undocumented Releases

2.4.2.1 *Documented Spills and Releases*

Documented spills and releases at the facility are summarized in Table 2-2. Release and spill documentation prior to 1990 is not likely to be as reliable as post-1990 documentation because of stricter reporting requirements under environmental legislation passed in the late 1980s, i.e., the Emergency Planning and Community Right-to-Know Act (EPCRA). Between 1991 and 1993, the entire facility was capped with concrete, and a storm water management system was installed to ensure complete containment of any future releases.

2.4.2.2 *Potential Undocumented Releases*

In addition to documented spills and releases, undocumented releases may have occurred at the facility. Between approximately 1958 and 1980, the west field was used for staining wood shakes and shingles, storage of stains, thinners, solvents, mineral spirits and non-processable wastes, but the area was not paved until 1982. Releases from the drums and tanks may have occurred due to container failures or operational error resulting in possible releases to the environment prior to paving of the west field.

Two USTs south and east of the warehouse, respectively, and 22 USTs in the north field were installed on the facility between 1958 and 1965. The USTs were used by the PPC to store materials such as thinners, solvents, and mineral spirits prior to 1970 and by Chemical Processors to store solvents, cyanide and other materials between 1970 and 1987. Other than the two documented releases that were contained and soil contamination that was removed during tank decommissioning in 1987, releases from the tanks may have occurred because of leaks in the tanks and piping, and operational error during the years of active use.

In the past, the on-site furnace used Therminol ®, an insulating oil product, which while in use, contained PCBs. A furnace fire in early 1974 may have resulted in PCB contamination in soils surrounding the furnace. Residual liquid may also have been released during the replacement of the furnace (Chempro, 1988a).

Further undocumented releases may have occurred during container handling operations and during transfer operations between trucks, tanks, and rail cars prior to paving and prior to the passage of EPCRA legislation.

2.4.3 Previous Environmental Investigations

The following is a summary of significant environmental investigative work that has been completed at the facility. The work has been described in a number of reports, which are summarized below. Full references to these reports are provided at the end of this section and the actual reports are available at EPA Region 10, Ecology's Northwest Regional Office, and at the public repository located at the Georgetown Gospel Church. A more thorough explanation of the methodologies implemented and the data are provided in Sections 4.0 and 7.0 of this report, respectively.

An Evaluation of Groundwater Contamination at the Chemical Processors Inc. Georgetown Facility (Harper Owes and Hart Crowser, 1983)

The purpose of this report was to determine whether chemicals from the facility were migrating downgradient of the facility, although no downgradient wells were installed. In July and September 1982, nine monitoring wells, G-1 through G-9, were installed in the shallow aquifer at the facility. An additional ten monitoring wells, HC-1 through HC-10, were installed in December 1982 and January 1983 facility. Seven of those wells were screened in the shallow aquifer, two wells were screened in the intermediate aquifer (HC-1 and HC-10) and one well was screened in the silt unit (HC-9). These two sets of wells were abandoned in 1989.

Solid Waste Management Unit Report (Chempro, 1988a)

PSC prepared a Solid Waste Management Unit (SWMU) Report in response to a request for information from EPA regarding potential releases of hazardous waste from closed SWMUs. This report contains a detailed history of operations at the facility from 1958 to 1988, lists releases that have occurred at the facility and describes the chemicals stored at the facility.

Phase I Hydrogeologic Investigation (SE/E, 1988)

A Phase I Hydrogeologic Investigation was performed as a part of the property transfer from the company to BEI. In November and December 1987, three soil borings were completed as two deep monitoring wells screened at 98 feet below ground surface below ground surface (bgs) (CG-1 and CG-2), and one shallow monitoring well screened at 30 feet bgs (CG-3). Soil and groundwater samples were collected during the installation of these wells. Two of these wells still exist at the facility and the chemical data are summarized in Section 7.0.

Phase II Hydrogeologic Investigation (SE/E, 1989b)

A Phase II Hydrogeologic Investigation was performed as a part of the RFI completed to satisfy the EPA consent order issued under Section 3008(h) of RCRA. The goal of the study was to complete the hydrogeologic and hydrogeochemical investigation of the facility initiated in previous studies. Wells installed during previous studies (G-1 through G-4 and G-7 through G-9, HC-4 through HC-6, and HC-8) were abandoned because of placement near fences, walls, and other obstructions. Twenty-nine new boreholes were drilled to characterize the subsurface environment including two deep (TB-1D, TB-5D), four intermediate (TB-5I, TB-7I, TB-10I, TB-13I) and 23 shallow borings (TB-1S through TB-14S, including two borings each at TB-3, TB-4, TB-5, TB-7, TB-8, TB-10, TB-11, TB-13 and TB-14). The borings were completed as monitoring wells for a total of 24 locations including two in the deep aquifer (CG-4-D, CG-5-D), four in the intermediate aquifer (CG-1-I, CG-2-I, CG-5-I, CG-9-I) and 16 in the shallow aquifer (two each at CG-1-S, CG-2-S, CG-5-S, CG-6-S, CG-7-S, CG-8-S, CG-10-S, CG-11-S). Many of these wells still exist at the facility. A beneficial groundwater use survey was conducted for the area within one-half mile of the facility. No drinking water wells were identified. Furthermore, 58 potential hazardous waste sites were identified within one-half mile of the facility.

Phase III Hydrogeologic Investigation (Off-Site RFI) (SE/E, 1991)

A Phase III (off-site) Hydrogeologic Investigation Work Plan was submitted as the first requirement of the facility Part B Permit. The purpose of the Phase III Hydrogeologic Investigation was to define the nature and extent of potential contamination in soils and groundwater upgradient, crossgradient, and downgradient of the facility, meeting the final requirements of the 3008(h) consent order. Throughout the Phase III activities since the third quarter 1992, all monitoring wells have been sampled quarterly. The Phase III activities have been described in a number of reports summarized below.

Semi-Annual RFI Progress Reports - February and August 1992 (BEI, 1992b/c)
Hand-augered soil samples were collected at 35 locations, and combined into 26 composite samples. A soil gas survey was conducted in 1991 in an attempt to delineate the extent of the groundwater plume migrating from the facility. Soil gas samples were collected from four locations on the facility and 21 locations that were upgradient and downgradient of the facility. A 72-hour shallow aquifer pumping test was conducted using the soil vapor extraction system pilot test wells.

Semi-Annual RFI Progress Reports - February and August 1993 (BEI, 1993a/b)
Monitoring wells CG-101 through CG-105 and CG-111 were installed and sampled. Five hand-augered soil samples were collected. Groundwater samples were collected from temporary wells at 17 locations upgradient, crossgradient and downgradient of the facility.

Georgetown Sewer Investigation Summary and Discussion of Potential Sources of Contamination at CG-102 Off-Site Well (BEI, 1993c)
The sewer lines running under Lucile Street and Denver Avenue were surveyed and deemed not to be a potential source of the VOC concentrations observed in monitoring well CG-102. Several USTs that had been used to store process materials at the current location of PPC on Airport Way, directly upgradient of well CG-102, were identified as potential sources of VOCs detected in well CG-102.

Semi-Annual RFI Progress Report - February 1994 (BEI, 1994a)
Twenty shallow groundwater samples were collected from direct-push temporary well locations outside the facility (RW-1 through RW-20). The results of this

sampling indicated that a contaminant plume containing volatile organic compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX) and chlorinated solvents, may be migrating from the vicinity of the current facility located directly to the east of the facility.

Semi-Annual RFI Progress Report - August 1996 (PSC, 1996)

Stormwater flow was measured at four locations along Denver Avenue South and South Lucile Street during dry, moderate rain, and heavy rain conditions to determine if the sewer was leaking to groundwater causing dilution and affecting near-surface flow. The results of the study gave no indication that the sewer was leaking to groundwater.

Semi-Annual RFI Progress Reports - February and August 1997 (PSC, 1997a/b)

Light nonaqueous-phase liquid (LNAPL) was intermittently detected in monitoring wells CG-6-S1, CG8-S1, and CG-11-S1. These wells were investigated during August, September, October, and November of 1996 for LNAPL, but no LNAPL was found.

Off-Site Hydropunch Investigation Report (PSC, 1998b)

As part of the Phase III Hydrogeologic Investigation, an Off-Site Hydropunch Investigation was conducted to determine the extent of impacted groundwater downgradient of the facility. After determining the extent of impacted groundwater, more permanent monitoring wells would be proposed per the Phase III Work Plan. The investigation was performed using a Geoprobe® direct-push sampling tool at 23 groundwater sampling locations downgradient of the facility. At each location, groundwater samples were collected from the assumed top of the shallow aquifer at approximately 15 feet bgs, the bottom of the shallow aquifer at approximately 30 feet bgs, the middle of the intermediate aquifer at approximately 45 feet bgs, the bottom of the intermediate aquifer at the silt aquitard at 60 feet bgs, and at 75 feet bgs if the aquitard was not encountered. Soil borings were installed in an attempt to identify to the depth of the bottom of the intermediate aquifer at six off-site locations to the west of the facility in order to characterize subsurface lithology. Downgradient of the facility, the surface elevation of the silt unit appeared to dip toward the Duwamish River with increasing distance from the facility. The surface of the silt unit was encountered at approximately 64 and 66 ft bgs in borings B4 and B6, respectively, but was not encountered in any other boring completed during this investigation.

North Field Intermediate Well Installation (PSC, 1999a)

As an addendum to the Phase III Hydrogeologic Investigation, two new intermediate wells (CG-11-I and CG-12-I) were installed in the north field to improve intermediate aquifer groundwater contours. The additional information provided by the installation of these wells indicated that groundwater in the intermediate aquifer flows approximately to the west rather than the southwest.

Off-Site Soil Gas Study Results Technical Memorandum (PSC, 2000a)

As outlined in the RFI Addendum Scope of Work and the Off-Site Soil Gas Sampling and Analysis Plan (PSC, 1999c), 16 soil gas and soil samples were collected to determine whether concentrations of volatile chemicals in soil gas could potentially pose a risk to human health via migration of soil gas into indoor air of local buildings. Detected VOC concentrations were used as input to an EPA-recommended vapor intrusion model (Johnson and Ettinger, 1991) to estimate potential indoor air concentrations.

Technical Memorandum Pumping Test Analysis - Shallow Aquifer (PSC, 2000b)

In March 1992, short-term and long-term pumping tests were conducted to estimate the average horizontal hydraulic conductivity and specific yield of the shallow aquifer at the facility. The purpose of this technical memorandum was to provide a more thorough analysis of the data set in the same manner that that intermediate aquifer pumping test was analyzed.

Technical Memorandum, Pumping Test Analysis - Intermediate Aquifer (PSC, 2000c)

In December 1999, short-term and long-term pumping tests were conducted to estimate the average horizontal hydraulic conductivity and specific yield of the intermediate aquifer at the facility. Drawdown and recovery were monitored and analyzed using the Hantush and Theis methods, and the Theis recovery method, respectively.

Groundwater Model Conceptual Site Model Report (PSC, 2000e)

The conceptual model describes the local hydrogeological parameters that were proposed to be used in a numerical flow model, using Visual MODFLOW®. The purpose of the model was to predict current and future groundwater and contaminant migration prior to the implementation of a remedial action for the purpose of evaluating remedial alternatives.

Groundwater Model Calibrated Model Report (PSC, 2000f)

This report presents the implementation of the conceptual site model for groundwater flow at the facility and in the surrounding area. The numerical simulations were performed using Visual MODFLOW® were conservatively calibrated and were validated.

Indoor Air Analysis Report (PSC, 2000g)

Indoor air samples were collected from the basements of two residences immediately downgradient of the facility to substantiate the results of the vapor intrusion model constructed as part of the Off-Site Soil Gas Survey. Additional soil gas, ambient air, and groundwater samples were collected concurrently to verify the source of any compounds detected in indoor air. The Washington State Department of Health (DOH) and EPA conducted indoor air sampling at the same residences as well as two local businesses shortly after PSC's sampling event, and found no immediate health concerns.

Groundwater Model Sensitivity Analysis Report (PSC, 2001)

A sensitivity analysis of the calibrated groundwater model was performed to show the sensitivity of the model output to small changes in model parameters. The most sensitive parameters were determined to be five hydraulic conductivity zones, two net recharge rates, four runoff recharge rates and one groundwater influx rate. The report also provides ranges of values for these parameters for which the model maintains sufficient calibration.

Technical Memorandums I-VI, Supplemental Off-Site Characterization (PSC, 2000i/k/l, 2001a/b/c)

The supplemental characterization was conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h) and was completed as two investigations: the Nature and Extent Investigation, which attempted to delineate the groundwater plume downgradient of the facility between approximately Denver Avenue and East Marginal Way, and the Source Area Investigation, which sought to characterize the presumed source of impacted groundwater near the facility. A total of 66 direct push borings were installed as part of the Nature and Extent Investigation in an attempt to define the nature and extent of the groundwater plume. At these locations, 168 discrete groundwater samples were collected at depths ranging from 10 ft bgs to 90 ft bgs. In addition, 38 direct push borings were installed close to the facility during the Source Area Investigation. At these locations, 263 discrete groundwater samples were collected at depths ranging from 10 ft bgs to 90 ft bgs. In addition, three borings (F16, F7 and B9) were logged to determine the depth of the silt confining layer. Boring F7 identified the silt layer at approximately 120 feet bgs.

Semi-Annual RFI Progress Report - February 2001 (PSC, 2001e)

As part of the requirements of the Soil Gas Sampling and Analysis Plan (PSC, 1999c), all wells with more than six inches of silt accumulation in the bottom were redeveloped. This included all four SVE wells. There were no VOCs detected in air samples from the SVE wells prior to or following well development indicating that the low productivity of the SVE system is not due to clogged well screens. Five permanent soil gas sampling ports, two shallow groundwater-monitoring wells, and two permanent soil moisture probes were installed along Denver Avenue South.

Technical Memorandum, Soil Gas Investigation, March 2001 Results (PSC, 2001d)

Groundwater and soil gas samples were collected just outside of five residences located within the known extent of the groundwater plume. The DOH collected indoor air samples at each of these residences concurrently. Two outdoor air samples were also collected to serve as background concentrations. The DOH report on indoor air sampling was not available at the time this report was prepared.

Draft Comprehensive RCRA Facility Investigation Report (PSC, 2001f)

This report summarized all data collected at the PSC Georgetown Facility, but emphasized the most recent data, which included the data collected as part of the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h) in the downgradient area between Denver Avenue South and East Marginal Way South.

Draft Human Health and Ecological Risk Assessment (FW, 2001)

The human health risk assessment showed that the pathway of highest concern was the inhalation pathway (contaminants in groundwater migrating into indoor air) and the receptor of highest concern was the on-site or off-site trench worker. The ecological risk assessment concluded that chemicals detected in soil would not be an ecological concern to terrestrial wildlife. It also concluded that chemicals detected in soil and groundwater would likely not reach the Duwamish Waterway.

Final RFI Well Installation Work Plan (PSC, 2001j)

Additional characterization of groundwater downgradient of the facility was proposed by PSC in the Draft RFI Report, and requested by EPA in its comments on that report, , which led to the creation of this work plan. The work plan was finalized based on EPA's comment letter dated October 26, 2001. In the final work plan, PSC proposed to install 55 new monitoring wells downgradient of the facility in three aquifer zones. The well locations were chosen based on chemical data from direct push locations in the area. In addition 13 soil borings were proposed for lithological logging and geotechnical soil sampling. The completion of these wells and the results of sampling those wells are provided in this RI.

Technical Memorandum VII: Proposed Locations for the Supplemental Off-Site Groundwater Characterization (PSC, 2001k)

This memorandum proposed 16 additional groundwater sampling locations downgradient of the facility based on results of the previous phases of nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h). The purpose of the new locations was to further characterize areas where potential non-PSC sources may be impacting groundwater and to investigate groundwater in the area west of East Marginal Way South.

Draft Natural Attenuation Monitoring Plan (PSC, 2002c)

This plan describes a voluntary groundwater sampling effort to gather geochemical and biological data from the facility and surrounding areas to support fate and transport discussions in the final remedial investigation report. In addition, these data may be used in the feasibility study as evidence to support the use of monitored natural attenuation as part of the final remedy for the facility. The results of natural attenuation sampling are provided in this RI.

Technical Memorandum VIII: Results of the Supplemental Off-site Groundwater Characterization and Proposed Monitoring Well Locations for the facility (PSC, 2002e)

This work was part of the nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h). This memo summarized the results of direct push groundwater samples collected as part of the Technical Memorandum VII proposal. The data were used to propose permanent monitoring well locations west of East Marginal Way in support of the RFI Well Installation Work Plan.

Technical Memorandum IX, Proposed Sampling Locations for the Supplemental Off-Site Groundwater Characterization (PSC, 2002n)

This memorandum was prepared as part of the nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h). The memo identified data gaps made apparent by the sampling results summarized in Technical Memorandum VIII, and proposed additional work to fill the data gaps. Five direct push boring locations sampled at multiple intervals were proposed. In addition, the installation of another boring near well nest CG-140 was also proposed to verify that the wells in the CG-140 nest are screened in the most contaminated zone of the shallow aquifer.

Technical Memorandum X: Proposed Sampling Locations for the Supplemental Off-Site Groundwater Characterization (PSC , 2003b).

This work was part of the nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h). This document provided the data from the Technical Memorandum IX field work and proposed two new direct push groundwater sampling locations that assisted PSC in filling chemical data gaps in the shallow aquifer near direct push location Q32.

Technical Memorandum XI, Supplemental Off-Site Characterization, Proposed Sampling Locations for the Supplemental Off-Site Groundwater Characterization (PSC, 2003c)

This work was part of the nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000). This document proposed ten new direct push groundwater sampling locations that assisted PSC in filling chemical data gaps in the shallow aquifer related to the inhalation pathway interim measure.

Technical Memorandum XII, Supplemental Off-Site Characterization (PSC, 2003f)

This work was part of the nature and extent characterization conducted in accordance with the Final Supplemental Off-Site Groundwater Characterization Work Plan (PSC, 2000h). This document provides the data from the Technical Memorandum XI field work. The purpose of the work was to characterize areas lacking adequate groundwater characterization data, based on the results of the Technical Memorandum I: Inhalation Pathway Interim Measure (FW, 2003) to proceed with the

Tier 1 and Tier 2 evaluations.

2.5 *Interim Measures History*

PSC currently has three interim measures are in place or in progress. The interim measures include an SVE system, depressurization systems to eliminate the groundwater to indoor air pathway (the inhalation pathway), and a subsurface barrier wall that will provide hydraulic control of groundwater. Final remedies will be considered as part of the FS, which will be produced after the Final RI Report is approved.

2.5.1 Soil Interim Measure

An interim measure to address soil contamination in the source area was installed in accordance with the requirements of the 1991 facility Part B Permit. In 1993, an Interim Measures Design and Implementation Work Plan (BEI, 1993d) was submitted to EPA, which provided specifications for the construction of an SVE system. In March 1994, an SVE system was installed in the North Field area of the facility, with the following objectives:

- Reduce the VOC concentrations within the vadose zone just above the groundwater table;
- Prevent or minimize the further spread of contamination, thereby stabilizing conditions at the facility while long-term remedies are pursued; and
- Reduce the contaminant concentrations of preformed vapors that may be migrating offsite.

SVE systems are designed to desorb volatile contaminants from unsaturated soil by vacuum extraction. The extracted air is treated to breakdown the contaminants before being released into the environment.

The SVE system consists of four SVE wells, V1, V2, V3, and V4 and originally included a catalytic oxidation unit (CATOX), which was the air treatment system. The SVE wells are screened in the vadose zone. Well construction information is provided in Section 4.0.

The SVE system had the highest removal rate during the first year of operation, after which time the removal rate dropped gradually, showing a tailing effect (PSC, 1998a). Approximately 19,051 lbs. of VOCs have been removed using the system. The system was turned off from February to August 1996 to allow the vadose zone to re-equilibrate; however, after resuming system operations, no increase in contaminant removal was observed. EPA and Ecology did not approve PSC's May 1998 request to turn the system off. Therefore, in 2000, PSC redeveloped the SVE wells to determine whether the well screens could be cleaned and performance of the system could be improved. However, this did not make a significant impact on the system's performance.

In 2002, PSC replaced the air treatment system on the SVE system, the catalytic oxidation system, with granular-activated carbon (GAC). On October 15, 2002, a pilot study was conducted to determine if GAC would be effective in treating the air stream from the SVE system. The pilot study found an unidentifiable source of acetone in the outlet air sample from the GAC unit. An effort made to determine the source of the acetone was unsuccessful, and PSC decided to replace the GAC with virgin carbon and rerun the pilot study. The carbon bed was replaced on January 28th, and the pilot study was rerun on February 7th. Potential ambient air concentrations resulting from VOC concentrations in the post-treatment air stream from the second study were modeled using the USEPA SCREEN3 air emissions model. The modeled values did not exceed the applicable cleanup levels for air. Ecology gave approval to restart the system on May 5, 2003. The system was restarted on May 8, 2003, at a removal rate of 120 standard cubic feet per minute (SCFM), which is the maximum rate at which air can be removed without also removing groundwater from the wells (PSC, 2003j). The first monthly sampling event was completed on June 25, 2003. Sample results from the SVE system since the GAC was put in place indicate an average removal rate of 2.71 pounds per day of total VOCs. GAC removal efficiency was 98.34%.

2.5.2 Groundwater Interim Measures

In June 2001, EPA and Ecology required that PSC implement groundwater interim measures with the following objectives:

- Establish hydraulic control of the NAPL and dissolved plumes emanating from the facility.
- Ensure that groundwater is not being used as drinking water or for other purposes such as gardening or industrial purposes.
- Prevent indoor inhalation exposure of residents and workers located between the PSC Georgetown Facility and Duwamish Waterway in areas known or reasonably expected to have volatile organic contamination in the upper portion of the shallow aquifer. In addition, the agencies required that PSC install an interim measure at 710 South Lucile Street without further analysis.

Each of these interim measures is discussed in more detail in the following subsections.

PSC met with EPA and Ecology on July 10, 2001, to discuss the timing of the interim measures implementation at the facility. PSC expressed concerns that a work plan for an interim measure to establish control of the plumes could not be adequately prepared by September 1, 2001, owing to the complexity of the task. The agencies agreed that the interim measure work plan would include a focused feasibility evaluation of technologies and a schedule for completing additional work plans that will be required before an interim measure for hydraulic control could be implemented.

In August 2001, PSC submitted the Draft Groundwater Interim Measures Work Plan to Ecology to satisfy the work plan requirement in the June 28, 2001 letter. The Draft Groundwater Interim Measures Work Plan summarized the actions that have been taken and that will be taken to further ensure that there are no human exposures to contaminated groundwater in the area to the west and southwest of the facility.

This work plan contained a general approach for the scope of work for the IPIM and the HCIM. The purpose of the HCIM was to prevent exposures from contaminants in groundwater migrating into indoor air.

The Draft Groundwater Interim Measures Work Plan also provided specific methodologies for the groundwater use survey interim measure. This interim measure was a requirement to increase the response rate to an earlier survey conducted by PSC of home and business owners in the area downgradient of the facility to determine if anyone uses groundwater for any purpose including drinking water, gardening, or industrial use.

PSC submitted a permit modification to Ecology to propose that two separate work plans be prepared to provide specific methodologies for the inhalation pathway interim measure and the hydraulic control interim measure. This permit modification was approved and PSC prepared the two additional work plans, which are discussed in further detail below.

2.5.2.1 *Requirement to Determine Groundwater Use*

In March 2002, PSC submitted the Draft Groundwater Use Update Report (PSC, 2002d), which summarized the work conducted to determine if anyone downgradient of the facility was using groundwater for drinking, agricultural use/gardening, or industrial use. A series of groundwater use surveys was conducted by mail in the area downgradient (as groundwater flows) from the facility where groundwater concentrations exceeded drinking water cleanup levels. A total of four mail surveys were conducted, prior to and after the interim measure requirement, to gain a thorough understanding of potential groundwater use in the area. The surveys were mailed on July 6, 2000; March 6, 2001; September 24, 2001; and December 21, 2001. Following the mail survey, a telephone survey was implemented in attempt to contact people who did not respond to the mail survey. The telephone survey was conducted in December 2001. The total response rate to all surveys conducted for this purpose was 73%. Of the 48 buildings in the survey area, PSC did not receive responses from 13 of the buildings as they either could not be contacted (wrong address, no phone number, etc.) or they refused to participate in the survey. The results of the surveys indicated that groundwater in the area was not being used by area residents and businesses. In addition to conducting these surveys, PSC also conducted a thorough records search to search for drinking water or industrial wells at Ecology, the EPA Office of Water's Public Water System Database, and the Seattle-King County Public Health Department Water System Database. No viable drinking water or industrial supply wells were identified between the facility and the Duwamish Waterway.

2.5.2.2 *Requirement to Implement Inhalation Pathway Interim Measures*

In August 2002, the Revised Inhalation Pathway Interim Measures Work Plan (FW, 2002) was submitted to Ecology. The purpose of the work proposed in this work plan was to determine whether residents and workers in the vicinity of the facility are being exposed to concentrations of chemicals migrating from contaminated groundwater into indoor air. This determination was made through the use of the IPIM Decision Tree. The IPIM Decision Tree is a tiered approach for evaluating specific locations in the affected area on a quarterly basis at least until a final remedy for the facility is implemented. The approach consists of three steps: 1) develop site-specific groundwater to indoor air volatilization factors (GIVFs) that represent the relationship of concentrations of VOCs in groundwater and concentrations in indoor air; 2) use the GIVFs to develop site-specific risk-based inhalation pathway interim measure action levels (IPIMALs) for each constituent of concern in groundwater throughout the affected area; and 3) use the IPIMALs and the decision tree to determine if indoor air concentrations of VOCs would potentially be above levels of concern.

Each quarter, PSC compared groundwater IPIMALs with groundwater concentrations for each well location in Study Area 2 to determine if the resulting cumulative inhalation risk (from vapor intrusion) exceeds 1E-05 or a hazard index (HI) of 1[4]. PSC then used the IPIM Decision Tree to determine the need for further evaluation or interim measures at individual buildings. Groundwater IPIMALs were also compared with groundwater concentrations already obtained from well and hydropunch samples downgradient of the facility. The first four quarterly analyses of groundwater monitoring data were provided in four separate technical memorandums (as listed below).

<u>Revised Inhalation Pathway Interim Measure, Technical Memorandum I, Development of GIVFs, Evaluation of Tier 3 Data from GIVF Study, and Evaluation of 2nd Quarter 2002 Groundwater Data, with Foster Wheeler and Pioneer Technologies (FW, 2003)</u>

The IPIM Technical Memorandum presented the approach and the results of the first evaluation performed under the IPIM Work Plan. This technical memorandum provided the following information:

- The results of the GIVF Study that was performed to gather site-specific data to develop the GIVFs;

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[4] Per WAC 173-340-700(5)(b)(c), PSC will evaluate the chemical-specific toxicity information to determine if it is appropriate to segregate the hazard quotients by target organ/critical effect (if the CEF for noncarcinogens is greater than 10). If the toxicity information indicates that it is appropriate to segregate the His, then the decision rules for evaluating the segregated HIs are as follows: If any of the segregated HIs are greater than 1, then the building will be proposed for Tier 4. If all of the segregated HIs are less than 1, then the building will be evaluated further during the next round of groundwater sampling.

- The GIVFs;
- The IPIMALs for groundwater;
- The initial list of Tier 3 buildings based on the first quarter 2003 groundwater data and recent reconnaissance borings; and
- The initial list of Tier 4 buildings based on the results of the GIVF Study and the first quarter 2003 groundwater data and recent reconnaissance borings.

Inhalation Pathway Interim Measure Technical Memorandum 2, Tier 1 and Tier 2 Evaluations of 3rd Quarter 2002 Groundwater Data by Pioneer Technologies Corporation (PTC, 2003a)
The purpose of this IPIM Technical Memorandum 2 (Tech Memo 2) was to present the results of the evaluation of 3rd Quarter 2002 groundwater monitoring data with IPIMALs in accordance with the IPIM Work Plan (FW, 2002).

Inhalation Pathway Interim Measure, Technical Memorandum 3, Tier 1 and Tier 2 Evaluations of 4th Quarter 2002 Groundwater Data by Pioneer Technologies Corporation (PTC, 2003b)
The purpose of this IPIM Technical Memorandum 3 (Tech Memo 3) was to present the results of the evaluation of 4th Quarter 2003 groundwater monitoring data with IPIMALs in accordance with the IPIM Work Plan (FW, 2002).

Inhalation Pathway Interim Measure, Technical Memorandum 4, Tier 1 and Tier 2 Evaluations of 1st Quarter 2003 Groundwater Data by Pioneer Technologies Corporation (PTC, 2003c)
The purpose of this IPIM Technical Memorandum 4 (Tech Memo 4) was to present the results of the evaluation of 1st Quarter 2003 groundwater monitoring data with IPIMALs in accordance with the IPIM Work Plan (FW, 2002). In addition, 13 additional groundwater reconnaissance

borings stations were sampled at the water table to fill in data gaps identified during previous characterization.

Final Depressurization System Design Document, Georgetown Facility, Seattle, Washington, by Pioneer Technologies, Advanced Radon Technologies (PTC/ART, 2003a)

This work plan describes how the IPIMs will be implemented at the buildings identified in Tech Memo 1 (FW, 2003), Tech Memo 2 (PTC, 2003a), and Tech Memo 3 (PTC, 2003b), Tech Memo 4 and any other future analysis of IPIMs. This is a general work plan that was developed to describe the technical specifications for typical IMs that will be constructed at residential and commercial buildings. The information contained in this work plan applies to all buildings.

By the end of 2003, approximately 50% of Tier 3 (further sampling required) projects will be completed, with reports pending on some buildings. In addition, all initial Tier 4 (install IPIMs) projects will be completed for buildings that PSC was allowed access to. PSC will continue with these projects through 2004 until they are completed.

2.5.2.3 *Requirement to Implement Inhalation Pathway Interim Measures at 710 S. Lucile Street*

Supplemental Groundwater Interim Measures Work Plan for the Groundwater to Indoor Air Pathway: Stone, Drew/Ashe & Jones Building, 710 South Lucile Street, Seattle, Washington (PSC, 2001i)

The purpose of this work plan was to provide methodology for diagnostic testing, general system installation, and system confirmatory testing. The revisions were based on comments received from EPA on the August 2001 draft of this plan. This work plan was originally prepared as a result of the determination of buildings requiring interim measures for the groundwater to indoor air pathway as described in the Draft Groundwater Interim Measures Work Plan, which was submitted to the agencies on August 31, 2001.

Final 95% Design Supplemental Groundwater Interim Measures Work Plan, Revision 1 for SDAJ, with PSC, Pioneer Technologies, and Advanced Radon Technologies (PSC/PTC/ART, 2003)

This plan presents the process that will be followed to implement the interim measure selected for the property located at 710 South Lucile Street, Seattle, WA. The purpose of this report was to provide the results of a Pilot Test that was performed on November 16, 2002 per the Groundwater Interim Measure Work Plan (PSC, 2001g) and to make revisions to this plan based on comments received from Ecology and the property owner on two previous drafts of the plan dated May 2002 and September 2002.

Inhalation Pathway Interim Measure, Proposed Depressurization System Design for 710 South Lucile Street, Seattle, WA, prepared by Pioneer Technologies with Advanced Radon (PTC/ART, 2003b)

This plan was developed to provide a building specific design to the owners and Ecology. PSC proposed two options for the owners to use for the final design, both of which would work equally well. As of October 2003, PSC and SAD agreed to terms of access and a design and plans for installation are underway.

2.5.2.4 *Requirement to Implement Hydraulic Control Interim Measures*

Revised Draft Hydraulic Control Interim Measures Work Plan, Georgetown Facility, Seattle, Washington, (PSC/URS, 2002)

This work plan outlines additional fieldwork required for the design of a HCIM that has been proposed for the facility. The proposed HCIM is a barrier wall that surrounds the source area and is anchored into the silt unit at the base of the intermediate aquifer. The objectives of the investigation were as follows:

- Determine the maximum extent of source zones potentially present to the east and north of the facility

- Collect information concerning the location of the silt aquitard to the east and north of the facility

- Collection of geotechnical data for use in designing the slurry barrier

- Collect samples for compatibility testing for use in designing the slurry barrier

These data were collected to fill the data gaps in the facility investigations and to provide information necessary to design the barrier wall. The results were summarized in the Final Hydraulic Control Interim Measure Construction Work Plan.

Final Hydraulic Control Interim Measure Construction Work Plan, Volumes I and II, Georgetown Facility, Seattle, by URS and Geomatrix (URS/Geomatrix, 2003)
This document presented the planned approach to implementing the HCIM in accordance with the requirements in the permit. This plan provides engineering specifications for the construction of the barrier wall including a construction plan, operating and maintenance plan, and a schedule for work and reporting.

The HCIM was design to achieve the following objectives.

- Encircle near-facility impacted groundwater extending into the uppermost aquitard with a barrier wall.

- Recover groundwater within the barrier wall to reduce the groundwater level within the wall and to maintain an inward groundwater gradient of 1-foot differential with groundwater outside the barrier wall.

- Treat and discharge recovered groundwater in accordance with applicable state and federal regulations.

- Implement construction and construction quality assurance procedures to ensure the barrier wall is installed properly and attains design performance standards.

- Develop a performance monitoring plan and system to confirm the barrier wall and groundwater recovery system design objectives.

To date, approximately fifty percent of the wall has been constructed and it is expected that the wall will be completed by the end of 2003.

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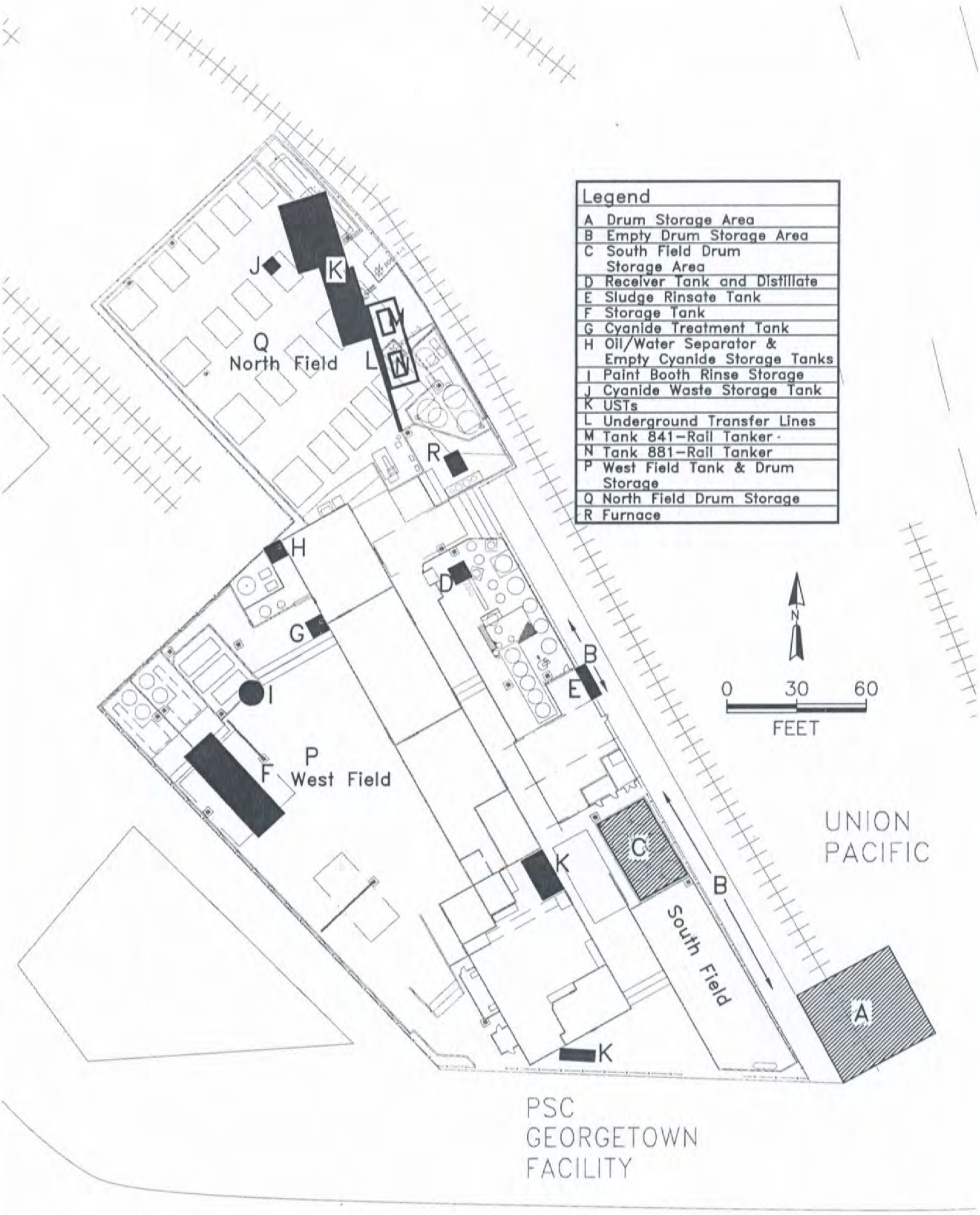

Legend

A	Drum Storage Area
B	Empty Drum Storage Area
C	South Field Drum Storage Area
D	Receiver Tank and Distillate
E	Sludge Rinsate Tank
F	Storage Tank
G	Cyanide Treatment Tank
H	Oil/Water Separator & Empty Cyanide Storage Tanks
I	Paint Booth Rinse Storage
J	Cyanide Waste Storage Tank
K	USTs
L	Underground Transfer Lines
M	Tank 841–Rail Tanker
N	Tank 881–Rail Tanker
P	West Field Tank & Drum Storage
Q	North Field Drum Storage
R	Furnace

PSC

TITLE:
Former Known Chemical Storage
and Handling Areas
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD.:	
DATE: 7/23/03	REV.:	FIGURE NO.: 2–1

Table 2-1
Closed Solid Waste Management Units
PSC Georgetown Facililty

Source Unit	Period of RCRA Use	Waste Type	Notes
Drum Storage Area A	1950s-1970s Drum Storage by Preservative Paint Company 1975-1980 Drum storage	U+C17nknown Drums of solidified asphalt, non-hazardous	Soil or asphalt surface by 1974. Metro reported some drums leaking in 1979. Drums removed in 1980. Sent to Pier 91 Facility for treatment.
Empty drum storage area B	1950s-1980 Preservative Paint Co. empty drum storage leased on easement outside fence	Empty drums previously contained solvents and solvent sludges	Empty drums were stored prior to being sent of-site for 1 reconditioning. Storage ceased in 1980.
Drum storage area C	Prior to 1985	Solvents, resins	Drums removed in 1985.
Receiver tank for distillate	1950s-1970	Re-distilled solvents	Concrete containment. Tank removed in 1976 due to tank leakage within containment. Inoractive 1970-1976. Removed 1976.
Sludge rinsate tank	1950s-1970	Preservative Paint paint booth sludge rinsate	Out of service 1970-1980. Removed 1980.
Tank #841 rail tanker	1980-1987	Recyclable and recycled solvent	1982 Concrete paving with berm added. Rail tanker decontaminated and removed in 1987.
Tank #881 rail	1970-1976 1976-1982 1982-1987	Solvent Cyanide waste Cyanide sludge	1982 Concrete paving with berm added. Rail tanker decontaminated and removed in 1987.
Storage tank (vinyl)	1974-1975	Paper mill liquor solution	
Cyanide treatment tank	1976-1977	Cyanide waste	Tank removed in 1987.
Oil/water separator	Prior to 1977 1977-1980	Oily wastewater Cyanide wastes, paints, listed solvents, chrome	Inactive 1980-1988.
Paint booth rinse storage tank	1978-1980	Paint booth rinse	Abandoned before 1980.
Cyanide waste storage tank	1978-1980	Low concentration cyanide waste	Containment: concrete or unpaved dirt. Removed in late 1980.
Tank 1	1950s or 1960s-1970 1973-1974 1974-1978	Vinyl acetate monomer for latex manufacture Gasoline product Product solvent	1980-1982 Tanks passed integrity test. Some ventlines failed but did not contain dangerous waste or product. October 1987: tanks were emptied, certified for removal by a marine chemist, decontaminated and scrapped. Some contaminated soil was removed and excavation was partially backfilled with excavated soil, lined with visqueen, and returned to grade with clean backfill. Concrete debris from tank excavation passed E toxicity and fish bioassay tests, and was approved for offsite disposal at a demolition debris landfill. November 1987: area covered by concrete pad and containment berms for use as container storage pad.
Tank 2	1950s or 1960s-1978	Solvents	
Tank 3	1950s or 1960s-1987	Recycled solvents	
Tank 4	1950s or 1960s-1987	Recycled solvents	
Tank 5	1950s or 1960s 1970s	Solvent Linseed oil for manufacture of alkyd	
Tank 6	1950s or 1960s 1970s 1978-1987	Solvent Linseed oil for manufacture of alkyd Solvent	
Tank 7	1950s or 1960s 1970s 1978-1987	Solvent Linseed oil for manufacture of alkyd Solvent	
Tank 8	1950 or 1960s-1970 1970s-1980	Unknown Linseed oil	Same as Tanks 1-7 except area was paved with concrete and used for company vehicle parking
Tank 9	1950s or 1960s-1987	Mineral spirits	
Tank A	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank B	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank C	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank D	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank E	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank F	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7

Table 2-1
Closed Solid Waste Management Units
PSC Georgetown Facility

Source Unit	Period of RCRA Use	Waste Type	Notes
Tank G	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank H	1950s or 1960s-1970 1970-1986	Unknown Recycled solvent	Same as Tanks 1-7
Tank I	1950s or 1960s-1970 1970-1980	Unknown Solvent	Same as Tanks 1-7 Inactive 1980-1986
Tank J	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank K	1950s or 1960s-1970 1970-1986	Unknown Solvent	Same as Tanks 1-7
Tank L	1950s or 1960s-1976 1976-1984 1984-1987	Unknown Cyanide waste Bleach for decontamination	Same as Tanks 1-7
Tank M	1950s or 1960s-1976 1976-1984 1984-1987	Unknown Cyanide waste Bleach for decontamination	Same as Tanks 1-7
Tank N	1950s or 1960s-1976 1976-1984 1984-1987	Unknown Cyanide waste Bleach for decontamination	Same as Tanks 1-7
Tank O	1960-1970 1970-1981	Unknown Cyanide waste	Same as Tanks 1-7 Out of service 1981-1987
Underground Transfer Lines	1950s or 1960s-1981	3 solvents and bleach lines, 1 linseed oil line, 2 soybean oil lines and 1 water line	Installed in early 1950s or 1960s with underground storage tanks. Pipes were severed, drained and capped when taken out of service in 1981. Sections of pipe within area of underground tank excavation were removed in October 1987.

Source: Solid Waste Management Unit Report (Chempro, 1988)

Table 2-2
Documented Releases to Soil
PSC Georgetown Facility

Date	Material Type	Quantity	Media	Nature of Release	Actions	Agency notified?
1979	Solidified asphalt	Unknown	Soil	Presumed to be leaking drums	Drums removed in 1980. Sent to Pier 91 Facility for treatment of contents.	Yes
10/7/1987	Cyanide contaminated liquid	¼ gallon each in fill lines or vent pipes of Tanks N and O	Soil	Fill lines or vent pipes were severed during underground tank removal	Released liquid was contained in the soil below the severed lines. Approximately ½ drum of soil contaminated by the release was immediately removed and transported to an approved offsite hazardous waste disposal facility.	No
4/22/1989	Oil-based paint sludge	2 gallons	Soil	Release from drum being transported when forklift hit pothole	Absorbent materials applied, remaining material swept up and replaced in drum.	No
########	Paint solvent	8 ounces	Soil	Spill on soil	Soil cleaned up, area pressure washed and wash water collected in drums and distilled.	No

3.0 PHYSICAL DESCRIPTION AND SETTING

This section describes the physical setting of the facility and surrounding area. The description includes the following elements: physiography and vegetation, surface water features, climate, geology, and hydrogeology.

3.1 *Physiography and Vegetation*

As shown in Figure 3-1, the facility is located within the Duwamish Basin, which lies south of downtown Seattle, Washington. The basin essentially consists of a linear valley situated between two north-south trending drumlinoid ridges. The basin lies within the Puget Sound Lowland, a physiographic/hydrologic province bordered b the Fraser River Valley on the north, the Cascade Range on the east and the Olympic Mountains on the west. This province is shown in Figure 3-2.

In the Georgetown area, most of the land on the Duwamish Valley floor is developed, so very little vegetation is present overall. However, some of the upland areas to the west and to the east of the valley floor are undeveloped, especially the steeper slopes. In these areas vegetation density varies from very sparse (e.g., at bedrock exposures) to dense. The native species that inhabit poorly drained slopes include fir, cedar, alde,r and madrona and understory species such as huckleberry, Oregon grape, salal, and blackberry (Morgan and Jones, 1995). Well-drained soils overlying coarse-grained outwash deposits are inhabited by wild grasses, bracken fern, Scotch broom, fir, and oak (Morgan and Jones, 1995).

The Duwamish Basin has a history of industrial, commercial, and residential land use. In the Georgetown neighborhood of south Seattle, land use is mixed industrial and residential. Most of the developed land in the area lies on the nearly level valley floor, with elevations ranging approximately from sea level (zero) to 25 feet. The highlands to the west and to the east generally vary in elevation from approximately 300 to 500 feet above mean sea level (MSL).

3.2 *Surface Water Features*

The Duwamish Basin is named for the Duwamish River, which drains it. The Duwamish River originates at the confluence of the Green and Black Rivers in Tukwila, and terminates at its mouth at the south end of Elliott Bay, an arm of Puget Sound. The lower 4.5 miles of the river is called the Duwamish Waterway (Fabritz et al, 1998). The mouth of the waterway consists of two main channels, the West Waterway and the East Waterway. The basin, which is about 13 miles long, is bounded on the west by the highlands of west Seattle, and on the east by the highlands of Beacon Hill. The Duwamish River flows predominantly northward and slightly westward between its origin and its mouth.

Figure 3-1 shows that, other than the Duwamish Waterway, no surface water bodies are known to be present within one mile of the facility. However, several prominent surface water features exist in the region surrounding the Duwamish Valley. Lake Washington is about two to three miles east of the waterway, but is part of a separate drainage. Elliott Bay bounds the Duwamish Valley on the north. Puget Sound lies about three miles west of the waterway, on the other side of a long, north-south trending highland.

Channel Characteristics and Discharge. Santos and Stoner (1972) described changes to the Green-Duwamish River basin prior to 1917. Bortleson et al (1980) compiled a detailed map of the former river channel and a historical summary of environmental changes to the shoreline and wetland at the Duwamish River and Elliott Bay. By 1917 the channel of the lower portion of the Duwamish River was straightened and dredged for navigation. The configuration of the river channel prior to extensive modification can be seen in an old USGS topographic map reproduced in Figure 3-3, which shows it to have a meandering form. Waterway development resulted in the abandonment of about 12.5 miles of former riverbed (Booth and Herman, 1998). These areas and other lowlands were filled with material excavated from the former riverbed.

The waterway's present channel is about 400 to 450 feet wide (estimated from topographic map; USGS, 1973) in the vicinity of the Georgetown neighborhood. The depth of the channel varies from approximately 49 feet below mean lower low water (MLLW) at the mouth, to 13 feet above MLLW at the 16th Avenue South bridge (river mile 5.9) (King County, 1999).

The Duwamish Waterway is fed by the Green River, which is regulated for flood control at the Howard Hanson dam. However, due to storm runoff and snowmelt, the volumetric discharge varies from day to day (King County, 1999). Dawson and Tilley (1972) report that the fresh-water discharge rate varies from 200 to 12,000 cubic feet per second (cfs).

Tidal Influence. The Duwamish Waterway is tidally influenced, primarily due to tidal forcing at its mouth, in Elliott Bay. Tides ranging from –4.6 to +14.8 feet MLLW have been observed at the waterway, and tide-induced flow reversals have been observed as far upstream as 13 miles from the mouth, in the Green River (King County, 1999). The National Ocean Service (NOS) reports the MSL datum for Seattle, Puget Sound as 2.021 meters (NOS, 1996) referenced to MLLW, or 6.631 feet MLLW. By subtraction then it is deduced that tides have been observed in the range from about –11.2 to +8.2 feet MSL.

Duwamish River Salinity. King County (1999) presents time series of salinity observed at three monitoring stations on the Duwamish River, over a period of approximately six months. At each station, salinity was measured hourly at various depths, including one meter below the water surface, one meter above the channel bottom, and at an intermediate depth. These data were used to calibrate a hydrodynamic and chemical transport model of the Duwamish Waterway and Elliott Bay (King County, 1999). Data from two of the stations are potentially relevant to groundwater flow in the area surrounding the facility – the Spokane Street bridge station and the 16th Avenue South bridge station. The third station is located near the Duwamish Yacht Club, which is located further upriver.

All of the salinity time series presented by King County (1999) have prominent diurnal and semidiurnal fluctuations, evidently tide-induced. Table 3-1 lists the time-average salinity measurements at each depth, for both stations. At each station the time-average salinity increases with water depth. Because water density is an increasing function of salinity, the average density also increases with depth, indicating the estuary is, on average, stably stratified. This is consistent with the findings of previous investigations (Dawson and Tilley, 1972; Santos and Stoner, 1972; Prych et al 1976).

Hart Crowser, Inc. (1992) present Duwamish River salinity and temperature data collected from transects located southwest of the facility. Their data include results from over 100 water samples collected over an 11.5-hour period. Because the sampling period is short relative to the time series presented by King County (1999), the results obtained by Hart Crowser are less likely to be representative of long-term average conditions at the waterway.

3.3 *Climate*

The following description was paraphrased from the National Climatic Data Center summary for the region surrounding the Seattle-Tacoma (SeaTac) International Airport weather station (NCDC, 2000); it applies to the Duwamish Basin as well. Figure 3-4 shows that SeaTac Airport is approximately eight miles south of the facility; the city of Tacoma is approximately 25 miles south of Seattle.

The mild climate of the Pacific Coast is modified by the Cascade Mountains, and to a lesser extent, by the Olympic Mountains. The climate is characterized by mild temperatures, a pronounced though not sharply defined rainy season, and considerable cloudiness, particularly during the winter months.

The Cascades are very effective in shielding the Seattle-Tacoma area from the cold, dry continental air during the winter, and from the hot, dry continental air during the summer. The extremes of temperature that occur in western Washington are the result of the occasional pressure distributions that force the continental air into the Puget Sound area. But the prevailing southwesterly circulation keeps the average winter daytime temperatures in the 40s (degrees Fahrenheit) and the nighttime readings in the 30s. During the summer, daytime temperatures are usually in the 70s with nighttime lows in the 50s. Extremes of temperatures, both in the winter and summer, are usually of short duration.

The middle of the dry season occurs in July or early August, with July being the driest month of the year. The rainy season extends from October to March, with December normally the wettest month. However, precipitation is rather evenly distributed throughout the winter and early spring months, with more than 75 percent of the yearly precipitation falling during the winter wet season. Most of the rainfall in the Seattle area comes from storms common to the middle latitudes. These disturbances are most vigorous during the winter as they move through western Washington. The storm track shifts to the north during the summer, and those storms that reach the state are not the wind and rain producers of the winter months. Local summer afternoon showers and a few thunderstorms occur in the Seattle-Tacoma area but they contribute relatively little precipitation.

The occurrence of snow in the Seattle-Tacoma area is extremely variable. Fallen snow usually melts before accumulating measurable depths. There are winters on record with only a trace of snow, but at the other extreme, over 21 inches has fallen in a 24-hour period. Usually, winter storms do not produce snow unless the storm moves in such a way to bring cold air out of Canada directly, or with only a short over-water trajectory.

The highest winds recorded in the Seattle-Tacoma area were associated with strong storms crossing the state from the southwest. Prevailing winds are from the southwest but occasional severe winter storms will produce strong northerly winds. During the summer months winds are relatively light, with occasional land-sea breeze effects creating afternoon northerly winds of 8 to 15 miles per hour. Fog or low clouds that form over the southern Puget Sound area in the late summer, fall, and early winter months often dominate the weather conditions during the late night and early morning hours, with visibility occasionally lower for a few hours near sunrise. Most of the summer clouds form along the coast and move into the Seattle area from the southwest.

Table 3-2 shows the average monthly total precipitation data for three weather stations in the vicinity of the facility. The King County Airport station is approximately two miles south-southeast of the facility, and is within the Duwamish Valley. The floor of the Duwamish Valley is relatively level, so topographically related spatial variations in precipitation within the valley are unlikely. Thus, variations in total monthly and total annual precipitation between different locations within the basin are expected to be insignificant. For these reasons the precipitation data from the King County Airport are considered to be representative of conditions at the facility.

The Portage Bay station is about seven miles north of the facility, while the SeaTac Airport station is about eight miles south of the facility. The periods of record for these stations are approximately 25 and 51 years, respectively. In contrast, the period of record for the King County Airport station is about 18 years. Furthermore, the period of record for the King County Airport station ends in 1965, whereas that for the SeaTac Airport station continues through 1999. For every month of the year except September and October, the data from the SeaTac Airport station more closely approximate conditions at the King County Airport station, than do those from the Portage Bay station.

Table 3-3 shows the minimum, maximum and mean annual precipitation data for the three stations. The relative difference between the average total annual precipitation values for the

SeaTac and King County Airport field stations is only about five percent. The relative difference between the minimum values for these two stations is approximately eight percent, while the maximum values differ by about 18 percent. These comparisons show that the total monthly and total annual precipitation at the SeaTac Airport station are fairly representative of conditions at the King County Airport and the Duwamish Valley. Therefore, the SeaTac precipitation data are considered representative of conditions at the facility. Figure 3-5 shows how the average daily precipitation at SeaTac Airport varies throughout the year.

3.4 *Regional Geology*

Galster and Laprade (1991) describe the geology of Seattle, Washington, emphasizing geological engineering considerations. Their stratigraphic sequence and a map of geologic features are presented in Figures 3-6 and 3-7.

Vaccaro et al (1998) present a detailed summary of the geologic setting of the Puget Sound Aquifer System, of which the Duwamish Basin is but one relatively small part. The following description of geologic units is based primarily on the information provided by Booth and Herman (1998), who described the geology of the Duwamish Basin and surrounding area.

Three principal geologic assemblages exist within the Duwamish Basin and define the groundwater system. From youngest to oldest, they are:

- Duwamish Valley Alluvium;
- A sequence of Glacial and Non-Glacial Sediments; and
- Bedrock.

Each of these assemblages is discussed below, in order of decreasing age.

Bedrock. The bedrock forms basement and bounds the aquifers. Where it is exposed, the bedrock is composed of marine and continental sedimentary rocks (e.g., claystone, siltstone, sandstone, and some coal; Morgan and Jones, 1995) and isolated intrusive igneous rocks, all of Tertiary age (between about 40 and 10 million years b.p. in this locale). It is exposed to the east and to the south of the Duwamish Basin. Further north, the upper surface of the bedrock descends from several hundred to over 1000 feet bgs. Further east, more extensive exposures suggest the bedrock thickness may exceed 3,000 feet.

Glacial and Non-Glacial Sediments. The sequence of glacial and non-glacial sediments can be divided into two groups, younger sediments and older sediments. The upland plain areas lying east and west of the Duwamish Valley are covered by glacial till that was deposited during the Vashon stade of the Fraser glaciation (Armstrong et al, 1965) approximately 15,000 years b.p. A sequence of older unconsolidated deposits underlies the Vashon deposits and extends well below sea level across much of the Duwamish Basin.

The older sediments include coarse- and fine-grained materials that directly overlie the bedrock. They are highly compacted from one or more episodes of post-depositional glaciation. Also, weathering has cemented many of the sediments by oxidation. These sediments are exposed at the present ground surface where erosion has removed the overlying till.

The younger sediments are more horizontally extensive than the older sequence. These sediments have a variety of textural characteristics and topographic expression, because the advance and retreat of the ice sheet caused the depositional environment to change rapidly. These sediments include four units: glacial silt, advance outwash, glacial till, and recessional outwash.

The glacial silt consists of laminated silt and clay, and is generally encountered at elevations less than 200 feet MSL. This unit, which is a regionally significant aquitard, in part forms the trough-like lower boundary of the Duwamish Valley alluvium described below (Fabritz et al, 1998).

The advance outwash unit, being of fluvial origin, is relatively coarse-grained. The broad uplands on both sides of the Duwamish Valley are underlain by this unit, whose thickness varies from less than 50 feet to as much as 300 feet. In the upland areas, this deposit is the primary shallow aquifer.

The glacial till consists of compact, heterogeneous sediment, typically several feet thick. Across the tops of the upland areas the glacial till is nearly continuous, but on their flanks it has been removed by erosion. Where present, the till tends to reduce the recharge to underlying aquifers owing to its relatively low permeability.

The recessional outwash consists of stream channel deposits and localized gravel and sand deposits. These deposits can form perched aquifers overlying the till.

Duwamish Valley Alluvium. Booth and Herman (1998) suggest that the sediments of the Duwamish Valley alluvium rest in a trough that was carved by glacial ice, and whose depth may be on the order of 200 feet bgs along the axis of the valley. The depth is believed to decrease to the south, and also to the east and west valley walls.

The Duwamish Valley alluvium was divided into a younger alluvium, an older alluvium and glacially overridden sediments by Booth and Herman (1998). The younger alluvium consists of clayey silt, organic silt, and sandy silts and silty sands with abundant organic material (e.g., wood fragments). The younger alluvium is typically encountered in the upper 15 to 20 feet of the subsurface in the southern part of the basin, and perhaps as deep as -100 feet MSL in the northern part toward the river's mouth.

The younger alluvium grades into the coarser, older alluvium with increasing depth. The older alluvium consists primarily of fine to medium sand. It contains less silt and organic matter than the younger alluvium. The older alluvium's thickness varies from about 10 to 30 feet, and its depth is roughly -30 feet MSL, in the southern part of the basin. Its depth is about 100 feet in the center of the valley. Typically the upper two-thirds are sand and silt, while the lower third is sandy silt. The older alluvium thins to the north and is locally absent.

The glacially overridden deposits typically consist of glacial silts that form the base of the alluvial sediments as they descend toward the north. In the southern part of the basin these sediments lie a few tens of feet bgs, and in the north as much as 200 feet bgs.

3.5 *Local Geology*

The information presented in this section is based on the findings of various field investigations. These results consist primarily of boring logs, which contain data on the inferred depth, thickness, lithology and other properties of subsurface materials. Table 3-4 lists the PSC borings for which information on the local geology is available. These include borings that were completed as part of environmental and/or geotechnical investigations of the facility. The locations of the borings are shown in Figures 3-8 and 3-9. Copies of the boring logs are presented in Appendix 3-A. Figure 3-10 shows the locations of two geologic cross-sections that have been constructed using data from a subset of these borings. Figure 3-11 is Section A-A' and is constructed perpendicular to the groundwater flow direction and includes borings in the vicinity of Denver Avenue. Figure 3-12 is Section C-C' and is parallel to the groundwater flow and covers an area from the Duamish Waterway to the site.

The following five geologic units, listed in order of increasing depth, have been identified from logs of soil borings:

- Shallow Sand Unit (including fill);
- Intermediate Sand and Silt Unit;
- Silt Unit;
- Deep Sand and Silt Unit; and
- Bedrock.

The upper four units are part of the Duwamish Valley alluvium regional geologic unit described by Booth and Herman (1998).

Shallow Sand Unit. The shallow sand and gravel unit consists of poorly graded, fine to medium sand with fine gravel. Organic matter (e.g., wood or other fibrous vegetative material) is commonly present, at levels varying from "trace" to "abundant". The thickness of this unit varies approximately from 21 feet (CG-111-I) to 46 feet (F9) at the PSC borings.

The upper portion of this unit consists of fill, which was emplaced during the industrial development of the area. The lower portion is composed of Duwamish River deposits (alluvium). In some areas the fill is composed of material that was dredged from the Duwamish River. Consequently the silts and sands of the fill may be difficult to distinguish from the native alluvium (Booth and Herman, 1998).

The shallow sand unit grades into the intermediate sand and silt unit.

Intermediate Sand and Silt Unit. The intermediate sand and silt unit consists of interbedded silty sand and sandy silt lenses, with thicknesses from 0.1 foot to more than one foot. The lenses are discontinuous and cannot be correlated between borings. In contrast to the shallow sand unit, wood debris and other organic material is prevalent at many locations. Shell fragments were encountered in most borings. These sediments are apparently of fluvial and marine origin, possibly deposited in an estuary.

At the PSC borings where this unit was penetrated, its thickness varies from approximately 13 feet (CG-101-I) to 68 feet (F9). For some off-site borings (K10, Y26, H14, M29) it is not possible to distinguish the intermediate/shallow contact. Where identifiable the contact dips to the west-southwest, consistent with the overall subsurface topography of the study area.

Silt Unit. The silt unit consists of silt with zero to five percent clay and, at some locations, 20 to 60 percent very fine sand. Clam shells and shell fragments are commonly present, as are wood fragments in "trace" quantities. Worm burrows, mud cracks, and occasional fine laminations were reported at some locations (e.g., at CG-102-D, CG-104-D). This material likely was deposited in a calm tidal environment, or in a floodplain as riverine overbank deposits.

Figure 3-13 shows the elevation of the silt unit's upper surface. The elevation of the upper surface varies approximately from –20.1 to –112 feet NAV88 between borings CG-106 and K10. Near the western boundary of the facility, where the most data are available, the upper surface of the silt unit appears to slope roughly toward the west and southwest. The depth of the silt unit at boring location K10, located at 5th Avenue and Lucile Street further supports that the unit dips to the west/southwest. This is best illustrated in cross section C-C'.

Figure 3-14 shows the thickness of the silt unit as inferred from the PSC borings. The silt unit is continuous across the facility footprint, where its total thickness varies approximately from 11 feet at CG-

106-D to 50 feet at CG-2D). The thickness encountered at CG-2-D is somewhat anomalous with a typical thickness near the facility ranging from 14 to 38 feet.

Deep Sand and Silt Unit. The deep sand and silt unit consists of sandy silt with 30 to 40 percent fine sand and interbedded lenses of silty sand, with gravel and cobbles at some locations (e.g., CG-1-D). Wood fragments and clam shells also reportedly were present. The sediments that comprise this unit are fluvial and marine deposits. This unit was encountered at all of the PSC "D" series permanent monitoring wells, where the depth of its upper surface varies approximately from 84 feet bgs (CG-4-D) to over 128.5 feet bgs (CG-2-D).

Little is known about the total thickness of the deep sand unit, because few borings fully penetrate it. Based on the depth-to-bedrock maps compiled by Yount (1985, 1991), the thickness of the deep sand and silt unit probably increases rapidly with distance as one moves from the facility toward the Duwamish River. The following section describes the data on which these maps are based.

Bedrock. The bedrock unit consists of consolidated sedimentary rock at the one PSC boring (CG-101-I) where it was encountered. The rock was described as gray interbedded sandstone and siltstone. The upper few feet of the bedrock (between about 56 and 62 feet bgs) appeared to be fractured. At greater depths - approximately from 62 to 65 feet bgs - the rock was described as "very well indurated". Drilling (by cable-tool method) ceased shortly after the bedrock was encountered at a total depth of 65 feet bgs.

A log from a geotechnical boring, advanced as part of the high-occupancy vehicle lane construction at Interstate Highway 5, indicates bedrock (sandstone) was encountered between 10 and 20 feet bgs (Ecology, 1993). The location of the boring was given as NW$^1/_4$, SE$^1/_4$, Section 20, T.24.N, R.4.E, which is less than 0.75 mile southeast of the facility.

A log from another geotechnical boring, this one located near the First Avenue South bridge on State Highway 509 (Yount et al, 1990), did not encounter bedrock. The total depth of this boring, which lies southwest of the facility, is 304 feet bgs.

Booth and Herman (1998) concluded that the uplands to the east of the valley are underlain almost exclusively by sedimentary bedrock of the Blakely Formation. The Blakely Formation is Tertiary in age, and consists of marine sandstone, conglomerate, and minor amounts of siltstone. The depth of the Blakely Formation increases both to the west and to the north.

Based on the depth-to-bedrock maps compiled by Yount et al (1985, 1991), the depth to bedrock is expected to increase rapidly as one moves westward from the facility, to a maximum of about 330 to 660 feet (100 to 200 meters) bgs near the Duwamish Waterway. The maps presented by Yount et al (1985, 1991) are based on a limited number of field data, but the control is fairly good in the area surrounding the facility. Horizontal control in this area is provided by the following data:

- One geotechnical boring located approximately west of the facility with posted depth to bedrock 95 meters (approximately 312 feet) bgs;

- One geotechnical boring located northwest of the facility, near the intersection of the Spokane Street bridge and the East Duwamish Waterway;

- Additional geotechnical borings located in the upland area immediately west of the Duwamish Valley; and

- Bedrock outcrops located east of the facility.

3.6 *Hydrogeology*

3.6.1 Hydrogeologic Units and Subsurface Hydraulic Properties

3.6.1.1 *Hydrogeologic Units*

The following five hydrogeologic units, listed in order of increasing depth, have been defined in the area surrounding the facility:

- Shallow Aquifer;
- Intermediate Aquifer;
- Silt Aquitard;
- Deep Aquifer; and
- Basement Confining Unit.

These units are directly correlated with the local geologic units described above. Table 3-5 shows the relationships between the hydrogeologic units and the local and regional geologic units.

Shallow Aquifer. The shallow aquifer corresponds to the shallow sand geologic unit, which includes surface fill. The shallow aquifer is unconfined, and extends from ground surface to depths between approximately 21 feet bgs (CG-111-I) and 46 feet bgs (F9) at the PSC borings. This unit is horizontally continuous, having been encountered at all of the borings in the area. The thickness generally increases from the area east of the facility, to the west.

Intermediate Aquifer. The intermediate aquifer corresponds to the intermediate sand and silt geologic unit. The intermediate aquifer is horizontally continuous across the PSC monitoring well network, where its thickness varies approximately from 13 feet (CG-101-I) to 68 feet (F9). This aquifer is bounded above by the shallow aquifer, to which it is hydraulically connected (Sweet-Edwards/EMCON, 1990). At some off-site borings (K10, H14, Y26, M29) the distinction between the shallow and intermediate aquifer is difficult to determine. Where identifiable the contact is consistent with the study area subsurface topography, dipping to the west-southwest. The intermediate aquifer is considered semi-confined.

At most borings the intermediate aquifer is bounded below by the top of the silt aquitard (see below). At one boring (CG-101-I) the silt aquitard appears to have pinched out as it approaches the valley wall. At this location the intermediate aquifer is bounded below by the basement confining unit.

Silt Aquitard. The silt aquitard corresponds to the silt geologic unit. This unit is continuous across the facility footprint, and extends beyond the footprint to the southwest. Where penetrated by the PSC borings, the total thickness of the silt aquitard varies approximately from 14 feet (CG-1-D) to 50 feet (CG-2-D). The depth of its upper surface ranges approximately from 30 to 112 feet bgs at those PSC borings where it was encountered.

Figure 3-14 shows the horizontal distribution and thickness of the silt aquitard in the area surrounding the facility. The silt aquitard hydraulically confines the underlying deep aquifer. Figure 3-13 shows the inferred topography of the silt aquitard's upper surface. The available data indicate that the upper surface is highest in the area east of the facility footprint and slopes westward.

Deep Aquifer. The deep aquifer corresponds to the deep sand and silt geologic unit. This unit is horizontally continuous throughout the boring network. Its upper surface coincides with the bottom of the silt aquitard, where the aquitard is present. Where the aquitard is absent, the upper surface of the deep aquifer coincides with the bottom of the intermediate aquifer. At the PSC borings, the depth of the deep aquifer's upper surface varies approximately from 84 feet bgs (CG-4-D) to over 128 feet bgs (CG-2-D). The unit's thickness is greater than 34 feet at boring CG-5-D. Based on the depth-to-bedrock map compiled by Yount et al (1991), the depth to bedrock is expected to increase rapidly with distance as one moves westward from the facility, to about 330 to 660 feet (100 to 200 meters) bgs near the Duwamish Waterway.

Basement Confining Unit. The basement confining unit corresponds to the bedrock geologic unit. The upper surface of the bedrock may be weathered and fractured. The base of the weathered zone forms a boundary between the relatively permeable overlying materials (i.e., unconsolidated sediments and weathered bedrock) and the relatively impermeable, underlying, unweathered bedrock. Based on its relatively low permeability, and low recharge in the east upland area, the bedrock basement is classified as a confining unit.

3.6.1.2 *Subsurface Hydraulic Properties*

This section describes the hydraulic properties of the hydrogeologic units. These properties include the following:

- Hydraulic conductivity
    - horizontal hydraulic conductivity
    - vertical hydraulic conductivity;
- Porosity; and
- Storage coefficient
    - specific yield (unconfined aquifer)

- storativity (confined aquifer).

As part of PSC's investigation of the facility, subsurface hydraulic properties were inferred (estimated) from various physical test data. These data consist primarily of the results of tests conducted on subsurface materials. These include field (in situ) tests and laboratory tests.

Table 3-6 summarizes the scope of hydraulic property testing performed as part of PSC's investigation of its facility. This table does not include hydraulic property testing that may have been performed during environmental/geotechnical investigations of other facilities. The results of the hydraulic property testing are summarized in Table 3-7.

Hydraulic Properties of the Shallow Aquifer

For the shallow aquifer, the greatest amount of variation in horizontal hydraulic conductivity estimates (Table 3-8) corresponds to the grain-size tests (approximately two orders of magnitude), followed by the pumping tests (slightly more than one order of magnitude). The highest estimates from the three types of test are in relatively close agreement, ranging from 1.5×10^{-2} centimeters/second (cm/s) (slug tests) to 5.3×10^{-2} cm/s (pumping tests).

The lower limits of the ranges of horizontal hydraulic conductivity estimates from the slug tests (3×10^{-3} cm/s) and the pumping tests (5.0×10^{-3} cm/s) also are in relatively close agreement. However, the lower limit of the range of estimates from the grain-size tests (4×10^{-4} cm/s) is about one order of magnitude lower than those of the slug and pumping tests.

Using only values from Table 3-7 that are rated 1 or 2 in data quality, the geometric mean of these values was used to determine a typical hydraulic conductivity of 3.2×10^{-2} cm/sec for the shallow aquifer.

The range of shallow-aquifer vertical hydraulic conductivity estimates from the rigid-wall tests (Table 3-9) is similar to the range of horizontal conductivity estimates from the pumping tests. This similarity is consistent with the geologic information for the unit, which suggests relatively little stratification. The vertical conductivity estimates from the triaxial tests, which are much lower than those from the rigid-wall tests, are probably more representative of local, fine-grained portions of the unit than of the unit as a whole.

The corresponding estimates of the horizontal-to-vertical hydraulic conductivity ratio for the shallow aquifer are listed in Table 3-10. The estimates of the conductivity ratio based on rigid-wall vertical conductivity tests (vertical) and the pumping tests (horizontal) are from 0.07 to 30. That the minimum value (0.07) is substantially less than one suggests that the range of estimates for the conductivity ratio is wider than what naturally occurs in the aquifer. In turn, this suggests that the upper limit of the range (30) may be higher than what naturally occurs at the field scale.

For the shallow aquifer, which is unconfined, Table 3-11 lists estimated values of volumetric porosity and specific yield, both of which are dimensionless. The porosity estimates range from 0.44, which is typical for a sand, to 0.59. The upper value (0.59) is high for a sand, and likely corresponds to a sample obtained from a part of the aquifer that is locally high in fines (e.g., silt, clay). Freeze and Cherry (1979) suggest that the porosities of sands and silts typically are between 0.25 and 0.50, while those of clays are from about 0.40 to 0.70.

Specific yield is the volume of water released from storage in an unconfined aquifer, per unit area of aquifer and per unit decline in water-table elevation. Freeze and Cherry (1979) report that specific yield is usually in the range from 0.01 to 0.30. Todd (1980) suggests that specific yields vary from approximately 0.03 (clay) to 0.44 (peat). Todd (1980) lists representative values of specific yield of sand from 0.23 (fine sand) to 0.38 (dune sand), and 0.25 for fine gravel. The specific yield estimates for the shallow aquifer are consistent with these guidelines.

Additionally, the entire range of specific yield estimates for the shallow aquifer is less than the lowest porosity estimate for the aquifer. This is consistent with the convention of interpreting specific yield as the drainable portion of the porosity.

In those areas where the fill is saturated, it is likely to exhibit approximately the same hydrogeologic properties as the native alluvium, because the fill was dredged from the Duwamish River (Booth and Herman, 1998).

Hydraulic Properties of the Intermediate Aquifer

For the intermediate aquifer, the horizontal conductivity estimates (Table 3-8) based on the slug-test results vary by more than two orders of magnitude, while those based on the pumping-test results vary by slightly more than one order of magnitude. The highest estimates from the two types of test are relatively close (2.4×10^{-3} cm/s from slug tests versus 5.1×10^{-3} cm/s from pumping test). In contrast, the lowest estimate from the slug tests is considerably lower than the lowest estimate from the pumping test (1.5×10^{-5} cm/s versus 3.7×10^{-4} cm/s).

The range of horizontal conductivity estimates based on slug-test results from the intermediate aquifer is considerably wider than that of the shallow aquifer. This is not true of the results from the pumping tests of the two aquifers. Slug-test results generally represent a smaller test volume than pumping test results. Therefore this difference suggests that the intermediate aquifer is more heterogeneous with respect to horizontal hydraulic conductivity than the shallow aquifer. This finding is consistent with the geologic information available for the two units.

As with the shallow aquifer, data in Table 3-7 with a data quality rating of 1 or 2 were used to compute a geometric mean. This mean of 1.1×10^{-4} cm/sec is considered the typical hydraulic conductivity or the intermediate aquifer.

The vertical conductivity estimates for the intermediate aquifer (Table 3-9) vary over nearly five orders of magnitude (7.3×10^{-8} - 6.4×10^{-3} cm/s). The range of estimates from the triaxial permeameter tests is approximately two orders of magnitude lower than the range from the rigid-wall tests. This reflects the fact that the triaxial tests are normally performed on finer-grained, less permeable samples, while rigid-wall tests are performed on coarser samples (Sevee, 1991). The triaxial test results probably are more representative of the finer material (e.g., the silt and clay lenses) within the intermediate aquifer, while the rigid-wall test results are probably more representative of the coarser material (e.g., sand and silty sand) within the intermediate aquifer.

Estimates of the horizontal-to-vertical hydraulic conductivity ratio for the intermediate aquifer are listed in Table 3-10. Conductivity ratio estimates based on the rigid-wall tests (vertical) and the pumping tests (horizontal) are from 0.06 to 400. That the minimum value (0.06) is substantially less than one suggests that the range of estimates for the conductivity ratio is wider than what naturally occurs in the aquifer. In turn, this suggests that the upper limit of the range (400) may be higher than what naturally occurs at the field scale. Bias notwithstanding, the upper limit is about one order of magnitude greater than that obtained for the shallow aquifer. This is consistent with the available geologic information, which indicates that the intermediate aquifer is substantially more stratified and heterogeneous than the shallow aquifer.

For the intermediate aquifer, which is semiconfined, Table 3-11 lists estimated values of volumetric porosity and storativity. The porosity estimates are from 0.36 to 0.57. The lower limit (0.36) is within the range of values reported by Freeze and Cherry (1979) for sand, 0.25 to 0.50. The upper limit (0.57) is high for sand, but is well within the range reported for clays (0.40 to 0.70).

Aquifer storativity is defined as the volume of water released from aquifer storage, per unit area of aquifer and per unit decline in aquifer potentiometric head. Like porosity, it is dimensionless.

Freeze and Cherry (1979) report that storativities of confined aquifers range from about 5×10^{-5} to 5×10^{-3}. The storativity results for the intermediate aquifer are well within this range.

Hydraulic Properties of the Silt Aquitard

Estimates of the vertical hydraulic conductivity of the silt aquitard are between 1.0×10^{-7} and 5.3×10^{-6} cm/s (Table 3-9). Freeze and Cherry (1979) report that the hydraulic conductivity of silt typically is between about 10^{-7} and 10^{-3} cm/s. Thus, the vertical conductivity estimates for the silt aquitard are within, and closer to the lower end of, this range. The horizontal hydraulic conductivity of the silt aquitard is expected to be somewhat greater than the vertical conductivity, because of stratification.

The range of vertical hydraulic conductivity estimates for the silt aquitard, based on 11 triaxial permeability tests, is less than two orders of magnitude. In contrast, the vertical conductivity estimates obtained from the intermediate aquifer span a range of almost five orders of magnitude. This wide range in vertical conductivity estimates is expected given the highly heterogeneous character of the intermediate aquifer's silts and sands. Even if the comparison is restricted to tests conducted on fine-grained materials (i.e., the triaxial tests), the vertical conductivity estimates from the silt aquitard vary considerably less than the estimates from the intermediate aquifer (i.e., less than two orders of magnitude versus about three orders of magnitude). These comparisons illustrate that the silt aquitard is much more homogeneous than the intermediate aquifer.

The highest vertical conductivity estimate for the silt aquitard (5.3×10^{-6} cm/s) is more than three orders of magnitude lower than the highest vertical conductivity estimate for the intermediate aquifer. The high contrast in the hydraulic conductivities of the two units, and the thickness and horizontal continuity of the silt unit, make it an effective confining unit.

Hydraulic Properties of the Deep Aquifer

The deep-aquifer horizontal conductivity estimates from slug-test results (Table 3-8) vary over more than three orders of magnitude. The lower limit of the estimates from the deep aquifer is below that of the intermediate aquifer, but the two ranges overlap considerably, from 1.5×10^{-5} to 8.5×10^{-4} cm/s. Based on these data and the known lithology of the deep aquifer (deep sand and silt geologic unit), it appears that the horizontal conductivity estimates from the deep-aquifer slug tests are more representative of the less conductive material in this unit than of the unit as a whole.

The horizontal hydraulic conductivity estimate from the laboratory test (1×10^{-2} cm/s) is about one order of magnitude greater than the upper limit of the estimates from the slug tests. This value is near the middle of the range of typical values for a "clean sand" (Freeze and Cherry, 1979), so it may be more representative of the more conductive material in the unit than of the unit as a whole.

The laboratory-test-based estimate of the deep aquifer's vertical conductivity ($4.8 \text{ x } 10^{-7}$ cm/s) is within, and closer to the lower end of, the range of hydraulic conductivity values reported for silt by Freeze and Cherry (1979). Therefore, it is probably more representative of the less conductive material in the deep aquifer than of the unit as a whole. On a scale of meters or greater, the horizontal conductivity of the deep aquifer probably exceeds the vertical conductivity, due to stratification.

Estimates of the horizontal-to-vertical conductivity ratio for the deep aquifer range from 8 to 2000.

Hydraulic Properties of the Basement Confining Unit

The bedrock basement is classified as a confining unit. This classification is consistent with the interpretations of other hydrogeologic studies. For example, in a numerical model analysis of groundwater flow in hypothetical basins within the Puget Sound lowland, Morgan and Jones (1995) considered the bedrock to be an impermeable boundary.

With regard to the Tertiary bedrock within the Duwamish Basin study area, Booth and Herman (1998) state: Groundwater flow in the bedrock is not expected to be significant relative to the glacial and alluvial sediments." Apparently the bedrock sandstones have very low permeabilities because of their fine-grained texture and degree of cementation, and the igneous intrusives are even less permeable because of their generally massive texture. Booth and Herman (1998) cite bedrock data collected during subsurface investigations for the Metro sewer line, in which the bedrock from the Tukwila and Renton Formations encountered in the upper Duwamish Basin was reported to be "impervious" and "relatively impervious" (Converse Consultants; 1985a, 1985b).

Finally, recharge to the underlying bedrock is limited by a layer of relatively impermeable till – the Vashon formation (Booth and Herman, 1998) – that blankets the surface of the upland area along the east side of the Duwamish Basin. This further limits the flow of groundwater within the bedrock underlying the deep aquifer along the east side of the Duwamish Waterway.

3.6.1.3 *Potentially Preferred Groundwater Pathways in the Shallow Aquifer*

Numerous underground utility corridors exist in the area downgradient of the facility between Denver Avenue and the Duwamish River. Some of these consist of pipelines resting in trenches that have been back-filled with porous materials such as gravel. When fully saturated, well-sorted gravel has a far greater hydraulic conductivity than the sand of the shallow aquifer. Thus, the potential exists for underground utility corridors to form preferred pathways for groundwater flow. For a back-filled trench to be a preferred groundwater pathway, the following conditions are required:

1. The trench backfill material must be present and be substantially (e.g., an order of magnitude) more conductive than the surrounding sediment.

2. Groundwater must intercept the trench, and the saturated thickness of the trench backfill must be sufficient to transmit significantly more water than would be transmitted if the trench was not present.

3. The hydraulic gradient must be aligned parallel or sub-parallel to the trench, so that there is a substantial hydraulic gradient within the trench fill material, and over a significant distance.

All sewer lines near the facility were investigated as part of the effort to develop a conceptual site model. Locations and depths of all sewer lines were determined and mapped. These maps are included as Figures 3-15 and 3-16. During the Remedial Investigation, One Call utility locators were contacted and provided PSC with a list of all companies with utility lines within the boundaries of South Hudson Street to the North, Airport Way South to the East, South Fidalgo Street. to the South, and ast. Marginal Way South to the West. PSC contacted all of the companies to ascertain whether their utility lines were buried at depths that might intercept the shallow aquifer. Several companies provided PSC with maps to assist in the investigation, but PSC was not authorized to publicly disclose the specific information contained on the maps. Therefore, only the general information is provided in this report. Puget Sound Energy Gas, Seattle City Light, Seattle Public Utilities, and Seattle Engineering Signal have utility lines that are most likely above the water table. King County Metro Sewer and Qwest have utility lines whose exact depths are uncertain. Electric Light Wave has utility lines that may be buried below the water table on East Marginal Way and on Fourth Avenue South but they were installed by directional boring, so there was no trenching or backfill involved. MCI and Williams Communication have not responded during repeated attempts to contact them regarding information about their utility lines in the area.

The next sections describe the information PSC obtained about utilities in the Georgetown area.

Public Utilities

Two underground public utility lines run along Denver Avenue South, roughly perpendicular to the average groundwater flow direction in the shallow aquifer. Additional underground lines run along the side streets: Lucile Street, Brandon Street, Bennett Street, and Dawson Street. These lines run west from Sixth Avenue South, approximately parallel to the direction of groundwater flow in the shallow aquifer. Figures 3-15 and 3-16 show the locations and elevations of the underground public utility lines. Each pipeline elevation corresponds to the top of the pipeline at the point where it intersects a manhole.

The underground utilities along Denver Avenue, shown in Figure 3-15, consist of a sanitary sewer line and a storm sewer line. The sanitary sewer line runs north and northwest, from Brandon and Bennett Streets. The elevation of the sanitary sewer line is approximately 3.75 to 5.2 feet City of Seattle Datum (COSD). The storm sewer lines are at two separate locations on Denver Avenue. One runs north from the corner of Bennett Street and Sixth Avenue South. The other runs east/west along Brandon Street, and northwest/southeast along Denver Avenue. The elevation of this pipeline is between 4.06 and 5.88 feet COSD.

The storm water pipelines that run along Lucile, Brandon, Bennett and Dawson Streets are at greater elevations than those on Denver Avenue. For example, the line on Brandon Street begins at the intersection with Denver Avenue, at elevation 4.06 feet COSD. The intersection of

Brandon Street and First Avenue South is the most westerly location for which the pipeline's elevation (7.37 feet COSD) was available.

Table 3-12 shows the elevations of the various pipelines in comparison to the wet-season water-table elevation. At the PSC wells on or near Denver Avenue (CG-103-S-1, CG-104-S-1 and CG-105-S-1), the shallow-aquifer groundwater elevations measured in the second quarter of 1999 ranged from 3.66 to 3.83 feet COSD, with an average value of 3.74 feet COSD. The hydrographs for these wells indicate that during most years groundwater elevations do not exceed 3.50 feet. Therefore, the water table is likely below the utility lines most years. Furthermore, during those years when groundwater elevations exceed 3.50 feet COSD, they do so for less than half of the year.

The groundwater elevations in the shallow aquifer decrease to the west. The valley floor is nearly level. Therefore, if the water table were to intersect a buried utility line during a wetter-than-average winter, the downgradient distance over which the intersection occurred would be limited.

Little information is available about the construction of the pipelines, which occured in the 1920s. The City determines the type of backfill material to use based on the geology of the area. In the Seattle tide-flats area, the City chose to use little gravel backfill due to the potential for compression of the dense sands and silts against the concrete and brick pipelines (City of Seattle, 2000b). Drawings obtained from the City show that when gravel backfill was used, it was used to fill only the lower half of the trench. For example, one drawing showed gravel in the bottom half of a 36-inch wide by 36-inch deep trench, for a 24-inch diameter pipeline. The top of the trench was back-filled with native material. However, it appears from the drawings that most of the pipelines on the streets running parallel to Lucile Street were constructed of steel-reinforced concrete with brick interior lining and no apparent non-native backfill.

Because the pipelines were installed above the water table and because most of the underground utility trenches in the area have little or no gravel backfill, the underground utility corridors are not preferential pathways for groundwater flow.

Private Utilities

As indicated in Table 3-13, the private utilities installed in the area between the facility and the Duamish Waterway were either installed at shallow depths (less than 5 feet bgs), or if located at a greater depth, were installed using directional boring techniques with no non-native material used. Puget Sound Energy Gas, has utility lines that are most likely above the water table. Qwest have utility lines whose exact depths are uncertain. Electric Light Wave has utility lines that may be buried below the water table on East Marginal Way and on Fourth Avenue South but they were installed by directional boring, so there was no trenching or backfill involved. MCI and Williams Communication have not responded during repeated attempts to contact them regarding information about their utility lines in the area. Based on the available data there is no evidence that utility corridors are providing a preferential pathway for groundwater flow.

3.6.2 Groundwater Flow Patterns

This section describes the spatial and temporal variation of groundwater elevations, and associated groundwater flow patterns.

The wells used to monitor groundwater elevations in each aquifer are listed in Table 3-14. The complete groundwater elevation data set is tabulated in Appendix 3-B. To illustrate the temporal variation of groundwater elevations, well hydrographs are presented in Figures 3-17 through 3-24 for well nests CG-104, CG-105, CG-106, GC-124, CG-128, CG-138, CG-140 and CG-143. These nests were chosen because they had wells installed at the water table, the deeper shallow zone and in the intermediate aquifer.

3.6.2.1 *Temporal Variation of Groundwater Elevations*

Hydrographs from the selected wells are characterized by prominent seasonal fluctuations (i.e., with period of one year), superimposed on less prominent shorter-period and longer-period fluctuations. These changes are consistent with the corresponding variations in total monthly precipitation. Correlation between groundwater elevations and total monthly precipitation is discussed below.

Although shorter-period fluctuations apparently contribute to the overall variability, their contribution is insufficient to mask the seasonal and longer-period fluctuations. Because the PSC hydrographs are based on monthly or quarterly measurements, it is not possible to further resolve the time period of the temporal fluctuations. However, short-term groundwater-level fluctuations do occur. For instance, groundwater-level fluctuations associated with atmospheric pressure fluctuations have been observed in intermediate- and deep-aquifer wells during pumping tests (PSC, 2000). Additionally, it is possible that short-term groundwater-level fluctuations occur because of other natural causes (e.g., earth tides) or artificial causes (e.g., local overburden stress variations owing to heavy trucks and freight trains).

Correlation of Groundwater Elevations with Monthly Total Precipitation. Each page on which the hydrographs are printed also has a graph of total monthly precipitation for comparison. The precipitation data are from the SeaTac Airport station. Groundwater levels in all three of the aquifers (shallow, intermediate, and deep) appear to be at least moderately well correlated with the monthly total precipitation values. The groundwater level fluctuations lag the precipitation fluctuations by at least a month.

The correlation between total monthly precipitation and groundwater levels suggests that the seasonal variation in precipitation is the primary cause of the seasonal variation in groundwater levels. In addition, seasonal variations in air temperature and cloud cover likely contribute to the seasonal variation in groundwater levels, because of their effects on evapotranspiration.

Aquifer Response Correlation of Hydrographs. Within the shallow aquifer, the groundwater elevations at the water table interval wells are strongly correlated to the elevations at the corresponding wells screened in the lower shallow aquifer. For example, groundwater elevations measured at well CG-104-S-1 are strongly correlated with those at well CG-104-S-2. This correlation between the hydraulic responses at different elevations indicates the shallow aquifer is hydraulically well connected in the vertical direction, with respect to seasonal and longer-period fluctuations.

The hydraulic responses of the shallow and intermediate aquifers also are strongly correlated. This suggests the two aquifers are hydraulically well connected, with respect to seasonal and longer-period pressure fluctuations. These two aquifers are not separated by a confining unit.

Generally the hydraulic responses of the wells in the intermediate aquifer are not as strongly correlated to those of the deep aquifer as they are to those of the shallow aquifer. The intermediate and deep aquifers are separated by a confining unit, the silt aquitard, and hence are not hydraulically connected were these measurements were made.

The intermediate and deep aquifers may be hydraulically coupled, with respect to seasonal variations, at some location(s) up-gradient from the facility. For instance, near the east side of the valley where recharge is expected to be relatively high, there may be a strong vertical component of groundwater flow across the silt aquitard during the wet winter months. This seasonal recharge might cause seasonal variations in groundwater levels to propagate to the deep aquifer. Alternatively, the silt aquitard may be discontinuous near the east side of the valley, thus increasing the degree of hydraulic connection there.

3.6.2.2 *Spatial Distribution of Groundwater Elevations*

This section describes the spatial variation of groundwater levels within the hydrogeologic units, and their influence on groundwater flow. It also discusses possible seasonal variation of groundwater flow patterns.

Mean groundwater levels were calculated from data collected from April 2002 to March 2003. These mean groundwater levels were used to construct contour maps of the groundwater elevations for the water table, the deeper shallow aquifer (wells screen 30 to 40 feet bgs), and the intermediate aquifer (wells screened from 40 to 90 feet bgs). The maps constructed using the average values are consistent with the monthly maps submitted to Ecology in the Quarterly Reports for the site. Based on the accumulated water level data and the hydrogeological setting of the study area, the groundwater flow regime appears to be stable, and does not vary in any significant manner through time.

Horizontal groundwater seepage velocities were calculated for the shallow and intermediate aquifers, and are listed in Table 3-21. These estimates were calculated using values from the upper end of the range of horizontal hydraulic conductivities, and values from the lower end of the range of porosity values. The effective porosity generally is less than the total porosity, because the total porosity includes contributions from dead-end pore space, which does not contribute to the material's fluid-transmission capacity.

Spatial Distribution of Groundwater Elevations in the Shallow Aquifer

In the PSC wells, measured depths to water (DTW) in the shallow aquifer have ranged from approximately four to 13 feet bgs. The DTW typically ranges about from five to ten feet bgs across the PSC monitoring network.

Figure 3-25 shows the horizontal distribution of the average groundwater elevations at the water table. The elevations vary from about 13.03 feet at well CG-101-S-1 to 6.72 feet at well CG-

140-WT. Average groundwater elevations in the shallow aquifer generally are highest east of the facility and decrease to the west-southwest. The average horizontal hydraulic gradient over the area of the PSC monitoring network has magnitude approximately 0.0016, with and overall direction of travel toward the west-southwest.

Figure 3-26 shows the horizontal distribution of the average groundwater elevations for wells sreened in the lower shallow aquifer. The elevations vary from vary from 12.88 feet at well CG-101-S2 to 5.43 feet at CG-145-35. Average groundwater elevations in the lower-shallow aquifer generally are highest east of the facility and decrease to the west-southwest. The average horizontal hydraulic gradient over the area of the PSC monitoring network has a magnitude of approximately 0.0016, with an overall direction of travel toward the west-southwest.

Spatial Distribution of Groundwater Elevations in the Intermediate Aquifer

Figure 3-27 shows the estimated horizontal distribution of the average groundwater elevations in the intermediate aquifer. The elevations vary from 12.50 feet at well CG-106-I, to 6.93 feet at well CG-141-50. Groundwater elevations are highest near to the east of the facility and decrease to the west. In the northern part of the monitoring network the horizontal fluid driving force is directed approximately westward; in the central part it is directed approximately toward the west-southwest. In the southeast part of the network the driving force is directed approximately toward the south-southwest. The hydraulic gradient is approximately 0.0016, and the direction is approximately west-southwest.

3.6.2.3 *Groundwater Recharge*

The following factors control recharge (Vaccaro et al, 1998): physical characteristics – topography, soil characteristics, land use and cover, and surficial geology – and water-budget components at or near the land surface – actual evapotranspiration, surface and subsurface runoff, and precipitation.

Precipitation provides water for the surface water flow system, the atmosphere, and the groundwater flow system. Precipitation is partitioned into runoff, evapotranspiration, and groundwater recharge. Precipitation is the main source of water for the groundwater system.

The upland area east of the Georgetown neighborhood consists primarily of sedimentary rocks of the Blakely Formation (Tertiary age), overlain by till (the Vashon Formation – Quaternary age). The till, which has a low permeability, is nearly continuous across the top of the upland. The east upland area is highly developed, with buildings and impermeable pavements covering much of the ground surface. These factors increase the likelihood that precipitation falling on the east upland will run off before it can infiltrate the surface and recharge the underlying bedrock.

In the area of the Georgetown neighborhood, the till of the Vashon Formation has been eroded from the western flank of the east upland area, exposing the Blakely Formation. The western flank of the east upland area consists of steep, west facing slopes. In some areas these slopes are blanketed with soil and are heavily vegetated; in other areas the consolidated bedrock, which is relatively impermeable, is exposed. These slopes cause some of the precipitation that falls on the upland area to be diverted westward toward the Duwamish River as overland flow. As this water flows westward toward the valley floor below, some of it infiltrates the unpaved ground surface. A portion of this infiltrating water is taken up by plants and transpired. Some of the infiltrated water may flow in the shallow subsurface for some distance and then discharge to the ground surface as a seep or perennial stream. The remaining infiltrated water is available to recharge the groundwater system.

Further west, toward the valley floor, the slopes decrease and a greater proportion of the land is developed. Because the Georgetown area is primarily industrial, much of the land surface is covered by impervious structures like buildings, and asphalt or concrete pavements. Little of the valley floor's surface is covered by vegetation, so transpiration is not expected to be significant. Hence much of the water that falls as precipitation is routed more or less directly to storm drains or surface conveyances (streets and gutters) before it has a chance to recharge the groundwater system. For these reasons the highest rates of recharge to the groundwater system are believed to occur along the east side of the Duwamish Valley.

3.6.2.4 *Groundwater Discharge and the Effect of the Duwamish Waterway*

The available groundwater elevation data indicate that groundwater in the shallow, intermediate and possibly the deep aquifers discharges to the Duwamish Waterway. The PSC well network extends to within 50 feet of the waterway, which is tide-influenced. The waterway would be expected to influence the groundwater elevations at nearby wells. For instance, if the stage of the waterway does not vary seasonally, then one would expect the waterway to dampen seasonal fluctuations in shallow groundwater levels, and that the amount of dampening would decrease as the distance from the waterway increased. Conversely, because the waterway is tide-influenced, one would expect that wells nearer the waterway would exhibit diurnal and semidiurnal fluctuations, and that these fluctuations would rapidly decrease in magnitude as the distance from the waterway increases. Two tidal monitoring studies were conducted using wells installed near the waterway, the first being conducted in during November and December of 2002 and the second in July and August of 2003

The purpose of the November-December 2002 tidal monitoring effort was to determine how much mixing was likely to occur in groundwater-monitoring wells near the Duwamish Waterway, due to the waterway tides. The purpose of the Jul-Aug 2003 tidal monitoring effort was to define baseline (ambient) hydraulic conditions for planned slug testing of wells.

For the November-December 2002 tidal monitoring session, the level-versus-time graphs shown in Figure 3-28 suggest that the water-level fluctuations at all three wells are both barometrically and tidally influenced. The tidal influence is effective on relatively short time scales (e.g., about 12 to 24 hours), whereas the barometric influence is effective on longer time scales (e.g., about four to five days and longer.) Therefore, in this case the remainder of the data were analyzed as follows:

- 72-hour moving averages were calculated for the following parameters:
  - water levels for each well
  - effective level for atmospheric pressure (i.e., pressure head in feet of water)
  - water level at Elliott Bay.

- Residual water levels were calculated by subtracting the 72-hour average levels from the corresponding water levels. This had the effect of removing long-term non-tidal trends, such as those due to a trend in atmospheric pressure, from the data.

- The residual (de-trended) water-level data were then used to estimate the tidal response parameters (lag and efficiency).

For the July-August 2003 tidal monitoring session, the pressure-versus-time and level-versus-time graphs shown in Figure 3-29 suggest the following:

- Water-level fluctuations at three of the wells (CG-140-WT, CG-141-WT and CG-141-50) are influenced barometrically but not tidally.

- Water-level fluctuations at two of the wells (CG-140-40 and CG-151-25) are influenced tidally but not barometrically.

Therefore, tidal response parameters were estimated for wells CG-140-40 and CG-151-25 only.

For both tidal monitoring sessions, the tidal response parameters were estimated using simple graphical methods. First, an elapsed time was chosen. Next, the corresponding lag and efficiency were estimated. Then the estimation procedures were repeated for a second elapsed time. The final parameter estimates were obtained as the average of the estimates corresponding to the two elapsed times.

For each elapsed time the time lag was estimated as follows. For each well and for the surface water level, the nearest (in time) two lower low levels were identified. That is, the first lower low level that occurred before the chosen time, and the first lower low level that occurred after the chosen time, were identified. The lower low levels were used because these were the most clearly identifiable features for this purpose. For each of the lower low levels identified, the elapsed time was estimated and the time lag (relative to the surface water level) was calculated. The time lag was then calculated as the average of the two calculated time lags. This procedure was repeated using a different elapsed time. The final time-lag estimate was calculated as the arithmetic average of the estimates corresponding to the two elapsed times. For the November-December 2002 tidal monitoring session, the chosen elapsed times were 13 and 23 days. For the July-August 2003 tidal monitoring session, the chosen elapsed times were 1.5 days and 2.5 days.

After the time lag was estimated, the tidal efficiency was estimated. The tidal efficiency was calculated as the ratio of the thickness of the water-level amplitude envelope for the well, to that of the tide. The upper limit of each envelope was defined by linearly interpolating between successive higher high levels. Similarly, the lower limit was defined by linear interpolation between successive lower low levels.

Table 3-16 describes the basic characteristics of the data collected during both tidal monitoring efforts.

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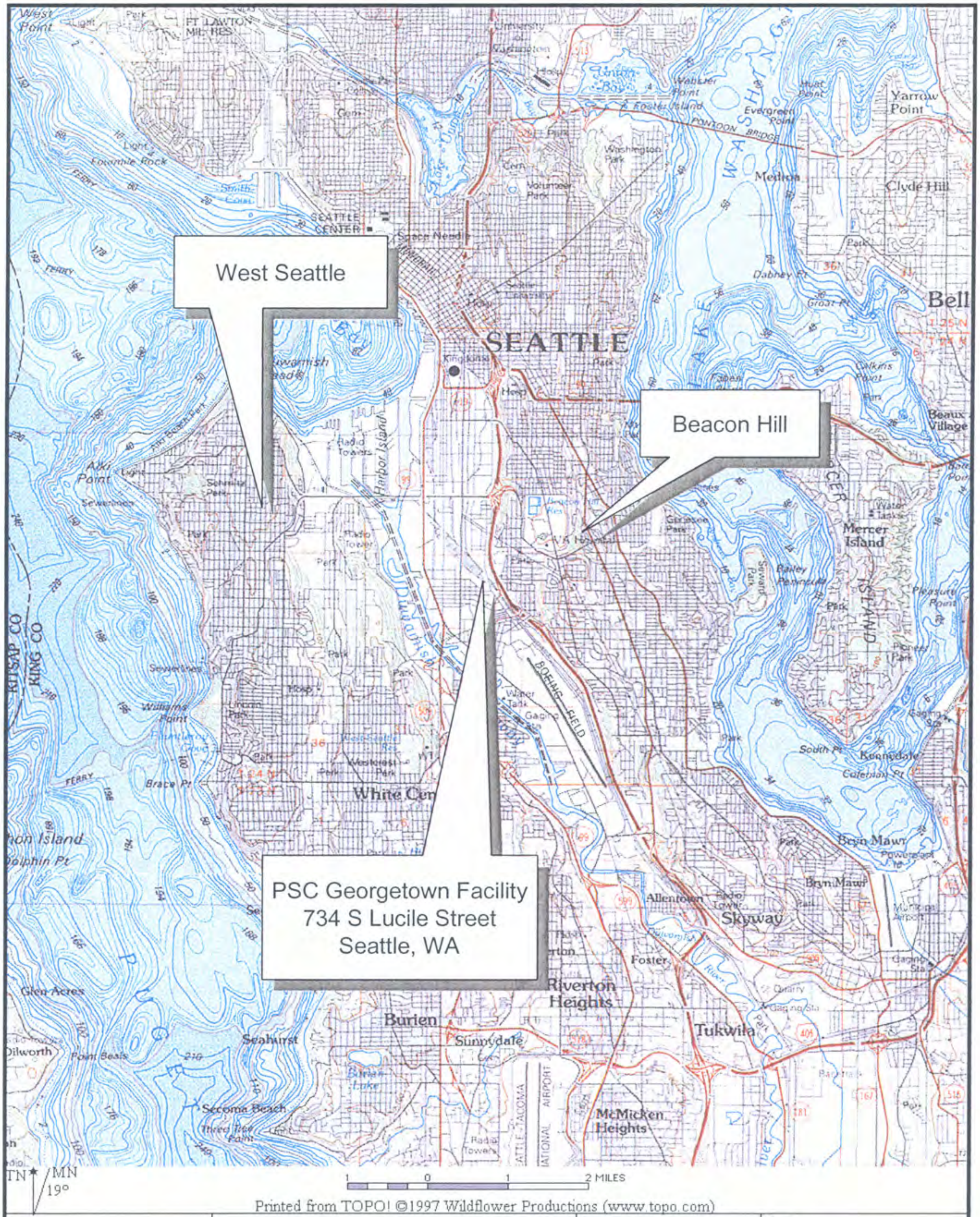

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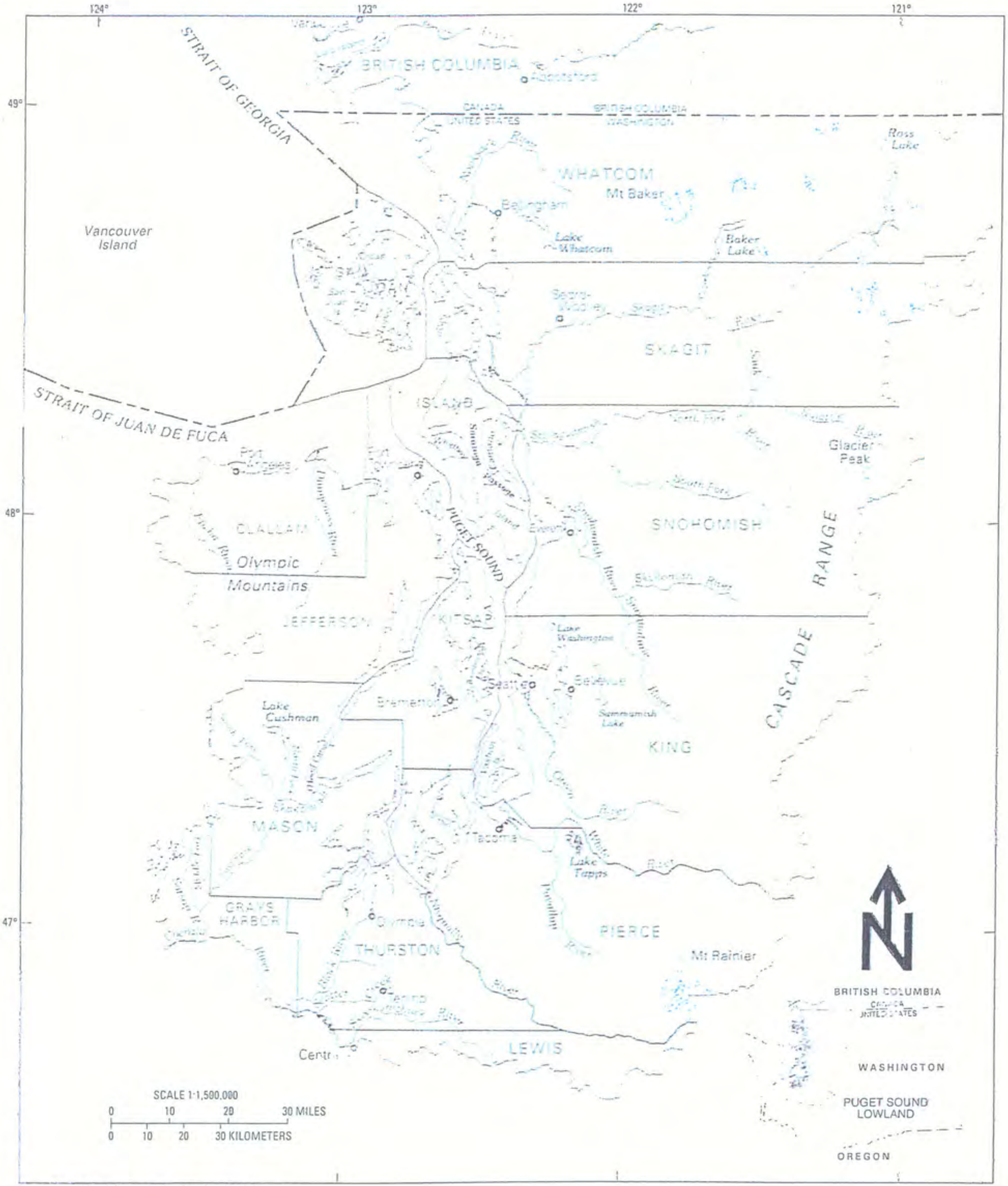
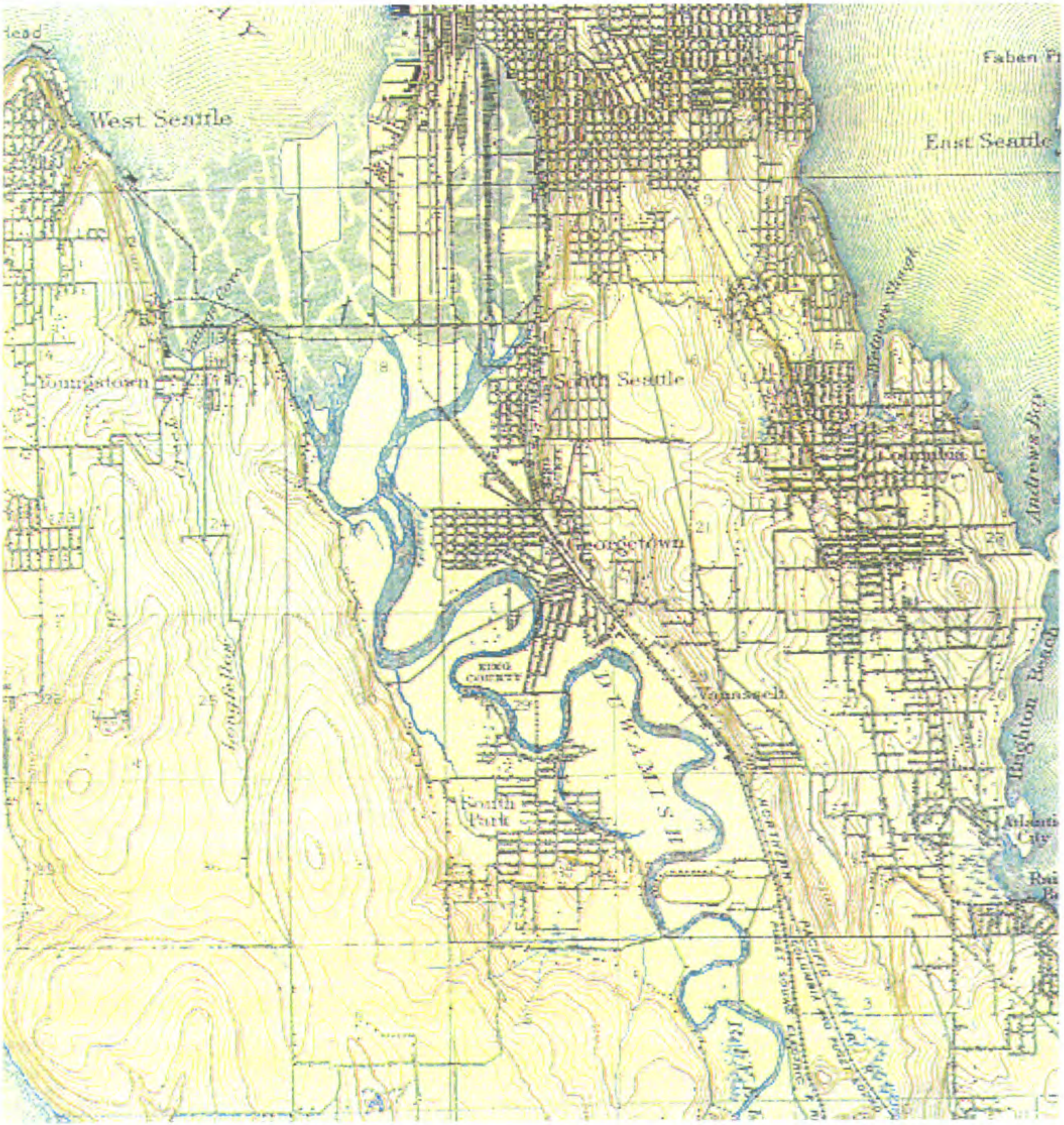
PSC	Title PSC Georgetown Facility, Beacon Hill, and West Seattle	Drawn dtb	Project RI2003
		Date 7/23/03	Figure 3-1



Base modified from U.S. Geological Survey digital data, 1:2,000,000, 1972

Source: Vaccaro et al., 1998

Puget Sound Lowland, Washington and B.C. Georgetown Facility		Project RFI Report
		Figure **3-2**



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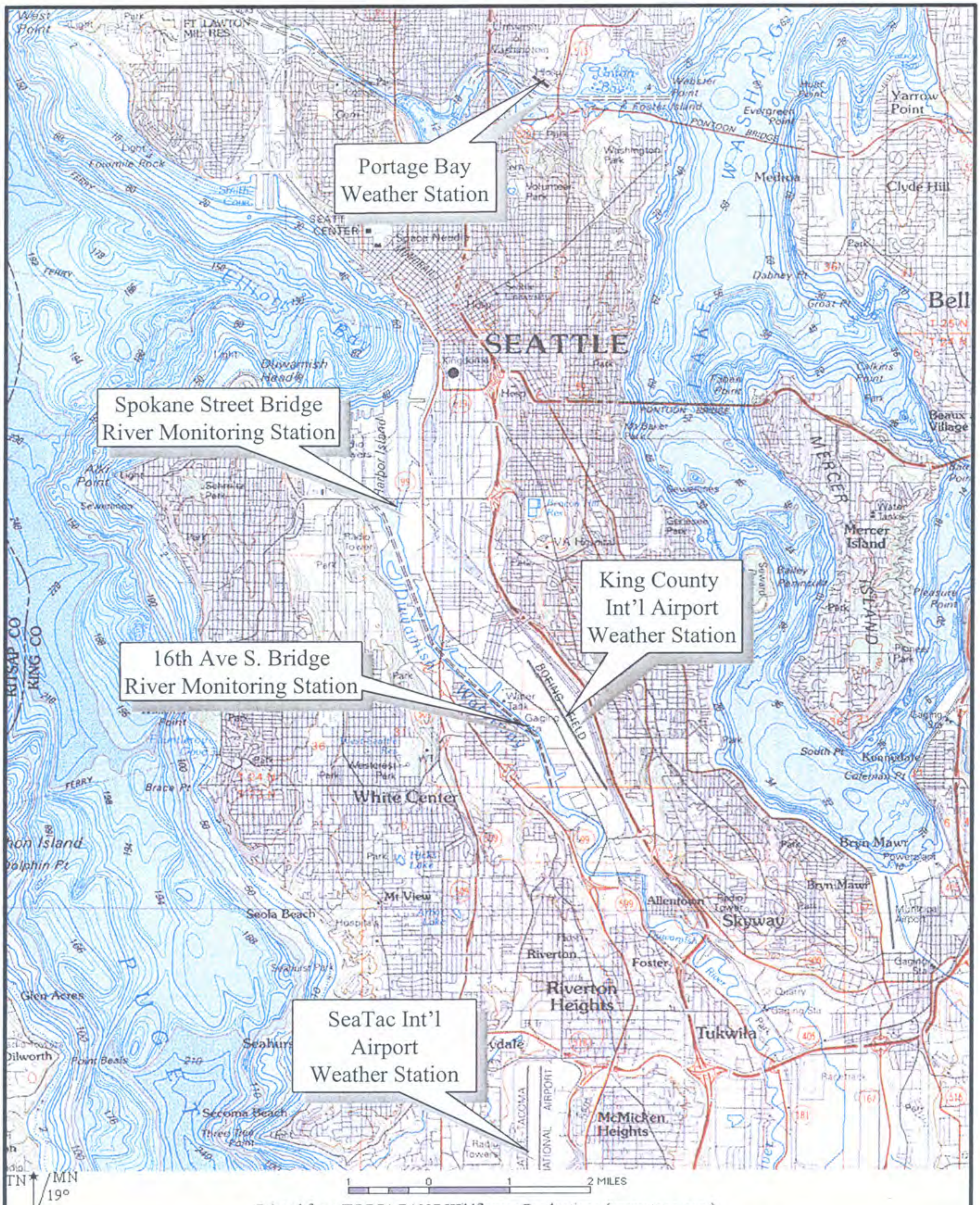
Source: U.S.-Geol. Survey 1909. Seattle Quadrangle.
15 Minute Series Topographical Map.

PSC	Duwamish River Valley 1909 Georgetown Facility		Project RI2003
			Figure 3-3



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PSC	Title Weather Stations and River Monitoring Stations Seattle, WA	Drawn dtb	Project RI2003
		Date 7/23/03	Figure 3-4

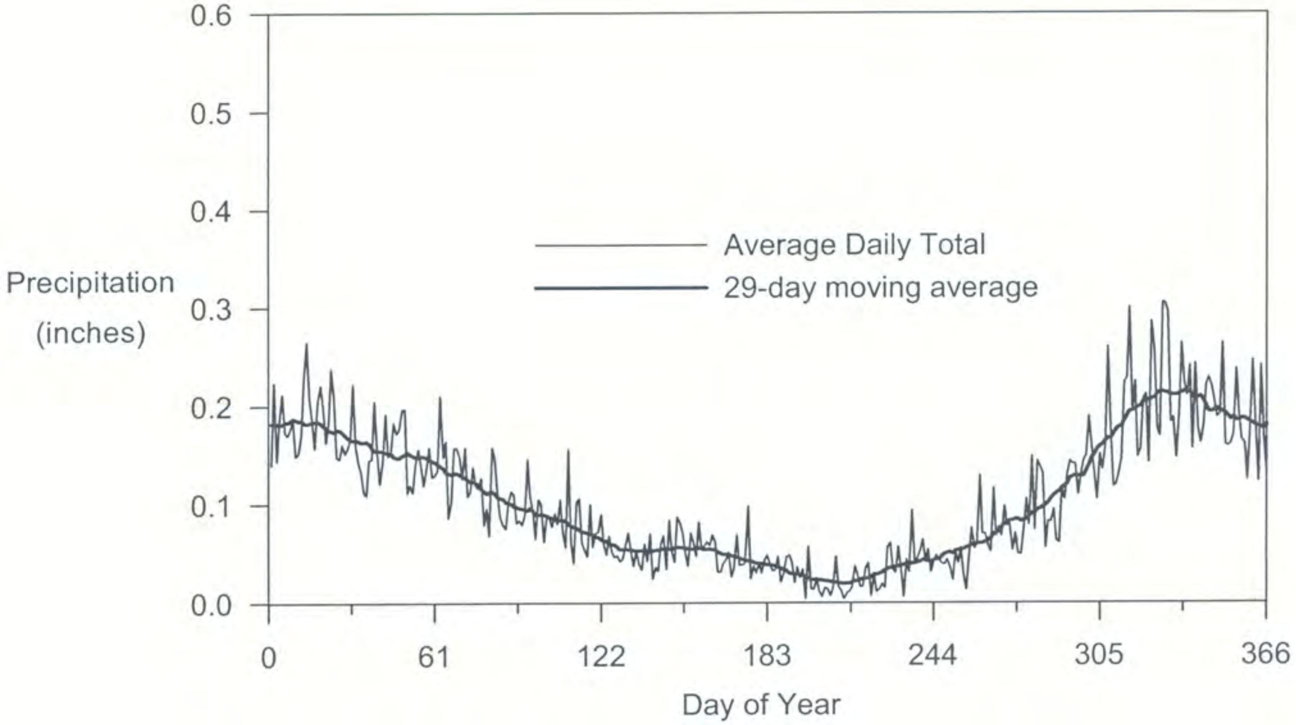


Figure 3-5 . Average daily precipitation at SeaTac Airport.

precip_day.grf

PERIOD	AGE (Ka)		GEOLOGIC/CLIMATIC UNITS		TIME/STRATIGRAPHIC UNITS		
Quaternary	Holocene		Winthrop Creek glacial		Alluvium, colluvium marine deposits, lahars, volcanic ash		
		3	"Hypsithermal interval"				
	Pleistocene	10	Fraser Glacial	Vashon Stade	Vashon Drift	Recessional deposits	
		13.5				Vashon Till	
						Esperance Sand	Advance outwash
						Lawton Clay	
		20	Olympia nonglacial		Discovery (Olympia) beds		
		60	Possession glacial		Possession Drift		
		80	Whidbey nonglacial		Whidbey Formation		
		100	Double Bluff glacial		Double Bluff Drift*		
		250	▨	▨	▨	▨	▨
		730	Salmon Springs Glacial	Upper glacial	Upper Salmon Springs Drift*		
				Nonglacial	Nonglacial sediments, tephra*		
		840		Lower glacial	Lower Salmon Springs Drift*		
			Puyallup nonglacial		Puyallup Formation*		
			Stuck glacial		Stuck Drift*		
			Alderton nonglacial		Alderton Formation*		
		2,000	Orting glacial		Orting Drift*		
Tertiary	Pliocene		▨	▨	▨	▨	▨
	Miocene		Continental		Hammer Bluff Formation*		
	Oligocene		Marine/estuarine		Blakeley Formation		
	Eocene		Continental - volcanic		Puget Group	Renton Formation	
						Tukwila Formation	
						Tiger Mountain Fm.*	
			Marine		Raging River Formation*		

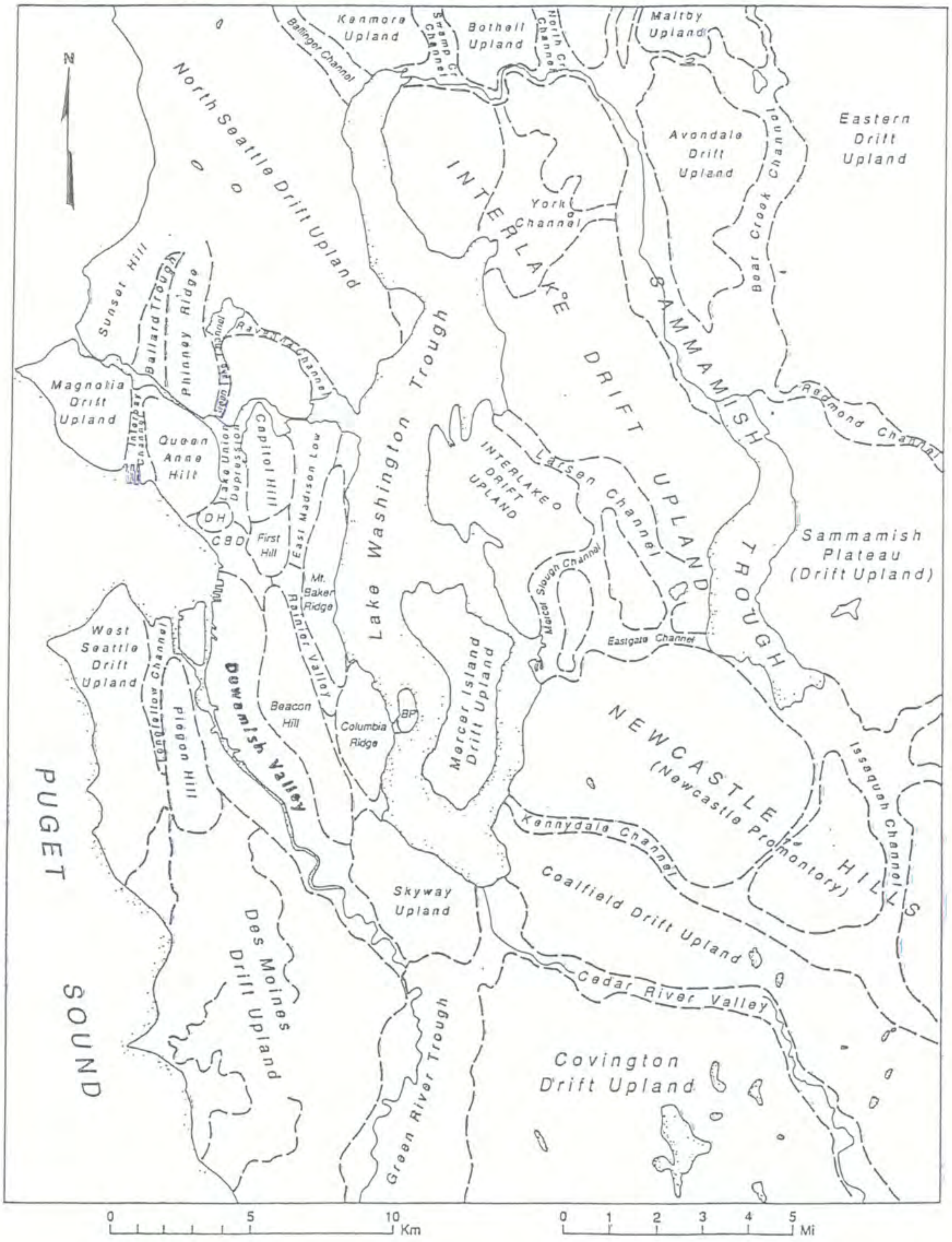
Source: Reprinted from R. W. Galster and W. T. Laprade, "Geology of Seattle, Washington, United States of America", Bulletin of the Association of Engineering Geologists, Vol. XXVIII, No. 3, pp. 235-302.

PSC

Stratigraphic Sequence
for the Seattle Area
Georgetown Facility

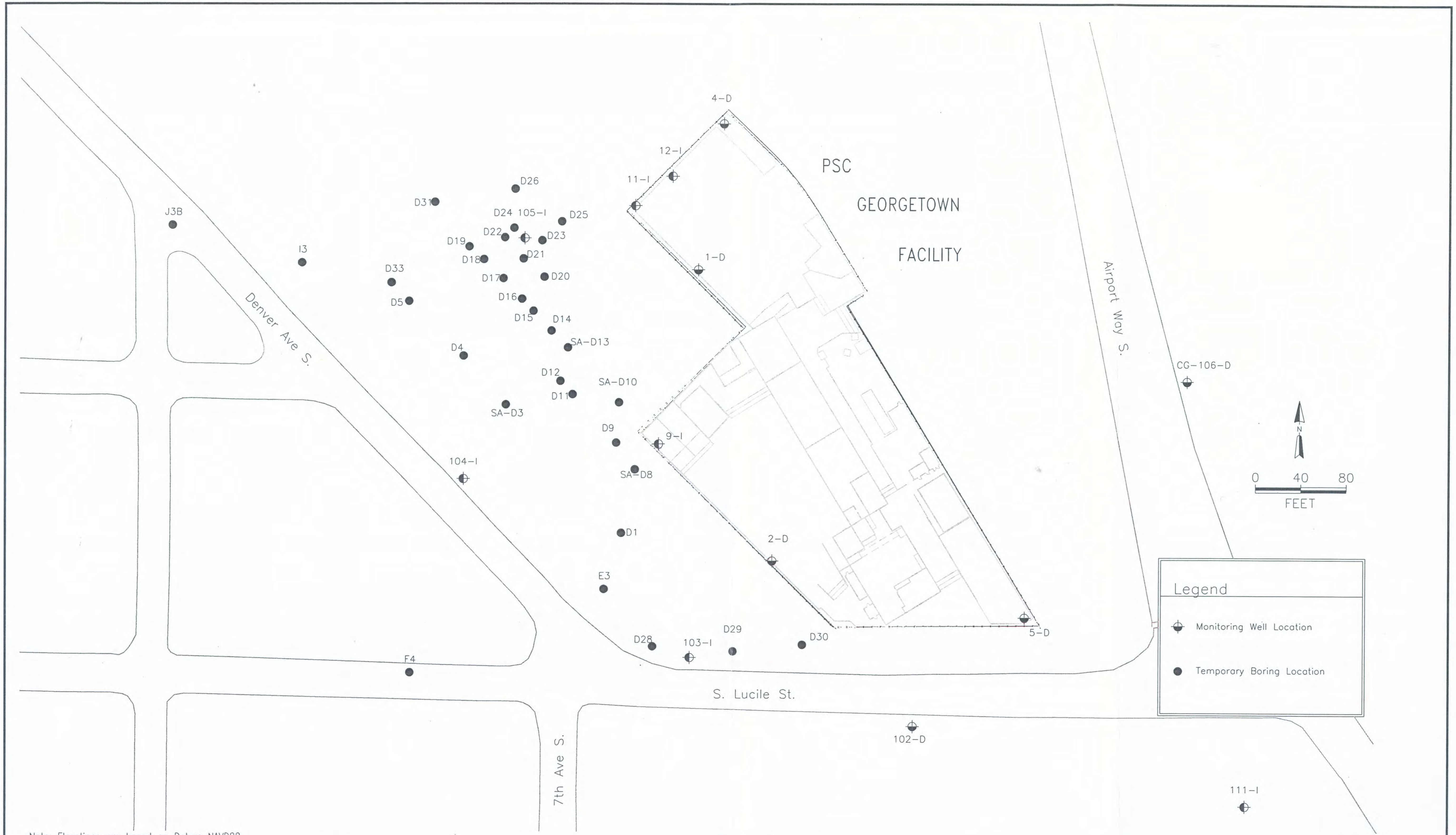
Project
RFI Report

Figure
3-6



Source: Reprinted from R. W. Galster and W. T. Laprade, "Geology of Seattle, Washington, United States of America", Bulletin of the Association of Engineering Geologists, Vol. XXVIII, No. 3, pp. 235-302.

PSC	**Local Geologic Features** **Georgetown Facility** **Seattle, WA**		Project RFI Report
			Figure 3-7



Note: Elevations are based on Datum NAVD88.

PSC

TITLE:
Borings Used for Geologic Interpretation
Near Facility
PSC Georgetown Facility

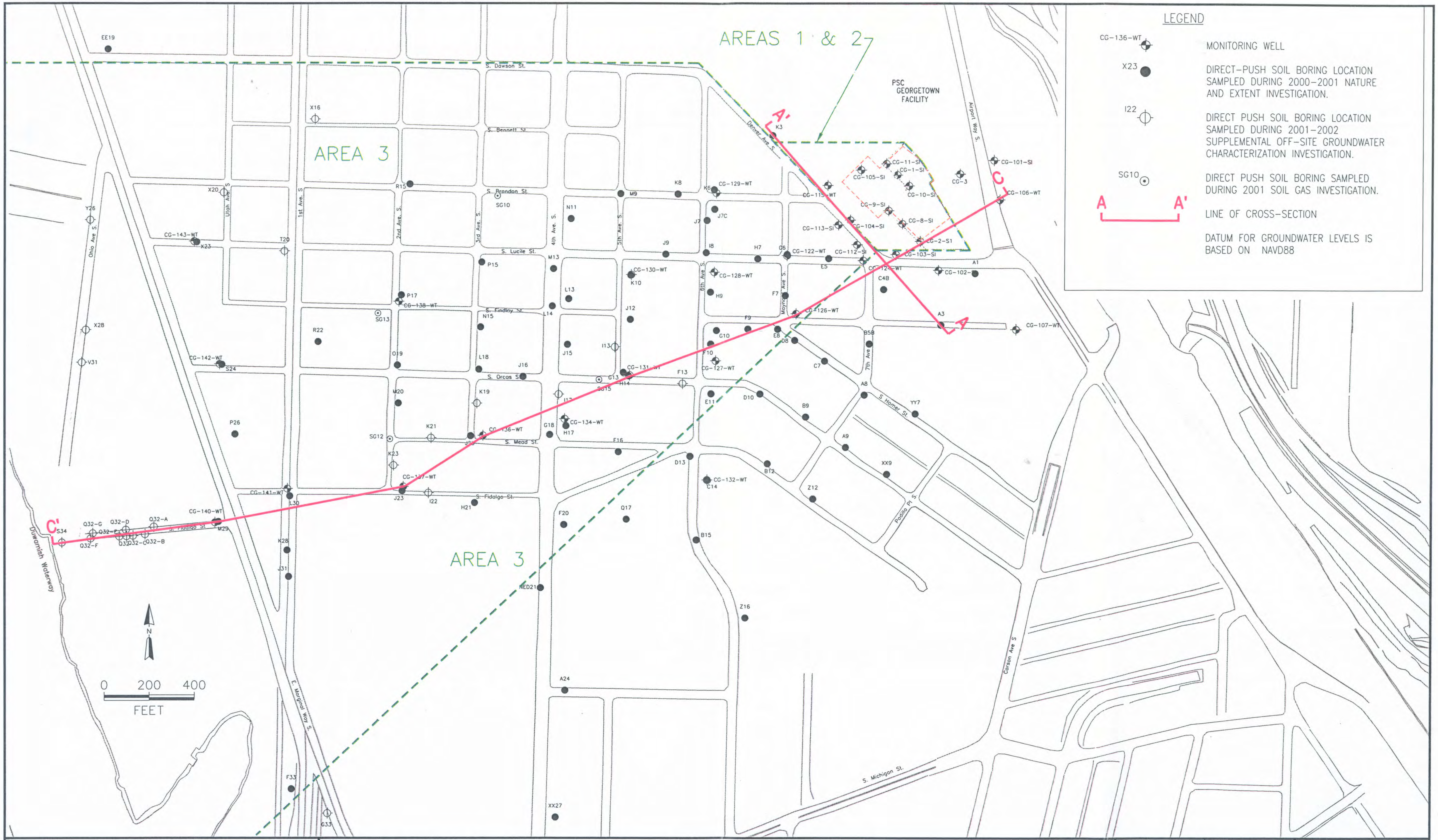
DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 11/5/03	REV.:	FIGURE NO.: 3-8

Note: Elevations are based on Datum NAVD88.

PSC

TITLE:
Borings Used for Geologic Interpretation
All Borings
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 11/5/03	REV.:	FIGURE NO.: 3-9



TITLE:
Cross-Section Location Map
for Geologic Interpretation
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003	
CHKD:	APPD:		
DATE: 10/21/03	REV.: 1	FIGURE NO.: 3-10	

LEGEND

CG-105 BORING/MONITORING WELL IDENTIFICATION

GROUND SURFACE

GEOLOGIC CONTACT

INDICATES CROSS-SECTION LINE CROSSING CITY STREETS

SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION

SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION

WT, S1, S2, 40, I, 75, D INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 75), AND DEEP (D) AQUIFERS

ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED
GP	GRAVEL WITH SAND, POORLY GRADED

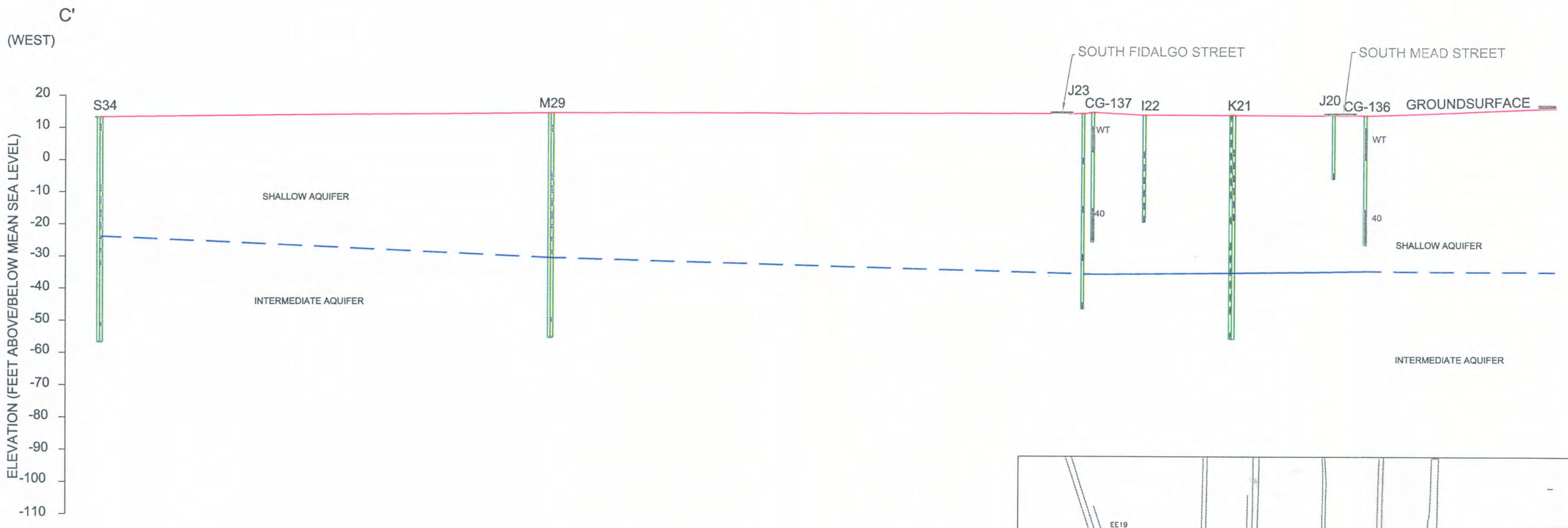
NOTES:

1. VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88
2. SOIL TYPES SHOWN FOR BORING CG-104 COMBINED FROM CG-104-S2, CG-104-I, AND CG-104-D

PSC

TITLE:
Cross Section A – A'
Geologic Interpretation
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 10/22/03	REV.:	FIGURE NO.: 3-11



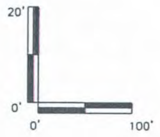
Cross Section C - C' continued on figure 3-16.

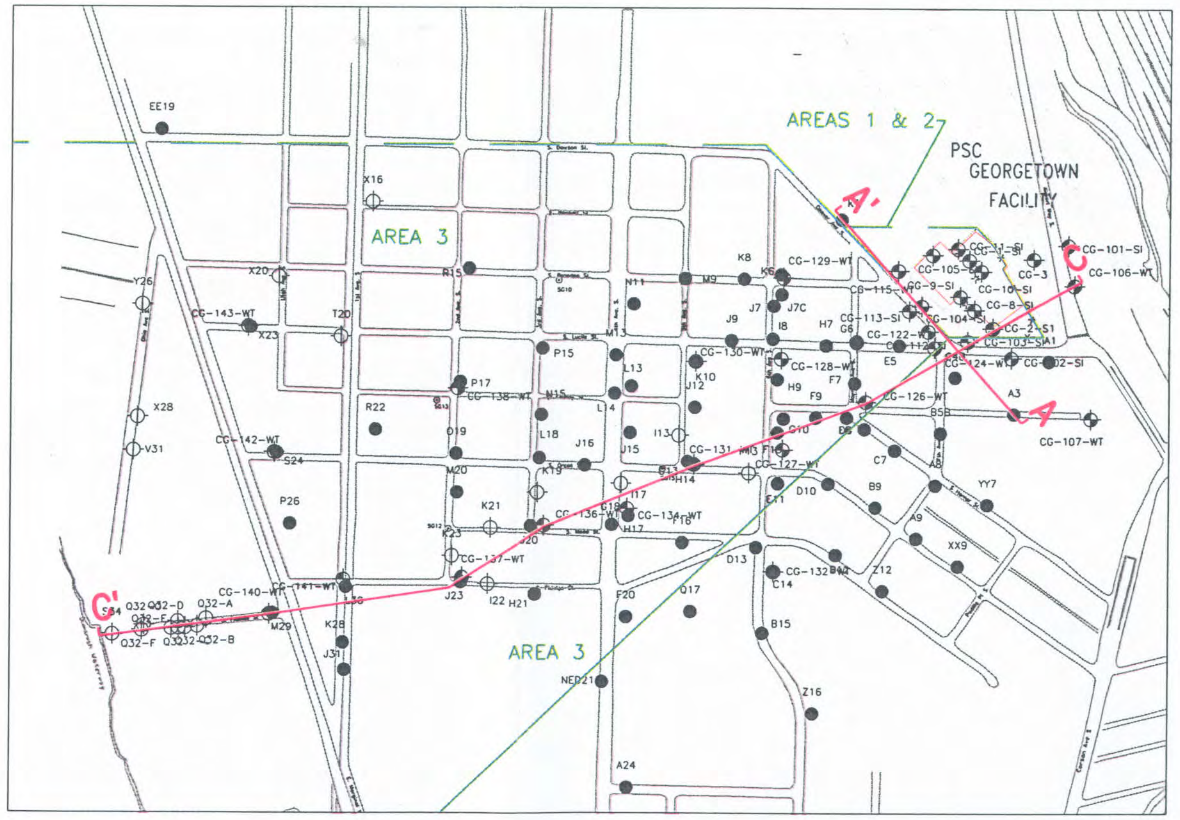
LEGEND

CG-105	BORING/MONITORING WELL IDENTIFICATION
—	GROUND SURFACE
— —	GEOLOGIC CONTACT
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
☒	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▤	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
WT,S1, S2, 40, I, 70, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 70), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED

NOTES:

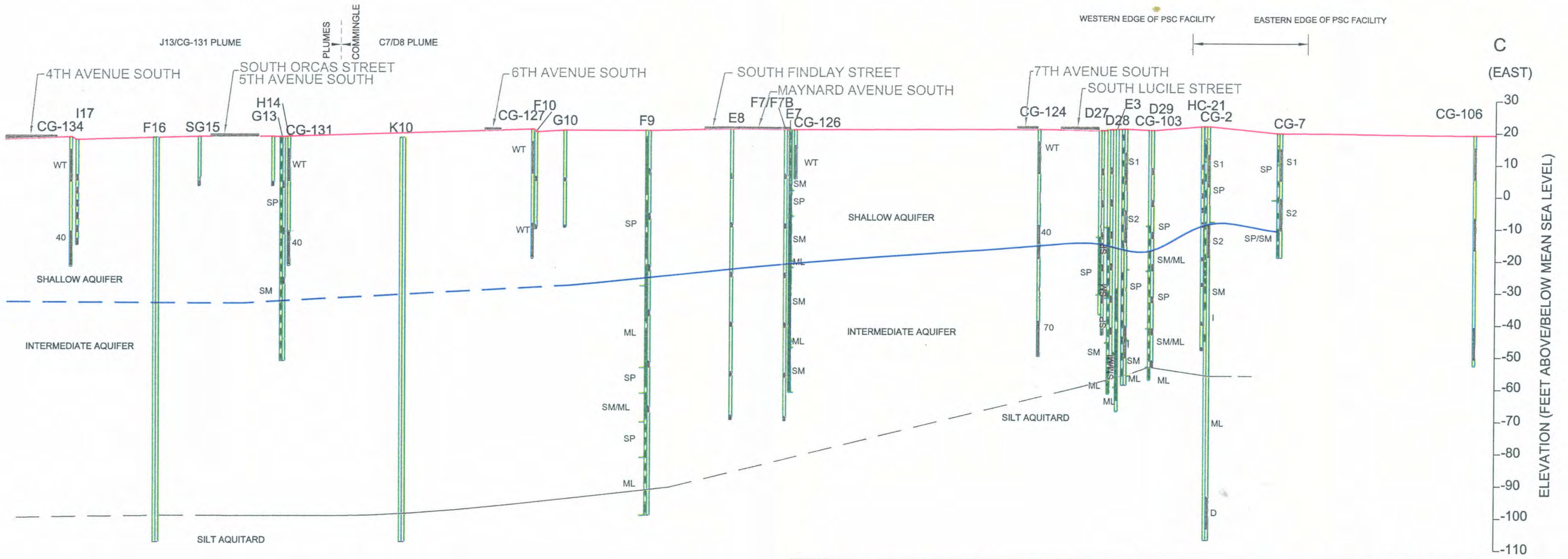
VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88





TITLE: Cross Section C – C' West Remedial Investigation PSC Georgetown Facility	DWN:	DES.:	PROJECT NO.: RI2003	
	CHKD:	APPD:	FIGURE NO.: 3-12a	
	DATE: 10/22/03	REV.:		

Cross Section C - C' continued on figure 3-15.

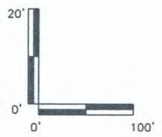


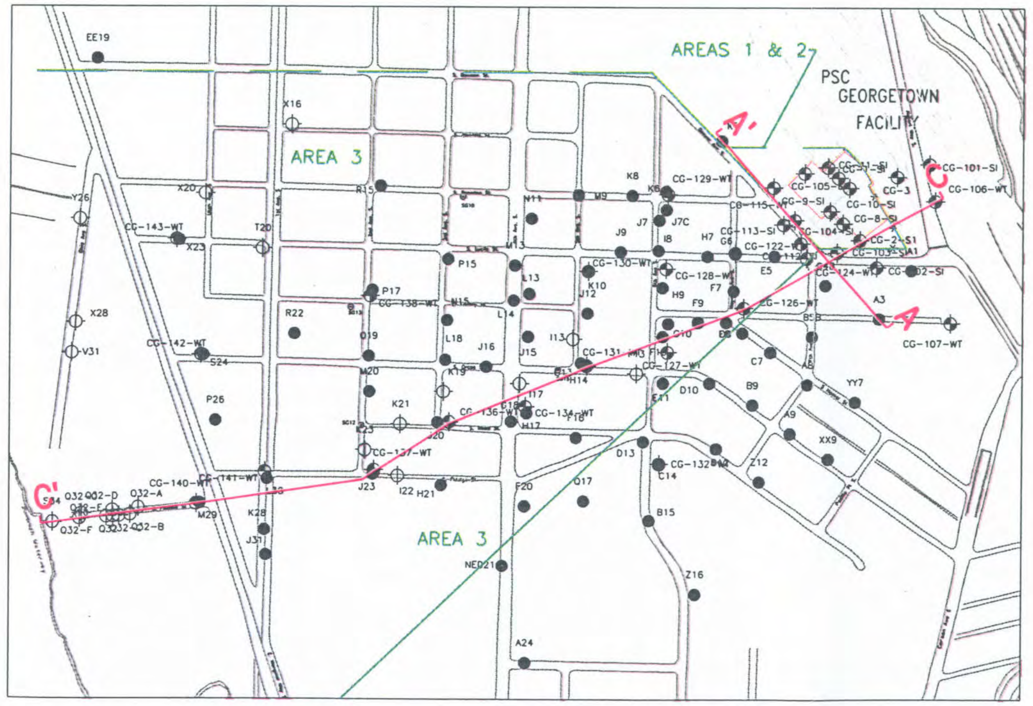
LEGEND

CG-105	BORING/MONITORING WELL IDENTIFICATION
▬	GROUND SURFACE
— —	GEOLOGIC CONTACT
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
☒	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
≣	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
WT,S1, S2, 40, I, 70, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 70), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED

NOTES:

VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88

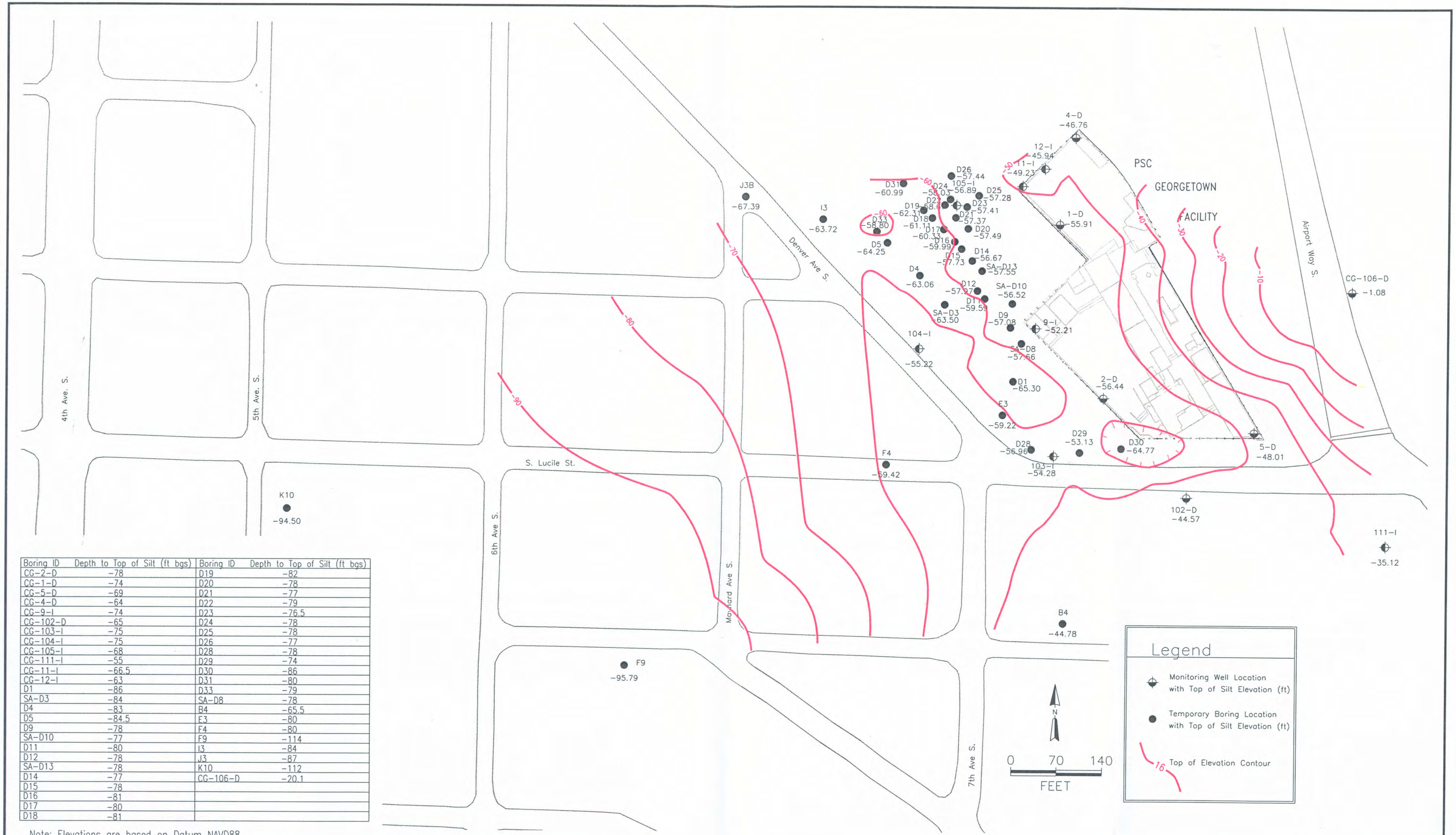




PSC

TITLE:
Cross Section C – C' East
Remedial Investigation
PSC Georgetown Facility

DWN:	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 10/22/03	REV.:	FIGURE NO.: 3–12b



Boring ID	Depth to Top of Silt (ft bgs)	Boring ID	Depth to Top of Silt (ft bgs)
CG-2-D	-78	D19	-82
CG-1-D	-74	D20	-78
CG-5-D	-69	D21	-77
CG-4-D	-64	D22	-79
CG-9-I	-74	D23	-76.5
CG-102-D	-65	D24	-78
CG-103-I	-75	D25	-78
CG-104-I	-75	D26	-77
CG-105-I	-68	D28	-78
CG-111-I	-55	D29	-74
CG-11-I	-66.5	D30	-86
CG-12-I	-63	D31	-80
D1	-86	D33	-79
SA-D3	-84	SA-D8	-78
D4	-83	B4	-65.5
D5	-84.5	E3	-80
D9	-78	F4	-80
SA-D10	-77	F9	-114
D11	-80	I3	-84
D12	-78	J3	-87
SA-D13	-78	K10	-112
D14	-77	CG-106-D	-20.1
D15	-78		
D16	-81		
D17	-80		
D18	-81		

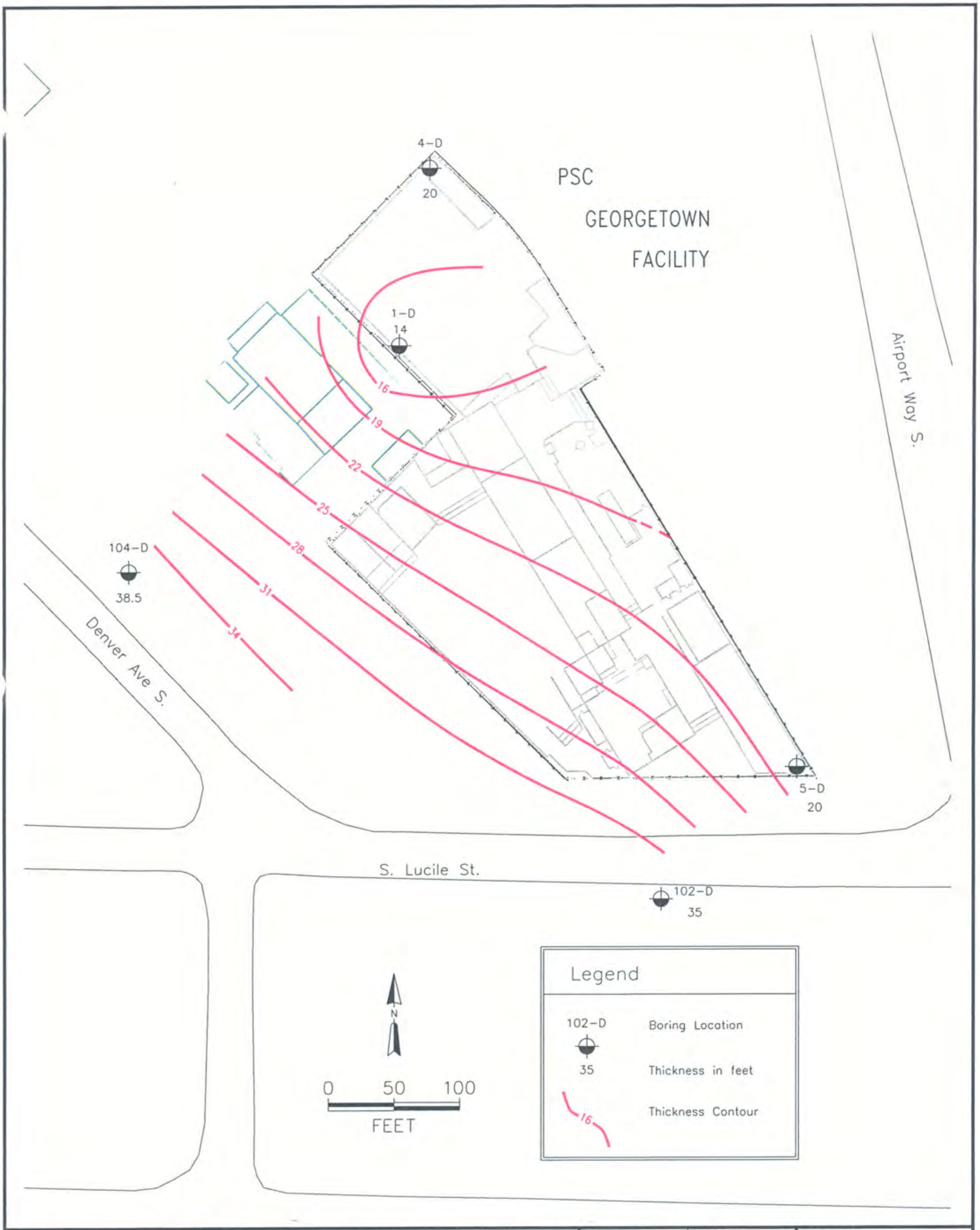
Note: Elevations are based on Datum NAVD88.

TITLE:

Elevation of Top of Silt Layer

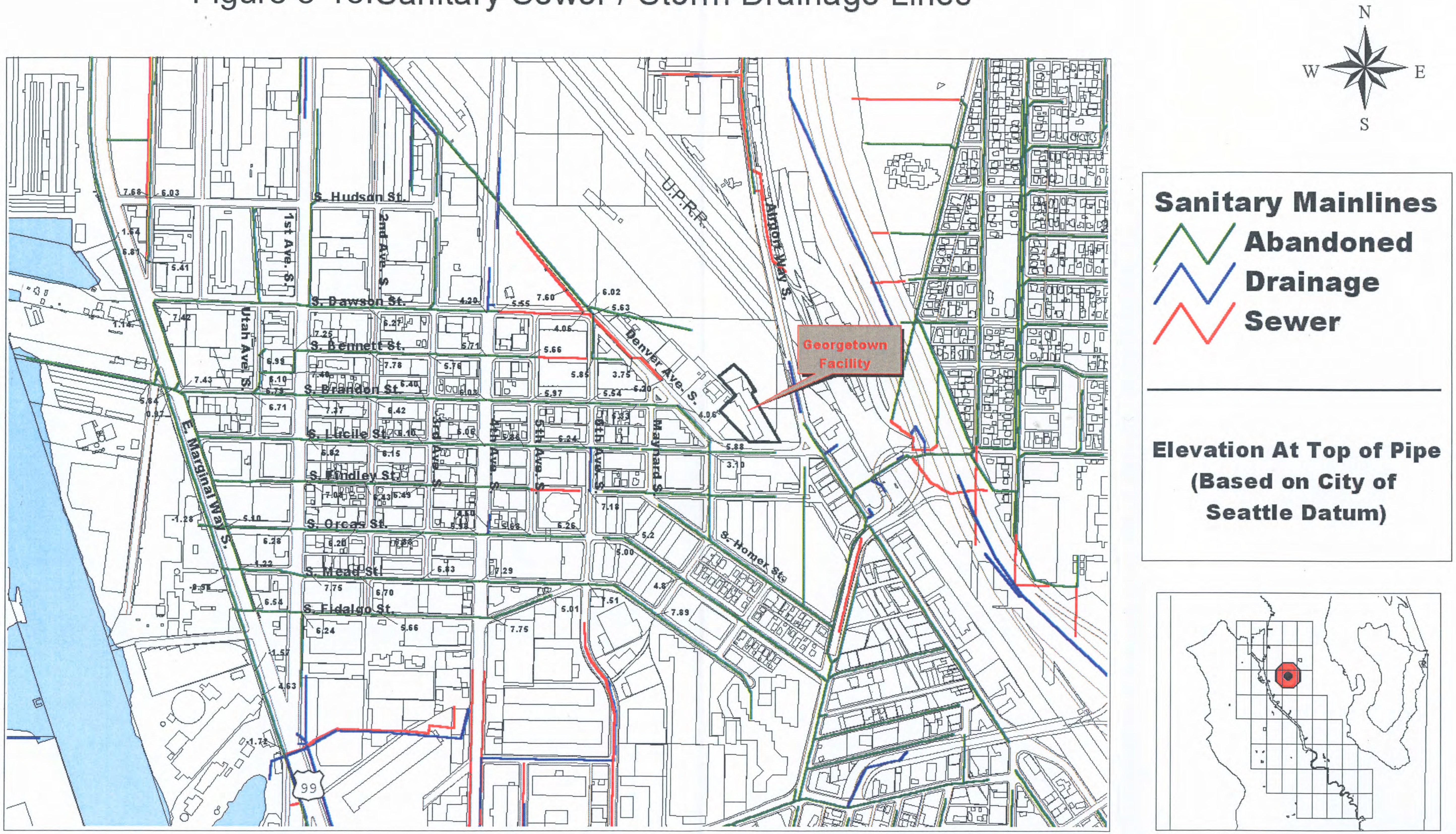
PSC Georgetown Facility

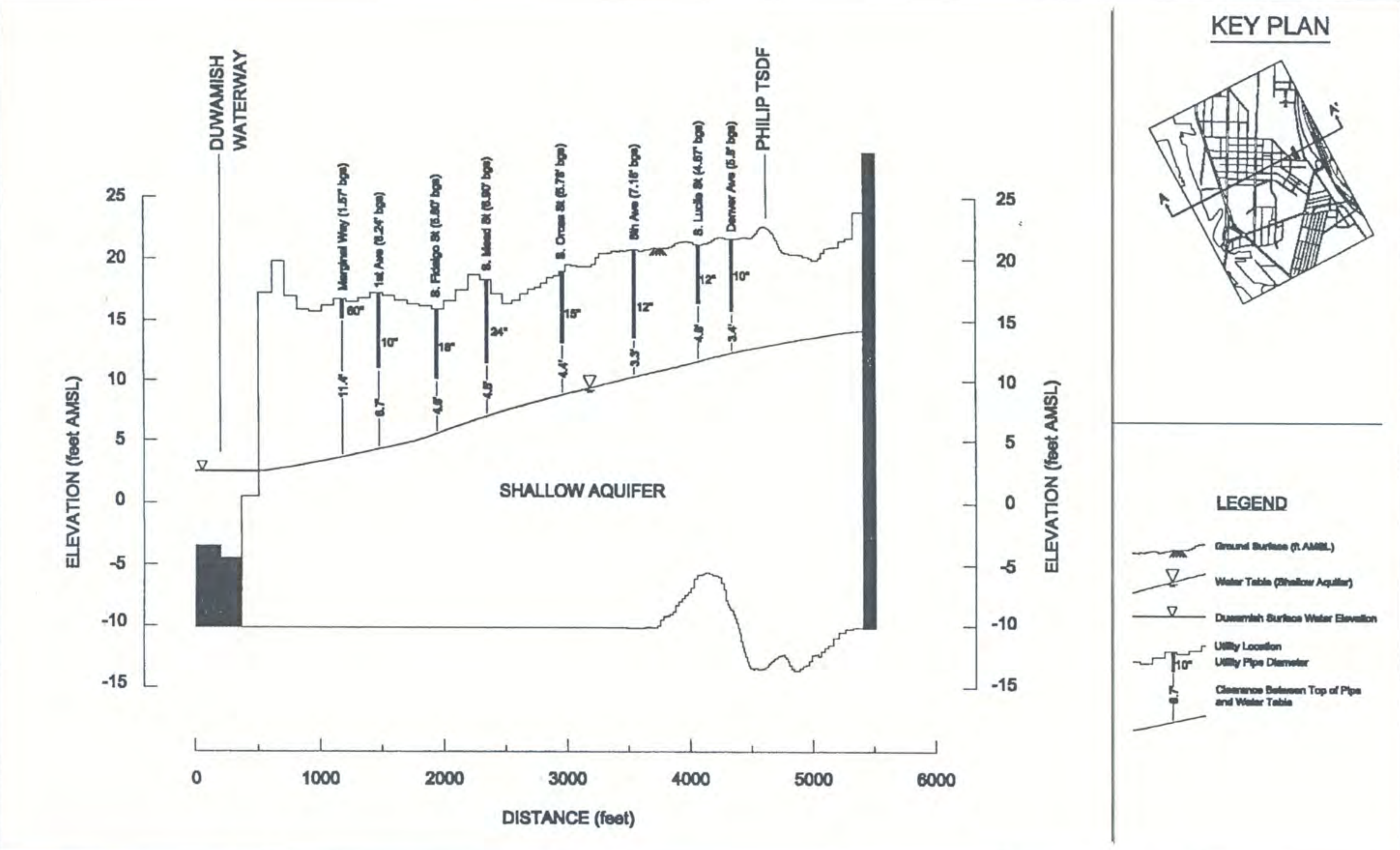
DWN: dtb	DES.:	PROJECT NO.: RI2003	
CHKD:	APPD:		
DATE: 10/22/03	REV.:	FIGURE NO.: 3-13	



PSC	TITLE: Silt Layer Thickness PSC Georgetown Facility	DWN: dtb	DES.:	PROJECT NO.: RI2003
		CHKD:	APPD:	
		DATE: 10/22/03	REV.:	FIGURE NO.: 3-14

Figure 3-15.Sanitary Sewer / Storm Drainage Lines

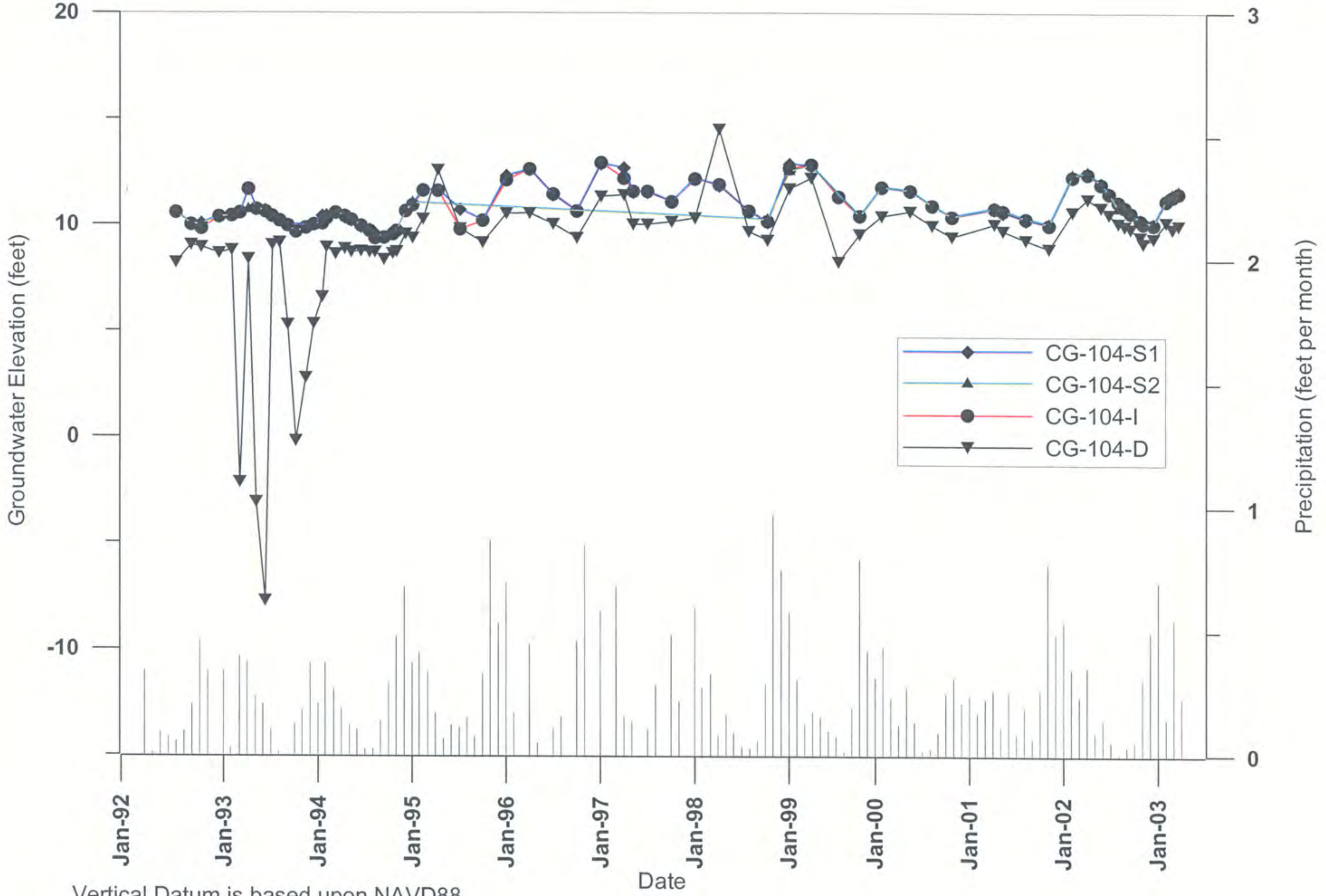




PSC

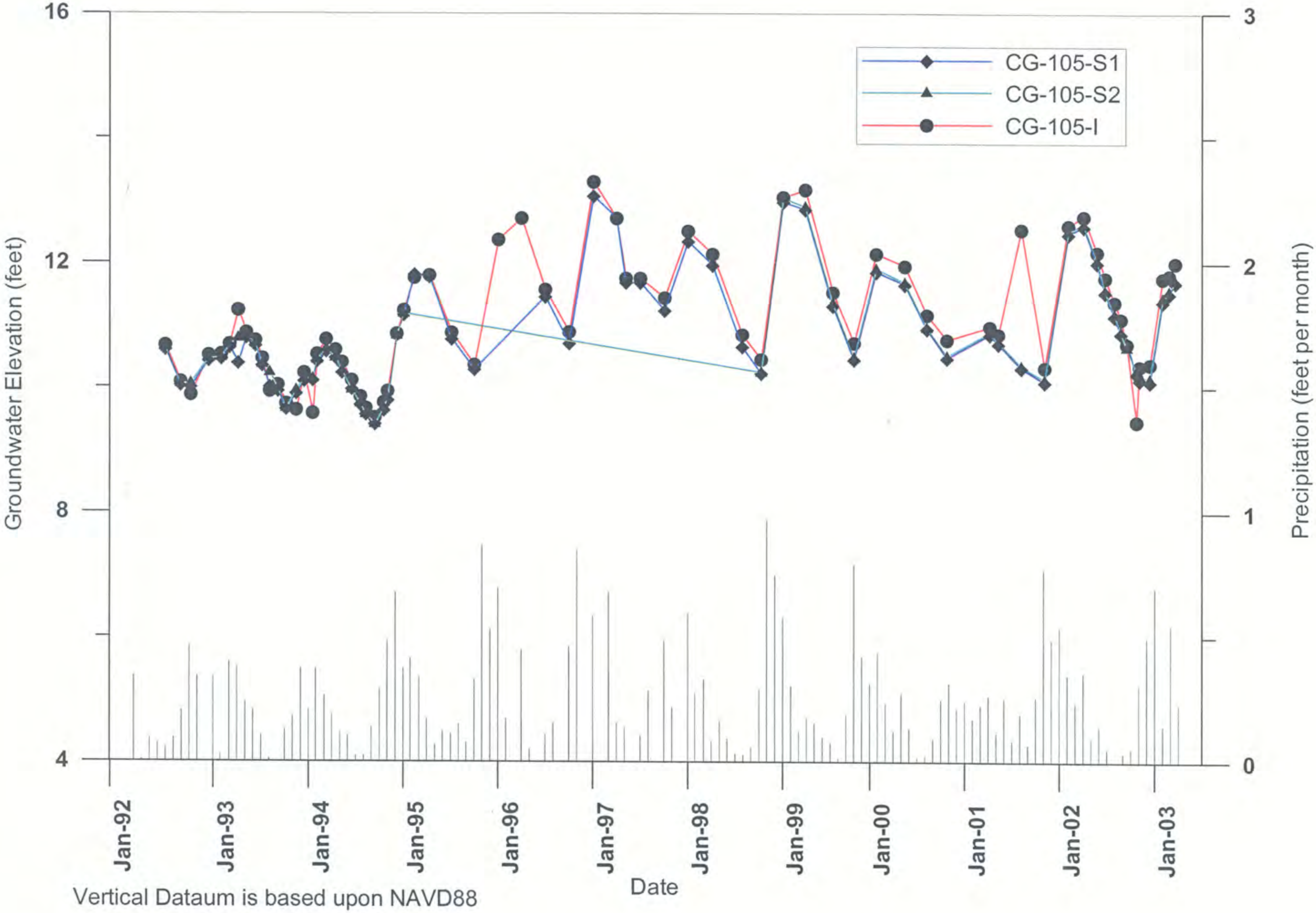
Title:	Created:	Project:
Utility Locations Cross Section PSC Georgetown	DTB	RI2003
	Date: 11/10/03	Figure: 3-16

Figure 3-17. Hydrographs for CG-104 Well Nest
Remedial Investigation
PSC Georgetown Facility



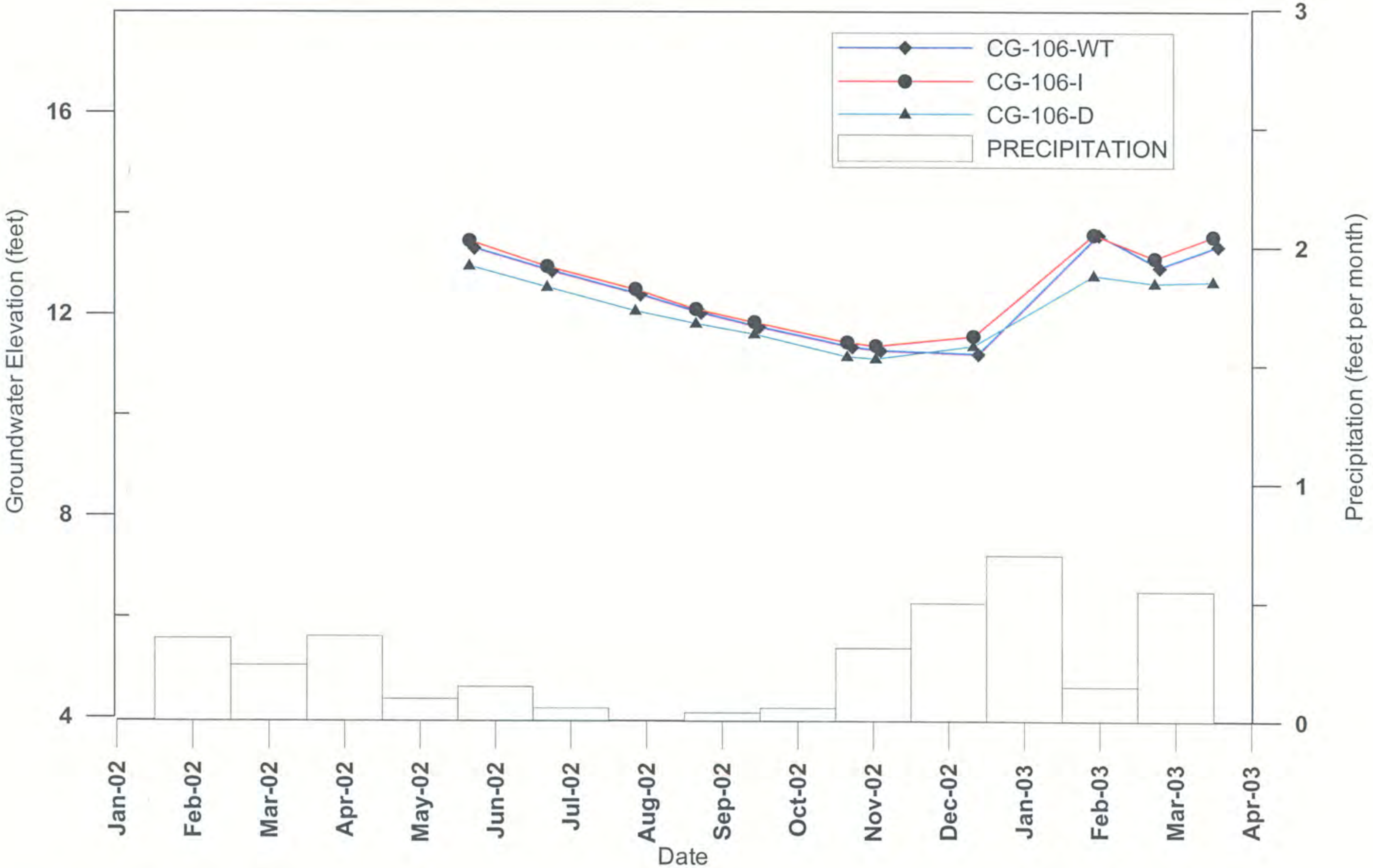
Vertical Datum is based upon NAVD88

Figure 3-18. Hydrographs for CG-105 Well Nest
Remedial Investigation
PSC Georgetown Facility



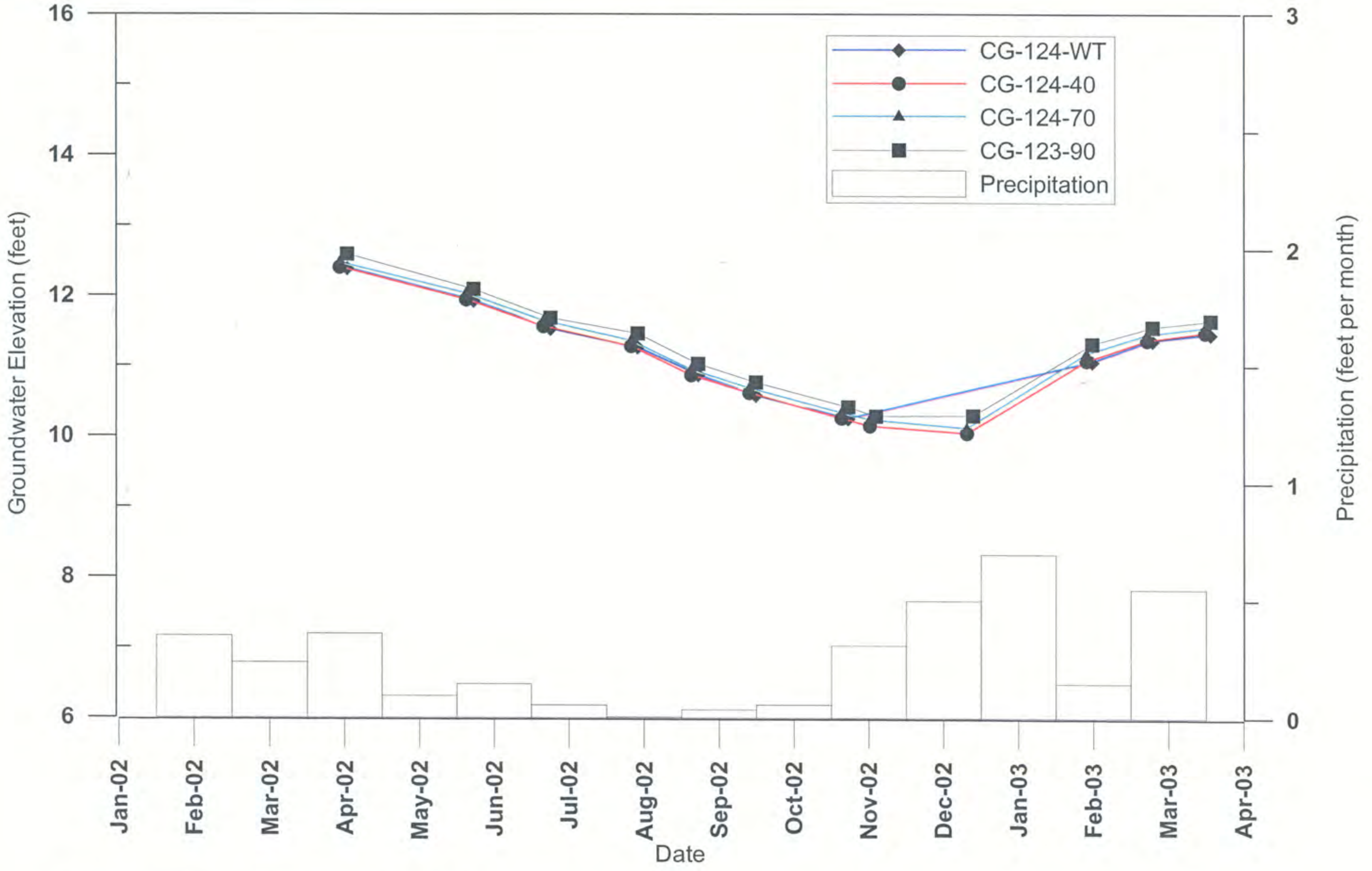
Vertical Dataum is based upon NAVD88

Figure 3-19. Hydrographs for CG-106 Well Nest
Remedial Investigation
PSC Georgetown Facility



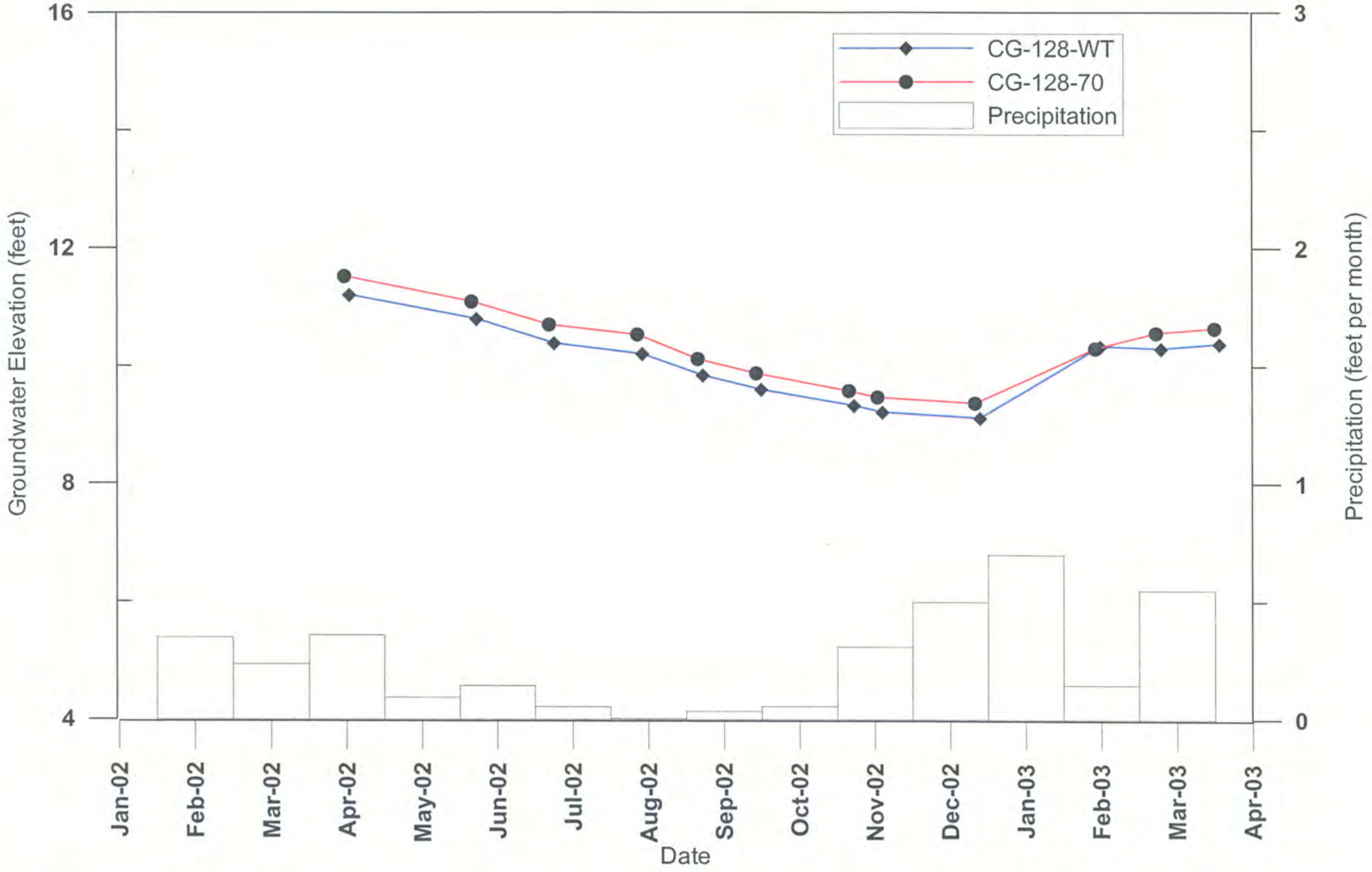
Vertical Datum is based upon NAVD88

Figure 3-20. Hydrographs for CG-124 Well Nest
Remedial Investigation
PSC Georgetown Facility



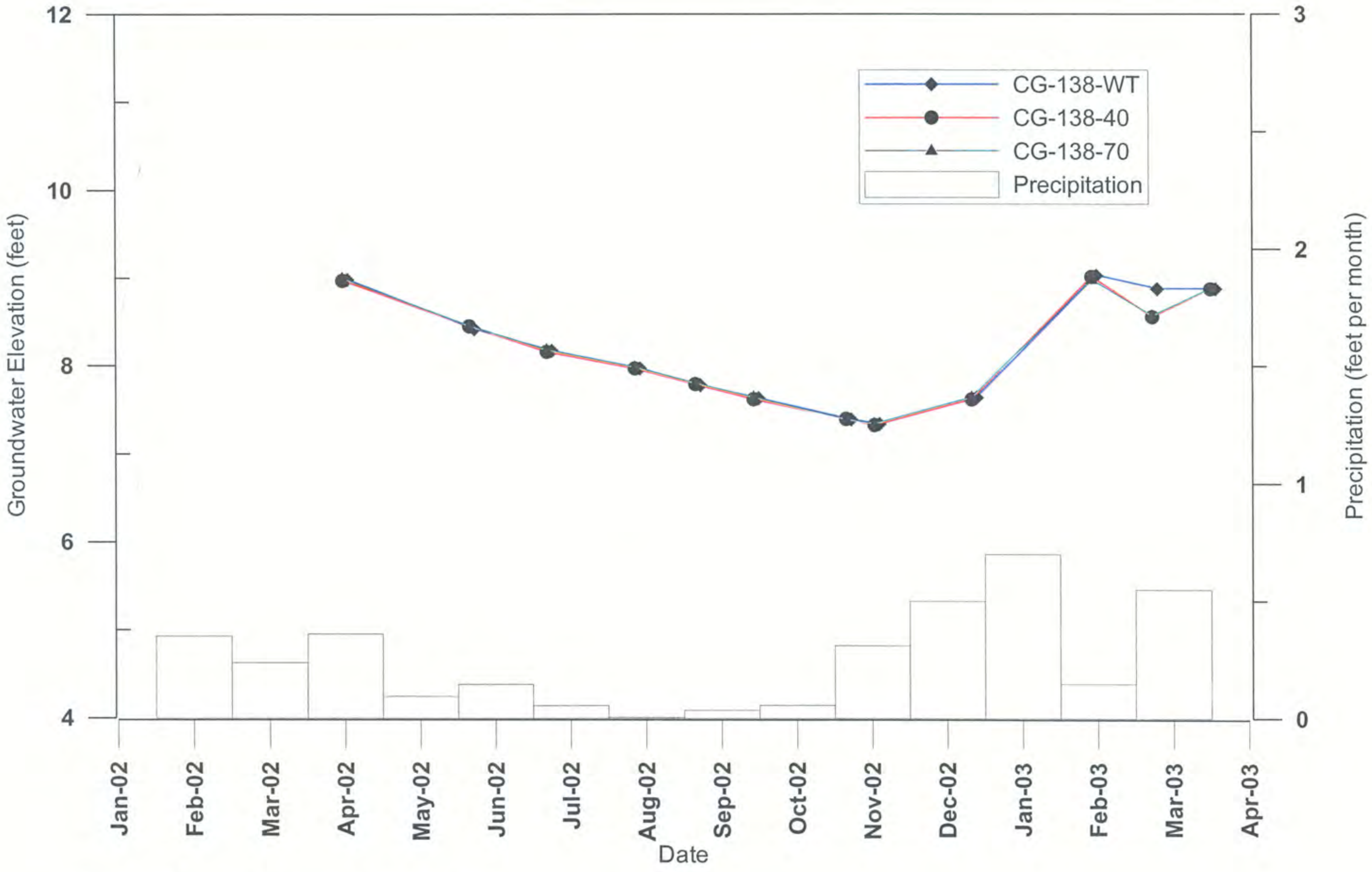
Vertical Datum is based upon NAVD88

Figure 3-21. Hydrographs for CG-128 Well Nest
Remedial Investigation
PSC Georgetown Facility



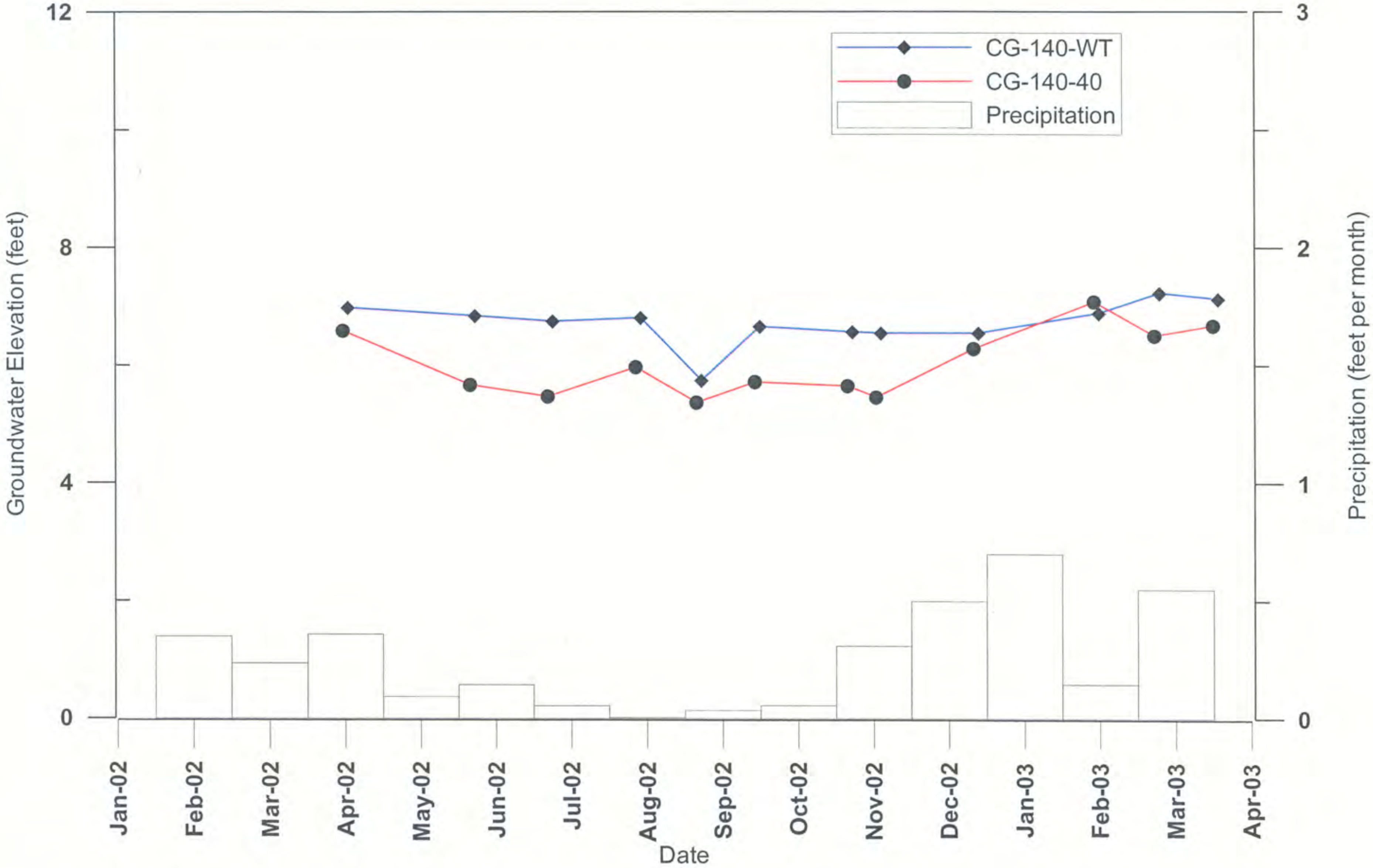
Vertical Datum is based upon NAVD88

Figure 3-22. Hydrographs for CG-138 Well Nest
Remedial Investigation
PSC Georgetown Facility



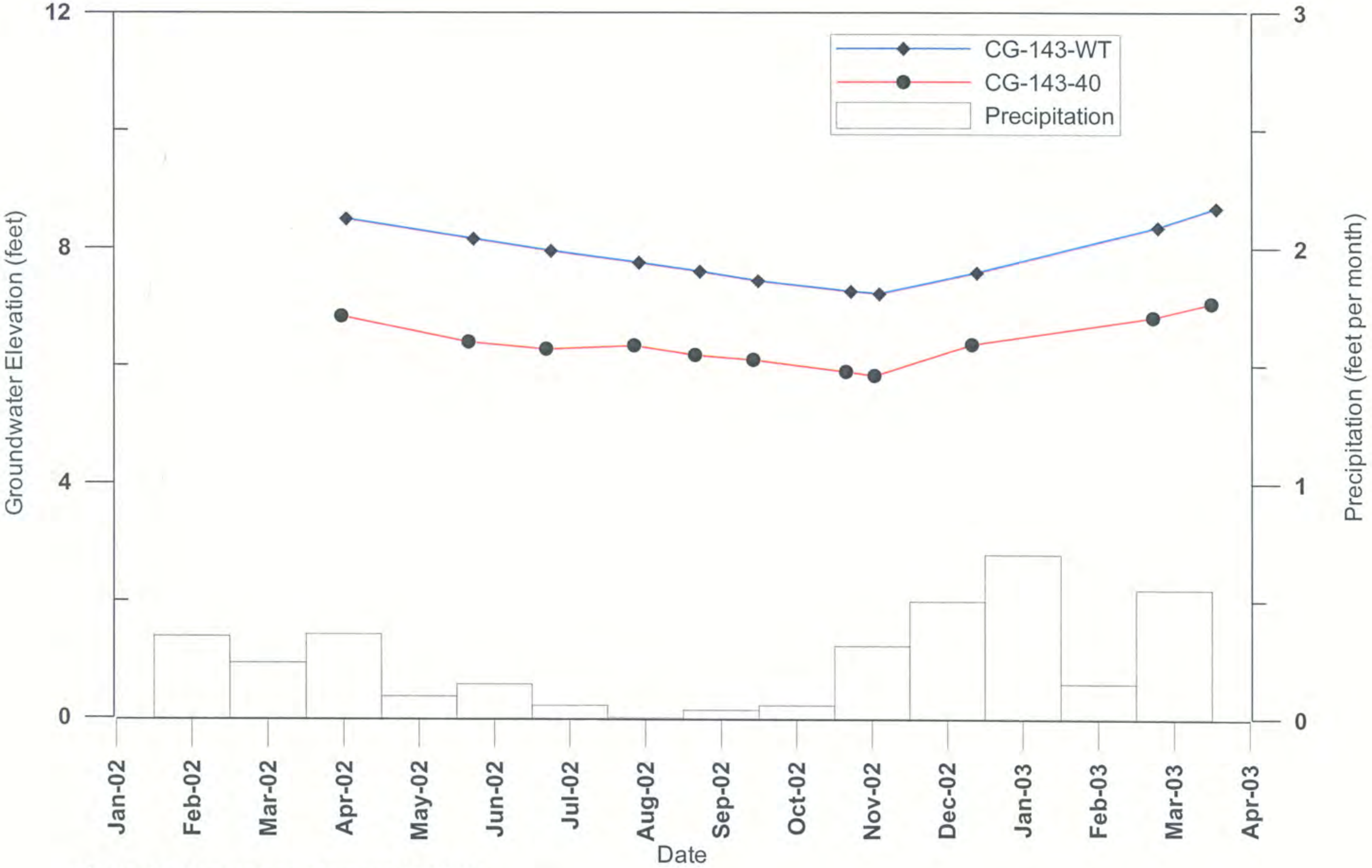
Vertical Datum is based upon NAVD88

Figure 3-23. Hydrographs for CG-140 Well Nest
Remedial Investigation
PSC Georgetown Facility



Vertical Datum is based upon NAVD88

Figure 3-24. Hydrographs for CG-143 Well Nest
Remedial Investigation
PSC Georgetown Facility



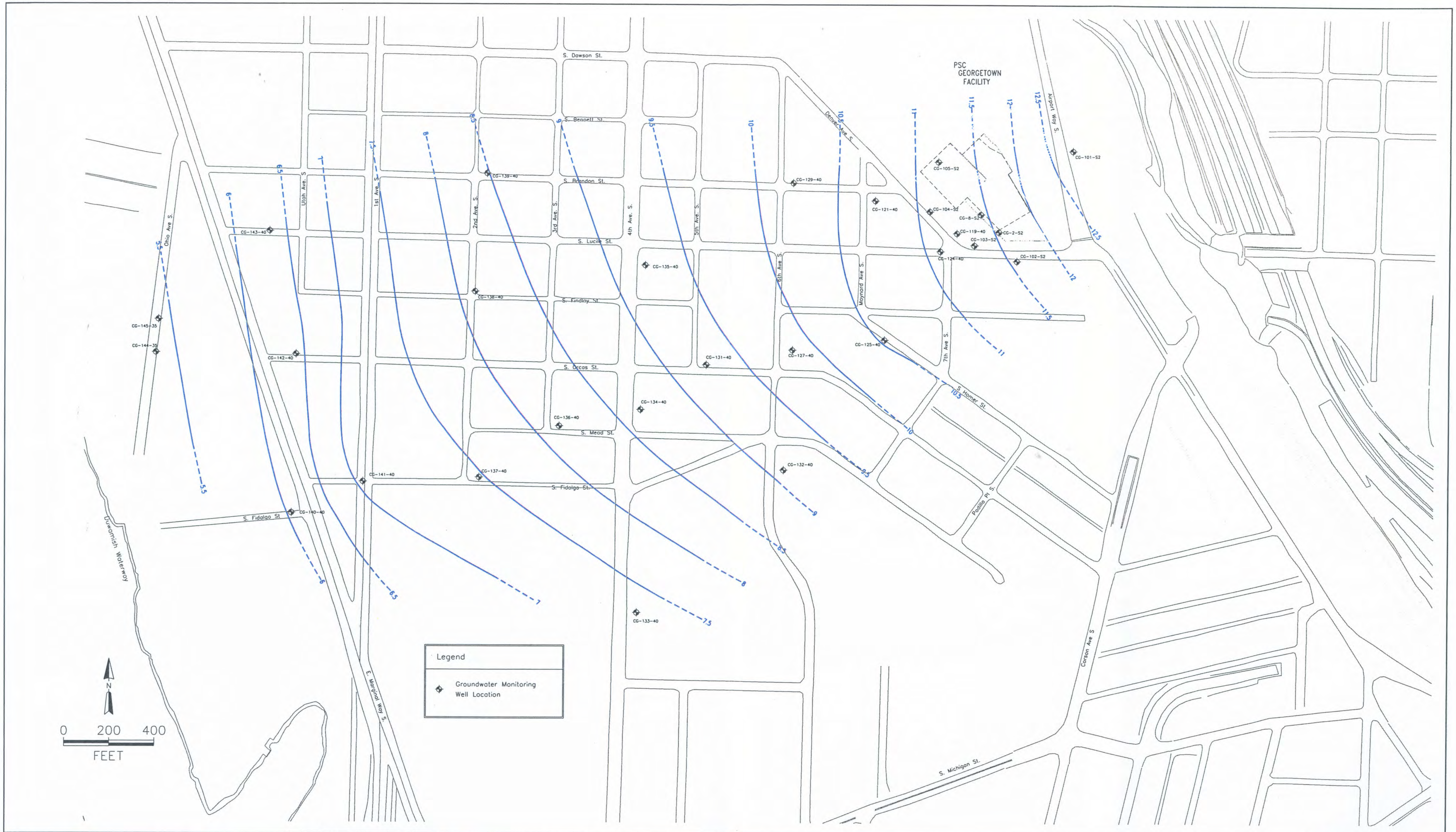
Vertical Datum is based upon NAVD88

PSC

TITLE:

Average Groundwater Flow Direction
At Water Table, April 2002 through March 2003
PSC Georgetown Neighborhood, Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003	
CHKD:	APPD:		
DATE: 11/6/03	REV.: 1	FIGURE NO.: 3-25	

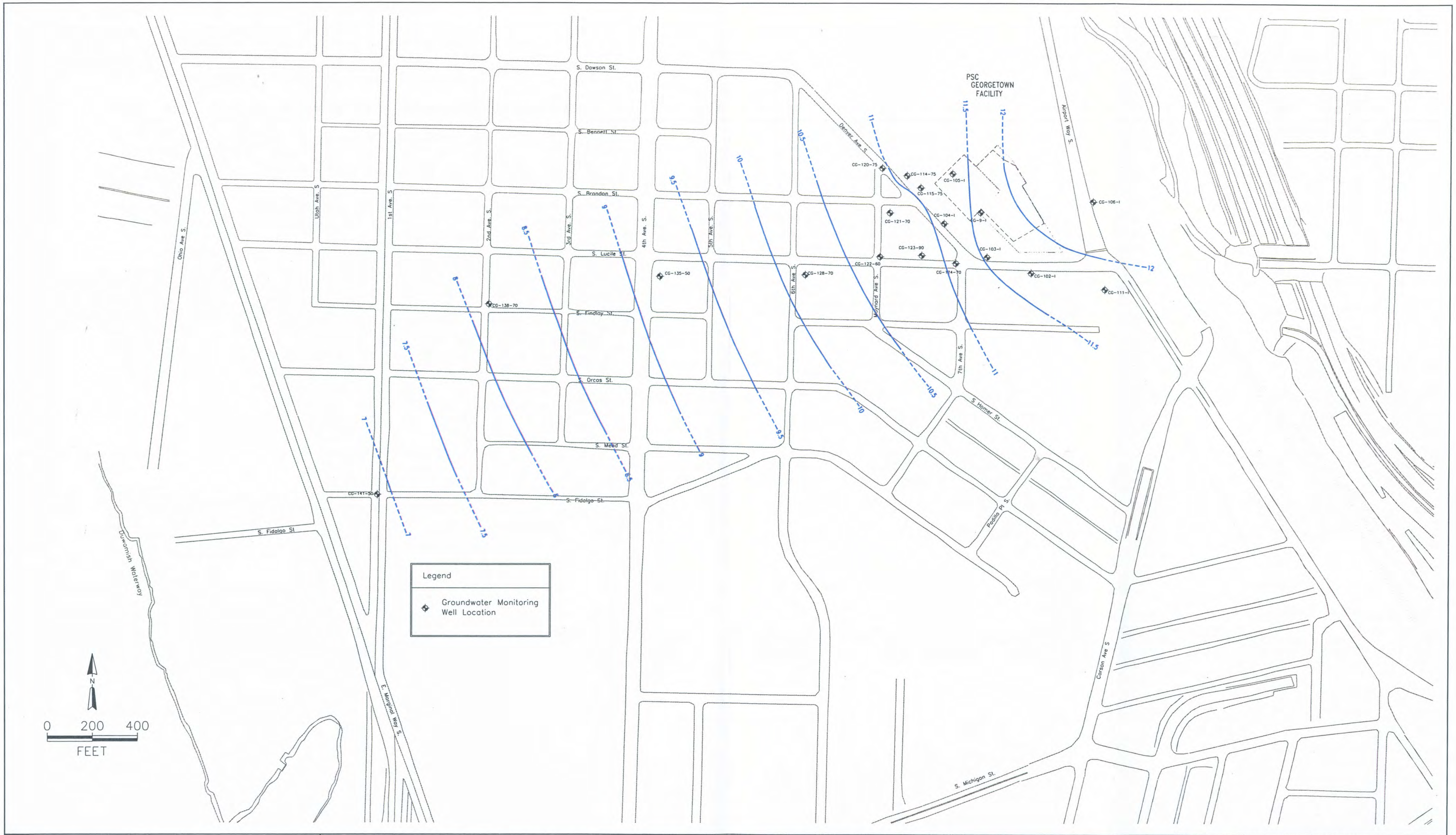


PSC

TITLE:

Average Groundwater Flow Direction
Lower Shallow Aquifer, April 2002 through March 2003
PSC Georgetown Neighborhood, Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 11/6/03	REV.: 1	FIGURE NO.: 3-26



PSC

TITLE:

Average Goundwater Flow Direction
Intermediate Aquifer, April 2002 through March 2003
PSC Georgetown Neighborhood, Remedial Investigation Study Area

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 11/6/03
REV.: 1
PROJECT NO.: RI2003
FIGURE NO.: 3-27

Table 3-1
Time-Average Salinity of Duwamish Waterway
PSC Georgetown Facility

STATION	DEPTH(1)	BEGIN		END		PERIOD DURATION (days)	MEAN SALINITY(2) (ppt) (3)	TOTAL DURATION(4) (days)	TWA(5) SALINITY (ppt) (3)
		Day	Date	Day	Date				
Spokane Street Bridge	Shallow	295	10/21/1996	320	11/15/1996	25	12.90	140	10.26
		323	11/18/1996	348	12/13/1996	25	10.01		
		354	12/19/1996	394	1/28/1997	40	7.92		
		425	2/28/1997	475	4/19/1997	50	10.95		
	Intermediate	340	12/5/1996	375	1/9/1997	35	29.59	65	29.94
		425	2/28/1997	455	3/30/1997	30	30.35		
	Deep	295	10/21/1996	335	11/30/1996	40	30.58	140	30.64
		340	12/5/1996	390	1/24/1997	50	29.84		
		424	2/27/1997	449	3/24/1997	25	31.82		
		450	3/25/1997	475	4/19/1997	25	31.16		
16th Avenue South Bridge	Shallow	280	10/6/1996	330	11/25/1996	50	4.91	75	3.60
		397	1/31/1997	422	2/25/1997	25	0.98		
	Intermediate	240	8/27/1996	260	9/16/1996	20	27.95	80	27.82
		300	10/26/1996	330	11/25/1996	30	27.87		
		335	11/30/1996	365	12/30/1996	30	27.69		
	Deep	240	8/27/1996	260	9/16/1996	20	27.24	50	27.58
		300	10/26/1996	330	11/25/1996	30	27.80		

(1) "Shallow" depth denotes one meter below water surface.
"Intermediate" denotes five meters above channel bottom.
"Deep" denotes one meter above channel bottom.
(2) Mean salinity data are from King County (1999).
(3) Salinities are reported as mass fractions, in units of parts per thousand (ppt).
(4) Total duration, in days, represents factor used to calculate TWA (see below).
(5) "TWA" denotes time-weighted average.

Table 3-2
Average Monthly Total Precipitation at Three Stations
PSC Georgetown Facility

MONTH	AVERAGE MONTHLY TOTAL PRECIPITATION (inches)		
	SeaTac Airport	King County Airport	Seattle
January	5.73	5.98	5.01
February	4.19	4.38	3.92
March	3.77	3.43	3.80
April	2.54	2.15	2.81
May	1.66	1.36	1.99
June	1.44	1.18	1.52
July	0.79	0.71	0.95
August	1.10	0.93	1.30
September	1.79	1.60	1.61
October	3.48	3.46	3.35
November	6.05	6.16	5.63
December	5.92	5.20	6.03

Source: WRCC (2000)

Table 3-3
Annual Total Precipitation Statistics for Three Stations
PSC Georgetown Facility

STATISTIC	**ANNUAL TOTAL PRECIPITATION** (inches)		
	SeaTac Airport	**King County Airport**	**Seattle**
Minimum	23.78	19.88	27.78
Maximum	54.61	50.40	51.56
Mean	38.46	36.55	37.92

Source: WRCC (2000)

Table 3-4
List of Borings Used for Geologic Interpretation
PSC Georgetown Facility

Boring Identifier	Total Depth (feet bgs)	Boring Identifier	Total Depth (feet bgs)	Boring Identifier	Total Depth (feet bgs)	Boring Identifier	Total Depth (feet bgs)
CG-1-D	109	CG-102-D	130	D15	82	E7	82
CG-2-D	128.5	CG-103-S1	20	D16	84	F4	98
CG-3	31.5	CG-103-S2	35.5	D17	84	F9	120
CG-1-S1	17.5	CG-103-I	80	D18	82	F16	126
CG-1-S2	30.5	CG-104-S1	18	D19	86	G3	90
CG-1-I	66	CG-104-S2	35	D20	80	G5	80
CG-2-S1	20.5	CG-104-I	70	D21	78	G33	132
CG-2-S2	51.5	CG-104-D	127	D22	82	H14	70
CG-2-I	70.5	CG-105-S1	17	D23	80	I3	90
CG-4-D	109.5	CG-105-S2	35	D24	82	J3	90
CG-5-S1	17	CG-105-I	76.5	D25	84	K10	130
CG-5-S2	45	CG-111-I	60	D26	79	K21	70
CG-5-I	64.5	CG-11-I	68	D27	57	M29	70
CG-5-D	123	CG-12-I	65	D28	82	P18	70
CG-6-S1	16.8	B12	45	D29	78	S15	70
CG-6-S2	38.5	F9	120	D30	88	S34	70
CG-7-S1	17.5	F16	126	D31	81	W23	70
CG-7-S2	38.5	D1	88	D33	81	Y26	70
CG-8-S1	20	D2	74	D34	75		
CG-8-S2	41.5	D3	86	D35	75		
CG-9-S1	19	D4	88	D36	75		
CG-9-S2	41.5	D5	89	F16	126		
CG-9-I	75	D6	78	E11	136		
CG-10-S1	17.5	D7	78	F7	122		
CG-10-S2	28.5	SA-D8	80	SB98-B4	70		
CG-11-S1	17	D9	82	SB98-B6	76		
CG-11-S2	41.5	D10	80	SB98-E7	82		
CG-101-S1	17.5	D11	84	SB98-J4	80		
CG-102-S1	18	D12	82	SB98-G5	80		
CG-102-S2	31.5	D13	82	SB98-I7	80		
CG-102-I	70	D14	80	E3	88		

Table 3-5
Relationships Between Geologic and Hydrogeologic Units
PSC Georgetown Facility

GEOLOGIC PERIOD	REGIONAL GEOLOGIC UNIT	LOCAL GEOLOGIC UNIT	HYDROGEOLOGIC UNIT
Quaternary	Duwamish Valley Alluvium	Shallow Sand Unit	Shallow Aquifer
		Intermediate Sand and Silt Unit	Intermediate Aquifer
		Silt Unit	Silt Aquitard
		Deep Sand and Silt Unit	Deep Aquifer
Tertiary	Bedrock	Bedrock	Basement Confining Unit

Table 3-6
Summary of Hydraulic Property Test/Sample Locations
PSC Georgetown Facility

HYDROGEOLOGIC UNIT	NUMBER OF TESTS / SAMPLE LOCATIONS					
	FIELD TESTS		LABORATORY TESTS			
	Slug Tests	Pumping Tests	Grain-Size Tests	Triaxial Permeability Tests	Rigid-Wall Permeameter Tests	Calculation from Specific Gravity
Shallow Aquifer	3 ($K_{horizontal}$)	3 ($K_{horizontal}$) 3 (S_y)	8 ($K_{horizontal}$)	4 ($K_{vertical}$)	16 ($K_{vertical}$)	24 (porosity)
Intermediate Aquifer	7 ($K_{horizontal}$)	1 ($K_{horizontal}$) 3 (S)	--	9 ($K_{vertical}$)	11 ($K_{vertical}$)	16 (porosity)
Silt Aquitard	--	--	--	11 ($K_{vertical}$)	--	6 (porosity)
Deep Aquifer	4 ($K_{horizontal}$)	--	1 ($K_{horizontal}$)	--	1 ($K_{vertical}$)	--
Basement Confining Unit	--	--	--	--	--	--

Notes:

1. "$K_{horizontal}$" and "$K_{vertical}$" denote horizontal and vertical hydraulic conductivity tests, respectively.
2. "S" and "S_y" denote storativity and specific yield, respectively.
3. The numbers listed in the table refer to either (a) the number of locations at which field tests were performed, or (b) the number of locations at which samples were collected and tested in the laboratory.

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
$K_{horizontal}$	Shallow Aq.	Harper-Owes, 1983	G-1	2.4 - 3.1	3.2E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	Harper-Owes, 1983	HC-4	9 - 14	4.2E-03	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Shallow Aq.	Harper-Owes, 1983	HC-5	7.5 - 12.5	1.5E-02	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Shallow Aq.	Harper-Owes, 1983	HC-5	7.5 - 12.5	5.0E-03	cm/s	Pumping	(unknown)	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1988	G-1	2.4 - 3.1	3.0E-03	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	CG-6-S-1	5 - 15	5.3E-02	cm/s	Pumping (Recov)	Cooper-Jacob	1
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	CG-9-S-1	7 - 17	3.0E-02	cm/s	Pumping (Recov)	Cooper-Jacob	1
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-11	27	4.E-04	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-12	20	4.E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-3	7	1.E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-3	30	3.E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-7	15	3.E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-7	43	5.E-03	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	SE/E, 1990	TB-9	15	3.E-02	cm/s	Grain size	Hazen	4
$K_{horizontal}$	Shallow Aq.	PSC, Jun 2000a	V-2	2 - 17	2.60E-02	cm/s	Pumping (Drawd)	Neuman	1
$K_{horizontal}$	Shallow Aq.	PSC, Jun 2000a	V-2	2 - 17	3.25E-02	cm/s	Pumping (Recov)	Theis-Jacob	1
$K_{horizontal}$	Shallow Aq.	PSC, Jun 2000a	V-3	2 - 17	2.70E-02	cm/s	Pumping (Drawd)	Neuman	1
$K_{horizontal}$	Shallow Aq.	PSC, Jun 2000a	V-3	2 - 17	3.69E-02	cm/s	Pumping (Recov)	Theis-Jacob	1
$K_{horizontal}$	Shallow Aq.	PSC, Jun 2000a	V-4	2 - 17	2.32E-02	cm/s	Pumping (Drawd)	Neuman	1
$K_{horizontal}$	Intermed. Aq.	Harper-Owes, 1983	HC-10	67 - 72	1.7E-05	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	Harper-Owes, 1983	HC-9	95.1 - 100.1	1.5E-05	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	SE/E, 1990	CG-1-I	53 - 63	8.E-04	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	SE/E, 1990	CG-1-I	54 - 63	8.E-04	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	SE/E, 1990	CG-2-I	55 - 65	2.4E-03	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	SE/E, 1990	CG-5-I	53.5 - 63.5	3.4E-04	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	SE/E, 1990	CG-9-I	63 - 73	1.8E-04	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	2.72E-03	cm/s	Pumping (Recov)	Theis-Jacob	2
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	3.65E-04	cm/s	Pumping (Drawd)	Hantush	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	8.55E-04	cm/s	Pumping (Drawd)	Theis	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	8.52E-04	cm/s	Pumping (Recov)	Theis-Jacob	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	1.35E-03	cm/s	Pumping	Theis-Jacob	2

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	3.65E-04	cm/s	Pumping	Hantush	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	8.67E-04	cm/s	Pumping	Theis	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	8.86E-04	cm/s	Pumping	Theis-Jacob	1
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	4.36E-04	cm/s	Pumping (Drawd)	Hantush	3
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	5.07E-03	cm/s	Pumping (Drawd)	Theis	3
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	4.40E-03	cm/s	Pumping (Recov)	Theis-Jacob	2
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	4.38E-04	cm/s	Pumping (Drawd)	Hantush	2
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	2.46E-03	cm/s	Pumping (Drawd)	Theis	2
$K_{horizontal}$	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	63 - 73	3.41E-03	cm/s	Pumping (Recov)	Theis-Jacob	2
$K_{horizontal}$	Deep Aq.	SE/E, 1988	CG-1-D	92.5 - 102.5	6.E-05	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Deep Aq.	SE/E, 1990	CG-2-D	112.5 - 122.5	8.E-05	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Deep Aq.	SE/E, 1990	CG-4-D	95 - 105	8.5E-04	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Deep Aq.	SE/E, 1990	CG-5-D	98 - 108	3.9E-06	cm/s	Slug	Hvorslev	3
$K_{horizontal}$	Deep Aq.	SE/E, 1990	TB-1	101	1.E-02	cm/s	Grain size	Hazen	4
$K_{vertical}$	Shallow Aq.	REG, 30 Jan 2001b	D12	34 - 36	1.2E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 30 Jan 2001b	D12	38 - 40	1.3E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 30 Jan 2001b	D12	46 - 48	1.9E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 30 Jan 2001b	D12	54 - 56	1.3E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 01 Feb 2001	F9	20 - 22	7.2E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 01 Feb 2001	F9	40 - 42	8.5E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	4 - 6	1.2E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	8 - 10	7.9E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	14 - 16	6.8E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	20 - 22	9.0E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	26 - 28	1.5E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	30 - 32	2.1E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	36 - 38	5.9E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	46 - 48	1.3E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	50 - 52	1.0E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 22 Feb 2001	D25	56 - 58	5.7E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 08 Jan 2001	SS-4	0 - 2	2.7E-05	cm/s	Pneumatic (Lab)	ASTM D-2545,	3

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
$K_{vertical}$	Shallow Aq.	REG, 08 Jan 2001	SS-4	2 - 4	4.4E-05	cm/s	Pneumatic (Lab)	SSSA Ch. 49	3
$K_{vertical}$	Shallow Aq.	REG, 08 Jan 2001	SS-6	0 - 2	4.9E-05	cm/s	Pneumatic (Lab)	ASTM D-2545, SSSA Ch. 49	3
$K_{vertical}$	Shallow Aq.	REG, 08 Jan 2001	SS-6	2 - 4	4.0E-05	cm/s	Pneumatic (Lab)		3
$K_{vertical}$	Shallow Aq.	REG, 6 May 2002	CG-106	30 - 31.5	2.9E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Shallow Aq.	REG, 6 May 2002	CG-106	14.5 - 16	3.2E-02	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 30 Jan 2001b	D12	58 - 60	2.3E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 30 Jan 2001b	D12	64 - 66	6.3E-04	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	D3	82 - 84	3.5E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	D7	76 - 78	4.6E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	F9	60 - 62	2.8E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	F9	80 - 82	6.7E-05	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	F9	100 - 102	6.4E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 01 Feb 2001	F9	118 - 120	9.0E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	REG, 22 Feb 2001	D25	60 - 62	7.9E-05	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 22 Feb 2001	D25	66 - 68	2.3E-05	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 22 Feb 2001	D25	70 - 72	7.3E-08	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	REG, 22 Feb 2001	D25	76 - 78	4.7E-03	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 10 Aug 1998	SB98-B4	59 - 60	1.3E-05	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 10 Aug 1998	SB98-B6	53 - 54	2.6E-04	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 10 Aug 1998	SB98-G5	55 - 56	1.1E-04	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	REG, 10 Aug 1998	SB98-I7	59 - 60	2.2E-05	cm/s	Rigid Wall	Darcy	3
$K_{vertical}$	Intermed. Aq.	SE/E, 1990	CG-1-I	45	4.0E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	SE/E, 1990	CG-2-I	50	1.4E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	SE/E, 1990	CG-5-I	49	2.8E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Intermed. Aq.	SE/E, 1990	CG-9-I	53	8.2E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 22 Feb 2001	D25	82 - 84	1.0E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 22 Feb 2001	D25	87 - 89	6.5E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 01 Feb 2001	D4	84 - 86	5.3E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 01 Feb 2001	D22	80 - 82	1.3E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	PSC, Oct 1998	CG-11-I	63.5	5.2E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	PSC, 1992	CG-102-I	67	7.7E-07	cm/s	Triaxial	Hvorslev	3

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
$K_{vertical}$	Silt Aquitard	PSC, 1992	CG-102-D	90	2.9E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	PSC, 1992	CG-104-D	93	3.5E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	PSC, 1992	SB-101	80	1.3E-06	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	SE/E, 1990	TB-1 / CG-4-D	75	9.5E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	SE/E, 1990	TB-5 / CG-5-D	75	5.3E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 2 May 2002	CG-106	46 - 48	1.7E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 23 Feb 2002	E3	86 - 88	4.5E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 14 Feb 2002	F4	96 - 98	6.1E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Silt Aquitard	REG, 12 FEB 2002	K10	128 - 130	1.2E-07	cm/s	Triaxial	Hvorslev	3
$K_{vertical}$	Deep Aq.	REG, 10 Aug 1998	SB98-B4	68 - 70	4.8E-07	cm/s	Rigid Wall	Darcy	3
Specific Yield	Shallow Aq.	PSC, Jun 2000a	V-2	2 - 17	0.256	--	Pumping (Drawd)	Neuman	1
Specific Yield	Shallow Aq.	PSC, Jun 2000a	V-3	2 - 17	0.236	--	Pumping (Drawd)	Neuman	1
Specific Yield	Shallow Aq.	PSC, Jun 2000a	V-4	2 - 17	0.183	--	Pumping (Drawd)	Neuman	1
Porosity	Shallow Aq.	REG, 30 Jan 2001a	CG-112	0 - 3	0.51	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001a	CG-112	3 - 6	0.51	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001a	CG-113	0 - 3	0.58	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001a	CG-113	3 - 6	0.52	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001b	D12	34 - 36	0.51	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001b	D12	38 - 40	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001b	D12	46 - 48	0.46	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 30 Jan 2001b	D12	54 - 56	0.53	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	4 - 6	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	8 - 10	0.50	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	14 - 16	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	20 - 22	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	26 - 28	0.48	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	30 - 32	0.48	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	36 - 38	0.49	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	46 - 48	0.44	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	50 - 52	0.49	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 22 Feb 2001	D25	56 - 58	0.52	--	Calc. from S.G.	--	3

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
Porosity	Shallow Aq.	REG, 01 Feb 2001	F9	20 - 22	0.51	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 01 Feb 2001	F9	40 - 42	0.49	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 03 Nov 1999	SS-4	0 - 2	0.59	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 03 Nov 1999	SS-4	2 - 4	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 03 Nov 1999	SS-6	0 - 2	0.58	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 03 Nov 1999	SS-6	2 - 4	0.51	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 13 Feb 2002	K-21	2 - 4	0.41	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 13 Feb 2002	K-21	4 - 6	0.33	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 13 Feb 2002	M29	0 - 2	0.37	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 13 Feb 2002	M29	2 - 4	0.47	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 13 Feb 2002	M29	4 - 6	0.50	--	Calc. from S.G.	--	3
Porosity	Shallow Aq.	REG, 2 May 2002	CG-106	14.5 - 16	0.36	--	Calc. from S.G	--	3
Porosity	Shallow Aq.	REG, 2 May 2002	CG-106	30 - 31.5	0.45	--	Calc. From s.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	D3	82 - 84	0.52	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	D7	76 - 78	0.47	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	F9	60 - 62	0.51	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	F9	80 - 82	0.50	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	F9	100 - 102	0.49	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 01 Feb 2001	F9	118 - 120	0.53	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 22 Feb 2001	D25	60 - 62	0.54	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 22 Feb 2001	D25	66 - 68	0.47	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 22 Feb 2001	D25	70 - 72	0.49	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 22 Feb 2001	D25	76 - 78	0.45	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 30 Jan 2001b	D12	58 - 60	0.45	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 30 Jan 2001b	D12	64 - 66	0.57	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 10 Aug 1998	SB98-B4	59 - 60	0.45	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 10 Aug 1998	SB98-B6	53 - 54	0.48	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 10 Aug 1998	SB98-G5	55 - 56	0.36	--	Calc. from S.G.	--	3
Porosity	Intermed. Aq.	REG, 10 Aug 1998	SB98-I7	59 - 60	0.45	--	Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 01 Feb 2001	D4	84 - 86	0.47	--	Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 01 Feb 2001	D22	80 - 82	0.48	--	Calc. from S.G.	--	3

Table 3-7
Summary of Hydraulic Property Test Results
PSC Georgetown Facility

PARAMETER	HYDRO-GEOLOGIC UNIT	DATA SOURCE	WELL OR SAMPLE IDENTIFIER	SAMPLE / SCREEN DEPTH (feet bgs)	VALUE	UNITS	TEST TYPE	ANALYSIS METHOD	DATA QUALITY
Porosity	Silt Aquitard	REG, 22 Feb 2001	D25	82 - 84	0.50	--	Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 22 Feb 2001	D25	87 - 89	0.52	--	Calc. from S.G.	--	3
Porosity	Silt Aquitard	PSC, Nov 1998	CG-11-I	63.5	0.51	--	Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 2 May 2002	CG-106	46-48	0.405		Calc. From S.G.	--	3
Porosity	Silt Aquitard	REG, 12 Feb 2002	E3	86 - 88	0.474		Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 12 Feb 2003	K10	128 - 130	0.507		Calc. from S.G.	--	3
Porosity	Silt Aquitard	REG, 12 Feb 2004	F4	96 - 98	0.454		Calc. from S.G.	--	3
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	4.89E-04	--	Pumping (Drawd)	Hantush	1
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-11-I	51 - 61	6.71E-04	--	Pumping (Drawd)	Theis	1
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	4.88E-04	--	Pumping (Drawd)	Hantush	1
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-12-I	48 - 58	6.41E-04	--	Pumping (Drawd)	Theis	1
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	58 - 68	2.69E-04	--	Pumping (Drawd)	Hantush	3
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	58 - 68	5.22E-04	--	Pumping (Drawd)	Theis	3
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	58 - 68	2.67E-04	--	Pumping (Drawd)	Hantush	2
Storativity	Intermed. Aq.	PSC, Jun 2000b	CG-9-I	58 - 68	7.03E-04	--	Pumping (Drawd)	Theis	2

NS = not specified

Table 3-8
Summary of Horizontal Hydraulic Conductivity Test Results
PSC Georgetown Facility

HYDROGEOLOGIC UNIT	HORIZONTAL HYDRAULIC CONDUCTIVITY (cm/s)							
	FIELD TESTS				LAB TESTS		ALL TESTS	
	Slug Tests		Pumping Tests		Grain-Size Tests			
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Shallow Aquifer	3.0E-03	1.5E-02	5.0E-03	5.3E-02	4.0E-04	4.0E-02	4.0E-04	5.3E-02
Intermediate Aquifer	1.5E-05	2.4E-03	3.7E-04	5.1E-03	--	--	1.5E-05	5.1E-03
Silt Aquitard	--	--	--	--	--	--	--	--
Deep Aquifer	3.9E-06	8.5E-04	--	--	1.0E-02	1.0E-02	3.9E-06	1.0E-02
Basement Confining Unit	--	--	--	--	--	--	--	--

Table 3-9
Summary of Vertical Hydraulic Conductivity Test Results
PSC Georgetown Facility

HYDROGEOLOGIC UNIT	VERTICAL HYDRAULIC CONDUCTIVITY (cm/s)					
	Triaxial Permeameter Tests		Rigid-Wall Permeameter Tests		All Tests	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Shallow Aquifer	2.7E-05	4.9E-05	1.9E-03	7.2E-02	2.7E-05	7.2E-02
Intermediate Aquifer	7.3E-08	6.7E-05	1.3E-05	6.4E-03	7.3E-08	6.4E-03
Silt Aquitard	1.0E-07	5.3E-06	--	--	1.0E-07	5.3E-06
Deep Aquifer	--	--	4.8E-07	4.8E-07	4.8E-07	4.8E-07
Basement Confining Unit	--	--	--	--	--	--

Table 3-10
Summary of Horizontal-to-Vertical Hydraulic Conductivity Ratio Estimates
PSC Georgetown Facility

SHALLOW AQUIFER						
Source of Horizontal Conductivity Estimates	**Source of Vertical Conductivity Estimates**					
	Triaxial Permeameter Tests		Rigid-Wall Permeameter Tests		All Laboratory Tests	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Slug Tests	6.E+01	6.E+02	4.E-02	8.E+00	4.E-02	6.E+02
Pumping Test	1.E+02	2.E+03	7.E-02	3.E+01	7.E-02	2.E+03
All Field Tests	6.E+01	2.E+03	4.E-02	3.E+01	**4.E-02**	**2.E+03**

INTERMEDIATE AQUIFER						
Source of Horizontal Conductivity Estimates	**Source of Vertical Conductivity Estimates**					
	Triaxial Permeameter Tests		Rigid-Wall Permeameter Tests		All Laboratory Tests	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Slug Tests	2.E-01	3.E+04	2.E-03	2.E+02	2.E-03	3.E+04
Pumping Test	6.E+00	7.E+04	6.E-02	4.E+02	6.E-02	7.E+04
All Field Tests	2.E-01	7.E+04	2.E-03	4.E+02	**2.E-03**	**7.E+04**

DEEP AQUIFER						
Source of Horizontal Conductivity Estimates	**Source of Vertical Conductivity Estimates**					
	Triaxial Permeameter Tests		Rigid-Wall Permeameter Tests		All Laboratory Tests	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Slug Tests	--	--	8.E+00	2.E+03	**8.E+00**	**2.E+03**

Table 3-11
Summary of Hydraulic Storage Property Test Results
PSC Georgetown Facility

HYDROGEOLOGIC UNIT	POROSITY (dimensionless)		STORAGE COEFFICIENT[1] (dimensionless)	
	Minimum	Maximum	Minimum	Maximum
Shallow Aquifer	0.44	0.59	0.18	0.26
Intermediate Aquifer	0.36	0.57	3.E-04	7.E-04
Silt Aquitard	0.47	0.52	--	--
Deep Aquifer	--	--	--	--
Basement Confining Unit	--	--	--	--

Notes:

(1) For the shallow aquifer, which is unconfined, the storage coefficient is the aquifer's specific yield.
For the intermediate aquifer, which is semi-confined, the storage coefficient is the aquifer's storativity.

Table 3-12
Elevations of Underground Utilities in Comparison to Wet Season Water Table
PSC Georgetown Facility

Nearest Measurement Location	**Second Quarter 1999 Groundwater Elevations** (feet, COSD)	**PIPELINE ELEVATIONS** (feet, COSD)					
		Denver Ave. Sewer	**Lucile St. Storm Water**	**Brandon St. Storm Water**	**Bennett St. Storm Water**	**Dawson St. Storm Water**	**Dawson St. Sewer**
CG-103-S1	3.66						
CG-104-S1	3.73	5.88					
CG-105-S1	3.83	4.06	4.06	4.06			
Maynard Street				5.33			
6th Avenue S.			6.24	5.54	5.85		4.06
5th Avenue S.			5.86	5.97	5.66		
4th Avenue S.			6.06	6.03	5.71	5.55	5.55
3rd Avenue S.			6.1	6.4	5.76		
2nd Avenue S.			6.15	6.42	7.78	6.27	
1st Avenue S.				7.37			

Table 3-13
Summary of Underground Utility Information
PSC Georgetown Facility

Utility	Contacted	Lines in Water Table (buried below 7 feet bgs)			GW Preferred Pathway	Comments
		Yes	No	Uncertain		
AT&T Broadband Cable	Yes		X		No	Outside Plant Engineer said there are no utilities of concern in the area.
Electric Light Wave	Yes			X	No	Lines exist along E. Marginal Way S. and 4th Ave S. at 8-12 feet bgs, but they were installed by directional boring, pushing the piping in, no backfill material, no trenching. The pipe is 3-inch diameter steel.
King County Metro Sewer	Yes				No	Site-specific, see sewer maps.
Level 3 Communications	Yes		X		No	All lines run along the rail track on Airport Way S, outside the area of concern.
Locating Inc.	No		X		No	Not in area according to One Call public utility locate
MCI Communications	Yes		X		No	MCI has not returned information pertaining to our request for information this year, but in 2001 they said there are no lines below the water table.
Metro Media Fiber Network	No		X		No	Not in area according to One Call public utility locate
BP Olympic Pipeline	No		X		No	Not in area according to One Call public utility locate
Puget Sound Energy Gas	Yes		X		No	All lines in area are installed from 30-36 inches or, in extremes, 1.5-5 feet bgs.
Qwest	Yes			X	?	There are lines in the area, however construction information is not available, as stated by Qwest representative in a letter to Ed Jones.
Seattle City Light	Yes		X		No	No lines buried deeper than 5 feet bgs.
Seattle Public Utilities	Yes		X		No	Site-specific, most lines are 3-4 feet bgs except on 1st Ave where the lines may be as deep as 5-7 feet bgs.
Seattle Engineering Signal	Yes		X		No	Generally everything is shallower than 5 feet bgs, except foundations.
Sprint Communications	Yes		X		No	All lines run along the rail track on Airport Way S, outside the area of concern.
AT&T Canada	Yes		X		No	All lines run along the rail track on Airport Way S, outside the area of concern.
Touch America	No		X		No	Not in area according to One Call public utility locate
360 Networks	Yes		X		No	Most lines run along the rail track on Airport Way S, outside the area of concern and all lines were installed 3-6 feet deep using a rail plow method that does not include any excavation or implacement of new material.
Williams Communications	Yes			X	?	There are lines on 4th Ave S., but our phone calls have not been returned by the Outside Plant Coordinator to get construction details.
Washington State DOT [1]	No		X		No	Not in area according to One Call public utility locate

[1] Were on list from draft RI, but not on One Call now

Table 3-14
Groundwater Elevation Monitoring Points
PSC Georgetown Facility

Shallow Aquifer		Intermediate Aquifer	Deep Aquifer
Upper Zone	Lower Zone		
CG-1-S1	CG-1-S2	CG-1-I	CG-1-D
CG-2-S1	CG-2-S2	CG-2-I	CG-2-D
CG-3	--	--	--
--	--	--	CG-4-D
CG-5-S1	CG-5-S2	CG-5-I	CG-5-D
CG-6-S1	CG-6-S2	--	--
CG-7-S1	CG-7-S2	--	--
CG-8-S1	CG-8-S2	--	--
CG-9-S1	CG-9-S2	CG-9-I	--
CG-10-S1	CG-10-S2	--	--
CG-11-S1	CG-11-S2	CG-11-I	--
--	--	CG-12-I	--
CG-101-S1	CG-101-S2	--	--
CG-102-S1	CG-102-S2	CG-102-I	CG-102-D
CG-103-S1	CG-103-S2	CG-103-I	--
CG-104-S1	CG-104-S2	CG-104-I	CG-104-D
CG-105-S1	CG-105-S2	CG-105-I	--
CG-106-WT	--	CG-106-I	--
--	--	CG-111-I	--
CG-112-S1	--	--	--
CG-113-S1	--	--	--
--	--	CG-114-75	--
CG-115-WT	--	CG-115-75	--
--	--	CG-120-75	--
--	CG-121-40	CG-121-75	--
CG-122-WT	--	CG-122-60	--
--	--	CG-123-90	--
CG-124-WT	CG-124-40	CG-124-70	--
--	CG-125-40	--	--
CG-126-WT	--	--	--
CG-127-WT	CG-127-40	--	--
CG-128-WT	--	CG-128-70	--
CG-129-WT	CG-129-40	--	--
CG-130-WT	--	--	--
CG-131-WT	CG-131-40	--	--
CG-132-WT	CG-132-40	--	--
CG-134-WT	CG-134-40	--	--
--	CG-135-40	CG-135-50	--
CG-136-WT	CG-136-40	--	--
CG-137-WT	CG-137-40	--	--
CG-138-WT	CG-138-40	CG-138-70	--
--	CG-139-40	--	--
CG-140-WT	CG-140-40	--	--
CG-141-WT	CG-141-40	CG-141-50	--
CG-142-WT	CG-142-40	--	--

Table 3-15
Estimated Average Groundwater Flow Rates
PSC Georgetown Facility

Hydrogeologic Unit	Horizontal Hydraulic Gradient	Assumed Horizontal Hydraulic Conductivity (cm/s)	Specific Discharge (m/s)	Assumed Effective Porosity	Seepage Velocity		
					(m/s)	(ft/day)	(ft/yr)
Shallow Aquifer	0.0016	5.3E-02	8.5E-07	0.44	1.9E-06	5.5E-01	200
	0.0014		7.4E-07		1.7E-06	4.8E-01	180
	0.0015		8.0E-07		1.8E-06	5.1E-01	190
Intermediate Aquifer	0.0019	5.1E-03	9.7E-08	0.36	2.7E-07	7.6E-02	28
	0.0015		7.7E-08		2.1E-07	6.0E-02	22
	0.0017		8.7E-08		2.4E-07	6.8E-02	25
Deep Aquifer	0.0094	3.0E-03	2.8E-07	0.40	7.1E-07	2.0E-01	73
	0.0064		1.9E-07		4.8E-07	1.4E-01	50
	0.0079		2.4E-07		5.9E-07	1.7E-01	61

Needs to be simplified to
reflect the last 4 quarter
approach and using
Modling inputs

Table 3-16
Summary of Data Collection for Tidal Monitoring

Tidal Monitoring Event	Measured Variable	Measurement Location	Datum	Units	Data Collector	Instrument	Measure-ment Interval (minutes)	Estimated Tidal Response	
								Time Lag (hours)	Efficiency (percent)
Nov-Dec 2002	Atmospheric Pressure	PSC Facility	vacuum	in Hg	PSC	Barometric PXD/PEDL	6	--	--
	Groundwater Pressure	Well CG-140-40	vacuum	psi	PSC	Submersible PXD/PEDL	6	3	7
		Well CG-144-35						3	4
		Well CG-145-35						2	5
	Surface WL	Elliott Bay	MLLW	feet	NOAA	Acoustic WL Sensor	60	0	100
Jul-Aug 2003	Atmospheric Pressure	PSC Facility	vacuum	in Hg	PSC	Barometric PXD/PEDL	10	--	--
	Groundwater Pressure	Well CG-140-WT	vacuum	psi	PSC	Submersible PXD/PEDL	10	--	0
		Well CG-140-40	atmos. pressure					4	7
		Well CG-141-WT	vacuum					--	0
		Well CG-141-50						--	0
		Well CG-151-25						2	41
	Surface WL	Elliott Bay	MLLW	feet	NOAA	Acoustic WL Sensor	60	0	100

Notes:

(1) "PXD" = pressure transducer
(2) "PEDL" = programmable electronic data logger
(3) "NOAA" = National Oceanic and Atmos. Admin.
(4) "in Hg" = inches of mercury
(5) "psi" = pounds per square inch
(6) "MLLW" = mean lower low water
(7) "WL" = water level
(8) "ET" = elapsed time

4.0 DESCRIPTION OF INVESTIGATIVE ACTIVITIES

PSC has conducted numerous investigations at the facility and between the facility and the Duwamish Waterway. The investigations initially focused on facility-related releases from above-ground and underground storage of hazardous constituents. Later, the investigations focused on areas where plumes from the releases from the facility are thought to have reached.

PSC has collected a considerable amount of data during remedial investigation activities. These activities have included:

- Installation of 103 monitoring wells and quarterly monitoring of these wells;
- Installation of 260 sample reconnaissance borings from which more than 976 groundwater samples were collected;
- Installation of 64 soil borings from which more than 215 soil samples were collected;
- Installation of 76 reconnaissance borings from which 84 soil gas samples were collected;
- Installation of five permanent soil gas ports that were sampled between four and six times; and
- Collection of 35 indoor air samples and 16 ambient air samples.

The investigative activities conducted for the three phases of the RI are summarized below. However, based on data quality assessments discussed in Section 5, not all of the data from these investigations were used for analyses in the RI and risk assessment (RA). In addition, PSC attempted to only use data that are representative of current conditions. In the end, all the soil data collected in the investigations described in this section were included in the RI and RA, but only the groundwater, soil gas, indoor air, and ambient air data collected between 2000 and 2003 were used.

4.1 *Groundwater Monitoring Well Installation*

Groundwater monitoring wells have been installed at the facility and upgradient and downgradient of the facility during investigations conducted between 1982 and 2003. All monitoring wells were installed by licensed drillers, in accordance with the State of Washington well construction requirements. The following is a discussion of the specific well construction methods used for each set of groundwater monitoring wells installed at the facility. Table 4-1 summarizes the completion details for all groundwater monitoring wells installed at the facility. Well construction diagrams for monitoring wells installed for An Evaluation of Groundwater–1982, Phase I, Phase II, Phase III and Post-Phase III are presented in Appendix 4A. Wells were installed according to PSC's standard operating procedure (SOP) No. PSC-105 or the applicable work plans. PSC SOPs are provided in Appendix 4B.

The monitoring well identification system used at the facility was established in the *Phase I Investigation* (SE/E, 1988). Each well designation consists of two alphabetic characters, "CG", which represent the facility's original name, Chempro Georgetown, followed by a number corresponding to the particular well location (e.g., CG-104). This number is followed by an alphabetic character, S1, S2, I, or D, which identifies the screened hydrogeologic unit. For example, CG-104-S1 designates a well screened in the water table zone of the shallow aquifer; CG-104-S2 designates a well screened in the lower shallow aquifer; CG-104-I designates a well screened in the intermediate aquifer, and CG-104-D designates a well screened in the deep aquifer. This identification system was modified during the 2002 RFI well installation to identify wells by the depth of the bottom of the screen or by "WT," for wells screened across the water table. For example, a well installed in 2002 that is screened to 40' would be called CG-140-40. All wells installed during and after that installation consist of the same "CG-" plus the well location number. Facility wells were numbered from CG-1 to CG-12 and wells upgradient and downgradient of the facility are numbered using 100-series numbers (except CG-3). The "V" wells are part of the soil vapor extraction (SVE) system.

Figure 4-1 shows locations of the existing groundwater monitoring wells. Multiple surveys have been performed throughout the investigative history at the facility. The Phase I through Phase III groundwater monitoring well measuring points were surveyed by Horton Dennis & Associates on April 7, 1995. Hugh G. Goldsmith & Associates, Inc. surveyed the first Post-Phase III wells on February 15, 2001. In 2001, PSC converted these values to the Hugh G. Goldsmith & Associates, Inc. coordinate system based on the North American vertical datum of 1988. The Post-Phase III wells installed in 2002 were surveyed by Hugh G. Goldsmith & Associates, Inc. on March 27-29 and May 15, 2002. The two wells installed in 2003 were surveyed by Hugh G. Goldsmith and Associates, Inc. on August 6, 2003. Table 4-2 shows the current measured elevations of groundwater monitoring wells at the facility. The following subsections describe the work completed and methodologies followed under each work plan.

4.1.1 An Evaluation of Groundwater – 1982

This investigation was conducted prior to the corrective action requirements at the facility and is sometimes referred to as the Pre-Phase I Investigation. Six monitoring wells were installed at the facility and slightly upgradient of the facility in July 1982 and three monitoring wells were installed in September 1982 by Harper-Owes. A cluster of five shallow monitoring wells and five additional monitoring wells were installed at the facility and slightly upgradient of the facility between December 1982 and January 1983 by Hart-Crowser. For this discussion, the Harper-Owes wells, (G-1 through G-9) are referred to collectively as the "G-series wells," and the wells installed by Hart-Crowser (HC-1 through HC-10) are referred to collectively as the "HC-series wells." Details of the drilling, well installation, and decontamination procedures relevant to this project were reported in An Evaluation of Groundwater at the Chemical Processors, Inc. Georgetown Facility (Harper/Owes and Hart Crowser, 1983). Figure 4-2 shows the locations of the monitoring wells.

The G-series wells were located to determine the direction of groundwater flow and to characterize chemical conditions of groundwater entering and leaving the facility. The G-series wells were screened in the upper portion of the saturated zone. All G-series wells were installed in July 1982 using a hollow-stem auger drill rig. The wells were constructed with threaded risers and capped, two-foot by four-inch diameter, 0.01-inch slot PVC screens. The annular space above the sand pack was apparently not back-filled with bentonite grout until February 1983. A concrete seal was placed above the bentonite-grout seal, in the interval from approximately one foot below ground surface (bgs) to ground surface. The surface completions were either aboveground, or flush-mounted.

Five of the HC-series wells (HC-1, HC-2, HC-3, HC-9, and HC-10) were located in a cluster and screened at various depths to characterize vertical hydrogeologic and chemical profiles. HC-1 through HC-3 were screened in the shallow aquifer, HC-9 was screened in the deep aquifer and HC-10 was screened in the intermediate aquifer. Additional HC-series wells (HC-4 through HC-8) were subsequently installed throughout the facility to further refine local hydrogeology and contaminant distribution. These wells were screened in the upper 4.5 feet of the saturated zone. All HC-series wells were installed using a CME-750 drill rig and hollow-stem augers. The auger size is unknown. The HC-series wells were constructed of 1.5-inch diameter risers, and five-foot by 1.5-inch diameter, 0.01-inch slot screens. In the HC-series wells: HC-1, HC-2, HC-3, and HC-9, sand (Lane Mtn. Sand #16) was poured into the annulus, filling the portion of the borehole from the bottom of the screen to two to three feet above the screen). Well HC-10 was back-filled with sand from the bottom of the screen up to the top of the screen, whereas HC-series wells HC-4 through HC-8, all screened in the shallow aquifer, were backfilled with sand from the bottom of the screen to 0.5 to 1.0 foot above the screen. In wells screened in the intermediate and deep aquifers, HC-9 and HC-10, four to seven feet of natural soil was placed above the sand. There is no record indicating the use of temporary conductor casing during the installation of wells HC-9 and HC-10. All HC-series wells were completed with grout up to the ground surface at the time of installation (Harper Owes and Hart Crowser, 1998).

4.1.2 Phase I Hydrogeologic Investigation Work Plan - 1987

Three monitoring wells (CG-1, CG-2 and CG-3) were installed in 1987 as part of the Phase I Investigation. Wells CG-1 and CG-2 were later renamed CG-1-D and CG-2-D, respectively, to indicate that these wells were screened in the deep aquifer. The designation for well CG-3 was not altered; however, it is screened in the lower shallow aquifer. Well CG-3 is screened at the base of the shallow aquifer. Details of the drilling, well installation, and decontamination procedures relevant to the Phase I wells are included in the *Phase I Hydrological Investigation Report* (SE/E, 1988) and summarized in Table 4-1. Figure 4-3 shows the locations of the Phase I wells.

Well CG-1-D was installed in the North Field within the vicinity of wells HC-8 and G-9. Well CG-2-D also was installed at the facility in the West Field. CG-3 was installed in a background location to the east-northeast of the facility. Both CG-1-D and CG-2-D wells were screened at depths with the most obviously affected media in the upper portion of the deep aquifer, as determined by sampling during borehole drilling. Well CG-3 was screened at a greater depth than the existing background wells (G-4 and G-5), at the base of the shallow aquifer. A dual casing technique was used during the installation of CG-1-D to minimize cross contamination across bedded silt and sands; however, this method was not used for CG-2-D.

Flush-mount security casings were installed over wells CG-1-D and CG-3. A six-inch diameter protective steel casing with a locking steel lid was cemented in place over CG-2-D, extending approximately two feet above and two feet below ground surface. The stand-up casing for CG-2-D was replaced with a flush-mount well casing when the West Field was paved. All wells were resurveyed to reflect the modifications to the well heads made necessary by the new concrete cap that was installed across the facility in the early 1990s.

4.1.3 Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis - 1988

Twenty-four wells were installed in 1989 as part of the Phase II Hydrogeologic Investigation. The wells were screened as follows:

Screened interval	Number of wells	Well identifications
Upper portion of the shallow aquifer	Nine wells	CG-1-S1, CG-2-S1, CG-5-S1, CG-6-S1, CG-7-S1, CG-8-S1, CG-9-S1, CG-10-S1 and CG-11-S1
Lower portion of the shallow aquifer	Nine wells	CG-1-S2, CG-2-S2, CG-5-S2, CG-6-S2, CG-7-S2, CG-8-S2, CG-9-S2, CG-10-S2 and CG-11-S2
Intermediate aquifer	Four wells	CG-1-I, CG-2-I, CG-5-I and CG-9-I
Deep aquifer	Two wells	CG-4-D and CG-5-D

Wells screened in the intermediate and deep aquifers were installed using temporary conductor casing to prohibit cross contamination of aquifers during well installation. Details of the drilling, well installation, and decontamination procedures relevant to the Phase II wells are included as part of the *Phase II Hydrogeological Investigation Report* (SE/E, 1989b) and summarized in Table 4-1. Figure 4-4 shows the location of the Phase II wells.

The locations of these wells were selected based on the monitoring well installation criteria established in the Phase II Hydrogeologic Investigation, 1990, using groundwater concentrations and groundwater flow directions. All of these wells were installed on the facility. The "S1" shallow aquifer wells were screened from two feet above to eight feet below the shallow aquifer water table. The "S2" shallow aquifer wells were screened at the base of the shallow aquifer, approximately 30 to 40 feet bgs. The intermediate wells were screened at the base of the middle silt and sand unit, approximately 55 to 65 feet bgs. The deep wells were screened in the upper portion of the deep aquifer.

4.1.4 Phase III [Off-Site] Hydrogeologic Investigation Work Plan - 1991

Seventeen wells were installed in 1992 as part of the Phase III Hydrogeologic Investigation. Five wells were screened in the upper portion of the shallow aquifer (CG-101-S1, CG-102-S1, CG-103-S1, CG-104-S1 and CG-105-S1), five wells in the lower portion of the shallow aquifer (CG-101-S2, CG-102-S2, CG-103-S2, CG-104-S2 and CG-105-S2), five wells in the intermediate aquifer (CG-102-I, CG-103-I, CG-104-I, CG-105-I, and CG-111-I) and two wells in the deep aquifer (CG-102-D and CG-104-D). All wells were installed upgradient, cross gradient and downgradient of the facility. Wells screened in the intermediate and deep aquifers were installed using temporary conductor casing to prohibit cross contamination of aquifers during well installation. Details of the drilling, well installation, and decontamination procedures relevant to the Phase III wells are included in the *Phase III (Off-site) Hydrogeologic Investigation* (SE/E, 1991) and are summarized in Table 4-1. Figure 4-5 shows the locations of the Phase III wells.

Wells CG-101-S1 and CG-101-S2 were installed to monitor upgradient water quality. These "101" wells were installed in place of the proposed wells, CG-3-S1 and CG-3-I, because of accessibility issues. Four clustered well groups (CG-102 through CG-105), with three to four wells in each group, were installed hydraulically down-gradient and cross-gradient from the facility. These wells are located on approximately 200-foot centers at distances from the facility ranging from 150 to 400 feet to the south, west, and northwest. The deep wells at CG-102 through CG-104 were installed to verify the continuity of the deep aquifer. The "S1" shallow aquifer wells were screened three feet above and seven feet below the shallow aquifer water table. The "S2" shallow aquifer wells were screened at the base of the shallow aquifer. The intermediate wells were screened at the base of the intermediate aquifer. The deep wells were screened within the upper portion of the deep aquifer.

4.1.5 Post-Phase III Hydrogeologic Investigation Work Plan Monitoring Wells

After completion of the *Phase III Hydrogeologic Investigation* (SE/E, 1991), fifty-six additional groundwater monitoring wells were installed at or in the vicinity of the facility. These wells were installed to fill specific data gaps that were identified by the EPA, Ecology, and PSC. Separate work plans were prepared prior to installation of these wells, as discussed in this section. Figure 4-6 shows the locations of the post-Phase III Hydrogeologic Investigation wells ("Post Phase III").

4.1.5.1 *North Field Investigation Work Plan*

Two wells, CG-11-I and CG-12-I, and a nested shallow aquifer piezometer within well CG-12-I were installed in September 1998 to provide information about the intermediate aquifer groundwater elevations and constituent concentrations near the northern boundary of the facility. CG-12-I was installed at the north end of the North Field and CG-11-I was installed clustered with the Phase II wells CG-11-S1 and CG-11-S2. Wells screened in the intermediate aquifer were installed using temporary conductor casing to prohibit cross contamination of aquifers during well installation. The wells were installed with slightly different construction (i.e., sand pack and screen type) than those installed during the Phase III Hydrogeologic Investigation based on recommendations from EPA.

A variance from the WAC 173-160-420 (3) "Minimum Standards for Construction and Maintenance of Wells" was required to construct the dual completion monitoring well and piezometer well, CG-12-I and CG-12-S1. The variance was granted on October 19, 1998, by the Water Resources Program, Department of Ecology (Ecology, 1998). Details of the drilling, well installation, and decontamination procedures relevant to these wells were reported in the *North Field Intermediate Well Installation Report* (PSC, 1999a) and are summarized in Table 4-1.

4.1.5.2 *Final Soil Gas Sampling and Analysis Plan -2000*

Two groundwater monitoring wells (CG-112-S1 and CG-113-S1) were installed in 2000 in accordance with the *Final Soil Gas Sampling and Analysis Plan* (PSC, 1999b). The purpose of the wells was to correlate sample results between water table interval groundwater samples and soil gas samples collected from similar depths at nested permanent soil gas ports. Each well was screened in the upper portion of the shallow aquifer. Details of the drilling, well installation, and decontamination procedures relevant to the soil gas/groundwater monitoring wells are included in the *Final Soil Gas Sampling and Analysis Plan* (PSC, 1999b) and are summarized in Table 4-1.

The wells were installed directly hydraulically downgradient of the facility. Well CG-113-S1 is located on the east side of the building located at 5409 Denver Avenue South. Well CG-113-S1 is located on the east side of the building located at 672 South Lucile Street. Well CG-112-S1 is co-located with soil gas port CG-2-SG. Well CG-113-S1 is co-located with two soil gas ports, CG-3-SG and CG-4-SG. The wells were screened through the water table, with two feet of the screen above the high water table mark and approximately eight feet of the screen below the water table.

4.1.5.3 *RFI Well Installation*

Fifty-four (54) groundwater monitoring wells were installed in 2002 and two wells additional wells were installed in 2003 in accordance with the *Final RFI Well Installation Work Plan* (PSC, 2001c). Wells were installed upgradient and downgradient of the facility between Airport Way South to the East and the Duwamish River to the West. The purpose of these wells was to provide a monitoring program to characterize groundwater upgradient and downgradient of the facility. The well locations were chosen based on chemical data from groundwater reconnaissance locations in the area.[1] In addition, 13 soil borings were installed for lithological logging and geotechnical soil sampling (S34, Y26, W23, M29, S15, P18, K21, F16, H14, K10, D13, and D10).

Wells were screened at different intervals, based on the chemical data from the reconnaissance borings, within the shallow, intermediate, and deep aquifers. Twenty-one (21) wells were screened at the water table, 23 wells were screened in the lower shallow aquifer, 11 wells were screened in the intermediate aquifer, and 1 well was screened in the deep aquifer. Wells screened in the intermediate and deep aquifers were installed using temporary conductor casing to prohibit cross contamination of aquifers during well installation. Details of the drilling, well installation, and decontamination procedures are included in the *Final RFI Well Installation Work Plan* (PSC, 2001c) and summarized in Table 4-1. Figure 4-6 shows the locations of the monitoring wells.

4.2 *Soil Gas Port Installation*

In 1991, a total of five soil gas monitoring ports (CG-2-SG, CG-3-SG, CG-4-SG, CG-5-SG, CG-6-SG) were installed hydraulically down-gradient of the facility. The purpose of the soil gas ports was to help quantify the potential for VOCs in groundwater to intrude into nearby basements. The locations of these ports were based on their proximity to the residences where the potential exposures were expected to be highest. These wells are located hydraulically downgradient of the facility, on Denver Avenue South.

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[1] Two wells were installed in 2003 to fill data gaps not filled by the initial RFI Well Installation in 2002. CG-151-25 was installed close to the Duwamish River at the west end of South Fidalgo Street. CG-140-30 was installed as part of the "140" cluster located at the intersection of South Fidalgo Street and East Marginal Way South. Well CG-151-25 is not included in the PCAMP and is only used for hydrological purposes, as it is the closest well to the Duwamish Waterway, but is immediately downgradient of another source area. Well CG-140-30 replaces well CG-140-WT in the PCAMP.

The soil gas monitoring ports were constructed similar to the groundwater monitoring wells. All soil gas ports were installed in accordance with the State of Washington well construction requirements that were in effect at the time of installation; however, they are screened in the vadose zone. The soil gas ports were constructed using one-inch diameter, stainless steel risers with six feet of one-inch diameter, stainless steel, 0.020-inch slot screen. The bottoms of the screens were fitted with caps. Airtight fittings were used to connect the top of the risers to a stainless steel ball valve that can be used to attach tubing between the port and an air sampling canister. Fittings were threaded with Teflon® tape. Details of the drilling, well installation, and decontamination procedures relevant to the soil gas ports are included in the *Final Soil Gas Sampling Analysis Plan* (PSC, 1999b). Hugh G. Goldsmith & Associates, Inc. surveyed the soil gas ports on February 15, 2001.

Soil gas monitoring port nomenclature is similar to that for the groundwater monitoring wells with one exception. In place of the single letter that indicates the aquifer in which the well is screened, the two-letter string “SG” is used to indicate a “soil gas” monitoring port screened in the vadose zone.

Table 4-3 summarizes the soil gas port completion details. Table 4-4 shows the survey information for the soil gas ports. Boring logs and construction diagrams for soil gas ports are presented in Appendices 4D and Figure 4-7 shows their locations.

4.3 *Soil Vapor Extraction Well Installation*

In 1993, four soil vapor extraction (SVE) wells (V-1 through V-4) were installed at the facility as a soil interim measure (BEI, 1992b). The purpose of the interim measure was to extract soil gas from the vadose zone in the North Field of the facility, to reduce (a) the concentrations of contaminants within the vadose zone soils and (b) the potential for vapors to migrate.

The locations of these ports were determined based on previous investigations, which indicated that the highest concentrations in soil and some of the highest concentrations in shallow aquifer groundwater had been detected in the North Field. Although the wells were intended to extract vapors from the vadose zone, the wells were screened in both the vadose zone and saturated zones to account for the groundwater table fluctuations. Well depths range from 17 to 28 feet bgs. Details of the drilling and well installation procedures are included in the *Interim Measures Selection Report* (BEI, 1992b) and are summarized in Table 4-5.

Horton Dennis & Associates surveyed the SVE well measuring points on April 7, 1995. In 2001, PSC converted these values to the Hugh G. Goldsmith & Associates, Inc. coordinate system based on the North American vertical datum of 1988. Table 4-6 presents the survey information for the SVE wells. Well construction diagrams for the SVE wells are presented in Appendix 4E and Figure 4-8 shows the SVE well locations.

4.4 *Groundwater Monitoring Well Decommissioning*

Monitoring wells within the PCAMP network that need to be replaced or decommissioned require a permit modification to be approved by the lead agency for the facility. Table 4-1 identifies PCAMP wells that have been abandoned and their abandonment date. Wells were decommissioned in a manner consistent with WAC 173-160. Available well decommissioning records are included in Appendix 4C. Not all records are available for wells decommissioned in the 1980s. Figure 4-9 shows the former locations of decommissioned wells including the wells that do not have available decommissioning records but are believed to have been decommissioned.

4.4.1 Phase II Hydrogeologic Investigation

Seven of the G-series wells (G-1, G-2, G-3, G-4, G-7, G-8 and G-9) and four of the HC-series wells (HC-4, HC-5, HC-6 and HC-8) were decommissioned between August 9 and August 14, 1989. The seven G-series wells were decommissioned because of questionable well construction practices. The four HC-series wells were decommissioned because they were judged obsolete (SE/E, 1989a). Wells G-5 and G-6 were not decommissioned because they could not be located at the time of the other G-series well decommissioning.

Wells G-1, G-2, G-3, G-4, G-7, G-8, G-9, HC-4 and HC-6 were located too close to fences, walls or overhead obstructions to permit overdrilling. These wells were decommissioned by first knocking the bottom of the well casing out with a steel pipe, then cementing a PVC cap with a camlock-fitted elbow joint to the top of each well casing. Bentonite/cement slurry, equivalent to three well volumes, was pumped into each well and forced through the bottom of the well screen. An attempt was made on each well to pull the casing out using a boom truck. All of the casings and screens were extracted from wells G-1, G-4 and G-8. Only the riser pipes were retrieved from wells G-2, G-3 and G-7. Well casings and screens could not be extracted from wells G-9, HC-4 and HC-6 (SE/E, 1989b).

Wells HC-5 and HC-8 were decommissioned by over-drilling the well casing with a Mobile B61 drill rig, using a six-inch i.d. auger. The upper six to eight feet of PVC casing was removed through the top of the auger because the PVC casing broke during over-drilling. Two to four feet of casing was left in the decommissioned borings. The borings were over-drilled by two feet below the bottom of the well. The borings were then back-filled with medium bentonite chips (Enviroplug brand). The chips were poured through the top of the hollow-stem auger as the auger flights were withdrawn. From 0.5 to one foot bgs, bentonite chips were poured into the open borehole. The hydrated chips were allowed to set for 24 hours and then sealed with concrete.

The remaining HC-series wells (HC-1, HC-2, HC-3, HC-7, HC-9 and HC-10) were not decommissioned with the G- and HC-series wells because they were considered potentially useful for a possible future groundwater recovery system. However, these wells were decommissioned later (in November 1992) because the methods used for their installation were considered unacceptable compared to current construction standards.

According to decommissioning records, the remaining HC wells were decommissioned by running a tremie pipe to the bottom of the well and pumping cement bentonite grout from the bottom up. When the well was full of grout, the tremie pipe was pulled and the well was topped off with grout. Grout was then pumped into the riser through a grout hose to force the grout out of the screen and into the formation. After pressure grouting the well, the top of the well was cut and the remaining space was filled with grout.

Wells G-1, G-2, G-9, HC-4 and HC-6 were replaced during the Phase II Hydrogeologic Investigation by wells CG-11-S1, CG-9-S1, CG-6-S1, CG-10-S1 and CG-8-S1, respectively. The replacement wells were completed prior to the next scheduled groundwater sampling event.

Wells CG-2-D and CG-4-D were decommissioned on January 22, 2002 in accordance with Permit Modification 43-2 submitted to EPA on August 24, 2001, because they were inappropriately constructed and not in compliance with the State of Washington well construction and wellhead protection requirements.

Well CG-7-S1 was decommissioned on August 6, 2002, in accordance with Permit Modification 50-1' submitted to Ecology on June 18, 2002, because the well integrity was poor and the well was out of compliance with state well maintenance regulations. This well was in a high traffic area and the well cap had been broken many times, possibly allowing surface water intrusion into the well.

Well CG-2-I was decommissioned on August 8, 2002, in accordance with Permit Modification 49-1' submitted to Ecology on April 14, 2002, because the well screen was broken, rendering it unusable for sampling and out of compliance with state well maintenance regulations.

In the Hydraulic Control Interim Measure Construction Work Plan (URS/Geomatrix, 2003) and permit modification request GTMOD-60-1, PSC proposed to abandon some wells because they were either within the wall alignment or so close to the proposed wall alignment that they would be damaged by the construction of the wall. The following wells were abandoned prior to wall construction in July 2003: CG-2S1, CG-2-S2, CG-7-S2, CG-8-S1, CG-8-S2, CG-9-S1, CG-9-S2, CG-9-I, CG-11-S1, CG-11-S2, CG-11-I, CG-12-S1. CG-12-I, CG-105-S1, CG-105-S2, CG-105-I. All wells were grouted in place, per applicable well decommissioning regulations in WAC-173-160. A tremie pipe was used to pump a bentonite grout to the bottom of the well to the top, forcing grout out the screen into the formation. After pressure grouting the well, the top of the well was cut and the remaining space was filled with grout.

4.5 *Groundwater Monitoring Well Development*

All wells were developed upon installation. Table 4-7 describes the development process for each well since Phase I. After the Permit became effective, well integrity was verified on an annual basis. If any wells did not meet well integrity requirements as specified in Section VII.H of the original Permit then those wells were developed annually. The following three sections describe the well development procedures used in the past and the current SOP for well development and well integrity methodologies.

4.5.1 Initial Well Development

4.5.1.1 *An Evaluation of Groundwater - 1982*

An Evaluation of Groundwater - 1982 groundwater monitoring wells (G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-9 and HC-4 through HC-8) were developed prior to collection of the first groundwater sample from the wells. More than 10 casing volumes of groundwater were evacuated during a one-week period to minimize potential well fabrication-related contamination. Information regarding the type of equipment used, the flow rate used for purging, and the total volume of water purged is unavailable.

4.5.1.2 *Phase I Hydrogeologic Investigation Work Plan - 1987*

Phase I groundwater monitoring wells (CG-1-D and CG-3) were developed by using a gasoline powered centrifugal pump. The flow rate was controlled at the discharge end using a ball valve. Both wells were pumped until the discharge water contained only a small amount of silt and fine sand. Because of its low yield, CG-2-D was developed using a bailer. Field documentation is unavailable to determine if the well ran dry, or how many attempts were made to develop this well. Water was removed using a ten-foot-long, 1.25-inch o.d., PVC, single check-valve bailer. The volume of water removed from CG-2-D was approximately 16 gallons. This well was not considered to be fully developed because less than three well volumes of groundwater were removed. Documentation regarding any further action taken to completely develop this well is unavailable. However, PSC redeveloped all monitoring wells in 1998 and checks silt build up in wells annually to determine if wells need to be redeveloped. Therefore, the initial development of these wells is not considered problematic for the quality of the data used in the RI.

4.5.1.3 *Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis - 1988*

Phase II groundwater monitoring wells (CG-1-S1, CG-1-S2, CG-1-I, CG-2-S1, CG-2-S2, CG-2-I, CG-4-D, CG-5-S1, CG-5-S2, CG-5-I, CG-5-D, CG-6-S1, CG-6-S2, CG-7-S1, CG-7-S2, CG-8-S1, CG-8-S2, CG-9-S1, CG-9-S2, CG-9-I, CG-10-S1, CG-10-S2, CG-11-S1, and CG-11-S2) were developed using a surge block and bailing and/or pumping with a Homelite Waterbug pump. The wells were considered developed once the groundwater was free of sediment, non-turbid, or showed no further improvement and field measurements of pH and conductivity stabilized within 10 percent. The recorded pumping rates ranged from 1.5 (CG-9-I) to 6.0 (CG-1-S1) gallons per minute (gpm). Well CG-5-D ran dry during development. Wells CG-2-I and CG-4-D were not purged a minimum of three well volumes, and were not considered fully developed. Documentation regarding any further action taken to completely develop these wells is unavailable. However, PSC redeveloped all monitoring wells in 1998 and checks silt build up in wells annually to determine if wells need to be redeveloped. Therefore, the initial development of these wells is not considered problematic for the quality of the data used in the RI.

4.5.1.4 *Phase III [Off-Site] Hydrogeologic Investigation Work Plan - 1991*

Phase III groundwater monitoring wells (CG-101-S1, CG-101-S2, CG-102-S1, CG-102-S2, CG-102-I, CG-102-D, CG-103-S1, CG-103-S2, CG-103-I, CG-104-S1, CG-104-S2, CG-104-I, CG-104-D, CG-105-S1, CG-105-S2, CG-105-I, and CG-111-I) were developed using a bailer or pump. Water quality parameters (turbidity, pH, and conductivity) were measured periodically during development. The wells were considered developed when two successive readings of the water quality parameters had stabilized to within 10 percent of each other. A minimum of three times the volume of water added to the borehole during drilling was removed from each well. Well CG-102-D ran dry during development. Well CG-104-D was not purged a minimum of three well volumes and was not considered fully developed. Documentation regarding any further action taken to completely develop this well is unavailable. The initial water level for well CG-105-S2 was not available to calculate the required three well volumes for purging. However, 450 gallons were removed during development. This is more than three times the estimated well volume. Therefore the well is considered to have been fully developed. PSC redeveloped all monitoring wells in 1998 and checks silt build up in wells annually to determine if wells need to be redeveloped. Therefore, the initial development of these wells is not considered problematic for the quality of the data used in the RI.

4.5.1.5 *Post Phase III Work Plan Investigations*

North Field Investigation, 1999

Groundwater monitoring wells (CG-11-I and CG-12-I) were developed using several methods because of poor recovery. The methods employed included pumping with a submersible pump (Grundfos brand, EZ-Reel model), bailing, and pumping with a peristaltic pump. When developing well CG-11-I, the PVC surge block was replaced by a Grundfos EZ-Reel submersible pump owing to its greater weight and diameter. Initially, the Grundfos EZ-Reel submersible pump was used to purge the wells, and was raised and lowered slowly through the screened interval. A bailer was used after the wells had been surged to remove excess sediment. A peristaltic pump was also used once in an attempt to remove sediment from the bottom of the well; however, this pump was ineffective because of the depth of the water. These methods were found to be relatively ineffective in developing the well to the point where it could fully recover. The PVC surge block was ineffective and the Grundfos pump was used as a surge block. After attempting this method (using the surge block) three times, the groundwater at CG-11-I returned to its pre-development elevation. However, this well does not meet the requirements of the current well development methodology requirements, because the water quality parameters did not stabilize or the well was not purged of five volumes of water.

Each of the methods described above were also used in developing well CG-12-I, and were also considered unsuccessful for this well. Consequently, a well development rig with a five-inch by two-inch surge block attached to a seven-foot, 30-pound rod was used. The surge block had a rubber lip around it, which created a relatively tight fit in the well. This enabled the surge block to create pressure and suction within the well as it was moved up and down the well screen. Following surging with the development rig, the well was pumped using the Grundfos EZ-Reel submersible pump throughout the screened interval. The water level recovered at a faster rate than previously observed, and the well was considered fully developed. This method was also used to successfully finish developing well CG-11-I.

Final Soil Gas Sampling and Analysis Plan, 2000

Groundwater monitoring wells CG-112-S1 and CG-113-S1 were developed using a Wattera® pump. The wells were developed according to SOP NO. PSC-121 (Appendix 4B). Water quality parameters (temperature, dissolved oxygen, turbidity, pH and conductivity) were measured periodically during development to determine adequate development. Once the water quality parameters stabilized over three consecutive readings and a minimum of three times the well volume of water had been removed, the wells were considered developed. In order to not disturb the recently placed sand pack, a surge block was not used to develop these wells.

RFI Well Installation, 2002-2003

The 54 groundwater monitoring wells installed in 2002 were developed using multiple battery powered, in-line Whale pumps according to the procedures in SOP NO. PSC-121 (Appendix 4B). Water quality parameters (temperature, dissolved oxygen, turbidity, pH and conductivity) were measured periodically during development to determine adequate development. Once the water quality parameters stabilized over three consecutive readings and a minimum of three times the volume of water had been removed, the wells were considered developed. In order to not disturb the recently placed sand pack, a surge block was not used to develop these wells.

2003 Well Installation

The two groundwater monitoring wells installed in 2003 were developed using a submersible pump according to the procedures in SOP NO. PSC-121 (Appendix 4B). Water quality parameters (temperature, dissolved oxygen, turbidity, pH and conductivity) were measured periodically during development to determine adequate development. Once the water quality parameters stabilized over three consecutive readings and a minimum of three times the volume of water had been removed, the wells were considered developed. In order to not disturb the recently placed sand pack, a surge block was not used to develop these wells.

4.5.2 Annual Well Development

Section VII.H.3 b) of the Permit states, "If the well has a build-up of one foot or more of sediment at the bottom, then the well is redeveloped and the sediment is removed." Well integrity is evaluated annually by pulling the dedicated pumps and measuring the total well depths. As an option, PSC may perform slug tests or specific capacity tests in accordance with condition VII.J.3 of the Part B permit.

Since 1998, PSC has implemented a well integrity standard that is stricter than the permit requires. Total well depths have been measured and recorded annually and all wells with 0.5 feet or more of silt buildup are redeveloped. Prior to 1998, annual well measurement and development were not well documented.

4.6 *Groundwater Sampling*

4.6.1 Monitoring Well Sampling Program

PSC has collected quarterly groundwater samples from the PCAMP network since 1993. Over the years the PCAMP network has been changed by removing wells, adding wells, and changing the analyte list. Changes to the PCAMP are recorded in Table 4-8a (PSC, 2002b). In addition, the current sampling program for natural attenuation monitoring is provided in Table 4-8b (PSC, 2002a). All groundwater data collected since 1993 are provided in Appendix 9A. As mentioned earlier, only groundwater data collected between the first quarter of 2000 and the first quarter of 2003 are included in the analysis provided in Section 9.0 and in the RA.

Figure 4-1 shows the current quarterly groundwater monitoring network, which consists of 82 active groundwater monitoring wells. Table 4-8 describes the current PCAMP sampling program including a well-by-well analyte list and sampling schedule. The frequencies of groundwater sampling and water level elevation measurements for each of the monitoring wells are shown in Table 4-9. These frequencies are consistent with those stipulated in Table VII-2 of the original RCRA Part B permit for the facility (EPA, 1991), the Pre-Corrective Action Monitoring Plan, and all permit modifications. Natural attenuation samples have been collected since the fourth quarter of 1999; however, this is not a permit requirement. Table 4-10 lists the natural attenuation parameters that have been analyzed since the fourth quarter of 1999.

One monitoring well is sampled biannually for the constituents listed in Appendix IX of 40 CFR 264 Part 264, as required by Permit Conditions VII.B.3 and VII.G.4 and as modified in Permit Mod GTMOD 5-4. Initially, the designated frequency was annual, beginning fourth quarter of

1982. Permit Condition VII.G.4 was modified, effective June 15, 1994, to conduct Appendix IX analysis biennially, beginning the fourth quarter of 1995. The designated well was selected by PSC, with approval of EPA. The selection and approval was based on well location and on the number and levels of constituents detected at the selected well. Wells that have been sampled for Appendix IX analysis include CG-5-S1, CG-9-S1, and CG-104-I. The well designated for Appendix IX analyses in Permit Mod GTMOD 5-4 is CG-104-I.

If any of the Appendix IX constituents that were initially not listed on the quarterly groundwater analyte list were detected, the concentrations of the detected constituents were reported to the EPA and/or Ecology and added to the analyte list for quarterly sampling under Permit requirement VII.G.4. Appendix IX analysis includes: VOCs, SVOCs, PCBs, Total Metals, Chlorinated and Organophosphorus Pesticides, Chlorinated Herbicides, Dioxins, Furans, Sulfide, and Cyanide.

All groundwater monitoring wells currently in the sampling program have dedicated pumps, except well V-1. V-1 is an operational venting well from the SVE system and does not have a dedicated pump. Dedicated pumps were installed in all groundwater monitoring wells without LNAPL (CG-11-S1 and CG-6-S1) prior to the first quarter 1994 quarterly sampling event (BEI, 1994b). Phase I, Phase II (excluding CG-11-S1 and CG-6-S1 due to product), and Phase III monitoring wells (excluding CG-11-I and CG-12-I which were not yet installed) had dedicated pumps installed on April 3, 1995. Since LNAPL had not been detected in the last five years at CG-11-S1 or CG-6-S1, those wells and CG-11-I and CG-12-I had dedicated pumps installed in November 1999.

The dedicated pumps installed in Phase I, II, and III wells were Grundfos® Redi-Flow II electric submersible pumps, provided and serviced by Instrumentation Northwest, Inc. However, it was determined that the Grundfos® pumps had problems associated with the low-flow sampling method, especially with wells screened in effervescent aquifers. The low flow rates were difficult to achieve using the Grundfos® pumps; resetting the pumps to maintain flow was often required, and increased groundwater temperatures occurred at some wells. At many of the wells that had experienced these problems, the Grundfos® pumps were replaced in 2002 by new Bladder pumps. Bladder pumps were pilot tested before purchase and the pilot test showed that the pumps were not affected by the effervescence. Table 4-1 shows which wells currently have each type of dedicated pump.

When the 54 RFI wells were installed in 2002, dedicated bladder pumps were installed at each well.

4.6.2 Water Level Measurements

The PCAMP requires that water levels be measured on a quarterly basis. Table 4-9 lists the frequency at which water levels have been measured at each well. The water levels are measured prior to each sampling event or at least 24 hours after the last day of sampling, if necessary. It is desirable to perform the water level survey in the shortest period of time that is practical. For this reason, each time a water level survey is performed, it is completed within a 24-hour period, usually within one working day.

The presence of undetected nonaqueous-phase liquids (NAPLs) may confound the interpretation of water level data. Light NAPLs (LNAPLs) are less dense than water and tend to float on the water surface, while dense NAPLs (DNAPLs) are denser than water and tend to sink to the bottom of the water column. Each well has been checked annually for the presence of LNAPL and DNAPL when the dedicated pumps are removed to measure sediment accumulation.

The methods used for measuring water levels and NAPL thickness are described in SOP NO. PSC-120 (Appendix 4B). At each well, the groundwater elevation is obtained by measuring the corresponding DTW, which is the distance from the surveyed measuring point (MP) to the upper surface of the water column in the well. By convention, DTW is understood to be positive when the water surface is below the MP, and negative when the water surface is above the MP. The groundwater elevation is calculated as the difference between the surveyed MP elevation and the DTW:

$$Z_{GW} = Z_{MP} - DTW$$

- where Z_{GW} is the inferred groundwater elevation and Z_{MP} is the surveyed elevation of the monitoring well's MP.

In 1994, LNAPL was detected at wells CG-6-S1 and CG-11-S1. When the high-volume purging technique for groundwater sampling was employed, the presence of LNAPL and DNAPL was checked prior to sampling. During the An Evaluation of Groundwater - 1982 Investigation, this was done by first measuring the depth to water using an Actat, Model 300, Olympic Well Probe. Then, the presence of NAPL was checked using a peristaltic pump and a Teflon® bailer. The pump was first used to intersect the upper liquid surface to observe the potential presence of LNAPL. Then, the bailer was lowered to the bottom of the well to observe the potential presence of DNAPL. During the Phase II investigations, water levels were measured using an Olympic Model 300 electric water probe. The potential presence of NAPL was evaluated using a clear Teflon® bailer, lowered to the top one foot of the water column and, after examination, to the bottom of the well (SE/E, 1989b).

Following the implementation of the low-flow sampling technique in November 1993, through a variance to the permit, an electric oil-water interface detector was used to measure the depth and thickness of floating or sinking contaminants. After dedicated pumps were installed in 1994, annual tests for DNAPL have been performed by pulling the pumps and then lowering an electric oil-water interface detector to the top of the water table to test for the presence of LNAPL, then to the bottom of the well to test for the presence of DNAPL. LNAPL has not been detected in any well since 1994 and DNAPL has not been detected in any well to date. The NAPL measurements are conducted at the same time well integrity tests are conducted each year.

4.6.3 Groundwater Sampling Methodology for Permanent Wells

Groundwater samples taken for analysis must contain only fresh formation water to be representative of the water-bearing zone. Water residing in the well casing and/or filter pack becomes stagnant as the solution chemistry of the formation water changes with changes in temperature, pressure, or gas content. In addition, wells should be sampled without disturbing the water column to ensure that water closest to the well is being sampled.

The methods used to sample groundwater monitoring wells have changed as technology and EPA recommended techniques have evolved. Consequently, several different groundwater sampling methods have been applied since 1982. The following sections describe the various methods used.

4.6.3.1 *High Volume Purge*

Monthly groundwater sampling from monitoring wells began August 9, 1982 and continued through January 20, 1983. Following January 1983, groundwater sampling continued on a periodic basis up to 1994. Prior to the second quarter 1994 sampling event, EPA approved the use of high-volume well purge and sampling techniques to collect groundwater samples from monitoring wells.

An Evaluation of Groundwater - 1982 Investigation

The G-series wells were sampled from 1982 through 1988. The groundwater sampling method employed from August 9, 1982 to December 2, 1982, used a vacuum pump and a 20-liter glass carboy. Approximately three casing volumes of groundwater were pumped from each well prior to sampling (Harper-Owes and Hart-Crowser, 1983). The groundwater sampling method employed after December 9, 1982 used a nitrogen air-lift displacement pump developed by Hart-Crowser & Associates. The pump was constructed of stainless steel and Teflon® components, with minimal sample-to-nitrogen contact area. Information regarding the pumping rate was not recorded in the Groundwater Monitoring Field Sampling Data Sheets. All sampling equipment was decontaminated with acid and acetone wash and triple rinsed with tap water prior to sampling. Samples were sent to Am Test, Inc., Laucks Testing Laboratories, Inc., and Chemical Waste Management, Inc. (Harper-Owes and Hart-Crowser, 1983).

Phase I Hydrogeological Investigation Work Plan - 1987

In December 1987, monitoring wells G-1, G-2, G-3, G-4, CG-1-D, CG-2-D and HC-9 were sampled. Wells G-2 and G-3 ran dry. Well HC-10 was broken at approximately 25 feet bgs and could not be sampled. Wells were purged using a Masterflex® Model 7549-39 high volume peristaltic pump with Tygon tubing except for well CG-2-D. A PVC bailer was used to purge well CG-2-D. Water quality parameters, pH and temperature were measured using a Yokogawa® Model 51 pH meter, and specific conductivity was measured using a Hanna® Model HI 8333 conductivity meter. All field test equipment was calibrated approximately every four hours during sampling. The temperature, pH, and specific conductivity were measured during well evacuation until successive readings of the parameters stabilized to within 10 percent of each other (SE/E, 1988).

Sampling commenced after a minimum of three pore volumes of groundwater were removed and stabilization was achieved. (Well CG-2-D ran dry and was sampled after recovery). Groundwater samples were obtained using a 2.96-foot long, 0.14-foot o.d. double check valve Teflon® bailer and a peristaltic pump with Tygon tubing, with the exception of well HC-9. Well HC-9 was sampled using a 0.05-foot o.d. double check-valve Teflon® bailer. Monofilament line was used for lowering the bailer into the well. Samples that were tested for dissolved priority pollutant metals were filtered through a 0.45-micron nitrocellulose filter placed at the discharge line of the peristaltic pump (SE/E, 1988). All groundwater sampling equipment was decontaminated between monitoring well locations to minimize cross-contamination.

Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis – 1988

Groundwater samples were collected in September and October 1989 from 24 new monitoring wells (CG-1-S1, CG-1-S2, CG-1-I, CG-2-S1, CG-2-S2, CG-2-I, CG-4-D, CG-5-S1, CG-5-S2,

CG-5-I, CG-5-D, CG-6-S1, CG-6-S2, CG-7-S1, CG-7-S2, CG-8-S1, CG-8-S2, CG-9-S1, CG-9-S2, CG-9-I, CG-10-S1, CG-10-S2, CG-11-S1, and CG-11-S2) and the three existing wells (CG-1-D, CG-2-D and CG-3) (SE/E, 1989b).

Each well was purged using either a high capacity peristaltic pump (Cole-Palmer® Master Flex Model #7549-30) and Tygon tubing, or a Teflon® bailer and polypropylene rope. Each monitoring well was purged until a minimum of three pore volumes had been removed. Groundwater temperature, pH, and specific conductivity were measured after the removal of each pore volume. Sampling commenced after two successive readings of the water quality parameters had stabilized to within 10 percent of each other, after three volumes were purged (SE/E, 1989b). Wells with insufficient well yield (CG-5-D and CG-2-D) were purged by lowering the water column to the top of the screen and allowing the well to partially recover overnight. The following day, the water level was again lowered to the top of the screen and then sampled. 10

Samples for VOC analyses were collected using a double check-valve Teflon® bailer equipped with a bottom-drain sampling device. Samples collected for dissolved metals were filtered at the time of sample collection using a QED® Sample Pro or similar 0.45-micron, in-line filter (SE/E 1988). All groundwater sampling equipment was decontaminated between monitoring well locations to minimize cross-contamination.

Phase III [Off-Site] Hydrogeologic Investigation Work Plan - 1991

In compliance with the work plan for the Phase III Hydrogeologic Investigation, groundwater samples continued to be collected quarterly for the 27 existing wells and 17 new monitoring wells (CG-101-S1, CG-101-S2, CG-102-S1, CG-102-S2, CG-102-I, CG-102-D, CG-103-S1, CG-103-S2, CG-103-I, CG-104-S1, CG-104-S2, CG-104-I, CG-104-D, CG-105-S1, CG-105-S2, CG-105-I, and CG-111-I).

To purge the wells, one of the following pieces of equipment was used:

- Masterflex® high-capacity peristaltic pump fitted with silicon and Tygon tubing;
- Teflon® bailer secured with monofilament line; or
- Grundfos® Redi-flo™ electric submersible pump.

Water quality parameters were measured using a HC DRT-15C turbidimeter, a Taylor® pocket thermometer, and a DSPH-3 or Corning® pH/conductivity meter and an Issco® 8-20 controller YSI 3800, purge saver, or similar water quality meter.

These wells were purged and sampled using methods similar to those used during the Phase II Hydrogeologic Investigation. In addition, after removing a minimum of three pore volumes, and after field parameters had stabilized, three consecutive measurements of turbidity, temperature, pH and specific conductivity were recorded. The goal of this sampling methodology was to maintain a water level above the screen and to keep total drawdown under 10 percent of the saturated screen length during purging and sampling. However, this was not always possible due to hydrogeological conditions or equipment problems (as discussed in Section 5.0). Samples were collected directly from the pump discharge line or using a Teflon® bailer. Samples collected for dissolved metals analysis were filtered at the time of collection using disposable QED® Sample Pro or similar 0.45-micron, in-line filters (SE/E, 1991). All groundwater sampling equipment was decontaminated between monitoring well locations to minimize cross-contamination.

4.6.3.2 *Low Flow*

On November 19, 1993, BEI requested a variance from the facility's *Pre-Corrective Action Groundwater Monitoring Plan (*BEI, 1992c*).* EPA partially approved the variance on December

10, 1993. Aspects of the variance that were approved included using dedicated sampling equipment and low flow sampling techniques, and eliminating equipment blanks for wells with dedicated sampling equipment. Beginning with the second quarter (June) 1994 sampling event, EPA approved low-flow purging and sampling techniques to obtain groundwater samples. Low-flow groundwater sampling techniques are described in Low-Flow Groundwater Sampling Procedure SOP NO. PSC-124 Revision 0 (Appendix 4B). When sampling the dedicated wells, an electric converter was connected to the Grundfos® Redi-Flow II submersible pump and operated at a low flow rate. Using the EPA-approved low-flow sampling technique, water was purged from the well at a rate of 1000 milliliters per minute (mL/min) or less while groundwater field parameters were monitored at three- to five-minute intervals from the beginning of purging. Sampling commenced after one well-volume of water had been purged and at least two consecutive readings of water quality parameters agreed within 10 percent.

Immediately prior to sampling, the pumping rate was reduced to no more than 100 mL/min to reduce the potential for degassing the sample of volatile constituents. Following the collection of VOC samples, the pumping rate could be increased to a rate that did not exceed 1000 mL/min. The sample bottles were filled directly from the sampling pump discharge hose. After all samples were collected and before turning off the pump, two final water quality readings were measured.

4.6.3.3 *Micropurge®*

On May 11, 1999, PSC requested a variance to the *Pre-corrective Action Groundwater Monitoring Plan* (BEI, 1992) to change the sampling method from low-flow to Micropurge®. On May 20, 1999 this request was granted on a trial basis. The PSC sampling team used EPA approved Micropurge® sampling techniques at the facility from the second quarter of 1999 until the first quarter of 2002. Wells were sampled according to the Micropurge® Groundwater Sampling Procedure SOP NO. PSC-124 Revision 3 (Appendix 4B).

In Micropurge® sampling, groundwater was purged at a rate of 300 mL/min or less while groundwater field parameters were monitored at three-minute intervals from the start of purging. Flow rate, water level and power converter hertz/pump speed were measured every three to five minutes while purging to insure that the flow rate was at or below 300 mL/min and that drawdown was not occurring. Sampling commenced once the following water quality parameters were deemed stable: pH, specific conductivity, temperature, dissolved oxygen, redox potential, and turbidity. There were two exceptions to the stability criteria: (1) if the well has run dry twice or (2) one full well volume of groundwater has been removed. If either of these exceptions occurred, the well was sampled even if the parameter readings had not stabilized.

The sample bottles were filled directly from the sampling pump discharge hose. Immediately before sampling, the pumping rate was reduced to no more than 100 mL/min to reduce the potential for degassing the sample of volatile constituents. Flow rate was then turned back up to 300 mL/min after the VOCs had been collected. The order of sampling was as follows: VOCs, SVOCs, PCBs, other organic constituents, total metals, and other inorganics. If the laboratory did not add the necessary preservatives to the new sample bottles prior to sampling, then the sampling team added the preservatives as prescribed by the lab.

After samples were collected and before turning the pump off, final water quality and water level readings were measured and recorded. .

4.6.3.4 *Revised Low-Flow Sampling*

On March 18, 2002, EPA approved a revised version of SOP No. PSC-124 dated February 22, 2002 for use in quarterly groundwater sampling.[2] This version of the SOP has been used for all

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[2] This revision of the SOP was prompted, in part, by a CME inspection by EPA in first quarter 2001 that lead to a Notice of Violation (NOV) and later to a Compliance Order. The NOVs criticized PSC for failing to meet monitoring well sampling standard operating procedures (even if the cause was related to naturally occurring

quarterly groundwater sampling since that time. The SOP was revised after PSC had reviewed the sampling techniques being used and determined that the SOP being used was too restrictive to properly comply with under normal field conditions and with the limitations of the sampling equipment. PSC reviewed federal guidance and discussed field problems with EPA and Ecology staff prior to revising the SOP. The main changes made to SOP No. PSC-124 included slightly increasing the flow rate limit, revising methodologies to counteract drawdown, factoring in the accuracy of the equipment being used, and recording temperature but not waiting for it to stabilize prior to sample collection. The general procedures for sampling technique remained approximately the same as the previous version of the SOP.

4.6.4 Groundwater Sampling from Reconnaissance Borings

In addition to quarterly groundwater sampling of groundwater monitoring wells, one-time groundwater samples were collected from reconnaissance borings during various investigations to provide additional information regarding the groundwater characterization of the facility and surrounding areas. Table 4-11 describes the groundwater samples collected from reconnaissance borings. A brief description of the investigations and the methods employed is given below.

4.6.4.1 *Phase I Investigation Work Plan - 1987*

Thirteen groundwater samples were collected during a property transfer assessment in December 1987 (SE/E, 1988). Samples were collected at discrete intervals from two reconnaissance borings during the installation of wells CG-1-D and CG-2-D, from approximately 10 to 89 feet bgs. Water samples were collected at 10-foot intervals in boring CG-1-D and at 20-foot intervals in boring CG-2-D. Figure 4-3 shows the sample locations for the Phase I Investigation.

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conditions in the aquifer). The Order required that PSC evaluate the possible uncertainties related to changing the sampling technique over time.

Groundwater samples were collected using a two-foot long, three-inch diameter, stainless steel Johnson® drive-point well screen with 0.010-inch slots attached to a threaded ten-foot length of two-inch diameter, black iron riser. The screen was advanced ahead of the drill casing. Prior to sampling, three times the volume of water inside the drive point and riser pipe were removed using a three-foot long by 1.25-inch o.d. Teflon® bailer for each sample collected. The volume was calculated from a measurement of the depth to water inside the riser. After the casing and screen were purged, the sample was collected using a 1.8-foot by 1.0-inch diameter single check-valve Teflon® bailer. Four sample bottles were filled at each sample interval, one for headspace analysis and three for laboratory testing (VOC, SVOC, phenols, total metals and cyanide). More information on the methods used to sample the reconnaissance borings are described in *Phase I Hydrogeologic Investigation* (SE/E, 1988a).

4.6.4.2 *Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis - 1988*

Thirty-nine groundwater samples were collected from reconnaissance borings during the Phase II Hydrogeological Investigation conducted in June 1989 through August 1989. At each "T" boring location, two to three groundwater samples were collected. Samples were collected from each of 14 reconnaissance borings at the following depths: the water table, approximately 18 to 22 feet below the water table, and at the termination depth (if greater than 29 feet bgs). Figure 4-10 shows the sampling locations for the Phase II Hydrogeological Investigation.

Contrary to the *Phase II Hydrogeological Investigation Proposal for Monitoring, Analyses, and Testing* (SE/E, 1989a), at least one volume of water inside the hollow-stem auger was not removed before the drive point was installed as had been stipulated. This variance was necessary because of heaving sands migrating up into the auger during the extraction of the water. However, one pore volume was removed from within the auger after the drive point was positioned. Groundwater samples were collected using a three-foot long, two-inch i.d. wound-wire stainless steel drive-point well screen with a black iron riser pipe. The screen was advanced ahead of the drill casing approximately 18 inches until the screen met refusal into soils from which a split-spoon sample had been removed.

The pre-sampling procedures described in the *Phase II Hydrogeological Investigation Proposal for Monitoring, Analyses, and Testing* (SE/E, 1989a) were not followed exactly.[3] Prior to sampling, the drive-point screen and casing were purged a minimum of three pore volumes using a peristaltic pump, or a Teflon® bailer and polypropylene rope. Water quality parameters (pH, specific conductivity and temperature) were measured after each pore volume was removed. Sampling commenced after water quality parameters stabilized within 10 percent of each other and at least three pore volumes were removed. Organic samples (VOC and SVOC) were collected using a double-check-valve Teflon® bailer equipped with a bottom drain. Inorganic samples (total and dissolved metals, and cyanide) were collected using a peristaltic pump with an in-line high capacity FF-8200 0.45 micron nitrocellulose disposable filter. More information on the methods used to sample the reconnaissance borings is given in *Phase II Hydrogeologic Investigation* (SE/E, 1989b).

4.6.4.3 *Phase III [Off-Site] Investigation Work Plan - 1991*

Semi-Annual Progress August 1993

Nineteen groundwater samples (GW-01 through GW-17, GW-103 and GW-104) were collected from reconnaissance borings as part of the Phase III Hydrogeological Investigation during 1993. Samples were collected with a RECON® System within the vicinity of the facility and in the Georgetown neighborhood from the upper part of the shallow aquifer (12-15 feet bgs). The RECON® System is a mobile laboratory consisting of laboratory-grade screening equipment and a hydraulic probe for direct-push sampling. Figure 4-11 shows the sampling locations for this Phase III Hydrogeological Investigation.

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[3] This is not considered an uncertainty in the RI, because PSC has collected much more recent monitoring well data and reconnaissance data that are used for analysis in the RI and RA.

Four samples were collected to determine the comparability of groundwater samples collected with the RECON® System with those collected from wells downgradient of the facility. Two samples (GW-103 and GW-104) were collected with the RECON® System, one adjacent to CG-103-S1 and one adjacent to CG-104-S1, and two samples collected from each of these wells. These groundwater samples were analyzed by both the RECON® System gas chromatograph (GC) and by an analytical laboratory by EPA Method 8240.

Groundwater samples were obtained by driving a one-inch o.d. steel probe to the expected depth of the water table. The groundwater sampling tool was attached to the end of the probe and consisted of a 19-inch stainless-steel screen enclosed in a steel sheath sealed by O-rings. Groundwater was not purged, and water quality parameters were not measured, prior to sample collection. The type of pump used and the rate of pumping are unknown. Samples were collected for VOC analysis. A Hewlett-Packard® Model 5890A Series II gas chromatograph (GC) was used for the headspace screening analysis. Compound separation and detection were performed using a 30-meter wide-bore DB-624 capillary column and a flame ionization detector (BEI, 1993). More information on the methods used to sample the reconnaissance borings are described in *Semi-Annual RFI Progress Report* (BEI, 1993).

Semi-Annual Progress Report February 9, 1994

Twenty groundwater samples (RW-1 through RW-20) were collected as part of the investigation to determine the location of additional step-out wells for the Phase III Investigation during August 1993. Samples were collected using the RECON® System, from 20 boreholes at the water table. The exact depths of the boreholes are not known. Figure 4-11 shows the sampling locations for this Phase III Investigation. The methods used to sample the reconnaissance borings are described in *Semi-Annual RFI Progress Report* (BEI, 1994a).[4]

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[4] This is not considered an uncertainty in the RI, because PSC has collected much more recent monitoring well data and reconnaissance data that are used for analysis in the RI and RA.

4.6.4.4 *Post-Phase III Hydrogeologic Investigation Work Plans*

Off-site Hydropunch® Investigation Work Plan, July 1998

More than 100 temporary groundwater samples were collected during the Off-site Hydropunch® Investigation, from July 16, 1998 through July 31, 1998. Figure 4-12 shows the sampling locations. Samples were collected from 21 Hydropunch® locations (reconnaissance borings) at four or five different depths. Sample locations were based on a 200-foot rectangular grid. Sampling occurred at: the following depths:

- the water table (approximately 15 feet bgs);
- the bottom of the shallow aquifer (approximately 30 feet bgs);
- the top of the intermediate aquifer (approximately 45 feet bgs);
- the bottom of the intermediate aquifer or the top of the silt unit (approximately 60 feet bgs); and
- approximately 75 feet bgs, only if the silt unit had not been encountered at a lesser depth in the same boring.

Groundwater samples were collected from monitoring wells following the low-flow procedure designated in SOP NO. PSC-124 Revision 0. Groundwater samples were collected through the following process:

- Attach a water sampling tool to the end of the drive rods.
- Insert the inner rods into the drive rods, engage the inner rod with the sampling tool, and remove the threaded plug, opening the sampling tool.

- Expose the screen by retracting the drive rods four feet.
- Run polyethylene tubing down the drive rods, with the top of the tubing attached to the peristaltic pump.
- Purge one gallon of groundwater prior to sample collection. Information regarding the flow rate is not available. Samples were collected from the bottom of the tubing for VOC analysis.
- No water quality parameters were measured while purging the direct-push reconnaissance borings.

The initial groundwater samples from reconnaissance borings were collected along rows one through three of the grid and were simultaneously sampled with PSC's neighboring groundwater monitoring wells. Specifically, reconnaissance samples from location B1 were collected at the same time that monitoring well cluster CG-5 was sampled. Reconnaissance samples from location C2 were collected at the same time that monitoring well cluster CG-102 was sampled. Reconnaissance samples from location D3 were collected at the same time that monitoring well cluster CG-103 was sampled. Reconnaissance samples from location F3 were collected at the same time that monitoring well cluster CG-104 was sampled. Reconnaissance samples from location H3 were collected at the same time that monitoring well cluster CG-105 was sampled. The groundwater samples from each well were obtained using the well's dedicated sampling equipment. More information on the methods used to sample the reconnaissance borings are described in the *Final Off-site Hydropunch Work Plan* (PSC, 1998).

North Field Intermediate Well Installation Work Plan - 1998

Two reconnaissance groundwater samples were collected during the North Field Intermediate Well Installation on September 4, 1998. Samples were collected at two discrete intervals in one borehole during the installation of well CG-12-I. One sample was collected at the water table and the second sample was collected at the bottom of the shallow aquifer. Figure 4-6 shows the sample locations for the North Field intermediate well installation.

Reconnaissance groundwater samples were collected using the same procedure as previously described in Section 4.6.3.3. Although no water quality parameters were measured, notes in the field book suggest that a qualitative evaluation was made regarding the turbidity of the groundwater, and that groundwater was purged until the water appeared to be relatively clear. Samples were analyzed for VOCs, SVOCs, PCBs/pesticides, TPH and metals. More information on the methods used to sample the reconnaissance borings is given in the *North Field Intermediate Well Installation Report* (PSC, 1999a).

Supplemental Offsite Groundwater Characterization, Source Area and Off-Site Nature and Extent of Plume Investigation Sampling and Analysis Plan - 2000

Between October 2000 and December 2000, 263 reconnaissance groundwater samples were collected as part of the Source Area Investigation portion of the Supplemental Offsite Groundwater Characterization. Samples were collected at ten-foot intervals from 38 boreholes. Sample locations were located directly downgradient (hydraulically) of the facility on a 25-foot rectangular grid. The samples were collected at 10foot or greater intervals, beginning at the water table in the shallow aquifer, and continuing until the silt aquitard was encountered. However, if a photo-ionization detector (PID) reading from a soil sample was high, then an additional groundwater sample was collected, and screened at the corresponding interval. If this interval was close to the original sampling location, subsequent locations were slightly adjusted to accommodate this sample. Figure 4-13 shows the sampling locations for the Source Area Investigation.

The actual number of sampling locations and sampling intervals changed during the field event based on the groundwater concentrations observed. Eight sampling locations on the Aronson property to the northwest of the facility were added based on observed groundwater concentrations. Four sampling locations were added outside of the Stone Drew/ Ashe Jones property based on observed groundwater concentrations. Four sampling locations (D-33 through D-36) were sampled at ten-foot intervals beginning at 63 feet bgs. VOC samples were collected at all Source Area Investigation sampling locations. Cyanide and some natural attenuation parameter groundwater samples were collected at designated locations to monitor up-gradient and down-gradient conditions.

Between October 2000 and April 2003, 180 reconnaissance borings were installed to collect 780 groundwater samples as part of the Off-site Nature and Extent Investigation during the Supplemental Offsite Groundwater Characterization. These samples were located throughout the Georgetown neighborhood, between the facility and the Duwamish Waterway. Sample locations were initially set on grid nodes approximately 250 feet apart. However, access was limited to the public right-of-way and sometimes sample locations had to be located further apart. Samples were collected at 15-foot depth intervals or continuously at some locations, with maximum sampling depths at each location based on exceedances of cleanup criteria in hydraulically up-gradient locations. Figure 4-14 shows the sampling locations for the Off-site Nature and Extent of Plume Investigation.

Sampling occurred in a step-out system depending on the depths and concentrations in the most recent step-out investigation. A total of eight step-out investigations were conducted. In addition, a few sample locations from the 1998 Hydropunch Investigation were re-sampled. The initial 10 sample locations were analyzed for the complete facility Method 8260 VOC list. Subsequent samples were only analyzed for those VOCs where the nature and extent was not defined.

Groundwater samples for both the Nature and Extent and Source Area Investigations were collected using Geoprobe® direct-push sampling tools. Groundwater samples were obtained by driving a one-inch o.d. steel probe to a given depth. Then, the 19-inch stainless-steel screen enclosed in a steel sheath was pushed out into the formation at the desired depth. Polyethylene 3/8-inch o.d. tubing was placed down the drive rods to the depth of the screen. Typically, one gallon of groundwater was purged prior to sample collection. Headspace of the purged water was measured using a Photovac® PID. Water quality parameters, turbidity, pH, temperature, dissolved oxygen, specific conductivity, and oxidation potential were monitored at three separate times during purging. Sometimes, less than one gallon was purged from a well because of less porous subsurface material and difficulty encountered with the pump at greater depths. In each instance, this was documented on the water quality sheet and in the field book.

To collect the groundwater samples, the pump was stopped and groundwater VOC samples were collected from the bottom of the tubing. If an entire 40-mL VOC vial did not fill within one tubing extraction, the bottle was discarded and a second attempt was made.

After the VOC samples were collected through the bottom end of the tubing, the tubing was re-inserted into the drive rods and cyanide and natural attenuation groundwater samples were collected, if necessary, through the top end of the tubing using the pump. If the volume of water was limited, not all water quality samples were collected from the deeper sampling intervals. After collecting the samples, the tubing was discarded and the sampling tools withdrawn and decontaminated.

More information on the methods used to sample the reconnaissance borings and results are given in the *Georgetown Supplemental Offsite Groundwater Characterization Work Plan* (PSC, 2000) and subsequent *Georgetown Supplemental Offsite Groundwater Characterization: Technical Memorandum I through XII.*

Indoor Air Analysis Investigation Sampling and Analysis Plan, 2000

Eleven groundwater reconnaissance samples were collected during the Indoor Air Analysis Investigation on August 29, 2000. Sample sites were located beneath homes, hydraulically upgradient of homes, and in the City rights-of-way near the sidewalks outside two homes. The samples were collected at the water table (10 to 12 feet bgs). Figure 4-15 shows the groundwater sample locations for the Indoor Air Analysis Investigation.

Groundwater samples were collected using Geoprobe® direct-push sampling tools. The drilling contractor, Cascade Drilling, custom fabricated the tools used for this investigation. The Geoprobe® rods were already in the ground from sampling soil gas. The screens did not have a sheath to uncover the screens, as the screens were already exposed while collecting the soil gas samples. To collect the groundwater samples, the one-inch o.d. steel rod was pushed deeper, from the vadose zone to the water table (8 to 12 feet bgs). At three locations, 672L-1, 672L-2 and 5409D-1, Geoprobe® rods were pushed at an angle near the side of the residences to obtain groundwater samples as close to the basements as possible. Drill rig access was limited on the east side of the 672 S. Lucile St. residence because of utilities and a large tree. Consequently, groundwater samples were collected on the west side of the house. Geoprobe® rods were installed vertically (at the remaining eight groundwater locations) along the sidewalk near the two residences.

Polyethylene 3/8-inch o.d. tubing was placed down the drive rods to the depth of the screen. One gallon of groundwater was purged prior to sample collection. Headspace of the purged water was measured using a Photovac® PID. Water quality parameters (turbidity, pH, temperature, dissolved oxygen, specific conductivity and oxidation potential) were monitored at three separate times during purging. Two 40-ml vials of groundwater were collected for VOC analysis, at flow rates less than 100 mL/min, from the top end of the tubing through the peristaltic pump. More information on the methods used to collect groundwater samples are described in the *Indoor Air Analysis Investigation*, (PSC, 2000b).

Soil Gas Investigation - March 2001

As part of the March 2001 Soil Gas Investigation, six groundwater reconnaissance samples were collected on March 22, 2001. Samples were located throughout the Georgetown neighborhood.

The samples were collected at the depth of the water table, which was 11 to 15 feet bgs or 15 to 19 feet bgs, depending on the location. Figure 4-16 shows the sample locations.

After removing the temporary soil gas ports, groundwater samples were collected using Geoprobe® direct- push sampling tools. Groundwater samples were obtained by driving a 0.65-inch o.d. steel probe to the water table. Then, the three-foot stainless steel, 0.004-inch slot screen enclosed in a steel sheath was pushed out into the formation at the desired depth. Polyethylene tubing was inserted down the drive rods to the depth of the screen. One gallon of groundwater was purged prior to sample collection using a peristaltic pump. Headspace of the purged water was measured using a Photovac® PID. Water quality parameters, turbidity, pH, temperature, dissolved oxygen, specific conductivity and oxidation potential were monitored at three separate times during purging.

VOC groundwater samples were collected by stopping the pump and collecting samples from the bottom of the tubing. If an entire 40-mL VOC vial did not fill within one tubing extraction, the bottle was discarded and a second attempt was made. North Creek Analytical Laboratories analyzed the groundwater samples.

More information on the methods used to sample the reconnaissance borings is given in the *Technical Memorandum: Soil Gas Investigation Results* (PSC, 2001a).

Hydraulic Control Interim Measure Work Plan - 2002

In June 2002, 141 groundwater samples were collected as part of the Hydraulic Control Interim Measure to assist in the design of a barrier wall surrounding the source area of contamination. The samples were collected using direct push methods according to the *Hydraulic Control Interim Measures Work Plan* (URS and PSC, 2002). All samples were analyzed for VOCs and some of the samples were analyzed for metals also. North Creek Analytical Laboratories analyzed the groundwater samples. Sample locations are shown in Figure 4-17.

4.7 *Soil Gas, Indoor Air and Ambient Air Sampling*

The following is a brief summary of the soil gas, indoor air, and ambient air data collected.

4.7.1 Permanent Soil Gas Port Sampling

PSC installed five permanent soil gas sampling ports to determine the relationship between the soil gas concentrations and groundwater concentrations in adjacent monitoring wells. Typically, the soil gas ports were sampled within the same groundwater sampling event on the same day and prior to the groundwater monitoring wells within the cluster. The soil gas ports screened at the four-foot interval were sampled prior to the soil gas ports screened at the seven-foot interval. The soil gas ports screened at the seven-foot interval were not sampled if groundwater was present in the well.

SOP NO. PSC-106 Revision 1 (Appendix 4B) describes the active soil gas sampling method used for sampling the soil gas ports. To be representative of the vadose zone, soil gas samples must contain only "fresh" formation soil gas. Soil gas residing in the port and/or filter pack becomes stagnant as the solution chemistry of the formation gas changes with changes in temperature, pressure and water table elevation. Therefore, soil gas ports need to be evacuated prior to sampling. A purge test was completed when the soil gas ports were initially installed according to the methods described in the *Final Soil Gas Sampling and Analysis Plan* (PSC, 1999b). Based on the findings of that test, three liters of soil gas were purged from the shallow soil gas ports and four liters of soil gas were purged from the deeper soil gas ports prior to sample collection.

Prior to purging the soil gas ports for each sampling event, soil moisture was measured. During the installation of the permanent soil gas ports, two Soil Moisture Sensor Theta Probes (Type ML2X, by Delta-T Devices) were buried at 4.5 and 7.5 feet bgs near CG-3-SG and CG-4-SG, respectively. The output line runs through the soil and was accessible in soil gas port CG-3-SG. A Moisture Meter (Type HH2, by Delta-T Devices) is used to read the soil moisture.

Soil gas ports were purged using an Amtek Alpha 1 Air Sampler. Purging of the soil gas ports was conducted using Teflon®-lined polyethylene tubing connected to the Amtek Alpha 1 Air Sampler and a dedicated Swagelok® fitting in the soil gas port. Samples were collected at a rate of 100 liters per minute (L/min).

All soil gas samples were collected in six-liter Summa® canisters. The Summa® canisters were prepared under negative pressure and equipped with a dedicated flow regulator and filter. The Summa® canisters were individually cleaned and certified to 0.02 parts per billion by volume (ppbv) total hydrocarbons (THC) by the contract laboratory for selective ion mode (SIM) VOC analysis by TO-14A. The tags on the canisters were labeled with the following information:

- Sample location identification number;
- Canister number;
- Date of the sample;
- Initial and final pressure; and
- Initials of the PSC sampling personnel.

The Summa® canisters were connected to the soil gas ports using dedicated Teflon®-lined polyethylene tubing and airtight Swagelok® fittings. The soil gas sampling was completed once the pressure on the Summa® canister read approximately -5.0" Hg. The Summa® canisters were sent by overnight courier to Air Toxics Laboratory in Folsom, California. The soil gas samples were analyzed for VOCs using the TO-14A SIM analysis in order to achieve the lowest possible detection limits. The analytes are listed in Table 4-11. Table 4-12 lists the soil gas port sampling frequency. Figure 4-7 shows the soil gas port locations. Soil gas sampling from permanent soil gas ports began in the first quarter of 2001 and ended in the fourth quarter of 2001. However, some of the soil gas ports were used for specific subsequent sampling events.

4.7.2 Temporary Soil Gas Port, Indoor Air, and Ambient Air Sampling

In addition to quarterly soil gas sampling of permanent soil gas ports, one-time soil gas, indoor air, and ambient air samples were collected during various investigations. Refer to Section 2.0 for more details on the purpose of those investigations. Table 4-13 and 4-14 list the temporary soil gas, indoor air, and ambient air samples collected. A brief description of the methods employed is included below.

4.7.2.1 *Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis - 1988*

Twelve soil gas samples were collected during the Phase II Hydrogeologic Investigation from July 5, 1989 to July 7, 1989. Sample locations were distributed throughout the Georgetown neighborhood. Samples were collected from the vadose zone (2.0 to 3.2 feet bgs) from 11 boreholes using an air pump in new disposable Tedlar® air sampling bags. Figure 4-18 shows the soil gas sampling locations for the Phase II Investigation.

Soil gas samples were collected using a soil gas probe (KVA® "HEFTY" model). Soil gas samples were obtained by driving a threaded 7/8-inch stainless steel rod with a 1.2-foot long, 7/8-inch slot screen to a depth of 2.0 to 3.2 feet bgs. The soil gas was allowed to equilibrate for 10 minutes. Prior to purging, the air sample pump was cleaned by purging with background air (an upwind location at the facility) for 15 minutes prior to use at each location. Ambient air samples also were collected to evaluate ambient air conditions. Then the probe was purged at a rate of five L/min for a period of 10 minutes using an SKC® model 224-30 air evacuation pump. Teflon® tubing was attached to a threaded fitting connected to the surface of the steel rods. The soil gas samples were collected into Tedlar® air sample bags. Two bags were filled at each location. Laucks Testing Laboratory analyzed the samples for VOCs.

More information on the methods used to sample the temporary soil gas ports is given in the *Phase II Hydrogeologic Investigation Report* (SE/E, 1989b).

4.7.2.2 Phase III [Off-Site] Hydrogeologic Investigation Work Plan - 1991

Twenty-three soil gas samples were collected during the Phase III Hydrogeologic Investigation from October 29, 1991 to November 21, 1991. Sample locations were located both at the facility and downgradient of the facility, with some locations hydraulically up-gradient of the facility.

Each soil gas sample was collected from a depth of one foot bgs in a single borehole completed in the vadose zone, in an air sample bottle. Figure 4-19 shows the soil gas sampling locations for the Phase III Investigation.

Soil gas samples were collected using a soil gas probe. Soil gas samples were obtained by driving a gas probe with a sampling point attached to the bottom of the probe. A hydraulic mechanism was used to push the probe into the ground. Information regarding purging activities prior to sampling is unavailable; it was not stipulated in the work plan for the Phase III Hydrogeologic Investigation. Samples were collected by attaching an adapter to the top of the soil gas probe. A vacuum pump was attached to the adapter and used to evacuate soil gas from the probe. To collect the sample, a hypodermic needle was inserted through the Silicon rubber and down into the stainless steel tubing of the adapter while the vacuum pump was running. The syringe was purged with soil gas. Then, without removing the syringe needle from the adapter, a ten-mL soil gas sample was collected. For samples having evacuation pressures less than 15 in Hg, evacuation lasted 30 seconds, and did not exceed five minutes. For samples having evacuation pressures greater than 15 in Hg, evacuation times were at least one minute but did not exceed five minutes. Information regarding ambient air samples is unavailable. Soil gas samples were screened in the field using a portable GC for the following VOCs: cis-1,2-

dichloroethene; total-1,2-dichloroethene; 1,1,1-trichloroethane; trichloroethene; toluene; ethylbenzene and possibly vinyl chloride; tetrachloroethene; and 1,1,2,2-tetrachloroethane.

More information about the methods used to sample the temporary soil gas ports is given in the *Phase III Hydrogeologic Investigation* (SE/E, 1991).

4.7.2.3 *Soil Gas Study Sampling and Analysis Plan - 1999*

Sixteen soil gas samples were collected for the Soil Gas Study on October 5, 1999. Eight borings were located at 50-foot intervals along the west side of Denver Avenue South, closest to the residences with basements. Samples were collected from two intervals in the vadose zone, one from ground surface to two feet bgs and one at the estimated depth of the basements, from three to four feet bgs. The samples were collected in 6L Summa® canisters, filling at a rate of 300 mL/min. Figure 4-20 shows the soil gas sampling locations.

Soil gas samples from the ground surface to one-foot bgs interval were collected using a garden shovel to overturn soil in a one-foot by one-foot square. This area was shielded from the wind by setting up a tent of plastic sheeting over the sampling area. The tent was set two to three feet above the ground surface. While one of the field personnel was digging, another set tubing for the pump within six inches of the soil being upheaved in order to collect the sample. This sampling method was used to provide conservative data for the scenario in which a person is kneeling on the ground digging in a garden or playing.

Soil gas samples were collected from three to four feet bgs using a soil gas probe. Soil gas samples were obtained by driving a threaded one-inch hardened steel rod with a one-foot long, 0.01-inch slot screen. The enclosed screen was pushed out into the formation from three to four feet bgs. Sealant was not placed at the ground surface around the rod. The soil gas was not allowed to stabilize prior to purging. Tubing was lowered to the screened interval, attached to an above ground air sampling pump, which had an outlet tube that connected to a depressurized

Summa® canister. Each Summa® canister filled six liters of soil gas at a rate of approximately 10 to 12 L/min. The Summa® canisters were individually cleaned and certified to 0.02 ppbv THC by the contract laboratory. Air Toxics Ltd. Of Folsom, California analyzed samples for VOC analysis by EPA Method TO-14 with SIM analysis.

One ambient air sample was collected at sampling location SG-3 at approximately one to four feet above ground surface. SG-3-2FB was collected over a period of approximately 20 minutes at 300 mL/min on October 5, 1999. The field blank was collected prior to intrusion of the soil or collecting the soil gas sample at SG-3.

More information on the methods used to sample the temporary soil gas ports is presented in the *Final Soil Gas Sampling and Analysis Plan* (PSC, 1999). These data were not used in the Final RI or RA.

4.7.2.4 *Indoor Air Analysis Sampling and Analysis Plan, 2000*

Sixteen soil gas samples (CSG-672L-1, CSG-672L-2, CSG-672L-3, CSG-672L-4, CSG-672L-5, ESG-672L-1, ESG-672L-2, ESG-672L-3, ESG-672L-4, ESG-672L-5, ISG-5409D-1, CSG-5409D-1, CSG-5409D-2, CSG-5409D-3, ESG-5409D-1, ESG-5409D-2 and ESG-5409D-3) were collected under the requirements of the *Indoor Air Sampling and Analysis Plan* (PSC, 2000) between August 21, 2000 and August 23, 2000. Two types of soil gas samples were collected for this project, active and passive. Eight active soil gas samples were collected from August 21 through August 22, 2000 using Summa® canisters. Eight passive soil gas samples were collected on August 23, 2000 using EMFLUX® passive soil gas samplers. Passive soil gas samples were collected with the EMFLUX® samplers placed at a screened interval at 6.5 feet bgs over a period of approximately 120 hours. Figure 4-15 shows the soil gas sample locations.

The sampling and analysis plan proposed collecting two soil gas samples through the floor of the basement near the indoor air samples, in order to correlate the soil gas data to the indoor air data.

Only one soil gas sample was collected through the concrete basement floor of the house at 5409 Denver Avenue South (ISG-5409d-1). This sample was collected at the same time as the indoor air samples were collected. This sample was collected from a screened interval, approximately one to two feet below the concrete floor. The 6L Summa® canister was filled over a period of 24 hours. The second sample was not collected from the basement floor of the house at 672 South Lucile Street because the exposed floor was not inside the house and the second location of exposed floor was not accessible.

Sample locations were located beneath the houses and hydraulically upgradient of the houses that were sampled for indoor air. Three soil gas samples were collected with angled drive points from three locations (672L-1, 672L-2 and 5409-1) from beneath the basement slabs of the two residences, 672 South Lucile Street and 5409 Denver Avenue South Soil gas samples also were collected from five drive points installed vertically along the City-right-of-way, hydraulically upgradient of the residences. Soil gas samples were collected through 1.25-inch stainless steel drive points with two-foot screens. The basement depths were expected to be approximately 5.5 feet bgs, and the screens of the drive points were installed from 5.5 to 7.5 feet bgs.

Following the installation of the drive points, the drive points were sealed and stabilized for a period of 24 hours. Tubing was set at mid-screen level, 6.5 feet, through a barbed brass fitting, which was inserted through a silicone stopper. At the other end of the stopper, another piece of tubing was attached and ran to the fitting on the Summa® canister. The Summa® canisters were set to fill over 24 hours. Each Summa® canister held six liters of air, sufficient volume to reach the method detection limit goals. Air Toxics LTD analyzed the samples using EPA Method TO-14 with SIM analysis.

Passive soil gas samples were collected using EMFLUX® samplers over a period of 120 hours to reach the lowest detection limits. Following the active soil gas sampling, the drive points were sealed and stabilized for 24 hours. At the end of the 24-hour period, EMFLUX® passive soil gas samplers were strung down to one inch above the bottom of the screen, using a wire attached to the top of the rod. Instead of aluminum foil or screw caps to seal the rods, PVC well caps were used. At the end of the 120-hour period, the EMFLUX® passive soil gas samplers were removed, the screened top was replaced with a solid top and placed in the original shipping containers. Beacon Environmental Services, Inc.'s subcontractor, Spectral Laboratory of Maryland, which specializes in analyzing EMFLUX® sampling devices, analyzed the samples using EPA Method TO-1.

PSC also collected indoor air samples from the two residences, 672 South Lucile Street and 5409 Denver Avenue South on August 16, 2000. These residences were resampled by the DOH one week later. On a separate occasion (March 2001) the EPA and DOH sampled indoor air while PSC sampled the soil gas and groundwater outside the residences being sampled for indoor air.

The residents of their homes were asked to leave their homes for a 72-hour period. Then, the sampling team performed the following tasks:

1. Screened the home for other sources of volatile contaminants.

2. Removed any obvious sources of indoor air contamination. Evacuated the home of five volumes of air. All of the doors and windows were opened and fresh air was punched into the house in order to flush the stagnant air from the house. A three-foot box fan was used to evacuate each of the basements in the homes. The fans ran at a rate of 10,300 cubic feet per minute (cfm).Allowed the homes to reach equilibrium over a 24-hour period. Following the evacuation, the windows and doors were sealed and left unoccupied for 24 hours.

3. Collected the samples. Samples were placed in areas where residents spent most of their time and at the height typical of the breathing zone. Two samples (IA-672L-1 and IA-672L-2) were collected from 642 South Lucile Street, sample IA-672-1 was collected from a sitting area and sample IA-672L-2 was collected from on top of a bed. One

sample (IA-5409D-1) was collected from 5409 Denver Avenue South, sample IA-5409-1 was collected from on top of a bed. Samples were collected in Summa® canisters over a 24-hour period.

4. Dismantled the sampling equipment and put the home back in order.

Two ambient air samples were collected at 5409 Denver Avenue South, A-Ambient-1 was collected over a period of two hours on August 14, 2000 from air that was being blown into the residence during the air exchange process prior to indoor air sampling. A-Ambient-2 was collected three feet above ground surface upgradient (via wind direction) of 5409 Denver Avenue South on the northeast corner in the City right-of-way over a period of 24 hours from August 15 to 16, 2000.

This indoor air sampling event was conducted at a time when there was a low-pressure weather system. Indoor air and ambient air samples were collected using 6L Summa canisters and were analyzed for VOCs using the TO-14 with SIM. Table 4-15 lists the compounds analyzed. More information on the methods used to sample indoor air is given in the *Indoor Air Analysis Report* (PSC, 2000b).

4.7.2.5 *Soil Gas Investigation - 2001*

Six soil gas samples (SG-9, SG-10, SG-12, SG-13, SG-14 and SG-15) were collected for the *Soil Gas Investigation* (March 2001) on March 22, 2001. Sample locations were located throughout the Georgetown neighborhood, correlating with the buildings in which indoor air samples were collected by the DOH. The DOH collected nine indoor air samples at one business and six residences within the Georgetown neighborhood.

PSC collected soil gas samples as close to the seven residential buildings undergoing indoor air sampling as possible, in the city right-of-way. The soil gas samples were collected from the vadose zone at the interval above the capillary fringe (four to six feet bgs), where soil gas concentrations are expected to be the highest, and where a basement slab would be located.

Soil gas samples were obtained by driving a threaded 1.5-inch hardened alloy steel riser with 1.25-inch by two-foot stainless steel, 0.01-inch slot screens. The screens, enclosed in a steel sheath, were pushed out into the formation from four to six feet bgs. Sealant was placed at the ground surface around the riser and the riser was sealed with a 1.25-inch #8 rubber stopper. The soil gas did not stabilize prior to purging. A total of three liters of air was purged from each riser prior to sampling to ensure that the air was representative of only soil gas. The air purged from each riser was purged using an Amtek® Alpha 1 Air Sampler.

After purging the soil gas, tubing was lowered to the screened interval, attached to a depressurized Summa® canister. Each Summa® canister filled six liters of soil gas at a rate of approximately 200 mL/min over a 30 minute period, which was an EPA-approved method for collection of soil gas samples from permanent soil gas ports (PSC, 1999b). The Summa® canisters were individually cleaned and certified to 0.02 ppbv THC by the contract laboratory. Air Toxics Ltd. of Folsom, California analyzed samples for VOC analysis by EPA Method TO-14 with SIM analysis. Figure 4-16 shows the soil gas sampling locations and Table 4-13 summarized the soil gas samples that were collected and their depth.

PSC also collected two ambient air samples at approximately 2.5 feet above the ground surface. An ambient air sample was collected at soil gas sample location SG-9 over a period of approximately 30 minutes at a rate of 200 mL/min to measure the ambient air quality at locations within the vicinity of the facility (CG-2-SG, CG-3-SG, CG-4-SC, CG-5-SG, CG-6-SG, SG-9 and SG-14). An ambient air sample was collected at soil gas sample location SG-13 over a period of approximately 30 minutes at a rate of 200 mL/min to measure the ambient air quality at locations near First Avenue South (SG-10, SG-12, SG-13 and SG-15).

More information on the methods used to sample the temporary soil gas ports is given in *Technical Memorandum: Soil Gas Investigation March 2001 Results* (PSC, 2001a).

4.7.2.6 *EPA and DOH Indoor Air Investigations*

The DOH conducted an indoor air investigation in cooperation with the Agency for Toxic Substances and Disease Registry (ASTDR) at homes and businesses near the facility. The ASTDR is part of the US DOH and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste.

The EPA and DOH have conducted two indoor air investigations, one during a low groundwater table season, and one during a high groundwater season. The 2000 sampling event was conducted during the low groundwater table season because VOCs can more readily migrate through the unsaturated zone when the soil pores do not contain significant amounts of infiltrating rainwater. During the 2000 sampling event, the EPA sampled two businesses and three residences in August 2000. Two of the three residences, 672 South Lucile Street and South Denver Avenue, were initially sampled by PSC, and then resampled by the EPA as part of this investigation (DOH, 2000).

The sampling event set to correlate with the high groundwater table season was conducted by DOH during March 22 and 23, 2001. DOH conducted an indoor air investigation in cooperation with the ASTDR at homes and businesses near the facility. Nine air samples were collected at one business and six residences within the Georgetown neighborhood. The sample locations are summarized in Table 4-14.

The indoor air samples were collected in SilicoCan® TM 6-Liter (L), stainless steel canisters with passive flow regulators for a period of 24 hours. The canister intake was set at a height that corresponds to the general breathing zone within the room sampled. The samples were analyzed for VOCs by T0-15 with SIM analysis in air, collected in specially-prepared canisters, and analyzed by gas chromatography/mass spectrometry (GC/MS). DataChem Laboratories decontaminated the canisters and performed the analyses. Figure 4-16 shows the sampling locations.

Some differences exist between the methods used by PSC and those of DOH to collect indoor air samples. This indoor air sampling event was conducted at a time when there was a medium-pressure weather system. Prior to sampling, DOH did not inspect the houses or remove any items or appliances. The houses were not purged of the stale air, nor were the houses sealed during the time of sampling. During the time of collecting the indoor air samples, the residents were not asked to vacate their buildings. At 5409 South Denver Avenue, during the March 2000 Soil Gas Investigation, the resident of the building was not present at the end of the 24-hour sampling period. As a result, EPA personnel were unable to access the indoor air canister and turn it off. This canister remained open for a period of 36 hours, 12 hours over the designated sample time.

4.7.2.7 *Inhalation Pathway Interim Measure Work Plan - 2002*

In August 2002, PSC conducted multi-media sampling at 10 residential type buildings, which included sampling two of the buildings twice within a week. This sampling event generated 28 indoor air samples, four crawl space air samples, 14 soil gas samples, seven ambient air samples, and 14 groundwater samples. Summaries of the samples collected for this sampling event are provided in Tables 4-11, 4-13, and 4-14. The objectives of this data collection event were (1) to determine to what degree vapor migration from groundwater to indoor air is occurring in areas of significant VOC concentrations in the groundwater directly downgradient of the facility, and (2) to use the site-specific data to develop site-specific GIVF that would then be used to develop site-specific IPIMALs for groundwater and indoor air.[5]

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[5] The GIVFs were developed to be sufficiently conservative to be health-protective in their use to estimate "upper-bound" indoor air concentrations for each chemical of potential concern (COPC) detected in groundwater throughout the affected area.

During the week of August 19, 2002, PSC conducted the sampling event at 10 building locations in the GIVF Study Area, shown in Figure 4-21. The GIVF Study Area is located within the mixed residential/industrial neighborhood that is hydraulically downgradient of the facility and would be most likely to be impacted by facility-related COPCs. Figure 4-21 shows the GIVF Study Area and the location of all samples collected during the sampling event. The COPCs were identified in the HHERA (FW, 2001). Three locations were re-sampled for indoor air on August 26 and 27, 2002. All sampling was performed in accordance with the IPIM Work Plan and Sampling and Analysis Plan (SAP)(FW, 2002).

Groundwater samples were collected over a two-day period using either direct push reconnaissance borings or by sampling a nearby permanent monitoring well screened at the water table. All groundwater samples were collected as close to the building as possible[6] and within 48 hours of the indoor air sample collection. Groundwater samples were obtained by driving a 0.65-inch o.d. steel probe to the water table. Then, the three-foot stainless steel, 0.004-inch slot screen enclosed in a steel sheath was pushed out into the formation at the desired depth. Polyethylene tubing was inserted down the drive rods to the depth of the screen. One gallon of groundwater was purged prior to sample collection using a peristaltic pump. Water quality parameters, turbidity, pH, temperature, dissolved oxygen, specific conductivity and oxidation potential were monitored at three separate times during purging. VOC groundwater samples were collected by stopping the pump and collecting samples from the bottom of the tubing. If an entire 40-mL VOC vial did not fill within one tubing extraction, the bottle was discarded and a

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[6] In some cases, samples were not collected directly adjacent to the building due to logistics (i.e., the drill rig could not be operated any closer to the building) or as a result of selecting to sample existing monitoring wells that were as near as possible. Distances from the buildings generally ranged from directly adjacent to within 25 feet, with two exceptions: at 412 South Lucile, the monitoring well selected for sampling was located approximately 300 feet from the residence, and similarly, the monitoring well sampled for 412 S. Orcas was located approximately 200 feet from the building.

second attempt was made. North Creek Analytical Laboratories analyzed the groundwater samples.

Indoor air samples (up to three samples from each selected building) were collected on the main floor in the primary breathing zones (bedroom and/or living room). If the building was a business, at least one sample was collected in the office area. For buildings with basements, at least one sample was collected from the basement area in areas where potential infiltration of soil gas was expected to be highest. To meet data quality objectives, at least one duplicate co-located indoor air sample was collected from each building.

Ambient air samples and one duplicate sample accompanied the indoor air samples to allow for indoor air COPC concentrations to be "adjusted" for ambient air intrusion. One ambient air sample (727H) was collected from outside the plume area. The remaining samples were collected from each block where indoor air samples were collected. To the extent possible, Summa canisters were placed at a sampling height of three meters (m) above the ground, upwind of the building.

Soil gas samples were collected from vertical shallow borings near the buildings. Soil gas was sampled from approximately four to eight feet below ground surface (bgs) (above the water table) using a direct push stainless-steel screen, in accordance with the work plan (Foster Wheeler, 2002). This depth is consistent with the depth of a basement foundation as well as the interval directly above the capillary fringe. A 6- liter Summa canister, equipped with dedicated flow regulators, was set to collect air samples over a 24-hour period to account for typical diurnal fluctuations in concentrations. VOCs in air samples were analyzed by GC/MS and/or GC/MS-SIM using the laboratory modified version of EPA methods TO-14A and TO-15 (EPA, 1999). All VOC air analyses were validated according to the validation requirements presented in the Quality Assurance Project Plan (QAPP).

Six geotechnical samples were collected from ground surface to six or eight feet bgs at locations throughout the GIVF Study Area. In accordance with the work plan, these borings were advanced to a depth of one foot above the capillary fringe. Although the generalized basement floor slab elevation is considered to be four to eight feet bgs, geotechnical data were also collected from zero to four feet bgs, as these shallower data are relevant for buildings without basements (e.g., buildings that are built slab-on-grade or with crawlspaces). Locations were selected to provide consistent area-wide coverage of the GIVF Study Area.

Grain-size testing was conducted on all samples in accordance with American Society for Testing Materials (ASTM)-D-422 using both sieve and hydrometer portions of the analysis. Soils were then classified using United States Department of Agriculture (USDA) soil texture based on grain size. To date, a total of 17 geotechnical samples have been collected to characterize the vadose zone soils west and south of the facility and 14 of these samples are from the GIVF Study Area.

Additional information about the field sampling procedures followed for this sampling event are provided in the Revised Inhalation Pathway Interim Measure Work Plan (FW, 2002) and the Revised Inhalation Pathway Interim Measure Technical Memorandum 1 (FW/PTC, 2003).

4.8 *Soil Sampling*

Prior to the development of the PSC SOPs in 1998, the sampling procedures included in the work plans for field investigations were followed for the individual projects. Currently, PSC field personnel sample soil according to SOP NO. PSC-102 and SOP NO. PSC-103 (Appendix 4B). Soil samples were collected during various investigations.

Subsurface soil sampling is conducted to obtain several types of information, including lithology (descriptive), chemical composition, and physical properties.

Subsurface stratigraphy can be inferred by visually inspecting soil samples and recording the observed lithology. This is done in accordance with the Unified Soil Class Identification guidelines for logging soil (ASTM, 2487-98). The seven categories that are observed include Munsell Color, grain size, sorting, moisture, compaction, indication of contaminants (odor or sheen) and general stratigraphic description.

Subsurface soil samples may also provide valuable information regarding geotechnical information such as hydraulic conductivity, porosity, compressibility, and grain-size distribution.

Subsurface soil samples may be analyzed for chemical analysis. Tables 4-15 and 4-16 list the soil samples collected for chemical analysis, sample locations, and depths. A brief description of the methods employed to collect subsurface soil samples for chemical analysis is included below.

4.8.1 An Evaluation of Groundwater - 1982

Eighteen soil samples were collected as part of the investigation for *An Evaluation of Groundwater Contamination at the Chemical Processors Inc., Georgetown Facility*, (Harper-Owes and Hart Crowser, 1983) on September 23, 1982. Samples were collected from six boreholes during the installation of groundwater monitoring wells (G-1, G-2, G-4, G-7, G-8 and G-9). Figure 4-22 shows the soil sampling locations for the investigation. The wells were installed in the boreholes following the soil sampling.

Soil samples were collected from one hydraulically upgradient borehole (G-4), two downgradient boreholes (G-1 and G-2), and borehole HC-1. Soil samples were collected using a hollow-stem auger drill rig. Soil samples from the G-series boreholes were obtained by collecting soil off of the hollow-stem auger at intervals of approximately 20- inches from depths ranging approximately 9 to 15 feet bgs. Soil samples from HC-1 were collected using a 1.5-inch split-spoon sampler. No information is available on field soil screening. Soil samples were collected in sealed jars and stored at four degrees Celsius. Laucks Testing Laboratory analyzed samples for metals and phenol.

More information on the methods used to sample the subsurface soil is given in *An Evaluation of Groundwater Contamination at the Chemical Processors, Inc. Georgetown Facility* (Harper-Owes and Hart Crowser, 1983).

4.8.2 Phase I Hydrogeologic Investigation Work Plan - 1987

Thirteen soil samples were collected for the *Phase I Hydrogeologic Investigation*, (SE/E, 1988) on November 24 through November 30, 1987. Samples were collected at 10-foot intervals from borehole G-1 and at 20-foot intervals from borehole CG-2 during the installation of groundwater monitoring wells CG-1-D and CG-2-D. Sample depths ranged approximately 10 to 90 feet bgs. Figure 4-22 shows the soil sampling locations for the Phase I Investigation. The Phase I wells were installed in the boreholes following the soil sampling.

Prior to sampling, the borehole was bailed dry, or one to three times the volume of water introduced during drilling was removed if the borehole could not be bailed dry. All soil samples were then collected using a Sprague and Henwood three-inch o.d., split-spoon sampler that was driving in advance of the drilled borehole into undisturbed soil. Blow counts were not counted during this investigation. Each sample was split into two portions. The first portion was used for field testing of VOCs and the second portion was prepared for laboratory testing. Samples were sent to ERCO in Cambridge, Massachusetts.

More information on the methods used to collect the subsurface soil samples is given in the *Phase I Hydrogeologic Investigation* (SE/E, 1988).

4.8.3 Phase II Hydrogeologic Investigation: A Proposal for Sampling and Analysis - 1988

Seventy-five soil samples were collected for the Phase II Hydrogeologic Investigation, between June 16, 1989 through August 30, 1989. Twenty-nine boreholes were drilled at 14 locations (TB-1 through TB-14). Figure 4-22 shows the soil sampling locations. Monitoring wells were installed at 24 of the boreholes in 10 locations, and four boring locations were decommissioned according to the *Phase II Hydrogeological Investigation Proposal for Monitoring, Analyses, and Testing* (SE/E, 1989a).

Sample locations were distributed throughout the facility and the neighboring properties. At nine locations (TB-3, TB-4, B-5, TB-7, TB-8, TB-10, TB-11, TB-13 and TB-14) boreholes were drilled to the base of the shallow aquifer. At two locations (TB-1 and TB-5), boreholes were drilled to the deep aquifer. Soil samples were collected at discrete intervals from approximately 2 to 105 feet bgs, at depths of approximately 2, 5, 7.5, 10, and 20 feet bgs, and at termination depth if the termination depth was greater than 29 feet bgs.

Soil samples were collected using a two- or three-inch split-spoon from undisturbed material at a maximum of 18 inches below the casing. In the shallow boreholes, soil samples were collected at discrete depths of approximately 2, 5, 7.5, 10, and 20 feet bgs and at termination depth if it was greater than 29 feet. The two-foot soil sample was collected from the boring sidewall after the sampling surface was scrapped clean of caked and exposed material. No soil samples were collected for chemical testing in the intermediate boreholes (TB-5, TB-7, TB-10 and TB-13). In the deep boreholes, soil samples were collected at approximately 50, 85, and 105 feet bgs. Samples were sent to Analytical Resources, Inc., Seattle, Washington for analysis.

More information on the methods used to sample soil is given in *the Phase II Hydrogeologic Investigation* (SE/E, 1989b).

4.8.4 Phase III Hydrogeologic Investigation

4.8.4.1 *Soil Samples From Hand-auger Boreholes*

Sixty-eight hand-augered soil samples were collected from 35 boreholes for the *Phase III Hydrogeologic Investigation*, between October 29, 1991 and May 30, 1993. Samples were collected at two intervals—two to three feet bgs (sample nomenclature indicated with an "S"), and seven to eight feet bgs (indicated by a "D"). Samples were combined into 26 composite samples, 13 from the shallow sampling depth and 13 from the deep sampling depth. Table 4-16 lists the samples that were composited. Figure 4-22 shows the hand auger soil sampling locations for the Phase III Investigation.

Soil sample locations were located throughout the facility. In the processing area, two soil samples were collected from each boring for chemical analysis (HA-104 through HA-117). The shallow sample was from the vadose zone at the native soil/fill interface (approximately 2.5-3.0 feet bgs), and the second sample was from the capillary fringe immediately above the water table (approximately eight feet bgs). Sample depths were indicated with an "S" or "D" at the end of each sample identifier. Samples from the south area (HA-121 through HA-126) and the cyanide area (HA-127 through HA-135) were only collected from the native soil/fill interface unless subsurface conditions indicated a second sample was warranted (SE/E, 1991). A second sample was not collected from boreholes HA-122 and HA-128.

In the cyanide area, samples HA-145 through HA-147 were not collected because of obstruction problems (BEI, 1992). In the process area, samples HA-136 through HA-144 were not collected because of access issues with Union Pacific Property. In the North Field area, samples HA-148 through HA-153 were not collected because of access issues with TASCO.

A stainless steel hand auger, approximately four-inch i.d., was used to drill the boreholes. In between sampling intervals, a post-hole digger was used to advance the boring. Soil samples were composited spatially, rather than vertically, with no more than three samples composited into one chemical sample. Soil was composited by removing the soil from the auger onto plastic sheeting using a stainless steel spoon to place the soil into containers. PID field screening information for the soil samples is not available. Soil samples underwent the following analyses: total metals, PCBs, VOCs, organic content, base neutral acids (BNAs), and toxicity characteristic leaching procedure (TCLP) metals. Samples were sent to Analytical Resources, Inc., Seattle, Washington, for analysis.

More information on the methods used to sample soil is given in the *Phase III Hydrogeologic Investigation Work plan* (SE/E, 1991).

4.8.4.2 *Soil Samples from Well Installation*

Thirty-nine soil samples were collected from 16 boreholes for *the Phase III Hydrogeologic Investigation*, from May 5, 1992 through July 6, 1992. Samples were collected at various intervals depending on the depth of the borehole. The Phase III wells were installed in the boreholes following the soil sampling.

These 16 boreholes were located near the facility. Two boreholes were located hydraulically upgradient of the facility (CG-101-S1 and CG-101-S2). Four clustered boring groups (CG-102 through CG-105) with three to four boreholes in each group, were drilled hydraulically downgradient and crossgradient of the facility. These boreholes are located on approximately 200-foot centers at distances ranging from 150 to 400 feet south, west and northwest of the facility.

The samples were collected using two-inch o.d. split-spoon or three-inch o.d. split-barrel samplers. The sampling spoon was driven 18 inches ahead of the auger. Soil samples were collected for chemical analysis from the upper shallow borings from depths of two, six and 10 feet bgs. Soil samples were collected from the base of the shallow aquifer from a depth of 20 feet bgs and at the base of the shallow zone, if greater than 30 feet bgs. Soil samples were collected from the intermediate aquifer at depths of 50 and 80 feet bgs. If the shallow zone was less than 30 feet thick, the 30-foot sample from the intermediate borehole was also submitted for analysis. Soil samples were collected from the deep boreholes at five-foot intervals below the first depth sampled in the intermediate boring. Soil samples were analyzed for the following compounds and parameters: VOCs, SVOCs, total metals, PCBs, and TCLP metals. Samples were sent to Analytical Resources, Inc., Seattle, Washington, for analysis.

More information on the methods used to sample soil is given in the *Phase III Hydrogeologic Work plan* (SE/E, 1991).

4.8.5 Post-Phase III Investigation Work Plans

4.8.5.1 *Soil Gas Sampling and Analysis Plan - 1999*

Sixteen soil samples were collected for the Soil Gas SAP as part of the Soil Gas Investigation, conducted in October 1999. Samples were collected along a 50-foot sampling grid along Denver Avenue South, at two intervals, one from zero to two feet bgs and another from two to four feet bgs. These samples were analyzed for VOCs to determine if any soil off the facility property was contaminated and might potentially contribute to soil gas contamination. Figure 4-22 shows the soil sample locations.

Soil samples were collected using Geoprobe® direct-push sampling tools by driving a one-inch o.d. steel probe to a given depth. The 24-inch stainless steel rod, lined with an acetate liner, was pushed out into the formation. Upon retrieving the rod, the soil samples were screened using a PID immediately after cutting the acetate liner. The soil sample was collected from the six-inch area within the liner with the highest reading. If the PID did not detect VOCs, then the sample was collected from the center of the acetate liner. The soil sample was immediately collected for VOC analysis in a jar with no headspace.

More information on the methods used to sample indoor air is given in the *Indoor Air Analysis Report* (PSC, 2000b).

4.8.5.2 *Supplemental Off-Site Groundwater Characterization - 2000*

Fifteen soil samples were collected for the Source Area portion of the Supplemental Off-site Investigation between October 9 through November 7, 2000. The purpose of the investigation was to define the edge of the presumed DNAPL Source Area by collecting groundwater samples on a 25-foot grid at ten-foot depth intervals. If soil indicated elevated VOCs during field screening, a soil sample was collected to determine if NAPL or NAPL residue was encountered. Samples were collected from nine boreholes. Depths of samples collected ranged approximately 30 to 76.5 feet bgs. Soil sampling locations for the 2000-2001 Supplemental Off-Site Investigation are presented in Figure 4-22.

Soil samples were collected using Geoprobe® direct-push sampling tools by driving a one-inch o.d. steel probe to a given depth. Then the 24-inch stainless-steel rod lined with an acetate shell, was pushed out into the formation. Upon retrieving the rod, the soil sample was screened using a PID immediately after cutting the acetate liner. If the field screening indicated the presence of elevated VOCs, then a soil sample was immediately collected for VOC analysis in a jar with no headspace. The soil sample was collected from the section of the soil sample with the highest PID reading. In addition, if PID readings were significantly elevated, a water-oil indicator field-screening kit was used to potentially identify NAPL or NAPL residue.

More information on the methods used to sample the soil is given in the *Supplemental Off-Site-Characterization Work plan* (PSC, 2000c).

4.8.5.3 *Tidal Studies*

A tidal study was conducted between 2002 and 2003 to determine the following information:

- Extent of tidal influence in shallow and intermediate aquifer wells
- Tidal cycle effect on water levels within the shallow and intermediate aquifer wells that are installed in the tidally affected area
- Extent of salt water mixing within the shallow and intermediate aquifer wells

In May 2002, PSC conducted a six-day tidal study at monitoring wells CG-140-WT, CG-141-30, CG-141-50, and CG-145-35. In November 2002, PSC began a 30-day tidal study in the wells closest to the Duwamish Waterway, CG-140-40, CG-144-35, and CG-145-35. In July 2003, a three-day tidal study was conducted at monitoring wells CG-140-WT, CG-140-40, CG-141-WT, CG-141-50, and CG-151-25.

For all three tidal studies, pressure transducers combined with a programmable electronic data logger, contained in a single housing, were used to measure pressure in each well and in the atmosphere. The submersible sensor/loggers were suspended from the tops of the well casings with pre-measured stainless-steel cables. The barometric sensor/logger was placed in a part of the PSC warehouse that is exposed to ambient atmospheric pressure but also sheltered from precipitation and solar radiation. PSC obtained historical tide data for Elliott Bay from the National Oceanic and Atmospheric Administration (NOAA) public web site (http://www.noaa.gov). These data were collected and verified by NOAA.

The measurement schedule was selected to satisfy several goals. First, the various types of data (e.g., atmospheric pressure, groundwater pressure) were collected synchronously, to simplify subsequent data processing and interpretation. Second, the measurement interval was sufficiently short to capture any substantial temporal variation in the measured quantities, so that the data records are representative.

After the field execution phase was completed, PSC transferred the data from the electronic data loggers to desktop computers for subsequent graphing and analysis.

4.8.5.4 *Slug Tests*

Slug tests have been conducted in each phase of investigation for the facility. The purpose of slug tests is to estimate horizontal conductivity. In general, the instruments used for the slug tests included pressure transducers with data loggers, water level indicators, and a pump or bailer. All water measurement equipment was factory calibrated. The water level indicator and the transducers had an accuracy of at least ± 0.01 foot. The transducers had data loggers that stored the data until the end of the test, at which time the data were downloaded onto a computer and interpreted and analyzed. In addition, manual water level measurements that were recorded in field log books or field forms were compared to the downloaded transducer data, if available, to verify the accuracy of the equipment.

Phase I Hydrogeological Investigation Work Plan - 1987

During the Phase I Hydrogeological Investigation, rising-head slug tests were performed at wells CG-1, CG-2, and existing wells G-1, G-4, and HC-10. The static water level was measured with an electronic water level indicator prior to the test, and then a slug of water was removed from each well using a peristaltic pump to lower the water levels in the wells. Following the removal of the water, the water level recovery was monitored with an electronic water level indicator until the water recovered to 70% of the static water level. The Hvorslev Variable Head Analysis was used to calculate the hydraulic properties of the wells.

Phase II Hydrogeological Investigation Proposal for Sampling and Analysis - 1988

During the Phase II Hydrogeological Investigation, rising-head slug tests were performed at wells CG-4-D, CG-5-D, CG-1-I, CG-2-I, CG-5-I, and CG-9-I. The static water level was measured with an electronic water level indicator prior to the test, and then a slug of water was removed from each well using a 7-foot long, 1.75-inch diameter PVC bailer. Following the removal of the bailer, the water level recovery was monitored with a Hermit SE 1000B data logger and a 10-psi transducer until the water level recovered to within 10 percent of the initial (static) level. Recovery data were analyzed using the Hvorslev analytical method (1951). Based on the aquifer conditions observed during well development, the hydraulic conductivity of the shallow aquifer was assumed to be too high to obtain meaningful data using the slug test method.

Phase III [Off-Site] Hydrogeological Investigation Work Plan - 1991

During the Phase III Hydrogeological Investigation, rising-head slug tests were performed at each new well following development. The tests were conducted in October 1992. Transducers with data loggers were set in each well to record the head until the water levels reached static conditions. A solid slug was used to conduct the tests.

Post Phase III Hydrogeological Investigation Work

Slug tests were performed in August 2003 as part of an effort to determine the horizontal conductivity of shallow and intermediate aquifer wells closest to the Duwamish Waterway. The study was conducted in wells CG-140-WT, CG-140-40, CG-141-WT, CG-141-50, and CG-151-25. The static water level was measured with an electronic water level indicator prior to the test, and then transducers with data loggers were placed at the bottom of the well screens. Solid PVC slugs were used ranging in length from 30 inches to 10 feet, depending on the height of the water column in the wells.

4.9 *Additional Investigations*

4.9.1 Underground Storage Tank Removal

During September and October 1987, 24 underground storage tanks were removed from the facility in conjunction with the Seattle Fire Department (SFD) and Ecology. Pictures of the tank removal are included in Appendix 2B. This removal was done to fulfill the requirement of the Seattle Fire Code Section 79.221, which mandated the removal of underground storage tanks that have been abandoned for a period of one year or less. Per guidance from Ecology and SFD, the tanks were removed by breaking up the existing concrete, removing the tank, backfilling the hole, and replacing the concrete. The tanks were removed under the Temporary Underground Fuel Tank Removal Permit issued by SFD, issued September 10, 1987 (SFD, 1987).

Prior to removal, each tank was made gas-free by a certified marine chemist. Initially, two tanks in the North Field (#8 and #9) were removed. Underground storage tank #8 was removed using a boom truck to lift the tank out onto plastic, where it was then inspected for leaks and its exterior was scraped and swept clean. Underground storage tank #9 was excavated mostly by hand because of its proximity to a water main. A crane was used to lift the tank out onto plastic, where it was inspected for leaks and its exterior was scraped and swept clean. Following the removal of underground storage tank #8 and #9, soil and water samples were collected and analyzed for VOCs. The excavations were backfilled using the original soil and broken concrete.

Underground storage tanks N and O were then removed using a backhoe. During the excavation of tanks N and O, a small amount (approximately one quart) of brown liquid trickled out of each line. The liquid from each line was sampled. The soil that came into contact with the liquid (about one-half drum) was quickly placed in a drum and removed from the facility by a Chempro employee outfitted in a Tyvek® suit and protective gloves. As the excavation of tank N continued, a small amount of black, tar-like material was seen in the north side of the excavation. Approximately 0.5 cubic yard of adjacent soil was scooped out and placed on a plastic sheet. A sample of this material was taken to the facility's on-site lab for analysis. Two groundwater samples (N-1 and N-2) and two soil samples (N-3 and N-4) were collected from the location of tank N and analyzed for VOCs by Analytical Resources, Inc. and for cyanide by Chempro's main lab. The excavation was backfilled using the original soil and broken concrete.

Underground storage tanks (A, B, C, D, E, F, G, H, I, J, K, L, M, #1, #2, #3, #4, #5, #6 and #7) were removed using a lifting eye. During the removal of tank A, a small puncture (2" x 2.5") in the tank was made and patched with plastic. Two soil samples were collected from the south bank of tank A. During the removal of tank M, three small pinholes in the tank were observed, these pinholes were promptly repaired with epoxy cement. A sample of the concrete pad was collected for analysis. Four soil samples (S1 through S4) were collected from the south end of the excavation area of tanks #1 through #7.

The excavation areas were backfilled using the original soil and broken concrete. The excavation area from tanks A through M was covered by a plastic sheet laid over the original compacted fill at a depth of approximately 3.5 feet bgs at the north end of the excavation, and at 5.5 feet bgs at the south end of the excavation. The excavation area from tanks #1 through #7 was covered by a plastic sheet placed over the original compacted fill at a depth of approximately three feet bgs. New fill material was placed over the plastic and compacted. Concrete was then set on top of the new fill material. Approximately 130 cubic yards of broken concrete were disposed of at the Coal Creek Demolition Debris Landfill. This material was originally the concrete pad covering fifteen of the underground storage tanks in the North Field of the facility. The material was not considered a dangerous waste, as it passed both the EP toxicity and 96-hour fish bioassay tests performed by Biomed Research Laboratories.

4.9.2 NAPL Investigation

4.9.2.1 *LNAPL Investigation - 1996*

An LNAPL Investigation was conducted in 1996 in accordance with the LNAPL Plan, (BEI, 1996). Philip completed monthly water level/hydrocarbon thickness measurements in wells CG-6-S1, CG-8-S1 and CG-11-S1 during August, September, October and November 1996. LNAPL were not detected in any wells during this investigation. Quarterly measurements were resumed in the first quarter of 1997.

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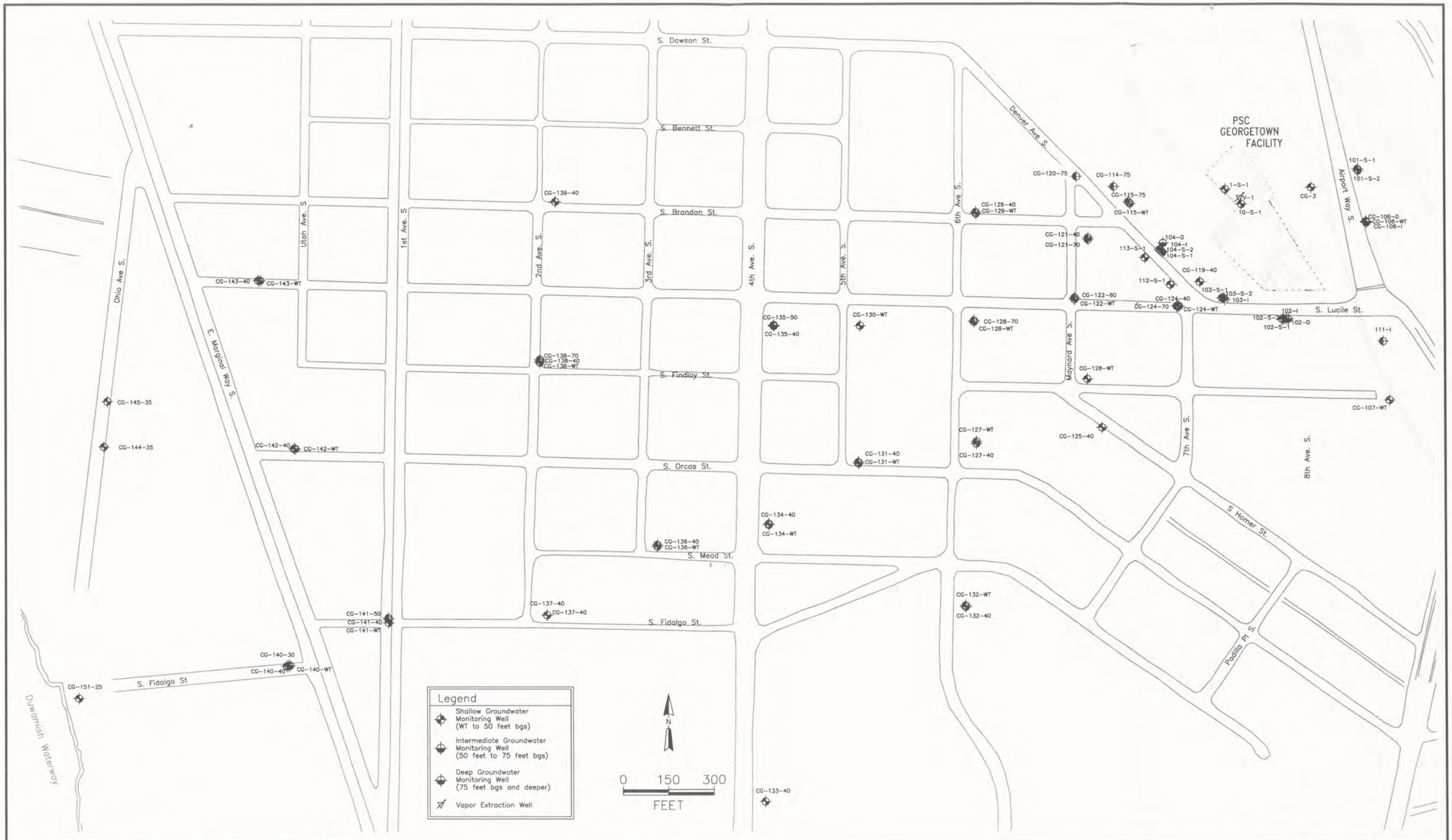
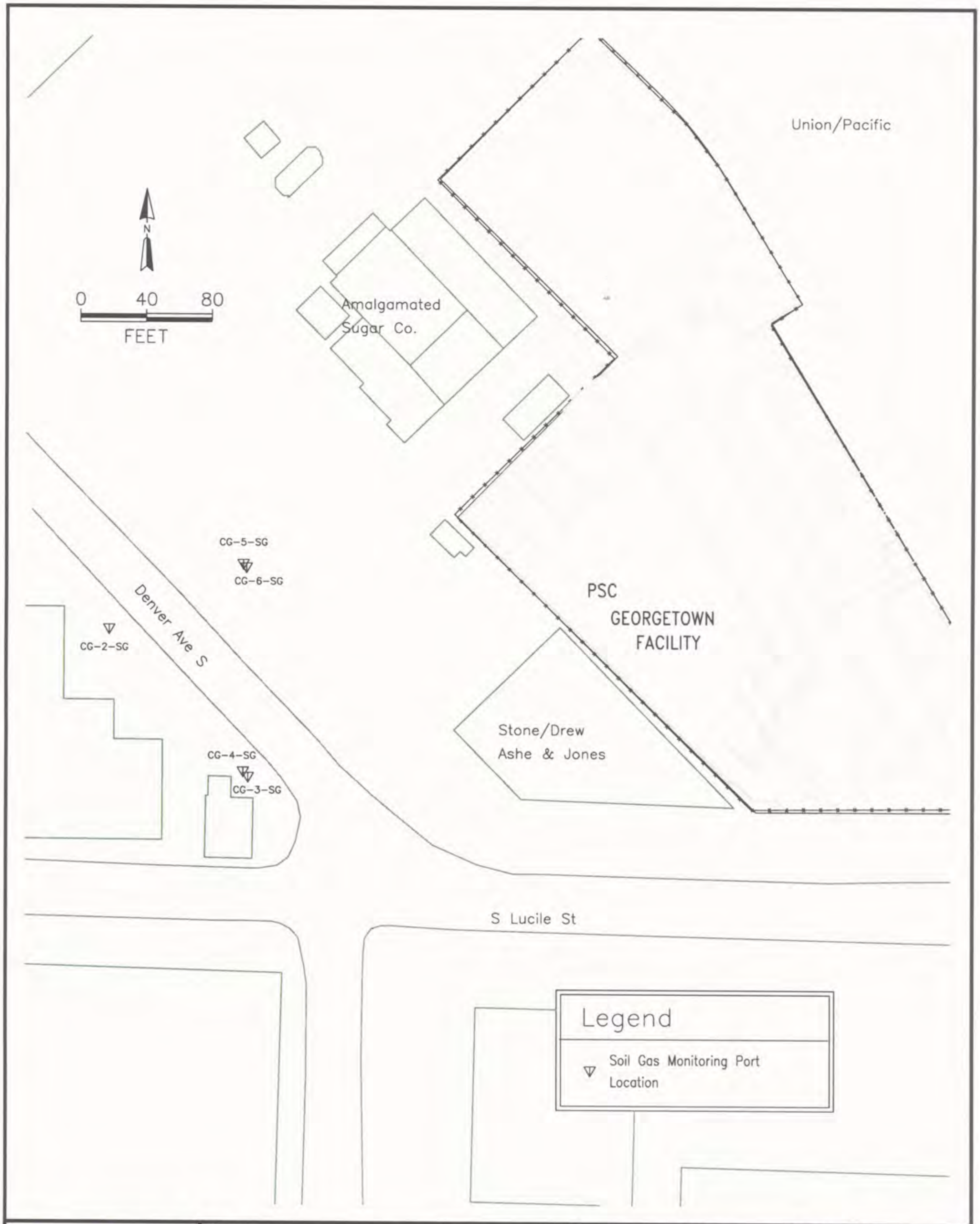


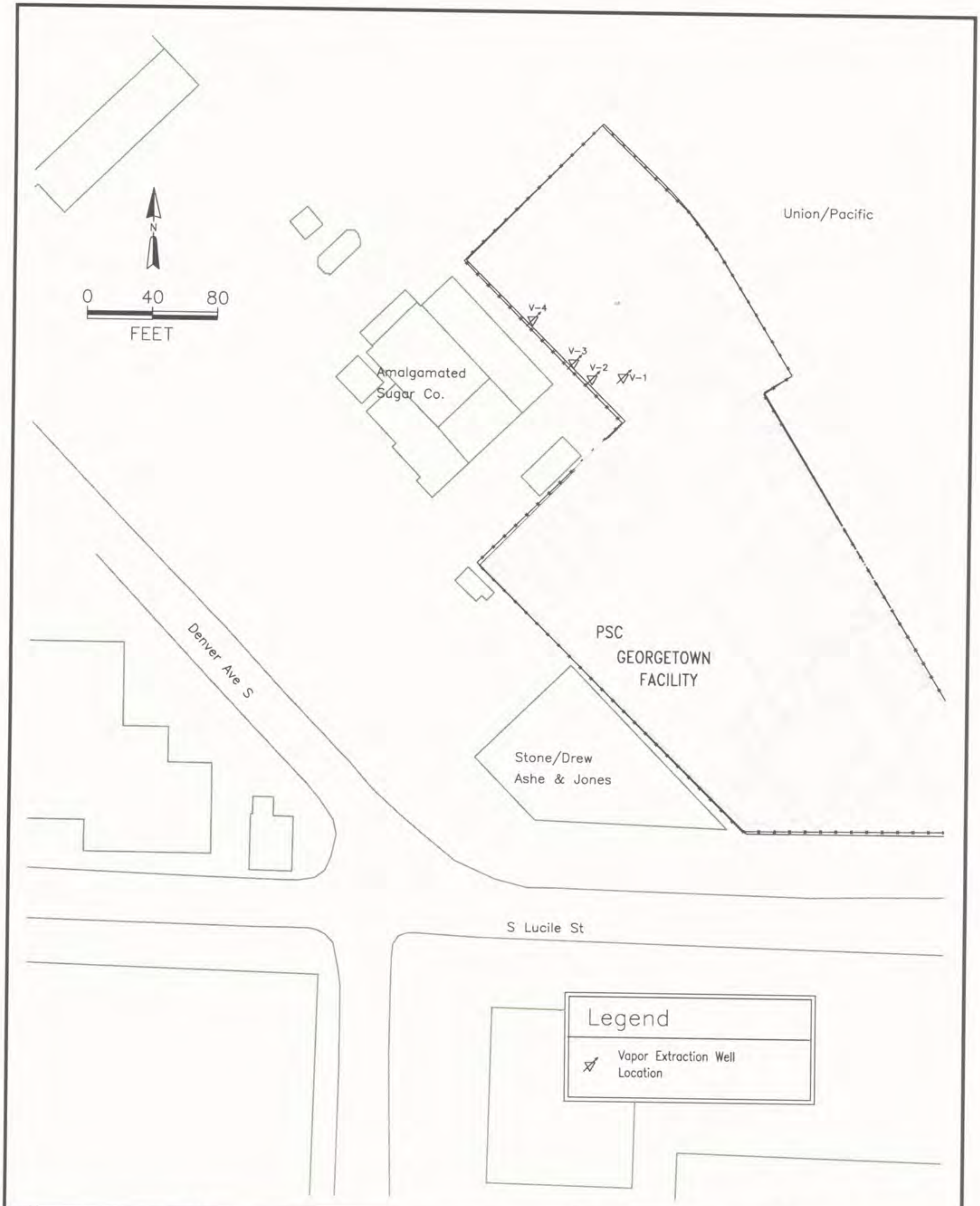
PSC

TITLE:
Current Monitoring Well Locations

DWN: dtb
DES.:
CHKD: cjm
APPD:
DATE: 10/30/03
REV.: 2
PROJECT NO.: RI2003
FIGURE NO.: 4-1



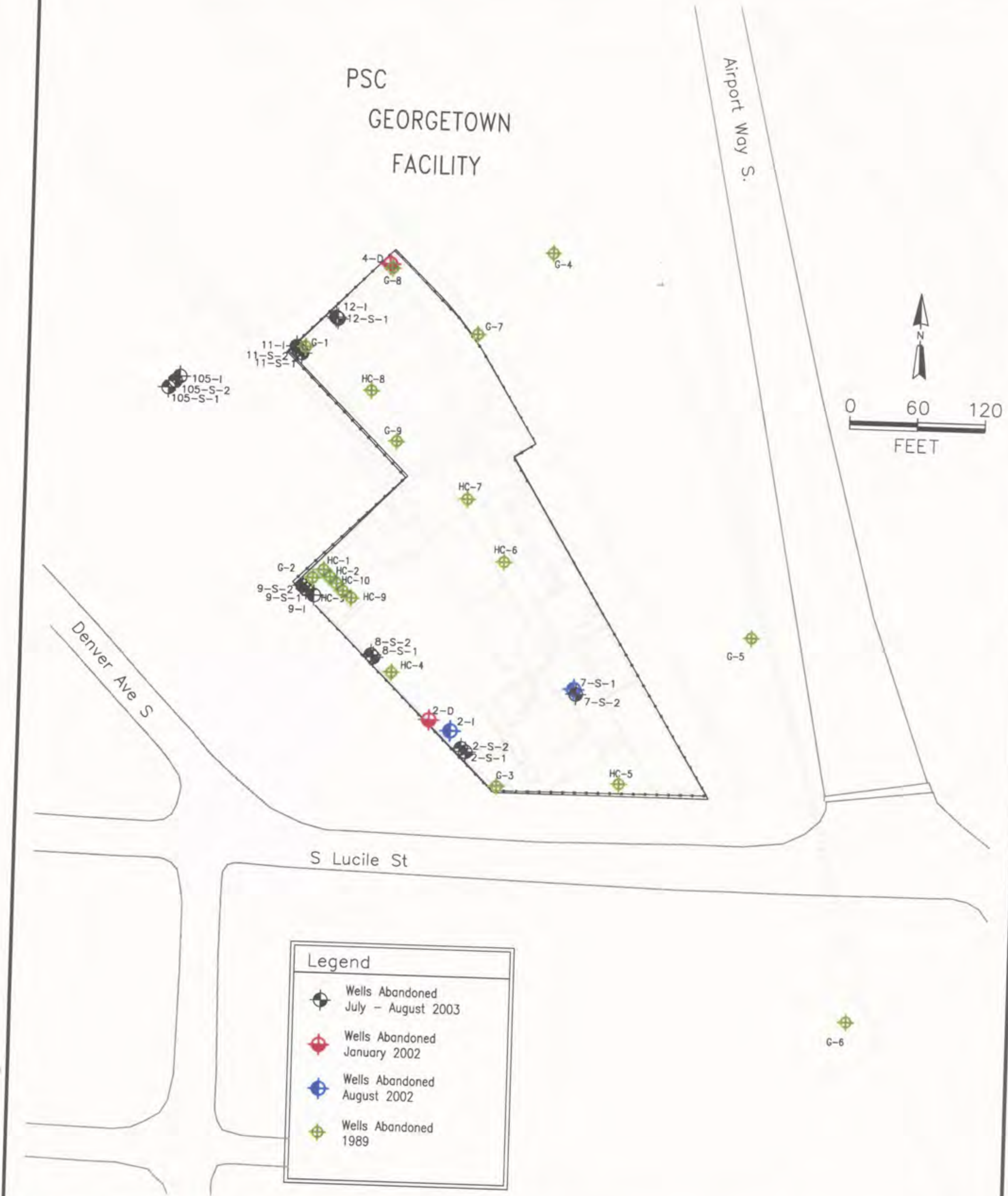
TITLE: Soil Gas Monitoring Port Locations 2000	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD: cjm	APPD:	
	DATE: 10/30/03	REV.:	FIGURE NO.: 4-7



PSC

TITLE:
Soil Vapor Extraction Well
Locations
1994

DWN: dtb
DES.:
CHKD: cjm
APPD:
DATE: 10/30/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 4-8



PSC

TITLE:
Location of Abandoned Monitoring Wells
1982 – 2003

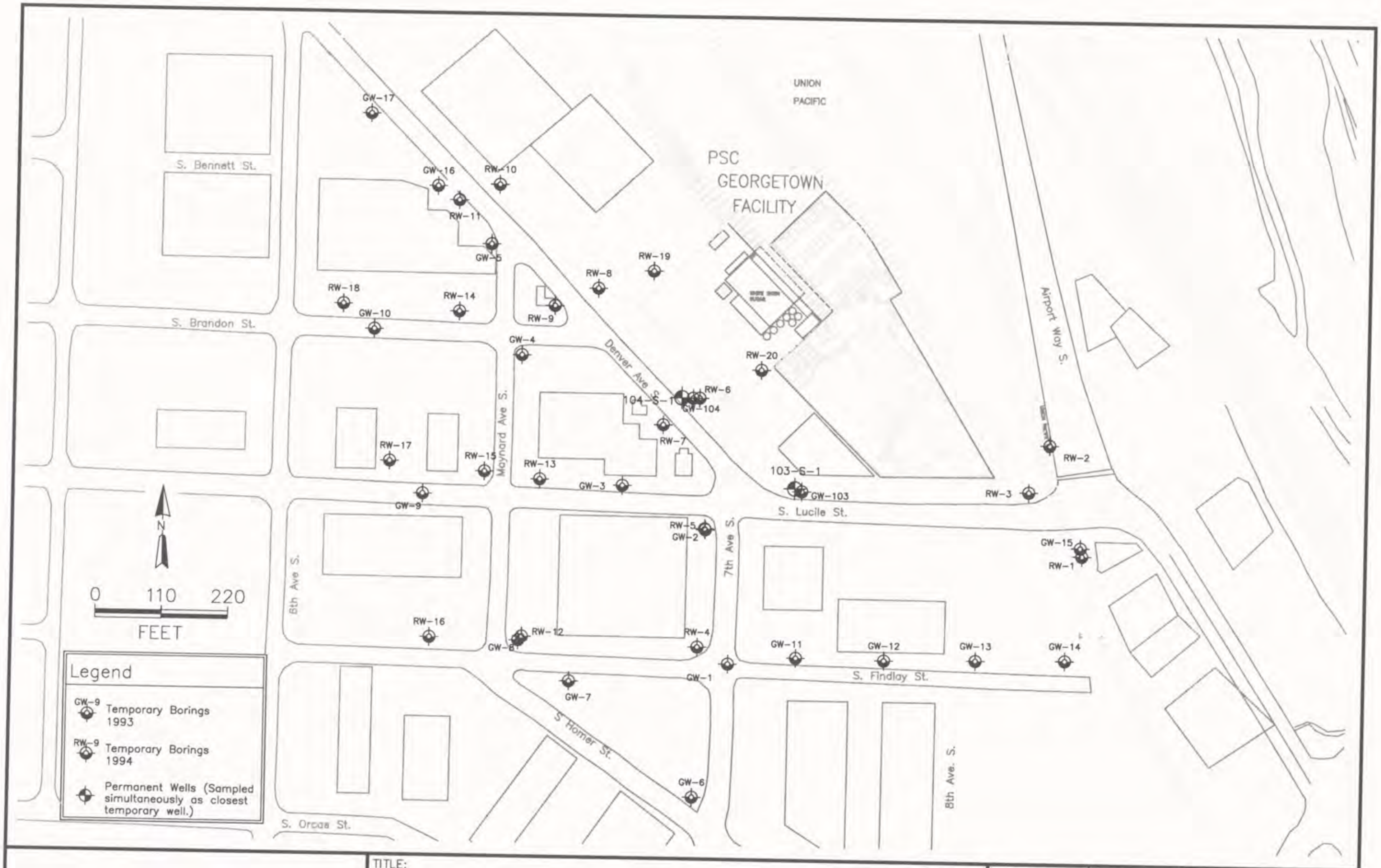
DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/30/03	REV.: 1	FIGURE NO.: 4–9

TITLE:
Groundwater Reconnaissance Boring
Locations – Phase II Hydrological
Investigation – 1989

DWN: dtb	DES.:
CHKD: cjm	APPD:
DATE: 10/30/03	REV.:

PROJECT NO.: RI2003

FIGURE NO.: 4–10

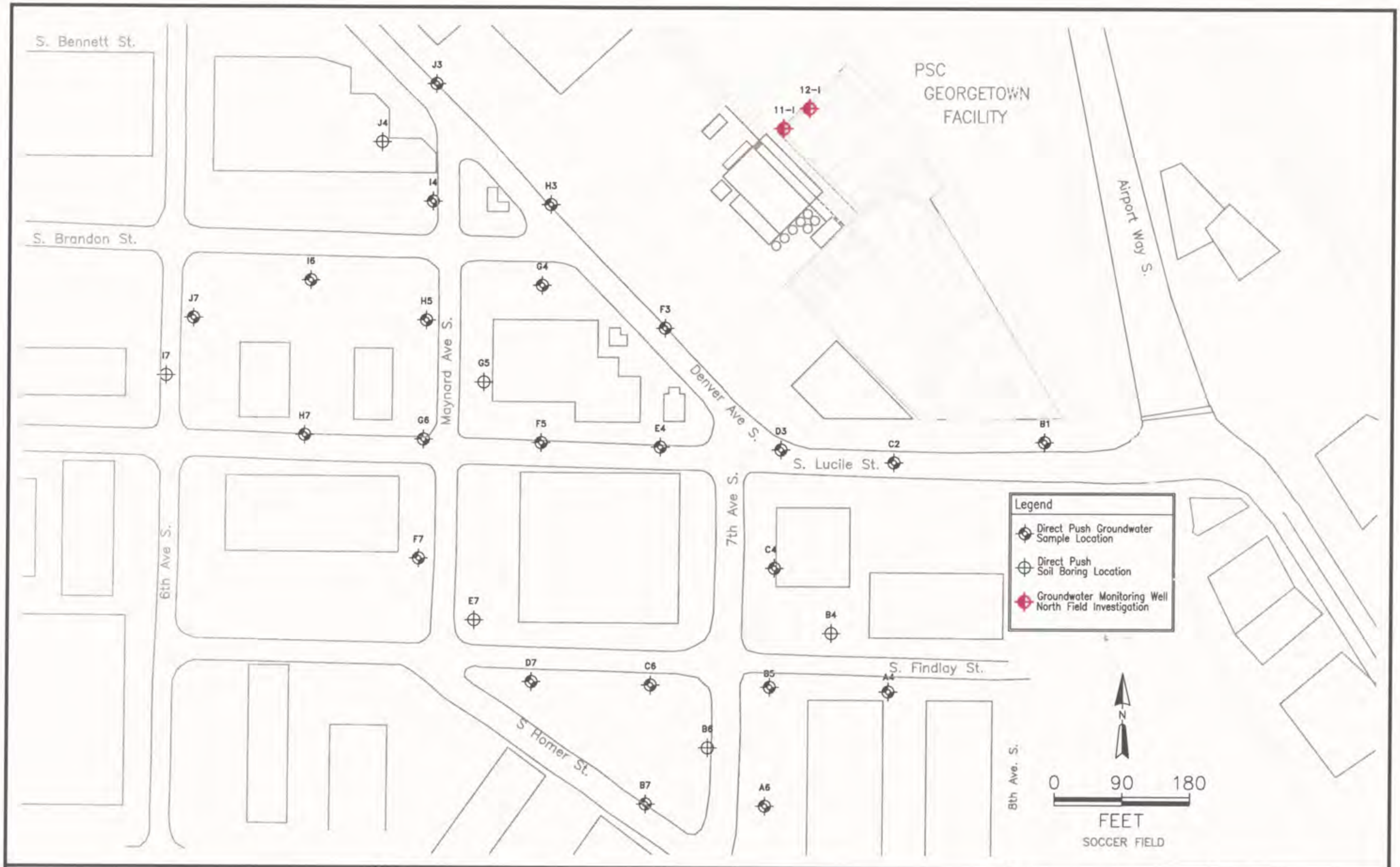


PSC

TITLE:

Groundwater Reconnaissance Boring Locations
Phase III Hydrological Investigation
1993 – 1994

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/30/03	REV.:	FIGURE NO.: 4–11

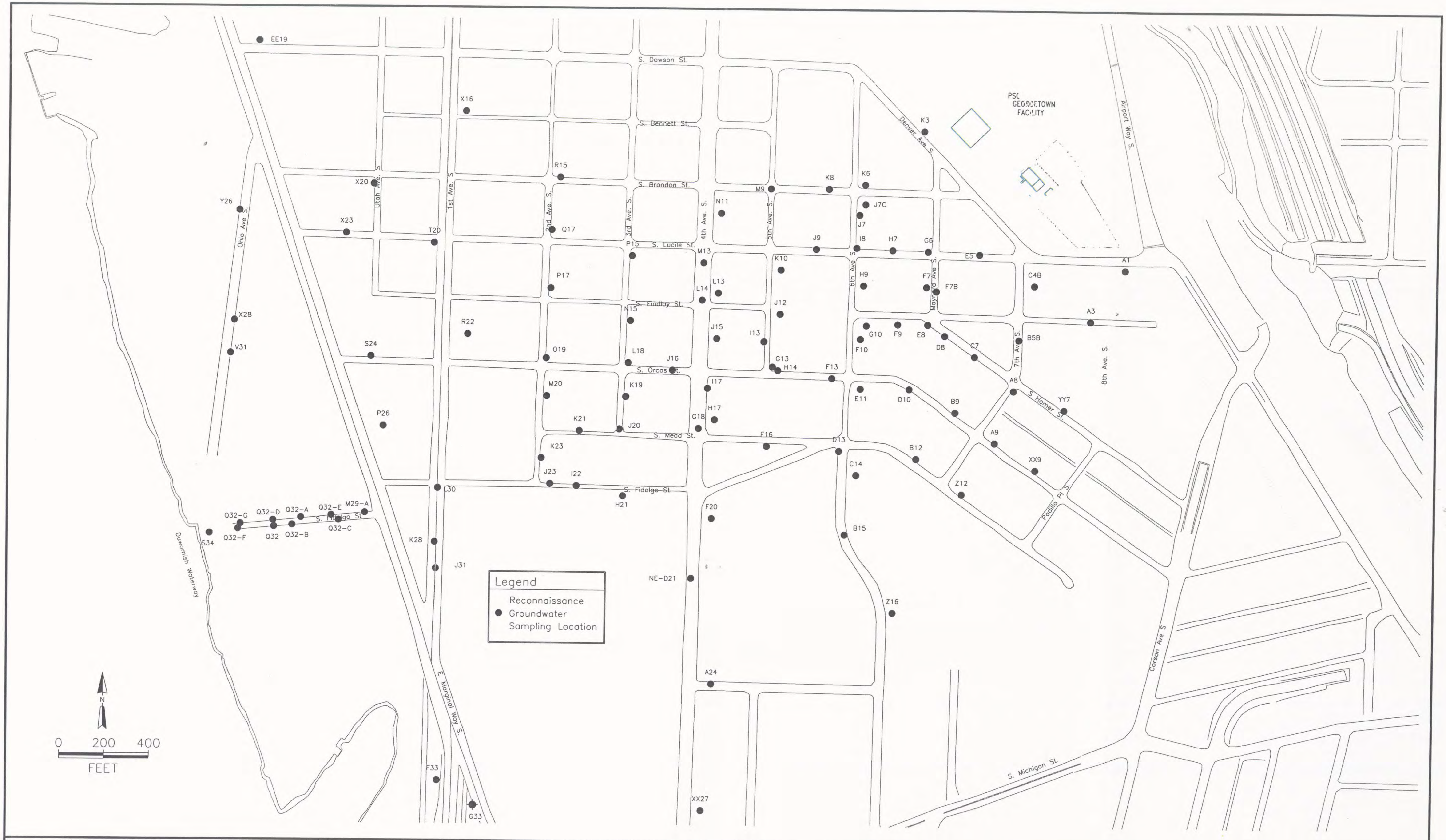


PSC

TITLE:
Groundwater Reconnaissance Boring Locations
Hydropunch Investigation and North Field
Investigation – 1998

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/30/03	REV.: 1	FIGURE NO.: 4–12

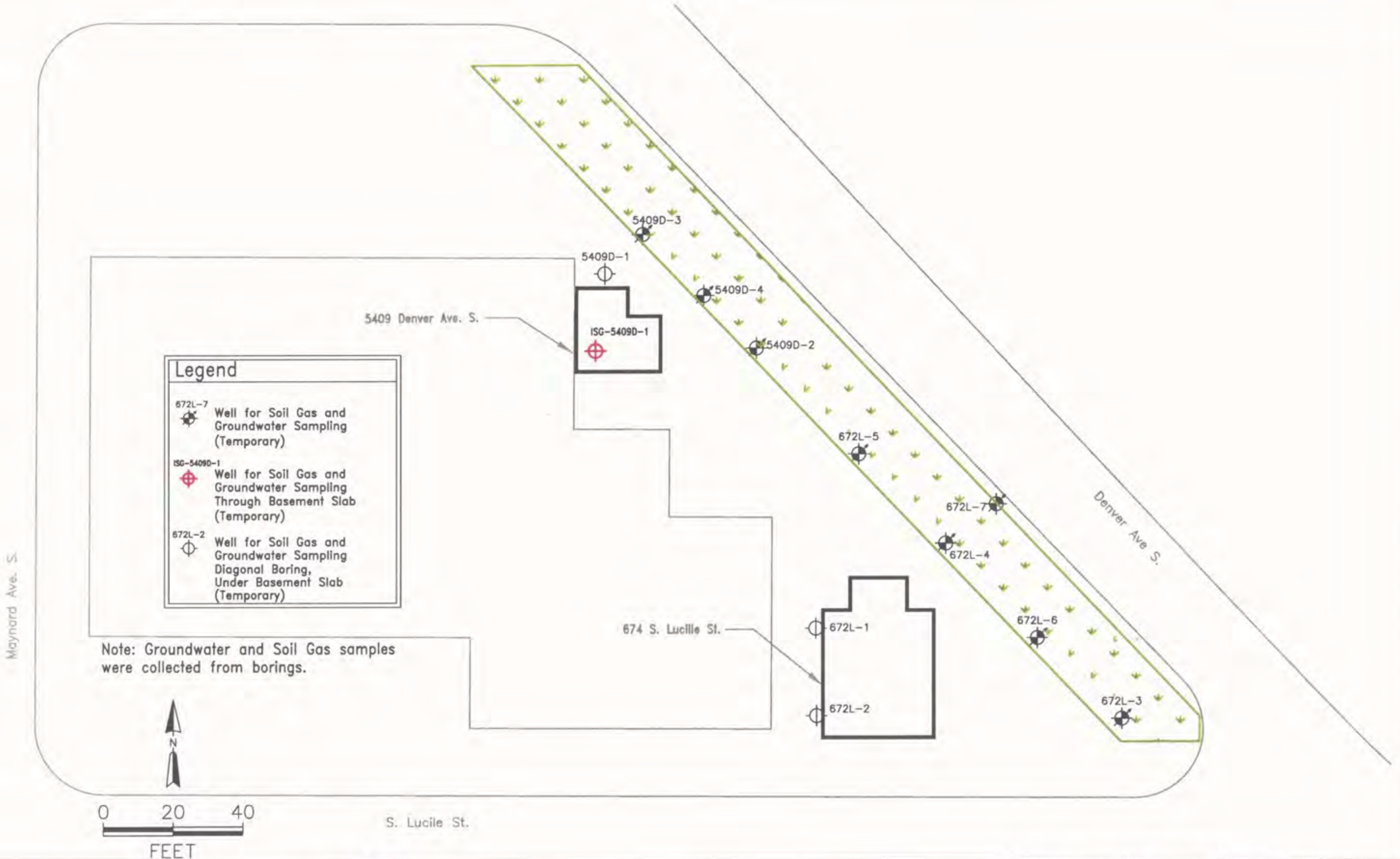
TITLE: Groundwater Reconnaissance Boring Locations – Source Area Investigation 2000 – 2001	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD: cjm	APPD:	
	DATE: 10/30/03	REV.: 1	FIGURE NO.: 4–13



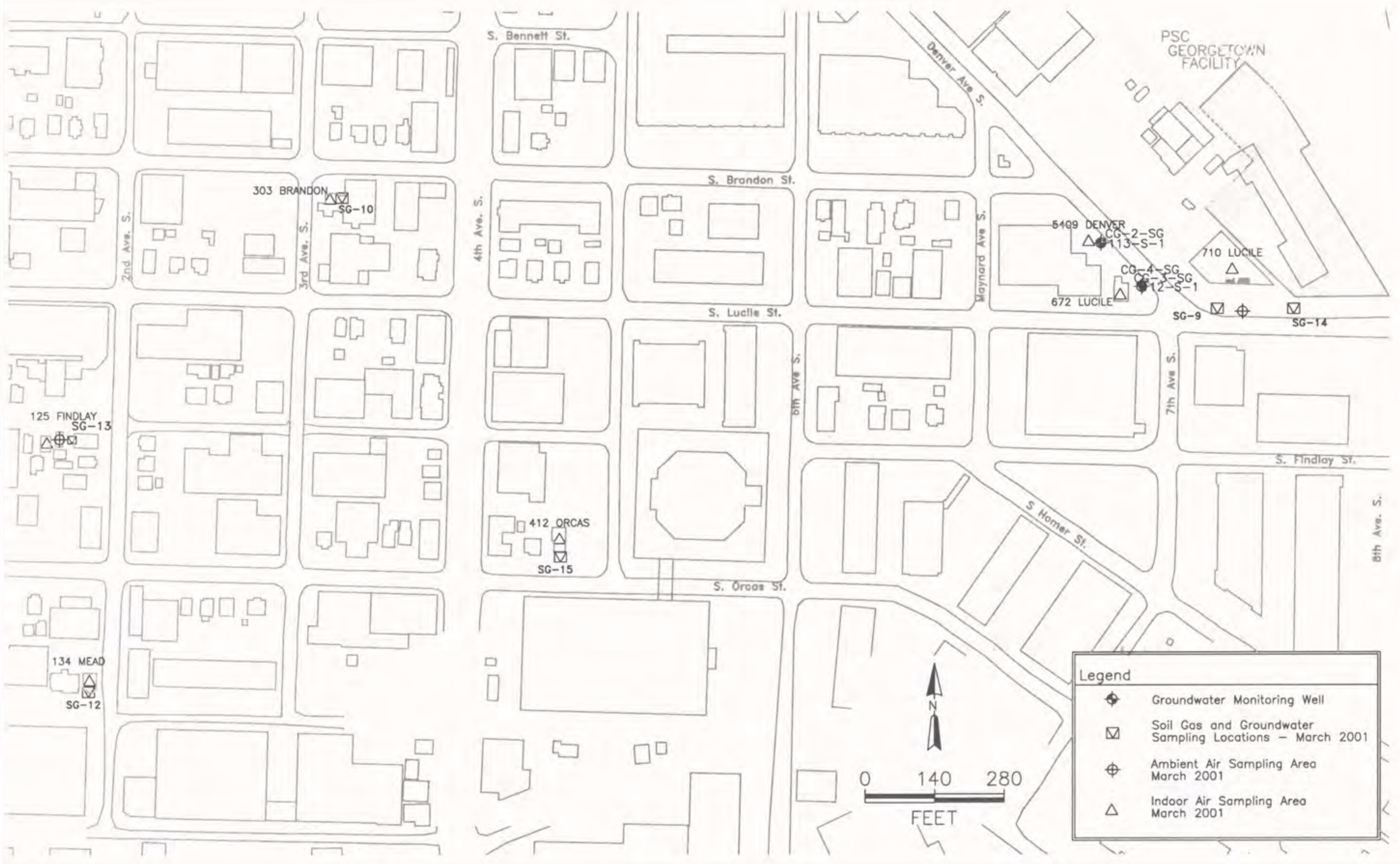
TITLE:

Groundwater Reconnaissance Boring Locations
Nature and Extent Investigation
2000 – 2003

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/30/03	REV.: 1	FIGURE NO.: 4-14



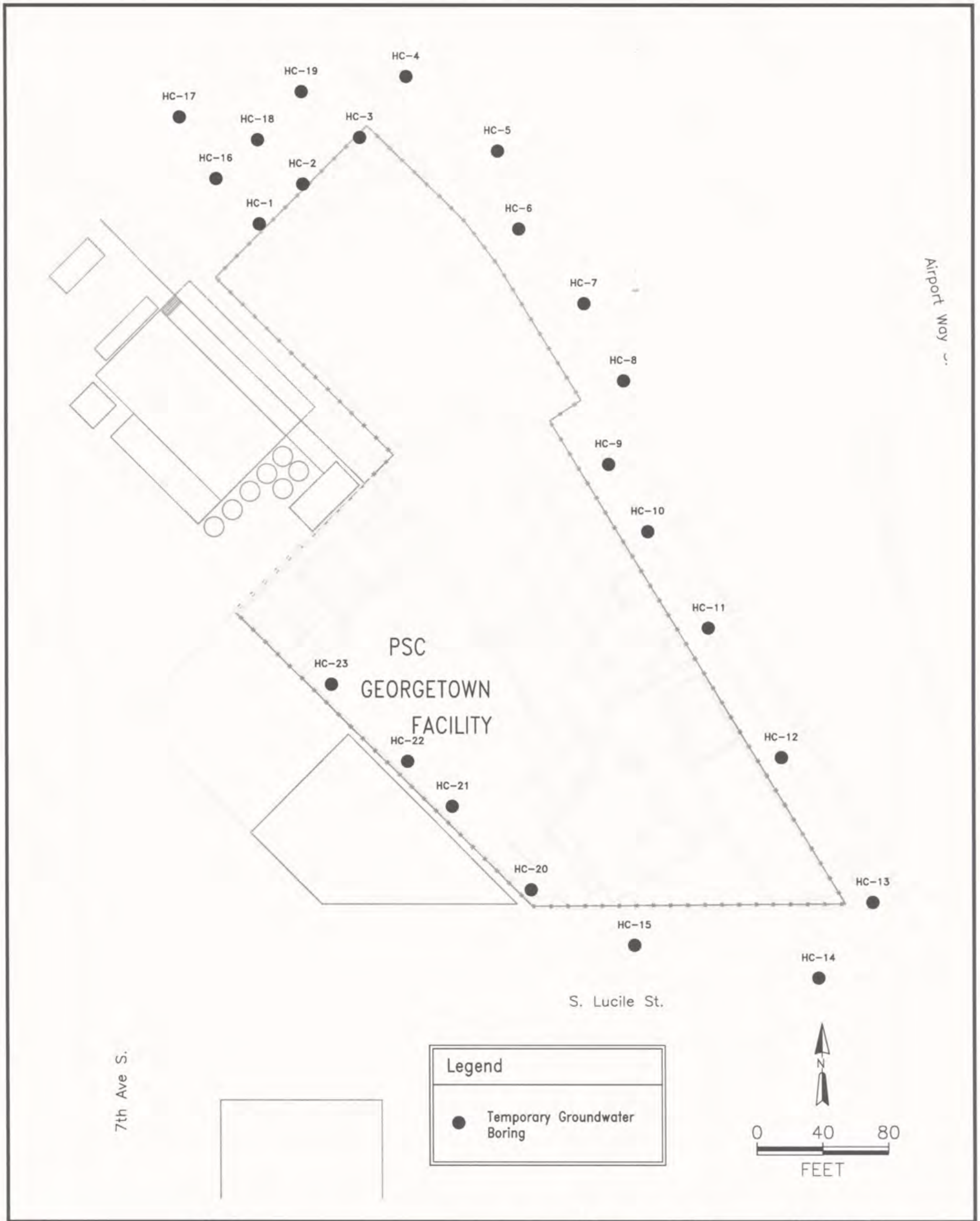
TITLE: Soil Gas and Groundwater Reconnaissance Boring Locations – Indoor Air Analysis Report 2000	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD: cjm	APPD:	
	DATE: 10/30/03	REV.: 1	FIGURE NO.: 4–15



PSC

TITLE:
Sampling Locations
Soil Gas Investigation
2001

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/30/03	REV.:	FIGURE NO.: 4–16

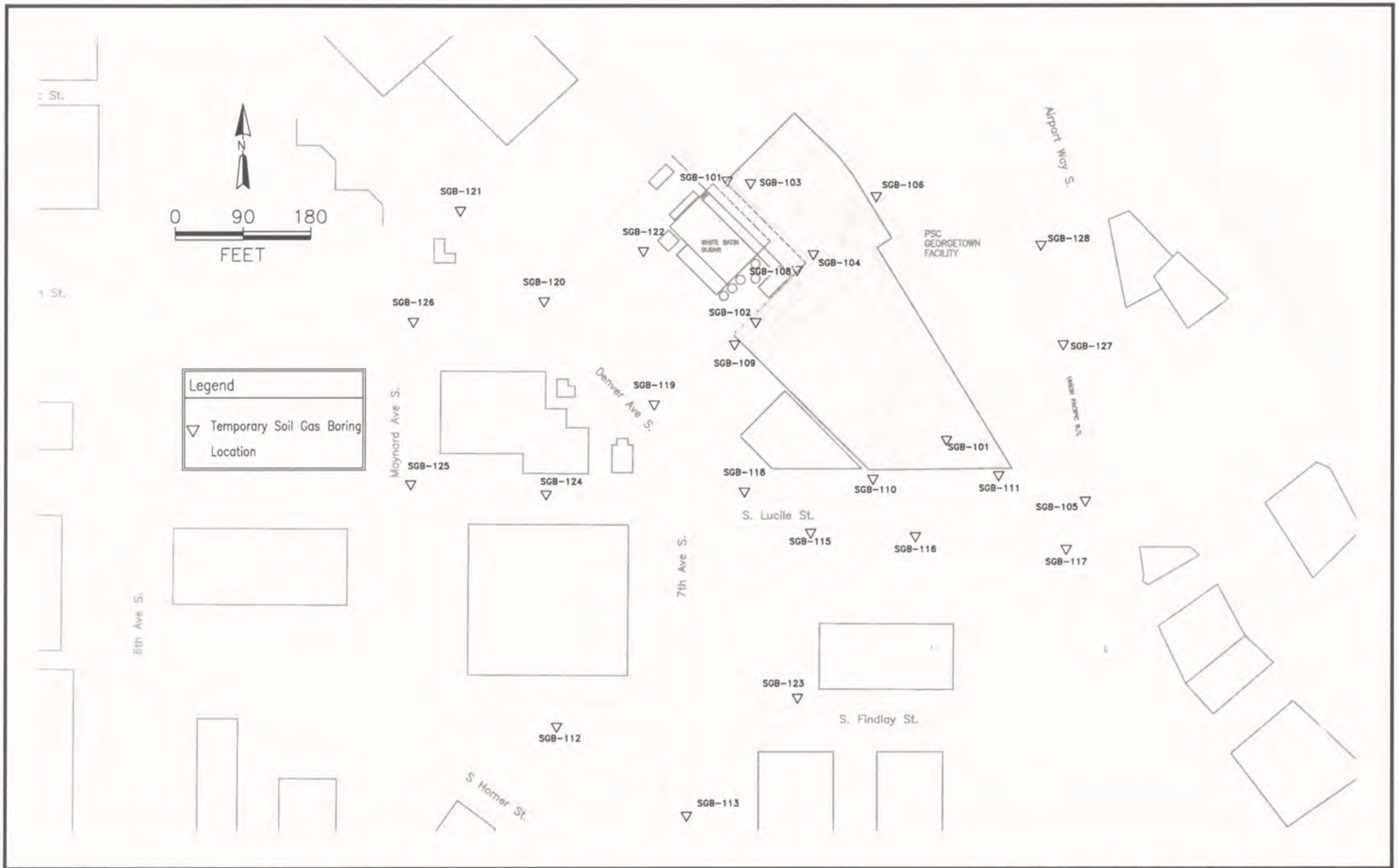


TITLE:
Groundwater Reconnaissance Boring Locations – HCIM Workplan 2002

DWN: dtb
DES.:
CHKD: cjm
APPD:
DATE: 10/30/03
REV.:

PROJECT NO.: RI2003
FIGURE NO.: 4-17

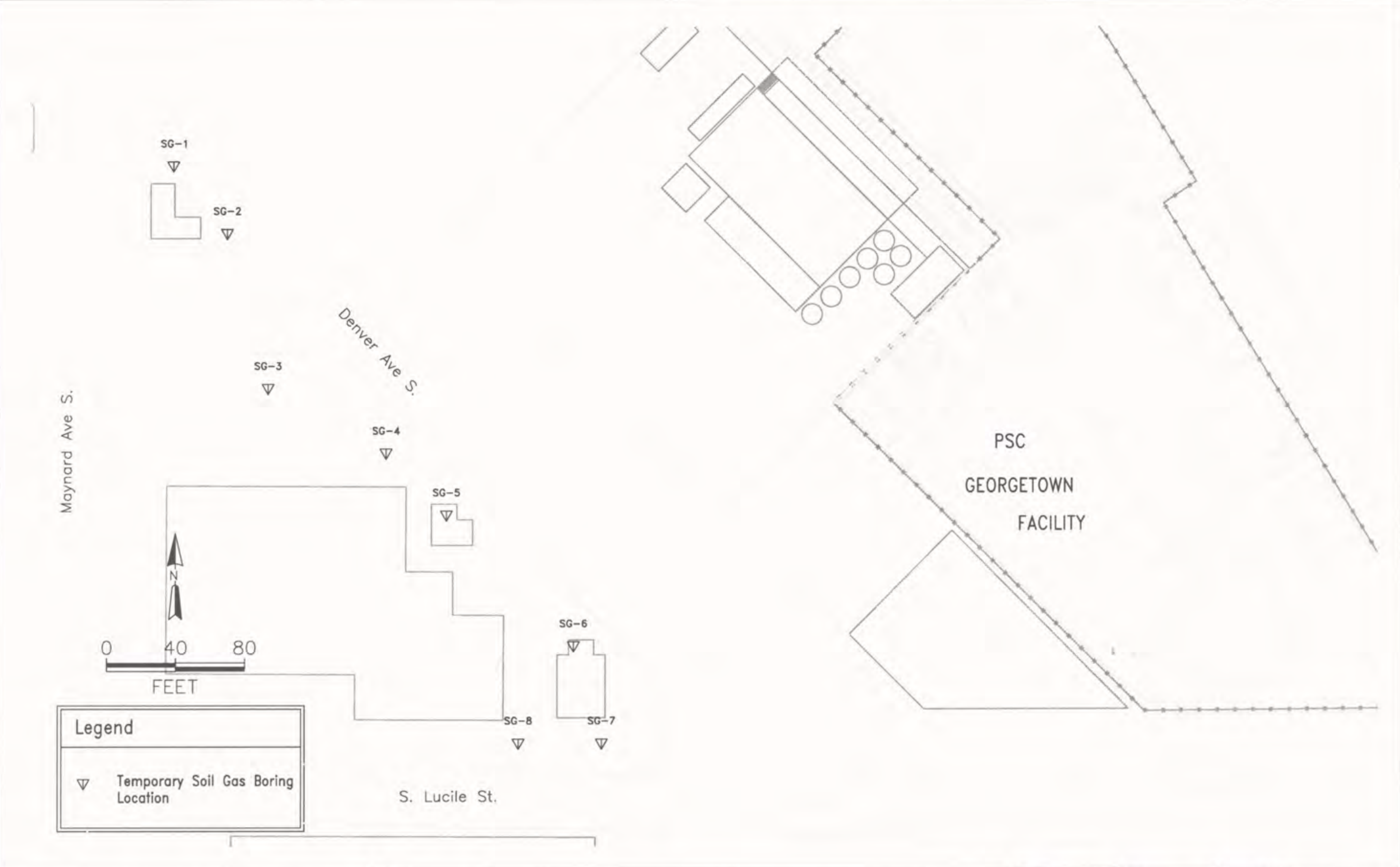
PSC	TITLE: Soil Gas Reconnaissance Boring Locations Phase II Hydrological Investigation 1989	DWN: dtb	DES.:	PROJECT NO.: RI2003
		CHKD: cjm	APPD:	FIGURE NO.: 4-18
		DATE: 10/30/03	REV.:	



PSC

TITLE:
Soil Gas Reconnaissance Boring Locations
Phase III Hydrological Investigation
1991

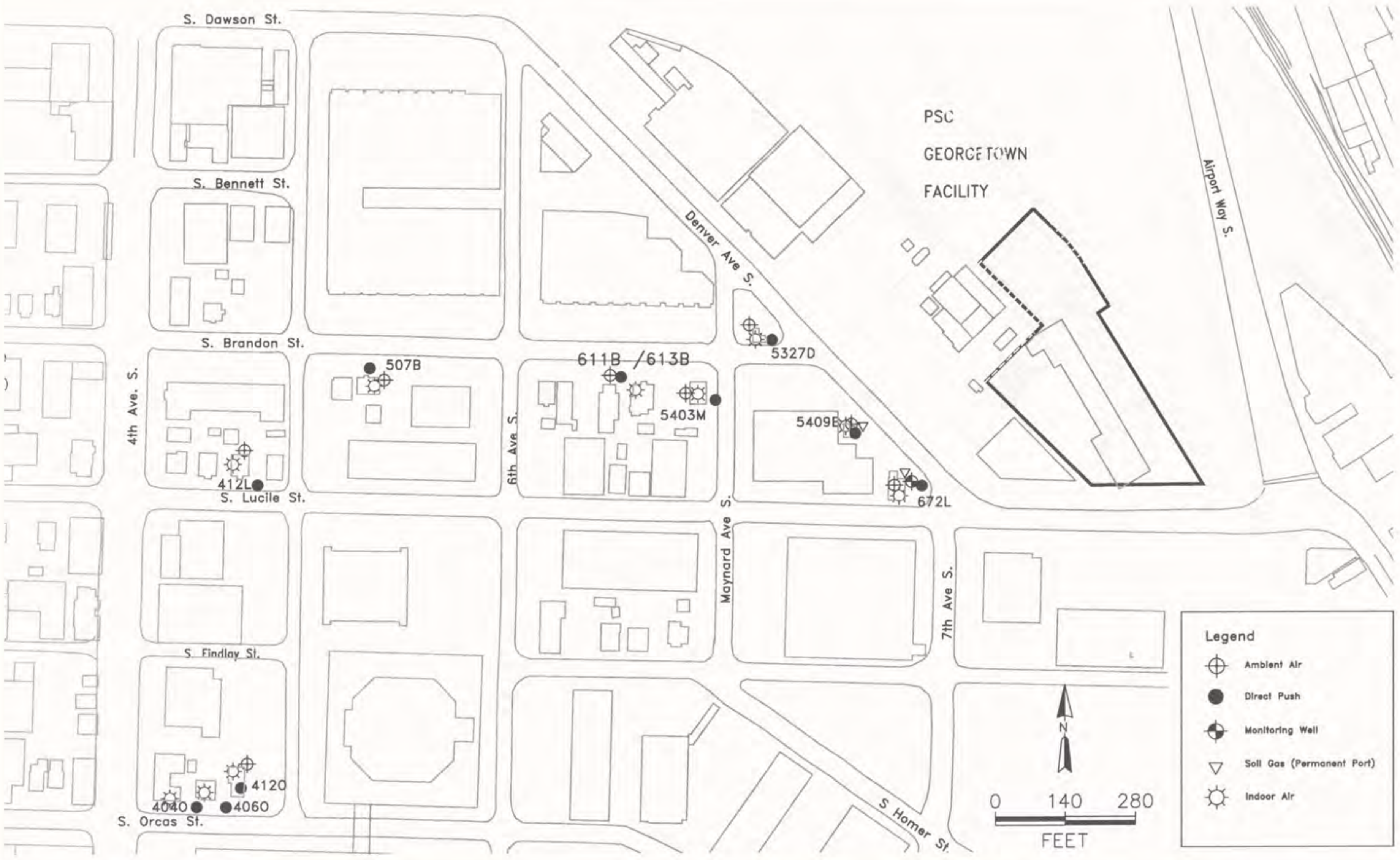
DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/31/03	REV.: 1	FIGURE NO.: 4-19



PSC

TITLE:
Soil Gas Reconnaissance Boring Locations
Soil Gas Study
1999

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/31/03	REV.:	FIGURE NO.: 4-20



PSC	TITLE: Sampling Locations GIVF Study Area 2002	DWN: dtb CHKD: cjm DATE: 10/29/03	DES.: APPD: REV.:	PROJECT NO.: RI2003 FIGURE NO.: 4-21

PSC

TITLE:
All Discrete Locations Sampled for Soil Chemical Analysis
Phase I, II, & III Hydrological Investigations
1987 - 2002

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 10/17/03	REV.:	FIGURE NO.: 4-22

Table 4-1
Groundwater Monitoring Well Construction Details

Phase	Well ID	General Well Information							Screened Sample Interval				Well Casing					Screen				
		Contractor	Drilling Method	Installation Date	Abandonment Date	Abandonment Method	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft from TOC)	Water Table Sample Interval	Lower Shallow Aquifer Sample Interval	Intermediate Aquifer Sample Interval	Deep Aquifer Sample Interval	Diameter (inches)	Material		Type of PVC joint	Centralizers	Diameter (inches)	Material		Slot Size (inches)	Screen Interval (ft bgs)
3	CG-101-S1	Burlington	Hollow Stem Auger	5/6/92	NA		17.5	17	x				2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	7-17.0
3	CG-101-S2	Burlington	Hollow Stem Auger	5/7/92	NA		32	30.5			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	20.5-30.5
3	CG-102-D	Holt Drilling	Cable Tool	7/13/92	NA		130	112				x	2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	101.5-111.5
3	CG-102-I	Holt Drilling	Cable Tool	6/17/92	NA		69	63			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	53-63.0
3	CG-102-S1	Burlington	Hollow Stem Auger	5/20/92	NA		17.8	17.3	x				2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	7.3-17.3
3	CG-102-S2	Burlington	Hollow Stem Auger	5/22/92	NA		31.5	30		x			2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	20-30.0
3	CG-103-I	Holt Drilling	Cable Tool	6/5/92	NA		80	71.5			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	61-71.0
3	CG-103-S1	Burlington	Hollow Stem Auger	5/8/92	NA		18	17.5	x				2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	7.5-17.5
3	CG-103-S2	Burlington	Hollow Stem Auger	5/11/92	NA		35.5	35		x			2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	25-35.0
3	CG-104-D	Holt Drilling	Cable Tool	7/20/92	NA		127	123				x	2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	113-123.0
3	CG-104-I	Holt Drilling	Cable Tool	6/14/92	NA		70	66			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	55.5-65.5
3	CG-104-S1	Burlington	Hollow Stem Auger	5/12/92	NA		18	17.5	x				2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	7.5-17.5
3	CG-104-S2	Burlington	Hollow Stem Auger	5/13/92	NA		33	30.5		x			2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	20.5-30.5
3	CG-105-I	Burlington	Cable Tool	6/11/92	7/28/03	Grout in place	76.5	66.2			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	56.2-66.2
3	CG-105-S1	Burlington	Hollow Stem Auger	5/14/92	7/28/03	Grout in place	17.5	17	x				2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	7-17.0
3	CG-105-S2	Burlington	Hollow Stem Auger	5/15/92	7/28/03	Grout in place	35	35		x			2	Sch. 40	PVC	Threaded	Bottom and top of screen	2	Sch. 40	PVC	0.01	25-35.0
2	CG-10-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/18/89	NA		17.5	15.5	x				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5.5-15.5
2	CG-10-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/15/89	NA		28.5	25		x			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	15-25
3	CG-111-I	Holt Drilling	Cable Tool	7/6/92	NA		60	52			x		2	Sch. 40	PVC	Threaded	Bottom and top of screen*	2	Sch. 40	PVC	0.01	42-52.0
3	CG-112-S1	Cascade Drilling	Hollow Stem Auger	11/20/00	NA		15.5	15	x				2	Sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	5-15
3-	CG-113-S1	Cascade Drilling	Hollow Stem Auger	11/20/00	NA		15.5	15.5	1				2	Sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	5-15
3	CG-11-I	Cascade Drilling	Hollow Stem Auger	9/3/98	7/28/03	Grout in place	68	66			1		2	Sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	56-66
2	CG-11-S1	Hokkaido Drill Co.	Hollow Stem Auger	07/1989	7/28/03	Grout in place	17	15	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5-15
2	CG-11-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/20/89	7/28/03	Grout in place	41.5	36	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	26-36
3	CG-12-I	Cascade Drilling	Hollow Stem Auger	9/4/98	8/7/03	Overdrill, grout	65	63			1		2	Sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	53-63
3	CG-12-S1	Cascade Drilling	Hollow Stem Auger	9/4/98	8/7/03	Overdrill, grout	18		1				2	Sch. 40	PVC	Threaded	NA	1	Sch. 40	PVC	0.01	6-16
1	CG-1-D	Holt Drilling	Cable Tool	11/28/87	NA		109	108				1	2	Sch. 80	PVC	Threaded	Bottom and top of screen*	2	Sch. 80	PVC	0.01	98-108
2	CG-1-I	Hokkaido Drill Co.	Cable Tool	8/30/89	NA		66	63			1		2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	53-63
2	CG-1-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/18/89	NA		17.5	15.5	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5.5-15.5
2	CG-1-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/18/89	NA		30.5	29.5		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	10.5-29.5
1	CG-2-D	Holt Drilling	Cable Tool	12/2/87	1/22/02	Grout in place	128.5	128				1	2	Sch. 80	PVC	Threaded	center of screen	2	Sch. 80	PVC	0.01	118-128
2	CG-2-I	Hokkaido Drill Co.	Cable Tool	8/22/89	8/8/02	Grout in place	70.5	65			1		2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	55-65
2	CG-2-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/31/89	7/28/03	Grout in place	20.5	18.5	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	8.5-18.5
2	CG-2-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/28/89	7/28/03	Grout in place	40.5	40.5		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	30.5-40.5
1	CG-3	Tacoma Pump/Drilling	Hollow Stem Auger	12/23/87	NA		31.5	30		1			2	Sch. 80	PVC	Threaded	bottom of screen	2	Sch. 80	PVC	0.01	20-30
2	CG-4-D	Hokkaido Drill Co.	Cable Tool	6/16/89	1/22/02	Grout in place	109.5	105				1	2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	95-105
2	CG-5-D	Holt Drilling	Cable Tool	6/29/89	NA		123	108				1	2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	98-108
2	CG-5-I	Hokkaido Drill Co.	Cable Tool	8/17/89	NA		64.5	63.5			1		2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	53.5-63.5
2	CG-5-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/5/89	NA		17	15	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5-15
2	CG-5-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/7/89	NA		45	44		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	34-44
2	CG-6-S1	Hokkaido Drill Co.	Hollow Stem Auger	07/1989	NA		16.8	15	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5-15
2	CG-6-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/10/89	NA		38.5	35		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	25-35
2	CG-7-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/14/89	8/6/02		17.5	15.5	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	5.5-15.5
2	CG-7-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/13/89	7/28/03	Grout in place	38	31		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	21-31
2	CG-8-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/27/89	7/28/03	Grout in place	20	18	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	8-18
2	CG-8-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/26/89	7/28/03	Grout in place	41.5	40.5		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	30.5-40.5
2	CG-9-I	Hokkaido Drill Co.	Cable Tool	8/25/89	7/28/03	Grout in place	75	73			1		2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	63-73
2	CG-9-S1	Hokkaido Drill Co.	Hollow Stem Auger	7/25/89	7/28/03	Grout in place	19	17	1				2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	7-17
2	CG-9-S2	Hokkaido Drill Co.	Hollow Stem Auger	7/24/89	7/28/03	Grout in place	41.5	41		1			2	Sch. 80	PVC	Threaded	NA	2	Sch. 80	PVC	0.01	31-41
3	CG-106-WT	Cascade Drilling	Hollow Stem Auger	4/25/02	NA		15	14.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4-14
3	CG-106-I	Cascade Drilling	Hollow Stem Auger	5/7/02	NA		38	36.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	26-36
3	CG-106-D	Cascade Drilling	Hollow Stem Auger	5/6/02	NA		72	70.67				1	2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	60-70
3	CG-107-WT	Cascade Drilling	Hollow Stem Auger	4/24/02	NA		15.17	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4.5-14.5
3	CG-114-75	Cascade Drilling	Hollow Stem Auger	3/20/02	NA		80	74.83			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	64.17-74.17
3	CG-115-WT	Cascade Drilling	Hollow Stem Auger	3/20/02	NA		16	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	5-15
3	CG-115-75	Cascade Drilling	Hollow Stem Auger	3/20/02	NA		80	75.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	65-75
3	CG-119-40	Cascade Drilling	Hollow Stem Auger	3/21/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-120-75	Cascade Drilling	Hollow Stem Auger	3/19/02	NA		80	75.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	65-75
3	CG-121-40	Cascade Drilling	Hollow Stem Auger	3/19/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-121-70	Cascade Drilling	Hollow Stem Auger	3/19/02	NA		73	70.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	60-70
3	CG-122-WT	Cascade Drilling	Hollow Stem Auger	3/5/02	NA		16.5	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	5-15
3	CG-122-60	Cascade Drilling	Hollow Stem Auger	3/5/02	NA		63	60.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	50-60

Table 4-1
Groundwater Monitoring Well Construction Details

Phase	Well ID	General Well Information							Screened Sample Interval				Well Casing					Screen				
		Contractor	Drilling Method	Installation Date	Abandonment Date	Abandonment Method	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft from TOC)	Water Table Sample Interval	Lower Shallow Aquifer Sample Interval	Intermediate Aquifer Sample Interval	Deep Aquifer Sample Interval	Diameter (inches)	Material		Type of PVC joint	Centralizers	Diameter (inches)	Material		Slot Size (inches)	Screen Interval (ft bgs)
3	CG-123-90	Cascade Drilling	Hollow Stem Auger	3/22/02	NA		95	90.5			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	79.83-89.83
3	CG-124-WT	Cascade Drilling	Hollow Stem Auger	3/27/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4.5-14.5
3	CG-124-40	Cascade Drilling	Hollow Stem Auger	3/27/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-124-70	Cascade Drilling	Hollow Stem Auger	3/27/02	NA		74	70.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	60-70
3	CG-125-40	Cascade Drilling	Hollow Stem Auger	3/18/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-126-WT	Cascade Drilling	Hollow Stem Auger	3/11/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-127-WT	Cascade Drilling	Hollow Stem Auger	3/21/02	NA		17.5	16.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	6-16
3	CG-127-40	Cascade Drilling	Hollow Stem Auger	3/21/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-128-WT	Cascade Drilling	Hollow Stem Auger	3/26/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4.5-14.5
3	CG-128-70	Cascade Drilling	Hollow Stem Auger	3/26/02	NA		74	70.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	60-70
3	CG-129-WT	Cascade Drilling	Hollow Stem Auger	3/5/02	NA		16.5	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	5-15
3	CG-129-40	Cascade Drilling	Hollow Stem Auger	3/5/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-130-WT	Cascade Drilling	Hollow Stem Auger	3/25/02	NA		16	14.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4-14
3	CG-131-WT	Cascade Drilling	Hollow Stem Auger	3/6/02	NA		16.5	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	5-15
3	CG-131-40	Cascade Drilling	Hollow Stem Auger	3/6/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-132-WT	Cascade Drilling	Hollow Stem Auger	3/11/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-132-40	Cascade Drilling	Hollow Stem Auger	3/11/02	NA		43	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-133-40	Cascade Drilling	Hollow Stem Auger	4/1/02	NA		41	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-134-WT	Cascade Drilling	Hollow Stem Auger	4/24/02	NA		15	15	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4.33-14.33
3	CG-134-40	Cascade Drilling	Hollow Stem Auger	4/1/02	NA		41	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-135-40	Cascade Drilling	Hollow Stem Auger	3/25/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-135-50	Cascade Drilling	Hollow Stem Auger	3/25/02	NA		52	50.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	40-50
3	CG-136-WT	Cascade Drilling	Hollow Stem Auger	3/18/02	NA		16	14.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	4-14
3	CG-136-40	Cascade Drilling	Hollow Stem Auger	3/19/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	30-40
3	CG-137-WT	Cascade Drilling	Hollow Stem Auger	3/13/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-137-40	Cascade Drilling	Hollow Stem Auger	3/13/02	NA		43	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-138-WT	Cascade Drilling	Hollow Stem Auger	3/7/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-138-40	Cascade Drilling	Hollow Stem Auger	3/7/02	NA		42	40.58		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	29.92-39.92
3	CG-138-70	Cascade Drilling	Hollow Stem Auger	3/7/02	NA		73	70.67			1		2	sch. 40	PVC	Threaded	NA	2	Sch. 40	prepacked PVC	0.01	60-70
3	CG-139-40	Cascade Drilling	Hollow Stem Auger	3/11/02	NA		43	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-140-WT	Cascade Drilling	Hollow Stem Auger	3/12/02	NA		16	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	5-15
3	CG-140-30	Cascade Drilling	Hollow Stem Auger	7/25/03	NA		31	30.05		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	20-30
3	CG-140-40	Cascade Drilling	Hollow Stem Auger	3/12/02	NA		43	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-141-WT	Cascade Drilling	Hollow Stem Auger	3/14/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-141-40	Cascade Drilling	Hollow Stem Auger	3/14/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-141-50	Cascade Drilling	Hollow Stem Auger	3/14/02	NA		52	50.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	40-50
3	CG-142-WT	Cascade Drilling	Hollow Stem Auger	3/13/02	NA		16	15.67	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	5-15
3	CG-142-40	Cascade Drilling	Hollow Stem Auger	3/13/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-143-WT	Cascade Drilling	Hollow Stem Auger	3/6/02	NA		16	15.17	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	4.5-14.5
3	CG-143-40	Cascade Drilling	Hollow Stem Auger	3/6/02	NA		42	40.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.02	30-40
3	CG-144-35	Cascade Drilling	Hollow Stem Auger	5/8/02	NA		37	35.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	25-35
3	CG-145-35	Cascade Drilling	Hollow Stem Auger	5/8/02	NA		37	35.67		1			2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	25-35
3	CG-151-25	Cascade Drilling	Hollow Stem Auger	7/25/03	NA		25.5	24.88	1				2	sch. 40	PVC	Threaded	NA	2	Sch. 40	PVC	0.01	15-25
									32	31	17	5										

Table 4-1
Groundwater Monitoring Well Construction Details

	Filter Pack		Seal	Conductor Casing							Pump	
Well ID	Type-Material	Filter Pack Interval (ft bgs)	Seal (ft bgs)	Conductor Casing #1 o.d. (inches)	Conductor Casing Depth (ft bgs)	Conductor Casing #2 o.d. (inches)	Conductor Casing Depth (ft bgs)	Conductor Casing #3 o.d. (inches)	Conductor Casing Depth (ft bgs)	Surface Seal	Type	Depth (feet from TOC)
CG-101-S1	10-20-silica sand	5.0-17.5	2-5	NA	NA	NA	NA	10.5	0-17.5	Concrete, steel flush mount	Grundfos	14.3
CG-101-S2	20-40-silica sand	18.5-32	0-18.5	NA	NA	NA	NA	10.5	0-32	Concrete, steel flush mount	Grundfos	26
CG-102-D	20-40-silica sand	99.5-112.0	1-99.5	21.5	0	18	32-67	12.5	67-130	Concrete, steel flush mount	Bladder	107
CG-102-I	20-40-silica sand	50.0-63.5	1-50	NA	NA	18	0-32	12.5	32-69	Concrete, steel flush mount	Grundfos	58.7
CG-102-S1	10-20-silica sand	5.3-17.8	1-5.3	NA	NA	NA	NA	10.5	0-17.8	Concrete, steel flush mount	Grundfos	15.9
CG-102-S2	20-40-silica sand	18.0-31.0	1-18	NA	NA	NA	NA	10.5	0-31.5	Concrete, steel flush mount	Grundfos	25.7
CG-103-I	20-40-silica sand	59.0-71.5	1-59	NA	NA	18	0-37	12.5	37-80	Concrete, steel flush mount	Grundfos	66.7
CG-103-S1	10-20-silica sand	5.5-18.0	0.5-5.5	NA	NA	NA	NA	10.5	0-18	Concrete, steel flush mount	Bladder	13.5
CG-103-S2	10-20-silica sand	22.0-35.5	1-22	NA	NA	NA	NA	10.5	0-35.5	Concrete, steel flush mount	Grundfos	30.7
CG-104-D	20-40-silica sand	111.0-123.5	0.5-111	21.5	0	18	33-69	12.5	69-127	Concrete, steel flush mount	Bladder	118.5
CG-104-I	20-40-silica sand	52.5-66.0	0.5-52.5	NA	NA	18	0-33	12.5	33-70	Concrete, steel flush mount	Grundfos	61.2
CG-104-S1	10-20-silica sand	5.5-18.0	1-5.5	NA	NA	NA	NA	10.5	0-18	Concrete, steel flush mount	Grundfos	15.4
CG-104-S2	10-20-silica sand	18.5-31.0	1-18.5	NA	NA	NA	NA	10.5	0-33	Concrete, steel flush mount	Grundfos	28
CG-105-I	20-40-silica sand	53.2-66.7	1-53.2	NA	NA	18	0-37	12.5	37-76.5	Concrete, steel flush mount	Grundfos	61.8
CG-105-S1	10-20-silica sand	5.0-17.5	0.5-5	NA	NA	NA	NA	10.5	0-17.5	Concrete, steel flush mount	Grundfos	15.6
CG-105-S2	10-20-silica sand	22.0-35.0	2-22	NA	NA	NA	NA	10.5	0-35	Concrete, steel flush mount	Bladder	30
CG-10-S1	Colorado Silica Sand #8/12	4.5-17.5	2-4.5	NA	NA	NA	NA	12	0-17.5	Concrete, steel flush mount	Grundfos	14.4
CG-10-S2	Colorado Silica Sand #8/12	13-26.5	1.5-13	NA	NA	NA	NA	12	0-28.5	Concrete, steel flush mount	--	--
CG-111-I	20-40-silica sand	39.0-52.5	1-39	NA	NA	18	0-22	12.5	22-60	Concrete, steel flush mount	Bladder	47.5
CG-112-S1	Monterey Sand #212	3.5-15.5	1.5-3.5	NA	NA	NA	NA	12.5	0-15.5	Concrete, steel flush mount	Bladder	12.5
CG-113-S1	Monterey Sand #212	4-15	1.5-4	NA	NA	NA	NA	12.5	0-15.5	Concrete, steel flush mount	Grundfos	9.5
CG-11-I	#20/40-silica sand	54-68	3-54	NA	NA	15	0-35	8	35-68	Concrete, steel flush mount	--	--
CG-11-S1	Colorado Silica Sand #8/12	4-17	1.5-4	NA	NA	NA	NA	12	0-17	Concrete, steel flush mount	Bladder	10.5
CG-11-S2	Colorado Silica Sand #8/12	23-37	1.5-23	NA	NA	NA	NA	12	0-41.5	Concrete, steel flush mount	--	--
CG-12-I	#20/40-silica sand	51-65	18, 3-51	NA	NA	15	0-35	8	35-65	Concrete, steel flush mount	--	--
CG-12-S1	2/12 silica sand	5-18	4-5	NA	NA	NA	NA	15	0-18	Concrete, steel flush mount	--	--
CG-1-D	Colorado Silica Sand #8/12	91-109	8-91	NA	NA	12.5	0-55	10.5	55-109	Concrete, steel flush mount	--	--
CG-1-I	Colorado Silica Sand #8/12	51-66	1.5-51	NA	NA	18	0-30	12.5	30-66	Concrete, steel flush mount	--	--
CG-1-S1	Colorado Silica Sand #8/12	4.5-17.5	1.5-4.5	NA	NA	NA	NA	12	0-17.5	Concrete, steel flush mount	Grundfos	
CG-1-S2	Colorado Silica Sand #8/12	17.5-30.5	1.5-17.5	NA	NA	NA	NA	12	0-30.5	Concrete, steel flush mount	--	--
CG-2-D	Colorado Silica Sand #8/12	113-128	5-113	NA	NA	NA	NA	10.5	0-128.5	Concrete, steel flush mount	--	--
CG-2-I	Colorado Silica Sand #8/12	48-66	1.5-48	NA	NA	18	0-30	12.5	30-70.5	Concrete, steel flush mount	--	--
CG-2-S1	Colorado Silica Sand #8/12	6.5-20.5	1.5-6.5	NA	0-32	NA	NA	12	0-20.5	Concrete, steel flush mount	Bladder	14.5
CG-2-S2	Colorado Silica Sand #8/12	4-28.5	1.5-27	NA	NA	NA	NA	12	0-40.5	Concrete, steel flush mount	--	--
CG-3	Colorado Silica Sand #8/12	16.5-30	1.5-18.5	NA	NA	NA	NA	7.5	0-31.5	Concrete, steel flush mount	Grundfos	25.7
CG-4-D	Colorado Silica Sand #8/12	90.5-108	1.5-93	21.5	NA	18	35-64	12.5	64-109.5	Concrete, steel flush mount	--	--
CG-5-D	Colorado Silica Sand #8/12	95-110	1.5-118	21.5	0-33	18	44-69	12.5	69-123	Concrete, steel flush mount	--	--
CG-5-I	Colorado Silica Sand #8/12	48-64.5	1.5-48	NA	NA	18	0-44	12.5	44-64.5	Concrete, steel flush mount	--	--
CG-5-S1	Colorado Silica Sand #8/12	4-17	1.5-4	NA	NA	NA	NA	12	0-17	Concrete, steel flush mount	--	--
CG-5-S2	Colorado Silica Sand #8/12	32-45	1.5-32	NA	NA	NA	NA	12	0-45	Concrete, steel flush mount	--	--
CG-6-S1	Colorado Silica Sand #8/12	4.5-17	1.5-4	NA	NA	NA	NA	12	0-16.8	Concrete, steel flush mount	--	--
CG-6-S2	Colorado Silica Sand #8/12	22.5-35.5	1.5-22.5	NA	NA	NA	NA	12	0-38.5	Concrete, steel flush mount	--	--
CG-7-S1	Colorado Silica Sand #8/12	5.5-17.5	1.5-5.5	NA	NA	NA	NA	12	0-17.5	Concrete, steel flush mount	--	--
CG-7-S2	Colorado Silica Sand #8/12	18-31.5	1.5-18	NA	NA	NA	NA	12	0-38	Concrete, steel flush mount	--	--
CG-8-S1	Colorado Silica Sand #8/12	6-20	1.5-6	NA	NA	NA	NA	12	0-20	Concrete, steel flush mount	--	--
CG-8-S2	Colorado Silica Sand #8/12	28.5-41.5	1.5-28.5	NA	NA	NA	NA	12	0-41.5	Concrete, steel flush mount	--	--
CG-9-I	Colorado Silica Sand #8/12	60.5-75	1.5-61	NA	NA	18	0-41	12.5	41-75	Concrete, steel flush mount	--	--
CG-9-S1	8x12-silica sand	5-19	1.5-5	NA	NA	NA	NA	12	0-19	Concrete, steel flush mount	Bladder	14.5
CG-9-S2	8x12-silica sand	28-41.5	1.5-28	NA	NA	NA	NA	12	0-41.5	Concrete, steel flush mount	--	--
CG-106-WT	Colorado Silica Sand #10/20	3.5-14.83	1.5-3.5	NA	NA	NA	NA	8.25	0-15	Concrete, steel flush mount	Bladder	9
CG-106-I	Colorado Silica Sand #10/20	23-37.17	3-23	NA	NA	NA	NA	8.25	0-38	Concrete, steel flush mount	Bladder	31
CG-106-D	Colorado Silica Sand #10/20	57-70	4-57	NA	NA	15	41	8.25	41-72	Concrete, steel flush mount	Bladder	65
CG-107-WT	Colorado Silica Sand #10/20	4-15.17	2-4	NA	NA	NA	NA	8.25	0-15.17	Concrete, steel flush mount	Bladder	9.5
CG-114-75	Colorado Silica Sand #20/40	62-74.17	2-62	NA	NA	NA	NA	8	0-80	Concrete, steel flush mount	Bladder	69
CG-115-WT	Colorado Silica Sand #10/20	4.5-16	2-4.5	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11
CG-115-75	Colorado Silica Sand #20/40	62-75	2-62	NA	NA	NA	NA	8	0-80	Concrete, steel flush mount	Bladder	70
CG-119-40	Colorado Silica Sand #10/20	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-120-75	Colorado Silica Sand #20/40	62-65	2-62	NA	NA	NA	NA	8	0-80	Concrete, steel flush mount	Bladder	70
CG-121-40	Colorado Silica Sand #10/20	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-121-70	Colorado Silica Sand #20/40	57-60	2-57	NA	NA	NA	NA	8	0-73	Concrete, steel flush mount	Bladder	64.5
CG-122-WT	Colorado Silica Sand #8/12	4.5-16	2-4.5	NA	NA	NA	NA	8	0-16.5	Concrete, steel flush mount	Bladder	11
CG-122-60	Colorado Silica Sand #10/20	47-50	2-47	NA	NA	NA	NA	8	0-63	Concrete, steel flush mount	Bladder	55

Table 4-1
Groundwater Monitoring Well Construction Details

	Filter Pack		Seal	Conductor Casing							Pump	
Well ID	Type-Material	Filter Pack Interval (ft bgs)	Seal (ft bgs)	Conductor Casing #1 o.d. (inches)	Conductor Casing Depth (ft bgs)	Conductor Casing #2 o.d. (inches)	Conductor Casing Depth (ft bgs)	Conductor Casing #3 o.d. (inches)	Conductor Casing Depth (ft bgs)	Surface Seal	Type	Depth (feet from TOC)
CG-123-90	Colorado Silica Sand #10/20	77-90.5	2-77	NA	NA	NA	NA	8	0-95	Concrete, steel flush mount	Bladder	84.5
CG-124-WT	Colorado Silica Sand #10/20	4-15.5	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11
CG-124-40	Colorado Silica Sand #10/20	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-124-70	Colorado Silica Sand #10/20	57-64	2-57	NA	NA	NA	NA	8	0-74	Concrete, steel flush mount	Bladder	65
CG-125-40	Colorado Silica Sand #10/20	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-126-WT	Colorado Silica Sand #8/12	4-15.25	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11.5
CG-127-WT	Colorado Silica Sand #10/20	5-17.17	2-5	NA	NA	NA	NA	8	0-17.5	Concrete, steel flush mount	Bladder	12
CG-127-40	Colorado Silica Sand #10/20	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-128-WT	Colorado Silica Sand #10/20	4-15.67	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	10
CG-128-70	Colorado Silica Sand #10/20	57-63	2-57	NA	NA	NA	NA	8	0-74	Concrete, steel flush mount	Bladder	64.5
CG-129-WT	Colorado Silica Sand #8/12	4.5-16.17	2-4.5	NA	NA	NA	NA	8	0-16.5	Concrete, steel flush mount	Bladder	10.5
CG-129-40	Colorado Silica Sand #8/12	29-41	2-29	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-130-WT	Colorado Silica Sand #10/20	3.5-15.5	2-3.5	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	10
CG-131-WT	Colorado Silica Sand #8/12	4.5-16.08	2-4.5	NA	NA	NA	NA	8	0-16.5	Concrete, steel flush mount	Bladder	10.5
CG-131-40	Colorado Silica Sand #8/12	27-41	2-27	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-132-WT	Colorado Silica Sand #8/12	4-15.33	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	10.5
CG-132-40	Colorado Silica Sand #8/12	28-41.17	2-28	NA	NA	NA	NA	8	0-43	Concrete, steel flush mount	Bladder	35
CG-133-40	Colorado Silica Sand #10/20	28-40.67	2.5-28	NA	NA	NA	NA	8	0-41	Concrete, steel flush mount	Bladder	34.5
CG-134-WT	Colorado Silica Sand #10/20	3.83-15	2-3.83	NA	NA	NA	NA	8	0-15	Concrete, steel flush mount	Bladder	10
CG-134-40	Colorado Silica Sand #10/20	27.83-40.67	3-27.83	NA	NA	NA	NA	8	0-41	Concrete, steel flush mount	Bladder	34.5
CG-135-40	Colorado Silica Sand #10/20	28-41.33	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-135-50	Colorado Silica Sand #10/20	38-51.33	2-38	NA	NA	NA	NA	8	0-52	Concrete, steel flush mount	Bladder	45
CG-136-WT	Colorado Silica Sand #10/20	3.5-15.33	2-3.5	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	9.5
CG-136-40	Colorado Silica Sand #10/20	28-41.33	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-137-WT	Colorado Silica Sand #8/12	4-15.67	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	10.5
CG-137-40	Colorado Silica Sand #8/12	28-41.17	2-28	NA	NA	NA	NA	8	0-43	Concrete, steel flush mount	Bladder	35
CG-138-WT	Colorado Silica Sand #8/12	4-15.5	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	10.5
CG-138-40	Colorado Silica Sand #8/12	28-40.58	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	34.5
CG-138-70	Pre pack	57-60	2-57	NA	NA	NA	NA	8	0-73	Concrete, steel flush mount	Bladder	64.5
CG-139-40	Colorado Silica Sand #8/12	28-41.08	2-28	NA	NA	NA	NA	8	0-43	Concrete, steel flush mount	Bladder	34.5
CG-140-WT	Colorado Silica Sand #8/12	4.5-16	2-4.5	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11
CG-140-30	Colorado Silica Sand #10/20	18-31	2-18	NA	NA	NA	NA	8	0-31	Concrete, steel flush mount	Bladder	TBD
CG-140-40	Colorado Silica Sand #8/12	28-41.58	2-28	NA	NA	NA	NA	8	0-43	Concrete, steel flush mount	Bladder	34.5
CG-141-WT	Colorado Silica Sand #8/12	4-15.67	2-4	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11
CG-141-40	Colorado Silica Sand #8/12	28-41.17	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	34.5
CG-141-50	Colorado Silica Sand #8/12	38-51.67	2-38	NA	NA	NA	NA	8	0-52	Concrete, steel flush mount	Bladder	44.5
CG-142-WT	Colorado Silica Sand #8/12	4.5-16	2-4.5	NA	NA	NA	NA	8	0-16	Concrete, steel flush mount	Bladder	11
CG-142-40	Colorado Silica Sand #8/12	28-41.67	2-28	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-143-WT	Colorado Silica Sand #8/12	4-15.25	2-4	NA	NA	NA	NA	8	0-15	Concrete, steel flush mount	Bladder	10.5
CG-143-40	Colorado Silica Sand #8/12	27-41.33	2-27	NA	NA	NA	NA	8	0-42	Concrete, steel flush mount	Bladder	35
CG-144-35	Colorado Silica Sand #10/20	23-36.17	2-23	NA	NA	NA	NA	8	0-37	Concrete, steel flush mount	Bladder	30
CG-145-35	Colorado Silica Sand #10/20	23-36.17	3-23	NA	NA	NA	NA	8	0-37	Concrete, steel flush mount	Bladder	30
CG-151-25	Colorado Silica Sand #10/20	13-25.5	2-13	NA	NA	NA	NA	8	0-25	Concrete, steel flush mount	NA	NA

Table 4-2
Summary of Monitoring Well Survey Data

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point (feet, City of Seattle Datum)
CG-101-S1	205881.59	1272890.13	19.51	19.18
CG-101-S2	205875.59	1272891.13	19.66	18.81
CG-102-D	205394.59	1272664.13	20.86	20.43
CG-102-I	205394.59	1272657.13	20.87	20.5
CG-102-S1	205394.59	1272649.13	20.95	20.58
CG-102-S2	205393.59	1272644.13	20.96	20.63
CG-103-I	205457.59	1272458.13	21.21	20.72
CG-103-S1	205463.59	1272449.13	21.19	20.68
CG-103-S2	205463.59	1272455.13	21.15	20.78
CG-104-D	205642.59	1272260.13	20.61	20.26
CG-104-I	205621.59	1272249.13	20.33	19.78
CG-104-S1	205612.59	1272258.13	20.29	19.88
CG-104-S2	205616.59	1272254.13	20.22	19.73
CG-105-I	205842.59	1272305.13	20.57	20.11
CG-105-S1	205832.59	1272295.13	20.35	20
CG-105-S2	205838.59	1272301.13	20.47	20.05
CG-10-S1	205768.59	1272513.13	19.22	18.73
CG-10-S2	205771.59	1272511.13	19.23	18.73
CG-111-I	205321.59	1272971.13	20.21	19.88
CG-112-S1	205507.09	1272283.43	21.03	20.57
CG-113-S1	205594.99	1272201.33	20.71	20.32
CG-11-I	205872.44	1272407.26	17.62	17.27
CG-11-S1	205866.59	1272412.13	17.75	17.18
CG-11-S2	205869.59	1272409.13	17.69	17.25
CG-12-I	205899.35	1272441.47	17.37	17.06
CG-1-D	205813.59	1272465.13	18.53	18.09
CG-1-I	205819.59	1272458.13	18.31	17.76
CG-1-S1	205816.59	1272461.13	18.45	18.02
CG-1-S2	205816.59	1272465.13	18.44	17.94
CG-2-D	205546.59	1272534.13	22.16	21.56
CG-2-I	205537.59	1272553.13	22.13	21.59
CG-2-S1	205519.59	1272567.13	22.17	21.57
CG-2-S2	205522.59	1272563.13	22.14	21.66
CG-3	205821.59	1272739.13	18.61	17.99
CG-4-D	205947.59	1272488.13	17.6	17.24
CG-5-D	205494.59	1272767.13	21.63	20.99
CG-5-I	205504.59	1272761.13	21.43	20.88
CG-5-S1	205500.59	1272765.13	21.5	21.05
CG-5-S2	205496.59	1272766.13	21.53	21.03
CG-6-S1	205667.59	1272606.13	18.66	18.2
CG-6-S2	205669.59	1272605.13	18.66	18.24
CG-7-S1	205577.59	1272661.13	19.29	18.82
CG-7-S2	205573.59	1272663.13	20.34	18.79

Table 4-2
Summary of Monitoring Well Survey Data

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point (feet, City of Seattle Datum)
CG-8-S1	205600.59	1272483.13	22.12	21.54
CG-8-S2	205602.59	1272481.13	22.11	21.6
CG-9-I	205653.59	1272429.13	22.37	21.79
CG-9-S1	205658.59	1272422.13	22.42	21.94
CG-9-S2	205661.59	1272419.13	22.42	21.9
CG-106-WT	205709.4	1272917.9	19.43	19.16
CG-106-I	205707.3	1272918.4	19.31	18.92
CG-106-D	205711.3	1272916.4	19.41	19.02
CG-107-WT	205130.4	1272991.51	19.44	19.05
CG-114-75	205824.99	1272100.83	20.33	20
CG-115-WT	205770.19	1272153.53	20.41	20.14
CG-115-75	205775.69	1272148.43	20.44	20.09
CG-119-40	205516.19	1272377.83	20.59	20.35
CG-120-75	205858.89	1271980.23	19.45	19.16
CG-121-40	205659.79	1272017.53	19.5	19.1
CG-121-70	205653.69	1272017.53	19.54	19.07
CG-122-WT	205459.29	1271973.23	20.04	19.59
CG-122-60	205464.79	1271973.63	20.05	19.73
CG-123-90	205440.79	1272198.93	20.6	20.33
CG-124-WT	205436.99	1272310.93	21.15	20.96
CG-124-40	205437.39	1272306.93	20.99	20.87
CG-124-70	205437.39	1272303.13	21.14	20.84
CG-125-40	205043.19	1272060.93	20.76	20.36
CG-126-WT	205200.59	1272013.73	20.63	20.3
CG-127-WT	204998.29	1271654.33	20.55	20.32
CG-127-40	204991.49	1271654.23	20.48	20.2
CG-128-WT	205385.99	1271647.03	18.81	18.36
CG-128-70	205390.49	1271647.53	18.81	18.35
CG-129-WT	205737.79	1271654.83	18.88	18.46
CG-129-40	205742.99	1271654.13	18.68	18.35
CG-130-WT	205374.39	1271278.53	17.64	17.28
CG-131-WT	204927.39	1271272.53	17.91	17.52
CG-131-40	204932.69	1271271.93	18.02	17.57
CG-132-WT	204468.39	1271617.33	18.69	18.5
CG-132-40	204463.79	1271617.33	18.62	18.31
CG-133-40	203836.2	1270968.61	16.74	16.45
CG-134-WT	204729.9	1270981.7	17.86	17.54
CG-134-40	204734	1270981.9	17.84	17.37
CG-135-40	205373.49	1270999.93	17.42	16.99
CG-135-50	205376.59	1270999.83	17.38	16.95
CG-136-WT	204660.59	1270620.13	15.03	14.67
CG-136-40	204665.79	1270620.33	15.07	14.34
CG-137-WT	204434.1	1270264.2	15.84	15.39

Table 4-2
Summary of Monitoring Well Survey Data

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point (feet, City of Seattle Datum)
CG-137-40	204438.8	1270264.3	15.88	15.43
CG-138-WT	205255.19	1270243.13	16.57	16.28
CG-138-40	205260.19	1270243.33	16.62	16.32
CG-138-70	205265.49	1270243.43	16.65	16.29
CG-139-40	205777.89	1270294.23	16.67	16.36
CG-140-WT	204275.99	1269432.83	15.36	15.02
CG-140-30	204273.9	1269422.7	15.25	14.9
CG-140-40	204274.99	1269427.63	15.28	14.87
CG-141-WT	204414.29	1269750.93	16.93	16.61
CG-141-40	204424.99	1269750.13	17.01	16.66
CG-141-50	204429.99	1269750.33	17	16.68
CG-142-WT	204976.69	1269451.43	16.82	16.38
CG-142-40	204977.19	1269446.93	16.72	16.26
CG-143-WT	205522.29	1269339.23	15.73	15.43
CG-143-40	205522.79	1269332.63	15.67	15.24
CG-144-35	204984	1268831.31	15.43	15.18
CG-145-35	205130.7	1268842.81	15.42	15.11
CG-151-25	204170.4	1268749.6	11.65	11.31

Table 4-3
Soil Gas Port Construction Details

Phase	Well ID	General Well Information						Well Casing					Screen					Filter Pack		Seal	Conductor Casing		Surface Seal
		Contractor	Drilling Method	Installation Date	Abandonment Date	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft bgs)	Diameter (inches)	Material		Type of PVC joint	Centralizers	Diameter (inches)	Material		Slot Size (inches)	Screen Interval (ft bgs)	Type-Material	Filter Pack Interval (ft bgs)	Seal (ft bgs)	Conductor Casing o.d. (inches)	Conductor Casing Depth (ft bgs) from	
Post	CG-2-SG	PSC	Hollow Stem Auger	11/20/00	NA	5.25	5	1	Stainless	Steel	Threaded	NA	1	Stainless	Steel	0.02	4.5-5	Monterey Sand #212	4.25-5.25	0.5-4.25	12.5	0-5.25	Concrete, steel flush mount
Post	CG-3-SG	PSC	Hollow Stem Auger	11/20/00	NA	5.25	5	1	Stainless	Steel	Threaded	NA	1	Stainless	Steel	0.02	4.5-5	Monterey Sand #212	3.75-5.25	0.5-3.75	12.5	0-5.25	Concrete, steel flush mount
Post	CG-4-SG	PSC	Hollow Stem Auger	11/20/00	NA	8.25	8	1	Stainless	Steel	Threaded	NA	1	Stainless	Steel	0.02	7.5-8	Monterey Sand #212	7.25-8.25	0.5-7.25	12.5	0-8.25	Concrete, steel flush mount
Post	CG-5-SG	PSC	Hollow Stem Auger	11/20/00	NA	5.25	5	1	Stainless	Steel	Threaded	NA	1	Stainless	Steel	0.02	4.5-5	Monterey Sand #212	4.25-5.25	0.5-4.25	12.5	0-5.25	Concrete, steel flush mount
Post	CG-6-SG	PSC	Hollow Stem Auger	11/20/00	NA	8.25	8	1	Stainless	Steel	Threaded	NA	1	Stainless	Steel	0.02	7.5-8	Monterey Sand #212	7.25-8.25	0.5-7.25	12.5	0-8.25	Concrete, steel flush mount

Table 4-4
Soil Gas Port Survey Information

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point Elevation (feet, City of Seattle Datum)
CG-2-SG	205595.09	1272200.225	20.7	20.7
CG-3-SG	205505.29	1272284.925	21.01	21.01
CG-4-SG	205508.59	1272281.925	21.03	21.03
CG-5-SG	205634.79	1272281.925	20.96	20.96
CG-6-SG	205632.69	1272283.825	20.89	20.89

Table 4-5
SVE Well Construction Details

Phase	Well ID	General Well Information						Well Casing				
		Contractor	Drilling Method	Installation Date	Abandonment Date	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft bgs)	Diameter (inches)	Material		Type of PVC joint	Centralizers
2	V-1	Rainier Ground Testing	Hollow Stem Auger	11/11/91	NA	35	28	5	sch. 40	PVC	Threaded	NA
2	V-2	Rainier Ground Testing	Hollow Stem Auger	11/07/91	NA	19	17	2	sch. 40	PVC	Threaded	NA
2	V-3	Rainier Ground Testing	Hollow Stem Auger	11/08/91	NA	19	17	2	sch. 40	PVC	Threaded	NA
2	V-4	Rainier Ground Testing	Hollow Stem Auger	11/01/91	NA	30	16.8	2	sch. 40	PVC	Threaded	NA

Screen				Filter Pack		Seal	Conductor Casing		
Material		Slot Size (inches)	Screen Interval (ft bgs)	Type-Material	Filter Pack Interval (ft bgs)	Seal (ft bgs)	Conductor Casing #3 o.d. (inches)	Conductor Casing Depth (ft bgs) from	Surface Seal
. 40	PVC	0.30 wire wrap	28-Feb	Unimin Granusil Silica Sand #16/30	1.5 - 35	1-1.5	14	0-35	Stand-up steel casing
. 40	PVC	.02	17-Feb	Unimin Granusil Silica Sand #16/30	1.5-19	0.9-1.5	14	0-19	Stand-up steel casing
. 40	PVC	.02	17-Feb	Unimin Granusil Silica Sand #16/30	1.5-19	1-1.5	14	0-19	Stand-up steel casing
. 40	PVC	.02	2-16.8	Unimin Granusil Silica Sand #16/30	1.4-30	0.8-1.4	14	0-30	Stand-up steel casing

Table 4-4
Soil Gas Port Survey Information

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point Elevation (feet, City of Seattle Datum)
CG-2-SG	205595.09	1272200.225	20.7	20.7
CG-3-SG	205505.29	1272284.925	21.01	21.01
CG-4-SG	205508.59	1272281.925	21.03	21.03
CG-5-SG	205634.79	1272281.925	20.96	20.96
CG-6-SG	205632.69	1272283.825	20.89	20.89

Table 4-5
SVE Well Construction Details

Phase	Well ID	General Well Information						Well Casing				
		Contractor	Drilling Method	Installation Date	Abandonment Date	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft bgs)	Diameter (inches)	Material		Type of PVC joint	Centralizers
2	V-1	Rainier Ground Testing	Hollow Stem Auger	11/11/91	NA	35	28	5	sch. 40	PVC	Threaded	NA
2	V-2	Rainier Ground Testing	Hollow Stem Auger	11/07/91	NA	19	17	2	sch. 40	PVC	Threaded	NA
2	V-3	Rainier Ground Testing	Hollow Stem Auger	11/08/91	NA	19	17	2	sch. 40	PVC	Threaded	NA
2	V-4	Rainier Ground Testing	Hollow Stem Auger	11/01/91	NA	30	16.8	2	sch. 40	PVC	Threaded	NA

Table 4-5
SVE Well Construction Details

Well ID	Screen					Filter Pack		Seal	Conductor Casing		Surface Seal
	Diameter (inches)	Material		Slot Size (inches)	Screen Interval (ft bgs)	Type-Material	Filter Pack Interval (ft bgs)	Seal (ft bgs)	Conductor Casing #3 o.d. (inches)	Conductor Casing Depth (ft bgs) from	
V-1	5	Sch. 40	PVC	0.30 wire wrap	28-Feb	Unimin Granusil Silica Sand #16/30	1.5 - 35	1-1.5	14	0-35	Stand-up steel casing
V-2	2	Sch. 40	PVC	.02	17-Feb	Unimin Granusil Silica Sand #16/30	1.5-19	0.9-1.5	14	0-19	Stand-up steel casing
V-3	2	Sch. 40	PVC	.02	17-Feb	Unimin Granusil Silica Sand #16/30	1.5-19	1-1.5	14	0-19	Stand-up steel casing
V-4	2	Sch. 40	PVC	.02	2-16.8	Unimin Granusil Silica Sand #16/30	1.4-30	0.8-1.4	14	0-30	Stand-up steel casing

Table 4-6
SVE Well Survey Information

Well ID	Location		Survey Data	
	Northing Coordinate (feet)	Easting Coordinate (feet)	Ground Surface Elevation (feet)	Measuring Point Elevation (feet, City of Seattle Datum)
V-1	205790.59	1272507.13	17.79	17.32
V-2	205464.949	1272808.82	17.38	NA
V-3	205454.139	1272819.40	17.22	NA
V-4	205426.199	1272847.99	16.85	NA

Table 4-7
Initial Groundwater Monitoring Well
Development Details

Well ID	Development Details				
	Development Method	**Drilling Fluid Used**	**Drilling Fluid Type**	**GW Purged (gallons)**	**3-5 Vol:**
CG-101-S1	Bailer/pump	Yes	Water	225	yes
CG-101-S2	Bailer/pump	Yes	Water	110	yes
CG-102-D	Bailer/pump	NA	NA	35	yes
CG-102-I	Bailer/pump	NA	NA	300	yes
CG-102-S1	Bailer/pump	Yes	Water	300	yes
CG-102-S2	Bailer/pump	Yes	Water	460	yes
CG-103-I	Bailer/pump	NA	NA	580	yes
CG-103-S1	Bailer/pump	Yes	Water	300	yes
CG-103-S2	Bailer/pump	Yes	Water	495	yes
CG-104-D	Bailer/pump	NA	NA	70	no
CG-104-I	Bailer/pump	NA	NA	605	yes
CG-104-S1	Bailer/pump	Yes	Water	215	yes
CG-104-S2	Bailer/pump	NA	NA	440	yes
CG-105-I	Bailer/pump	Yes	Water	660	yes
CG-105-S1	Bailer/pump	Yes	Water	225	yes
CG-105-S2	Bailer/pump	Yes	Water	450	yes
CG-10-S1	Bailer/HomeliteWaterbug pump	NA	NA	100	yes
CG-10-S2	Bailer/HomeliteWaterbug pump	NA	NA	220	yes
CG-111-I	Bailer/pump	NA	NA	220	yes
CG-112-S1	Wattera Pump	No		27	yes
CG-113-S1	Wattera Pump	No		36	yes
CG-11-I	Grundfos EZ-Reel Submersible	NA	NA	30.5	no
CG-11-S1	Bailer/HomeliteWaterbug pump	NA	NA	110	yes
CG-11-S2	Bailer/HomeliteWaterbug pump	NA	NA	270	yes
CG-12-I	Grundfos EZ-Reel Submersible	NA	NA	63.32	yes
CG-1-D	Centrifugal Pump	Yes	Water	400	yes
CG-1-I	Bailer/HomeliteWaterbug pump	NA	NA	75	yes
CG-1-S1	Bailer/HomeliteWaterbug pump	NA	NA	100	yes
CG-1-S2	Bailer/HomeliteWaterbug pump	NA	NA	260	yes
CG-2-D	Bailer	Yes	Water	16	no
CG-2-I	Bailer/HomeliteWaterbug pump	NA	NA	55	no
CG-2-S1	Bailer/HomeliteWaterbug pump	NA	NA	160	yes
CG-2-S2	Bailer/HomeliteWaterbug pump	NA	NA	330	yes
CG-3	Centrifugal Pump	Yes	Water	45	yes
CG-4-D	Bailer/HomeliteWaterbug pump	NA	NA	55	no
CG-5-D	Bailer/HomeliteWaterbug pump	NA	NA	50	yes
CG-5-I	Bailer/HomeliteWaterbug pump	NA	NA	80	yes
CG-5-S1	Bailer/HomeliteWaterbug pump	NA	NA	60	yes
CG-5-S2	Bailer/HomeliteWaterbug pump	NA	NA	380	yes
CG-6-S1	Bailer/HomeliteWaterbug pump	NA	NA	110	yes
CG-6-S2	Bailer/HomeliteWaterbug pump	NA	NA	275	yes
CG-7-S1	Bailer/HomeliteWaterbug pump	NA	NA	80	yes
CG-7-S2	Bailer/HomeliteWaterbug pump	NA	NA	220	yes
CG-8-S1	Bailer/HomeliteWaterbug pump	NA	NA	140	yes
CG-8-S2	Bailer/HomeliteWaterbug pump	NA	NA	330	yes
CG-9-I	Bailer/HomeliteWaterbug pump	NA	NA	6 pv	yes
CG-9-S1	Bailer/HomeliteWaterbug pump	NA	NA	140	yes
CG-9-S2	Bailer/HomeliteWaterbug pump	NA	NA	350	yes
V-1	Not Available	NA	NA	Not Available	Not Available
CG-106-WT	In-line Whale Pumps	No	NA	70	yes
CG-106-I	In-line Whale Pumps	No	NA	110	yes
CG-106-D	In-line Whale Pumps	No	NA	160	yes
CG-107-WT	In-line Whale Pumps	No	NA	65	yes
CG-114-75	In-line Whale Pumps	No	NA	165	yes

Table 4-7
Initial Groundwater Monitoring Well Development Details

Well ID	Development Details				
	Development Method	Drilling Fluid Used	Drilling Fluid Type	GW Purged (gallons)	3-5 Vol:
CG-115-WT	In-line Whale Pumps	No	NA	65	yes
CG-115-75	In-line Whale Pumps	No	NA	160	yes
CG-119-40	In-line Whale Pumps	No	NA	120	yes
CG-120-75	In-line Whale Pumps	No	NA	170	yes
CG-121-40	In-line Whale Pumps	No	NA	115	yes
CG-121-70	In-line Whale Pumps	No	NA	150	yes
CG-122-WT	In-line Whale Pumps	No	NA	68	yes
CG-122-60	In-line Whale Pumps	No	NA	135	yes
CG-123-90	EZ Reel Submersible Grundfos Pump	No	NA	180	yes
CG-124-WT	In-line Whale Pumps	No	NA	70	yes
CG-124-40	In-line Whale Pumps	No	NA	110	yes
CG-124-70	In-line Whale Pumps	No	NA	160	yes
CG-125-40	In-line Whale Pumps	No	NA	110	yes
CG-126-WT	In-line Whale Pumps	No	NA	70	yes
CG-127-WT	In-line Whale Pumps	No	NA	75	yes
CG-127-40	In-line Whale Pumps	No	NA	115	yes
CG-128-WT	In-line Whale Pumps	No	NA	70	yes
CG-128-70	In-line Whale Pumps	No	NA	150	yes
CG-129-WT	In-line Whale Pumps	No	NA	68	yes
CG-129-40	In-line Whale Pumps	No	NA	75	yes
CG-130-WT	In-line Whale Pumps	No	NA	~55	yes
CG-131-WT	In-line Whale Pumps	No	NA	70	yes
CG-131-40	In-line Whale Pumps	No	NA	115	yes
CG-132-WT	In-line Whale Pumps	No	NA	70	yes
CG-132-40	In-line Whale Pumps	No	NA	120	yes
CG-133-40	In-line Whale Pumps	No	NA	110	yes
CG-134-WT	In-line Whale Pumps	No	NA	70	yes
CG-134-40	In-line Whale Pumps	No	NA	105	yes
CG-135-40	In-line Whale Pumps	No	NA	110	yes
CG-135-50	In-line Whale Pumps	No	NA	135	yes
CG-136-WT	In-line Whale Pumps	No	NA	85	yes
CG-136-40	In-line Whale Pumps	No	NA	115	yes
CG-137-WT	In-line Whale Pumps	No	NA	75	yes
CG-137-40	In-line Whale Pumps	No	NA	115	yes
CG-138-WT	In-line Whale Pumps	No	NA	80	yes
CG-138-40	In-line Whale Pumps	No	NA	110	yes
CG-138-70	In-line Whale Pumps	No	NA	150	yes
CG-139-40	In-line Whale Pumps	No	NA	80	yes
CG-140-WT	In-line Whale Pumps	No	NA	55	yes
CG-140-30	Submersible Pump	No	NA	162	yes
CG-140-40	In-line Whale Pumps	No	NA	120	yes
CG-141-WT	In-line Whale Pumps	No	NA	55	yes
CG-141-40	In-line Whale Pumps	No	NA	110	yes
CG-141-50	In-line Whale Pumps	No	NA	125	yes
CG-142-WT	In-line Whale Pumps	No	NA	75	yes
CG-142-40	In-line Whale Pumps	No	NA	120	yes
CG-143-WT	In-line Whale Pumps	No	NA	60	yes
CG-143-40	In-line Whale Pumps	No	NA	120	yes
CG-144-35	In-line Whale Pumps	No	NA	120	yes
CG-145-35	In-line Whale Pumps	No	NA	120	yes
CG-151-25	Submersible Pump	No	Water	187	yes

Table 4-8a
Groundwater Monitoring Program - 2004

		Permit Required Analyses									Other MTCA Required Analyses	
Method Requirements	**Water Levels**	**VOC by 8260**	**SVOC by 8270[1]**	**1,4-Dioxane by mod 8270***	**PCB by mod 8082**	**WA MTCA-EPH**	**WA MTCA-VPH**	**Total Metals by 6020 (Pb)**	**Total Metals by 6020 (As)**	**Cyanide by 9010B**	**Oxygenates[1] & n-hexane by 8260**	**1,2-Dibromoethane by 8011**
Bottle Requirements		4 x 40 ml vial	2 x 1L amber glass	1 x 1L amber glass	2 x 250 mL amber glass	2 x 1L amber glass	2 x 40 mL	2 x 250 mL poly	2 x 250 mL poly	1 x 500 mL poly	1 X 40 mL	1 x 1L amber glass
Preservative		HCl				HCl	HCl	HNO3	HNO3	NaOH	HCl	
CG-1-S1	1,2,3,4	4	4	4	4			4	4	4	4	
CG-205-S1	1,2,3,4	4	4	4	4			4	4	4	4	
CG-205-S2	1,2,3,4	4	4	4	4			4	4	4	4	
CG-205-I	1,2,3,4	4	4	4	4			4	4	4	4	
CG-3	1,2,3,4	4	4	4	4	4	4	4	4	4	4	
BF-01		1,2,3,4									1,2,3,4	
CG-10-S1	1,2,3,4	4	4	4	4			4	4	4	4	
CG-101-S1	1,2,3,4	4	4	4	4	4	4	4	4	4	4	
CG-101-S2	1,2,3,4	4	4	4	4	4	4		4		4	
CG-102-S1 *	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-9-102-S1	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-102-S2	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-102-I	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4	4	1,2,3,4	
CG-102-D	1,2,3,4	1,4	4	4		4	4	4	4	4	1,4	
CG-103-S1	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4		4		1,2,3,4	
CG-103-S2	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4		4		1,2,3,4	
CG-103-I *	1,2,3,4	1,2,3,4	1,4	1,4				4	4	4	1,2,3,4	
CG-9-103-I	1,2,3,4	1,2,3,4	1,4	1,4				4	4	4	1,2,3,4	
CG-104-S1	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4		4		1,2,3,4	
CG-104-S2	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4	4	4		1,2,3,4	
CG-104-I *[2]	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4	4	1,2,3,4	
CG-9-104-I	1,2,3,4	1,2,3,4	1,4	1,4				4	4	4	1,2,3,4	
CG-104-D	1,2,3,4	1,4	4	4				4	1,4	4	1,4	
BF-02		1,2,3,4									1,2,3,4	
CG-106-WT	1,2,3,4	4	4	4	4	4	4	4	4	4	4	
CG-106-I	1,2,3,4	4	4	4		4	4	4	4	4	4	
CG-106-D	1,2,3,4	4	4	4		4	4	4	4	4	4	
CG-107-WT	1,2,3,4	4	4	4	4			4	4	4	4	
CG-111-I	1,2,3,4	4	4	4		4	4	4	4	4	4	
CG-112-S1	1,2,3,4	1,2,3,4	1,4	1,4	4				4		1,2,3,4	
CG-113-S1	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4	4	1,2,3,4	
CG-114-75	1,2,3,4	1,2,3,4	1,4	1,4				4	1,4	1,4	1,2,3,4	
CG-115-WT	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4	4	4		1,2,3,4	
CG-115-75	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4	1,4	1,2,3,4	
CG-119-40	1,2,3,4	1,2,3,4	1,4	1,4	4	4	4		4		1,2,3,4	
CG-120-75	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	1,4	4	1,2,3,4	
CG-121-40	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-121-70	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	1,4	1,4	1,2,3,4	
CG-122-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-122-60	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	1,4	4	1,2,3,4	
CG-123-90	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4	4	1,2,3,4	

Table 4-8a
Groundwater Monitoring Program - 2004

		Permit Required Analyses									Other MTCA Required Analyses	
Method Requirements	**Water Levels**	**VOC by 8260**	**SVOC by 8270^1**	**1,4-Dioxane by mod 8270***	**PCB by mod 8082**	**WA MTCA-EPH**	**WA MTCA-VPH**	**Total Metals by 6020 (Pb)**	**Total Metals by 6020 (As)**	**Cyanide by 9010B**	**Oxygenates^1 & n-hexane by 8260**	**1,2-Dibromoethane by 8011**
Bottle Requirements		4 x 40 ml vial	2 x 1L amber glass	1 x 1L amber glass	2 x 250 mL amber glass	2 x 1L amber glass	2 x 40 mL	2 x 250 mL poly	2 x 250 mL poly	1 x 500 mL poly	1 X 40 mL	1 x 1L amber glass
Preservative		HCl				HCl	HCl	HNO3	HNO3	NaOH	HCl	
CG-9-123-90*	1,2,3,4	1,2,3,4	1,4	1,4				4	4	4	1,2,3,4	
BF-03		1,2,3,4										
CG-124-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-124-40	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-124-70	1,2,3,4	1,2,3,4	1,4	1,4		4	4	1,4	1,4	4	1,2,3,4	
CG-125-40	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-126-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-127-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-127-40	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-128-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-128-70	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4	4	1,2,3,4	
CG-129-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4	4	4		1,2,3,4	
CG-129-40	1,2,3,4	1,2,3,4	1,4	1,4					4		1,2,3,4	
CG-130-WT	1,2,3,4	1,2,3,4	1,4	1,4					4		1,2,3,4	
CG-131-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-131-40	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-132-WT	1,2,3,4	1,2,3,4	1,4	1,4		4	4		4		1,2,3,4	
CG-132-40	1,2,3,4	1,2,3,4	1,4	1,4					4		1,2,3,4	
CG-133-40	1,2,3,4	1,2,3,4		1,4								
CG-134-WT	1,2,3,4	1,2,3,4		1,4								
CG-134-40	1,2,3,4	1,2,3,4		1,4								
CG-135-40	1,2,3,4	1,2,3,4		1,4								
BF-04		1,2,3,4		1,4								
CG-135-50	1,2,3,4	1,2,3,4										
CG-136-WT	1,2,3,4	1,2,3,4										
CG-136-40	1,2,3,4	1,2,3,4										
CG-137-WT	1,2,3,4	1,2,3,4										
CG-137-40	1,2,3,4	1,2,3,4										
CG-138-WT	1,2,3,4	1,2,3,4										
CG-138-40	1,2,3,4	1,2,3,4										
CG-138-70	1,2,3,4	1,2,3,4										
CG-139-40	1,2,3,4	1,2,3,4										
CG-140-WT	1,2,3,4											
CG-140-30	1,2,3,4	1,2,3,4										
CG-140-40	1,2,3,4	1,2,3,4										
CG-141-WT	1,2,3,4	1,2,3,4										
CG-141-40	1,2,3,4	1,2,3,4										
CG-141-50	1,2,3,4	1,2,3,4										
CG-142-WT	1,2,3,4	1,2,3,4										
CG-142-40	1,2,3,4	1,2,3,4										
CG-143-WT	1,2,3,4	1,2,3,4										

Table 4-8a
Groundwater Monitoring Program - 2004

		Permit Required Analyses									Other MTCA Required Analyses	
Method Requirements	**Water Levels**	**VOC by 8260**	**SVOC by 8270[1]**	**1,4-Dioxane by mod 8270***	**PCB by mod 8082**	**WA MTCA-EPH**	**WA MTCA-VPH**	**Total Metals by 6020 (Pb)**	**Total Metals by 6020 (As)**	**Cyanide by 9010B**	**Oxygenates[1] & n-hexane by 8260**	**1,2-Dibromoethane by 8011**
Bottle Requirements		4 x 40 ml vial	2 x 1L amber glass	1 x 1L amber glass	2 x 250 mL amber glass	2 x 1L amber glass	2 x 40 mL	2 x 250 mL poly	2 x 250 mL poly	1 x 500 mL poly	1 X 40 mL	1 x 1L amber glass
Preservative		HCl				HCl	HCl	HNO3	HNO3	NaOH	HCl	
CG-143-40	1,2,3,4	1,2,3,4										
CG-144-35	1,2,3,4	1,2,3,4										
CG-145-35	1,2,3,4	1,2,3,4										
CG-151-25	1,2,3,4	1,2,3,4										
V-1	1,2,3,4	4										
Trip Blanks (15 Days)		1,2,3,4					4					

1 = Beginning of February 3 = Beginning of August
2 = Beginning of May 4 = Middle of October to Beginning of November
* Extra volume for MS/MSD

[1] Oxygenates include: tert-butyl alcohol, ethanol, 1,2-dibromomethane, diisopropyl ether, MTBE, and tert-amyl methyl ether.

[2] Well CG-104-I is sampled for Appendix IX analyses biennially. The next sampling event is scheduled for 1Q04.

Highlighted analyses should be run by standard method first, then if possible, rerun by SIM to reach RL Goals. This may not always be possible due to matrix interference, etc... Use a * on COC to indicate and text *"Samples with a * should have VOCs and SVOCs run for 5 day TAT, if the results indicate that 25 ml purge or SIM analyses can be run to achieve the reporting limits goals, then the lab should run the samples for such low-level analyses at that time"*

EPH/VPH analyses that are voluntary - not required by permit mod 59-1

Table 4-8b
Natural Attenuation Groundwater Monitoring Program

Natural Attenuation Monitoring Program

Method Requirements	Water Quality Parameters (DO, eh, pH, temp, Spec Cond)	Field Test for Ferrous Iron	Methane, Ethene, Ethane by RSK 175	Nitrate by 300	TOC by 415.1	Sulfate by 300	Bicarbonate Alkalinity by SM2320B
Bottle Requirements	**Field Test**	**Field Test**	3 x 40 mL	H2SO4	1 x 250 ml amb septum	1 x 500 mL poly filtered	1 x 500 mL poly
Preservative	**none**	**none**	HCl	1 x 500mL	H2SO4		
CG-104-S1	1,4	1,4	1,4	1,4	1,4	1,4	1,4
BF01	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-104-S2	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-104-I*	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-104-D	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-106-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-106-I	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-9-104-I	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-106-D	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-124-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-124-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-124-70	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-127-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-127-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-128-70	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-130-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-134-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-134-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-135-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-141-WT	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-141-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-143-40	1,4	1,4	1,4	1,4	1,4	1,4	1,4
CG-144-35	1,4	1,4	1,4	1,4	1,4	1,4	1,4
Trip Blanks (10 Days)			1,4				

1 = Beginning of February
4 = Middle of October to Beginning of November

Table 4-9
Groundwater Monitoring Well
Sampling Frequency

Monitoring Well Name	Water Quality Monitoring Frequency	Water Level Elevation Measurement Frequency*
CG-1-S1	Quarterly 1992- 4th qtr 2001/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-1-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-1-I	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-1-D	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-2-S1	Quarterly 1992- 4th qtr 2001/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-2-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-2-I	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through 1st qtr 2002
CG-2-D	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through 4th qtr 2001
CG-3	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-4-D	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through 4th qtr 2001
CG-5-S1	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-5-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-5-I	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-5-D	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-6-S1	Quarterly 1992- 4th qtr 2000/Semi-annually through 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-6-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-7-S1	Quarterly 1992- 4th qtr 2000/Semi-annually through 2001	Monthly 18 mos./Quarterly through April 2002
CG-7-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-8-S1	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-8-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-9-S1	Quarterly 1992- 4th qtr 2001/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-9-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-9-I	Quarterly 1992- 4th qtr 2001	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-10-S1	Quarterly 1992- 4th qtr 2001/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-10-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-11-S1	Quarterly 1993-4th qtr 2001/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-11-S2	Quarterly 1992-4th qtr 1994	Monthly 18 mos./Quarterly through 1995
CG-11-I	Quarterly 4th qtr 1998- 4th qtr 2001	Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-12-I	Quarterly 4th qtr 1998- 4th qtr 2001	Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-101-S1	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-102-S1	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-102-S2	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-102-I	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-102-D	Quarterly 1992- 1st qtr 2003/Semi-annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-103-S1	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-103-S2	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-103-I	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-104-S1	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-104-S2	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-104-I	Quarterly 1992- present	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-104-D	Quarterly 1992- 1st qtr 2003/Semi-annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-105-S1	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-105-S2	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-105-I	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-106-WT	Quarterly May 2002 - 1st qtr 2003/Annually	Monthly 12 mos./Quarterly
CG-106-I	Quarterly May 2002 - 1st qtr 2003/Annually	Monthly 12 mos./Quarterly
CG-106-D	Quarterly May 2002 - 1st qtr 2003/Annually	Monthly 12 mos./Quarterly
CG-107-WT	Quarterly May 2002 - 1st qtr 2003/Annually	Monthly 12 mos./Quarterly
CG-111-I	Quarterly 1992- 1st qtr 2003/Annually	Monthly 18 mos./Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-112-S1	Quarterly 2001- present	Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-113-S1	Quarterly 2001- present	Quarterly through April 2002/Monthly 12 mos./Quarterly
CG-114-75	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-115-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-115-75	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-119-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-120-75	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-121-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-121-70	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-122-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-122-60	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-123-90	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-124-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-124-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-124-70	Quarterly May 2002 - present	Monthly 12 mos./Quarterly

Table 4-9
Groundwater Monitoring Well
Sampling Frequency

Monitoring Well Name	Water Quality Monitoring Frequency	Water Level Elevation Measurement Frequency*
CG-125-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-126-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-127-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-127-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-128-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-128-70	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-129-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-129-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-130-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-131-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-131-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-132-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-132-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-133-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-134-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-134-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-135-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-135-50	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-136-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-136-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-137-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-137-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-138-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-138-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-138-70	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-139-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-140-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-140-30	Quarterly August 2003 - present	Quarterly
CG-140-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-141-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-141-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-141-50	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-142-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-142-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-143-WT	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-143-40	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-144-35	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-145-35	Quarterly May 2002 - present	Monthly 12 mos./Quarterly
CG-151-25	Not in monitoring program (sampled once 9/03)	Quarterly
G-1	1982-1988	Periodically
G-2	1982-1988	Periodically
G-3	1982-1988	Periodically
G-4	1982-1988	Periodically
G-5	1982-1988	Periodically
G-6	1982-1988	Periodically
G-7	1982-1988	Periodically
G-8	1982-1988	Periodically
G-9	1982-1988	Periodically
HC-1	1982-1988	Periodically
HC-2	1982-1988	Periodically
HC-3	1982-1988	Periodically
HC-4	1982-1988	Periodically
HC-5	1982-1988	Periodically
HC-6	1982-1988	Periodically
HC-7	1982-1988	Periodically
HC-8	1982-1988	Periodically
HC-9	1982-1988	Periodically
HC-10	1982-1988	Periodically

*Monthly X Mos./Quarterly = monthly for the first X months of pre-corrective action monitoring and quarterly thereafter.

Table 4-10
Natural Attenuation Sampling Frequency
Georgetown Facility

			Analyte																							
Quarter	Year	Well	Methane/Ethane/ Ethene	TOC	Hardness	Total Sulfide	TDS	Total Alkalinity	IC Acid Scan	Nitrite	Nitrate	Total Coliform	CO2	Salinity	Fe+2	Fe+3	Sulfate	Floride	Chloride	Dissolved Maganese	Total Maganes	Ammonia	Calcium	Magnesium	Potassium	Sodium
4th	1999	CG-9-S1	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
		CG-9-I	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
		CG-101-S1	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
		CG-104-S1	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
		CG-104-I	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
		CG-111-I	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x							
1st	2000	CG-9-S1	x	x				x			x		x		x		x		x							
		CG-9-I	x	x				x			x		x		x		x		x							
		CG-101-S1	x	x				x			x		x		x		x		x							
		CG-11-S1	x	x		x		x	x	x	x		x		x	x	x		x	x						
		CG-11-I	x	x		x		x	x	x	x		x		x	x	x		x	x						
		CG-104-S1	x	x				x			x		x		x		x		x							
		CG-104-I	x	x				x			x		x		x		x		x							
		CG-105-S1	x	x		x		x	x	x	x		x		x	x	x		x	x						
		CG-105-I	x	x		x		x	x	x	x		x		x	x	x		x	x						
		CG-111-I	x	x				x			x		x		x		x		x							
2nd		CG-9-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-11-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
3rd		CG-9-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-9-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-11-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
4th		CG-9-S1	x	x		x		x		x	x						x		x	x						
		CG-9-I	x	x		x		x		x	x						x		x	x						
		CG-11-S1	x	x		x		x		x	x						x		x	x						
		CG-11-I	x	x		x		x		x	x						x		x	x						
		CG-101-S1	x	x		x		x		x	x						x		x	x						
		CG-104-S1	x	x		x		x		x	x						x		x	x						
		CG-104-S2	x	x		x		x		x	x						x		x	x						
		CG-104-I	x	x		x		x		x	x						x		x	x						
		CG-105-S1	x	x		x		x		x	x						x		x	x						
		CG-105-S2	x	x		x		x		x	x						x		x	x						
		CG-105-I	x	x		x		x		x	x						x		x	x						
		CG-111-I	x	x		x		x		x	x						x		x	x						
1st	2001	CG-9-S1	x	x		x		x		x	x		x			x	x		x	x	x					
		CG-9-I	x	x		x		x		x	x		x			x	x		x	x	x					
		CG-10-S1	x																							
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-11-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-12-I	x																							
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x	x	x					
		CG-111-I	x				x																			
		CG-113-S1	x	x		x		x		x	x		x		x	x	x		x	x	x					
2nd		CG-1-D					x																			
		CG-2-D					x																			
		CG-4-D					x																			
		CG-5-D					x																			
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-11-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-9-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-9-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-102-D					x																			
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-D					x																			
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-113-S1	x	x		x		x		x	x		x		x	x	x		x							
3rd		CG-1-S1				x																				
		CG-1-I				x																				
		CG-1-D				x	x																			
		CG-2-S1				x																				
		CG-2-I				x																				
		CG-2-D				x	x																			
		CG-3				x																				
		CG-4-D				x	x																			
		CG-5-S1				x																				
		CG-5-I				x																				
		CG-5-D				x	x																			
		CG-8-S1				x																				
		CG-9-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-9-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-10-S1				x																				
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x							

Table 4-10
Natural Attenuation Sampling Frequency
Georgetown Facility

Quarter	Year	Well	Analyte Methane/Ethane/ Ethene	TOC	Hardness	Total Sulfide	TDS	Total Alkalinity	IC Acid Scan	Nitrite	Nitrate	Total Coliform	CO2	Salinity	Fe+2	Fe+3	Sulfate	Floride	Chloride	Dissolved Maganese	Total Maganese	Ammonia	Calcium	Magnesium	Potassium	Sodium
4th		CG-11-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-12-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-102-S1				x																				
		CG-102-S2				x																				
		CG-102-I				x																				
		CG-102-D				x	x																			
		CG-103-S1				x																				
		CG-103-S2				x																				
		CG-103-I				x																				
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-D				x	x																			
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-112-S1				x																				
		CG-113-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-1-S1				x																				
		CG-1-I				x																				
		CG-1-D				x	x																			
		CG-2-S1				x																				
		CG-2-I				x																				
		CG-2-D				x	x																			
		CG-3				x																				
		CG-4-D				x	x																			
		CG-5-S1				x																				
		CG-5-I				x																				
		CG-5-D				x	x																			
		CG-6-S1				x																				
		CG-7-S1				x	x																			
		CG-8-S1				x																				
		CG-9-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-9-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-10-S1				x																				
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-11-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-12-I				x																				
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-102-S1				x																				
		CG-102-S2				x																				
		CG-102-I				x																				
		CG-102-D				x	x																			
		CG-103-S1				x																				
		CG-103-S2				x																				
		CG-103-I				x																				
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-D				x	x																			
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-112-S1				x																				
		CG-113-S1	x	x		x		x		x	x		x		x	x	x		x							
1st	2002	CG-1-S1				x																				
		CG-2-S1				x																				
		CG-3				x																				
		CG-9-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-10-S1				x																				
		CG-11-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-101-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-102-S1				x																				
		CG-102-S2				x																				
		CG-102-I				x																				
		CG-102-D				x	x																			
		CG-103-S1				x																				
		CG-103-S2				x																				
		CG-103-I				x																				
		CG-104-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-104-D				x	x																			
		CG-105-S1	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-S2	x	x		x		x		x	x		x		x	x	x		x							
		CG-105-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-111-I	x	x		x		x		x	x		x		x	x	x		x							
		CG-112-S1				x																				
		CG-113-S1	x	x		x		x		x	x		x		x	x	x		x							
2nd		CG-3	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-11-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-101-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-102-S1				x															x					
		CG-102-S2				x															x					
		CG-102-I				x															x					
		CG-102-D				x															x					
		CG-103-S1				x															x					
		CG-103-S2				x															x					
		CG-103-I				x															x					
		CG-104-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x

Table 4-10
Natural Attenuation Sampling Frequency
Georgetown Facility

Quarter	Year	Well	Analyte																						
			Methane/Ethane/ Ethene	TOC	Hardness	Total Sulfide	TDS	Total Alkalinity	IC Acid Scan	Nitrite	Nitrate	Total Coliform	CO2	Salinity	Fe+2	Fe+3	Sulfate	Floride	Chloride	Dissolved Maganese	Total Maganes	Ammonia	Calcium	Magnesium	Potassium	Sodium
		CG-106-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-107-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-111-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-112-S1				x															x					
		CG-113-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-114-75				x															x					
		CG-115-WT				x															x					
		CG-115-75				x															x					
		CG-119-40				x															x					
		CG-120-75				x															x					
		CG-121-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-121-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-60	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-123-90	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-125-40				x															x					
		CG-126-WT				x															x					
		CG-127-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-127-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-128-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-130-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-135-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-144-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-145-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
3rd		CG-3	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-101-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-102-S1				x															x					
		CG-102-S2				x															x					
		CG-102-I				x															x					
		CG-102-D				x															x					
		CG-103-S1				x															x					
		CG-103-S2				x															x					
		CG-103-I				x															x					
		CG-104-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-107-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-111-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-112-S1				x															x					
		CG-113-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-114-75				x															x					
		CG-115-WT				x															x					
		CG-115-75				x															x					
		CG-119-40				x															x					
		CG-120-75				x															x					
		CG-121-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-121-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-60	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-123-90	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-125-40				x															x					
		CG-126-WT				x															x					
		CG-127-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-127-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-128-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-130-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-135-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-144-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-145-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
4th		CG-3	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-101-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-102-S1																			x					
		CG-102-S2																			x					
		CG-102-I																			x					
		CG-102-D																			x					
		CG-103-S1																			x					
		CG-103-S2																			x					
		CG-103-I																			x					
		CG-104-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x

Table 4-10
Natural Attenuation Sampling Frequency
Georgetown Facility

Quarter	Year	Well	Analyte																					
			Methane/Ethane/ Ethene	TOC	Hardness	Total Sulfide	TDS	Total Alkalinity	IC Acid Scan	Nitrite	Nitrate	Total Coliform	CO2	Salinity	Fe+2	Fe+3	Sulfate	Floride	Chloride	Dissolved Maganese	Total Maganes	Ammonia	Calcium	Magnesium	Potassium	Sodium
		CG-104-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-107-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-111-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-112-S1													x						x					
		CG-113-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-114-75													x						x					
		CG-115-WT													x						x					
		CG-115-75													x						x					
		CG-119-40													x						x					
		CG-120-75																			x					
		CG-121-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-121-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-60	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-123-90	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-125-40																			x					
		CG-126-WT																			x					
		CG-127-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-127-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-128-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-130-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-135-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-144-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-145-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
1st	2003	CG-3	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-101-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-102-S1																			x					
		CG-102-S2																			x					
		CG-102-I																			x					
		CG-102-D																			x					
		CG-103-S1																			x					
		CG-103-S2																			x					
		CG-103-I																			x					
		CG-104-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-104-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-S2	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-105-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-106-D	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-107-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-111-I	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-112-S1																			x					
		CG-113-S1	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-114-75																			x					
		CG-115-WT																			x					
		CG-115-75																			x					
		CG-119-40																			x					
		CG-120-75																			x					
		CG-121-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-121-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-122-60	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-123-90	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-124-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-125-40																			x					
		CG-126-WT																			x					
		CG-127-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-127-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-128-70	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-130-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-134-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-135-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-140-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-141-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-WT	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-143-40	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-144-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x
		CG-145-35	x	x		x	x	x		x	x		x		x	x	x		x		x	x	x	x	x	x

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

				Analysis								
Phase	Source	Sample Location	Depth (ft bgs)	VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
Pre-Phase I Hydrogeologic Investigation	Sweet-Edwards/Emcon & Associates, 1987	CG-1	10	x	x	x	x		x	x		
			20	x	x	x	x		x	x		
			30	x	x		x		x	x		
			40	x	x		x		x	x		
			51	x	x		x		x	x		
			59	x	x		x		x	x		
			74	x	x		x		x	x		
			81	x	x		x		x	x		
			89.3	x	x		x		x	x		
		CG-2	19.5	x	x		x		x	x		
			34	x	x		x		x	x		
			59	x	x		x		x	x		
			80	x	x		x		x	x		
Phase II, Hydrogeologic Investigation	Sweet-Edwards/Emcon & Associates, 1990	TB-1	7-10	x		x			x	x	x	
			20-23	x		x			x	x	x	
			30.5-33.5	x		x			x	x	x	
		TB-2	6-9	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
			29-32	x		x			x	x	x	
		TB-3	6.5-9.5	x		x			x	x	x	
			19-22	x		x			x	x	x	
			34-37	x		x			x	x	x	
		TB-4	5-8	x		x			x	x	x	
			18-21	x		x			x	x	x	
			30-33	x		x			x	x	x	
		TB-5	7.5-10.5	x		x			x	x	x	
			19-22	x		x			x	x	x	
			41-44	x		x			x	x	x	
		TB-6	9-12	x		x			x	x	x	
			19-22	x		x			x	x	x	
			28.5-31.5	x		x			x	x	x	
		TB-7	9-12	x		x			x	x	x	
			19-22	x		x			x	x	x	
			47-50	x		x			x	x	x	
		TB-8	9.5-12.5	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
			38-41	x		x			x	x	x	
		TB-9	9-12	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
			37.5-40.5	x		x			x	x	x	
		TB-10	'8-11	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
			37-40	x		x			x	x	x	
		TB-11	8-11	x		x			x	x	x	
			19-22	x		x			x	x	x	
		TB-12	6-9	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
		TB-13	6.5-9.5	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
		TB-14	6-9	x		x			x	x	x	
			18.5-21.5	x		x			x	x	x	
			33-36	x		x			x	x	x	
Phase III Hydrogeologic Investigation	Burlington Environmental, Inc., 1993	GW-01	12-14	x								
		GW-02	12-14	x								
		GW-03	13-14	x								
		GW-04	13-14	x								
		GW-05	13-14	x								
		GW-06	13-14	x								
		GW-07	13-14	x								
		GW-08	13-14	x								
		GW-09	13-14	x								
		GW-10	13-14	x								
		GW-11	13-14	x								
		GW-12	13-15	x								
		GW-13	13-15	x								
		GW-14	13-15	x								
		GW-15	13-15	x								
		GW-16	12-14	x								
		GW-17	12-14	x								
		GW-103	12-14	x								
		GW-104	12-14	x								
	Burlington Environmental, Inc. 1994	RW-1		x								
		RW-2		x								
		RW-3		x								
		RW-4		x								
		RW-5		x								
		RW-6		x								
		RW-7		x								
		RW-8		x								
		RW-9		x								
		RW-10		x								
		RW-11		x								
		RW-12		x								
		RW-13		x								
		RW-14		x								
		RW-15		x								

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		RW-16		x								
		RW-17		x								
		RW-18		x								
		RW-19		x								
		RW-20		x								
Post-Phase III Investigations	Philip Services Corp., 1999	CG-12-I	15	x		x		x	x			x
			29	x		x						
Post-Phase III Investigations	Philip Services Corp., 1998	HP98-A4	14	x								
			30	x								
			45	x								
			67	x								
		HP98-A6	15	x								
			30	x								
			45	x								
			74	x								
		HP98-B1	14	x								
			30	x								
			45	x								
			68	x								
		HP98-B5	15	x								
			30	x								
			45	x								
			68.5	x								
		HP98-B7	15	x								
			30	x								
			45	x								
			75	x								
		HP98-C2	15	x								
			30	x								
			45	x								
			65	x								
		HP98-C4	16	x								
			30	x								
			45	x								
			64	x								
		HP98-C6	-15	x								
			30	x								
			45	x								
			70	x								
		HP98-D3	15	x								
			30	x								
			45	x								
			63	x								
		HP98-D7	15	x								
			30	x								
		HP98-D8	45	x								
			74	x								
		HP98-E4	15	x								
			30	x								
			45	x								
			60	x								
		HP98-F3	15	x								
			30	x								
			45	x								
			60	x								
		HP98-F5	15	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-F7	15	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-G4	15	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-G6	20	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-H3	15	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-H5	20	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-H7	45	x								

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
			60	x								
			72	x								
		HP98-I4	20	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-I6	20	x								
			30	x								
			45	x								
			60	x								
			75	x								
		HP98-J3	20	x								
			30	x								
			45	x								
			60	x								
			68	x								
		HP98-J5	20	x								
			30	x								
			45	x								
			60	x								
			75	x								
Post-Phase III Investigations	Philip Services Corp., Oct. 2000	A1	15	x	x					x		
		A1-30-1000	30	x	x					x		
		A24-15-0201	15	x	x					x		
		A24-30-0201	30	x	x					x		
		A24-45-0201	45	x	x							
		A3-15-1000	15	x	x							
		A3-30-1000	30	x	x							
		A8-15-1000	15	x	x							
		A8-30-1000	30	x	x							
		A8-45-1000	45	x	x							
		A8-60-1000	60	x	x							
		A9-15-1100	15	x	x							
		A9-30-1100	30	x	x							
		A9-45-1100	45	x	x							
		B12-15-1000	15	x	x							
		B12-30-1000	30	x	x							
		B12-45-1000	45	x	x							
		B9-15-1100	15	x	x							
		B9-30-1100	30	x	x							
		B9-45-1100	45	x	x							
		B9-60-1100	60	x	x							
		C7-15-1000	15	x	x					x		
		C7-30-1000	30	x	x					x		
		C7-45-1000	45	x	x					x		
		C7-60-1000	60	x	x					x		
		C7-75-1000	75	x	x					x		
		D10-13-1000	13	x	x					x		
		D10-15-1100	15	x	x					x		
		D10-23-1000	23	x	x					x		
		D10-30-1100	30	x	x							
		D10-33-1000	33	x	x							
		D10-43-1000	43	x	x							
		D10-45-1100	45	x	x							
		D10-53-1000	53	x	x							
		D10-58-1000	58	x	x							
		D10-60-1100	60	x	x							
		D10-68-1000	68	x	x							
		D10-74-1000	74	x	x							
		D11-13-1000	13	x	x							
		D11-23-1000	23	x	x							
		D1-13-1000	13	x	x							
		D11-33-1000	33	x	x							
		D1-14-1000	14	x	x							
		D11-43-1000	43	x	x							
		D11-53-1000	53	x	x							
		D11-60-1000	60	x	x							
		D11-74-1000	74	x	x							
		D12-13-1000	13	x	x							
		D12-23-1000	21	x	x							
		D12-33-1000	33	x	x							
		D1-24-1000	24	x	x							
		D12-43-1000	43	x	x							
		D12-53-1000	53	x	x							
		D12-63-1000	63	x	x							
		D12-73-1000	73	x	x							
		D13-13-1000	13	x	x							
		D13-15-1000	15	x	x							
		D13-23-1000	23	x	x							
		D13-30-1000	30	x	x							
		D13-33-1000	33	x	x							
		D1-34-1000	34	x	x							
		D13-43-1000	43	x	x							
		D13-45-1000	45	x	x							
		D13-53-1000	53	x	x							

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		D13-60-1000	60	x	x							
		D13-63-1000	63	x	x							
		D13-73-1000	73	x	x							
		D14-13-1000	13	x	x							
		D14-23-1000	23	x	x							
		D14-33-1000	33	x	x							
		D1-44-1000	44	x	x							
		D14-43-1000	43	x	x							
		D14-53-1000	53	x	x							
		D14-63-1000	63	x	x							
		D14-68-1000	68	x	x							
		D14-78-1000	78	x	x							
		D15-13-1000	13	x	x							
		D15-23-1000	23	x	x							
		D15-33-1000	33	x	x							
		D1-54-1000	54	x	x							
		D15-43-1000	43	x	x							
		D15-53-1000	53	x	x							
		D15-63-1000	63	x	x							
		D15-73-1000	73	x	x							
		D16-13-1000	13	x	x							
		D16-23-1000	23	x	x							
		D16-33-1000	33	x	x							
		D1-64-1000	64	x	x							
		D16-43-1000	43	x	x							
		D16-53-1000	53	x	x							
		D16-63-1000	63	x	x							
		D16-70-1000	70	x	x							
		D17-13-1000	13	x	x							
		D17-23-1000	23	x	x							
		D17-33-1000	33	x	x							
		D1-74-1000	74	x	x							
		D17-43-1000	43	x	x							
		D17-53-1000	53	x	x							
		D17-63-1000	63	x	x							
		D17-73-1000	73	x	x							
		D18-13-1000	13	x	x							
		D18-23-1000	23	x	x							
		D18-33-1000	33	x	x							
		D18-43-1000	43	x	x							
		D18-53-1000	53	x	x							
		D18-63-1000	63	x	x							
		D18-73-1000	73	x	x							
		D19-13-1000	13	x	x							
		D19-23-1000	23	x	x							
		D19-33-1000	33	x	x							
		D19-43-1000	43	x	x					x		
		D19-53-1000	53	x	x					x		
		D19-63-1000	63	x	x					x		
		D19-73-1000	73	x	x					x		
		D19-82-1000	82	x	x					x		
		D20-13-1000	13	x	x							
		D20-23-1000	23	x	x							
		D20-33-1000	33	x	x							
		D20-43-1000	43	x	x							
		D20-53-1000	53	x	x							
		D20-63-1000	63	x	x							
		D20-73-1000	73	x	x							
		D21-13-1000	13	x	x							
		D21-23-1000	23	x	x							
		D21-33-1000	33	x	x							
		D2-14-1000	14	x	x							
		D21-43-1000	43	x	x							
		D21-53-1000	53	x	x							
		D21-63-1000	63	x	x							
		D21-76-1000	76	x	x							
		D22-13-1000	13	x	x							
		D22-23-1000	23	x	x							
		D22-33-1000	33	x	x							
		D2-24-1000	24	x	x							
		D22-43-1000	43	x	x							
		D22-53-1000	53	x	x							
		D22-63-1000	63	x	x							
		D22-73-1000	73	x	x							
		D22-83-1000	83	x	x							
		D23-13-1000	13	x	x							
		D23-23-1000	23	x	x							
		D23-33-1000	33	x	x							
		D2-34-1000	34	x	x							
		D23-43-1000	43	x	x							
		D23-53-1000	53	x	x							
		D23-63-1000	63	x	x							
		D23-73-1000	73	x	x							
		D24-13-1000	13	x	x							
		D2-42-1000	42	x	x							
		D24-23-1000	23	x	x							

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		D24-33-1000	33	x	x							
		D24-43-1000	43	x	x							
		D24-53-1000	53	x	x							
		D24-63-1000	63	x	x							
		D24-73-1000	73	x	x							
		D25-13-1000	13	x	x							
		D25-17-1000	17	x	x							
		D2-52-1000	52	x	x							
		D25-26-1000	26	x	x							
		D25-36-1000	36	x	x							
		D25-46-1000	46	x	x							
		D25-56-1000	56	x	x							
		D25-66-1000	66	x	x							
		D25-76-1000	76	x	x							
		D26-13-1000	13	x	x							
		D2-62-1000	62	x	x							
		D26-23-1000	23	x	x							
		D26-33-1000	33	x	x							
		D26-43-1000	43	x	x							
		D26-53-1000	53	x	x							
		D26-63-1000	63	x	x							
		D26-73-1000	73	x	x							
		D27-13-1000	13	x	x							
		D27-23-1000	23	x	x							
		D27-33-1000	33	x	x							
		D27-43-1000	43	x	x							
		D27-53-1000	53	x	x							
		D27-63-1000	63	x	x							
		D28-13-1000	13	x	x							
		D28-23-1000	23	x	x							
		D28-33-1000	33	x	x							
		D28-43-1000	43	x	x							
		D28-53-1000	53	x	x							
		D28-63-1000	63	x	x							
		D28-73-1000	73	x	x							
		D29-13-1000	-13	x	x							
		D29-23-1000	23	x	x							
		D29-33-1000	33	x	x					x		
		D29-43-1000	43	x	x					x		
		D29-53-1000	53	x	x					x		
		D29-63-1000	63	x	x					x		
		D29-73-1000	73	x	x					x		
		D30-13-1000	13	x	x					x		
		D30-23-1000	23	x	x							
		D30-33-1000	33	x	x					x		
		D30-53-1100	53	x	x							
		D30-63-1100	63	x	x							
		D30-73-1100	73	x	x							
		D31-13-1000	13	x	x							
		D31-23-1000	23	x	x							
		D3-13-1000	13	x	x							
		D31-33-1000	33	x	x							
		D31-43-1000	43	x	x							
		D31-53-1000	53	x	x							
		D31-63-1000	63	x	x							
		D31-73-1000	73	x	x							
		D32-13-1000	13	x	x							
		D32-23-1000	23	x	x							
		D3-23-1000	23	x	x							
		D32-33-1000	33	x	x							
		D32-43-1000	43	x	x							
		D32-53-1000	53	x	x							
		D32-63-1000	63	x	x							
		D32-73-1000	73	x	x							
		D3-33-1000	33	x	x							
		D33-63-1000	63	x	x							
		D33-71-1000	71	x	x							
		D33-77-1000	77	x	x							
		D3-43-1000	43	x	x							
		D34-63-1000	63	x	x							
		D34-73-1000	73	x	x							
		D3-53-1000	53	x	x							
		D35-63-1000	63	x	x							
		D35-73-1000	73	x	x							
		D3-63-1000	63	x	x							
		D36-63-1000	63	x	x							
		D36-73-1000	73	x	x							
		D37-13-1000	13	x	x							
		D37-23-1000	23	x	x							
		D3-73-1000	73	x	x							
		D37-33-1000	33	x	x							
		D37-43-1000	43	x	x							
		D37-53-1000	53	x	x							
		D37-63-1000	63	x	x					x		
		D37-73-1000	73	x	x					x		
		D3-83-1000	83	x	x					x		

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		D38-63-1000	63	x	x					x		
		D38-73-1000	73	x	x					x		
		D4-13-1000	13	x	x					x		
		D4-23-1000	23	x	x					x		
		D4-33-1000	33	x	x							
		D4-43-1000	43	x	x					x		
		D4-53-1000	53	x	x					x		
		D4-63-1000	63	x	x					x		
		D4-73-1000	73	x	x					x		
		D4-83-1000	83	x	x					x		
		D5-13-1000	13	x	x					x		
		D5-23-1000	23	x	x					x		
		D5-33-1000	33	x	x							
		D5-43-1000	43	x	x					x		
		D5-53-1000	53	x	x					x		
		D5-63-1000	63	x	x					x		
		D5-73-1000	73	x	x					x		
		D5-77-1000	77	x	x							
		D6-14-1000	14	x	x							
		D6-24-1000	24	x	x							
		D6-34-1000	34	x	x							
		D6-42-1000	42	x	x							
		D6-52-1000	52	x	x							
		D6-62-1000	62	x	x							
		D6-72-1000	72	x	x							
		D7-14-1000	14	x	x							
		D7-24-1000	24	x	x							
		D7-34-1000	34	x	x							
		D7-44-1000	44	x	x							
		D7-54-1000	54	x	x							
		D7-64-1000	64	x	x							
		D7-74-1000	74	x	x							
		D8-15-1000	15	x	x							
		D8-30-1000	30	x	x							
		D8-45-1000	45	x	x							
		D8-60-1000	60	x	x							
		D8-75-1000	75	x	x							
		D9-13-1000	13	x	x							
		D9-23-1000	23	x	x							
		D9-33-1000	33	x	x							
		D9-43-1000	43	x	x							
		D9-53-1000	53	x	x							
		D9-57-1000	57	x	x							
		D9-67-1000	67	x	x							
		D9-77-1000	77	x	x							
		E11-15-1100	15	x	x							
		E11-30-1100	30	x	x							
		E11-45-1100	45	x	x							
		E5-15-1000	15	x	x							
		E5-30-1000	30	x	x							
		E5-45-1000	45	x	x							
		E5-60-1000	60	x	x							
		E8-15-1000	15	x	x							
		E8-30-1000	30	x	x							
		E8-45-1000	45	x	x							
		E8-60-1000	60	x	x							
		E8-75-1000	75	x	x							
		E8-90-1000	90	x	x							
		EE19-15-0201	15	x	x							
		EE19-30-0201	30	x	x							
		EE19-45-0201	45	x	x							
		F16-15-1000	15	x	x							
		F16-30-1000	30	x	x							
		F16-45-1000	45	x	x							
		F16-60-1000	60	x	x							
		F33-15-0201	15	x	x							
		F33-30-0201	30	x	x							
		F33-45-0201	45	x	x							
		F33-60-0201	60	x	x							
		F7-15-1000	15	x	x							
		F7-30-1000	30	x	x							
		F7-45-1000	45	x	x							
		F7-60-1000	60	x	x							
		F7-75-1000	75	x	x							
		F7-90-1000	90	x	x							
		H14-15-1100	15	x	x							
		H14-30-1100	30	x	x							
		H14-45-1100	45	x	x							
		H17-15-1000	15	x	x							
		H17-30-1000	30	x	x							
		H17-45-1000	45	x	x							
		H17-60-1000	60	x	x							
		H9-15-1000	15	x	x							
		H9-30-1000	30	x	x							
		H9-45-1000	45	x	x							
		H9-60-1000	60	x	x							

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		H9-75-1000	75	x	x							
		J12-15-1100	15	x	x							
		J12-30-1100	30	x	x							
		J12-45-1100	45	x	x							
		J15-15-1000	15	x	x							
		J15-30-1000	30	x	x							
		J15-45-1000	45	x	x							
		J23-15-0101	15	x	x							
		J23-45-0101	45	x	x							
		J23-45-0101	45	x	x							
		J23-60-0101	60	x	x							
		J31-15-0201	15	x	x							
		J31-30-0201	30	x	x							
		J31-45-0201	45	x	x							
		J31-60-0201	60	x	x							
		J9-15-1000	15	x	x							
		J9-30-1000	30	x	x							
		J9-45-1000	45	x	x							
		J9-60-1000	60	x	x							
		J9-75-1000	75	x	x							
		K10-15-1100	15	x	x							
		K10-30-1100	30	x	x							
		K10-45-1100	45	x	x							
		K3-15-1100	15	x	x							
		K3-30-1100	30	x	x							
		K6-15-1000	15	x	x							
		K6-30-1000	30	x	x							
		K8-15-1000	15	x	x							
		K8-30-1000	30	x	x							
		L13-15-1000	15	x	x							
		L13-30-1000	30	x	x							
		L13-45-1000	45	x	x							
		L30-15-0201	15	x	x							
		L30-30-0201	30	x	x							
		L30-45-0201	45	x	x							
		L30-60-0201	60	x	x							
		M20-15-0101	15	x	x							
		M20-30-0101	30	x	x							
		M20-45-0101	45	x	x							
		M20-60-0101	60	x	x							
		N11-15-1000	15	x	x							
		N11-30-1000	30	x	x							
		N11-45-1000	45	x	x							
		NED21-15-0101	15	x	x							
		NED21-30-0101	30	x	x							
		NED21-45-0101	45	x	x							
		NED21-45-0101	45	x	x							
		NED21-60-0101	60	x	x							
		P17-15-0101	15	x	x							
		P17-30-0101	30	x	x							
		P17-45-0101	45	x	x							
		P17-60-0101	60	x	x							
		P17-75-0201	75	x	x							
		P26-30-0201	30	x	x							
		P26-45-0201	45	x	x							
		P26-60-0201	60	x	x							
		R15-15-0101	15	x	x							
		R15-30-0101	30	x	x							
		R15-45-0101	45	x	x							
		S24-15-0201	15	x	x							
		S24-30-0201	30	x	x							
		S24-45-0201	45	x	x							
		S24-60-0201	60	x	x							
		S24-75-0201	75	x	x							
		SA-D8-14-1000	14	x	x							
		SA-D8-24-1000	24	x	x							
		SA-D8-34-1000	34	x	x							
		SA-D8-44-1000	44	x	x							
		SA-D8-52-1000	52	x	x							
		SA-D8-56-1000	56	x	x							
		SA-D8-66-1000	66	x	x							
		SA-D8-76-1000	76	x	x							
		X23-30-0201	30	x	x							
		X23-45-0201	45	x	x							
		X23-60-0201	60	x	x							
		X23-75-0201	75	x	x							
		Z16-15-0101	15	x	x							
		Z16-30-0101	30	x	x							
		X23-19-0301	19	x	x							
		P26-19-0301	19	x	x							
		H21-15-0301	15	x	x							
		J20-19-0301	19	x	x							
		B15-15-0301	15	x	x							
		C14-15-0301	15	x	x							
		I8-15-0301	15	x	x							
		F10-15-0301	15	x	x							

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		F10-30-0301	30	x	x							
		G10-15-0301	15	x	x							
		G10-30-0301	30	x	x							
		H7-15-0301	15	x	x							
		L14-15-0301	15	x	x							
		L14-30-0301	30	x	x							
		P15-15-0301	15	x	x							
		G13-15-0301	15	x	x							
		M9-15-0301	15	x	x							
		G18-15-0301	15	x	x							
		G18-30-0301	30	x	x							
		XX27-15-0301	15	x	x							
		F20-15-0301	15	x	x							
		F20-30-0301	30	x	x							
		K6-15-0301	15	x	x							
		M13-15-0301	15	x	x							
		M13-30-0301	30	x	x							
		J7-15-0301	15	x	x							
		G6-15-0301	15	x	x							
		F7-15-0301	15	x	x							
		Z12-15-0301	15	x	x							
		XX9-15-0301	15	x	x							
		YY7-15-0301	15	x	x							
Post-Phase III Investigations	Philip Services Corp., September 2000	W672L-1	10-12	x	x							
		W672L-2	10-12	x	x							
		W672L-3	10-12	x	x							
		W672L-4	10-12	x	x							
		W672L-5	10-12	x	x							
		W672L-6	10-12	x	x							
		W672L-7	10-12	x	x							
		W540D-1	10-12	x	x							
		W540D-2	10-12	x	x							
		W540D-3	10-12	x	x							
		W540D-4	10-12	x	x							
Post-Phase III Investigations	Philip Services Corp., 2001	SG-9-W-0301	15	x	x							
		SG-10-W-0301	19	x	x							
		SG-12-W-0301	19	x	x							
		SG-13-W-0301	19	x	x							
		SG-14-W-0301	15	x	x							
		SG-15-W-0301	19	x	x							
Post-Phase III Investigations	Philip Services Corp., Oct. 2000	G33-W-53-0202	53	x								
		G33-W-57-0202	57	x								
		G33-W-61-0202	61	x								
		G33-W-65-0202	65	x								
		G33-W-69-0202	69	x								
		G33-W-73-0202	73	x								
		G33-W-77-0202	77	x								
		G33-W-81-0202	81	x								
		G33-W-92-0202	92	x								
		G33-W-102-0202	102	x								
		G33-W-107-0202	107	x								
		G33-W-114-0202	114	x								
		V31-W-13-0202	13	x								
		V31-W-17-0202	17	x								
		V31-W-21-0202	21	x								
		V31-W-25-0202	25	x								
		V31-W-29-0202	29	x								
		V31-W-33-0202	33	x								
		V31-W-37-0202	37	x								
		V31-W-41-0202	41	x								
		V31-W-45-0202	45	x								
		V31-W-64-0202	64	x								
		X28-W-13-0202	13	x								
		X28-W-17-0202	17	x								
		X28-W-21-0202	21	x								
		X28-W-25-0202	25	x								
		X28-W-29-0202	29	x								
		X28-W-33-0202	33	x								
		X28-W-37-0202	37	x								
		X28-W-41-0202	41	x								
		X28-W-45-0202	45	x								
		X28-W-64-0202	64	x								
		S34-W-64-0202	64	x								
		Q32-W-13-0202	13	x								
		Q32-W-17-0202	17	x								
		Q32-W-21-0202	21	x								
		Q32-W-25-0202	25	x								
		Q32-W-29-0202	29	x								
		Q32-W-33-0202	33	x								
		Q32-W-37-0202	37	x								
		Q32-W-41-0202	41	x								
		Q32-W-45-0202	45	x								
		Q32-W-64-0202	64	x								
		G33-W-13-0202	13	x								
		G33-W-17-0202	17	x								
		G33-W-21-0202	21	x								

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		G33-W-25-0202	25	x								
		G33-W-29-0202	29	x								
		G33-W-33-0202	33	x								
		G33-W-37-0202	37	x								
		G33-W-41-0202	41	x								
		G33-W-45-0202	45	x								
		G33-W-49-0202	49	x								
		S34-W-37-0202	37	x								
		S34-W-41-0202	41	x								
		S34-W-45-0202	45	x								
		Y26-W-13-0202	13	x								
		Y26-W-17-0202	17	x								
		Y26-W-21-0202	21	x								
		Y26-W-25-0202	25	x								
		Y26-W-29-0202	29	x								
		Y26-W-33-0202	33	x								
		Y26-W-37-0202	37	x								
		Y26-W-41-0202	41	x								
		Y26-W-45-0202	45	x								
		S34-W-13-0202	13	x								
		S34-W-17-0202	17	x								
		S34-W-21-0202	21	x								
		S34-W-25-0202	25	x								
		S34-W-29-0202	29	x								
		S34-W-33-0202	33	x								
		X16-W-12-0302	12	x					x			
		X16-W-16-0302	16	x							x	
		X16-W-20-0302	20	x							x	
		X16-W-24-0302	24	x					x			
		X16-W-28-0302	28	x					x			
		X16-W-32-0302	32	x							x	
		T20-W-12-0302	12	x					x			
		T20-W-16-0302	16	x					x			
		T20-W-20-0302	20	x					x			
		T20-W-24-0302	24	x					x			
		T20-W-28-0302	28	x							x	
		T20-W-32-0302	32	x							x	
		X20-W-12-0302	12	x					x			
		X20-W-16-0302	16	x							x	
		X20-W-20-0302	20	x							x	
		X20-W-24-0302	24	x							x	
		X20-W-28-0302	28	x					x			
		X20-W-32-0302	32	x							x	
		F13-12-0302	12	x					x			
		F13-16-0302	16	x					x			
		F13-20-0302	20	x					x			
		F13-24-0302	24	x					x			
		F13-28-0302	28	x					x			
		F13-32-0302	32	x					x			
		I13-12-0302	12	x					x			
		I13-16-0302	16	x					x			
		I13-20-0302	20	x					x			
		I13-24-0302	24	x					x			
		I13-28-0302	28	x					x			
		I13-32-0302	32	x					x			
		K23-12-0302	12	x							x	
		K23-16-0302	16	x					x			
		I17-W-12-0302	12	x					x			
		I17-W-16-0302	16	x					x			
		I17-W-20-0302	20	x					x			
		I17-W-24-0302	24	x					x			
		I17-W-28-0302	28	x					x			
		I17-W-32-0302	32	x					x			
		K19-W-12-0302	12	x					x			
		K19-W-16-0302	16	x					x			
		K19-W-20-0302	20	x					x			
		K19-W-24-0302	24	x					x			
		K19-W-28-0302	28	x					x			
		K19-W-32-0302	32	x					x			
		K23-20-0302	20	x					x			
		K23-24-0302	24	x							x	
		K23-28-0302	28	x							x	
		K23-32-0302	32	x					x			
		I22-12-0302	12	x					x			
		I22-16-0302	16	x					x			
		I22-20-0302	20	x					x			
		I22-24-0302	24	x					x			
		I22-28-0302	28	x					x			
		I22-32-0302	32	x					x			
		K21-12-0302	12	x							x	
		K21-16-0302	16	x							x	
		K21-20-0302	20	x					x			
		K21-24-0302	24	x					x			
		K21-28-0302	28	x							x	
		K21-32-0302	32	x					x			
Post-Phase III	Philip Services	Q32A-W-14-1202	14	x								

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

				Analysis								
Phase	Source	Sample Location	Depth (ft bgs)	VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
Investigations	Corp., Oct. 2000	Q32A-W-18-1202	18	x								
		Q32A-W-22-1202	22	x								
		Q32A-W-26-1202	26	x								
		Q32A-W-30-1202	30	x								
		Q32A-W-34-1202	34	x								
		Q32A-W-38-1202	38	x								
		Q32A-W-42-1202	42	x								
		Q32B-W-14-1202	14	x								
		Q32B-W-18-1202	18	x								
		Q32B-W-22-1202	22	x								
		Q32B-W-26-1202	26	x								
		Q32B-W-30-1202	30	x								
		Q32B-W-34-1202	34	x								
		Q32B-W-38-1202	38	x								
		Q32B-W-42-1202	42	x								
		Q32D-W-14-1202	14	x								
		Q32D-W-18-1202	18	x								
		Q32D-W-22-1202	22	x								
		Q32D-W-26-1202	26	x								
		Q32D-W-30-1202	30	x								
		Q32D-W-34-1202	34	x								
		Q32D-W-38-1202	38	x								
		Q32D-W-42-1202	42	x								
		Q32-G-W-14-1202	14	x								
		Q32-G-W-18-1202	18	x								
		Q32-G-W-22-1202	22	x								
		Q32-G-W-26-1202	26	x								
		Q32F-W-14-1202	14	x								
		Q32F-W-18-1202	18	x								
		Q32F-W-22-1202	22	x								
		Q32F-W-26-1202	26	x								
		Q32F-W-30-1202	30	x								
		Q32F-W-34-1202	34	x								
		Q32F-W-38-1202	38	x								
		Q32F-W-42-1202	42	x								
		Q32M29-W-19-1202	19	x								
		Q32M29-W-23-1202	23	x								
		Q32M29-W-27-1202	27	x								
		Q32M29-W-31-1202	31	x								
		Q32M29-W-35-1202	35	x								
Post-Phase III Investigations	FW, 2002	5327D-GW1-0802		x								
		613B-GW1-0802		x								
		412O-GW1-0802		x								
		406O-GW1-0802		x								
		404L-GW1-0802		x								
		412L-GW1-0802		x								
		5403M-GW1-0802		x								
		613B-GW1-0802		x								
		507B-GW1-0802		x								
Post-Phase III Investigations	URS & PSC, 2002	HC-8-W-9-0602	9	x	x							
		HC-8-W-21-0602	21	x	x							
		HC-8-W-29-0602	29	x	x							
		HC-8-W-33-0602	33	x	x							
		HC-8-W-37-0602	37	x	x							
		HC-8-W-41-0602	41	x	x							
		HC-8-W-45-0602	45	x	x							
		HC-8-W-49-0602	49	x	x							
		HC-8-W-53-0602	53	x	x							
		HC-8-W-57-0602	57	x	x							
		HC-6-W-9-0602	9	x	x							
		HC-6-W-21-0602	21	x	x							
		HC-6-W-29-0602	29	x	x							
		HC-6-W-41-0602	41	x	x							
		HC-6-W-49-0602	49	x	x							
		HC-6-W-57-0602	57	x	x							
		HC-4-W-9-0602	9	x	x				x			
		HC-4-W-13-0602	13	x	x							
		HC-4-W-21-0602	21	x	x				x			
		HC-4-W-25-0602	25	x	x							
		HC-4-W-33-0602	33	x	x							
		HC-4-W-29-0602	29	x	x				x			
		HC-4-W-37-0602	37	x	x							
		HC-4-W-41-0602	41	x	x				x			
		HC-4-W-49-0602	49	x	x				x			
		HC-1-W-9-0602	9	x	x				x			
		HC-1-W-13-0602	13	x	x							
		HC-1-W-17-0602	17	x	x							
		HC-1-W-21-0602	21	x	x				x			
		HC-1-W-25-0602	25	x	x							
		HC-1-W-29-0602	29	x	x				x			
		HC-1-W-33-0602	33	x	x							
		HC-1-W-41-0602	41	x	x				x			
		HC-1-W-49-0602	49	x	x				x			
		HC-3-W-9-0602	9	x	x				x			
		HC-3-W-13-0602	13	x	x							
		HC-3-W-17-0602	17	x	x							

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis: VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		HC-3-W-21-0602	21	x	x				x			
		HC-3-W-25-0602	25	x	x							
		HC-3-W-29-0602	29	x	x				x			
		HC-3-W-33-0602	33	x	x							
		HC-3-W-37-0602	37	x	x							
		HC-3-W-41-0602	41	x	x				x			
		HC-3-W-49-0602	49	x	x				x			
		HC-3-W-53-0602	53	x	x							
		HC-3-W-57-0602	57	x	x							
		HC-13-W-9-0602	9	x	x				x			
		HC-13-W-21-0602	21	x	x				x			
		HC-13-W-29-0602	29	x	x				x			
		HC-13-W-41-0602	41	x	x				x			
		HC-13-W-49-0602	49	x	x				x			
		HC-10-W-9-0602	9	x	x				x			
		HC-10-W-21-0602	21	x	x				x			
		HC-10-W-29-0602	29	x	x				x			
		HC-10-W-41-0602	41	x	x				x			
		HC-10-W-49-0602	49	x	x				x			
		HC-11-W-9-0602	9	x	x				x			
		HC-11-W-21-0602	21	x	x				x			
		HC-11-W-29-0602	29	x	x				x			
		HC-11-W-41-0602	41	x	x				x			
		HC-11-W-49-0602	49	x	x				x			
		HC-15-W-9-0602	9	x	x				x			
		HC-15-W-13-0602	13	x	x							
		HC-15-W-17-0602	17	x	x							
		HC-15-W-21-0602	21	x	x				x			
		HC-15-W-29-0602	29	x	x				x			
		HC-15-W-41-0602	41	x	x				x			
		HC-15-W-49-0602	49	x	x				x			
		HC-16-W-9-0602	9	x	x				x			
		HC-16-W-13-0602	13	x	x							
		HC-16-W-17-0602	17	x	x							
		HC-16-W-21-0602	21	x	x				x			
		HC-16-W-25-0602	25	x	x							
		HC-16-W-29-0602	29	x	x				x			
		HC-16-W-41-0602	41	x	x				x			
		HC-16-W-49-0602	49	x	x				x			
		HC-17-W-9-0602	9	x	x				x			
		HC-17-W-21-0602	21	x	x				x			
		HC-17-W-29-0602	29	x	x				x			
		HC-17-W-41-0602	41	x	x				x			
		HC-17-W-49-0602	49	x	x				x			
		HC-18-W-9-0602	9	x	x				x			
		HC-18-W-13-0602	13	x	x							
		HC-18-W-17-0602	17	x	x							
		HC-18-W-21-0602	21	x	x				x			
		HC-18-W-29-0602	29	x	x				x			
		HC-18-W-41-0602	41	x	x				x			
		HC-18-W-49-0602	49	x	x				x			
		HC-19-W-9-0602	9	x	x				x			
		HC-19-W-13-0602	13	x	x							
		HC-19-W-21-0602	21	x	x				x			
		HC-19-W-29-0602	29	x	x				x			
		HC-19-W-41-0602	41	x	x				x			
		HC-19-W-49-0602	49	x	x				x			
		HC-22-W-13-0702	13	x	x				x			
		HC-22-W-17-0702	17	x	x							
		HC-22-W-21-0702	21	x	x				x			
		HC-22-W-25-0702	25	x	x							
		HC-22-W-29-0702	29	x	x				x			
		HC-22-W-37-0702	37	x	x							
		HC-22-W-41-0702	41	x	x				x			
		HC-22-W-45-0702	45	x	x							
		HC-22-W-49-0702	49	x	x				x			
		HC-22-W-61-0702	61	x	x				x			
		HC-22-W-65-0702	65	x	x							
		HC-22-W-69-0702	69	x	x							
		HC-23-W-13-0702	13	x	x				x			
		HC-23-W-17-0702	17	x	x							
		HC-23-W-21-0702	21	x	x				x			
		HC-23-W-25-0702	25	x	x							
		HC-23-W-29-0702	29	x	x				x			
		HC-23-W-33-0702	33	x	x							
		HC-23-W-37-0702	37	x	x							
		HC-23-W-41-0702	41	x	x				x			
		HC-23-W-45-0702	45	x	x							
		HC-23-W-49-0702	49	x	x				x			
		HC-23-W-53-0702	53	x	x							
		HC-23-W-61-0702	61	x	x				x			
		HC-21-W-13-0702	13	x	x				x			
		HC-21-W-17-0702	17	x	x							
		HC-21-W-21-0702	21	x	x				x			
		HC-21-W-25-0702	25	x	x							
		HC-21-W-29-0702	29	x	x				x			

Table 4-11
Temporary Groundwater Samples
Georgetown Facility

Phase	Source	Sample Location	Depth (ft bgs)	Analysis								
				VOC	OVA or PID	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest
		HC-21-W-41-0702	41	x	x				x			
		HC-21-W-49-0702	49	x	x				x			
		HC-21-W-61-0702	61	x	x				x			
		HC-21-W-69-0702	69	x	x				x			
		HC-20-W-13-0702	13	x	x				x			
		HC-20-W-21-0702	21	x	x				x			
		HC-20-W-29-0702	29	x	x				x			
		HC-20-W-41-0702	41	x	x				x			
		HC-20-W-49-0702	49	x	x				x			
		HC-20-W-61-0702	61	x	x				x			
		HC-20-W-69-0702	69	x	x				x			
		HC-7-W-21-0602	21	x	x				x			
		HC-7-W-29-0602	29	x	x				x			
		HC-7-W-37-0602	37	x	x							
		HC-7-W-41-0602	41	x	x				x			
		HC-7-W-45-0602	45	x	x							
		HC-7-W-49-0602	49	x	x				x			
		HC-7-W-9-0602	9	x	x				x			
	Philip Services Corp., Oct. 2000	J16-10-0403	10	x								
		N15-9-0403	9	x								
		J7c-10-0403	10	x								
		C4b-11-0403	11	x								
		B5b-11-0403	11	x								
		K28-11-0403	11	x								
		R22-11-0403	11	x								
		Q17-9.5-0403	9.5	x								
		O19-11.5-0403	11.5	x								
		L18-9.75-0403	9.75	x								

Table 4-12
Soil Gas Port Sampling Frequency
Georgetown Facility

Soil Gas Ports	Sampling Events	Date
CG-2-SG	First Quarter 2001 Monitoring Event	03/23/01
	Second Quarter 2001 Monitoring Event	05/21/01
	Third Quarter 2001 Monitoring Event	08/10/01
	Fourth Quarter 2001 Monitoring Event	11/13/01
	IPIM Sampling Event	08/21/02
CG-3-SG	First Quarter 2001 Monitoring Event	03/23/01
	Second Quarter 2001 Monitoring Event	05/21/01
	Third Quarter 2001 Monitoring Event	08/10/01
	Fourth Quarter 2001 Monitoring Event	11/13/01
	IPIM Sampling Event	08/22/02
	IPIM Sampling Event	08/28/02
CG-4-SG	First Quarter 2001 Monitoring Event	03/23/01
	Second Quarter 2001 Monitoring Event	05/21/01
	Third Quarter 2001 Monitoring Event	08/10/01
	Fourth Quarter 2001 Monitoring Event	11/13/01
	IPIM Sampling Event	08/21/02
	IPIM Sampling Event	08/28/02
CG-5-SG	Soil Gas Purge Test	01/24/01
	First Quarter 2001 Monitoring Event	03/23/01
	Second Quarter 2001 Monitoring Event	05/21/01
	Third Quarter 2001 Monitoring Event	08/10/01
	Fourth Quarter 2001 Monitoring Event	11/13/01
CG-6-SG	Soil Gas Purge Test	01/24/01
	First Quarter 2001 Monitoring Event	03/23/01
	Second Quarter 2001 Monitoring Event	05/21/01
	Third Quarter 2001 Monitoring Event	08/10/01
	Fourth Quarter 2001 Monitoring Event	11/13/01

Table 4-13
Temporary Soil Gas Samples
Georgetown Facility

Phase	Source	Sample Location	Sampling Method	Depth (ft bgs)	Analysis
			Active/Passive		VOC
Phase II	Sweet-Edwards/Emcon, 1990	TB-2-SG-17	Active	2.0-3.2	x
		TB-3-SG-9		2.0-3.2	x
		TB-4-SG-11		2.0-3.2	x
		TB-5-SG-1		Background	x
		TB-5-SG-2		1.9-2.6	x
		TB-6-SG-3		2.0-3.2	x
		TB-7-SG-4		2.0-3.2	x
		TB-8-SG-5		2.0-3.2	x
		TB-10-SG-6		2.0-3.2	x
		TB-11-SG-14		2.0-3.2	x
		TB-13-SG-15		2.0-3.2	x
		TB-14-SG-16		2.0-3.2	x
Phase III	Sweet-Edwards/Emcon, 1991	SGB-101	Active	1	x
		SGB-102		1	x
		SGB-103		1	x
		SGB-104		1	x
		SGB-105		1	x
		SGB-109		1	x
		SGB-110		1	x
		SGB-111		1	x
		SGB-112		1	x
		SGB-113		1	x
		SGB-114		1	x
		SGB-115		1	x
		SGB-116		1	x
		SGB-117		1	x
		SGB-118		1	x
		SGB-119		1	x
		SGB-120		1	x
		SGB-121		1	x
		SGB-122		1	x
		SGB-123		1	x
		SGB-124		1	x
		SGB-125		1	x
		SGB-126		1	x
		SGB-127		1	x

Table 4-13
Temporary Soil Gas Samples
Georgetown Facility

Phase	Source	Sample Location	Sampling Method	Depth	Analysis
			Active/Passive	(ft bgs)	VOC
Post-Phase III	PSC, 2001	SG-1	Active	2	x
				4	x
		SG-2		2	x
				4	x
		SG-3		2	x
				4	x
		SG-4		2	x
				4	x
		SG-5		2	x
				4	x
		SG-6		2	x
				4	x
		SG-7		2	x
				4	x
		SG-8		2	x
				4	x
	PSC, 2000	CSG-672L-1	Active	6.5	x
		CSG-672L-2		6.5	x
		CSG-672L-3		6.5	x
		CSG-672L-4		6.5	x
		CSG-672L-5		6.5	x
		ESG-672L-1	Passive	6.5	x
		ESG-672L-2		6.5	x
		ESG-672L-3		6.5	x
		ESG-672L-4		6.5	x
		ESG-672L-5		6.5	x
		ISG-5409D-1	Active	6.5	x
		CSG-5409D-1		6.5	x
		CSG-5409D-2		6.5	x
		CSG-5409D-3		6.5	x
		ESG-5409D-1	Passive	6.5	x
		ESG-5409D-2		6.5	x
		ESG-5409D-3		6.5	x
	PSC, 2001	SG-9	Active	4-6	x
		SG-10		4-6	x
		SG-12		4-6	x
		SG-13		4-6	x
		SG-14		4-6	x
		SG-15		4-6	x
	FW, 2002	613B-SG1-0802	Active	6-8	x
		5403M-SG1-0802		6-8	x
		412O-SG1-0802		5-7	x
		406O-SG1-0802		5-7	x
		404O-SG1-0802		5-7	x
		412L-SG1-0802		5-7	x
		507B-SG1-0802		6-8	x
		613B-SG1-0802		6-8	x
		5327D-SG1-0802		6.5-8.5	x

Table 4-14
Indoor Air Samples
PSC Georgetown Facility

Phase	Report	Sample Location	Sample Identifier	Date	Sampling Method
					(Active/Passive)
Post-Phase III Work Plan	PSC, September 2000	672 S. Lucile St.	IA-672L-1	8/15/00	Active
			IA-672L-2		
		5409 Denver Ave. S.	IA-5409D-1	8/15/00	
	PSC, March 2001	710 S. Lucile St.*	PS-IAO710-0301	3/01	Active
		303 S. Brandon St.*	PS-IAO303-0301	3/01	
		134 S. Mead St.*	PS-IAO134-0301	3/01	
		125 S. Findlay St.*	PS-IAO125-0301	3/01	
		412 S. Orcas St.*	PS-IAO412-0301	3/01	
		672 S. Lucile St.*	PS-IAO672-0301	3/01	
		5409 Denver Ave. S.*	PS-IA-5409-0301	3/01	
	GIVF Study IPIM Work Plan (Aug. 2002)	672 S. Lucile St.	672L-IA1-0802	8/19/02	Active
			672L-IA2-0802		
		672 S. Lucile St.	672L-IA1-0802	8/27/02	
			672L-IA2-0802		
			672L-IA3-0802		
		5409 Denver Ave. S.	5409D-IA1-0802	8/19/02	
			5409D-IA2-0802		
		5403 Maynard Ave. S.	5403M-IA1-0802	8/19/02	
			5403M-IA2-0802		
		5327 Denver Ave. S.	5327D-IA1-0802	8/26/02	
			5327DC-IA1-0802		
		412 S. Lucile St.	412L-IA1-0802	8/19/02	
			412L-IA2-0802		
			412L-IA3-0802		
		613 S. Brandon St.	613B-IA1-0802	8/19/02	
			613B-IA2-0802		
		611 S. Brandon St.	611BC-IA1-0802	8/19/02	
		613 S. Brandon St.	613B-IA1-0802	8/26/02	
			613B-IA2-0802		
		611 S. Brandon St.	611BC-IA1-0802	8/26/02	
		404 S. Orcas St.	404O-IA1-0802	8/19/02	
			404O-IA2-0802		
		406 S. Orcas St.	406O-IA1-0802	8/19/02	
			406O-IA2-0802		
		412 S. Orcas St.	412O-IA1-0802	8/19/02	
			412O-IA2-0802		
		507 S. Brandon St.	507B-IA1-0802	8/21/02	Active
			507B-IA2-0802		
* Samples were collected by the Washington State Department of Health					

Table 4-15
Soil Samples
PSC Georgetown Facility

Phase	Report	Boring Location	Sample Location	Depth (feet bgs)	Analysis			Analysis									
					VOC	OVA Field Test	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest	TOH	EP-Tox	TCLP Metals	Organic Content
Pre-Phase I Investigation	Harper Owes, 1982	G-1	G-1					x		x	x			x			
			G-1-1					x		x	x			x			
			G-1-2					x		x	x			x			
			G-1-3					x		x	x			x			
			G-1-4					x		x	x			x			
			G-1-5					x		x	x			x			
		G-2	G-2					x		x	x			x			
			G-2-1					x		x	x			x			
			G-2-2					x		x	x			x			
			G-2-3					x		x	x			x			
			G-2-4					x		x	x			x			
			G-2-5					x		x	x			x			
		G-4	G-4					x		x	x			x			
			G-4-1					x		x	x			x			
			G-4-2					x		x	x			x			
			G-4-5					x		x	x			x			
		G-7	G-7											x			
		G-8	G-8											x			
		G-9	G-9											x			
Phase I	Sweet-Edwards/Emcon, 1988	CG-1	CG-1/S-1B	10-11.5	x	x	x			x	x		x				
			CG-1/S-2B	20-21.5	x	x	x			x	x		x				
			CG-1/S-3B	30-31.5	x	x	x	x		x	x		x				
			CG-1/S-4B	40-41.5	x	x	x			x	x		x				
			CG-1/S-5B	50-51.5	x	x	x	x		x	x		x				
			CG-1/S-6B	58-59.5	x	x	x			x	x		x				
			CG-1/S-7B	68-69.5	x	x	x			x	x		x				
			CG-1/S-8B	78-79.5	x	x	x			x	x		x				
			CG-1/S-9B	88-89.5	x	x	x			x	x		x				
		CG-2	CG-2/S-1B	18-19.5	x	x	x			x	x		x				
			CG-2/S-2B	38-39.5	x	x	x			x	x		x				
			CG-2/S-3B	58-59.5	x	x	x			x	x		x				
			CG-2/S-4B	78-79.5	x	x	x			x	x		x				
Phase II	Sweet-Edwards/Emcon, 1990	TB-1	TB-1-2	2	x		x			x					x		
			TB-1-5	5	x		x			x					x		
			TB-1-8	8	x		x			x					x		
			TB-1-10	10	x		x			x					x		
			TB-1-20	20	x		x			x							
			TB-1-33	33	x		x			x							
			CG-4-50	50	x		x			x							
			CG-4-80	80	x		x			x							
			CG-4-105	105	x		x			x							
		TB-2	TB-2-2	2	x		x			x					x		
			TB-2-5	5	x		x			x					x		
			TB-2-7.5	8	x		x			x					x		
			TB-2-10	10	x		x			x					x		
			TB-2-20	20	x		x			x							
			TB-2-31	31	x		x			x							
		TB-3	TB-3-2	2	x		x			x					x		
			TB-3-5	5	x		x			x					x		
			TB-3-7	7	x		x			x					x		
			TB-3-10	10	x		x			x					x		
			TB-3-20	20	x		x			x							
			TB-3-35	35	x		x			x							

Table 4-15
Soil Samples
PSC Georgetown Facility

Phase	Report	Boring Location	Sample Location	Depth	Analysis			Analysis									
				(feet bgs)	VOC	OVA Field Test	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest	TOH	EP-Tox	TCLP Metals	Organic Content
Phase II		TB-4	TB-4-2	2	x		x			x					x		
			TB-4-5	5	x		x			x					x		
			TB-4-7.5	8	x		x			x					x		
			TB-4-10	10	x		x			x					x		
			TB-4-20	20	x		x			x							
			TB-4-32	32	x		x			x							
		TB-5	TB-5-2	2	x		x			x					x		
			TB-5-5	5	x		x			x					x		
			TB-5-7.5	8	x		x			x					x		
			TB-5-10	10	x		x			x					x		
			TB-5-20	20	x		x			x							
			TB-5-43	43	x		x			x							
			TB-5-58	58	x		x			x							
			TB-5-85	85	x		x			x							
		TB-6	TB-6-2	2	x		x			x					x		
			TB-6-5	5	x		x			x					x		
			TB-6-7.5	8	x		x			x					x		
			TB-6-10	10	x		x			x					x		
			TB-6-20	30	x		x			x							
			TB-6-31	31	x		x			x							
		TB-7	TB-7-2	2	x		x			x					x		
			TB-7-5	5	x		x			x					x		
			TB-7-8	8	x		x			x					x		
			TB-7-10	10	x		x			x					x		
			TB-7-20	20	x		x			x							
			TB-7-48	48	x		x			x							
		TB-8	TB-8-2	2	x		x			x					x		
			TB-8-5	5	x		x			x					x		
			TB-8-10	10	x		x			x					x		
			TB-8-20	20	x		x			x							
			TB-8-40	40	x		x			x							
		TB-9	TB-9-2	2	x		x			x					x		
			TB-9-5	5	x		x			x					x		
			TB-9-8	8	x		x			x					x		
			TB-9-10	10	x		x			x					x		
			TB-9-20	20	x		x			x							
			TB-9-40	40	x		x			x							
		TB-10	TB-10-2	2	x		x			x							
			TB-10-5	5	x		x			x							
			TB-10-9.5	10	x		x			x							
			TB-10-20	20	x		x			x							
			TB-10-40	40	x		x			x							
		TB-11	TB-11-2	2	x		x			x					x		
			TB-11-5	5	x		x			x					x		
			TB-11-7	7	x		x			x					x		
			TB-11-10	10	x		x			x					x		
			TB-11-20	20	x		x			x							
		TB-12	TB-12-2	2	x		x			x					x		
			TB-12-5	5	x		x			x					x		
			TB-12-7	7	x		x			x					x		
			TB-12-10	10	x		x			x					x		
			TB-12-20	20	x		x			x							

Table 4-15
Soil Samples
PSC Georgetown Facility

Phase	Report	Boring Location	Sample Location	Depth (feet bgs)	Analysis			Analysis									
					VOC	OVA Field Test	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest	TOH	EP-Tox	TCLP Metals	Organic Content
Phase II		TB-13	TB-13-2	2	x		x			x					x		
			TB-13-5	5	x		x			x					x		
			TB-13-7	7	x		x			x					x		
			TB-13-10	10	x		x			x					x		
			TB-13-20	20	x		x			x							
		TB-14	TB-14-2	2	x		x			x							
			TB-14-5	5	x		x			x							
			TB-14-7	7	x		x			x							
			TB-14-10	10	x		x			x							
			TB-14-20	20	x		x			x							
			TB-14-36	36	x		x			x							
Phase III	Sweet-Edwards/Emcon, 1991		HAC-01D	7-8	x		x			x			x		x	x	
			HAC-01S	2-3	x		x			x			x		x	x	
			HAC-02D	7-8												x	
			HAC-02S	2-3												x	
			HAC-03D	7-8									x			x	
			HAC-03S	2-3									x			x	
			HAC-04D	7-8									x			x	
			HAC-04S	2-3									x			x	
			HAC-05D	7-8	x		x						x		x	x	
			HAC-05S	2-3	x		x						x		x	x	
			HAC-06D	7-8	x					x			x			x	
			HAC-06S	2-3	x					x			x		x	x	
			HAC-07D	7-8									x			x	
			HAC-07S	2-3									x			x	
			HAC-08D	7-8	x								x			x	
			HAC-08S	2-3	x	x				x			x		x	x	
			HAC-09D	7-8									x				
			HAC-09S	2-3									x				
			HAC-10D	7-8									x				
			HAC-10S	2-3									x				
			HAC-11D	7-8	x		x						x			x	
			HAC-11S	2-3	x		x			x			x		x	x	
			HAC-12D	7-8									x				
			HAC-12S	2-3									x				
			HAC-14D	7-8									x			x	
			HAC-14S	2-3									x			x	
		CG-101-S1	CG-101-S-2	2	x		x			x			x			x	
			CG-101-S-6	6	x		x			x			x		x	x	
			CG-101-S-10	10	x		x										
			CG-101-S-20	20	x		x										
		CG-101-S2	CG-101-S-30	30	x		x								x		
		CG-101-I	CG-101-I-50	50	x		x		x	x						x	
		CG-102-S1	CG-102-S-2	2	x		x			x			x			x	
			CG-102-S-6	6	x		x			x			x		x	x	
			CG-102-S-10	10	x		x			x			x			x	
			CG-102-S-20	20	x		x			x			x			x	
		CG-102-S2	CG-102-S-30	30	x		x			x			x		x	x	
		CG-102-I	CG-102-I-50	50	x		x			x							
			CG-102-I-65	65	x		x			x						x	
		CG-103-S1	CG-103-S-2	2	x		x									x	
			CG-103-S-6	6	x		x								x		
			CG-103-S-10	10	x		x										
			CG-103-S-20	20	x		x			x			x			x	
		CG-103-S2	CG-103-S-30	30	x		x			x			x		x	x	
		CG-103-I	CG-103-I-50	50	x		x			x						x	
			CG-103-I-75	75	x		x			x						x	

Table 4-15
Soil Samples
PSC Georgetown Facility

Phase	Report	Boring Location	Sample Location	Depth	Analysis			Analysis									
				(feet bgs)	VOC	OVA Field Test	SVOC	Phenols	TPH-G, -D	Total Metals	Cyanide	Dissolved Metals	PCB/Pest	TOH	EP-Tox	TCLP Metals	Organic Content
		CG-104-S1	CG-104-S-2	2	x	PID	x			x			x			x	
			CG-104-S-6	6	x	PID	x			x			x		x	x	
			CG-104-S-10	10	x	PID	x			x			x			x	
			CG-104-S-20	20	x		x			x			x			x	
		CG-104-S2	CG-104-S-30	30	x		x			x			x		x	x	
		CG-104-I	CG-104-I-50	50	x		x			x						x	
			CG-104-I-70	70	x		x			x						x	
		CG-105-S1	CG-105-S-2	2	x		x			x			x			x	
			CG-105-S-6	6	x		x			x			x		x	x	
			CG-105-S-10	10	x		x			x			x			x	
			CG-105-S-20	20	x		x			x			x			x	
		CG-105-S2	CG-105-S-30	30	x		x			x			x		x	x	
		CG-105-I	CG-105-I-50	50	x		x			x						x	
			CG-105-I-75	75	x		x			x						x	
		CG-111-I	CG-111-I-10	10	x		x			x			x			x	
			CG-111-I-20	20	x		x			x			x			x	
			CG-111-I-30	30	x		x			x			x			x	
			CG-111-I-40	40	x		x			x			x			x	
			CG-111-I-50	50	x		x			x						x	
Post-Phase III	Philip Services Corp., September 2000, A	SS-1	SS-1-2	2	x	x											
			SS-1-4	4	x	x											
		SS-2	SS-2-2	2	x	x											
			SS-2-4	4	x	x											
		SS-3	SS-3-2	2	x	x											
			SS-3-4	4	x	x											
		SS-4	SS-4-2	2	x	x											
			SS-4-4	4	x	x											
		SS-5	SS-5-2	2	x	x											
			SS-5-4	4	x	x											
		SS-6	SS-6-2	2	x	x											
			SS-6-4	4	x	x											
		SS-7	SS-7-2	2	x	x											
			SS-7-4	4	x	x											
		SS-8	SS-8-2	2	x	x											
			SS-8-4	4	x	x											
	Philip Services Corp., September 2000, B	D1	D1-40.5-1000	41	x	x											
		D1	D1-42.5-1000	43	x	x											
		D6	D6-38-40-1000	40	x	x											
		D7	D7-43.5-1000	44	x	x											
		SA-D8	SA-D8-49.5-1000	50	x	x											
		SA-D8	SA-D8-53.5-1000	54	x	x											
		D2	D2-30-1000	30	x	x											
		D2	D2-39-1000	39	x	x											
		D18	D18-69.5-1000	70	x	x											
		D18	D18-74-76-1000	76	x	x											
		D18	D18-76.5.1000	77	x	x											
		D22	D22-66-68-1000	68	x	x											
		D22	D22-70-72-1000	72	x	x											
		D25	D25-12-14-1000	14	x	x											
		SA-D13	SA-D13-62-64-1000	64	x	x											
	Tech Memo XII	K28	K28-30-0403	30									x				x
		R22	R22-30-0403	30									x				x
		Q17	Q17-30-0403	30									x				x
		L18	L18-30-0403	30									x				x

Table 4-16
Phase III Hand Auger Composite Soil Samples
PSC Georgetown Facility

Composite Sample	Depth (feet)	Borings Included	Location
HAC-01S	2-3	HA-101S, HA-102S, HA-107S	Process Area
HAC-01D	7-8	HA-101D, HA-102D, HA107D	Process Area
HAC-02D	7-8	HA-103D, HA-105D, HA-106D	Process Area
HAC-02S	2-3	HA-103S, HA-105S, HA-106S	Process Area
HAC-03D	7-8	HA-104D, HA-113D	Process Area
HAC-03S	2-3	HA-104S, HA-113S	Process Area
HAC-04D	7-8	HA-112D, HA-114D	Process Area
HAC-04S	2-3	HA-112S, HA-114S	Process Area
HAC-05D	7-8	HA-108D, HA-115D, HA-110D	Process Area
HAC-05S	2-3	HA-108S, HA-115S, HA-110S	Process Area
HAC-06D	7-8	HA-109D, HA-116D, HA-117D	Process Area
HAC-06S	2-3	HA-109S, HA-116S, HA-117S	Process Area
HAC-07D	7-8	HA-118D, HA-119D, HA-120D	Process Area
HAC-07S	2-3	HA-118S, HA-119S, HA-120S	Process Area
HAC-08D	7-8	HA-123D, HA-124D	South Area
HAC-08S	2-3	HA-122S, HA-123S, HA-124S	South Area
HAC-09D	7-8	HA-121D, HA-125D, HA-126D	South Area
HAC-09S	2-3	HA-121S, HA-125S, HA-126S	South Area
HAC-10D	7-8	HA-127D, HA-129D	Cyanide Area
HAC-10S	2-3	HA-127S, HA-128S, HA-129S	Cyanide Area
HAC-11D	7-8	HA-130D, HA-131D, HA-132D	Cyanide Area
HAC-11S	2-3	HA-130S, HA-131S, HA-132S	Cyanide Area
HAC-12D	7-8	HA-134D, HA-135D	Cyanide Area
HAC-12S	2-3	HA-134D, HA-135D	Cyanide Area

Final Comprehensive
Remedial Investigation Report
Part I of IV
Volume 2 of 7

For Philip Services Corporation's
Georgetown Facility
734 S. Lucile Street,
Seattle, Washington
WAD 00081 2909

Submitted to:
Washington State Department of Ecology

By: Philip Services Corporation
955 Powell Avenue SW
Renton, Washington 98055

In coordination with:

Pioneer Technologies Corporation
2612 Yelm Highway SE
Suite B
Olympia, WA 98501-4826

Geomatrix Consultants, Inc
One Union Square
600 - University Street, Suite 1020
Seattle, WA 98101

Farallon Consulting, L.L.C.
320 Third Avenue NE
Issaquah, Washington 98027

Exponent®, Environmental Group
4000 Kruse Way Place
Building 2, Suite 285
Lake Oswego, Oregon 97035

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5.0 DATA QUALITY AND USABILITY ASSESSMENT

A data quality and usability assessment was completed to determine whether the quality of the data used in the RI report is sufficient to support the use of the data for their intended purposes and to identify and minimize areas of uncertainty involving remedial decision-making.

The data quality and usability assessment is divided into the following sections:

- Purpose of the Data Quality and Usability Assessment
- Requirements for a Data Quality and Usability Assessment
- Summary of Data Quality Objectives and Sampling Design
- Assessment of Sampling Techniques
- Assessment of Analytical Data Quality
- Assessment of Data Management Activities
- Conclusions
- References

Aspects of data quality and usability have already been addressed in prior RI assessments and reporting. For example, assessment of analytical data quality (data validation) has been completed approximately quarterly and integrated into the iterative RI process and decision-making. Data quality reviews (i.e., data validation reports) have been previously submitted. A separate data quality and usability assessment is provided for the Human Health and Ecological RA in Part II of this RI report.

Uncertainties related to the use of data in modeling or other types of assessments have been described in the particular section of the report in which those results are discussed. For example, a separate data quality and usability assessment is provided for the RA in Part II of this RI report.

5.1 Purpose of the Data Quality and Usability Assessment

The data quality and usability assessment was completed to satisfy the March 11, 2002 final permit modification requirements to Sections VII.A.4.a) (9) and (10) (Ecology 2002). Section VII.A.4.a) (9) requires the following:

> "(r)esults of quality assurance activities and how and why they relate to the RI Report's findings and conclusions, as specified in the final RI Scope of Work (Attachment MM) and final, approved Risk Assessment Work Plan. This assessment of data quality shall be consistent with EPA's July 1996 Guidance for Data Quality Assessment (QA/G-9), and any updates provided in EPA's Quality Assurance Website at http://www.epa.gov/r10earth/offices/oea/r0qahome.htm."

Section VII.1.4 a) (10) requires the following:

> "(a) discussion of the analysis of data usability and the results of that analysis. As required by the RFI SOW and Risk Assessment Work Plan, the Permittee shall calculate and evaluate the potential error associated with findings."

The data quality and usability assessment was also completed to satisfy the Ecology and EPA Region 10 comments on the Draft RI (PSC, 2001c); to discuss data quality from a data validation perspective; and to demonstrate that the data collected are of sufficient quality to support the risk assessment, interim measure evaluations, and the feasibility study.

To meet the objectives of the data quality and usability assessment, guidance specified in the following EPA documents was used:

- *Guidance for Data Quality Assessment, Practical Methods for Data.* EPA QA/G-9, QA00 Update (EPA, 2000a).

- *Guidance for the Data Quality Objectives Process.* EPA QA/G-4 (EPA, 2000b).
- *Guidance for the Data Quality Objectives Process for Hazardous Waste Investigations.* EPA QA/G-4HW (EPA, 2000c).
- *Guidance for Data Usability in Risk Assessment (Part A) Final.* Publication 9285.7-09A (EPA, 1992).
- *Guidance on Environmental Data Verification and Data Validation.* EPA QA/G-8. EPA/240/R-02/004 (EPA, 2002).

5.2 Requirements for a Data Quality and Usability Assessment

A data quality and usability assessment is a systematic procedure for documenting and assessing applicable data to determine whether the data quality objectives (DQOs) established for a project have been met. PSC followed the requirements for completing a data quality and usability assessment (EPA, 2000a) by incorporating the following five steps:

1. *Review the DQO and Sampling Design.* This step included a review of the original DQO outputs to verify that they are still applicable. In addition, a review of the sampling design and data collection was completed to evaluate consistency with the DQOs.
2. *Conduct a Preliminary Data Review.* This step included a review of applicable quality assurance reports, calculation of basic statistics, and graphic presentation of applicable quality control data. This process provided information about the structure of the data sets and identification of any patterns, relationships, or possible anomalies that may exist within the data. The intent of this step was to evaluate actual performance versus established objectives, where each "critical" variable was evaluated to determine whether stated project objectives were met. If, upon the completion of this second step, it was determined that project objectives were not met, then the uncertainty relative to the project objectives needed to be defined.

3. *Select the Statistical Test.* This step included selecting the most appropriate procedure(s) for summarizing and analyzing the data based on the review of the DQOs, sampling design, and preliminary data review. The key underlying assumptions must hold true for the statistical procedures to be valid and identified. However, not every concern that may be identified during the data quality and usability assessment could be addressed by a statistical test. Rather, in some instances, qualitative statements more appropriately address the data quality and usability.

4. *Verify the Assumptions of the Statistical Test.* This step included verifying whether the underlying assumptions are valid, or whether departures that may be identified are considered acceptable given the actual data and other information that is known about the project.

5. *Draw Conclusions from the Data.* This step included performing calculations that may be required for the statistical test(s) and documenting the inferences that may be derived from the calculations or other analyses performed.

Completion of the five-step process, described above, can be divided into three principal categories: (1) data usability checks; (2) statistical analyses; and (3) assessments (or scientific analyses). The general purpose of completing this process was to evaluate the quality of the data collected during sampling and analysis and to answer such questions as: (1) Can a decision be made with the desired confidence with respect to the quality of the data? and (2) How well has the sampling design met the DQOs? Brief descriptions of how the three categories were applied to this data usability assessment are provided below.

5.2.1 Data Usability Checks

Data usability checks included a review of sampling and analytical activities. To complete the data usability checks, guidance specified by EPA in *Guidance on Environmental Data Verification and Data Validation* (EPA, 2002) was used. This process involved two primary steps: data verification and data validation.

Data verification of sampling information and analytical data occurred at several levels throughout the course of sample collection and analysis. Data were validated after the field activities were completed, the results reported by the laboratory were available, and all data were verified, and prior to use of the data for interpretive activities. The purpose of the verification and validation procedures was to assess whether the data conformed to the established DQOs and to identify limitations of the data when they did not conform to project-specific requirements and DQOs.

5.2.1.1 *Data Verification*

Data verification is a process of determining whether samples were collected and analyzed according to procedures prescribed in field sampling plans, the field and laboratory SOPs, and the QAPP. Data verification included: (1) verifying that all data required to meet project objectives were collected; (2) verifying correctness of sampling and analysis; and (3) verifying conformity to procedures and requirements stated in sampling plans, SOPs, QAPPs, analytical methods, and contractual agreements.

Verification procedures are usually completed during sample collection and during sample preparation and analysis. Field sampling verification included the review of various sampling information (e.g., field sampling plans, sampling logs, field sampling audits, and custody records). Laboratory data verification included the review of bench sheets, manual entry or transcriptions of data, and any professional judgments made by a chemist during sample preparation, analysis, and calculation and reporting of the final concentrations. Verification of conformance to method-specific requirements was also completed by the laboratory to determine whether data are of usable quality or reanalyses are required. Any nonconformance issues identified during the laboratory's verification of the data were corrected and documented. Data quality deviations that were identified by the laboratory were discussed in the laboratory case narrative.

The majority of the analytical data used in this report were verified on a project basis after completion of each sampling event. The exception to this was the soil data, which were collected more than 10 years ago and did not provide sufficient information to conduct a thorough data verification. For this report, laboratory data verification generally included the review of analyses and calculation and reporting of the final concentrations.

The inputs to data verification that were reviewed for this project included:

- Sample collection information (e.g., field sampling logs, drilling logs, chain-of-custody (COC) forms, and shipping records)
- Sample receipt information (e.g., COC forms, internal laboratory receipt records and login forms, and other applicable laboratory records)
- Sample preparation information (e.g., service request forms, COC forms, and sample preparation bench sheets)
- Sample data (e.g., service request forms, COC forms, analytical run logs, instrument printouts, calculation worksheets, sample results forms, and associated quality control measurement results forms)
- Records information (e.g., internal laboratory checklists or non-conformance worksheets).

5.2.1.2 *Data Validation*

Data validation is the process of evaluating the usability of verified data with respect to the planned objectives of the project. Data validation consisted of the following objectives: (1) verifying that field and laboratory measurements meet the user's needs, (2) providing information to the data user regarding data quality based on any identified degree of variability, and (3) determining whether project-specific DQOs were met. Inputs to data validation included assessing applicable field and laboratory data, as described below.

The inputs to the validation of field data reviewed for this project included:

- Evaluating field records for consistency
- Reviewing field instrument calibration and quality control measurement data
- Identifying deviations encountered during field sampling and the potential impact on data quality
- Reviewing COC forms for completeness
- Reviewing field sampling reports
- Discussions or interviews with field staff.

The inputs to validation of laboratory data reviewed for this project included:

- Reviewing project-specific documents (e.g., work plans, sampling plans, and QAPPs)
- Completing technical system audits of the analytical laboratory
- Reviewing laboratory SOPs
- Reviewing and validating laboratory data deliverables
- Reviewing data validation reports.

5.2.2 Statistical Analyses

Various statistical analyses of data were completed following suggestions provided in the *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 2000a). The types of statistical analyses that were completed varied depending upon the type of data or information.

5.2.3 Scientific Analyses

Scientific analyses (or assessments) of the data were also completed to provide more information concerning the data or to evaluate data not amenable to traditional statistical analysis. The type of analysis (or assessment) depended upon the type of information, data, or technical issue(s) to be addressed. The types of assessments used for this process included:

- Completing statistical tests to identify potential outlier data
- Assessing data reported for multiple measurements (or analyses) that were completed at the same sampling location
- Evaluating whether there may be observed seasonal fluctuations
- Assessing data obtained using different methods for the same chemicals of concern
- Determining whether there may have been effects from fluctuation of the water table
- Determining whether there may have been effects due to effervescence of water samples during collection
- Comparing the results of data from filtered and unfiltered samples
- Assessing the overall accuracy and precision of the analytical data.

5.3 Summary of Data Quality Objectives and Sampling Design

Work plans, sampling and analysis plans, and QAPPs for relevant data used in the RI and RA were reviewed to identify the DQOs and to determine whether the DQOs were met. The data sets that were assessed for quality and usability in the RI and RA included the following:

- First quarter 2000 to first quarter 2003 monitoring well data
- First quarter 2000 to first quarter 2003 reconnaissance borehole groundwater data

- Cation/anion data from August 2003
- On-site soil data (i.e., all soil data from the facility)
- Off-site soil data (i.e., all other data, G33 and the surface soil data from 1999)
- Soil gas data from first quarter 2000 to first quarter 2003
- Indoor air and ambient air data from first quarter 2000 to first quarter 2003
- Water level data from 1992 to first quarter 2003
- Tidal study data from 2002 and 2003
- Pumping test data from 1992 and 1999
- Geotechnical soil data from 1991 to 2003
- Slug test data from 1988, 1989, 1992, and 2003

The DQOs and sampling design for these applicable sampling events are summarized below.

5.3.1 Phase I Hydrogeologic Investigation (August 1988)

A Phase I hydrogeologic investigation was performed by Sweet-Edwards/EMCON (SE/E, 1987) as a part of the property transfer from Chempro to BEI. The scope of work is discussed in greater detail in the *Phase I Hydrogeological Investigation* report (SE/E, 1987).

The purpose of the investigation was to summarize the current and historical data and develop a preliminary facility characterization. The work completed for this investigation included the following tasks:

- Reviewed and evaluated previous facility investigation report (Harper Owes, 1983). Installed and developed three monitoring wells at two locations at the facility and one location upgradient of the facility. Two deep monitoring wells, CG-1 and CG-2, were completed below a depth of 98 feet. One shallow monitoring well, CG-3, was completed above a depth of 30 feet upgradient of the facility.

- Collected soil and groundwater samples at discrete depths in the two deep boreholes for analysis of VOCs, SVOCs, metals, cyanide, PCBs, and pesticides.
- Collected groundwater samples from new wells CG-1, CG-2, and CG-3, and from existing wells G-1, G-4, and HC-9. Analyzed samples for VOCs, SVOCs, metals, cyanide, PCBs, and pesticides.
- Performed aquifer testing via slug tests and analysis in wells CG-1, G-2, and HC-10.
- Surveyed each new well, except CG-3, and all existing wells except G-6 and HC-8 to a recognized datum.
- Measured groundwater levels in new and existing wells.

The objectives of this investigation were typically met. The observations and/or conclusions derived for this investigation included the following:

- Monitoring well CG-2 was abandoned in 2002 because conductor casing was not used to install this well, resulting in possible cross contamination between the shallow, intermediate, and deep aquifers within this monitoring well. As such, data from this well were suspected to be not representative of the deep aquifer. This uncertainty will not have an impact on the RI because deep aquifer facility monitoring wells were removed from the PCAMP groundwater monitoring program in 2002, as the data were determined to be unnecessary for achieving the objectives of that program.
- Groundwater data from the deep boreholes collected via reconnaissance borehole methods were not used in the RI or RA because there are sufficient data from more recent, properly designed monitoring wells at these locations using the low-flow

sampling technique. Soil data from these boreholes are included in the RI and RA and are considered representative of the source area of COPCs.

- Slug tests were performed in three wells; however, only wells G-1 and CG-1D produced results of sufficient quality to be incorporated into the RI Report. This is not considered a data gap for the RI, because numerous other hydraulic conductivity tests were completed at the facility during later phases of investigation of sufficient quality to be included in the RI Report.
- All monitoring wells were resurveyed a number of times since the installation of these three new wells because there have been changes in the top of casing elevations as a result of paving and other activities. PSC is using the more recent survey data for contouring and mapping purposes.

5.3.2 Phase II Hydrogeologic Investigation (December 1989)

A Phase II hydrogeologic investigation (SE/E, 1989) was performed as a part of the RFI completed for Chempro in order to satisfy the EPA consent order issued under Section 3008(h) of RCRA. The scope of work is discussed in greater detail in the *Chemical Processors, Inc. Georgetown Facility, Phase II Hydrogeological Investigation, Proposal for Monitoring, Analyses, and Testing* (SE/E, 1989).

The objective of the study was to complete the hydrogeologic and hydrogeochemical investigation of the facility initiated in previous studies. The work completed for this investigation included the following tasks:

- Twenty-nine new boreholes were drilled to characterize the subsurface environment, including two deep (TB-1D, TB-5D), four intermediate (TB-5I, TB-7I, TB-10I, TB-13I) and 23 shallow boreholes (TB-1S through TB-14S, with two boreholes each at TB-3, TB-4, TB-5, TB-7, TB-8, TB-10, TB-11, TB-13 and TB-14).

- The boreholes were completed as monitoring wells at 24 locations, including two in the deep aquifer (CG-4-D, CG-5-D), four in the intermediate aquifer (CG-1-I, CG-2-I, CG-5-I, CG-9-I) and 16 in the shallow aquifer (two each at CG-1-S, CG-2-S, CG-5-S, CG-6-S, CG-7-S, CG-8-S, CG-10-S, CG-11-S).

- Slug tests were performed in each of the two new deep wells and four new intermediate wells to estimate horizontal hydraulic conductivity of the deep and intermediate aquifers.

- Short-term aquifer pumping tests were performed in three of the new shallow wells to estimate horizontal hydraulic conductivity of the shallow aquifer.

- Eleven existing monitoring wells (G-1 through G-4 and G-7 through G-9, HC-4 through HC-6, and HC-8) were abandoned because they were located too close to fences, walls, and other obstructions.

- Two rounds of groundwater samples were obtained from the 24 new wells and 3 existing wells.

- Static water levels were measured on three occasions in the 24 new wells and 3 existing wells and hydraulic gradients were determined.

- Soil gas sampling was conducted at 11 test borehole locations.

- A groundwater beneficial use study was completed.

The objectives of this investigation were typically met. The observations and/or conclusions derived from this investigation included the following:

- The intermediate aquifer monitoring wells may not have been screened in the zone of highest contamination. The only groundwater reconnaissance sampling that occurred in the T-boreholes prior to well installation was for the shallow aquifer. This data gap was addressed in 2002 when PSC installed a new set of monitoring wells based on chemical data and the re-interpreted depth of the silt confining unit.

- The lithological logging that was conducted for the purpose of determining the screened interval of the intermediate wells may not have adequately identified the top of the confining unit, where PSC has now determined most of the groundwater contamination is located in the intermediate aquifer. This data gap was addressed in 2002 when PSC installed a new set of monitoring wells based on chemical data and the depth of the silt confining unit.

- Results obtained from soil gas sampling conducted at 11 test borehole locations were not used in the RI because more recent soil gas data used in the RI and RA are more representative of current conditions.

- Soil data from boreholes are considered representative of the source area of COPCs.

- All monitoring wells have had water levels measured numerous times since 1987 and the RI report looks at these trends over time and averages of water levels in each aquifer. Water levels, which have been measured in all PSC wells since 1987, were analyzed in the RI for trends over time and average water levels in each aquifer.

- All monitoring wells were resurveyed a number of times since the installation of the new wells because there have been changes in the top of casing elevation as a result of paving and other facility activities. The more recent survey data are being used for contouring and mapping purposes.

- A groundwater beneficial use study was completed; however, the results of this study are superseded by more recent beneficial use evaluations that have been incorporated into the RI.

5.3.3 Phase III Off-Site Hydrogeologic Investigation (1991–Present)

A Phase III off-site hydrogeologic investigation work plan (SE/E, 1991) was submitted as the first requirement of the facility Part B Permit. This investigation was intended to define the nature and extent of potential contamination in soils and groundwater upgradient, crossgradient and downgradient of the facility, meeting the final requirements of the 3008(h) consent order.

The scope of work is discussed in greater detail in the *Phase III [Off-Site] Hydrogeologic Work Plan, Chempro Georgetown Facility, Seattle, Washington* (SE/E 1991).

The objectives of this work were to:

- Verify the continuity of geologic and hydrogeologic conditions beneath areas hydraulically downgradient of the facility.
- Define the nature and extent of potential contamination in subsurface soils and groundwater downgradient of the facility that may have resulted from operations at the facility.
- Complete the requirements of the RI under Part VII.A of Permit No. WAD 00812909, issued by EPA as part of the RCRA Part B Permit for the facility.

The work completed for this investigation included the following:

- Monitoring wells CG-101-S1, CG-101-S2, CG-102-S1, CG-102-S2, CG-102-I, CG-102-D, CG-103-S1, CG-103-S2, CG-103-I, CG-104-S1, CG-104-S2, CG-104-I, CG-104-D, CG-105-S1, CG-105-S2, CG-105-I and CG-111 were installed and sampled.
- Groundwater samples were collected from temporary wells at locations upgradient and downgradient of the facility.
- A 72-hour shallow-aquifer pumping test was conducted using the soil vapor extraction system pilot test wells (V2, V3, and V4).
- Hand-auger soil samples were collected at 35 locations, and combined into 26 composite samples.

- A soil gas survey was conducted in 1991 in an attempt to delineate the extent of the groundwater plume migrating from the facility. Soil gas samples were collected from four facility locations and 21 locations upgradient and downgradient of the facility.

The objectives of this investigation were typically met. The observations and/or conclusions derived for this investigation included the following:

- The intermediate aquifer monitoring wells may not have been screened in the zone of highest contamination. This data gap was addressed in 2002 when PSC installed a new set of monitoring wells based on chemical data and the depth of the silt confining unit.
- The lithological logging that was conducted for the purpose of determining the screened interval of the intermediate wells may not have adequately identified the top of the confining unit, where PSC has now determined most of the groundwater contamination is located in the intermediate aquifer. This data gap was addressed in 2002 when PSC installed a new set of monitoring wells based on chemical data and the depth of the silt confining unit.
- Groundwater data from the reconnaissance boreholes are not being used because more recent data from reconnaissance boreholes sampled between 1999 and 2003 better represent current conditions and used a more reliable low-flow sampling technique.
- Soil gas sampling data were not used because more recent soil gas data used in the RI and RA is more representative of current conditions.
- Soil data from boreholes are considered representative of the source area of COPCs.
- Many of the shallow aquifer wells are useful in the PCAMP.
- Recent groundwater and soil data are included in the RI and RA. These data are considered representative of facility and nearby conditions and were collected using acceptable procedures approved by Ecology.

- Pumping test data from the SVE wells are incorporated into the RI.
- Chemical soil data obtained from all hand-auger soil samples are incorporated into the RI and RA. These data are considered representative of conditions at the facility and were collected using acceptable procedures.
- All monitoring wells have had water levels measured numerous times since 1987 and the RI report uses these data to evaluate trends over time in hydrographs

5.3.4 North Field Intermediate Well Installation (September 1998)

As an addendum to the Phase III hydrogeologic investigation (SE/E, 1991), two new intermediate wells (CG-11-I and CG-12-I) were installed in the North Field to improve intermediate aquifer groundwater contours (PSC, 1999a). These wells were logged to the top of what appeared to be the silt unit and screened at that location. The scope of work is discussed in greater detail in the *North Field Intermediate Well Installation Report, Philip Services Corp. Georgetown Facility, Seattle, Washington* (PSC, 1999a).

The objectives of this investigation were typically met. The observations and/or conclusions derived for this investigation included the following:

- After conducting more geological work at the facility, it was determined that these wells may not have been screened at the top of the silt unit and were removed from the PCAMP. This data gap was addressed in 2002 when PSC installed a new set of monitoring wells based on chemical data and the re-interpreted depth of the silt confining unit.

5.3.5 Indoor Air Evaluations

Indoor air, ambient air, soil gas, and groundwater data were collected for the RI, RA, and the IPIM in three studies conducted in 2000 (PSC, 2000c; Exponent, 2000a), 2001 (PSC, 2001b), and 2002 (FW, 2002, FW/PTC 2003a).

Indoor air and ambient air samples were intended to provide real concentrations of COPCs in air, but these concentrations were confounded by other sources of air contamination including urban sources (traffic, airplanes, industrial sources) and residential sources (cleaners, upholstery, carpeting, dry cleaning). Therefore, PSC collected additional data in an attempt to determine the sources of the COPCs identified in indoor air. These data included groundwater, ambient air, and soil gas samples. Groundwater samples were collected as close to the indoor air sample area as possible to determine whether COPCs in the indoor air were detected in groundwater, and to evaluate groundwater as a potential source of the COPCs. The ambient air sample concentrations were measured in areas upgradient (via wind) of the indoor air sampling areas to determine whether COPCs detected in ambient air were also detected in indoor air. This sampling was conducted to evaluate whether ambient air could have been a source of the COPCs and whether its contribution to indoor air in buildings may have increased the levels of COPCs to those levels that would exceed risk-based criteria. Soil gas samples were collected in the same locations as the groundwater samples to help determine whether COPCs may be entering buildings from the subsurface at levels exceeding risk-based criteria.

The scope of work is discussed in greater detail in the *Final Soil Gas Sampling and Analysis Plan. Philip Services Corp. Georgetown Facility, Seattle, Washington* (PSC, 2000c), the *Final Quality Assurance Project Plan. Soil Gas Sampling and Analysis: Georgetown Facility, Seattle, Washington* (Exponent,2000a), the *Technical Memorandum, Soil Gas Investigation March 2001 Results* (PSC, 2001a), and the *Revised Inhalation Pathway Interim Measures Work Plan* (FW, 2002).

5.3.5.1 *Indoor Air Analysis Sampling and Analysis Plan (August 2000) and Indoor Air Analysis Report (September 2000)*

Indoor air studies were completed in 2000 (PSC, 2000a). The purpose of this investigation was to collect indoor air samples from the basements of two residences immediately downgradient (via groundwater) of the facility to validate the results of the vapor intrusion model constructed as part of the Off-Site Soil Gas Study (PSC, 1999b, 2000c; Exponent, 2000a). In addition, soil gas, ambient air, and groundwater samples were collected concurrently. The scope of work is discussed in greater detail in the *Indoor Air Sampling and Analysis Plan. Philip Services Corp. Georgetown Facility, Seattle, Washington* (PSC, 2000a).

5.3.5.2 *Soil Gas Investigation, March 2001 Results*

The DOH conducted an indoor air investigation on behalf of ASTDR at homes and business near the facility. DOH chose to sample during the wet season, since PSC had conducted testing during the dry season. Therefore, sampling was conducted in March 2001. DOH conducted indoor air sampling at nine residential type buildings downgradient (via groundwater) from the facility. The DOH's intent was to characterize overall indoor air risks for people living or working in the buildings being sampled. The DOH was not concerned about the source of the contamination during their study; therefore, they did not collect soil gas samples, groundwater samples, or ambient air samples, but PSC did collect those data simultaneously with DOH sampling. The scope of work is discussed in greater detail in the *Technical Memorandum, Soil Gas Investigation March 2001 Results* (PSC, 2001a).

5.3.5.3 *Revised IPIM Technical Memorandum 1 (February 2003)*

The purpose of this investigation was to determine whether vapor migration from groundwater to indoor air is occurring in areas of significant VOC concentrations in groundwater. In addition, PSC planned to use the multi-media data to develop site-specific GIVFs that would be used to develop IPIMALs. PSC identified a GIVF study area immediately downgradient (via groundwater) of the facility that is also an area where groundwater concentrations exceed cleanup levels protective of the indoor air pathway. In total, ten buildings were included in the study and two of those buildings were sampled twice. The scope of work is discussed in greater detail in the *Revised Inhalation Pathway Interim Measures Work Plan* (FW, 2002).

In order to meet the objectives established for these investigations and to obtain data that were both representative of local conditions and the modeling using conservative approaches, the following actions were implemented:

- Selected locations (buildings) immediately downgradient of the facility were sampled because they would be expected to have the highest concentrations of COPCs in off-site groundwater and therefore would be good locations to determine whether exposure pathways existed.

- Selected locations where people would have the highest potential for exposure to the identified pathways were sampled, such as residences, where people spend most of their time.

- Soil gas and groundwater sample intervals were chosen to coincide with the depth of the basements of the houses near the sample locations to estimate the concentrations of soil and soil gas contaminants outside the basement walls.

- Indoor air, ambient air, and soil gas samples were analyzed by EPA Method TO-14/TO-15, the method recommended by EPA guidance documents for air sampling (EPA, 2002).

- Geotechnical soil samples were collected so site-specific data could be used as input values in the model to predict indoor air concentrations from soil gas concentrations.

The objectives of this investigation were typically met. The observations and/or conclusions derived for this investigation included the following:

- During the 2000 study, vinyl chloride, methylene chloride and 1,2-dichloroethane were detected in indoor air, but could not be attributed to ambient air or typical household COPCs. An unidentified potential source of these compounds is possible. The DOH and EPA conducted indoor air sampling at the same residences (as well as two local businesses) shortly after PSC's sampling event, and found no immediate health concerns (DOH, 2000).

- PSC could not gain access to all the buildings in the area immediately downgradient of the facility, referred to as the GIVF study area in the 2002 study. Therefore, PSC had to use alternate sample locations in areas where groundwater contained much lower concentrations of VOCs, which made the process of determining whether the pathway exists more difficult. Sampling inside buildings located where groundwater contained low concentrations of VOCs created the possibility that GIVFs may be overestimated or underestimated. However, in the IPIM work plan, PSC used a very conservative analysis to determine which buildings would require an IPIM. Using very conservative screening levels protective of the groundwater to indoor air pathway, PSC decided to install IPIMs in all residential buildings where COPC concentrations in groundwater indicated, , that a building's indoor air may exceed risk-based air screening levels. Although PSC could have sampled all of those locations before making a final determination as to whether a building required an IPIM, PSC instead took the conservative approach for the residential locations.

- Initially, PSC used soil gas analyses quantitatively by modeling soil gas concentrations to indoor air concentrations to assist in making risk-based decisions. However, EPA and Ecology project team members did not believe that the soil gas sampling methodology resulted in soil gas samples that were truly representative of subsurface conditions, even though they had approved the methods used in the work plan submitted in 2000 and the methods were recommended in EPA guidance documents. A revised soil gas sampling methodology was provided in the 2002 revised work plan (FW, 2002) that followed recommendations in EPA's latest guidance document. This methodology was approved by Ecology, but the agencies still only allowed PSC to use the data qualitatively. PSC again revised the methodology in 2003 (SOP-129) to follow EPA's even more recent recommendations for soil gas sampling in their latest guidance, but Ecology decided that these data also could be used only qualitatively. This approach is considered very conservative because the data are considered by many to be representative of subsurface conditions.

- The same ambient air sampling methodologies were used for all three sampling events in 2000, 2001 and 2002, except in 2001 the ambient air samples were only collected for 30 minutes, rather than 24 hours. Because there are some uncertainties relating to the comparability of these data sets, the 2001 data have not been quantitatively compared or used in the RI, RA, or IPIM.

Additional uncertainties related to calculating the GIVF and modeling exercises were discussed in the reports for these investigations, as referenced above.

5.3.6 Final Supplemental Off-Site Characterization Work Plan (September 2000) and Technical Memoranda I-XII, Supplemental Off-Site Characterization (October 2000–June 2003)

Supplemental groundwater characterization studies of areas downgradient of the facility (PSC, 2000b; Exponent, 2000b) were completed as part of the RI. The scope of work is discussed in greater detail in the *Final Supplemental Off-site Groundwater Characterization Work Plan. Philip Services Corp. Georgetown Facility, Seattle, Washington* (PSC, 2000b) and the *Final Quality Assurance Project Plan. Supplemental Offsite Groundwater Characterization: Georgetown Facility, Seattle, Washington* (Exponent, 2000b). The objectives of these studies were to:

- Determine the extent of VOC groundwater contamination that may be migrating from the facility in areas that were not fully defined during the 1998 Off-site Hydropunch® Investigation (PSC, 1998)

- Determine the maximum extent of potential DNAPL source zones potentially present downgradient of the North Field

- Determine the horizontal and vertical distribution of groundwater COPCs that may be migrating from the North Field and portions of the West Field

- Collect more detailed information concerning the location and characteristics of the silt aquitard immediately downgradient of the facility

- Further characterize the horizontal and vertical extent of groundwater contamination downgradient of the facility, to gain information about potential non-PSC sources of contamination, and to better characterize the nature and extent of COPCs in the water table aquifer to assess risks related to the inhalation pathway interim measure

To meet the objectives of these investigations, the scope of work for this project included the following tasks:

- Nature and extent investigation, conducted between 2000 and 2003, which included a total of 126 reconnaissance boreholes. At these locations, 385 discrete groundwater samples were collected at depths ranging from 10 feet bgs to 90 feet bgs.
- The source area investigation, to determine the distribution of groundwater migrating from the North and West Fields of the facility, included 38 reconnaissance boreholes located close to the facility. At these locations, 263 discrete groundwater samples were collected at depths ranging from 10 feet bgs to 90 feet bgs.
- The silt unit downgradient of Denver Avenue South was lithologically logged to determine the depth of the silt confining layer. Boreholes F7 and H identified the silt layer at approximately 120 feet and 130 feet, respectively.

The objectives of this investigation were typically met. The observations and/or conclusions derived from this investigation included the following:

- The data are representative of groundwater collected from monitoring wells that were later installed at former reconnaissance borehole locations; however, there is always some level of uncertainty associated with subsurface investigations. For example, during this study, sample locations were about 250 feet apart in the first six stages and sometimes further apart in the later stages. The 99 boreholes cover an area that is approximately 4,000 feet by 1,500 feet. Because of this sampling design, there may be potential data gaps in the horizontal characterization. PSC addresses this issue in Section 13.

- Most boreholes were logged continuously to the maximum depth of the direct push drill rig, which was approximately 130 feet. It is believed that the silt unit dips below the 130-feet mark around reconnaissance location F7 and its presence or depth beyond that approximate location is uncertain. There has been debate between PSC and Ecology and EPA on the issue of whether the silt unit disappears downgradient of the facility or not. The agencies were concerned that if the confining unit was absent, COPCs from the facility could potentially migrate downward. PSC has not been able to determine whether the silt unit exists all the way to the Duwamish; however, there is evidence that it does exist, and that it dips deeper toward the waterway, as do the other geological units.[1]The relevance of this issue has diminished because PSC has installed a barrier wall around the source of the COPCs and the areas of highly affected groundwater. The wall keys into the silt confining unit on all sides, as verified by boreholes installed as part of the HCIM. Although there continues to be groundwater contamination in areas downgradient of the facility, it is in the dissolved phase and does not affect groundwater as deep as the silt confining unit in areas where the silt confining unit cannot be confirmed (the deepest concentrations of VOCs detected downgradient of the facility are approximately 70 feet bgs).

5.3.7 Final RFI Well Installation Work Plan (November 2001)

Fifty-six groundwater monitoring wells were installed in 2002 and two wells were installed in 2003 in accordance with the *Final RFI Well Installation Work Plan* (PSC, 2001c). Wells were installed upgradient and downgradient of the facility. In addition, 13 soil boreholes were installed for lithological logging and geotechnical soil sampling. The scope of work is discussed

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[1] The evidence is that prior to reaching the true silt confining unit, heaving sand is encountered that is typically present for a couple of feet prior to reaching the dense silt confining unit. PSC encountered the heaving sand material in boreholes along East Marginal Way South, but was unable to drill deeper due to the limitations of the drill rig being used.

in greater detail in the *Final RFI Well Installation Work Plan, Philip Services Corp Georgetown Facility, Seattle, Washington* (PSC, 2001c).

The objective of this work was to address four identified data gaps from the Draft RFI, which included:

- Undefined nature and extent of groundwater contamination to the west of East Marginal Way South
- Whether there are other potential sources of contamination contributing to the groundwater contamination between the facility and the Duwamish Waterway
- Insufficient permanent monitoring wells to confirm the nature and extent of COPCs in groundwater (including any seasonal variations) that may be migrating from the facility
- Insufficient hydrogeological characterization of subsurface soils between approximately Denver Avenue South and the Duwamish River. The work plan addressed additional characterization of the following:
  - Soil types
  - Existence of a silt aquitard beyond Denver Avenue South
  - The depth of the water table beyond Denver Avenue South
  - The direction of water flow beyond Denver Avenue South

To meet the objectives of these investigations, the scope of work for this project included installing additional monitoring wells downgradient of the facility in three aquifer zones. The well locations were chosen based on chemical data from reconnaissance borehole locations in the area. The new monitoring wells have provided PSC with four rounds of data to use for the RI and RA. These data will be used along with recent reconnaissance data to characterize the nature and extent of COPCs in groundwater that may be migrating from the facility. Some of these wells (along with some of the recent reconnaissance locations) are located in areas where PSC believes other sources of groundwater contamination exist. PSC has apprised Ecology's Toxics Cleanup Program of the data that provide evidence of other sources of contamination in the area downgradient of the facility.

Since the installation of the new monitoring wells, PSC has collected 12 rounds of water levels and now has sufficient information to verify groundwater flow directions in each aquifer. These measurements were collected from 36 wells in the upper shallow aquifer, 29 wells in the lower shallow aquifer, 22 wells in the intermediate aquifer, and five wells in the deep aquifer.

The objectives of this investigation were typically met. The observations and/or conclusions derived for this investigation included the following:

- After evaluating the chemical groundwater data from these new monitoring wells for the RI, PSC has determined that some of the intermediate aquifer monitoring wells do not intersect hot spots of contamination outside of the barrier wall; however, PSC will propose additional wells to monitor this contamination in the HCIM Long-Term Monitoring Plan that is due in December 2003.
- As discussed in Sections 9 and 13, installation of these monitoring wells provided additional information about the nature and extent of contamination in the area between the facility and the Duwamish Waterway. These data provided additional evidence of potential non-PSC groundwater plumes. However, these data did not provide additional information on the location of the sources of the potential non-PSC groundwater plumes. This is a data gap; however, PSC believes it has defined the extent of its groundwater plume and that Ecology should identify others to address this data gap.

5.3.8 Draft Natural Attenuation Monitoring Plan (March 2002)

A natural attenuation monitoring plan (PSC, 2002b) was completed to obtain data to support fate and transport discussions in the final RI report. The work involved voluntary groundwater sampling to obtain additional geochemical and biological data for the attenuation analyses. The data also provide site-specific information to support the use of monitored natural attenuation as part of the final remedy. . The scope of work is discussed in greater detail in the *Draft Natural Attenuation Monitoring Plan, Georgetown Facility, Seattle, Washington* (PSC, 2002b).

The objectives of the monitoring were two-fold:

- Determine the types of natural attenuation processes that are occurring in order to understand more about the fate and transport processes at the facility and downgradient of the facility. (See discussion of the nature and extent of contamination in this RI.)
- Gather baseline data to document that natural attenuation is occurring at the facility and downgradient of the facility. This would provide information to support the potential use of monitored natural attenuation as part of the final remedy, assuming that it can be implemented while also being protective of human health and the environment.

The objectives of this investigation were met.

5.3.9 Revised Pre-Corrective Action Monitoring Plan (June 2002)

The PCAMP (PSC, 2002c) was designed to monitor the groundwater quality migrating from the facility. The PCAMP is to be followed until the remedial measures monitoring and compliance monitoring programs are established in accordance with conditions VII.D and VII.E of the permit). The scope of work is discussed in greater detail in the *Revised Pre-Corrective Action Monitoring Plan, Parts I and II, Philip Services Corp. Georgetown Facility, Seattle, Washington* (PSC, 2002c).

The PCAMP included the following objectives:

- Assess the environmental impact on the groundwater caused by historic and current facility operations by determining the nature and extent of groundwater contamination

- Provide data to evaluate human health risks associated with potential exposures to groundwater contamination
- Provide data to evaluate ecological risks associated with potential exposures to groundwater contamination
- Monitor effectiveness of interim measures
- Determine seasonal variation in groundwater concentrations
- Determine seasonal groundwater flow direction and elevation
- Collect groundwater samples according to the revised SOP to ensure that chemical concentrations are representative of groundwater quality near the monitoring well.

The observations pertaining to each of these objectives are discussed below.

5.3.9.1 *Nature and Extent of Impacted Groundwater*

PSC has initially defined the nature and extent of impacted groundwater using a series of direct-push groundwater samples collected in steps from the facility boundary to the groundwater-to-surface water discharge locations along the Duwamish Waterway, nearly 0.8 mile from the facility. The COPCs were primarily VOCs; therefore, PSC monitored for the entire facility VOC list at monitoring locations closest to the facility and reduced the list as compounds were not detected downgradient. This assisted PSC in narrowing the list of COPCs to those that could potentially be associated with the impacted groundwater migrating from the facility.

The data gathered from this investigation were used to determine lateral placement and screen depth for the permanent monitoring wells installed in 2002 throughout the area between the facility and the Duwamish Waterway. Although facility related COPCs consist of more than VOCs, the reconnaissance borehole investigations concentrated on the risk driving COPCs, which are VOCs. Therefore, the proposed monitoring program for the PCAMP network added some analyte groups to new wells closest to the facility to assess the presence of other chemicals of interest that were detected at the most downgradient wells. Those other COPCs included SVOCs, PCBs, inorganics, and TPH. A minimum of 10 quarters of data, including VOCs and other COPCs that remain above cleanup levels during that time period, will be collected from all wells in the PCAMP network, which will provide a sufficient baseline to determine the nature and extent of impacted groundwater migrating from the facility.

5.3.9.2 *Human Health and Ecological Risks*

Groundwater samples from all of the wells screened at the water table (wells with identifications ending in WT or S1) will be used to assess the risk to human health via the vapor intrusion and inhalation pathways per the *Draft Groundwater Interim Measures Work Plan* (PSC, 2001b) in the RA. These data are most representative of the groundwater closest to the foundations of buildings, and can be used, along with air monitoring results, to model indoor air concentrations within buildings immediately above the wells.

PSC has installed six wells between East Marginal Way South and the Duwamish Waterway. The purpose of these wells is to verify the extent of contamination and determine whether contaminated groundwater is entering surface water. Four of these wells are screened in the zones of contamination identified from the results of the direct-push groundwater sampling. The data from these wells can be used to estimate potential human health risks from contact with surface water and potential ecological risks if data suggest that contaminated groundwater is entering surface water.

5.3.9.3 *Effectiveness of Interim Measures*

Well V1 is sampled for VOCs quarterly at the same time the PCAMP wells are sampled to measure the effectiveness of the SVE system. This well is located within the radius of influence of the SVE system that was installed to remove VOCs from the vadose zone soils.

Groundwater samples from all of the wells screened at the water table (wells with identifications ending in S1 or WT), except V1, will be used to assess the risks to human health via the vapor intrusion and inhalation pathways per the *Final Inhalation Pathway Interim Measures Work Plan* (FW, 2002). These data are most representative of the groundwater closest to the foundations of buildings and can be used with models to estimate indoor air concentrations within buildings near the wells.

A number of wells will be used to monitor the effectiveness of the HCIM. Additional wells, as proposed in the final HCIM design (URS and Geomatrix, 2003), will be installed to assist in monitoring this interim measure.

5.3.9.4 *Seasonal Variation in Groundwater Concentrations*

Between 2002 and 2003, PSC collected 12 consecutive months of groundwater elevation data from all wells in the PCAMP network. This was completed in April 2003; groundwater elevation measurement events are now scheduled quarterly in February, May, August, and October/November. This measurement schedule will provide sufficient data to determine seasonal trends in groundwater concentrations throughout the monitoring network.

5.3.9.5 *Groundwater Flow Direction and Elevation*

The PCAMP requires a minimum of 10 quarters of water level data from all wells in the PCAMP network followed by semiannual water level measurements in the high and low water level seasons. This will provide sufficient data to determine seasonal trends in water elevations and in groundwater flow directions.

In addition, the water level measurement form has been modified for this facility to provide a place to record the ventilation time of the wells to ensure that the final water level measurement is the stable water level. This should reduce uncertainties in determining flow directions, particularly in wells that have significant effervescence.

5.3.9.6 *Collection of Representative Groundwater Samples*

The revised groundwater sampling SOP follows EPA guidance written to ensure that groundwater samples are representative of groundwater quality. Provisions in the SOP that address this issue include:

- Collecting samples at a low flow rate to minimize drawdown and volatilization
- Reducing the amount of water purged (to less than one or more well volumes) prior to sampling by having more realistic stability requirements
- If a well cannot consistently meet the stability requirements stated in the SOP, the project manager should evaluate whether the use of another sampling technique would meet stability requirements so that a representative groundwater sample can be collected
- Redeveloping wells annually that have more than 1 foot of sedimentation to ensure that the well is sufficiently clear of fine particles that may bias the sample results

The objectives of this investigation were typically met. There have been very few problems associated with this new SOP. Appendix 5A provides an analysis of this SOP in comparison to other SOPs that have been used between 2000 and 2003.

5.3.10 Revised Draft Hydraulic Control Interim Measures Work Plan (May 2002)

An HCIM investigation (PSC, 2002a) was required to design the HCIM that has been proposed for the facility. The scope of work is discussed in greater detail in the *Draft Hydraulic Control Interim Measures Work Plan* (PSC, 2002a). The HCIM is a barrier wall of soil/bentonite or similar technology that surrounds the source area and areas of highly impacted groundwater and is anchored into the silt unit at the base of the intermediate aquifer.

The objectives of the HCIM investigation were to:

- Determine the maximum extent of source zones potentially present to the east and north of the facility
- Collect information concerning the location of the silt aquitard to the east and north of the facility
- Collect geotechnical data for use in designing the barrier wall
- Collect samples for compatibility testing for use in designing the barrier wall

To meet the objectives of this investigation, the following actions were completed:

- Ten groundwater reconnaissance boreholes were installed in an approximate 100-feet grid system. The groundwater samples were collected continuously and field screened for VOCs. Samples that were indicative of impacted groundwater were submitted to the laboratory for analysis.
- Five geotechnical boreholes were installed at approximately 200-feet intervals along the facility boundary. The boreholes were logged at 5-feet intervals from ground surface to 10 feet into the silt-confining unit. A Shelby® tube sample was collected for soil geotechnical analysis at selected depths to gather samples from each lithological unit for compressive strength testing with the slurry material.
- A number of other geotechnical soil analyses were conducted on the soil samples (grain size, triaxial strength, permeability, Atterberg limits, and moisture content). Soil and groundwater samples were also collected for compatibility testing of media at the facility with the slurry material.

The objectives of this investigation were met.

5.4 Assessment of Sampling Techniques

This section will describe the general types of uncertainties (or errors) that have been encountered with certain sampling procedures. This section only focuses on samples or field data collected for the purposes of the RI and RA. Section 5.1 provides a list of the data that are included in the RI and RA. Project specific sampling problems, as they relate to DQOs, were identified in Section 5.3. Section 4 provides a detailed description of the sampling techniques used for each investigation, regardless of whether the data were included in the RI or RA.

5.4.1 Groundwater Sampling

Various sampling techniques have been used to collect groundwater samples. Sampling methods have changed as technological developments and recommended techniques from EPA are issued. For the groundwater sampling events discussed below, high volume purge, low-flow, and micropurge sampling techniques were used.

As discussed in Section 4, two slightly different SOPs have been used for sampling permanent groundwater monitoring wells between 2000 and 2003. In addition, in 2002, PSC replaced many of the dedicated Grundfos® Redi-Flow submersible pumps with submersible bladder pumps. Therefore, Exponent conducted an analysis of groundwater data from this period of time to determine the effect of changing the SOP and pumps in wells. As a result of that study, it was determined that changing the SOP had no measurable effect on the chemical concentrations in the monitoring wells; however, changing the SOP and the pumps has improved the water quality measurements and adherence to the SOP. The full study and results are provided in Appendix 5A.

5.4.2 Soil Sampling and Geotechnical Soil Sampling

Soil sampling methods have not changed from the Phase I to the Phase III RI work. The methodologies provided in the Phase I hydrogeological work plan are similar to those provided in PSC's current SOP for soil sampling. Geotechnical soil sampling methods have also not changed from the Phase I to the Phase III RI work. The methodologies provided in the Phase I Hydrogeological Work Plan are similar to those provided in the most recent work plans.

5.4.3 Soil Gas, Indoor Air, and Ambient Air Sampling

PSC has tried to use current sampling methodologies for all sampling work; however, methods of soil gas, indoor air, and ambient air sampling to characterize the groundwater to indoor air pathway of VOCs for human health exposures has been changing quickly over the last three years. Therefore, PSC has modified its sampling approach over this period to keep up with the new methods that have been designed to collect the most representative samples.

All three sampling events conducted in 2000, 2001, and 2002 used a similar sampling technique that involved driving stainless steel drive points to a depth equivalent to that of a basement slab, approximately 4-8 feet bgs. However, each event used slightly different sampling techniques, as described below:

1. Soil gas samples were collected from permanent soil gas sampling ports in 6-liter Summa® canisters. The 6-liter Summa® canisters were prepared under negative pressure and equipped with a dedicated flow regulator and filter. The 6-liter Summa® canisters were individually cleaned and certified to 0.02 ppbv THC by the contract laboratory for analysis of VOCs using gas chromatography/mass spectrometry with selective ion monitoring (GC/MS-SIM) by EPA Method TO-14/TO-15.

2. One-time soil gas, indoor air, and ambient air samples were collected during various investigations, as are described in Section 2. For the investigations, soil gas samples were collected by one of the following techniques:

    - Use of a soil gas probe (KVA® "HEFTY" model) where the soil gas was obtained by driving a stainless steel rod to a depth of 2.0 to 3.2 feet bgs for sampling completed in 1989. The soil gas was allowed to equilibrate for 10 minutes. Prior to purging, the air sample pump was cleaned by purging with background air (an upwind location at the facility) for 15 minutes prior to use at each location. Ambient air samples also were collected to evaluate ambient air conditions. The probe was purged at a rate of five liter/min for a period of 10 minutes using an air evacuation pump. Teflon® tubing was attached to a threaded fitting connected to the surface of the steel rods. The soil gas samples were collected into Tedlar® air sample bags.

- Use of a soil gas probe where the soil gas was collected by attaching an adapter to the top of the soil gas probe for sampling completed in 1991. A vacuum pump was attached to the adapter and used to evacuate soil gas from the probe. To collect the sample, a hypodermic needle was inserted through the silicone rubber and down into the stainless steel tubing of the adapter while the vacuum pump was running. The syringe was purged with soil gas. Then, without removing the syringe needle from the adapter, a 10-mL soil gas sample was collected. Soil gas samples were screened in the field using a portable GC for selected VOCs. A duplicate of the soil gas samples was also submitted for laboratory confirmation.

- Soil gas samples were collected from three to four feet bgs using a soil gas probe for sampling completed in 1999. Soil gas samples were obtained by driving a hardened steel rod with an enclosed slot screen. The screen was pushed out into the formation from three to four feet bgs. Sealant was not placed at the ground surface around the rod. The soil gas was not allowed to stabilize prior to purging. Tubing was lowered to the screened interval, attached to an aboveground air sampling pump, which had an outlet tube that connected to a depressurized 6-liter Summa® canister. Each Summa® canister was filled with 6 liter of soil gas at a rate of approximately 10 to 12 liter/min. The 6-liter Summa® canisters were individually cleaned and certified to 0.02 ppbv THC by the contract laboratory. Air Toxics Ltd. of Folsom, California analyzed samples for VOCs using GC/MS-SIM by EPA Method TO-14/TO-15.

3. In August 2000, sampling and analysis of soil gas samples collected through the floors of basements was completed in order to correlate the soil gas data to the indoor air data. Active and passive soil gas samples were collected using 6-liter Summa® canisters.

Passive soil gas samples were collected with the EMFLUX® samplers placed at a screened interval of 6.5 feet bgs over a period of approximately 120 hours.

Active soil gas samples were collected in 6-liter Summa® canisters over a period of 24 hours. Following the installation of the drive points, the drive points were sealed and stabilized for a period of 24 hours. Tubing was set at mid-screen level, 6.5 feet, through a barbed brass fitting, which was inserted through a silicone stopper. At the other end of the stopper, another piece of tubing was attached and ran to the fitting on the 6-liter Summa® canister. The 6-liter Summa® canisters were set to fill over 24 hours. Each Summa® canister held 6 liter of air, which provided sufficient volume to reach the method detection limit goals. Air Toxics Ltd. of Folsom, California analyzed samples for VOCs using GC/MS-SIM by EPA Method TO-14/TO-15.

Passive soil gas samples were collected using EMFLUX® samplers over a period of 120 hours to reach the lowest detection limits. Following the active soil gas sampling, the drive points were sealed and stabilized for 24 hours. At the end of the 24-hour period, EMFLUX® passive soil gas samplers were strung down to one inch above the bottom of the screen, using a wire attached to the top of the rod. Instead of aluminum foil or screw caps to seal the rods, PVC well caps were used. At the end of the 120-hour period, the EMFLUX® passive soil gas samplers were removed, the screened top was replaced with a solid top, and the samplers were placed in the original shipping containers. Beacon Environmental Services, Inc.'s subcontractor, Spectral Laboratory of Maryland, which specializes in analyzing EMFLUX® sampling devices, analyzed the samples using EPA Method TO-1. In addition to the active and passive indoor air samples, ambient air samples were also collected using the 6-liter Summa® canisters.

4. In March 2001, sampling and analysis of soil gas samples collected through the floors of basements was completed. Sample locations were located throughout the Georgetown neighborhood, correlating with the houses and businesses in which the indoor air samples were collected by DOH. Samples were collected from the vadose zone (four to six feet

bgs) in 6-liter Summa® canisters over a period of approximately 30 minutes at a rate of 200 mL/minute, which is the EPA-approved method for collection of soil gas samples from permanent soil gas ports.

Soil gas samples were obtained by driving a hardened alloy steel riser with two-feet stainless steel slot screens. The screens were enclosed in a steel sheath and pushed out into the formation from four to six feet bgs. Sealant was placed at the ground surface around the riser and the riser was sealed with a rubber stopper. The soil gas did not stabilize prior to purging. A total of three liters of air were purged from each riser prior to sampling to ensure that the air was representative of only soil gas. After purging the soil gas, tubing was lowered to the screened interval, attached to a depressurized 6-liter Summa® canister and used to collect soil gas at a rate of approximately 200 ml/minute. In addition, ambient air samples were also collected using the 6-liter Summa® canisters. The 6-liter Summa® canisters were individually cleaned and certified to 0.02 ppbv THC by the contract laboratory. Air Toxics Ltd. of Folsom, California analyzed samples for VOCs using GC/MS-SIM by EPA Method TO-14/TO-15.

5. EPA sampled two businesses and three residences in August 2000. Two of the three residences were initially sampled by PSC, and then resampled by EPA as part of this investigation (DOH 2000). The sampling event set to correlate with the high groundwater table season was conducted during March 22 and 23, 2001. DOH conducted an indoor air investigation in cooperation with the ASTDR at homes and businesses near the facility. The indoor air samples were collected in SilicoCan® 6-liter stainless steel canisters with passive flow regulators for a period of 24 hours. The canister intake was set at a height that corresponds to the general breathing zone within the room sampled. The samples were analyzed for VOCs by EPA Method TO-15 using GC/MS-SIM.

6. In August 2002, indoor air and ambient air samples (including groundwater samples) were collected as part of the initial IPIM study to assist in developing chemical-specific

interim groundwater cleanup levels and to evaluate whether VOC concentrations in groundwater may be adversely affecting indoor air at levels that pose a health concern at some buildings in the neighborhood near the facility. Indoor air and ambient air samples were collected using 6-liter Summa® canisters and were analyzed by Air Toxics Ltd. of Folsom, California for VOCs using GC/MS-SIM by EPA Method TO-14/TO-15.

Because there are some uncertainties relating to the comparability of the soil gas data sets, the data have not been quantitatively compared or used in the RI, RA, or IPIM. The same ambient air sampling methodologies were used for all three sampling events in 2000, 2001, and 2002, except in 2001 the ambient air samples were only collected for 30 minutes, rather than 24 hours. Because there are some uncertainties relating to the comparability of these data sets, the 2001 data have not been quantitatively compared or used in the RI, RA, or IPIM.

5.4.4 Field Data Measurements and Uncertainties

Field data are results from monitoring and measuring instruments or tests conduced by personnel in the field. Four types of field measurements are pertinent to the RI:

- Groundwater elevation measurements
- Water quality results
- Hydraulic property data
- Geological soil logs

The sources of data, instrument calibration, instrument accuracy, consistency in data collection activities, documentation, data review, and the types of error and uncertainty that may be associated with the field data are discussed below.

5.4.4.1 *Groundwater Elevation Measurements*

The methods used to measure groundwater elevation have not changed since 1993, except for the change in 2002 to allow wells to vent prior to recording the water level. This change was implemented as a result of erroneous measurements in the past that were likely a result of pressure buildup in the well from effervescence. This change has improved the quality of the water level measurements, but has not made the use of older data unreliable; like all water level measurement data, quality checking is required to ensure that the water level is representative of that well. There are multiple types of errors that can occur during water level measurement and the remainder of this subsection focuses on those general types of errors and uncertainties.

Measurement Time—Resolution: Generally, each DTW measurement is accompanied by a specification of the time that the measurement was made (i.e., year, month, day, hour, and minute). If recorded accurately, data with greater time resolution introduce less uncertainty than data with lower time resolution.

Measurement Time—Appropriateness: DTW measurements should not be made immediately following events that artificially disturb the groundwater system, except under certain controlled conditions (e.g., aquifer pumping tests or well slug tests). If a DTW measurement is made immediately after a well has been installed or developed, or immediately following groundwater sampling, without first allowing the water level to equilibrate, the resulting data are not representative of ambient conditions.

Horizontal Control: The horizontal position of a well must be specified (typically by land survey) relative to a known datum if the groundwater elevation data are to be useful. Wells whose horizontal positions are not known are unsuitable for use in estimating the spatial distribution of groundwater elevations.

Vertical Control: The elevation of a well's MP must be specified relative to a known datum, or its groundwater elevation measurements cannot be related to those at other wells. If a well's MP has not been surveyed to a known datum, then its hydrograph can still be plotted, but it only gives the relative change in groundwater elevation over time at that well.

Screened Interval: If the water level data for a well are to be used to estimate groundwater elevation, there must be sufficient information available to reliably determine which hydrogeologic unit the well is screened in. This means there must be a borehole log for the well that shows the screened interval, and from which it is possible to identify the corresponding hydrogeologic unit.

Duration of Measurement Series: To infer the seasonal and longer-term hydraulic response at a well, it is desirable to have a series of groundwater elevation measurements covering a long period (years, if possible). If the data series is too short, the measured elevations may be biased toward climatic conditions corresponding to that particular period (e.g., drought conditions). In that case, the record of groundwater levels may not be representative of the longer period.

Measurement Accuracy: The accuracy of groundwater elevation measurements depends in part on the instrument used, and in part on the way it is used. Each type of instrument has an upper limit on the accuracy of its measurements, which is based on the assumption that the instrument is properly used. Under some conditions, the measurements may be less accurate. For instance, low battery power or instrument malfunction may contribute to inaccurate results. Therefore, both the inherent physical limitations of the instrument and the conditions of its use contribute uncertainty to the results.

Measurement Precision: Normally the elevation of the MP is surveyed to within ±0.01 feet. Under ideal conditions, the DTW measurement also is precise to within ±0.01 feet. Consequently, under ideal conditions the groundwater elevations have a precision of ±0.02 feet. Field measurements are collected from multiple locations with specified time frames to ensure that any atmospheric effects or tidal influences (few wells only) on precision are minimized and well within the range of values used for control in contouring.

Groundwater elevation data are potentially subject to following types of errors:

- DTW measurement error and DTW transcription error, or failure to accurately record the measured DTW in the log book while in the field
- Basic procedural error (e.g., well is not vented for a sufficient period of time prior to DTW measurement)
- Equipment-specific procedural error, or the failure to properly follow device manufacturer's recommended operating procedure, use of a measurement device that is improperly calibrated, excessively worn or poorly maintained, or defective
- Data entry error or failure to properly enter the measured DTW in the electronic database while in the office
- MP elevation survey error

DTW measurement errors may be due to transcription errors on field records, false positive readings from condensation on the inside of the well riser, and false negative readings from a well with water that has a low specific conductivity that makes it difficult for the water elevation meter to operate correctly. Most of these types of potential errors are corrected in the field prior to entry into the database for use in decision-making. Comparing the data from a year earlier to the measurements being collected in the field assists in reducing the potential for a transcription error in the field.

The most common type of procedural error that may be encountered when completing DTW measurements is failure to properly vent a well prior to measurement. Pressure buildup in the wells causes the water level to rise or fall when the well is capped; thus wells must be vented prior to collection of water level measurements and readings must be double-checked after a few minutes to determine whether the water level has stabilized or not. Based on review of water elevation maps, this latter type of error appears to be the most common. Deep wells tend to be more sensitive to venting. In general, water level data that are obviously incorrect or anomalous are not used as control points when contouring groundwater data. If the error is not obvious, the data point may be used to compile the water elevation contour maps and, therefore, could reduce the accuracy of the map slightly.

The likelihood of equipment-specific error (e.g., failure of the water-level indicator) is considered very low. If the water-level indicator is not working at all (i.e., indicated by the alarm not sounding when the indicator enters the water), the sensor on the instrument is checked, and then the batteries. A sensitivity setting on the water-level indicators can be adjusted to the specific conductivity of the well; therefore, if a well has low specific conductivity, the sensor may be not be activated when it reaches the water column. If neither of those issues appears to be the problem, problems with instrument wiring will be checked. If there are no visible problems, the instrument will be sent to the manufacturer for repair.

Data entry errors may occur, but this source of error is minor. The DTW field data are provided to the database manager in the office, who then enters the information manually into the database. The water elevations are calculated by subtracting the DTW measurement from the MP elevation. Once the tables and water elevation contour maps are created for each aquifer, a senior hydrogeologist or project manager reviews the data for accuracy and sometimes decides to eliminate certain measurements from the maps because of potential measurement error.

MP errors may occur, but this source of error is minor. Each well's measuring point has been surveyed by a certified surveyor to an accuracy of ±0.01 feet. The survey data are provided on Table 4-2 in Section 4. The survey data are based on the City of Seattle vertical datum. The surveyors used existing control points as well as other structural control points to verify the accuracy of the survey. Overall, there is a low amount of uncertainty related to water elevation data for the facility and surrounding areas because of the amount of data available and the quality control mechanisms in place.

5.4.4.2 *Water Quality Results*

Field water quality data are documented using field forms and field log books or direct electronic data downloads from the water quality measurement instrument. PSC has been using electronic data downloads since January 1999. Water quality data from the fourth quarter 2000 to the first quarter 2003 are included in this report. Older data are available, but only the most recent data are used in this report. The data used in this report are provided in Section 9 as part of the natural attenuation discussion.

Water quality parameters are recorded using a flow-through cell, which contains water quality sensors in one probe for temperature, dissolved oxygen, oxidation reduction potential (ORP), specific conductivity, and pH. From the first quarter 1999 through the fourth quarter 2000, PSC has used a YSI® 6-Series Environmental Monitoring System multi-parameter water quality meter and since the fourth quarter 2000, PSC has used the YSI® or a Horiba® U-22 water quality meter. A DRT® 15CE turbidimeter is used to independently record turbidity measurements. The dissolved oxygen sensor on these instruments and the turbidity meter (a stand alone meter) require daily calibration; the ORP meter, specific conductivity meter, and pH meter all require weekly calibration. The temperature meter is factory calibrated and does not require field calibration. If a specific water quality sensor does not appear to be functioning correctly (i.e., it does not stabilize or the measurements appear to be outside the normal range for that well), then that specific sensor would be recalibrated for that parameter in the field. From the first quarter 2003 to the present, PSC has been primarily using the QED® FC5000T water quality meter, and only using the YSI® or Horiba® as backup equipment. The manufacturer's recommended calibration requirement for this instrument is weekly for all the sensors. The DRT® 15CE turbidimeter is calibrated daily.

The accuracy of the water quality instruments is listed in Table 5-1. The accuracy of all the water quality meters is within EPA's requirements for measuring the stability of the measured parameters. The consistency of data collection for water quality measurements is primarily based on the accuracy of the equipment calibration because the methodology for collecting the readings is straightforward and adhered to properly.

The major problems that have occurred relating to water quality testing include the following:

PROBLEM	CAUSE	EFFECT
Dissolved oxygen readings are sporadic	The dissolved oxygen membrane may need replacement or recalibration.	This problem is identified by the field geologist and can be addressed in the field.[2] Therefore, there should be no effect on the sample quality as long as a sample is not collected before the problem is addressed.
ORP continually decreases	May be a natural condition of the aquifer, but may also be related to the calibration of the dissolved oxygen meter, which is used in the ORP calculation.	This problem is normally identified by the field geologist and can be addressed in the field.[2] Therefore, there should be no effect on the sample quality as long as a sample is not collected before the problem is addressed.
Calibration drift	During the course of a day, the calibration parameters may drift as a result of change in atmospheric temperature, drastic differences in water quality, equipment problems, etc.	Generally, this type of problem is detectable by the field geologist because each well has typical water quality limits. Atypical readings or a change in readings during monitoring would signal a problem with the equipment. If the geologist catches the problem, the equipment can be recalibrated during the day. If the problem is not caught, a false positive or negative situation could arise. In general, only the false positive situation would cause uncertainty. This topic is described in more detail below.

An evaluation of the effectiveness of the Micropurge® technique and the low-flow sampling technique was completed by Exponent (2001, 2003). Exponent also compared the analytical data from the revised low-flow groundwater sampling technique to the previous results collected with the Micropurge® technique. The results of these two evaluations are presented in Appendices 5A and 5B. It was concluded that problems encountered with water quality testing have not resulted in significant sample quality issues since the Micropurge® and low-flow sampling techniques were implemented.

These evaluations included the following observations:

- There was no sudden and consistent high or low bias in concentrations of indicator analytes after the implementation of the Micropurge® and revised low-flow sampling methods.
- Spikes in field parameters and variations from sampling methods were not consistently associated with spikes (either high or low) in VOC concentrations.
- In instances where there were variations from the SOP guidelines (either Micropurge® or revised low-flow procedures), there was no observed sudden and consistent high or low bias in concentrations of organic compounds.
- For those instances where significant changes in temperature, aquifer effervescence, or unsteady flow rate occurred, no consistent correspondence to indicator analyte concentration trends was observed.
- Instances of significant drawdown during purging were inconclusive with respect to potential effects on sample concentrations.

Based on these observations, Exponent concluded that the Micropurge® and revised low-flow sampling methods have resulted in data of comparable quality to those produced using previous sampling methods. Variations from PSC's SOP protocols within the ranges observed during this evaluation did not correspond to high- or low-biased concentration data. Therefore, it is concluded that these sampling techniques have improved the likelihood of collecting samples that are representative of aquifer conditions by reducing the pumping rate and refining the stability requirements of water quality. This has resulted in an overall improvement of data quality with the inception of the new SOP.

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[2] When these problems occur, it becomes obvious to the field geologist that maintenance or recalibration may be necessary and sampling is stopped to address the problem. If the problem cannot be fixed in the field, a different water quality meter is used to complete sampling (a second one owned by PSC or a rental).

5.4.4.3 *Hydraulic Tests*

A number of hydraulic tests have been conducted at the facility, including geotechnical tests, slug tests, and pumping tests. Geotechnical analyses have been conducted in nearly every investigation at the facility as well as areas upgradient and downgradient of the facility. Slug tests were conducted in all three phases of hydrogeological investigations for the facility. Two pumping tests were conducted, including the shallow aquifer pumping test in March 1992 and the intermediate aquifer pumping test in December 1999. The shallow pumping test was required for the soil vapor extraction system interim measure. The intermediate aquifer test was required by the RFI addendum. Both tests were conducted by PSC personnel. General data quality issues related to hydraulic testing are discussed first, followed by specific data collection activities for geotechnical analyses, slug tests, and pumping tests.

The hydraulic test results generally exhibit some degree of variability. The causes of this variability include the following: (1) measurement error, (2) the combination of natural spatial variability and differences in the effective material volume associated with the various test methods, and (3) different data interpretation methods (e.g., different analytical models).

Section 3 provides the ranges of hydraulic property estimates obtained from the physical testing performed by PSC and its contractors for each hydrogeologic unit. In some cases, a range of estimates is reported even though the table lists only one test/sample location. There are two possible reasons for this:

- Sometimes two or more analysis methods were used to interpret the same data from a single test. Different analysis methods, which are based on different assumptions, generally lead to different estimates.
- Sometimes two or more subsets of data from the same test were analyzed independently, leading to multiple estimates. For instance, the long-term pumping test of the shallow aquifer conducted in 1992 consisted of a drawdown phase followed by a recovery phase. By analyzing these two subsets of the test data independently, different hydraulic

conductivity estimates were obtained. In addition, drawdown data collected from different observation wells during the same test were analyzed independently, thus giving a range of estimates for the drawdown phase of this test.

5.4.4.4 *Hydraulic Anisotropy*

The subsurface materials that were tested consist primarily of layered, unconsolidated sediments. Such materials are expected to exhibit some hydraulic anisotropy, both locally (i.e., on a scale of one meter or less) and on a field scale (i.e., tens of meters, or more). However, PSC is not aware of any evidence of large-scale cross bedding or systematic dip of strata that would cause the principal axes of the hydraulic conductivity tensor to deviate substantially from the horizontal and vertical directions when considered on a field scale. When measured on a field scale, one would expect the horizontal hydraulic conductivity to equal or exceed the vertical conductivity.

For the shallow and intermediate aquifers, the ratios of horizontal-to-vertical hydraulic conductivity were calculated for comparison. The ratios were calculated directly from the corresponding horizontal and vertical hydraulic conductivity estimates. The range of conductivity ratio estimates can be considered a rough measure of the natural spatial variation of hydraulic anisotropy within the hydrogeologic unit. Two factors that can cause this range to be narrower or wider than what occurs naturally are the following:

- Correlation between horizontal and vertical hydraulic conductivity values
- Disparity between the effective spatial scales of the tests

The horizontal conductivity at each test location is expected to be positively correlated with the vertical conductivity at the same location. The conductivity ratio estimates were calculated without regard to any such correlation. Thus, the range of the ratio estimates is wider than what would be obtained if one could simultaneously test both the horizontal and vertical hydraulic conductivities of a fixed volume of subsurface material.

The vertical conductivity estimates are from laboratory tests on relatively low-volume material samples, while the most reliable horizontal conductivity estimates are from pumping tests, for which the effective test volume is probably thousands of times greater. At the scale of the laboratory test, the subsurface material is much more heterogeneous than at the field scale. Consequently, the conductivity ratio estimates are much more variable than would have been obtained if the two types of test had been conducted at the field scale. One possible indication that a range of conductivity ratio estimates is too wide is that the range includes values that are substantially less than one. On a field scale, the conductivity ratio is always expected to equal or exceed one.

The most reliable estimates of the field-scale conductivity ratio are likely to be those based on horizontal conductivity estimates from the pumping tests, because these generally give the most reliable estimates of the field-scale horizontal conductivity.

Criteria were developed for evaluating the quality and consistency of data collection for the hydraulic property data. The data quality criteria are divided into the following categories:

- Geological association
- Test location (within a given hydrogeologic unit)
- Test scale
- Test duration
- Test type (hydraulic versus non-hydraulic)
- Test type (*in situ* versus *ex situ*)

Although these categories overlap somewhat, this scheme is convenient for discussion and data classification. Each of the categories is considered separately below.

Geological Association—Deposits within the same geologic unit can be correlated at the field scale. For example, at two different locations within a given hydrostratigraphic unit of similar texture, the depositional environments are likely to have been similar on this scale. This characteristic is likely to manifest itself by similar physical properties for the unit across the areas being evaluated. Consequently, test data from within the same geologic unit are considered more representative (less uncertain) than data from other geologic units.

Test Location (within a given hydrogeologic unit)—With few exceptions, the physical properties of natural geologic materials exhibit spatial variability and spatial correlation. Therefore, in the absence of information to suggest otherwise, test results from nearby locations are generally considered to give more reliable estimates of physical properties than results from distant locations.

Test Scale—Due to the natural spatial variability of geologic materials, hydraulic property test results are inherently scale-dependent. Laboratory tests operate on relatively small samples of material, with dimensions on the order of centimeters. For field-scale groundwater flow, the relevant test scale is likely on the order of tens or hundreds of meters. For these reasons field test results are considered more representative than laboratory test results of hydraulic properties relevant to field-scale analyses. In the absence of field test results, laboratory test results can be used, but the associated uncertainty is greater.

Perhaps because slug tests effectively test smaller material volumes than aquifer pumping tests, slug test results tend to be more heavily affected by drilling fluid disturbances and imperfect well development (Butler 1998). As a result, slug test data are generally considered less reliable than aquifer pumping test data for estimating hydraulic properties relevant to field-scale groundwater flow.

Test Duration—This criterion is applicable to field hydraulic tests. The effect of test duration is similar to that of test scale. As the test duration increases, the volume of aquifer material that is effectively tested increases. Therefore, hydraulic property estimates from long-duration pumping tests are considered more reliable than those from short-duration tests.

Test Type (hydraulic versus non-hydraulic)—Consider the determination of hydraulic conductivity. Hydraulic tests are those that cause groundwater to flow through the material being tested, and then use the measured flow rate and hydraulic response to calculate the estimated hydraulic conductivity. At the field scale, these include aquifer pumping and well slug tests. At the laboratory scale, these include constant-head and falling-head permeameter tests (Sevee 1991).

Non-hydraulic tests are those that measure or test some other property of the material, and then relate the measured property to its hydraulic properties using theoretical or empirical relationships. An example is the estimation of hydraulic conductivity from grain-size (sieve) and porosity test results. Domenico and Schwartz (1998) list a number of such methods. These non-hydraulic methods utilize theoretical relationships based on assumptions that cannot be directly verified. Hydraulic test methods, being more direct than the non-hydraulic methods, are believed to be more reliable for estimating hydraulic properties. Non-hydraulic methods may be useful for corroborating other test results (e.g., to within an order of magnitude).

Test Type (*in situ* versus *ex situ*)—In addition to the scale of the test, there are other differences between field (*in situ*) and laboratory (*ex situ*) hydraulic property tests. Unlike a field test, a laboratory test requires that a sample of the material be removed from the subsurface and transported to a laboratory. Sample collection and transportation present opportunities for the sample to be physically disturbed in such a way that modifies its physical properties. It is especially difficult to obtain an undisturbed sample of unconsolidated material. In this respect, field tests are superior to laboratory tests.

The results of an evaluation of the criteria developed for evaluating the quality and consistency of data collection for the hydraulic property data can be summarized as follows:

Geological Association:

- More reliable: Physical test data from the appropriate geologic unit
- Less reliable: Published test data for geologically similar media

Test Location (within a given hydrogeologic unit):

- More reliable: Test data from nearby locations
- Less reliable: Test data from distant locations

Test results for horizontal hydraulic conductivity:

- More reliable: Aquifer pumping test data
- Less reliable: Well slug test data, laboratory grain size analysis data

Test methods for vertical hydraulic conductivity estimation:

- More reliable: Laboratory permeameter test data
- Less reliable: Laboratory grain-size analysis test data

Test methods for specific yield (unconfined aquifer):

- More reliable: Aquifer pumping test data
- Less reliable: Laboratory porosity test data

Test methods for specific storage/storativity:

- More reliable: Aquifer pumping test data
- Less reliable: Calculation from data on porosity and compressibility

The results of the hydraulic property data quality evaluation are presented in Section 3, Table 3-7. The data quality rankings vary from one, which represents the highest quality, to four, which represents the lowest quality.

5.4.4.5 *Geotechnical Soil Testing for Hydraulic Properties*

As mentioned previously, the geotechnical sample hydraulic tests are less preferred than active testing of the aquifer. This is due, in part, to the uncertainty of the sample collection methods as well as the rationale listed above. The methodology for geotechnical soil sampling generally involves the following processes:

- Determining the sample interval from the work plan or via field screening;
- Obtaining adequate sample volume for the geotechnical analyses planned; and
- Keeping the sample undisturbed prior to geotechnical analysis.

The process that creates the most uncertainty is determining the sample interval, especially since it is typically not possible to see the sample for geotechnical analysis as the "Shelby Tube" in which it is normally collected is constructed of steel and is 3 feet long. Therefore, it is possible that the interval for sampling was missed or that there is not a sufficient amount of sample for the planned analyses. If this were a subsurface sample, it would be difficult to resample the location without going back and drilling a new borehole. It is very important to make sure that the sample is not disturbed before analysis; however, it is generally difficult to determine whether a sample has been disturbed or not. This creates some uncertainty with the laboratory geotechnical analyses.

5.4.4.6 *Slug Tests*

The instruments used for the slug tests included pressure transducers with data loggers, water level indicators, and a pump or bailer. All water measurement equipment was factory calibrated in accordance with manufacturer's instructions. The water level indicator and the transducers had an accuracy of at least ±0.01 feet. The transducers had data loggers that stored the data until the end of the test, at which time the data were downloaded onto a computer and interpreted and analyzed. In addition, manual water level measurements that were recorded in field log books or field forms were compared to the downloaded transducer data, if available, to verify the accuracy of the equipment.

5.4.4.7 *Shallow Aquifer Pumping Test*

The instruments used for the slug tests included pressure transducers with data loggers, water level indicators, and a pump or bailer. All water measurement equipment was calibrated. The water level indicator and the transducers had an accuracy of ±0.01 feet. Data loggers stored the data until the end of the test, at which time the data were downloaded onto a computer and interpreted and analyzed. In addition, manual water level measurements that were recorded in field log books or field forms were compared to the downloaded transducer data, if available, to verify the accuracy of the equipment.

One major specific problem that was encountered in the shallow aquifer pumping test was that there was a slight increase in drawdown during the later part of the recovery test. It is not known why this occurred. It is possible that it was due to an external stress on the aquifer or that the pressure transducers failed resulting in a time-dependent systematic error. It is extremely unlikely that all three of the observation well transducers failed simultaneously and in the same way, leading to similar responses at the wells. No documentation was found that suggests field equipment malfunctioned. More likely, an external stress on the aquifer was responsible for the drawdown. In any case, when the data were reanalyzed in April 2000, only those data from the earlier part of the recovery phase were used. Therefore, there is a low potential for uncertainty with this data set, as PSC was conservative in choosing the data to interpret, leaving out any data that appeared to have uncertainties.

The uncertainty related to the shallow aquifer-pumping test is relatively low after PSC reanalyzed the data in 2000. This was a typical aquifer-pumping test with no substantial problems. Section 3, Table 3-10describes the specific data quality of each pumping test type and analysis method .

5.4.4.8 *Intermediate Aquifer Pumping Test*

The instruments used for the slug tests included pressure transducers with data loggers, water level indicators, and a pump or bailer. All water measurement equipment was factory calibrated. The water level indicator and the transducers had an accuracy of at least ±0.01 feet. The transducers had data loggers that stored the data until the end of the test, at which time the data were downloaded onto a computer and interpreted and analyzed. In addition, manual water level measurements that were recorded in field log books or field forms were compared to the downloaded transducer data, if available, to verify the accuracy of the equipment.

Specific problems that were encountered in the intermediate aquifer-pumping test included:

- Wells CG-9-I, CG-11-I, and CG-12-I flooded with rainwater during a storm event, which disrupted the test;
- The pumping rate was too high for the test, causing the pumping well to run dry; and
- The transducer in the deep observation well was placed too deep during the pre-test monitoring; therefore, it did not register any pressure variation observations.

The wells that flooded had the transducers pulled so that the wells could be capped and recover. Then the surface water was removed from the area. Later in the study, the transducers were again placed in the wells that flooded to see if there was an effect over time on these wells from pumping. In spite of these disturbances, the patterns that were observed in the hydraulic responses of the other intermediate aquifer wells were also observed at CG-9-I and CG-11-I. The transducer in the deep aquifer was inadvertently placed too deep in the well during the pre-test monitoring to adequately record the head in the well; however, this mistake was corrected during the actual short-term and long-term pumping tests. Therefore, the overall effect of this mistake on the pumping test results is minimal.

For the short-term pumping test, data from CG-11-I could not be used with certainty in the analysis because the well flooded during the test. This was the closest well to the pumping well. Therefore, this could have had a false-negative effect on the data. For the long-term pumping test in the intermediate aquifer, wells CG-9-I, CG-11-I, and CG-12-I flooded, which may have distorted or masked the responses. Wells CG-11-I and CG-12-I were the closest wells to the pumping well.

As described above, the long-term pumping test in the intermediate aquifer had a high degree of uncertainty associated with the results because of pumping rate variation and well flooding that occurred during the test. The data from the short-term pumping test in the intermediate aquifer were more reliable than those from the long-term test as the data were less variable and there were fewer problems with the pumping rates and flooding of the wells.

5.4.4.9 *Summary of Hydraulic Testing*

In general, the pumping tests provide the most reliable hydraulic data available for storage/storativity, specific yield, and hydraulic conductivity estimates. Therefore, the pumping test data from the shallow aquifer and the short-term test data from the intermediate aquifer will be used for decision-making purposes because of the uncertainty with other sources of data. However, for site-specific decisions that require data from a particular area of the facility or a particular well, geotechnical data or slug test data may also be used.

5.4.4.10 *Geological Soil Logs*

Soil borehole logs are produced in the field by a trained field geologist and are verified by a senior geologist. The borehole logs contain the following information: USGS soil type, soil color, grain size, sorting, moisture content, compaction, indication of contamination (e.g., odor, sheen), and general stratigraphic description (GIS). All geological logs for soil boreholes installed at the facility and areas upgradient and downgradient of the facility are included in Appendix 3A.

Soil logging does not require the use of any instruments that require calibration. The only equipment used to assist in logging are items such as a measuring stick, magnifying glass, water, Munsell color chart, USGS soil description chart, other borehole logs from the area, field forms, and writing instruments. Consistency of soil logging procedures is the most important factor for this activity. Each field geologist is trained in borehole logging. Each field form shows the types of descriptions required for each sample description in order to eliminate confusion over what is required. Each field geologist is provided with a USGS soil description chart and a Munsell Soil Color chart for use in soil logging to keep those types of descriptions as accurate as possible. In addition, when drilling, old borehole logs are brought into the field to compare with new soil descriptions and ensure that the same soil types are described similarly for consistency. Soil descriptions are described on field forms that are signed by the field geologist. The field supervisor or project manager then reviews the finalized soil borehole logs to ensure consistency of logging and completion of the field log. These forms are provided to the database manager, who enters this information into PSC's GIS for use in generating electronic borehole logs and geological cross sections.

Typical problems that may occur with preparing soil borehole logs include:

- Different field geologists may interpret the same soil type differently;
- Missing information on density, sorting, or similar characteristics could result in improper decisions about the beginning of a new soil type or geological interface; and
- Slough, missing soil in a sample, or non-continuous soil sampling could cause confusion in interpretation of geological unit intervals.

Soil logging inconsistency is the most important potential of uncertainty. However, PSC has put in place administrative procedures in an attempt to eliminate this form of uncertainty. As described above, the field team is well trained, uses USGS and Munsell field guides, and has old borehole logs on hand in the field to compare soil descriptions and remain consistent in describing the same types of soil. The likely source of the most uncertainty for this procedure would be from slough, missing soil in a sample, or non-continuous soil sampling. Most soil logging has been conducted in the shallow and intermediate units, which do not have a distinctive soil changes at a specific interval to distinguish the exact end of the shallow aquifer and beginning of the intermediate aquifer. The silt confining unit, however, is somewhat distinctive in that there is an intermittent silt layer of a few feet mixed with sand followed by a dense, approximately 20-feet-thick layer of gray silt. This was identified throughout the area from the facility to Denver Avenue South.

5.4.5 Assessment of Field Quality Control Samples

Results for field quality control samples (i.e., field duplicate samples, split samples, trip blanks, field blanks, and equipment rinsate blanks) were evaluated to assess sample collection techniques, possible sources of contamination, interferences that may be attributed to the sample matrix, and, to some degree, the bias and precision of the reported results. In addition, results reported for all various field blank samples were evaluated to determine whether results reported as detected in the samples were the result of contamination and were reported as false positives.

Summaries of results for the applicable field quality control samples are contained in the compact disc (CD) included with this report.

5.4.5.1 *Field Duplicate/Spilt Samples*

Results for field duplicate or split samples were evaluated to assess the homogeneity of the samples collected in the field and the precision of the sampling process. A summary of the relative percent differences (RPDs) for the field duplicate/split results is presented in Appendix 5C.

Results from the analysis of field duplicates or splits were used to evaluate the precision of the analysis by calculating the RPD between the results obtained. Overall, the RPDs calculated for all field duplicate/split pairs are considered acceptable. There did not appear to be any systematic bias suggesting that sampling techniques were the cause of some relatively elevated RPDs that were occasionally encountered. The most probable explanation for elevated RPDs appears to be comparing results from an undiluted sample to a field duplicate sample that was diluted (or vice-versa), a sample and field duplicate sample that were analyzed at two different dilutions, slight differences in concentrations at or near the method detection limit (MDL) or method reporting limit (MRL), and/or a sample and field duplicate sample with slightly different suspended solids.

5.4.5.2 *Trip Blanks*

Results for trip blanks (carried with sample coolers when sampling for VOC constituents) were evaluated to determine whether there may have been possible contamination during sample transport. A summary of analytes reported as detected in the trip blanks is presented in Appendix 5D.

Target analytes were typically not detected in the trip blanks and the results reported are considered acceptable. In those instances when an analyte was detected in a trip blank, the rules specified by the applicable EPA functional guidelines documents (EPA 1994, 1999) were followed.

5.4.5.3 *Field Blanks*

Results for field blanks (also referred to as environmental blanks) were evaluated to determine whether possible contamination of the samples may have occurred from the sampling environment (e.g., airborne contamination). A summary of analytes reported as detected in the field blanks is presented in Appendix 5E.

Target analytes were typically not detected in the field blanks and the results reported are considered acceptable. In those instances when an analyte was detected in a field blank, the rules specified by the applicable EPA functional guidelines documents (EPA 1994, 1999) were followed.

5.4.5.4 *Equipment Rinsate Blanks*

Results for equipment rinsate blanks (collected whenever non-dedicated or non-disposable sampling equipment was used) were evaluated to determine the effectiveness of equipment decontamination procedures in the field. A summary of analytes reported as detected in the equipment rinsate blanks is presented in Appendix 5F.

Target analytes were typically not detected in the equipment rinsate blanks and the results reported are considered acceptable. In those instances when an analyte was detected in a field blank, the rules specified by the applicable EPA functional guidelines documents (EPA 1994, 1999) were followed.

5.5 Assessment of Analytical Data Quality

An assessment of analytical data quality was conducted to verify that quality assurance and quality control procedures were completed and documented as required during sample collection and analysis and that the quality of the data is sufficiently high to support its intended uses. The assessment of the analytical data quality included evaluating the technical usability of the verified data with respect to the planned objectives of the project. The results used for the RI that were subjected to data validation are considered acceptable.

The assessment of the analytical data quality for the RI included:

- Reviewing project-specific documents (e.g., work plans, sampling plans, and QAPPs);
- Completing technical system audits (TSAs) of the analytical laboratory;
- Reviewing laboratory SOPs;
- Reviewing and validating laboratory data deliverables; and
- Reviewing data validation reports.

A review of project-specific documents (e.g., work plans, sampling plans, and QAPPs) was completed to confirm established DQOs were met. The results of these reviews concluded that project requirements were generally being met. Aspects of data quality and usability have already been addressed in prior RI assessments and reporting and subsequent program changes have been integrated into the iterative RI process and decision-making.

TSAs were completed in 2002 and 2003. The purpose of the TSAs was to verify that laboratory analysis and field sampling procedures were completed in accordance with project-established DQOs and to identify potential problems that may have occurred during either sampling or analysis. The TSAs consisted of onsite reviews of field activities or laboratory analyses and included, but are not limited to, the following components:

- Field and laboratory personnel, facilities, and equipment;
- SOPs for field activities;
- Chain-of-custody procedures and records;
- Instrument calibration and maintenance procedures and records;
- Standards preparation and verification procedures and records;
- Documentation of analytical methods;
- Sample storage conditions;
- Data reduction, processing, and reporting procedures; and
- Documentation of field quality control procedures.

The results of the TSAs concluded that all field and laboratory operating procedures were being completed in accordance with project requirements. No major quality issues were identified. Only minor deviations were identified and corrective actions were implemented as required.

Details regarding the two TSAs that have been completed were previously submitted to the agencies by PSC and are not repeated in this RI report.

Laboratory SOPs have been reviewed to ensure the analytical procedures and quality control measurements used at the laboratories are compliant with method-specific requirements and the method quality objectives (MQOs) and data quality indicators (DQIs) established for the RI. It has been concluded the laboratory SOPs are compliant.

Review and validation of laboratory data deliverables has been completed for much of the data pertinent to this RI. Applicable data validation reports were prepared and were previously submitted to the agencies by PSC in various project reports.

5.5.1 Data Validation Procedures

Data validation was completed during the course of the RI to meet the following objectives: (1) verify that measurements (field and laboratory) meet the user's needs, (2) provide information to the data user regarding data quality by assignment of individual data qualifiers based on the associated degree of variability, and (3) determine whether project-specific DQOs were met. Data validation procedures included evaluating the sample results and applicable quality control results reported by the laboratory. The data were validated in accordance with guidance specified by the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999) for organic compound analyses and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994) for metals and conventional parameter analyses, as applicable. Modifications to validation protocols were made to accommodate quality control requirements for methods that are not specifically addressed by the functional guidelines and to incorporate method-specific control limits and requirements.

Data that did not meet applicable control limits for quality control measurements were qualified as estimated (*J*), restated as undetected (*U*), or rejected (*R*) because one or more of the quality control criteria were not met. All data qualified as estimated (*J*) have an acceptable degree of uncertainty and represent data of good quality and reasonable confidence (EPA 1989, 1996). In a few instances, data-validation-specified quality control criteria (EPA 1994, 1999) were not met. In many of these situations, the affected data often did not require qualification of sample results because the exceedances were determined to be minor (e.g., an MS recovery was slightly outside the specified control limit) and alternative method-specific acceptance criteria could be used (e.g., averaging the percent differences of continuing calibration results rather than using analyte-specific percent differences) to assess the acceptability of the data reported. Summaries of all previously validated data were included in reports previously submitted by PSC to the agencies and are not repeated in this RI report.

As required by the regulatory agencies, validation of most of the data used in the RI and RA included 100-percent reviews, 25-percent reviews, 10-percent reviews, and abbreviated reviews of the data. The laboratory information that was reviewed for the data validation reviews, as applicable to the analyses completed, is described below.

For the abbreviated data validations completed, the following laboratory deliverables were reviewed:

- Case narratives discussing analytical problems (if any) and procedures;
- Chain-of-custody documentation to verify completeness of the data set;
- Results for method blanks, trip blanks, field blanks, and/or equipment rinsate blanks to determine whether an analyte reported as detected in any sample was the result of possible contamination at the laboratory, contamination during transport of samples, or contamination during field sampling, respectively;
- Results for applicable surrogate compound, laboratory control spikes (LCS) (i.e., blank spikes) and duplicate LCS, and matrix spike/matrix spike duplicate (MS/MSD) recoveries to assess analytical accuracy;

- Results for applicable laboratory duplicate sample, duplicate LCS, and MSD analyses to assess analytical precision; and

- Laboratory summaries of analytical results.

In addition, results for all field duplicate samples were evaluated to provide additional information in support of the quality assurance review. Abbreviated validation did not include verification of applicable instrument tuning, instrument calibrations, internal standards, laboratory calculations and transcriptions, or review of instrument printouts and bench sheets because full data packages were not submitted by the laboratory. The laboratory case narratives did not indicate any significant problems with data that were not reviewed.

For the 100-percent, 25-percent, and 10-percent data validations completed, the following laboratory deliverables were reviewed:

- Case narratives discussing analytical problems (if any) and procedures;

- Chain-of-custody documentation to verify completeness of the data set;

- Sample preparation logs or laboratory summary result forms to verify analytical holding time constraints were met;

- Results for instrument tuning for VOC, SVOC, and applicable metals analyses and initial and continuing calibration results to assess instrument performance;

- Results for method blanks, trip blanks, field blanks, and/or equipment rinsate blanks to determine whether an analyte reported as detected in any sample was the result of possible contamination at the laboratory, contamination during transport of samples, or contamination during field sampling, respectively;

- Results for internal standards performance (VOC, SVOC, and applicable metals analyses) to ensure that instrument sensitivity and response were stable during the analysis of the samples;
- Results for applicable surrogate compound, LCS (i.e., blank spikes) and duplicate LCS, and MS/MSD recoveries to assess analytical accuracy;
- Results for applicable laboratory duplicate sample, duplicate LCS results, and/or MSD analyses to assess analytical precision;
- Instrument printouts (e.g., chromatograms, mass spectra, and quantification reports) to assess the validity of analyte identification as either detected or undetected and to verify quantification of sample results; and
- Laboratory summaries of analytical results.

In addition, results for all applicable field quality control samples (e.g., field duplicate samples) were evaluated to provide additional information in support of the quality assurance review.

5.5.2 Algorithms to Assess Quality Control Results

Data verification and validation included checking that quality control procedures were completed at the required frequencies and that the results met the control limits defined in the method descriptions or by the project DQIs. DQIs for measurement data are usually expressed in terms of accuracy (precision and bias), completeness, representativeness, comparability, and sensitivity. The equations used to determine whether measurement targets for project DQIs were met for each quality control procedure are defined below.

Precison (Duplicate Analyses)—Precision for duplicate chemical analyses were calculated as the RPD between the duplicate samples. This formula was used to assess precision for both laboratory and field duplicate samples:

$$\%RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

where:

D_1 = sample value

D_2 = duplicate sample value.

Bias (Surrogate, MS/MSD), and LCS Recoveries—Spiked samples provide an indication of the bias of the analysis system. The recovery of surrogate MS/MSD, and LCS spikes were calculated as the ratio of the recovered spike concentration to the known spiked quantity:

$$\%R = \frac{A - B}{C} \times 100$$

where:

A = the analyte concentration determined experimentally from the spiked sample

B = the background level determined by a separate analysis of the unspiked sample (not applicable for LCSs)

C = the amount of the spike added

Completeness—The ratio of the number of valid measurements compared to the number of expected measurements, expressed as a percentage. Field and analytical data may be specified at different completeness levels. Completeness was calculated for each sample type by dividing the number of valid measurements (all measurements except rejected data) actually obtained by the number of valid measurements:

$$\%\text{Completeness} = \frac{\text{Valid Data Obtained}}{\text{Total Data Planned}} \times 100$$

To be considered complete, the data sets must also contain all QC check analyses that verify the precision and accuracy of the results.

Representativeness—The degree to which data accurately and precisely represent the true value of a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness of field and laboratory data is attained through the use of consistent methods of data collection, including field methods, sampling procedures, sample preservation and handling, calibration of field and laboratory instruments, and analytical procedures.

Comparability—The confidence with which one data set can be compared with another. All data for this investigation were obtained using consistent analytical methods to ensure comparability of the results within the study, and every reasonable effort was made to maintain comparability with other studies completed for the facility. Comparability of data is attained by following established protocols for sample collection and analysis and recording field and laboratory data in consistent units.

Sensitivity—The detection limit of the sample preparation and analysis process is defined as "the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte is greater than zero" (40 CFR 136B). In other words, it is the point at which qualitative, not quantitative, identification can be made. In practice, the limit of detection is defined as three times the standard deviation of the blank or background response adjusted for the amount of sample typically extracted and the final extract volume of the method.

Best professional judgment was used to adjust the limit of detection upward in cases where high instrument precision (i.e., low variability) resulted in a calculated limit of detection and equivalent instrument response less than the absolute sensitivity of the analytical instrument. The actual reporting limit for environmental samples is generally higher than the instrument detection limit because the sample matrix tends to contribute to fluctuations in the instrument's background signal. Laboratory personnel determined reporting limits based on their experience with samples of similar matrix to those collected for this study and on the response of each instrument to samples for this study. The method reporting limits are verified during data validation.

The laboratory completed dilutions, as required by the analytical methods, to obtain concentrations that were within the linear range of the instrument or to minimize the effects of matrix interferences to obtain reportable results. In a few instances, however, some VOC results had to be reported at a concentration that was above the upper linear range of the instrument. This occurred because subsequent dilutions resulted in undetected results due to the presence of elevated concentrations of other target and/or non-target analytes. It was not practical for the laboratory to complete enough dilutions to obtain concentrations that were within the linear range of the instrument for all target analytes.

5.5.3 Data Assessment Results

A large portion of the data assessments were completed during the validation of data that was previously completed. As was stated earlier, the data assessment and data validation provides information for evaluating the usability of verified data with respect to the planned objectives of the project. This is completed to meet the following objectives: (1) verify that field and laboratory measurements meet the user's needs, (2) provide information to the data user regarding data quality based on any identified degree of variability, and (3) determine whether project-specific DQOs were met.

To meet the objectives of the data quality and usability assessment, statistical analysis of pertinent data was completed to determine the minimum, maximum, and median results of surrogate, MS/MSD, and LCS recoveries and the RPDs of duplicate results. The results of this statistical analysis were plotted to determine the distribution of the data and to determine whether any systematic trends were evident that may affect the overall quality of the analytical results used in this RI. Plots and statistical summaries of the applicable bias and precision measurements are presented in Appendix 5G. Summaries of these results are also contained in the CD included with this report. Other information reviewed included an evaluation of all blank results (i.e., laboratory method blanks, trip blanks, field blanks, and equipment blanks) and field duplicate/split results. A summary of all analytes reported as detected in the blanks is presented in Appendices 5D–F and 5H and the results of the field duplicate/split results are contained in the CD included with this report.

Upon completion of the data assessment of bias and precision measurements, it is concluded that systematic trends that could affect the overall quality of the data were not evident. Applicable upper and lower control limits were exceeded; however, these occurrences are routinely encountered during the analysis of environmental samples. However, sometimes these occurrences were indications of poor laboratory performance.

When DQIs for bias and precision were exceeded, applicable data were qualified as either estimated (*J*) or rejected (*R*). Summaries of the qualified data that were validated are presented in Appendix 5I. Often, DQIs exceeded for bias and precision were attributable to dilutions of the samples that were required due to elevated concentrations of target analytes and to minimize matrix effects and interferences for non-target analytes. These occurrences result in the inability to quantify a measure of bias or precision and are not indicative of poor data quality.

A review of all blank results indicated no inherent problem with laboratory or field contamination sources. Occasional contamination of blanks was encountered. In these instances, data were qualified as estimated (*J*) or were restated as undetected (*U*). Data qualified because of blank contamination are summarized in Appendix 5I. Analytes reported as detected in the blanks are summarized in Appendices 5D–F and Appendix 5H.

Overall, it is concluded that the data that have been validated and that are presented in this RI are usable. Data were qualified for several reasons, which is not unusual given the matrices sampled, the presence of interferences, detections of target analytes at high concentrations in some samples, and other reasons discussed throughout this RI. Summaries of data qualified during data validation have been previously submitted to the agencies by PSC in various project reports and RI Progress Reports.

5.6 Assessment Data Management Activities

The main types of data that are collected for the facility include analytical data, water elevation data, water quality data, and geotechnical data. PSC receives the hardcopy data from the laboratory and a copy of the data is sent to the data validator. Data are entered electronically from the laboratories' electronic data deliverables. This electronic data deliverable is then validated and data qualifiers assigned during data validation are entered. Any discrepancies identified are typically resolved with the laboratory project manager. This check serves to verify the integrity of the project database and the accuracy of data handling at the laboratory. All data qualifier entries are checked by data management and/or data validation personnel to ensure correct data entry. Any errors identified at this point are corrected in the database. Once the validated data and validated electronic data deliverable are completed, the data are entered in to the project database. The server containing all data is routinely backed up.

All analytical and water elevation data are stored electronically in PSC's GISKey® data management system, which uses FoxPro® as its database and GISKey® and AutoCAD® as the drawing mechanism for the GIS. Water quality data and geotechnical data are stored in Excel® files. All water level data are manually entered in the database and are verified once they are entered. All pertinent geotechnical data are entered into Excel® data tables for use in reports. All other data are available in hard copy form in the facility files, and have been reported in appendices of previous reports.

From the onset of data collection activities through 1999, all analytical data were manually entered in the database, which may have led to transcription errors. The current data management system, which has been in place since first quarter 1999, requires the laboratory to provide electronic deliverables to PSC in a format that can be easily downloaded into GISKey®. This greatly reduces the potential for data-entry error.

The early data collected through 1999 have undergone a manual quality control check prior to preparation of the tables and analysis of the data for the RI. Hard copies of soil data laboratory reports were compared to database printouts to look for transcription errors in all entered values (detections and non-detections). All corrections to the soil data have been made to the database. Ten percent of groundwater metals and TPH data were compared to the database to look for transcription errors in all entered values (detections and non-detections). There is limited uncertainty related to the quality of some of the older groundwater data in the database, based on the following factors.

- Possible transcription errors from manual data entry prior to 1999.
- The database defaults to round off numbers unless the database manager changes the default in the database.
- Old laboratory data packages showed an "*H*" laboratory qualifier for mercury. There was no description on the laboratory reports for this qualifier and our data validator has never seen this qualifier used before. Therefore, there is some uncertainty involved with this information.
- In addition, recent metals and TPH data from North Creek Analytical have had "*J*" flagged data for results detected between the reporting limit and the detection limit in the electronic data deliverable (EDD), but the same result was listed as not-detected in the hard copy report from the laboratory. The laboratory is aware of this problem and is working to correct it. The PSC data manager is aware of this problem and has corrected the database for such identified occurrences.

5.7 Conclusions

An assessment of analytical data quality was conducted to verify that quality assurance and quality control procedures were completed and documented as required during sample collection and analysis and that the quality of the data is sufficiently high to support their intended uses. The assessment of the analytical data quality included evaluating the technical usability of the verified data with respect to the planned objectives of the project. The results used for the RI that were subjected to data validation are considered acceptable. The assessments of data quality that were completed did not identify significant data quality issues. Rather, the issues that were identified are considered typical for investigations that have been completed during the course of this RI.

The assessment of the sampling techniques verified that approved sampling methodologies at the time of each investigation were used and that any uncertainties have been defined and clearly stated in this RI report. The data, from a validation perspective, are generally of good quality.

The assessment of the DQOs and sampling design of the various investigations completed have demonstrated each subsequent investigation has met the project's objectives. Since this large-scale investigation has been an iterative RI process, concerns and observations noted from each investigation have been sufficiently addressed with subsequent investigation. The data collected are of sufficient quality to support the risk assessment, interim measure evaluations, and the feasibility study.

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Table 5-1
Water Quality Instrument Accuracy and Stabilization Requirements for Groundwater Sampling

Water Quality Parameter	SOP Stabilization Requirements	SOP Stabilization Requirements	Horiba U-22	YSI	QED PurgeSaver	Issco 820	Turbidimeter	QED FC5000T
Time Period	**2Q94 - 1Q99**	**1Q99 - present**	**4Q00 - present**	**1Q99 - present**	**~1996 - 4Q98**	**~1994 - ~1995**	**2Q94 - present**	**1Q03 - present**
Dissolved Oxygen	3 readings w/in 10% of each other	3 readings w/in 10% of each other	± 0.2 mg/L	2% of reading or 0.2 mgA	2 to 5%	± 0.2 mg/L	na	± 0.2 mg/L
ORP	3 readings w/in 10% of each other	3 readings w/in 10% of each other	± 15 mV	± 20 mV	± 2%	± 20 mV	na	± 20 mV
Temperature	3 readings w/in 10% of each other	3 readings w/in 3% of each other	± 1 deg C	± 0.27 deg F or ± 0.15 deg C	1 deg C or ± 1.8 deg F	± 0.15 deg C	na	± 0.10 deg C
Specific Conductivity	3 readings w/in 10% of each other	3 readings w/in 3% of each other	± 3%	+ 5% of reading or 0.001 mS/cm	± 3%	± 1%	na	± 0.001 mS/cm
pH	3 readings w/in 10% of each other	3 readings w/in 0.1 pH unit of each other	± 0.1 pH Units	0.2 pH Units	± 2 pH Units	± 0.2 pH Units	na	± 0.2 pH Units
Turbidity	3 readings w/in 10% of each other	3 readings w/in 10% of each other	na	na	na	na	± 0.02 NTUs	± 0.05 NTUs

6 GROUNDWATER BENEFICIAL USE AND POINT OF COMPLIANCE

In accordance with the PSC Georgetown facility's Part B permit, this section describes results of a groundwater beneficial use analysis, as well as proposed modifications to the groundwater cleanup point(s) of compliance for the facility. MTCA guidance was followed in development of both the beneficial use analysis and the proposed modifications to the groundwater point of compliance.

6.1 *Evaluation of Groundwater Beneficial Use Proximate to the PSC Georgetown Facility*

The designation of the highest beneficial use of groundwater in a particular area is established by several different agencies, including Ecology, the Washington State Department of Health, and county and city governments. The requirements, rules and guidance of each of these agencies was considered in the determination of the highest beneficial use of groundwater.

6.1.1 Groundwater Beneficial Use under MTCA

According to WAC 173-340-720, groundwater cleanup levels at a particular location must be based on the highest beneficial use of groundwater, that is, use as drinking water, unless groundwater at the particular location meets the criteria listed in WAC 173-340-720 (2) (a) through (c). Groundwater in the shallow, intermediate, and deep aquifers in the vicinity of the facility was evaluated using each criterion presented in WAC 173-340-720 (2). Those criteria are listed below, followed by a discussion of groundwater or aquifers impacted by releases from the facility. Groundwater in all three aquifers migrates to the southwest eventually discharging to the Duwamish Waterway, as discussed in Section 3.0. Therefore, the "area of interest" is defined to include groundwater located in the shallow, intermediate, or deep aquifer in the area between the facility and the Duwamish Waterway. This regulatory analysis combined with site-specific groundwater use designations, provides a framework for setting alternate cleanup standards that meet the specific criteria of WAC 173-340-720(2).

WAC 173-340-720 (2) defines all groundwater as potable unless all of the following can be demonstrated:

(a) The groundwater does not serve as a current source of drinking water.

Information from a number of sources indicates that groundwater does not currently serve as a source of drinking water in the area of interest:

- There are no water supply wells within one mile downgradient and cross-gradient of the facility (Ecology, 2003; USGS, 2001; EDR, 2003), encompassing the area of interest.
- Several surveys of businesses and residences located in the area of interest were conducted by PSC in 2000 and 2001 (PSC, 2001). The results of the surveys, summarized in Section 2.0, indicated that no supply wells exist at any of the responding properties.
- A review of Ecology's files for well logs found only monitoring wells in the area of interest (Ecology, 2003).
- A survey of the EPA Office of Water Public Water System database (EDR, 2003) and United States Geological Survey (USGS) Water Well database (USGS, 2003) indicated that there are no supply wells within one mile downgradient and cross-gradient of the facility, encompassing the area of interest.
- A review of the Seattle-King County Health Department Water System database in 1997 found no public water supply wells in the Duwamish Valley north of the south end of Boeing Field (Herman and Snider, 1998).

- There are no registered water rights for groundwater in the area of interest on file at the Department of Ecology (Ecology, 2003).

- No residential or public supply wells are known to exist within the area between the facility and the Duwamish Waterway. The vicinity is served by the Seattle Public Utilities water system, which is supplied by the Cedar and Tolt River Watersheds in the foothills of the Cascade Mountains and during the times of peak demand, the Highline Well Field. The Highline Well Field consists of three wells located near the Riverton Heights Reservoir in Burien, just north of Sea-Tac Airport (City of Seattle, 2001), which is approximately five miles south of the facility, and is not hydraulically connected to the area of interest.

(b) The groundwater is not a potential future source of drinking water for any of the following reasons:

(i) The groundwater is present in insufficient quantity to yield greater than 0.5 gallon per minute on a sustainable basis to a well constructed in compliance with chapter 173-160 WAC and in accordance with normal domestic water well construction practices for the area in which the site is located.

It is likely that the shallow, intermediate, and deep aquifers in the area of interest can yield more than 0.5 gallons per minute based on pumping tests (BEI, 1993; PSC, 2000a; 2000b) and field observations.

(ii) The groundwater contains natural background concentrations of organic or inorganic constituents that make use of the water as a drinking water source not practicable. Groundwater containing total dissolved solids at concentrations

> **greater than 10,000 mg/L shall normally be considered to have fulfilled this requirement. (Note: The total dissolved solids concentration provided here is an example. There may be other situations where high natural background levels also meet this requirement.)**

MTCA defines "practicable" as "capable of being designed, constructed and implemented in a reliable and effective manner including consideration of cost. When considering cost under this analysis, an alternative shall not be considered practicable if the incremental costs of the alternative are disproportionate to the incremental degree of benefits provided by the alternative over other lower cost alternatives" (WAC 173-340-200).

Groundwater in the Duwamish Valley is generally considered to be of poor quality (SPU, 2003c) as it is naturally saline with high concentrations of total dissolved solids rendering the groundwater unacceptable for use as a source of drinking water (Herman and Snider, 1998). These saline conditions can be attributed to the influence of tidal mixing in the shallow and intermediate aquifers, and to residual salinity from deposition of the aquifer materials in the deep aquifer. Furthermore, high levels of iron and manganese have been noted historically in groundwater in the shallow aquifer (Herman and Snider, 1998). Analysis of water quality in groundwater in the shallow, intermediate, and deep aquifers just upgradient of the PSC facility shows results that are consistent with the general observations. The groundwater quality in the shallow, intermediate, and deep aquifers just upgradient and cross-gradient of the PSC facility will be discussed in more detail in this section and in Appendix 6A. Although the concentrations of these parameters may be reduced by treatment, the cost of the treatment will make the use of the groundwater not practicable.

Required Treatment

The need for treatment was determined by a comparison of site-specific natural background concentrations to the DOH's and EPA's Maximum Contaminant Levels (MCLs). See WAC 246-

290 and WAC 246-291; 40 CFR 141, 143. WAC 246-290 and WAC 246-291 contain the state's primary and secondary MCLs for groundwater as the maximum permissible concentrations of selected organic and inorganic constituents in groundwater used as a public drinking water supply. Public water supplies encompass all water systems with the exception of a private well serving a single-family residence. While the private water supply well serving a single-family residence is not required by law to meet these standards, these standards are recommended for use with single family wells in order to protect the health of the users (DOH, 2001). Primary MCLs are chemical, physical, and bacteriological standards selected to prevent adverse health effects while secondary MCLs are standards developed to control factors such as taste and odor. Although secondary MCLs are not enforceable limits, these values are recommended guidelines (EPA, 2002). Exceedance of a secondary MCL requires the need for treatment before the water can be used as a source of domestic water. Site-specific background concentrations in the shallow/intermediate aquifers and deep aquifer were compared with primary and secondary MCLs since these represent the best available indicators of whether groundwater is suitable for use as a source of drinking water without treatment.

Site-specific natural background concentrations were calculated using data from upgradient and cross-gradient monitoring wells CG-101-S-1, CG-101-S2, CG-3, CG-106-WT, CG-106-I, CG-107-WT and CG-111-I, shown in Figure 4, which are considered to be representative of background conditions in the shallow and intermediate aquifers, and CG-106-D, which is considered to be representative of conditions in the deep aquifer, as discussed in Appendix 6A. As discussed in Section 3, the shallow and intermediate aquifers are hydraulically interconnected, with no confining unit between these water-bearing zones. This hydraulic interconnection indicates that groundwater may move between these aquifers depending on the head difference between these aquifers. Consequently, if the groundwater from either the shallow or intermediate aquifer is considered to be non-potable, the groundwater from both aquifers should be considered non-potable. Therefore, the shallow and intermediate aquifers were considered together for the evaluation of natural background conditions. The groundwater samples collected from these wells likely represent area background for organic constituents and natural background for inorganic constituents and other water quality parameters as discussed in Appendix 6A.

Data from groundwater monitoring events conducted from the first quarter 2000 through the second quarter 2003 were used in the calculation of site-specific background concentrations. The background turbidity was calculated using stabilized water quality readings collected during the quarterly groundwater monitoring events. These values should accurately reflect a hypothetical best case for domestic wells because the monitoring wells at the facility and in the surrounding area were constructed using domestic well construction guidelines (WAC 173-160) and were sampled using low-flow methodology designed to minimize turbidity. Upper end percentiles were selected as site-specific background concentrations, as specified in WAC-173-340-709. The distribution of the available background data for each parameter was tested for normality and lognormality. The 90th percentile value was selected as the background concentration for lognormally distributed parameters and the 80th percentile was selected as the background concentration for normally distributed parameters. Calculated background concentrations for the shallow/intermediate aquifers and deep aquifer for the PSC Georgetown Facility area are summarized in Tables 6-1 and 6-2.

For the shallow and intermediate aquifers, background concentrations of turbidity and coliform bacteria exceed their primary MCLs while concentrations of iron, manganese, total dissolved solids, and color exceed their secondary MCLs, as presented in Table 6-1. Turbidity, a measure of the cloudiness of the water, is often associated with the presence of disease-causing microorganisms. Coliforms, which are often used as an indicator of the presence of other potentially harmful bacteria (EPA, 2002), were detected in groundwater samples collected from wells screened in the shallow and intermediate aquifers. Excess iron and manganese in water result in rusty or blackish brown coloration, a bitter, metallic taste, staining of household fixtures and laundry, and particulates. Elevated concentrations of total dissolved solids, or salts, can cause deposits, colored water, and staining and can impart a salty taste to water. Color may also indicate dissolved organic material or bacteria.

For the deep aquifer, all reported concentrations of arsenic and turbidity exceeded primary MCLs and all reported concentrations of ferric iron, dissolved manganese, and total dissolved solids exceeded secondary MCLs, as presented in Table 6-2.

Site-specific natural background concentrations were compared with MCLs to determine the suitability of untreated groundwater for use as a source of drinking water. Owing to the natural concentrations of several water quality parameters including iron, manganese, turbidity, color, and total dissolved solids, groundwater from the shallow, intermediate, and deep aquifers would likely require treatment before use as a source of drinking water. The potential costs of this treatment are discussed in the following section.

Potential Treatment Costs

Groundwater from the shallow/intermediate aquifer and the deep aquifer would need to be treated to reduce concentrations of turbidity, coliform bacteria, iron, manganese, total dissolved solids, and color prior to its use as drinking water. Groundwater from the deep aquifer would also need to be treated to reduce arsenic concentrations. There are a number of different treatment technologies available to address these parameters, as described in Table 6-3. A review of the advantages and disadvantages of these treatment options indicates that reverse osmosis (RO) is likely the most cost-effective of the available treatment options (Geomatrix, 2003). RO can be used to reduce concentrations of undesirable dissolved or suspended constituents and to remove salts, other impurities, viruses, and bacteria from water to improve the aesthetics and taste.

Reverse osmosis uses a membrane that is semi-permeable, allowing the water that is being purified to pass through it, while rejecting the contaminants. RO technology uses a process known as cross-flow to allow the membrane to continually clean itself. Some of the fluid passes through the membrane and the rest continues downstream, sweeping the rejected species away from the membrane. An additional 25% of the desired total water flow would be used as cross-flow and disposed to a sanitary sewer. While there are significant amounts of water being disposed, this cost is relatively minor compared to the chemical usage required by other equivalent treatment alternatives. The costs associated with the treatment of the groundwater from the shallow/intermediate aquifer and the deep aquifer were evaluated for two potable groundwater use scenarios: a typical single-family residential water supply and a typical small public water supply system.

For a typical single-family residence, costs associated with treating groundwater with a RO system were calculated based on providing a 2 gallon-per-minute flow as a peak demand for household use[1] with a typical daily usage rate of 128 gallons of water per day for a typical Seattle household (SPU, 2003a). A typical home reverse osmosis system would likely be followed by a ultraviolet (UV) photo-oxidation, a polishing step that should kill any pathogens which were not removed during reverse osmosis, or if there were an undetected failure of the RO membrane. The treatment equipment required for a single family well system includes a sediment filter, RO and UV units, and a secondary distribution pump, configured as shown in Figure 6-1. The costs associated with purchasing, maintaining and operating this system at a 128 gallon/day rate are approximately $1,800 per year[2]. In comparison, the cost of this same amount of water would be approximately $269 annually based on the current Seattle Public Utilities 2003 residential rate schedule (SPU, 2003b). The costs for water treatment alone for a single-

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[1] Reverse osmosis treatment costs were calculated using the Osmonics cost estimating RO Tools™ website (GEWT, 2003) based on peak usage of 2 gpm. Operational costs were scaled to reflect the fact that while the peak rate was 2 gpm, the overall rate is approximately 0.11 gpm.

[2] Capital cost for equipment amortized over 10-year service life.

family residence would be over six times higher than the cost for the same amount of water provided by Seattle Public Utilities[3].

For a public water supply system, costs associated with treating groundwater with RO were estimated based on a desired production rate of 1,000 gpm, as this is the smallest supply system typically in use in the region due to the considerable costs of constructing a public water supply system (CPSWSF, 2001). As in the case of the single-family residence, when using reverse osmosis, the pumping rate must be increased by 25% to provide adequate water for cleaning the filtration membranes. Figure 6-2 shows a schematic of the equipment for the public water supply system. The additional treatment equipment includes the filter, the reverse osmosis equipment and a chlorination step. While reverse osmosis treatment removes coliform bacteria from the water, subsequent chlorination is required to ensure that the water remains pathogen-free until it reaches the consumer.

The incremental cost to treat water to supply 1,000 gpm is equivalent to $1,570,260 per year as capital and operation and maintenance (O&M) costs, or $974 per acre-ft. This cost estimate for treating groundwater does not account for the expense of installing wells, acquiring easements, and purchasing the land required to construct a public water supply system as these costs would be incurred in any public water system development scenario. Furthermore, multiple wells would need to be installed over a large area with wells separated by at least approximately 1500 feet, as the uppermost aquifer cannot provide more than 250 gpm from a single well without dewatering the aquifer[4].

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[3] The costs associated with the installation of a well and the purchase of a pump and control system were not included in the cost estimates for treatment but are estimated to be similar to the cost of installing a new connection of a single family residence to the city water lines at the street. These costs are not considered an added cost for this scenario. The cost of installing a well, pump and control system or connecting to a public water supply are estimated to be on the order of $5,000-$10,000.

[4] Based on simple MODFLOW simulation using hydraulic conductivity and specific yield of 1×10^{-2} cm/s and 0.225, respectively for the hallow aquifer and 5×10^{-3} and 5.06×10^{-4}, respectively for the intermediate aquifer.

The City of Seattle can currently supply such large bulk quantities of water to a public water supply system at an approximate cost of $517 per acre-foot of water (SPU, 2003a). The incremental cost of treating the extracted groundwater is approximately twice as expensive as purchasing the same amount of water at wholesale cost from the City of Seattle.

The estimated treatment costs for groundwater from the Georgetown area are based on reducing groundwater concentrations to levels just below primary and secondary MCLs. Treated groundwater is still likely to be of lower quality than that available from Seattle Public Utilities (SPU) as SPU strives to deliver a consistent and high quality water product[5]. Seattle Public Utilities currently obtains water from the Cedar River and the South Fork of the Tolt River, which both have extremely low mineral contents as presented in Table 6-4, and also maintains a small wellfield in the Highline area of South King County for additional capacity during periods of peak demand. These existing supplies are projected to meet demands through at least 2020. Several alternative potential future sources of water also being considered by SPU to meet any increases in demand in the future include Snoqualmie Aquifer, utililization of Tacoma's Second Supply Project, dead storage on Chester Morse Lake, additional drawdown from Lake Youngs, the North Fork of the Tolt River, as well as conservation and water re-use for industrial purposes and irrigation.

In summary, the costs required to install and maintain a well and the required water treatment equipment are multiple times greater than those associated with obtaining water from Seattle Public Unities. In addition, the quality of the treated groundwater is still likely to be inferior to that available to Seattle Public Utilities customers from the region's multiple surface water and groundwater sources. The cost of treating groundwater from the shallow, intermediate and deep aquifers compared with the costs associated with obtaining water from other identified sources

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[5] SPU has an internal maximum target concentration of 100 mg/L TDS for the water they provide (SPU, 2003c) while the MCL for TDS is 500 mg/L (EPA, 2002).

via the public utilities renders the use of area groundwater as a source of drinking water not practicable under WAC 173-340-720(2)(ii).

(iii) The groundwater is situated at a great depth or location that makes recovery of water for drinking purposes technically impossible.

Groundwater is recoverable from all three aquifers.

(c) The department determines it is unlikely that hazardous substances will be transported from the contaminated groundwater to groundwater that is current or potential future source of drinking water, as defined in (a) and (b) of this subsection, at concentrations which exceed groundwater quality criteria published in chapter 173-200 WAC.

As discussed earlier in this chapter, the contaminated groundwater at the facility is not a current or future potential source of drinking water. Groundwater at the facility generally flows to the southwest and eventually discharges to the Duwamish Waterway. The groundwater between the facility and the Duwamish Waterway is not a current source of drinking water, and the Duwamish Waterway itself is not a potential source of drinking water. Furthermore, this groundwater is never likely to be considered a potential future source of drinking water due to poor water quality, as discussed above, and regulatory concerns discussed in Section 6.1.2.

d) Even if groundwater is classified as a potential future source of drinking water under (b) of this subsection, the department recognizes that there may be sites where there is an extremely low probability that the groundwater will be used for that purpose because of the site's proximity to surface water that is not suitable as a domestic water supply. An example of this situation would be shallow ground waters in close proximity to marine waters such as on Harbor Island in Seattle. At such sites, the department may allow groundwater to be classified as non-potable for the purposes of this section if each of the

following conditions can be demonstrated. These determinations must be for reasons other than that the groundwater or surface water has been contaminated by a release of a hazardous substance at the site.

(i) The conditions specified in (a) and (c) of this subsection are met;

Conditions specified in (a) and (c) of this subsection have been met.

(ii) There are known or projected points of entry of the groundwater into the surface water;

As discussed in Section 3, groundwater flows in a west-southwesterly direction from the facility towards the Duwamish Waterway.

(iii) The surface water is not classified as a suitable domestic water supply source under Chapter 173-201A WAC; and

The groundwater at and downgradient of the facility does not discharge to a potential source of drinking water. The Duwamish Waterway is specifically classified as a Class B surface water under WAC-173-201A-130. Class B surface water is characteristically used for the following purposes: industrial and agricultural water supply, stock watering, fish and shellfish, wildlife habitat, recreation, commerce, and navigation. Unlike Class A or Class AA surface waters, Class B surface waters are not characteristically used as domestic water supply sources. Therefore, the Duwamish Waterway is not classified as a suitable domestic water supply source under WAC 173-201A.

(iv) The groundwater is sufficiently hydraulically connected to the surface water that the groundwater is not practicable to use as a drinking water source.

Groundwater located near the Duwamish Waterway is slightly brackish as a result of influence by the saline waters in the Waterway. Results of the July 2003 tidal monitoring study indicate that the zone of brackish water intrusion extends approximately 1,000 feet inland from the Waterway in the shallow and intermediate aquifers to CG-140 , as shown in Figure 6-3. As a result, groundwater located up to 1,000 feet from the Waterway is sufficiently hydraulically connected to surface water such that it is not practicable to use as a drinking water source. This distance could also be increased by pumping groundwater from a well located outside this area if the tidal mixing zone is within the radius of influence of the well. A 600-foot radius around a well is considered to the "preliminary short-term groundwater contribution area" under WAC-246-291-100.

In summary, the groundwater at and downgradient of the faiclity is not a current or potential future source of drinking water, nor is the surface water of the Duwamish Waterway. The likelihood of interconnection between the COPC-impacted groundwater and groundwater that is a current or potential future source of drinking water is extremely low.

6.1.2 Groundwater Beneficial Use Under Current Local Regulations

Current local regulations and well construction practices also prevent the use of groundwater at and in the vicinity of the facility as a potential drinking water source by prohibiting the installation of new wells in the area. These include the following regulations:

- King County Rules require connection to existing water supplies where available (King County, 2003). The entire Georgetown neighborhood is served by the Seattle Public Utilities water system.

- Domestic water wells are permitted only for single family residences on lots of five acres or greater (King County, 2003). There are currently no residential lots of this size, and thus, significant consolidation of lots would need to occur to meet this requirement.

- In the Duwamish Valley, a water right is required for any new water supply source except for the exempted single domestic user of less than 5,000 gallons per day. Water rights in the Duwamish Basin would be difficult to obtain because the Green-Duwamish Basin instream flow requirements are not currently being met. The instream flows constitute a prior water right and as such have a priority on water use. In addition, a reduction in freshwater discharge to the waterway could alter the balance of estuarine flow conditions and potentially affect water quality (Herman and Snider, 1998).

- Well setback requirements for water wells[6] require that the wells be at least:
  - 100 feet from known or potential sources of contamination, which may include hazardous waste sites, chemical and petroleum storage areas, pipelines used to convey materials with contamination potential and areas of salt water intrusion (WAC 173-160-171);
  - 100 feet from public roads (King County, 2003);
  - 100 feet from surface water (King County, 2003);
  - 100 feet from sewers and septic systems (King County, 2003);
  - 100 feet from railroad tracks, underground storage tanks, and power utility and gas lines (King County, 2003); and
  - 1,000 feet from solid waste landfills (King County, 2003).

The impact of these setbacks in the area downgradient of the facility is illustrated in Figure 6-4. In addition, there are a number of former landfills with uncertain boundaries in the industrial area

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[6] Setback requirements from WAC 173-160-171 do not apply specifically to public supply wells as these wells can only be located by the Department of Health or the local health authority.

surrounding the Georgetown facility (Seattle-King County Department of Health, 1985), severely limiting, if not eliminating, the areas in which a well could be placed.

6.1.3 Additional Beneficial Use Considerations

As discussed in the previous sections, the evaluation of the groundwater quality in the vicinity of the facility with respect to potability determination criteria specified in MTCA supports the designation of the groundwater as non-potable. In addition, the likelihood that groundwater from the shallow or intermediate aquifers will be used as a source of drinking water is further diminished by the following:

- The Duwamish Valley aquifers are not listed as one of the city's long-range water supply options (City of Seattle, 1997), indicating that the use of the more than 20 listed alternate water supply sources would have to be impracticable before the use of the Duwamish aquifers would be considered.

- The City of Seattle has stated that they are not "interested in using the shallow aquifer for drinking water because of the treatment requirements and public health and safety concerns" (City of Seattle, 1997)[7].

- The Seattle-King County Department of Public Health has stated that future requests for the development of drinking water wells in the Duwamish Valley would "most likely be refused since there is a higher and better source of water in the area" (Seattle-King County Department of Public Health, 1997).

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[7] The City's definition of the shallow aquifer encompasses both the shallow and intermediate aquifers defined for the purposes of this report.

- The presence of organic chemicals in upgradient and cross-gradient wells indicates that there are other uncontrolled sources of groundwater contamination in the area proximate to the facility.

6.1.4 Groundwater Beneficial Use Designations in the Duwamish Valley

There are several other sites in the Duwamish Valley where groundwater has been either designated as non-potable or protection of surface water has been deemed the highest beneficial use of groundwater. These sites include, but are not limited to: Harbor Island, Southwest Harbor Project, Great Western Chemical, Fostoria Business Park, Spencer Industries, Holnam Markey Site, the former All City Wrecking Site and the Myrtle Street Property, shown in Figure 6-5. Cleanup standards developed for these sites are based on the protection of surface water as a non-potable water body.

6.1.5 Summary and Conclusions of Groundwater Beneficial Use Evaluation

The groundwater in the area of interest is not currently used as a source of drinking water and is not classified as a potential future source of drinking water under WAC 173-340-720 (2). Furthermore, it is highly unlikely that the groundwater contamination in the shallow, intermediate, and deep aquifers in the area of interest is hydraulically connected to any groundwater or surface water that is a potential future source of drinking water. Groundwater in parts of the area of interest is also rendered not potable by the intrusion of brackish water from the Duwamish Waterway. Various state and local regulations prohibit the installation and use of drinking water wells in the area of interest by requiring connection to the available public supply and through numerous setback requirements that severely limit the area in which a well could be installed.

In summary, drinking water is not the highest beneficial use of groundwater at or near the PSC Georgetown facility based on background groundwater analytical results and current drinking water quality regulations. This determination is consistent with studies at other sites located in the Duwamish Valley that have evaluated the highest beneficial use of groundwater. The highest beneficial use of groundwater in the area is the protection of surface water as a non-potable water body. Groundwater in all three aquifers that discharges to the Duwamish Waterway is classified for use as wildlife habitat and for shellfish harvesting. Groundwater cleanup standards considered for chemicals of potential concern are protective of these uses.

6.2 *Groundwater Point of Compliance*

The groundwater point of compliance is the point or points where the applicable groundwater cleanup standards must be attained for a site to be in compliance with cleanup standards. Section VII.A.4.a.6 of the facility permit defines the groundwater point of compliance as "those wells where the lowest of the following screening criteria are, or have been since January 1, 1998, exceeded: Washington State Department of Ecology Model Toxics Control Act (MTCA) Method B groundwater cleanup criteria; MTCA Method A groundwater cleanup criteria; EPA SDWA Maximum Contaminant Levels (MCLs), and non-zero MCL goals, and conservative, peer-reviewed (by the scientific community), ecological risk-based concentrations for Duwamish River receptors approved by the Director in the Risk Assessment". However, section VII.A.4.a.7 of the permit contains a provision for the potential modification of this point of compliance.

WAC 173-340-720 (8) allows for a conditional point of compliance in cases where it is not practicable to meet cleanup levels throughout the site within a reasonable restoration time frame. In determining whether the cleanup levels can be met in a reasonable time frame, the following factors should be considered:

1. Potential risks posed by the site to human health and the environment;
2. Practicability of achieving a shorter restoration time frame;
3. Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

4. Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
5. Availability of alternative water supplies;
6. Likely effectiveness and reliability of institutional controls;
7. Ability to control and monitor migration of hazardous substances from the site;
8. Toxicity of the hazardous substances at the site; and
9. Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

This conditional point of compliance should be established as close as practicable to the source of the hazardous substances. Unless the property is near or adjacent to surface water and the cleanup levels are based on the protection of surface water, the conditional point of compliance should be established within the property boundary. Conditional points of compliance may also be established off-site in cases where co-mingled plumes are present.

6.2.1 Proposed Modifications to the Groundwater Point of Compliance

A subsurface barrier wall is currently being constructed around the majority of the facility, and will be an integral component of the final cleanup action. The purpose of the barrier wall is to prevent the most highly contaminated groundwater from continuing to impact groundwater downgradient of the facility. Essentially, the barrier wall will function as a source containment remedy. Although groundwater within the barrier wall will be extracted, treated, and discharged to the combined sewer, it is not anticipated that contaminated groundwater located within the barrier wall will meet applicable cleanup standards within a predictable timeframe. Therefore, a conditional point of compliance must be established.

A proposed conditional point of compliance will be located on PSC-owned property [or on adjacent property of third parties from whom PSC has obtained a permanent subsurface easement and restrictive covenants acceptable to Ecology], just outside the barrier wall in a downgradient and cross-gradient direction. Further evaluation of the chemical and hydraulic response of the groundwater will be required following the installation of the barrier wall in order to assess the suitability of the proposed conditional point of compliance. As a result, this proposed conditional point of compliance is preliminary, and may be altered following completion of the feasibility study and an appropriate remedy evaluation period. The proposed point of compliance will be formalized during the permit modification required for the final remedy.

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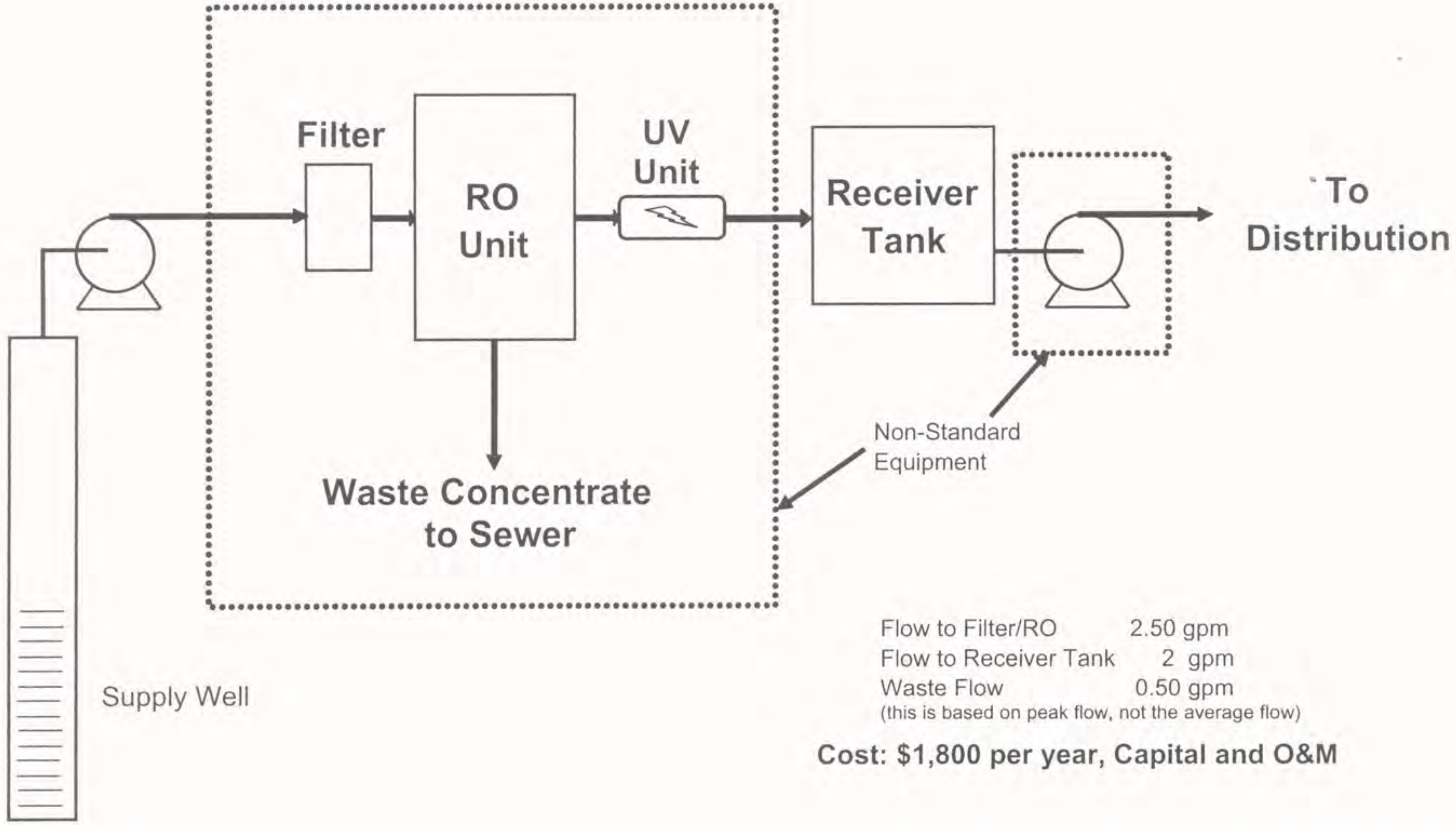


Flow to Filter/RO	2.50 gpm
Flow to Receiver Tank	2 gpm
Waste Flow	0.50 gpm

(this is based on peak flow, not the average flow)

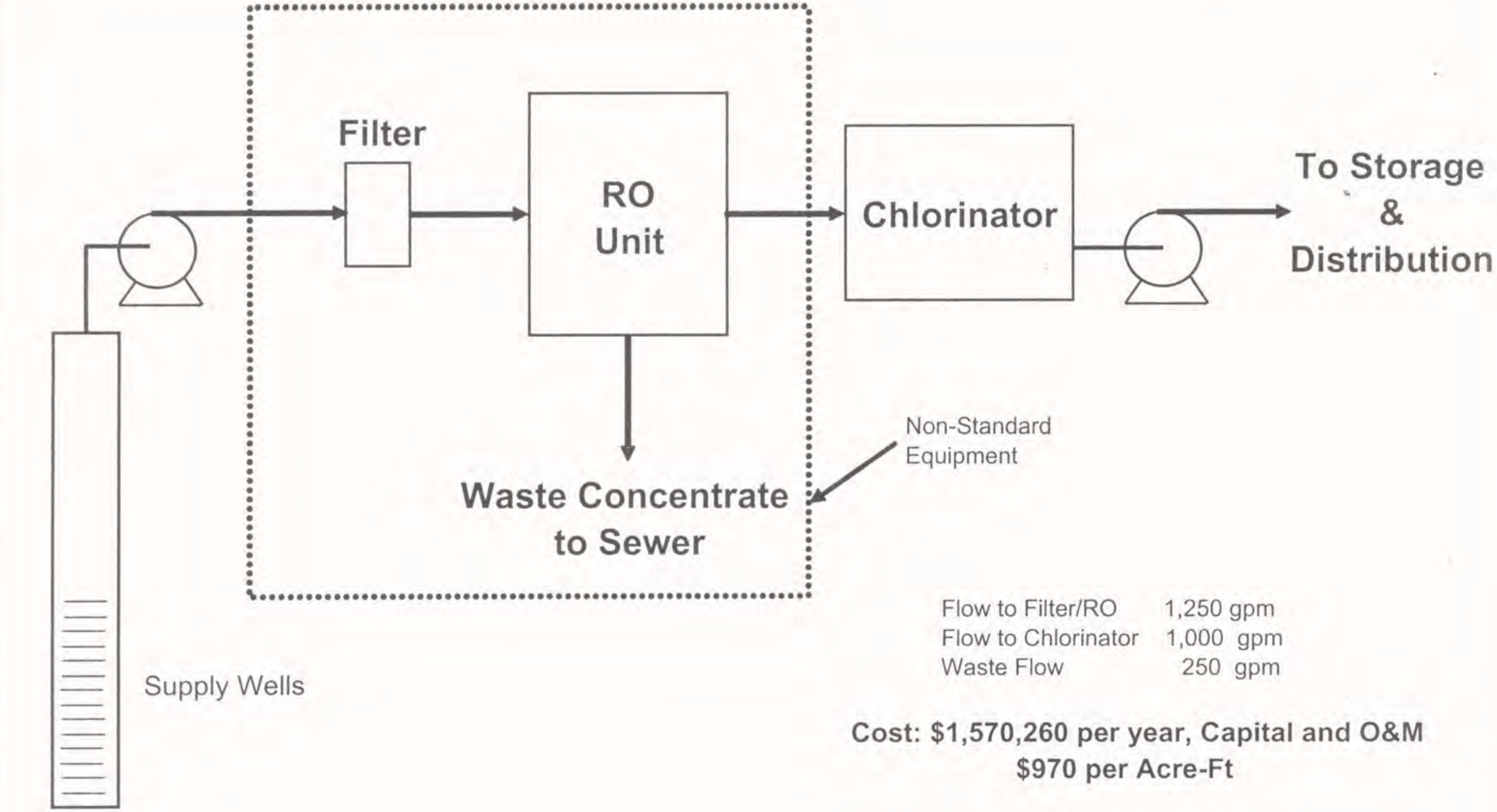
Cost: $1,800 per year, Capital and O&M

GEOMATRIX

SINGLE FAMILY GROUNDWATER TREATMENT SYSTEM
Philip Services Corporation Georgetown Facility
Seattle, Washington

Project No.
8719

Figure
6-1



Flow to Filter/RO	1,250 gpm
Flow to Chlorinator	1,000 gpm
Waste Flow	250 gpm

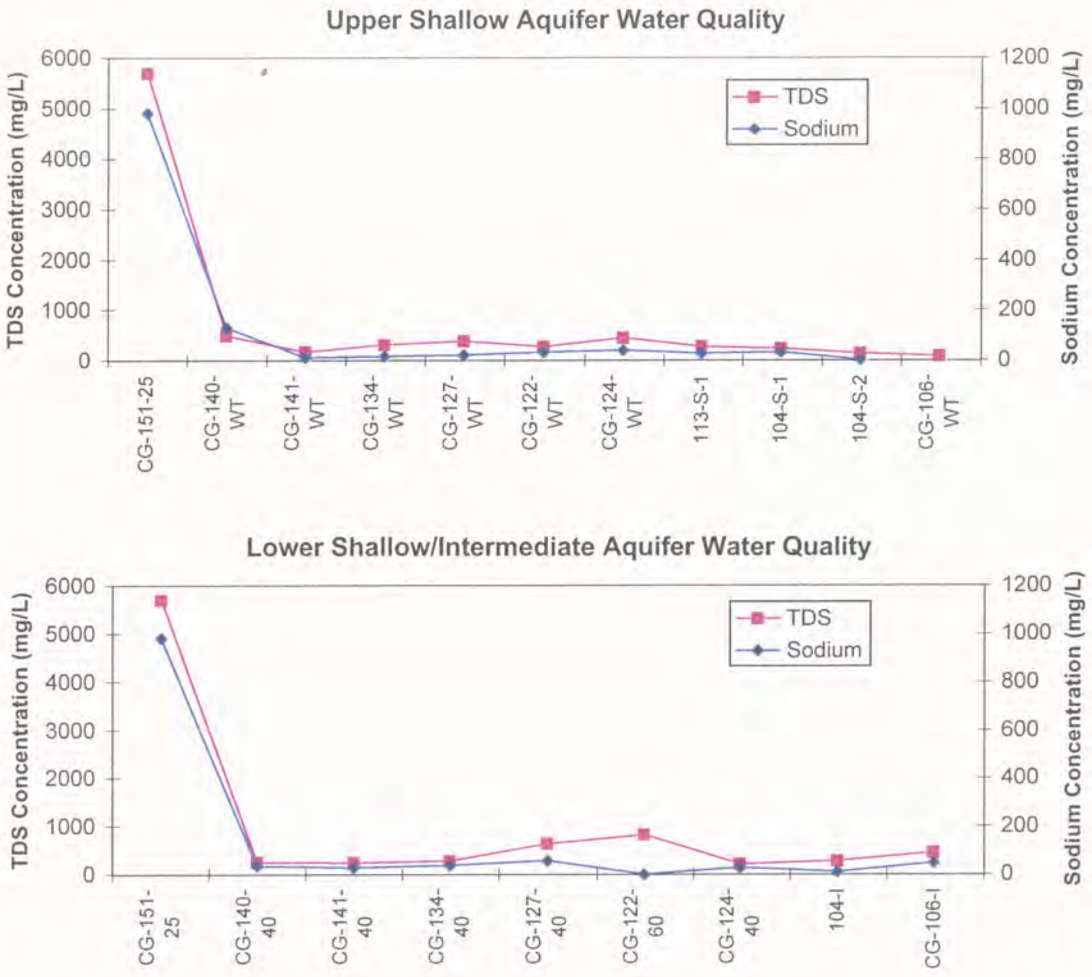
Cost: $1,570,260 per year, Capital and O&M
$970 per Acre-Ft

GEOMATRIX

PUBLIC WATER SUPPLY TREATMENT SYSTEM
Philip Services Corporation Georgetown Facility
Seattle, Washington

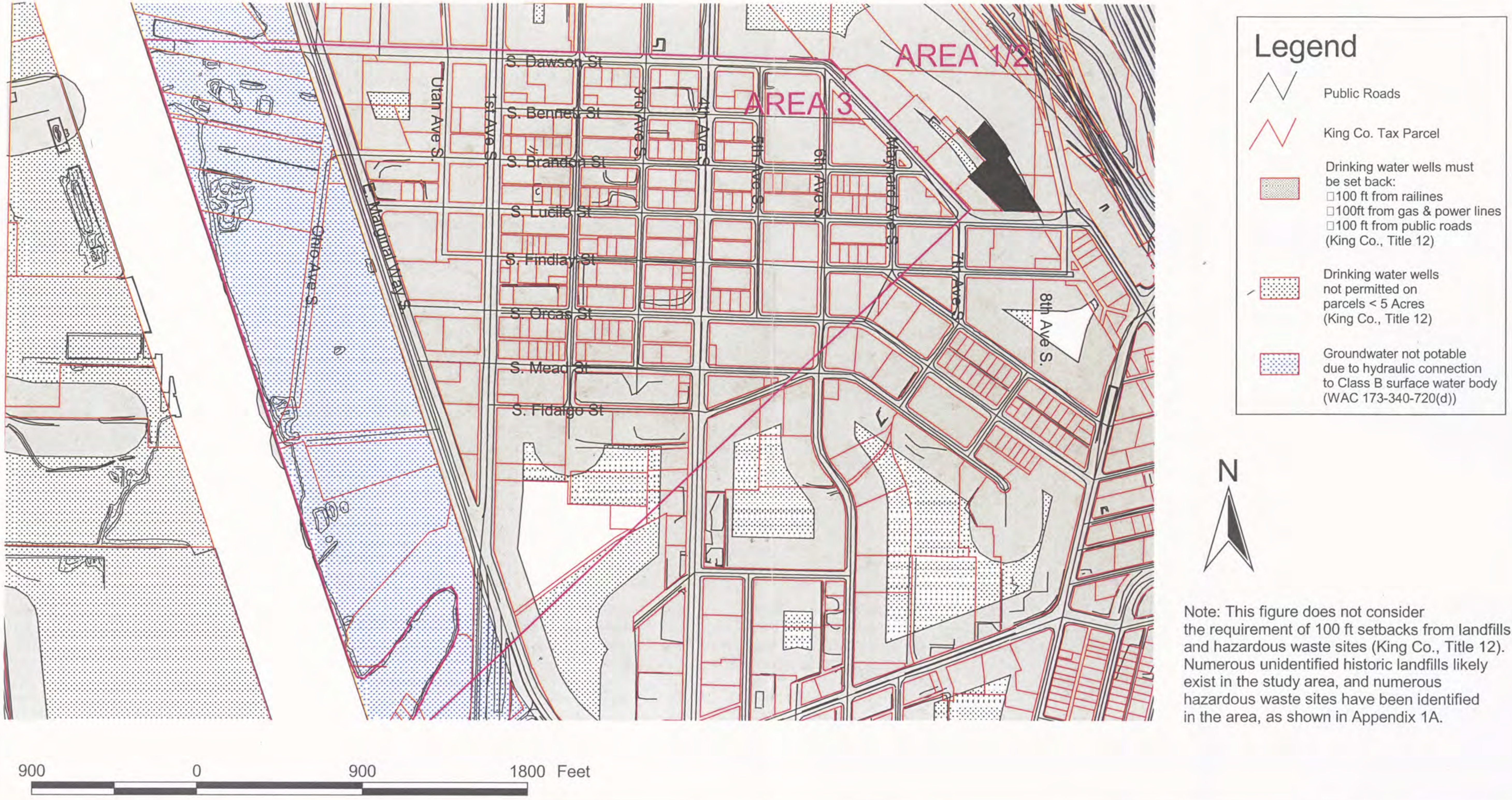
Project No.
8719

Figure
6-2



PSC

Figure 6-3
Water Quality with Distance from the Duwamish Waterway
PSC Georgetown Facility



Note: This figure does not consider the requirement of 100 ft setbacks from landfills, and hazardous waste sites (King Co., Title 12). Numerous unidentified historic landfills likely exist in the study area, and numerous hazardous waste sites have been identified in the area, as shown in Appendix 1A.

PSC

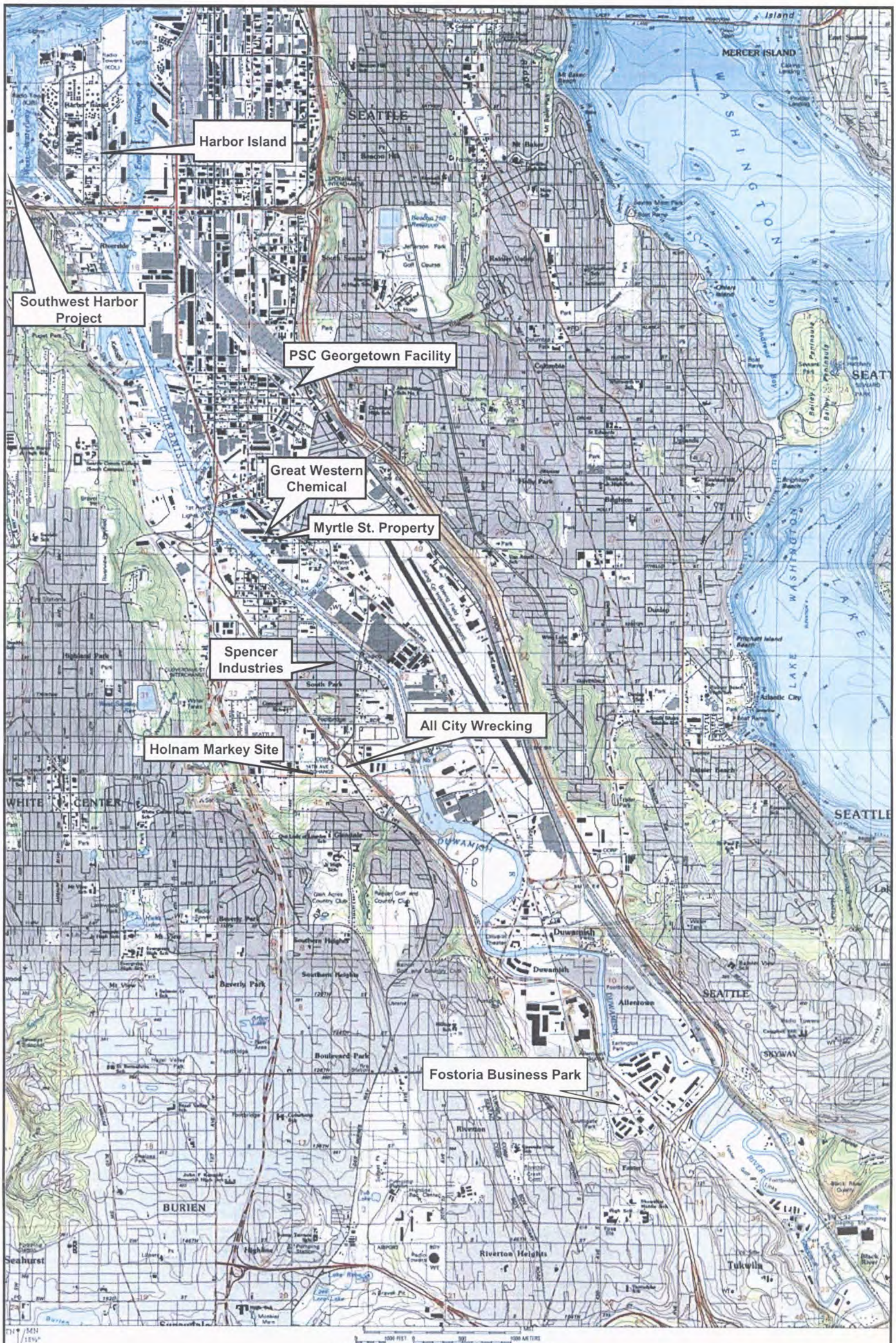
Well Placement Restrictions
Based on Current Regulations
PSC Georgetown Facility

Drawn by: DTB

Project: RI2003

Date: 8/29/2003

Figure Number: 6-4



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PSC

Locations of Sites in Duwamish River Valley where Highest Beneficial Use is not as a Source of Drinking Water

Project
RI 2003

Figure
6-5

Table 6-1

Site-Specific Background Concentrations in Groundwater from the Shallow and Intermediate Aquifers

PSC Georgetown Facility

Compound	Number of Samples	Number of Detects	Frequency of Detection	Units	Minimum Detected Concentration	Maximum Detected Concentration	Average Detected Concentration	Distribution of Data	Background Concentration	Primary MCL	Secondary MCL	Exceeds MCL?
Antimony	21	0	0%	ug/L	---	---	---	---	---	6	---	---
Arsenic	57	30	53%	ug/L	0.0724	12.5	1.21	lognormal	1.51 *	10	---	no
Barium	48	20	42%	ug/L	5.43	46.9	17	lognormal	21.53	2,000	---	no
Beryllium	21	0	0%	ug/L	---	---	---	---	---	4	---	---
Cadmium	31	0	0%	ug/L	---	---	---	---	---	5	---	---
Chloride	52	52	100%	ug/L	3790	343000	81677.5	**	22,320 *	---	250,000	no
Chromium	29	17	59%	ug/L	1.07	20.6	4.30	lognormal	4.56 *	100	---	no
Chromium (Hexavalent)	17	3	18%	ug/L	16.6	24.2	---	---	---	100	---	---
Copper	47	23	49%	ug/L	1	34.8	4.391	**	2 *	1,300	---	no
Cyanide	54	5	9%	ug/L	10	41.9	20.46	normal	---	200	---	no
Ferric Iron	**46**	**26**	**57%**	**ug/L**	**290**	**39200**	**4396.61**	**lognormal**	**2,726 ***	—	**300**	**Yes**
Ferrous Iron	**41**	**10**	**24%**	**ug/L**	**514**	**17000**	**4217.9**	**lognormal**	**312 ***	—	**300**	**Yes**
Ferrous Iron (Field Test)	**21**	**18**	**86%**	**ug/L**	**40**	**3010**	**1283.33**	**normal**	**1,904**	—	**300**	**Yes**
Iron	**15**	**9**	**60%**	**ug/L**	**313**	**8600**	**3234.778**	**normal**	**2,408 ***	—	**300**	**Yes**
Lead	55	6	11%	ug/L	1.08	5.75	3.02	normal	---	15	---	---
Magnesium	41	41	100%	ug/L	1120	17400	6792.68	lognormal	17,136	---	---	---
Manganese	**52**	**45**	**87%**	**ug/L**	**12.2**	**988**	**222.99**	**	**569**	—	**50**	**Yes**
Mercury	25	0	0%	ug/L	---	---	---	---	---	2	---	---
Nickel	45	22	49%	ug/L	1	9.25	2.194	lognormal	2.93	100	---	no
Nitrate(as N)	51	13	25%	ug/L	183	638	339.15	lognormal	330	10,000	---	no
Nitrite (as N)	52	2	4%	ug/L	82	280	181	**		1,000	---	no
Potassium	41	32	78%	ug/L	561	31700	12641.91	lognormal	22140.89 *	---	---	---
Selenium	47	8	17%	ug/L	1.44	6.12	2.206	lognormal	1.55	50	---	no
Silver	42	0	0%	ug/L	---	---	---	---	---	---	100	---
Sodium	41	41	100%	ug/L	2250	359000	81000.73	**	64000 *	---	---	---
Sulfate	52	37	71%	ug/L	449	49400	9551.68	lognormal	12766.66	---	250,000	no
Sulfide	53	0	0%	ug/L	---	---	---	---	---	---	---	---
Thallium	21	0	0%	ug/L	---	---	---	---	---	2	---	---
Total Dissolved Solids	**41**	**41**	**100%**	**ug/L**	**13000**	**1100000**	**313682.93**	**lognormal**	**684378.9**	—	**500,000**	**Yes**
Vanadium	15	11	73%	ug/L	1.08	16.7	3.77	lognormal	5.83 *	---	---	---
Zinc	10	2	20%	ug/L	18.4	61.9	40.15	**	---	---	5,000	no
Turbidity	**68**	**68**	**100%**	**NTU**	**0**	**290**	**12.145**	**lognormal**	**11.5**	**1**	---	**Yes**
Coliforms	**4**	**3**	**75%**	**CFU/100ml**	**17**	**5100**	**1284**	**	**76 ***	**>0**	---	**Yes**
Color	**7**	**6**	**86%**	**color units**	**5**	**120**	**55**	**normal**	**94.71**	—	**15**	**Yes**

Notes:

ug/L = micrograms per liter = parts per billion (ppb)

mg/L = milligrams per liter = parts per million (ppm)

NTU = Nephelometric units

CFU = Colony forming units

MCL = Maximum contaminant level (WDOH, 1995 and Updates; EPA, 2002)

Bold text indicates that background concentration exceeds MCL

Background concentrations were calculated in accordance with WAC-173-340-709 using data from CG-3, CG-101-S1, CG-101-S2, CG-106-WT, CG-106-I, CG-107-WT and CG-111-I for the shallow and intermediate aquifers.

Data from January 2000 through May 2003 were used for all parameters except coliforms. Coliform data were collected in August and November 1999.

Background concentrations were not calculated for parameters with six or fewer data points as statistics can not be reliably calculated from small data sets.

* In cases where the upper 90th percentile was greater than 4 times the 50th percentile, 4 times the 50th percentile was used as the background concentration.

** Distribution could not be determined; non-parametric statistical methods were used.

Table 6-2
Site-Specific Background Concentrations in Groundwater from the Deep Aquifer
PSC Georgetown Facility

Compound	Number of Samples	Number of Detects	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Detected Concentration	Distribution of Data	Background Concentration	Primary MCL	Secondary MCL	Exceeds MCL?
Antimony	3	0	0%	---	---	---	---	---	6	---	---
Arsenic	**6**	**6**	**100%**	**11.5**	**15.9**	**13.43**	**lognormal**	**15.88**	**10**	**—**	**Yes**
Barium	6	3	50%	4.74	41.9	19.18	**	---	2,000	---	no
Beryllium	3	0	0%	---	---	---	---	---	4	---	---
Cadmium	3	0	0%	---	---	---	---	---	5	---	---
Chloride	**5**	**5**	**100%**	**156,000**	**234,000**	**200,600**	**lognormal**	**254,873**	**—**	**250,000**	**Yes**
Chromium	3	3	100%	2.85	13.6	7.04	**	---	100	---	no
Chromium (Hexavalent)	3	1	33%	38	38	---	---	---	100	---	---
Copper	6	6	100%	23.5	75.6	38.53	**	133.8	1,300	---	no
Cyanide	4	0	0%	---	---	---	---	---	200	---	no
Ferric Iron	**4**	**4**	**100%**	**123**	**13,000**	**3,788**	**lognormal**	**4,485 ***	**—**	**300**	**Yes**
Ferrous Iron	3	0	0%	---	---	---	---	---	---	300	no
Ferrous Iron (Field Test)	3	3	100%	110	360	236.67	**	---	---	300	no
Iron	**2**	**2**	**100%**	**483**	**510**	**496.5**	**	**—**	**—**	**300**	**Yes**
Lead	6	4	67%	1.06	14	4.785	**	4.03 *	15	---	---
Magnesium	5	5	100%	5,980	9,440	7,078	**	26,720 *	---	---	---
Manganese	**7**	**7**	**100%**	**126**	**257**	**162**	**	**596 ***	**—**	**50**	**Yes**
Mercury	3	0	0%	---	---	---	---	---	2	---	---
Nickel	6	6	100%	5.5	16.6	9.36	**	32.9 *	100	---	no
Nitrate(as N)	5	0	0%	---	---	---	---	---	10,000	---	no
Nitrite (as N)	5	0	0%	---	---	---	---	---	1,000	---	no
Potassium	5	5	100%	17,100	21,600	16,336	**	76,200 *	---	---	---
Selenium	6	6	100%	1.58	2.68	1.97	lognormal	2.61	50	---	no
Silver	6	0	0%	---	---	---	---	---	---	100	---
Sodium	5	5	100%	532,000	593,000	560,800	lognormal	593,567	---	---	---
Sulfate	5	5	100%	5,630	7,560	6,880	**	28,520 *	---	250,000	no
Sulfide	5	0	0%	---	---	---	---	---	---	---	---
Thallium	3	0	0%	---	---	---	---	---	2	---	---
Total Dissolved Solids	**5**	**5**	**100%**	**1,400,000**	**1,600,000**	**1,480,000**	**	**6,000,000 ***	**—**	**500,000**	**Yes**
Vanadium	1	1	100%	44.9	44.9	44.9	---	---	---	---	---
Zinc	0	0	0%	---	---	---	---	---	---	5,000	no
Turbidity	**6**	**6**	**100%**	**4.86**	**446**	**100.29**	**lognormal**	**141.74**	**1**	**—**	**Yes**
Color	**1**	**1**	**100%**	**400**	**400**	**400**	**—**	**—**	**—**	**15**	**Yes**

Notes:
ug/L = micrograms per liter = parts per billion (ppb)
mg/L = milligrams per liter = parts per million (ppm)
NTU = Nephelometric units
MCL = Maximum contaminant level (WDOH, 1995 and Updates; EPA, 2002)
Bold text indicates that background concentration exceeds MCL
Background concentrations were developed in accordance with WAC-173-340-709 using data from CG-106-D
Background concentrations were not calculated for parameters with six or fewer data points as statistics can not be reliably calculated from small data sets.
* In cases where the upper 90th percentile was greater than 4 times the 50th percentile, 4 times the 50th percentile was used as the background concentration.
** Distribution could not be determined; non-parametric statistical methods were used.

Table 6-3
Comparison of Potential Groundwater Treatment Technologies
PSC Georgetown Facility

Treatment Option	Parameter Addressed						Advantages	Disadvantages
	Arsenic	Iron	Manganese	Total Dissolved Solids	Turbidity	Pathogens		
Ion Exchange (cation and anion exchange)	√	√	√	√	√		Effective at treating dissolved constituents. Proven technology used widely for commercial, industrial, and public water supply. Softeners used widely for home water treatment systems.	Costly; ion exchange resins can become fouled, requiring periodic maintenance. Requires prefiltering. Requires use of hazardous chemical regenerants (brine, caustic soda, acid). Waste regenerant must be disposed of appropriately. May produce hazardous waste. Hazardous waste disposal required.
Distillation	√	√	√	√	√		Effective at treating most of the constituents	Expensive, high energy use. Requires proper operation and maintenance. Produces concentrated waste for disposal. Waste could be hazardous due to arsenic.
Aeration and Filtration		√	√		√		Can remove dissolved and particulate iron and manganese and turbidity. Proven technology, widely used for public water treatment system.	Requires specialized equipment and proper operation/maintenance. Not suited for single family resdience.
Chlorination						√	Widely used and proven for disinfection of water supplies.	Hazardous chemical storage and handling; not appropriate for residential use
Ultraviolet (UV) Oxidation						√	Proven disinfection method. Simple technology, requires minimal effort for operation.	Fouling potential requires maintenance to be effective.
Reverse Osmosis	√	√	√	√	√		Proven technology. Treats multiple parameters in a single step. Fairly simple operation, doesn't require hazardous chemical use.	Expensive. Periodic maintenance is required to maintain operation. May require chemical feed to control fouling. Requires disposal of concentrate (20-25% of total flow). Requires prefiltering.

Table 6-4
2003 Seattle Public Utilities Annual Analysis of Cedar & Tolt Water Supplies
Detected Concentrations, May 2003

Cedar Distribution = South of the ship canal & lower elevations North of ship canal.
Tolt Distribution = Higher elevations North of the ship canal.

Water Quality Parameter	State Dept. of Health Maximum Contaminant Level	CEDAR	TOLT	Minimum Reporting Level
Primary Standards *	**MCL**			
Antimony	6 ug/L	ND	ND	3.0
Arsenic	50 ug/L	ND	ND	1.0
Asbestos $	7 million fibers/L (>10um long)	ND	ND	0.2
Barium	2000 ug/L	ND	ND	5.0
Beryllium	4 ug/L	ND	ND	2.0
Cadmium	5 ug/L	ND	ND	0.2
Cyanide	200 ug/L	ND	ND	10.0
Chromium	100 ug/L	ND	ND	1.0
Fluoride	4 mg/L	0.86	0.96	0.10
Haloacetic Acids, Total ~	60 ug/L	24.9	25.0	5.0
Nickel	100 ug/L	ND	ND	10.0
Mercury	2 ug/L	ND	ND	0.1
Nitrate-Nitrogen	10 mg/L	0.046	0.128	0.010
Nitrite-Nitrogen	1 mg/L	ND	ND	0.002
Selenium	50 ug/L	ND	ND	3.0
Thallium	2 ug/L	ND	ND	2.0
Trihalomethanes, Total~	80 ug/L	28.2	32.2	0.5
Turbidity	5 NTU for Cedar/ 0.30 NTU for Tolt	0.49	0.15	0.05
Secondary Standards **	**SMCL**			
Aluminum	50 - 200 ug/L	72.3	26.5	3.0
Chloride	250 mg/L	3.71	2.83	0.5
Color	15 std. units	ND	ND	5.0
Copper ^	1000 ug/L	ND	ND	1.0
Fluoride	2 mg/L	0.86	0.96	0.10
Iron	0.3 mg/L	0.027	0.015	0.004
Manganese	50 ug/L	3	ND	1.0
pH, range ++ ^	6.5 - 8.5 pH units	7.79 - 8.47	8.09 - 8.65	NA
Silver	100 ug/L	ND	ND	1.0
Solids,Total Dissolved	500 mg/L	47.5	37.0	5.0
Specific Conductance	700 umhos/cm	67.8	57.8	5.0
Sulfate	250 mg/L	1.32	2.12	1.0
Zinc	5 mg/L	ND	ND	0.02
Other Parameters ^	**Units**			
Alkalinity, Total (as CaCO3)	mg/L	22.3	15.4	2.0
Calcium, (as CaCO3)	mg/L	25.6	23.2	2.0
Hardness, (as CaCO3)	mg/L	30.1	24.6	2.0
Hardness, (as CaCO3)	grains/gal.	1.74	1.42	0.1
Magnesium	mg/L	1.08	0.34	0.02
Oxygen, Dissolved	mg/L	11.2	15.9	0.5
Potassium	mg/L	0.26	0.13	0.020
Silica, Reactive	mg/L	7.90	5.40	1.0
Sodium	mg/L	2.31	1.12	0.02
Temperature, annual range	deg. C.	5 - 20	5 - 20	NA
Total Organic Carbon (treatment plant	mg/L	1.05	1.11	0.20
Lead, Source water	ug/L	ND	ND	1.0
	Action Level			
Lead, Residential Survey @	15 ug/L	11.1	30.9	1.0
Copper, Residential Survey @	1300 ug/L	263	969	1.0

Primary and Secondary Standards were measured at the Intake to the distribution system after treatment.

* Health stds.: Supplier subject to public notification.
** Aesthetic stds.: Supplier not subject to public notification.
~ Average of the last 4 quarters testing, through 5/03.
++ January-May 2003, 10-90th percentile
$ Test results 12/15/95 - analysis not required in 2003
^ Representative of the Seattle distribution system.

@ Measured at 90th percentile of overnight standing residential samples from homes with copper pipes and lead solder, 1997. New samples will be collected in late 2003 and again in early 2004.

1 ppm = 1 mg/L = 1000 ug/L

ND = Not Detected at or above the Minimum Reporting Level

Seattle Public Utilities Water Quality Laboratory, 800 S. Stacy St., Seattle 98134 (206) 684-7834
http://www.seattle.gov/util/services/waterquality/

7.0 SOURCES OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern (COPCs) have been detected in environmental media at the facility and in the surrounding area. Although there are known and suspected sources of these COPCs on the PSC property that have resulted in impacted groundwater originating on the PSC property and migrating off-site, some of the contamination detected in off-site samples is likely to be associated with other sources. This section presents a discussion of the potential sources of constituents, identification of COPCs and the properties of the identified COPCs.

A number of constituents have been detected in soil, groundwater, indoor air, soil gas, and ambient air during environmental investigations conducted by PSC at the facility and in areas surrounding the facility. This area encompasses locations at, downgradient, crossgradient and upgradient of the PSC facility and is referred to in this report as the "RI Study Area." The discussion of the nature and extent of these constituents at and downgradient of the facility is presented in terms of three evaluation units, presented in Figure 7-1, based on different types of current and plausible future land uses in each area:

- **Area 1** – is the facility.

- **Area 2** – comprises two properties, the TASCO and the SAD property located immediately hydraulically downgradient of the facility (east of Denver Avenue and north of South Lucile Street).

- **Area 3** – comprises mixed used residential/industrial/commercial properties located hydraulically downgradient from the facility (west of Denver Avenue and south of South Lucile Street extending to the Duwamish Waterway).

These are the same designations used in the HHERA, presented in Part II of this report.

7.1 *PSC Source*

Historical information from the facility and the results from numerous field investigations indicate that there were two primary sources of COPCs released to soil and eventually groundwater, on the PSC property: (1) surface releases during historical operations across the facility, and (2) subsurface releases from USTs and their associated piping located in the North Field. These potential releases, discussed in Section 2, and the resulting impacted media are discussed in more detail in this section.

7.1.1 Surface Releases

The surface releases are thought to have resulted in impacts to soil and the dissolved constituents detected in groundwater in the shallow aquifer at the facility. While most of the COPCs at the site were likely released in some amount as part of a surface spill, the surface spills are thought to have been the primary source of the PCBs detected in groundwater at the facility as PCBs have been detected in groundwater in the water table sample interval only. Surface releases may also have resulted in the release of some NAPL.

7.1.2 UST Source Area

Releases from the USTs and associated piping are thought to have been of greater magnitude than the surface releases. Groundwater analytical results indicate that a DNAPL, composed primarily of chlorinated solvents, may be present in the subsurface as a result of releases from the USTs and their associated piping. For DNAPL to exist in the subsurface, the quantity released must exceed the amount that can be dissolved in water or sorbed to soil. Because DNAPLs are more dense than water, released DNAPL that is not trapped as residual product tends to migrate downward through the aquifer. Subtle permeability contrasts in the aquifer material have a controlling influence on DNAPL migration. Groundwater flow typically does not have much effect on DNAPL migration (Pankow and Cherry, 1996). As such, DNAPL pathways in the saturated zone are generally complex, difficult, or impossible to fully characterize, and therefore, uncertain.

The DNAPL present in Area 2 is thought to be composed primarily of trichloroethene (TCE), although a number of COPCs including phenols have been detected in groundwater believed to be very close to some DNAPL[1]. An approximate guideline for the possible existence of upgradient DNAPL is a dissolved groundwater concentration greater than 1% of saturation (Pankow and Cherry, 1996). Figures 7-2 and 7-3 present the distribution of TCE as a percentage of its solubility, and provide an estimate of the locations where DNAPL may currently exist in the subsurface. These figures indicate that DNAPL may have migrated from the UST area to depth of 55 to 70 feet below the ground surface, and laterally onto the northern portion of the TASCO property. As the DNAPL migrated downward, it would encounter layers of low permeability at the interface of the shallow and intermediate aquifers and below, causing it to also migrate laterally. This lateral migration would be caused by the general westward sloping of the subsurface topography. Based on the elevated concentrations of TCE, and its degradation products found in groundwater at wells on the former TASCO property, it appears that a DNAPL source area may now exist in the western portion of the North Field and on the TASCO property itself. Groundwater flow lines defined by groundwater elevation maps prepared for the shallow and intermediate aquifers further support this hypothesis.

Low concentrations of COPCs detected in the deep aquifer are thought to be attributed to the migration of contaminated water from the intermediate aquifer to the deep aquifer during the installation of several deep wells and the absence of a seal between the intermediate and deep aquifers in CG-2-D, that has since been decommissioned.

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[1] Compounds other than chlorinated ethenes have been detected in groundwater in the intermediate aquifer near the assumed DNAPL location. The concentrations of these compounds are typically much lower relative to solubility than TCE, suggesting that the DNAPL is primarily TCE. However, the presence of other compounds in the intermediate aquifer in this area indicates that the DNAPL may have also contained smaller percentages of other compounds.

7.2 *Other Potential Sources*

The PSC property is located in a historically industrial corridor, and thus, it is highly likely that some of the constituents detected in samples located downgradient of the facility could be a result of releases from other current and former businesses in the area. A brief and not exhaustive discussion of potential off-site sources is presented in Appendix 1A. The evaluation of the nature and extent of impacted groundwater indicates a number of additional sources of groundwater contamination throughout the area, as described in detail in Section 9.4. In addition, contaminants detected in indoor air and ambient air in the area of the PSC facility may also be attributable to sources other than the PSC facility, as discussed in Section 10.

7.3 *Chemicals of Potential Concern*

A number of constituents have been detected in soil, groundwater, indoor air, soil gas, and ambient air during PSC's environmental investigations in the RI Study Area. The discussion of the nature and extent of contamination focuses on those constituents identified as COPCs in the HHERA, summarized in Table 7-1. The evaluation of the nature and extent of COPCs identified in soil, groundwater and air samples is discussed below.

7.3.1 Soil

The nature and extent of COPCs in soil was evaluated by comparing all soil analytical data toMTCA Industrial Soil cleanup levels (CLs) (WAC 173-340-745), summarized in Table 7-2. These cleanup levels are protective of direct contact with soil under industrial occupational exposure scenarios. Potential exposure to soil at the facility is very limited as the majority of the facility is covered with concrete. The discussion of the nature and extent of soil contamination is limited to those constituents identified as COPCs and is presented in Section 8.

7.3.2 Groundwater

The nature and extent of COPCs in groundwater was evaluated by comparing all groundwater analytical results from 2000 forward with MTCA groundwater cleanup levels[3] protective of:

- human health (based the vapor intrusion into indoor air and groundwater to surface water pathways), and
- the environment (based on aquatic receptors) to determine the COPCs for groundwater.

The cleanup levels based on the protection of indoor air were calculated by developing air cleanup levels based on MTCA equations 750-1 and 750-2 and dividing them by a groundwater-to-indoor air volatilization factor (GIVF). Groundwater cleanup levels based on the protection of human exposures to surface water were calculated based on MTCA equations 730-1 and 730-2 and are protective of exposure to surface water and ingestion of aquatic organisms. The groundwater cleanup levels based on the protection of ecological receptors was based on the ecological screening levels defined in the HHERA. Groundwater cleanup levels are summarized in Table 7-2. The discussion of the nature and extent of groundwater contamination is limited to those constituents identified as COPCs and is presented in Section 9.

7.3.3 Soil Gas, Indoor Air, Ambient Air

As described in Section 4, PSC has conducted a number of indoor air, ambient air, and soil gas sampling events to assess the potential for VOCs to migrate from the subsurface into buildings. COPCs in air were identified by comparing indoor air analytical results from 2000-2003 with

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[3] As described in more detail in the HHERA, cleanup levels under MTCA are typically designed to be protective of unrestricted (residential) land-use. Any deviations from these exposure assumptions, such as for industrial use, or from the equations provided in MTCA, such as for the calculation of groundwater cleanup levels protective of indoor air, are reserved for the calculation of remediation levels. While the cleanup levels developed for the RI Study Area are more appropriately referred to as remediation levels, they will be referred to in the text of the RI report as cleanup levels in an effort to minimize confusion. Separate remediation levels may still be proposed in the FS consistent with the technologies and/or clean-up options being evaluated.

MTCA Method B air cleanup levels (WAC 173-340-750). These cleanup levels are protective of residential exposure to air. The discussion of the nature and extent of air contamination is limited to those constituents identified as COPCs and is presented in Section 10.

7.4 *Properties of COPCs*

This section presents a general description of the COPCs identified throughout the RI study area. The discussion has been organized into groups of COPCs related by a common source, or similar physical chemical properties that might control their fate and transport, as shown in Table 7-1. The discussion for VOCs includes BTEX, chlorinated ethenes, chlorinated ethanes, chlorinated methanes, and other VOCS. The discussion for SVOCs includes polycyclic aromatic hydrocarbons (PAHs), phenols, and other SVOCs while PCBs and inorganic constituents are discussed as separate groups.

7.4.1 VOCs

7.4.1.1 *BTEX*

BTEX were identified as COPCs. BTEX are components of light end petroleum products, such as gasoline, and are used in a wide variety of industries including the manufacture of paints and varnishes (HSDB, 2003). BTEX readily biodegrade to water and carbon dioxide or methane under a variety of geochemical conditions (Wiedemeier et al., 1999). BTEX compounds are expected to be relatively mobile in the environment but will also likely be lost from soil and groundwater as a result of rapid volatilization and/or biodegradation.

7.4.1.2 *Chlorinated Ethenes*

Chlorinated ethenes, tetrachloroethene (PCE), TCE, 1,1-dichloroethene (1,1,-DCE), cis- and trans-1,2-dichloroethene (1,2-DCE), vinyl chloride, and ethene, were identified as COPCs. Chlorinated ethenes, often used as solvents and degreasing agents in a wide variety of industries (HSDB, 2003), are readily biodegraded under the correct geochemical conditions. Highly chlorinated ethenes, such as PCE and TCE, typically biodegrade more quickly under anaerobic conditions while the less chlorinated ethenes, such as vinyl chloride, typically degrade more quickly under aerobic conditions. The biodegradation of chlorinated ethenes occurs by step-wise dechlorination; thus, PCE degrades to TCE which degrades to cis-1,2- DCE, then vinyl chloride and finally, ethene and ethane as presented in Figure 7-4. The biodegradation of chlorinated ethenes is discussed in more detail in Section 9. Chlorinated ethenes are expected to be relatively mobile in the environment but will also likely be lost from soil and groundwater as a result of volatilization and/or biodegradation.

7.4.1.3 *Chlorinated Ethanes*

Chlorinated ethanes, 1,1,1-trichloroethane (1,1,1-TCA), 1,1,2-trichloroethane (1,1,2-TCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethane (1,1-DCA), chloroethane, and ethane were identified as COPCs. 1,1,1-TCA, 1,1,2-TCA and 1,2-DCA, often used as solvents and cleaning agents (HSDB, 2003), are readily biodegraded under the correct conditions, as discussed in Section 9. 1,1,1-TCA biodegrades to 1,1-DCA which in turn can be biodegraded to chloroethane. 1,2-DCA may also biodegrade to chloroethane. Chloroethane is not likely to biodegrade but rather undergo abiotic transformation to acetate (EPA, 1998). Chlorinated ethanes are expected to be relatively mobile in the environment but will also likely be lost from soil and groundwater as a result of volatilization and/or biodegradation.

7.4.1.4 *Chlorinated Methanes*

Chlorinated methanes, carbon tetrachloride, chloroform, methylene chloride, and chloromethane, were identified as COPCs. Chlorinated methanes are solvents used as pesticides and cleaning agents (HSDB, 2003) commonly used in laboratories, and thus, are common laboratory contaminants (EPA, 1989). Carbon tetrachloride can be reductively dechlorinated to chloroform which biodegrades into methylene chloride, which in turn can be biodegraded to chloromethane (Wiedemeier et al., 1999). Chlorinated methanes are expected to be relatively mobile in the environment but will also likely be lost from soil and groundwater as a result of volatilization and/or biodegradation.

7.4.1.5 *Ketones*

Three ketones, acetone, methyl isobutyl ketone (MIBK) and 2-hexanone, were identified as COPCs. Ketones are typically used as solvents and are common laboratory contaminants (EPA, 1989). Acetone and MIBK also occur naturally as a metabolic byproduct of plants and animals. In addition, acetone can be released into the atmosphere by volcanoes and forest fires. Ketones are expected to exhibit very high mobility in the environment and are also expected to volatize or biodegrade rapidly (HSDB, 2003).

7.4.1.6 *Chlorinated Volatile Aromatic VOCs*

Several aromatic VOCs, including 1,2,4-trimethybenzene, 1,3,5-trimethylbenzene, cumene, n-propylbenzene, sec-butylbenzene, n-hexane, n-butylbenzene and p-isopropyltoluene, were identified as COPCs. These COPCs are used as solvents and paint thinners and are often found in light end petroleum products. These COPCs are expected to exhibit low mobility in soil and groundwater and may biodegrade slowly under aerobic conditions (HSDB, 2003).

7.4.1.7 *Other VOCs*

1,1,2-Trichlorotrifluoroethane, dichlorodifluoromethane, carbon disulfide and styrene have been identified as COPCs. 1,1,2-Trichlorotrifluoroethane and dichlorodifluoromethane are chlorofluorocarbons (CFCs) that were scheduled for production phase-out in the U.S. in 1987 as part of the Montreal Protocol. These compounds were formerly used as pesticides, dry cleaning solvents, propellants, and refrigerants. CFCs are expected to exhibit moderate mobility in soil and groundwater and are not expected to biodegrade (HSDB, 2003).

Carbon disulfide is used as an insecticide, in paints, varnishes and enamels and is a chemical intermediate for the manufacture of many chemicals. Carbon disulfide is expected to exhibit moderate mobility in the environment (HSDB, 2003).

Styrene is used in plastic and resins, as a dental filling component, as a component in agricultural products, and has also been found in combustion engine exhaust, waste incineration exhaust and cigarette smoke. Styrene also occurs naturally in sap of some trees. Styrene is expected to exhibit low mobility in the environment and is likely to rapidly biodegrade (HSDB, 2003).

7.4.2 SVOCs

7.4.2.1 *Polycyclic Aromatic Hydrocarbons (PAHs)*

A number of PAHs , including 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,I)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene and pyrene, were identified as COPCs. PAHs are a group of chemicals that are ubiquitous in the environment and are formed during the incomplete burning of coal, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. PAHs occur in the environment both naturally and as a result of anthropogenic releases of petroleum products, and are often divided into two groups, light (LPAHs) and heavy (HPAHs), based on the size of the compound. LPAHs are considered to be moderately mobile in the environment and are also readily biodegradable, similar to BTEX compounds, while HPAHs are typically fairly immobile in the environment because of their low water solubilities, low volatilization potential, and strong tendencies to adsorb to soil. Biodegradation is the primary natural mechanism of reduction of HPAH concentrations in soil (HSDB, 2003).

7.4.2.2 *Phenols*

Phenolic COPCs, including phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, and pentachlorophenol, have a wide variety of industrial uses including use as disinfectants and solvents. Phenolic compounds are generally used as disinfectants and fungicides while pentachlorophenol, in particular, has been used to prevent fungal decay in wood products and as a defoliant. 2,4-Dimethylphenol and 2- and 4-methylphenols are also used as solvents in the manufacture of resins and paints. Phenolic compounds typically exhibit low mobility in the environment due to low water solubilities, low volatilization potential, and strong tendencies to adsorb to soil (HSDB, 2003).

7.4.2.3 *Chlorinated Semi-Volatile Aromatics*

1,2,4-Trichlorobenzene, 1,2-dichlorobenzene and 1,4-dichlorobenzene are used as used as degreasing agents, insecticides, herbicides, and wood preservatives. 1,4-Dichlorobenzene is also used as a deodorant for restrooms while 1,2,4-trichlorobenzene is found in dyes and transformer oil (HSDB, 2003). These COPCs are expected to exhibit low mobility in soil and groundwater and may be destroyed through slow biodegrade or abiotic degradation (HSDB, 2003).

7.4.2.4 *Phthalates*

Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were identified as COPCs. Phthalates were formerly used as pesticides and are currently used as plasticizers and ink solvents, and are common laboratory contaminants. Phthalates tend to exhibit low mobility in the environment due to low water solubilities, low volatilization potential, and strong tendencies to adsorb to soil (HSDB, 2003).

7.4.2.5 *Other SVOCs*

Benzoic acid, carbazole, dibenzofuran, and 1,4-dioxane were identified as COPCs. The COPC 1,4-dioxane is typically associated with the presence of 1,1,1-TCA, as it is often used as a stabilizing agent in products formulated with 1,1,1-TCA. The use of 1,4-dioxane as a solvent and in paint and varnish strippers has also been reported (EPA, 2003a). When present in groundwater, 1,4-dioxane migrates conservatively, with little retardation, sorption, or biodegradation likely to occur.

Formed in combustion processes, benzoic acid is found in automobile exhaust, refuse combustion, and tobacco smoke and is also widely distributed in nature and naturally occurs in food such as berries. Benzoic acid exhibits relatively high mobility in the environment but is also expected to biodegrade rapidly (HSDB, 2003).

Dibenzofuran is a carrier for dyeing and printing textiles (combined with methylnaphthalenes) and is used in the manufacture of dyes and plastics. Dibenzofuran is expected to exhibit low to no mobility in soil, and if detected in groundwater, is likely associated with dissolved organic matter. This COPC has been reported to biodegrade although biodegradation rates under anaerobic conditions are likely to be slow (HSDB, 2003).

Carbazole, a compound used in the manufacture of dyes, insecticides, and detergents. This COPC is likely to exhibit moderate to low mobility in soil and groundwater and has been reported to biodegrade (HSDB, 2003).

7.4.3 Polychlorinated Biphenyls

PCBs are mixtures of synthetic organic chemicals used in hydraulic fluid and in electrical transformers. PCBs have not been produced commercially in the United States since October of 1977 (HSDB, 2003). In the environment, PCBs occur as mixtures of congeners with compositions differing from the commercial mixtures as the composition of PCB mixtures changes over time after release to the environment. PCBs typically exhibit extremely low mobility in the environment due to their low water solubility and high affinity for soil. In general, PCBs are persistent in the environment and the persistence of PCBs increases with an increase in the degree of chlorination. Lesser chlorinated PCBs, such as Aroclor 1221 and 1232, biodegrade relatively rapidly while moderately chlorinated PCBs, Aroclors 1016, 1242 and 1248 biodegrade slowly, and higher chlorinated PCBs, Aroclors 1254 and 1260, may be resistant to biodegradation (HSDB, 2003). Low concentrations of particularly persistent organic compounds, such as PCBs, can be found in surface soil and sediment throughout much of the state due to global use of these hazardous substances; the low concentrations found throughout the state are considered by Ecology to be natural background concentrations (WAC 173-340-200).

7.4.4 Total Petroleum Hydrocarbons

Total petroleum hydrocarbons, more commonly known as TPH, is a complex mixture of hundreds of chemicals, each with individual fate and transport characteristics. Constituents that fall within the gasoline range of TPH are typically fairly mobile in the environment while those associated with the lube oil range of TPH are less mobile. The biodegradation of petroleum hydrocarbons has been reported for numerous sites under a wide variety of conditions, indicating that it is likely to occur at most sites (Wiedemeier et al., 1999).

7.4.5 Inorganic Constituents

Several inorganic constituents were identified as COPCs. The source of many of these constituents is uncertain as they may occur in the environment as a result of natural background conditions, changes in geochemical conditions or a release. The geochemical factors that control the distribution of several of the redox-sensitive constituents (As, Ni, etc.) in groundwater in the RI study area are discussed in more detail in Section 9.

7.4.5.1 *Arsenic*

Naturally elevated concentrations of arsenic have been detected in both soil and groundwater throughout western Washington (San Juan, 1994; DOH, 1999). Reports of groundwater arsenic concentrations exceeding 10 ppb in public water supply systems throughout Western Washington are numerous (DOH, 1999), as presented in Figure 7-5. However, the source of the elevated arsenic has not been determined.

Several potential explanations of the elevated arsenic concentrations observed in the Western Washington area have been offered. These include:

- Arsenic deposition from the former ASARCO Tacoma smelter located in Ruston (KCEHD, 2000);

- Widespread use of arsenical pesticides under agriculture throughout the region;

- Arsenic-rich minerals in the sediments that form the soils and aquifer materials throughout the region (Welch et al., 2000); and

- Arsenic mobilization and transport from Tertiary bedrock in the foothills of the Cascade Mountains, as has been observed in the area of Granite Falls, Washington (Troost, 2002).

In groundwater, arsenic typically exists as oxyanions with oxidation states of III (arsenite) and V (arsenate). The dominance of arsenite ($H_nAsO_3^{n-3}$) or arsenate ($H_nAsO_4^{n-3}$) is strongly dependent upon the pH and Eh of the groundwater (Vance, 1995). The reduction of arsenate to arsenite can promote arsenic mobility because arsenite is generally less strongly adsorbed to aquifer materials than is arsenate. Arsenic mobility in groundwater is usually controlled by redox conditions, pH, biological activity, and adsorption/desorption reactions and increases with increasing pH and more reducing conditions (Hinkle and Polette, 1998).

7.4.5.2 *Barium*

Barium occurs naturally in the earth's crust, particularly in igneous rocks, sandstone, shale, and coal, and is typically released to the environment through the weathering of rocks and minerals (ATSDR, 1992). Barium is generally soluble at all pH and redox conditions, but will form the insoluble barium sulfate or barium phosphate in the presence of sulfate or phosphate. Barium is the main constituent of barium chromate, also known as Yellow 31, a pigment in paint (HSDB, 2003)

7.4.5.3 *Cadmium*

Cadmium is often found in spent solutions from plating operations and phosphate fertilizers as well as naturally in the earth's crust. Cadmium is more mobile in aquatic environments than most other heavy metals and can exist in groundwater as the hydrated ion, or as ionic complexes with other inorganic or organic substances. Because cadmium exists only in the +2 oxidation state in water, aqueous cadmium is not strongly influenced by the oxidizing or reducing potential of the water. However, under reducing conditions, cadmium may form cadmium sulfide, which is poorly soluble and tends to precipitate. Precipitation and sorption to mineral surfaces, hydrous metal oxides, and organic materials are the most important processes for removal of cadmium from solution. Cadmium concentration in water is inversely related to the pH and the concentration of organic material in the water (ATSDR, 1999a).

7.4.5.4 *Chromium*

Chromium is found naturally at elevated levels in volcanically derived minerals (ATSDR, 2000), such as those which form the aquifer matrix in the RI study area. Chromium is used in the manufacture of steel and nonferrous alloys, metal-plating, refractory materials, cement, asphalt roofing, chromate preservatives and chromate pigments for paints (HSDB, 2003). Chromium is typically present as the highly toxic Cr (IV) under strongly oxidizing conditions and the much less toxic Cr(III) under moderately oxidizing to reducing conditions (Lyman et al, 1987). Consequently, the chromium detected in groundwater samples collected as part of this RI was likely all present as Cr(III). The solubility of Cr (III) is controlled by precipitation as hydroxides and oxides, as well as sorption (Lyman et al., 1987).

7.4.5.5 *Copper*

Copper, which occurs naturally in soils, is used in agricultural products such as insecticides, fungicides, herbicides, and wood preservatives; anti-fouling paints; catalysts; corrosion inhibitors; electrolysis and electroplating processes; electronics; fabric and textiles; flame-proofing materials; fuel additives; glass and ceramics (HSDB, 2003). Copper exists in three oxidation states: +2, +1, and 0 and as it has a strong affinity for soil, typically exhibits low mobility in the environment, except at low pHs (<4) (ATSDR, 2002).

7.4.5.6 *Cyanide*

Cyanide is found naturally in the fruits, seeds, roots, and leaves of numerous plants, and is used in metal-finishing, herbicides (ATSDR, 1997a). Cyanide occurs most commonly as hydrogen cyanide in water, although it can also occur as the cyanide ion, alkali and alkaline earth metal cyanides (potassium cyanide, sodium cyanide, calcium cyanide), relatively stable metallocyanide complexes (ferricyanide complex $[Fe(CN)6]^{-3}$), moderately stable metallocyanide complexes (complex nickel and copper cyanide), or easily decomposable metallocyanide complexes (zinc cyanide $[Zn(CN)_2]$, cadmium cyanide $[Cd(CN)_2]$). Hydrogen cyanide and the alkali metal cyanides are not likely to be strongly sorbed onto sediments and suspended solids because of their high water solubilities. Mobility is lowest in soils with low pH and high concentrations of free iron oxides, positively charged particles, and clays. Cyanide concentrations can be reduced as a result of biodegradation (ATSDR, 1997a).

7.4.5.7 *Lead*

Lead, which occurs naturally in the environment, was also used as a paint and gasoline additive until the early 1990's (ATSDR, 1999b). Elevated lead concentrations in soil in the Puget Sound area have been associated with historical emissions from the ASARCO Smelter in Tacoma. The mobility of lead in groundwater is limited by the formation of insoluble lead sulfates, carbonates, hydroxides, and phosphates (ATSDR, 1999b).

7.4.5.8 *Mercury*

Mercury is used in chloralkali production, mining operations and ore processing, metallurgy and electroplating, chemical manufacturing, ink manufacturing, pulp and paper mills, leather tanning, pharmaceutical production, and textile manufacture and occurs naturally in the environment. The element has three valence states and is found in the environment in the metallic form and in the form of various inorganic and organic complexes. In soils and surface waters, mercury can exist in the mercuric (Hg+2) and mercurous (Hg+1) states as a number of complex ions with varying water solubilities. Mercury tends to exist in volatile forms (e.g., metallic mercury and dimethylmercury) at low pHs (<3) and in solid forms at more moderate pHs (>4). Hg+2 can be microbially reduced to the more volatile elemental mercury. Adsorption of mercury in soil is decreased with increasing pH and/or chloride ion concentrations and leaching is a relatively insignificant transport process in soils. The most common organic form of mercury, methylmercury, is soluble and mobile in the environment (ATSDR, 1999c).

7.4.5.9 *Nickel*

Nickel, found naturally in soils, is used in the production of steel and various alloys, specialty ceramics, magnets and electronic circuitry, electroplating, and in various pigments used in paints (HSDB, 2003). The speciation and physicochemical state of nickel is important in considering its behavior in the environment and availability to biota. Nickel will strongly sorb to mineral surfaces, such as iron and manganese oxides, but its mobility increases with decreasing pH (ATSDR, 1997b).

7.4.5.10 *Selenium*

Selenium is released to the environment in exhaust from coal and oil combustion facilities, selenium refining factories, base metal smelting and refining factories, mining and milling operations, and semiconductor manufacturers as well as from plants, bacteria, weathering processes, and volcanic activity. The primary factor determining the fate of selenium in the environment is its oxidation state. Selenium is stable in four valence states (-2, 0, +4, and +6) and forms chemical compounds similar to those of sulfur. The heavy metal selenides (-2) are insoluble in water, as is elemental selenium. The inorganic alkali selenites (+4) and selenates (+6) are soluble in water. In general, the more soluble and mobile forms of selenium (e.g., selenite and selenate) dominate under aerobic and alkaline conditions. Under reducing conditions, selenium will precipitate from solution as elemental selenium. Once formed, elemental selenium is stable over a wide range of pH values and a range of mildly oxidizing to reducing conditions (ATSDR, 2001).

7.4.5.11 *Silver*

Silver is a rare element used in batteries, electroplating, and photography (HSDB, 2003). In water, silver is typically found as the monovalent ion in the form of sulfate, bicarbonate, or sulfate salts; as part of more complex ions with chlorides and sulfates; and adsorbed to particulate matter (ATSDR, 1990).

7.4.5.12 *Vanadium*

Vanadium is widely distributed at low concentrations in the earth's crust. Elemental vanadium does not occur in nature, but its compounds exist in over 50 different mineral ores and in association with fossil fuels. It has six oxidation states (1-, 0, 2+, 3+, 4+, and 5+) of which 3+(less soluble), 4+, and 5+(more soluble) are the most common. Vanadium can precipitate from solution with calcium and copper, as well as organic matter and ferric oxide (ATSDR, 1992).

7.4.5.13 *Zinc*

Zinc, a micronutrient present naturally in soils, is used in paints formulated for priming metals (HSDB, 2003). Zinc occurs in the environment mainly in the +2 oxidation state and is one of the most mobile of the heavy metals. It can form soluble complexes with a number of constituents, including organic matter and sulfate (Lyman et al, 1987). Sorption and the formation of insoluble zinc sulfide in anaerobic environments limit the mobility of zinc in the environment (ATSDR, 1994).

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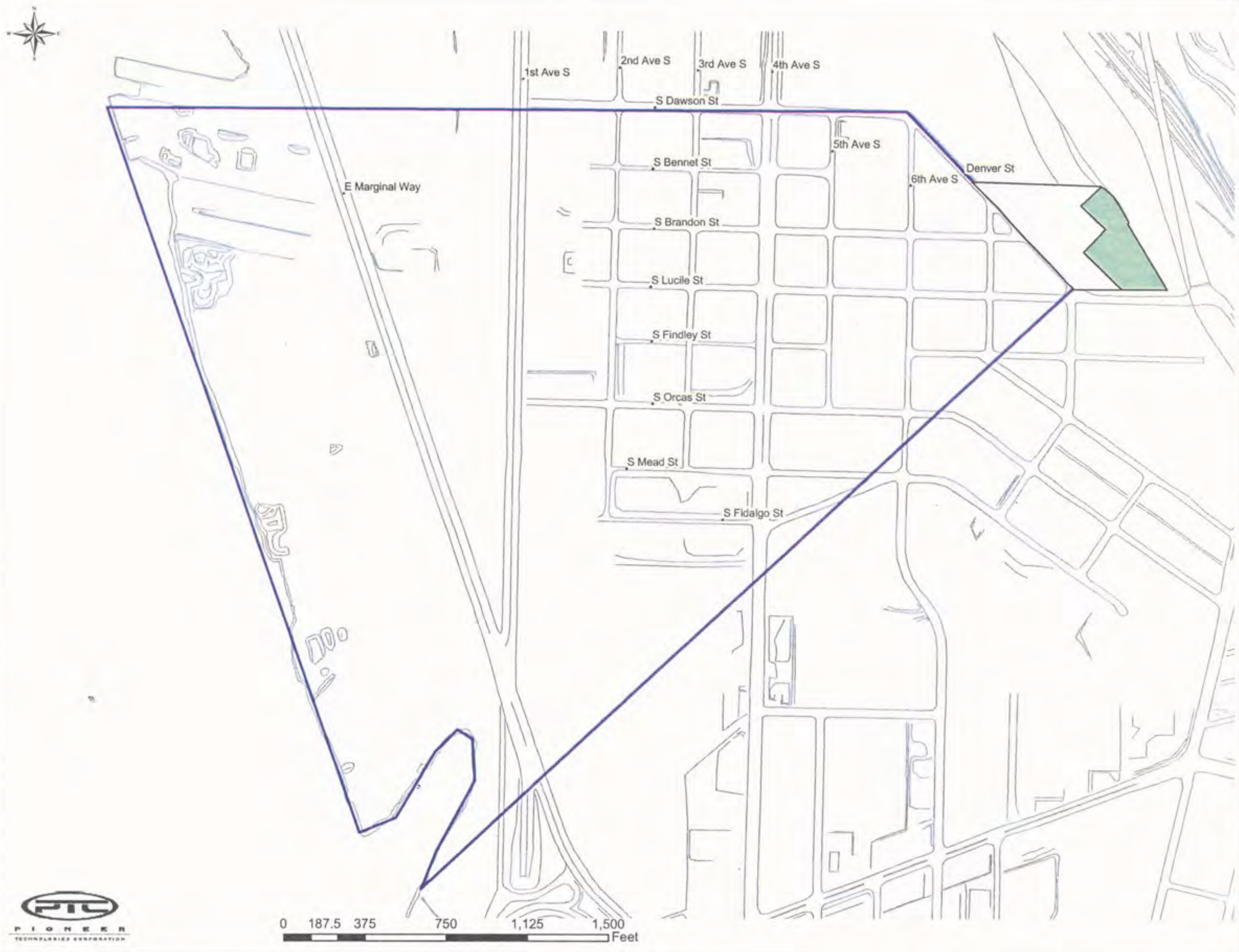
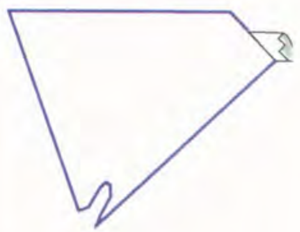


Legend

— Roads
🟩 Area 1
☐ Area 2
☐ Area 3



Notes

- Areas 1, 2 and 3 Were Designated in the Draft Risk Assessment PSC 2001.

RI Study Area Evaluation Units for the PSC Georgetown Facility Remedial Investigation

Figure 7-1

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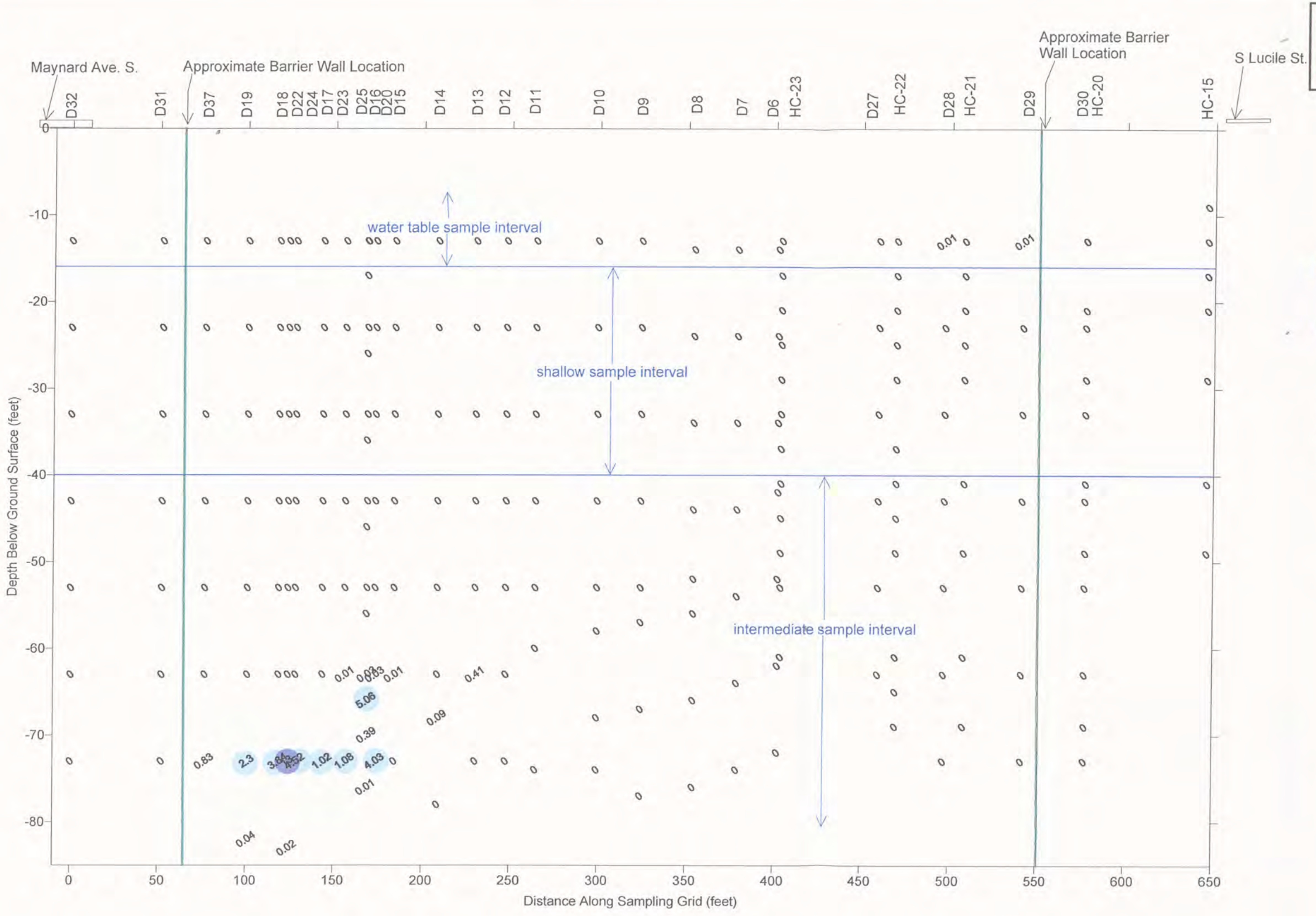


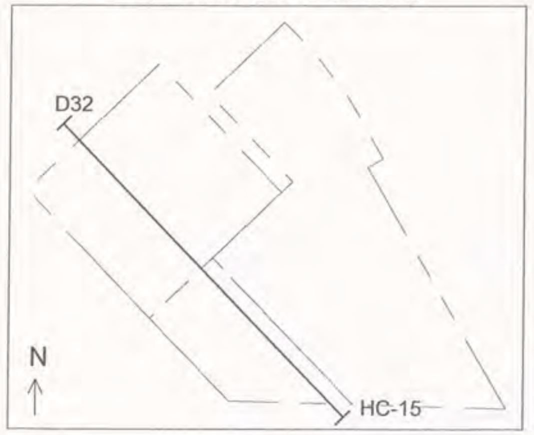
Figure 7-2
Potential Location of
DNAPL in the Subsurface
PSC Georgetown Facility

● TCE Concentrations as a Percent of TCE Solubility >1

● TCE Concentrations as a Percent of TCE Solubility >10

Note:
The presence of DNAPL may be indicated by dissolved concentrations greater than or equal to 1% of the solubility of the constitiuent.

Location of Cross-Section



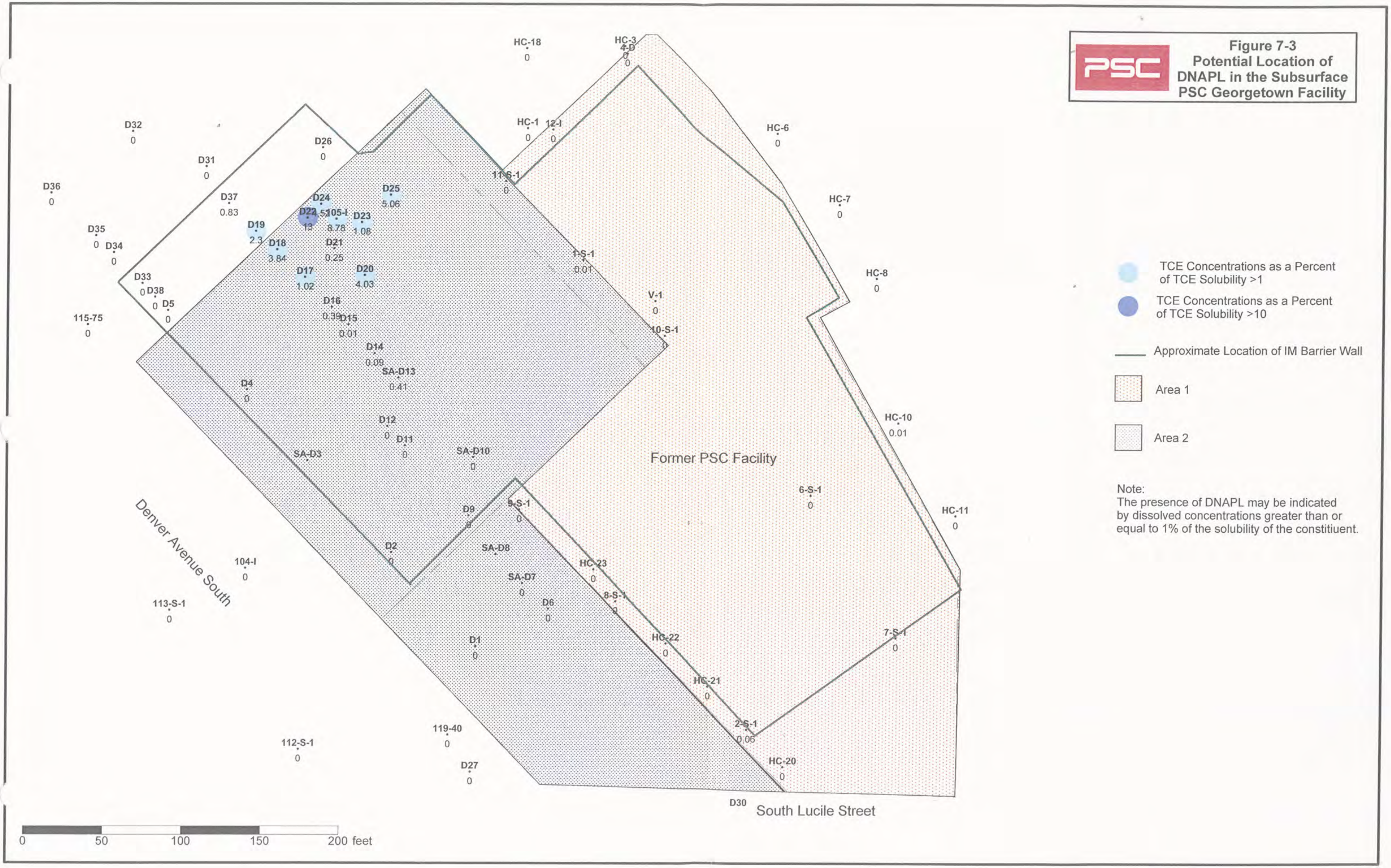
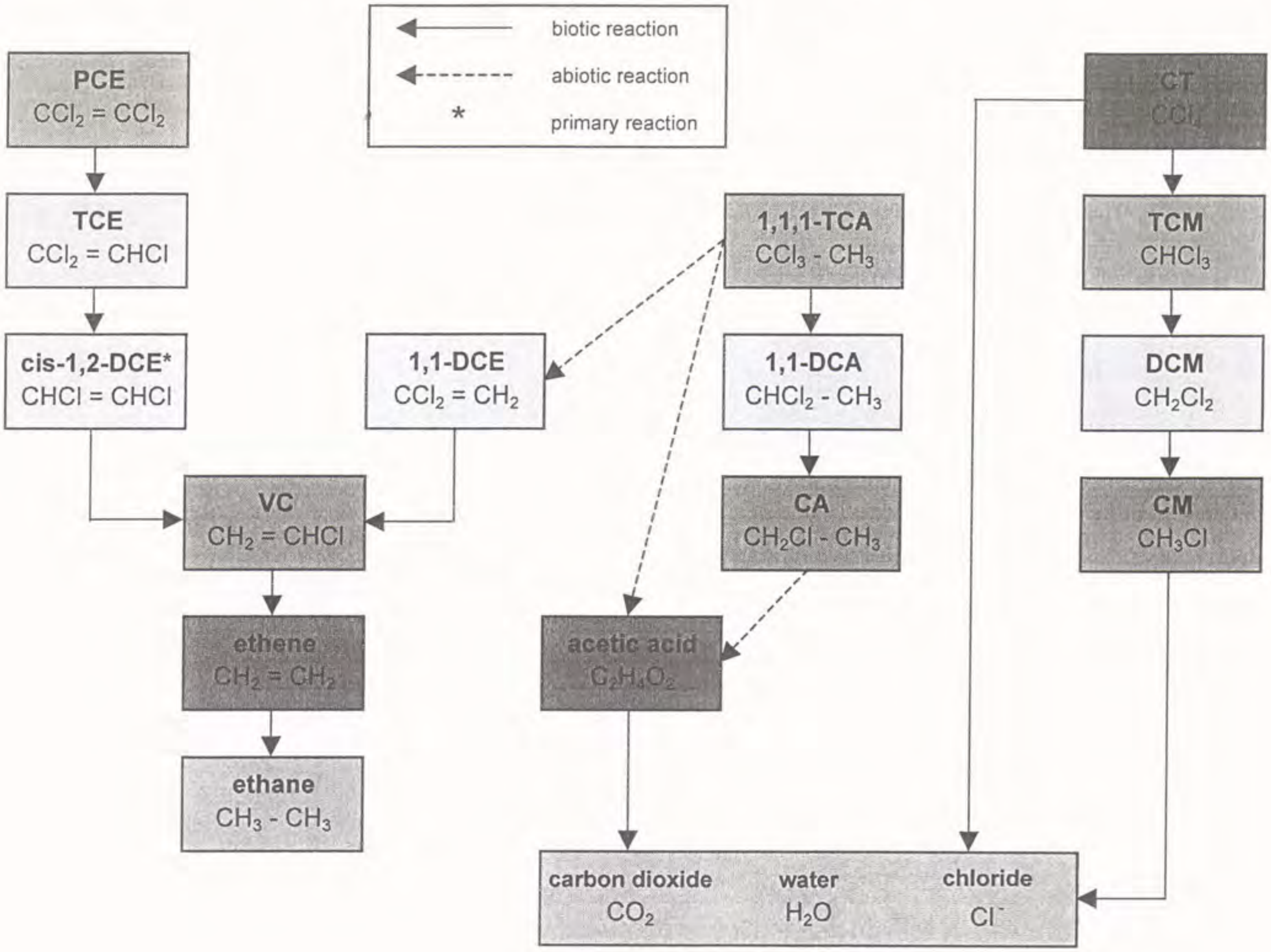


Figure 7-3
Potential Location of
DNAPL in the Subsurface
PSC Georgetown Facility

- ● TCE Concentrations as a Percent of TCE Solubility >1
- ● TCE Concentrations as a Percent of TCE Solubility >10
- — Approximate Location of IM Barrier Wall
- ▨ Area 1
- ▨ Area 2

Note:
The presence of DNAPL may be indicated by dissolved concentrations greater than or equal to 1% of the solubility of the constituent.

Figure 7-4
Abiotic and Biotic Transformation Pathways for Selected Chlorinated Solvents
PSC Georgetown Facility Remedial Investigation

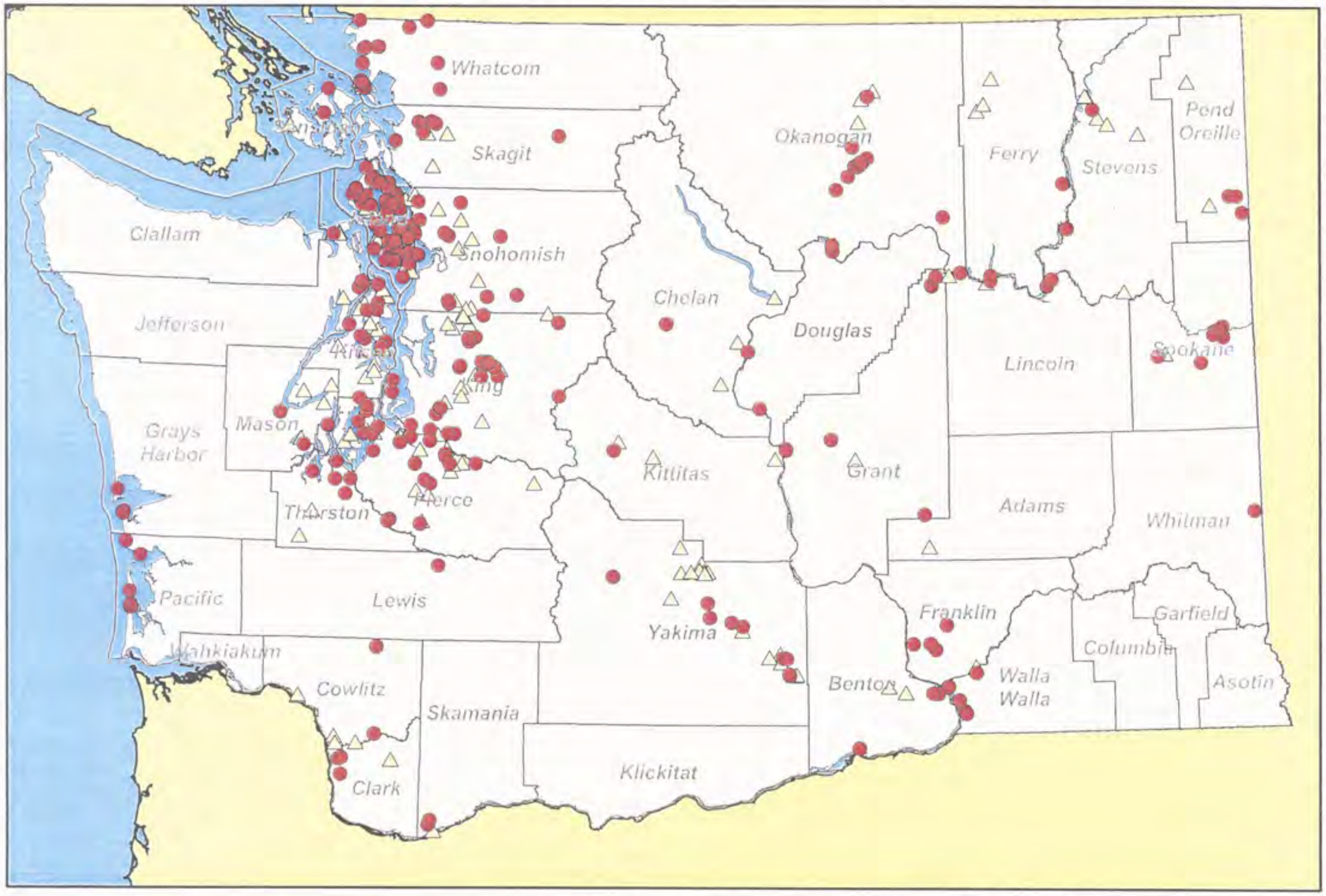


(Adapted from Weidemeier et al, 1999; after McCarty and Semprini, 1994; after Vogel et al, 1987)

Figure 7-5

Arsenic Detections in Washington Public Water Supplies

Sources At or Above Arsenic Drinking Water Standard of 10 ppb



● Group A Systems – Water Systems that meet the federal definition of a public water system: those that regularly serve 15 or more residential connections or 25 or more persons, 60 or more days per year. WAC 246-290-020

△ Group B Systems – Water systems usually serving 2-14 connections and less than 25 persons or more than 25 but for fewer than 60 days per year. WAC 246-291-010. Group B systems are not subject to the revised MCL for arsenic.

Disclaimer
The Washington State Department of Health (DOH) does not warrant the accuracy, reliability or timeliness of any information published on this map and assumes no responsibility for errors in the content or the information provided. Persons or entities that rely on any information obtained from this map do so at their own risk.

Contact Information
Trace Warner, Source Monitoring Coordinator
Division of Drinking Water
Washington State Department of Health
P.O. Box 47822
Olympia, WA 98504-7822
Voice: (360) 236-3097
E-mail: trace.warner@doh.wa.gov

Overview

This map shows Washington Group A & B public water sources that have detected arsenic in their drinking water at or above the recently adopted drinking water Maximum Contaminant Level (MCL) standard for arsenic.

EPA recently announced a new rule that protects public health by strengthening the drinking water standard for arsenic, changing the federal drinking standard from 50 parts per billion (ppb) to 10 ppb. The new, more stringent standard addresses long-term health effects of exposure to low levels of arsenic in drinking water, including cancers and cardiovascular diseases.

The Department of Health supports this important public health protection measure, and will work with water utilities and other stakeholders in our state during the next few years to ensure drinking water delivered by the public water supplies meets this new standard.

In Washington, the new standard may require as many as 240 Group A public water systems to take action addressing arsenic in their sources of drinking water.

This new rule culminates years of debate about protecting the public's health from arsenic in drinking water. It is expected to be among the most costly of new EPA rules to implement, requiring substantial investment by communities with arsenic problems as well as regulatory oversight by the state Department of Health.

Data Criteria

Values illustrated exceed 10 PPB and were selected from samples taken between January 1st, 1993 and April 1st, 2003. Emergency and inactive sources are excluded.

Washington State Department of Health

Environmental Health Programs
Division of Drinking Water
Last Modified on May 2, 2003
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Table 7-1
Summary of Chemicals of Potential Concern (COPCs)
PSC Georgetown Facility

	Soil	Groundwater		Indoor Air
		Human Health	Ecological	
Volatile Organic Compounds				
Chlorinated Ethenes				
Tetrachloroethylene	x	x	x	x
Trichloroethylene	x	x	x	x
1,1-Dichloroethylene	x	x	x	
cis-1,2-Dichloroethylene	x	x	x	
trans-1,2-Dichloroethylene	x	x	x	
Vinyl chloride	x	x	x	x
Ethene		x	x	
Chlorinated Ethanes				
1,1,1-Trichloroethane	x	x	x	
1,1,2-Trichloroethane	x			
1,1-Dichloroethane	x	x	x	
1,2-Dichloroethane	x	x	x	x
1,4-Dioxane		x		
Chloroethane		x		
Ethane		x	x	
Chlorinated Methanes				
Carbon Tetrachloride				x
Methylene chloride	x	x		x
Chloroform	x	x	x	x
Chloromethane				x
BTEX				
Benzene	x	x		x
Ethylbenzene	x	x	x	
Toluene	x	x		
Xylene (total)	x	x	x	
Ketones				
2-Hexanone	x	x	x	x
Acetone	x			
Methyl isobutyl ketone (MIBK)	x		x	
Chlorinated Volatile Aromatics				
1,2,4-Trimethylbenzene	x	x	x	x
1,3,5-Trimethylbenzene	x	x	x	x
Cumene	x	x	x	
n-Butylbenzene	x	x	x	
n-Hexane		x	x	
p-Isopropyltoluene	x	x		
Propylbenzene	x	x	x	
sec-Butylbenzene	x	x	x	
Other VOCs				
1,1,2-Trichlorotrifluoroethane	x	x		
Carbon disulfide			x	
cis-1,3-Dichloropropene				
Dichlorodifluoromethane		x	x	
trans-1,3-Dichloropropene				
Styrene			x	

Table 7-1
Summary of Chemicals of Potential Concern (COPCs)
PSC Georgetown Facility

	Soil	Groundwater		Indoor Air
		Human Health	Ecological	
Semi-volatile Organic Compounds				
Polycyclic Aromatic Hydrocarbons (PAHs)				
1-Methyl naphthalene		x	x	
2-Methylnaphthalene	x	x	x	
Acenaphthene	x			
Benzo(a)anthracene	x			
Benzo(a)pyrene	x			
Benzo(b)fluoranthene	x			
Benzo(g,h,i)perylene	x			
Benzo(k)fluoranthene	x			
Chrysene	x			
Dibenzo(a,h)anthracene	x			
Fluoranthene	x			
Fluorene	x			
Indeno(1,2,3-c,d)pyrene	x			
Naphthalene	x	x	x	
Phenanthrene	x			
Pyrene	x			
Phenols				
2,4-Dimethylphenol	x	x	x	
2-Methylphenol	x		x	
4-Methylphenol	x	x	x	
Methylphenol		x	x	
Pentachlorophenol	x	x	x	
Phenol	x		x	
Chlorinated Semi- Volatile Aromatics				
1,2,4-Trichlorobenzene	x			
1,2-Dichlorobenzene	x		x	
1,4-Dichlorobenzene				x
Phthalates				
Bis(2-ethylhexyl) phthalate	x	x	x	
Di-n-butylphthalate	x			
Other SVOCs				
Benzoic acid			x	
Carbazole	x			
Dibenzofuran	x			
1,4-Dioxane		x	x	
PCBS				
Aroclor 1016	x	x	x	
Aroclor 1232		x	x	
Aroclor 1254	x			
Aroclor 1260	x			
Inorganic Constituents				
Arsenic	x	x		
Barium	x	x	x	
Cadmium	x			
Chromium	x	x	x	
Copper	x	x	x	
Cyanide	x	x	x	
Hexavalent Chromium		x	x	
Lead	x	x	x	
Manganese		x	x	
Mercury	x			
Nickel	x	x	x	
Selenium		x	x	

Table 7-1
Summary of Chemicals of Potential Concern (COPCs)
PSC Georgetown Facility

	Soil	Groundwater		Indoor Air
		Human Health	Ecological	
Silver	x			
Vanadium		x	x	
Zinc	x	x	x	
Total Petroleum Hydrocarbons				
C10-C12 (EPH) Aromatics		x		
C8-C10 (EPH) Aliphatics		x		
C8-C10 (EPH) Aromatics		x		
C8-C10 (VPH) Aromatics		x		
Diesel		x		
Gasoline		x		
Lube Oil Hydrocarbons		x		
TotalExtractablePetroleum HC		x		
TotalVolatilePetroleum HC		x		

Notes:

Chemicals of potential concern are identified in the HHERA.

Table 7-2
Summary of Cleanup Levels
PSC Georgetown Facility

	Groundwater Protection of Surface Water (MTCA Fisher)	Industrial Soil	Groundwater Protection of Indoor Air (Residential)	Ecological Groundwater Protection of Surface Water
	Minimum of MTCA Equation 730-1 and 730-2	Minimum of MTCA Equation 745-4 and 745-5	Minimum of MTCA Equation 750 1 / GIVF and 750-2 / GIVF	Ecological SW Screening Level
Compound	ug/L	mg/kg	ug/L	ug/L
1,1,1-trichloroethane	129,629.63	556,521.74	10,949.45	11.00
1,1,2-trichloroethane	25.27	956.94	29.04	1,200.00
1,1,2-trichlorotrifluoroethane	1,440,329.22	43,636,363.64	12,087.59	11,000.00
1,1-dichloroethane	54,012.35	198,757.76	7,515.70	47.00
1,1-dichloroethylene	23,148.15	99,378.88	532.06	25.00
1,1-dichloropropene				0.06
1,2,4-trichlorobenzene	227.42	14,545.45	27,379.23	110.00
1,2,4-trimethylbenzene	1,507.32	72,727.27	130.14	400.00
1,2-dichlorobenzene	4,196.64	130,909.09	11,187.98	14.00
1,2-dichloroethane	59.35	599.40	12.88	910.00
1,2-dichloroethene	2,880.66	17,888.20		590.00
1,3,5-trimethylbenzene	1,080.25	72,727.27	97.62	400.00
1,4-dioxane	184.13	2,272.73		0.00
1-methyl Naphthalene				2.10
2,4-dimethylphenol	552.79	13,333.33		131.00
2-hexanone	45,088.57	58,181.82	6,089.84	99.00
2-methylnaphthalene	2,222.22	13,090.91		2.10
2-methylphenol	20,576.13	33,333.33		13.00
4-methylphenol	2,090.80	3,333.33		1,000.00
Acenaphthene	642.79	40,000.00		1,000.00
Acetone	81,018.52	66,666.67		1,500.00
Aroclor 1016	0.00	46.67	176.47	0.01
Aroclor 1016/1242	0.00	12.50	30.88	0.00
Aroclor 1232	0.00	12.50		0.01
Aroclor 1254	0.00	12.50	13.72	0.00
Aroclor 1260	0.00	12.50	9.05	0.00
Arsenic	0.10	33.33		36.00
Barium	286.70	93,333.33		4.00
Benzene	22.66	1,355.17	9.60	130.00
Benzo(a)anthracene	0.30	102.74		0.03
Benzo(a)pyrene	0.03	10.27		0.01
Benzo(b)fluoranthene	0.30	102.74	78.54	0.00
Benzo(ghi)perylene				0.00
Benzo(k)fluoranthene	0.30	102.74		0.00
Bis(2-ethylhexyl) Phthalate	3.56	1,785.71		3.00
C10-c12 (eph) Aromatics		33,333.33		0.00
C8-c10 (eph) Aliphatics		20,000.00		0.00
C8-c10 (eph) Aromatics		33,333.33		0.00
C8-c10 (vph) Aromatics		33,333.33		0.00
Cadmium				0.00
Carbazole	2.16	1,250.00		0.00
Chloroethane	894.00	25,701.43	54,374.42	230,000.00
Chloroform	6,913.58	19,875.78	4.11	28.00
Chromium				10.00
Chrysene	2.96	1,027.40	8,878.83	0.00
Cis-1,2-dichloroethylene	3,200.73	19,875.78	727.08	11,600.00
Copper	2,664.61	49,333.33		3.10
Cumene	1,994.30	145,454.55	749.01	7.30
Cyanide	51,851.85	26,666.67		1.00
Di-n-butyl Phthalate	2,913.03	66,666.67		35.00
Dibenzo(a,h)anthracene	0.07	25.68		0.00
Dibenzofuran				3.70
Dichlorodifluoromethane	56,360.71	290,909.09	63.61	0.00
Diesel				0.00
Ethane				0.00

Table 7-2
Summary of Cleanup Levels
PSC Georgetown Facility

Compound	Groundwater Protection of Surface Water (MTCA Fisher) Minimum of MTCA Equation 730-1 and 730-2 ug/L	Industrial Soil Minimum of MTCA Equation 745-4 and 745-5 mg/kg	Groundwater Protection of Indoor Air (Residential) Minimum of MTCA Equation 750 1 / GIVF and 750-2 / GIVF ug/L	Ecological Groundwater Protection of Surface Water Ecological SW Screening Level ug/L
Ethene				0.00
Ethylbenzene	6,913.58	145,454.55	12,624.04	7.30
Fluoranthene	90.18	26,666.67		6.16
Fluorene	3,456.79	58,181.82		3.90
Gasoline				0.00
Hexavalent Chromium	486.11	4,000.00		10.00
Indeno(1,2,3-cd)pyrene	0.30	102.74		0.00
Lead				2.50
Lube Oil Hydrocarbons				0.00
Manganese	37,835.65	62,266.67		120.00
Mercury			7.90	0.01
Methane				0.00
Methyl Isobutyl Ketone (mibk)	103,703.70	116,363.64	1,043,973.07	170.00
Methylene Chloride	960.22	9,937.89	321.33	2,200.00
Methylphenol				1,650.00
N-butylbenzene	356.37	58,181.82		490.00
N-hexane	777.78	119,254.66		0.58
Naphthalene	4,938.27	29,090.91	591.58	12.00
Nickel	1,103.23	26,666.67		8.20
P-isopropyltoluene			749.01	10,000.00
Pentachlorophenol	4.91	208.33		7.90
Phenanthrene				6.30
Phenol	555,555.56	200,000.00		118.00
Propylbenzene	682.26	14,545.45	268.65	7.30
Pyrene	2,592.59	20,000.00		0.00
Sec-butylbenzene	89.09	14,545.45	231.41	490.00
Silver	25,925.93	6,666.67		1.90
Tetrachloroethylene	0.39	101.01	5.01	98.00
Toluene	48,459.67	290,909.09	4,961.25	9.80
Trans-1,2-dichloroethylene	32,817.63	39,751.55	652.62	11,600.00
Trichloroethylene	1.53	136.36	0.40	47.00
Vinyl Chloride	3.96	53.24	1.28	11,600.00
Xylene (total)	2,729.04	290,909.09	1,442.09	20,000.00
Zinc	16,548.46	400,000.00		81.00

Notes:

ug/L = micrograms per liter = parts per billion (ppb)

ug/kg = micrograms per kilogram = parts per billion (ppb)

8.0 NATURE AND EXTENT OF IMPACTED SOIL

This section describes the results of soil sampling conducted at the facility. Historically, a number of soil investigations have been conducted at the PSC Georgetown facility. Soil samples were collected as part of the RI between 1987 and the present. Most soil samples were collected in Area 1 because the source area of the releases is thought to be in this area. Section 4.0 describes the purpose and methodology of each soil investigation, and Figures 8-1 and 8-2 show the soil sample locations. Soil analytical data for detected constituents are provided in Appendix 8A and summarized on figures in references in the text and in Appendix 8B.

All soil analytical data from samples collected between zero and 15 feet bgs were compared with MTCA Industrial Soil cleanup levels (WAC 173-340-745), as summarized in Table 7-2. These cleanup levels are protective of direct contact with soil under industrial occupational exposure scenarios. Potential exposure to soil at the facility is very limited as the majority of the facility is covered with concrete. The discussion of the nature and extent of soil contamination is limited to those compounds identified as COPCs in the HHERA as summarized in Section 7.0. A description of the characteristics of the COPCs is also presented in Section 7.0.

8.1 *VOCs*

The known nature and extent of VOCs in soil at the facility are discussed in the following subsections. Many of the VOC concentrations observed in samples collected in the North Field are unlikely to be representative of current conditions since most of the sampling was done prior to the installation of the SVE system in 1994. Current VOC concentrations in North Field soil are likely to be lower than those in the samples collected prior to the operation of the SVE system because the system, described in more detail in Section 2.0, has removed 19,051 lbs of contamination.

8.1.1 BTEX

BTEX have been detected at sample locations throughout the facility, as shown in Figure 8-3 for benzene. None of the BTEX compounds were detected in soil at the facility at concentrations exceeding applicable cleanup levels. The highest BTEX concentrations were generally detected in the North Field and in the Process Area at depths between 5 and 7 feet bgs. Elevated BTEX concentrations were detected in soil at the western boundary of both of these areas, suggesting that soil beyond the facility boundary may also contain detectable concentrations of BTEX, but these are not likely to exceed the MTCA cleanup levels. None of the BTEX compounds were detected above cleanup levels in soil samples collected outside the facility. Of the BTEX compounds, toluene was detected at the highest concentrations and benzene was detected at concentrations significantly lower than the other three compounds. Toluene, ethylbenzene, and xylenes concentrations are presented in Figures 8B-1 through 8B-3 in Appendix 8B.

8.1.2 Chlorinated Ethenes

Chlorinated ethene compounds, including PCE , TCE, 1,2-DCE, and vinyl chloride, were detected in soil at sample locations throughout the facility footprint, although the highest concentrations were generally detected in the North Field. However, most of the soil samples from the North Field were collected prior to the implementation of the SVE system and, thus, likely overestimate the current concentrations in soil at the facility. Much lower concentrations were detected in the samples collected after the SVE system began operation. TCE and PCE concentrations in soil were generally higher than the concentrations of total 1,2-DCE and cis-1,2-DCE detected in the same sample. Vinyl chloride and 1,1-DCE were also detected, but in fewer soil samples than TCE and PCE .

PCE

PCE was detected in soil through the facility, as shown in Figure 8-4. The highest PCE concentrations were generally detected in the North Field and in the Process Area at depths between 2 and 7 feet bgs. The concentrations detected at two locations, TB-2 at 5 feet bgs (140 milligrams per kilogram [mg/kg]) and TB-12 at 5 feet bgs (290 mg/kg) exceeded the applicable cleanup level but all other detected concentrations were below the cleanup level. PCE was detected in soil at the western boundary of both of these areas but at concentrations below the applicable cleanup level. All soil samples with PCE concentrations above the cleanup level are within the area of the planned hydraulic barrier wall. PCE was not detected above applicable cleanup levels in soil samples collected outside Area 1.

TCE

TCE was detected in soil throughout the facility as shown in Figure 8-5. The highest TCE concentrations were detected primarily in the North Field at depths between 2 and 10 feet bgs. The concentrations detected at three locations, TB-2 at 5 feet bgs (150 mg/kg), TB-14 at 5 feet bgs (170 mg/kg) and TB-12 at 5 feet bgs (460 mg/kg), exceed the cleanup level. Each of these locations are within the area of the planned hydraulic barrier wall. TCE was detected in soil at the western boundary of the North field, but at concentrations below the cleanup level. TCE was not detected above applicable cleanup levels in soil samples collected outside the facility. The distribution of TCE concentrations in the North Field is similar to that of PCE suggesting that the TCE may be present as either a breakdown product of the PCE release or that the release was a mixture of TCE and PCE. The concentrations of TCE detected at soil sampling location TB-3 were significantly less than those of PCE, suggesting either a lack of biodegradation or a recent PCE release relative to when the sample was collected in 1989.

Cis-1,2-DCE and total 1,2-DCE

Cis-1,2-DCE and total 1,2-DCE were detected in soil throughout the facility, but neither compound was detected at concentrations exceeding applicable cleanup levels. 1,2-DCE was detected in the North Field and Process Area, similar to PCE and following its spatial distribution, but also was detected in the West Field. 1,2-DCE was not detected above applicable MTCA cleanup levels in soil samples collected outside the facility. Cis-1,2-DCE and total 1,2-DCE concentrations detected in soil in Area 1 are presented in Figures 8B-4 and 8B-5 in Appendix 8B.

1,1-DCE

1,1-DCE was detected at only two soil sampling locations at the facility at depths of 5 to 7 feet bgs in the North Field, but at concentrations which do not exceed the applicable cleanup level. 1,1-DCE was not detected above applicable cleanup levels in soil samples collected outside the facility. 1,1-DCE concentrations detected in soil in Area 1 are presented in Figure 8B-6 in Appendix 8B.

Vinyl Chloride

Vinyl chloride was detected sporadically at soil sampling locations at the facility. Vinyl chloride was detected primarily at depths of 10 feet bgs or greater, which might correspond to the saturated zone as groundwater is typically at less than 10 feet bgs in this area. This suggests that the vinyl chloride was present was a result of anaerobic biodegradation of more highly chlorinated compounds such as PCE, TCE, and 1,2-DCE. Vinyl chloride was not detected at concentrations exceeding the cleanup level. Vinyl chloride was not detected above applicable cleanup levels in soil samples collected outside the facility. Vinyl chloride concentrations detected in soil in Area 1 are presented in Figure 8B-7 in Appendix 8B.

8.1.3 Chlorinated Ethanes

Chlorinated ethane compounds, 1,1,1-TCA, 1,1,2-TCA and 1,2-DCA, have been detected at sample locations throughout the facility with the highest chlorinated ethane concentrations detected generally in the North Field at depths between 2 and 7 feet bgs. However, none of the detected concentrations exceeded the applicable cleanup levels. 1,1,1-TCA, 1,1-DCA, and 1,2-DCA concentrations appear to follow the same spatial distribution pattern, as presented in Figure 8-6 for 1,1,1-TCA, indicating that the compounds were either released as a mixture or the release was undergoing biodegradation. In addition, none of the chlorinated ethane compounds were detected above cleanup levels in soil samples collected outside the facility. 1,1,2-TCA, 1,1-DCA and 1,2-DCA concentrations detected in soil in Area 1 are presented in Figures 8B-8, 8B-9 and 8B-10 in Appendix 8B.

8.1.4 Chlorinated Methanes

Chlorinated methane compounds chloroform and methylene chloride have been detected at sample locations throughout the facility. Chloroform was detected at low concentrations sporadically across the facility and at sample locations outside the facility but all concentrations were below the applicable cleanup levels. Methylene chloride was detected at most soil sampling locations at the facility with the highest concentrations detected in the North Field and Process Area at depths between 5 and 7 feet bgs. Methylene chloride was also detected in soil samples collected outside the facility. However, none of the concentrations detected in samples collected at or outside of the facility exceeded the applicable cleanup levels. Chloroform and methylene chloride concentrations detected in soil in Area 1 are presented in Figures 8B-11 and 8B-12 in Appendix 8B.

8.1.5 Ketones

Several ketones have been detected in soil at sample locations throughout the facility. The highest ketone concentrations were generally detected in the North Field at varying depths. The spatial distribution of the detected concentrations of each compound appear to be moderately correlated. The ketones were also detected in soil from sampling locations collected outside the facility. However, none of the concentrations detected in samples collected at or outside of the facility exceeded the applicable cleanup levels. Ketone concentrations detected in soil in Area 1are presented in Figures 8B-13 through 8B-15 in Appendix 8B.

8.1.6 Aromatic VOCs

Several aromatic VOCs (n-propylbenzene, n-butylbenzene, sec-butylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, cumene and p-isopropyltoluene) were detected in soil at sample locations in the North Field. The highest concentrations of all of these compounds were detected in samples located at depths between 4.5 and 7.5 feet bgs. However, none of the concentrations detected in samples collected at the facility exceeded the applicable cleanup levels. None of these compounds were detected in soil at sample locations outside the facility.

Aromatic VOC concentrations detected in soil in Area 1 are presented in Figures 8B-16 through 8B-22 in Appendix 8B.

8.1.7 Other VOCs

1,1,2-Trichlorotrifluoroethane was detected in soil at sample locations across the facility with the highest concentrations detected in the Process Area and the North Field at depths ranging between 5 and 7 feet bgs. However, none of the concentrations detected in samples collected at the facility exceeded the applicable cleanup levels. 1,1,2-Trichlorotrifluoroethane was not detected in soil at sample locations outside the facility. 1,1,2-Trichlorotrifluoroethane concentrations detected in soil in Area 1 are presented in Figure 8B-23 in Appendix 8B.

8.2 *SVOCs*

SVOCs can be divided into several classes of compounds including light and heavy PAHs, phenols, phthalates, and chlorinated aromatics. The known nature and extent of SVOCs in soil at the facility is discussed in the following subsections.

8.2.1 LPAHs

LPAHs, naphthalene, and 2-methylnaphthalene, were detected in soil from sampling locations throughout the facility, in a similar distribution to BTEX compounds. The highest LPAH concentrations were generally detected in the Process Area and the North Field, at depths between 5 and 7 feet bgs but none of the detected concentrations exceeded applicable cleanup levels. LPAHs were also detected at concentrations below cleanup levels in soil from sampling locations outside the facility. LPAHs detected in soil in Area 1 are presented in Figures 8B-24 and 8B-25 in Appendix 8B.

8.2.2 HPAHs

HPAHs , acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, phenanthrene, and pyrene, were detected in soil from sampling locations throughout the facility, as shown in Figure 8-7 for benzo(a)pyrene. The spatial distributions of the HPAHs are strongly correlated with one another as HPAHs are typically found together. The highest HPAH concentrations were generally detected in the North Field and in the Process Area at depths between 2 and 5 feet bgs. Several HPAHs were also detected at low concentrations in soil from sample locations outside the facility. However, none of the concentrations detected in samples collected at or outside the facility exceeded the applicable cleanup levels. HPAHs detected in soil in Area 1 are presented in Figures 8B-26 through 8B-37 in Appendix 8B.

8.2.3 Phenols

Phenolic compounds, 2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, phenol, and pentachlorophenol, were detected in soil from sampling locations throughout the facility as shown in Figure 8-8 for phenol. The highest concentrations of phenolic compounds were generally detected in the western corner of the North Field at depths between 2 and 5 feet bgs but all detected concentrations were below the applicable cleanup levels. Phenol and 2,4-dimethylphenol were detected at higher concentrations than 2- and 4-methylphenol and pentachlorophenol. Phenolic compounds were not detected above soil cleanup levels in soil from sample locations outside the facility. Phenolic compounds detected in soil in Area 1 are presented in Figures 8B-38 through 8B-41 in Appendix 8B.

8.2.4 Chlorinated Aromatics

The chlorinated aromatic compounds 1,2-dichlorobenzene and 1,2,4-trichlorobenzene have been detected in soil at sampling locations across the facility. The majority of the highest concentrations of these compounds were detected in soil in the North Field at depths ranging between 2 and 5 feet bgs but all detected concentrations were below the applicable cleanup levels. 1,2-Dichlorobenzene and 1,2,4-trichlorobenzene were not detected in soil from sample locations outside the facility. Chlorinated aromatics detected in soil in Area 1 are presented in Figures 8B-42 and 8B-43 in Appendix 8B.

8.2.5 Phthalates

Two phthalate compounds, bis(2-ethylhexyl)phthalate and di-n-butylphthalate, were detected in soil sampling locations across the facility. The highest concentrations of phthalates were detected in the western part of the North Field at depths ranging between 2 and 5 feet bgs but all detected concentrations were below the applicable cleanup levels. Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were not detected in soil at concentrations exceeding applicable cleanup levels from sample locations outside the facility. Phthalates detected in soil in Area 1 are presented in Figures 8B-44 and 8B-45 in Appendix 8B.

8.2.6 Other SVOCs

Dibenzofuran was detected at low concentrations in soil at sampling locations through the facility. The highest concentrations of dibenzofuran were detected in the North Field and Processing Area at depths between 2 and 5 feet bgs. No cleanup level is available for dibenzofuran. Dibenzofuran concentrations detected in soil in Area 1 are presented in Figure 8B-46 in Appendix 8B. Carbazole was detected once in soil in the Processing Area below the cleanup level. Carbazole was not detected in soil at sampling locations outside the facility.

8.3 *PCBs*

Aroclor 1016/1242, 1254 and 1260 were detected in soil at sampling locations across the facility as presented in Figures 8-9 for Aroclor 1016/1242. The highest PCB concentrations were generally detected in the former Cyanide and Acid/Alkaline Areas and Former Processing Area in the upper sample interval, at 2 feet bgs, and concentrations appeared to decrease slightly with depth. These areas are within the HCIM barrier wall currently being installed. Aroclor 1016/1242 was detected in soil at sample locations in these areas at concentrations exceeding the cleanup levels. Aroclor 1254 and Aroclor 1016/1242 were detected at concentrations exceeding the applicable cleanup levels in only one sample (HAC-21, 2 feet bgs) in the West Field which is outside the HCIM. These compounds were not detected above cleanup levels in the sample from 7 feet bgs at this location. Aroclor 1260 was not detected in soil at sampling locations at the facility at concentrations exceeding the applicable cleanup level. PCBs were not detected above applicable cleanup levels in soil at sampling locations outside the facility. PCBs detected in soil in Area 1 are presented in Figures 8B-47 and 8B-48 in Appendix 8B.

8.4 *Inorganics*

The nature and extent of inorganic constituents detected in soil at the facility is summarized in this section. Many inorganic constituents can occur naturally in bedrock, sediments, and soils of Washington state due solely to the geologic and hydrogeologic processes that formed these materials (San Juan, 1994). Therefore, concentrations of inorganic constituents detected in soil were compared with cleanup levels and background concentrations developed for the Puget Sound area (San Juan, 1994). Inorganic concentrations detected in soil in Area 1 are presented in Figures 8B-49 through 8B-57 in Appendix 8B.

8.4.1 Arsenic

Arsenic was detected consistently in soil at sampling locations across the facility, as shown in Figure 8-10. Arsenic concentrations detected in soil at the facility ranged between 0.089 mg/kg and 14 mg/kg (1-D, 89 feet bgs). The highest concentrations were detected in several samples collected at depth in northwest corner of the North Field. Concentrations appear to increase with depth suggesting that the detected arsenic may be naturally occurring. Arsenic concentrations reported for the Puget Sound area ranged between 1.45 mg/kg and 17.17 mg/kg with a calculated background value of 7.3 mg/kg (San Juan, 1994). No detected concentrations of arsenic exceeded the applicable cleanup level.

8.4.2 Barium

Barium was detected consistently in soil at sampling locations across the facility. Barium concentrations appeared to decrease slightly with depth although the number of nested sampling locations was limited. Elevated barium concentrations were detected in soil at all depths sampled in the North Field but the highest concentration was detected in the Processing Area at a depth of 2 feet bgs (HAC-08, 880 mg/kg). No detected concentrations of barium exceeded the applicable cleanup level.

8.4.3 Cadmium

Cadmium was detected sporadically in soil at sampling locations across the facility at concentrations ranging between 0.298 mg/kg and 7.7 mg/kg (12-I, 34 feet bgs) with more consistent detections in the western portion of the North Field. There was no apparent trend in detected concentration with depth. Cadmium concentrations reported for the Puget Sound area ranged between 0.1 mg/kg and 5.0 mg/kg with a calculated background value of 0.8 mg/kg (San Juan, 1994). There is no cleanup level for cadmium.

8.4.4 Chromium

Chromium was detected fairly consistently in soil at sampling locations across the facility at concentrations ranging between 5 mg/kg and 257 mg/kg with the highest concentrations detected at the facility were in the North Field at depths ranging between 2 and 5 feet bgs. Concentrations appeared to decrease with depth. Chromium concentrations reported for the Puget Sound area ranged between 12 mg/kg and 235 mg/kg with a calculated background value of 48.2 mg/kg (San Juan, 1994). There is no cleanup level for chromium.

8.4.5 Copper

Copper was detected fairly consistently in soil at sampling locations across the facility at concentrations ranging between 5 mg/kg and 230 mg/kg with the highest concentrations detected at the facility in the North Field at depth. Copper concentrations reported for the Puget Sound area ranged between 4 mg/kg and 243.5 mg/kg with a calculated background value of 36.4 mg/kg (San Juan, 1994). No detected concentrations of barium exceeded the applicable cleanup level.

8.4.6 Cyanide

Cyanide was detected sporadically in soil at sampling locations across the facility at concentrations ranging between 1 mg/kg and 25 mg/kg with the highest concentrations detected in the North Field and the West Field in the top 5 feet of soil. Cyanide was not detected at concentrations exceeding the applicable cleanup level.

8.4.7 Lead

Lead was detected sporadically in soil at sampling locations across the facility at concentrations ranging between 1 mg/kg and 1,900 mg/kg (TB-4, 2 feet bgs) with the highest concentrations in the uppermost sampling interval. Lead concentrations reported for the Puget Sound area ranged between 4.65 mg/kg and 29.6 mg/kg with a calculated background value of 16.8 mg/kg (San Juan, 1994). There is no applicable cleanup level for lead[1].

8.4.8 Mercury

Mercury was detected sporadically in soil at sampling locations across the facility at concentrations ranging between 0.02 mg/kg and 2.4 mg/kg (TB-9, 2 feet bgs) with the highest concentrations generally in the uppermost sample interval. Mercury concentrations reported for the Puget Sound area ranged between 0.01 mg/kg and 0.09 mg/kg with a calculated background value of 0.07 mg/kg (San Juan, 1994). There is no cleanup level for mercury.

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[1] There are no Method B MTCA cleanup levels for lead, due to the lack of verified toxicity values available for the constituent.

8.4.9 Nickel

Nickel was detected fairly consistently in soil at sampling locations across the facility at concentrations ranging between 3.3 mg/kg and 13 mg/kg (TB-14, 2 feet bgs) with no apparent pattern to the spatial distribution of concentrations. Nickel concentrations reported for the Puget Sound area ranged between 9.0 mg/kg and 244 mg/kg with a calculated background value of 38.2 mg/kg (San Juan, 1994). No detected concentrations of nickel exceeded the applicable cleanup level.

8.4.10 Silver

Silver was detected in soil at only one location at the facility, HAC-11 at a depth of 3 feet bgs in the Former Cyanide Area at a concentration of 36.3 mg/kg, which is below the cleanup level of 6,866 mg/kg.

8.4.11 Zinc

Zinc was detected fairly consistently in soil at sampling locations across the facility at concentrations ranging between 14 mg/kg and 226 mg/kg. Zinc concentrations reported for the Puget Sound area ranged between 12 mg/kg and 132.5 mg/kg with a calculated background value of 85.1 mg/kg (San Juan, 1994). No detected concentrations of zinc exceeded the applicable cleanup level.

8.5 *Uncertainties*

There are a number of uncertainties associated with the evaluation of the nature and extent of COPCs in soil based on the available soil analytical results. These uncertainties include:

- Soil samples were not collected in several areas of the facility because of the presence of buildings and/or containment that were part of the operational facility during the soil sampling events.

- Many of the soil samples are collected from discrete depths, with gaps between sampling intervals. These samples may not be representative of the soil between the sampling intervals.

- The majority of the soil samples were collected over 10 years ago and thus may not be representative of current conditions. This is especially true for VOCs in soil in the North Field because the SVE system has been in operation since 1994 and has removed 19,051lbs of VOCs. Current concentrations of VOCs in soil in the North Field are likely to be less than those in the reported samples.

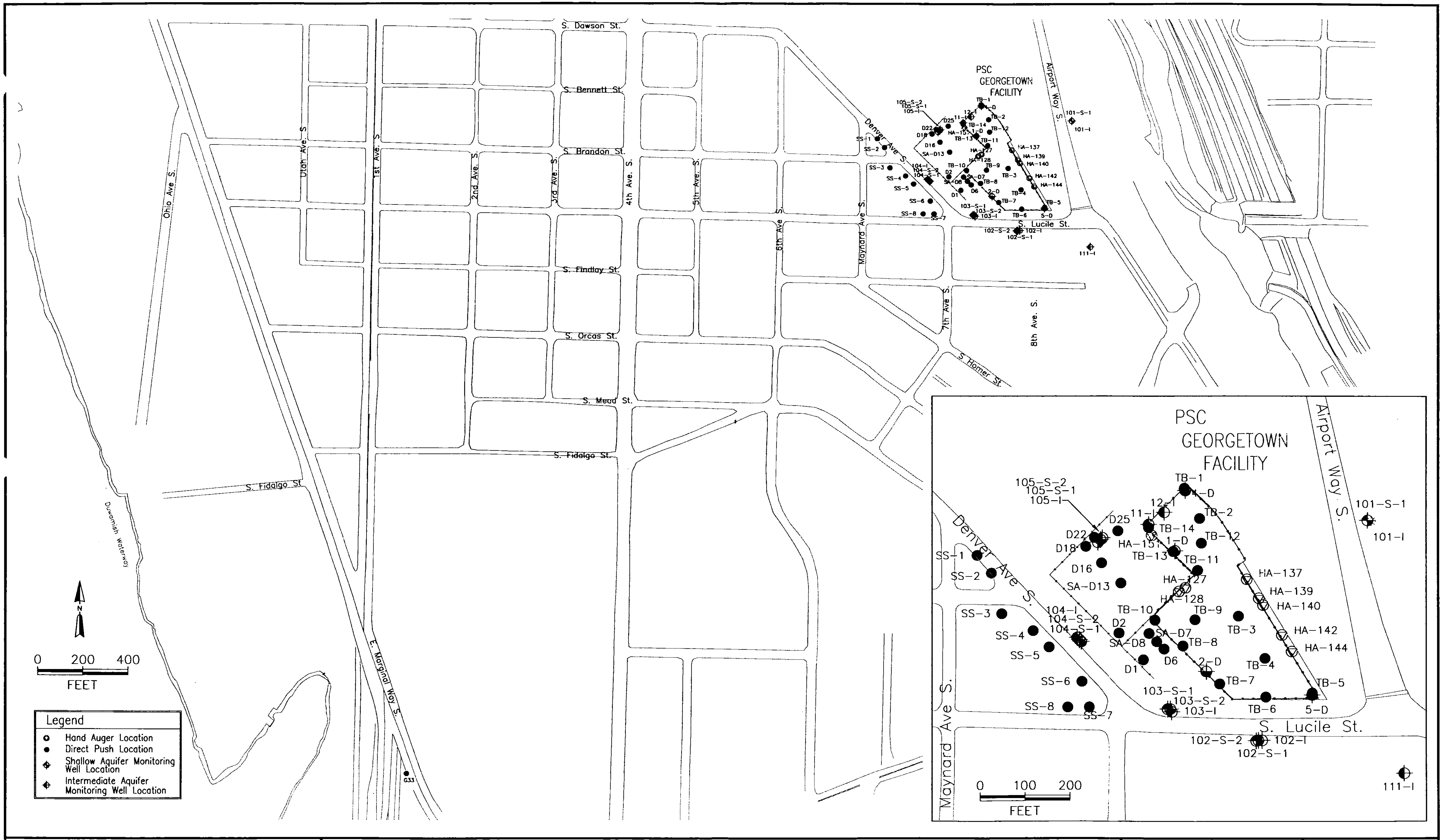
- The sample reporting limits for many compounds were elevated because of matrix interference. As a result, some compounds may have been present but not detected owing to the lack of precision associated with the sample quantitaion limit.

- Many of the available soil analytical results are from composite samples which could result in an under-estimation or over-estimation of the extent of COPC-impactedsoil. Composite samples could mask the presence of a hotspot or could suggest that elevated concentrations exist over a wider area than they actually do.

There are a number of uncertainties associated with the evaluation of the nature and extent of COPC-impacted soil at the facility. However, most of the detected concentrations are below applicable cleanup levels, and all of the locations with concentrations detected above cleanup levels, except one along the property boundary in the West Field, will be within the HCIM.

8.6 *Summary*

Only four constituents, PCE, TCE and PCBs (Aroclor 1016 /1242) were detected above MTCA industrial cleanup levels in soil at the facility. The areas where these constituents exceeded cleanup levels are shown in Figure 8-11. Concentrations of PCE and TCE exceeding applicable cleanup levels were detected in soil samples collected at a depth of approximately 5 feet bgs from the eastern side of the North Field in the area of the former USTs and underground transfer lines. TCE was also detected at concentrations exceeding applicable cleanup levels in the northwest corner of the North Field at a depth of 5 feet bgs. Aroclors 1016/1242 was detected at concentrations exceeding applicable cleanup levels in soil samples collected from depths between 2 and 7 feet bgs along the eastern property boundary in the former East Check-in Area, North Tank Area and Process Area as well as along the western property boundary in the former cyanide area and anti-freeze storage areas. These areas are all within the area of the HCIM . Aroclors 1016/1242 was detected at concentrations exceeding the applicable cleanup levels at a depth of 2 feet bgs along the western property boundary in the West Field. This location will not be within the area encompassed by the HCIM, but will remain capped, thus preventing leaching to groundwater.

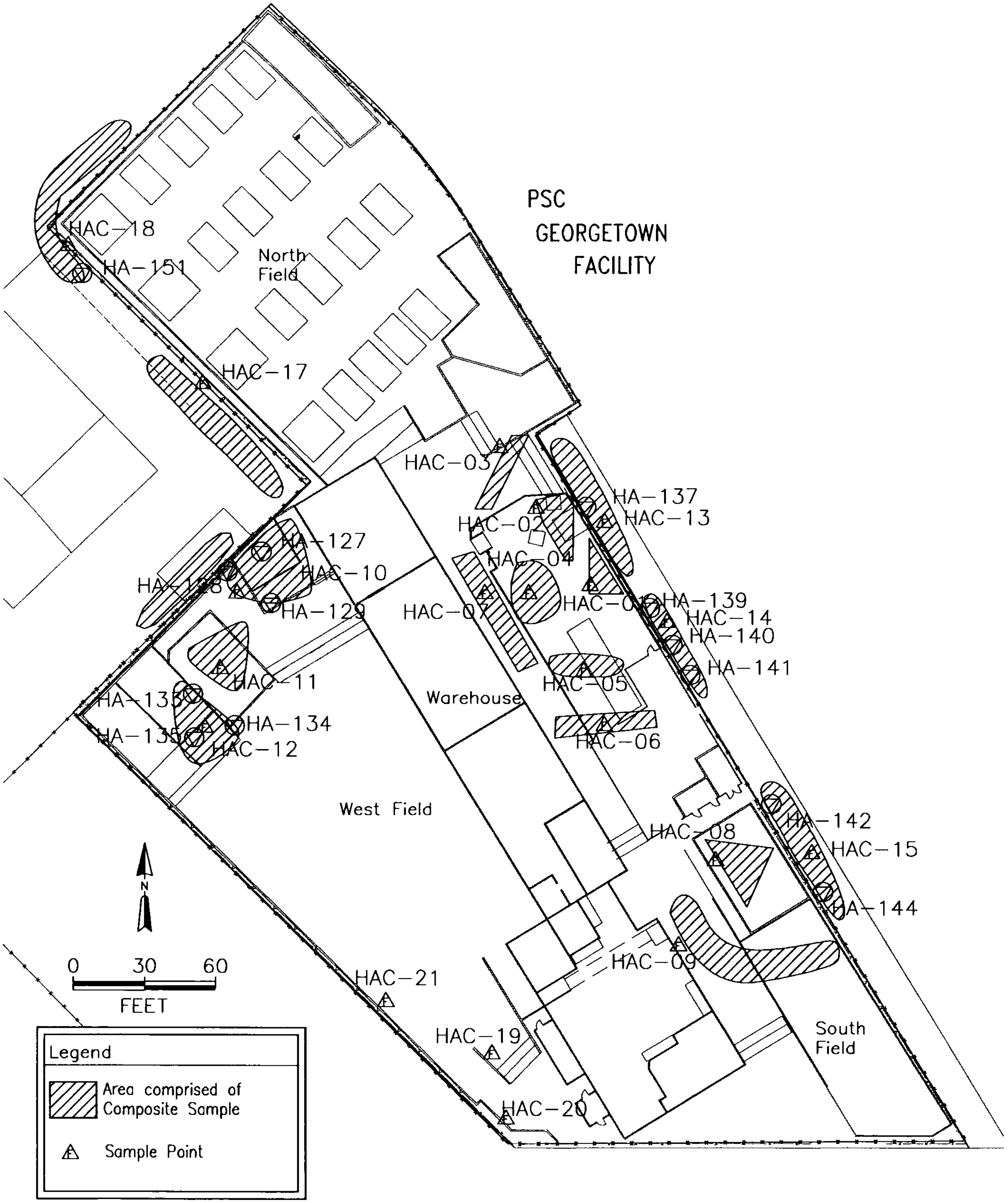


PSC

TITLE:

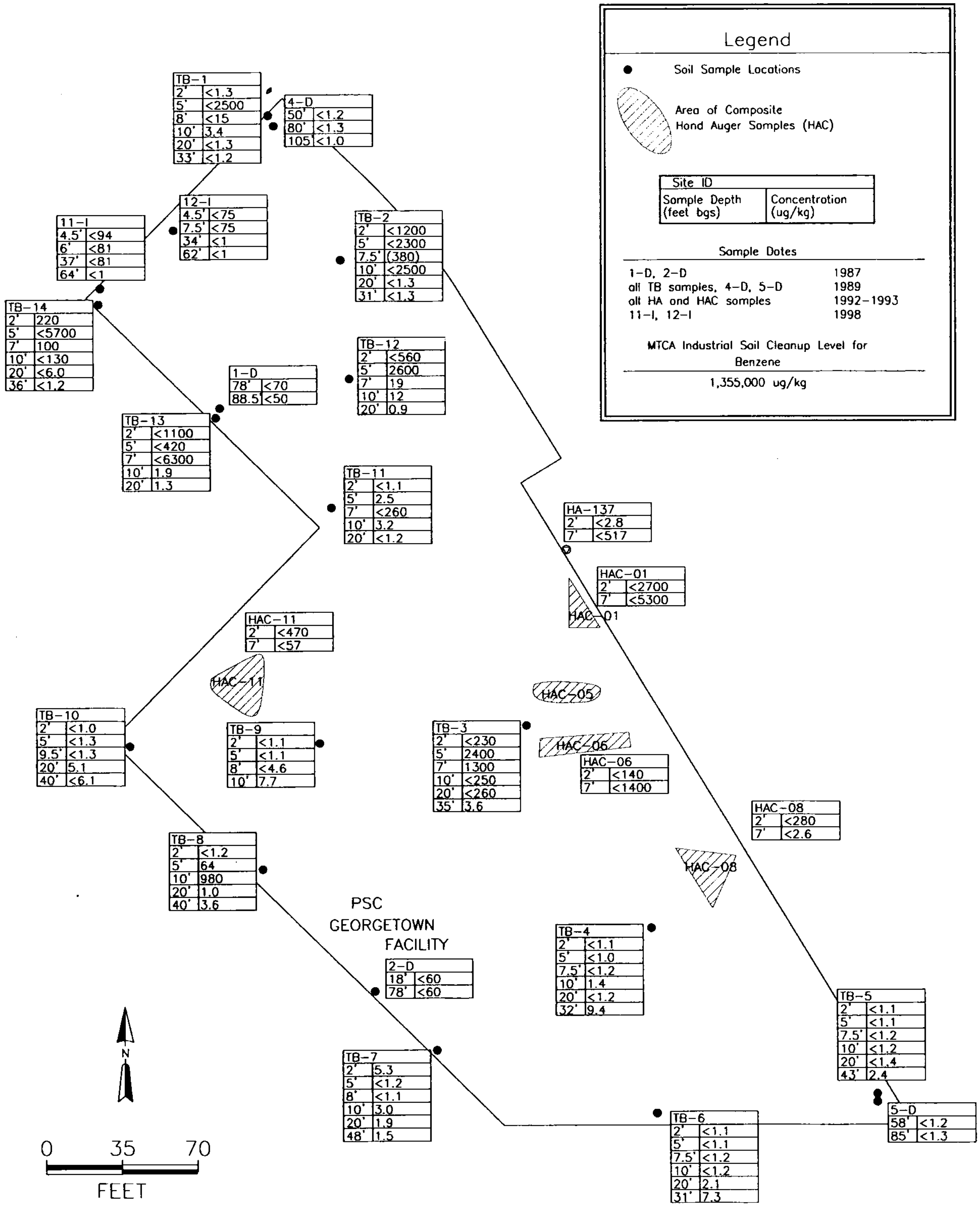
All Discreet Locations Sampled for Soil Chemical Analysis
Phase I, II, & III Hydrological Investigations
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 10/17/03	REV.:	FIGURE NO.: 8-1



PSC

TITLE: Composite Soil Sample Locations PSC Georgetown Facility	DWN: dtb	DES.:	PROJECT NO.: RI2003	
	CHKD:	APPD:	FIGURE NO.: 8-2	
	DATE: 9/11/03	REV.:		

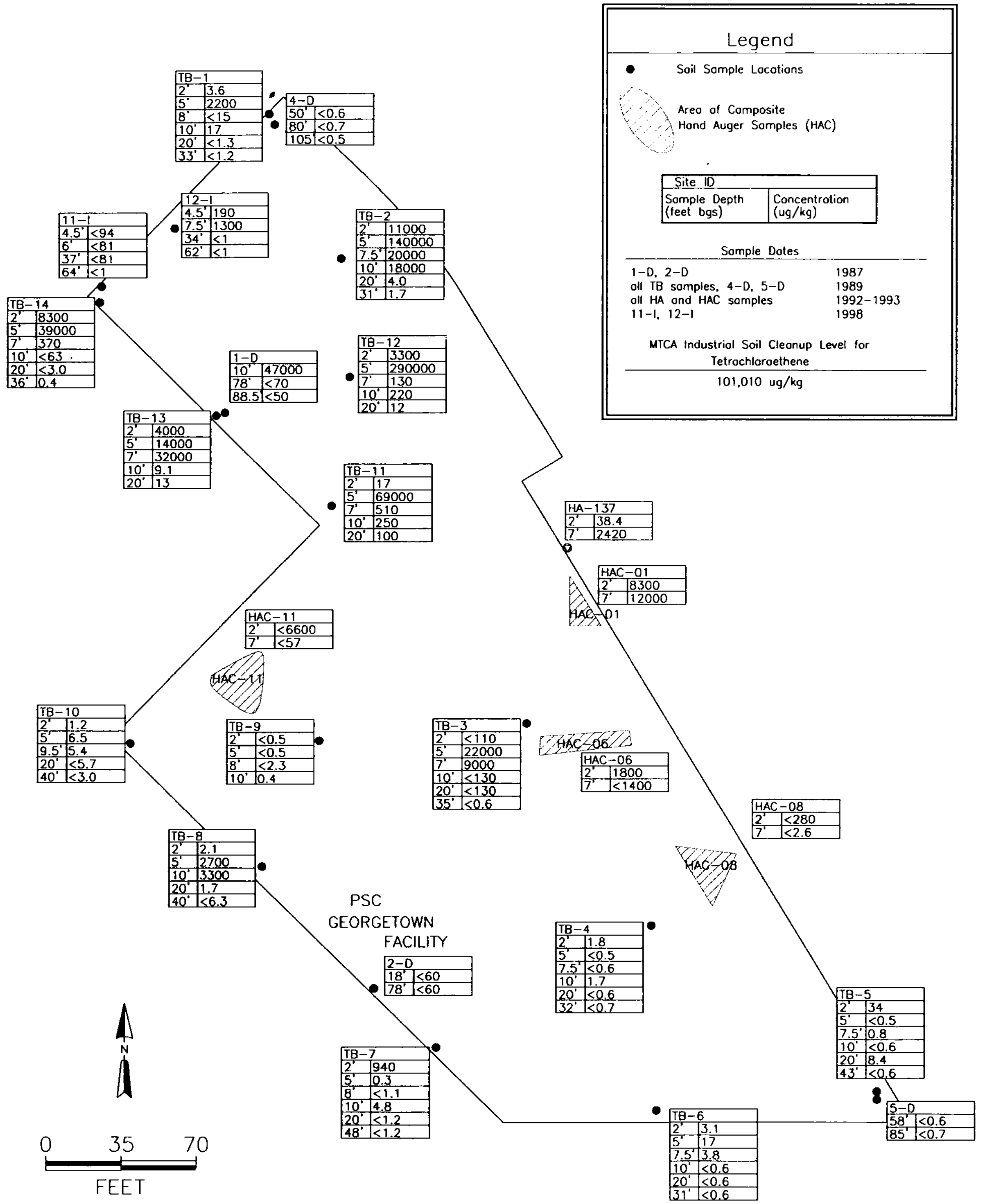


PSC

TITLE:

Benzene Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 9/12/03	REV.:	FIGURE NO.: 8-3



PSC

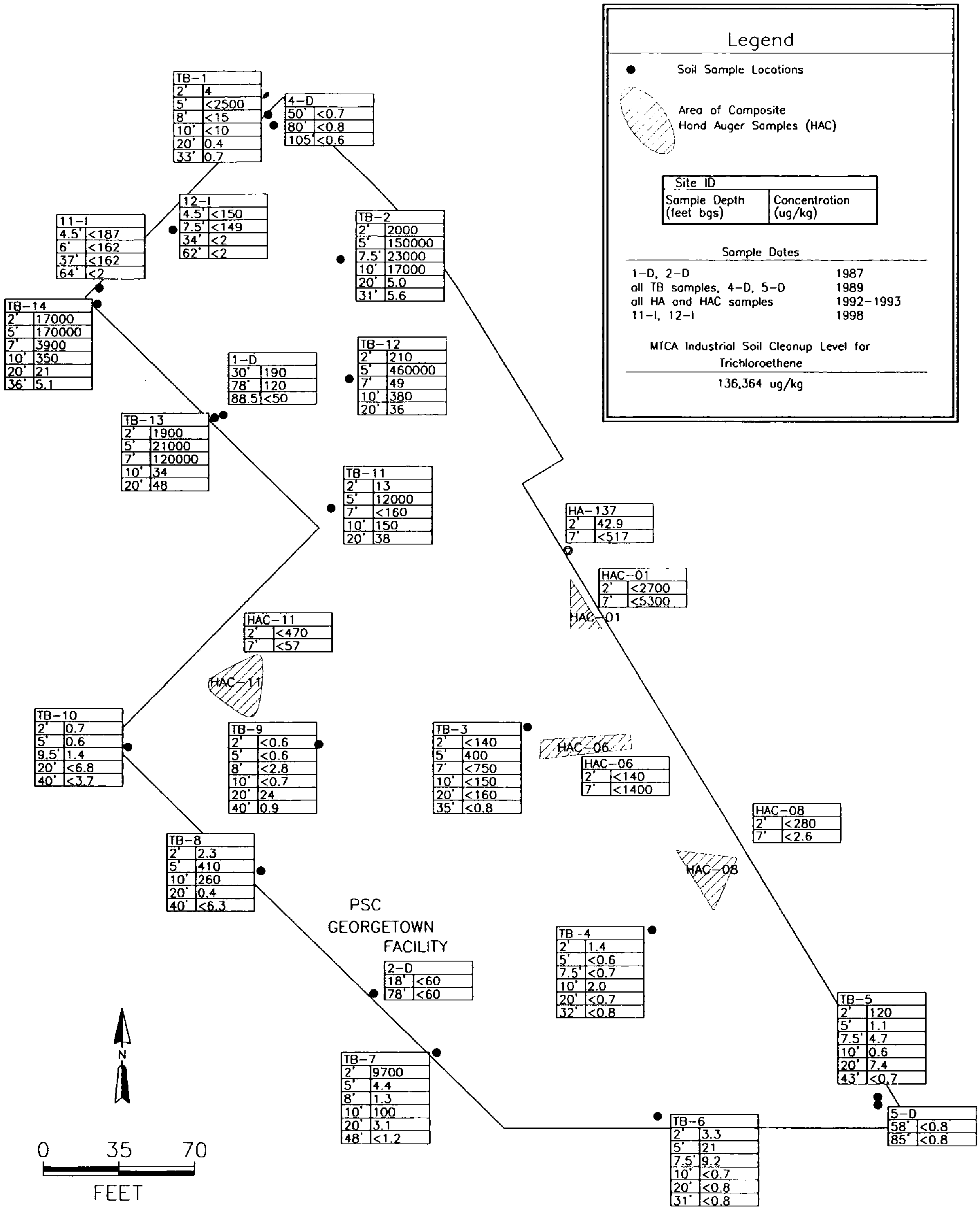
TITLE:

Tetrachloroethene Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 9/15/03
REV.:

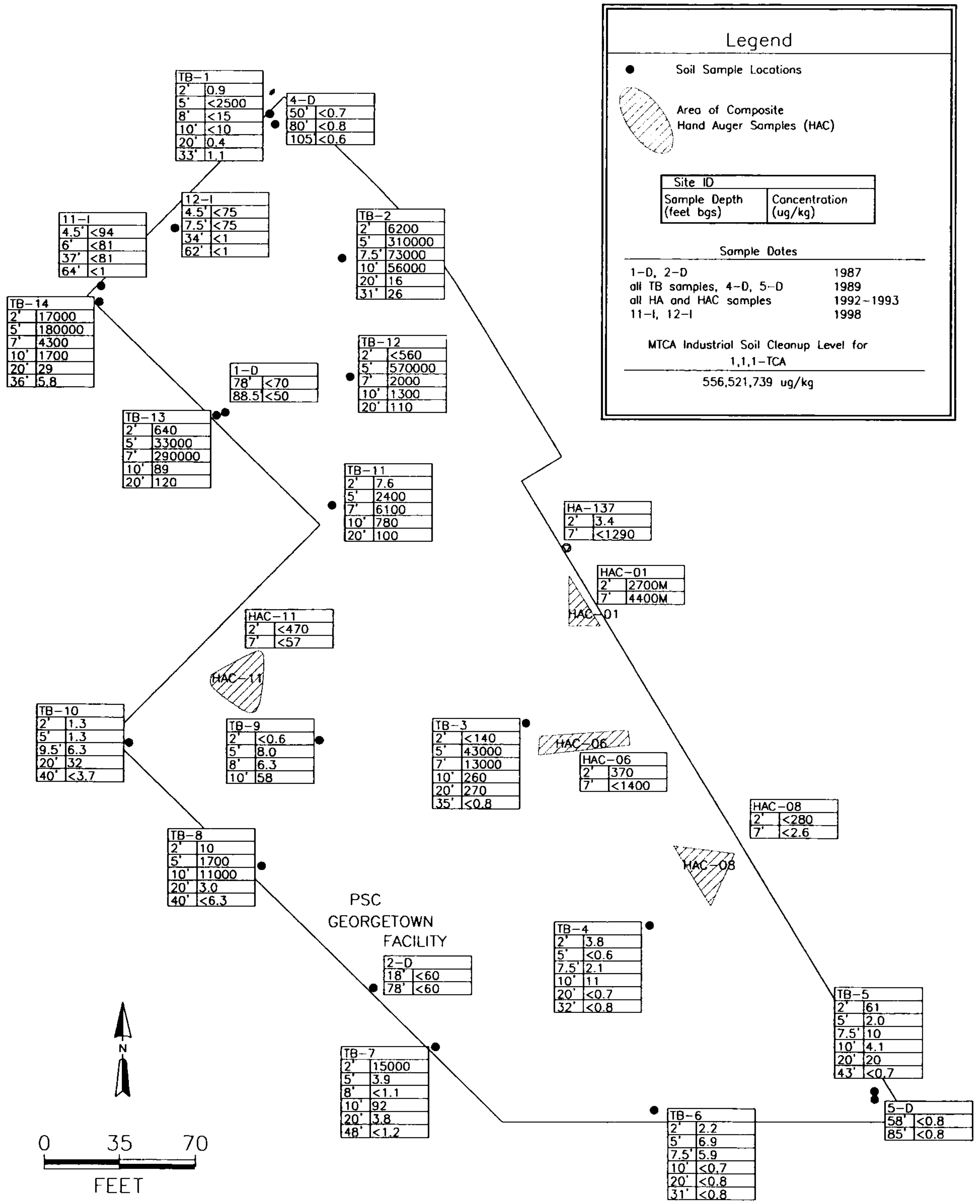
PROJECT NO.: RI2003

FIGURE NO.: 8-4



TITLE:
Trichloroethene Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 9/15/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 8-5



TB-1	
2'	0.9
5'	<2500
8'	<15
10'	<10
20'	0.4
33'	1.1

4-D	
50'	<0.7
80'	<0.8
105'	<0.6

12-I	
4.5'	<75
7.5'	<75
34'	<1
62'	<1

11-I	
4.5'	<94
6'	<81
37'	<81
64'	<1

TB-2	
2'	6200
5'	310000
7.5'	73000
10'	56000
20'	16
31'	26

TB-14	
2'	17000
5'	180000
7'	4300
10'	1700
20'	29
36'	5.8

TB-12	
2'	<560
5'	570000
7'	2000
10'	1300
20'	110

1-D	
78'	<70
88.5'	<50

TB-13	
2'	640
5'	33000
7'	290000
10'	89
20'	120

TB-11	
2'	7.6
5'	2400
7'	6100
10'	780
20'	100

HA-137	
2'	3.4
7'	<1290

HAC-01	
2'	2700M
7'	4400M

HAC-11	
2'	<470
7'	<57

TB-10	
2'	1.3
5'	1.3
9.5'	6.3
20'	32
40'	<3.7

TB-9	
2'	<0.6
5'	8.0
8'	6.3
10'	58

TB-3	
2'	<140
5'	43000
7'	13000
10'	260
20'	270
35'	<0.8

HAC-06	
2'	370
7'	<1400

HAC-08	
2'	<280
7'	<2.6

TB-8	
2'	10
5'	1700
10'	11000
20'	3.0
40'	<6.3

TB-4	
2'	3.8
5'	<0.6
7.5'	2.1
10'	11
20'	<0.7
32'	<0.8

2-D	
18'	<60
78'	<60

TB-5	
2'	61
5'	2.0
7.5'	10
10'	4.1
20'	20
43'	<0.7

TB-7	
2'	15000
5'	3.9
8'	<1.1
10'	92
20'	3.8
48'	<1.2

5-D	
58'	<0.8
85'	<0.8

TB-6	
2'	2.2
5'	6.9
7.5'	5.9
10'	<0.7
20'	<0.8
31'	<0.8

Legend

● Soil Sample Locations

▨ Area of Composite Hand Auger Samples (HAC)

Site ID	
Sample Depth (feet bgs)	Concentration (ug/kg)

Sample Dates

1-D, 2-D	1987
all TB samples, 4-D, 5-D	1989
all HA and HAC samples	1992-1993
11-I, 12-I	1998

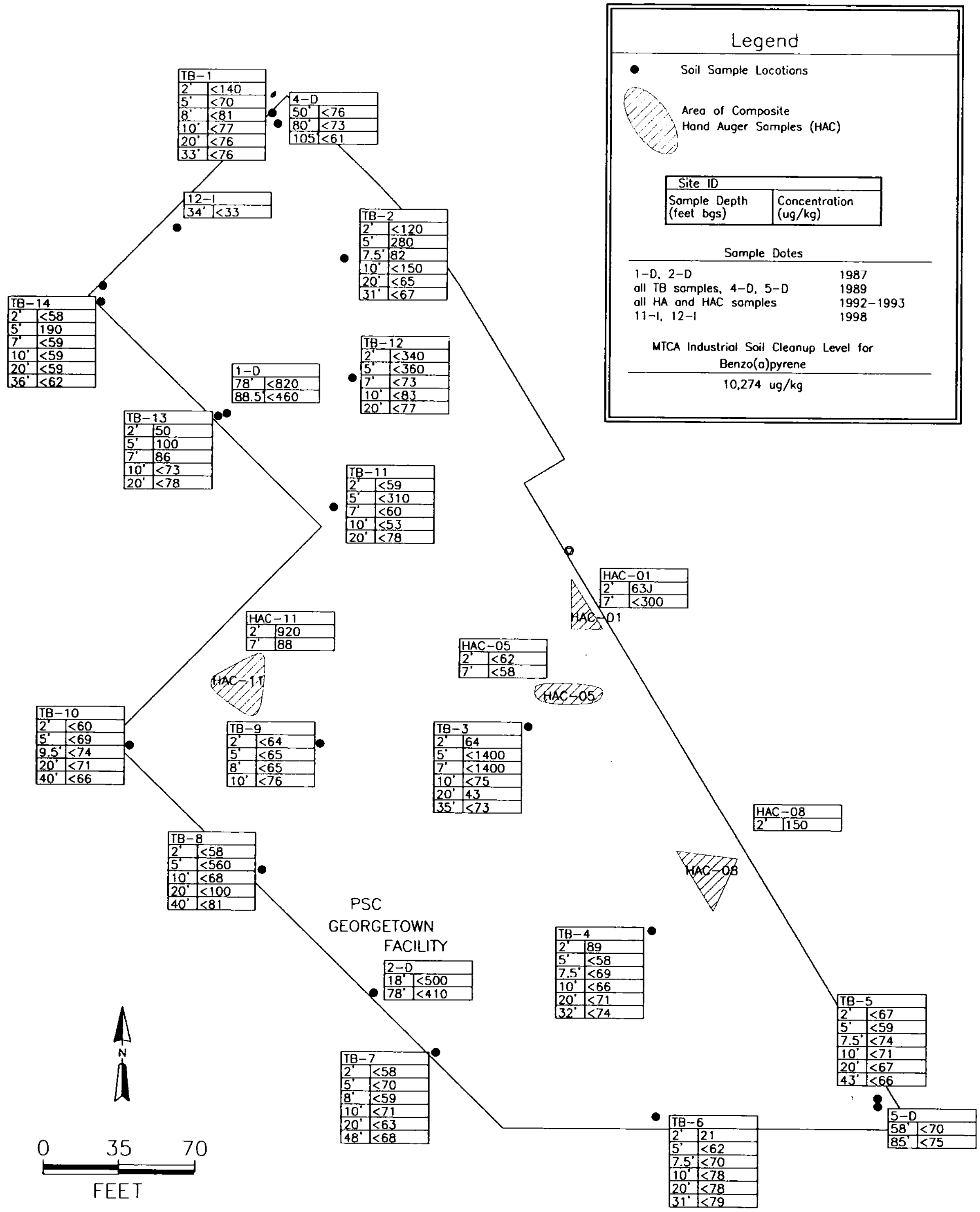
MTCA Industrial Soil Cleanup Level for 1,1,1-TCA

556,521,739 ug/kg

PSC

TITLE:
1,1,1-TCA Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 9/15/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 8-6



Legend

● Soil Sample Locations

▨ Area of Composite Hand Auger Samples (HAC)

Site ID	
Sample Depth (feet bgs)	Concentration (ug/kg)

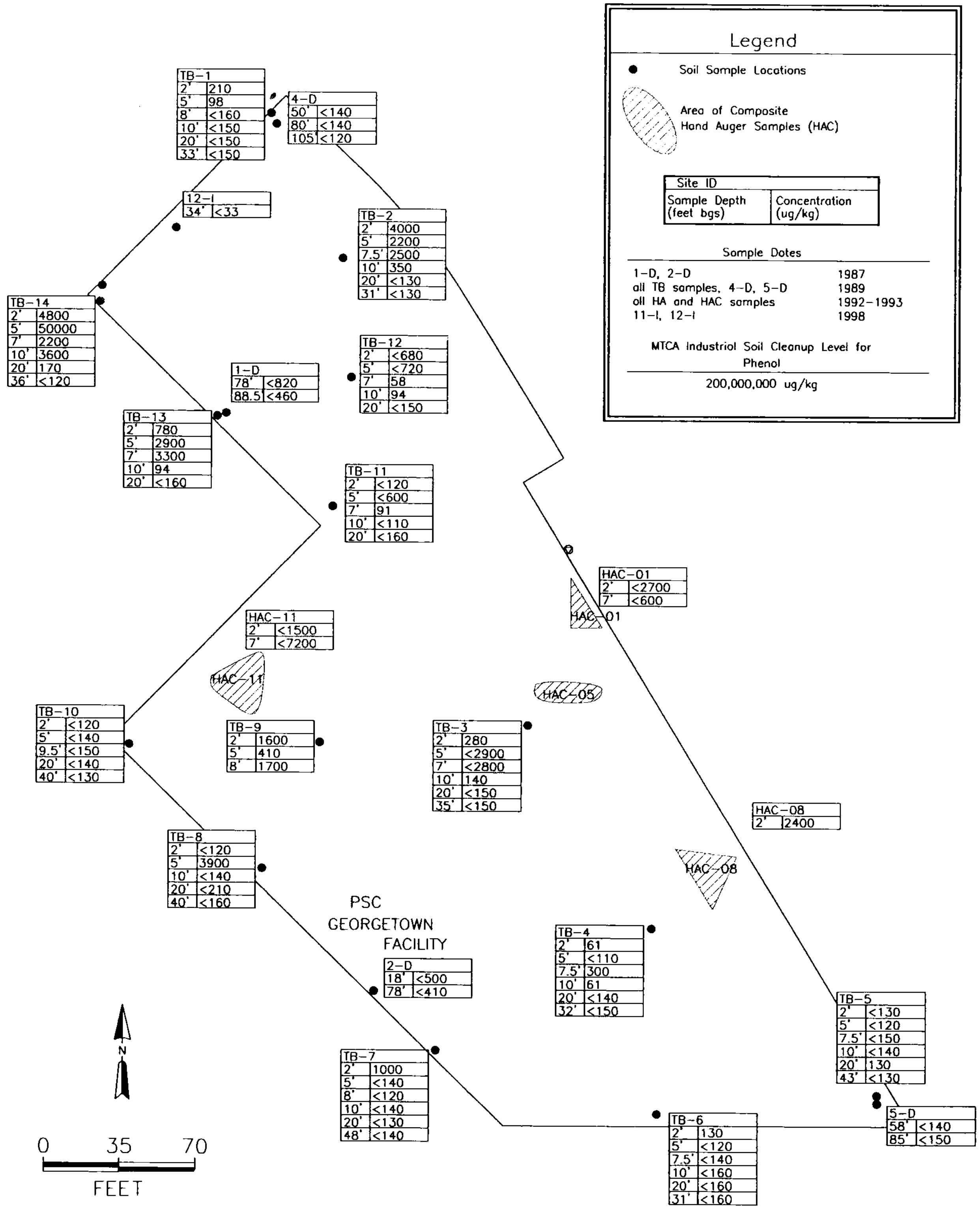
Sample Dates

1-D, 2-D	1987
all TB samples, 4-D, 5-D	1989
all HA and HAC samples	1992-1993
11-I, 12-I	1998

MTCA Industrial Soil Cleanup Level for Benzo(a)pyrene

10,274 ug/kg

TITLE: Benzo(a)pyrene Concentrations in Soil On-Site Soil Sample Locations PSC Georgetown Facility	DWN: dtb	DES.:	PROJECT NO.: RI2003
	CHKD:	APPD:	
	DATE: 9/16/03	REV.:	FIGURE NO.: 8-7



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● Soil Sample Locations

▨ Area of Composite Hand Auger Samples (HAC)

Site ID	
Sample Depth (feet bgs)	Concentration (ug/kg)

Sample Dates

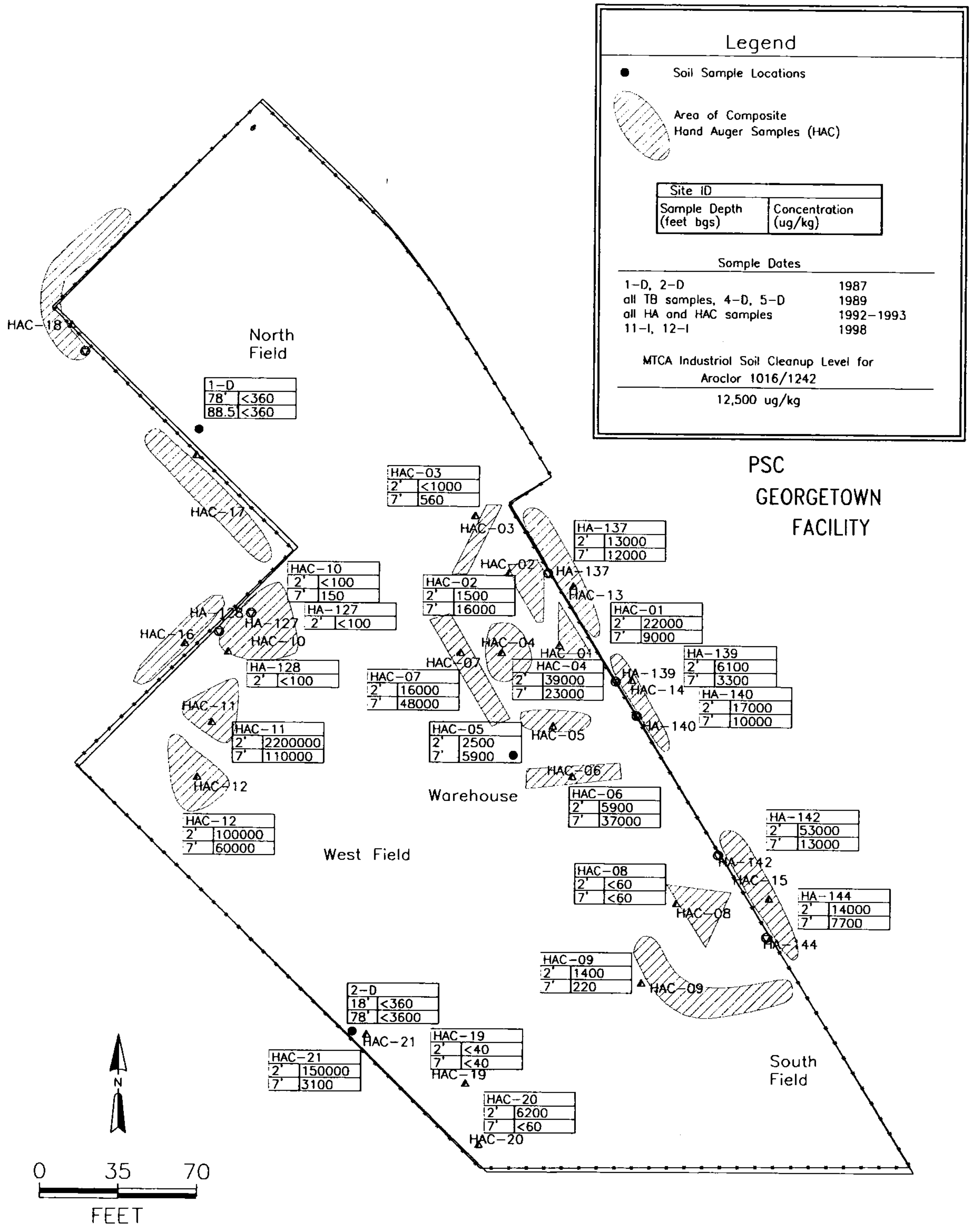
1-D, 2-D	1987
all TB samples, 4-D, 5-D	1989
all HA and HAC samples	1992-1993
11-I, 12-I	1998

MTCA Industrial Soil Cleanup Level for Phenol

200,000,000 ug/kg

TITLE:
Phenol Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

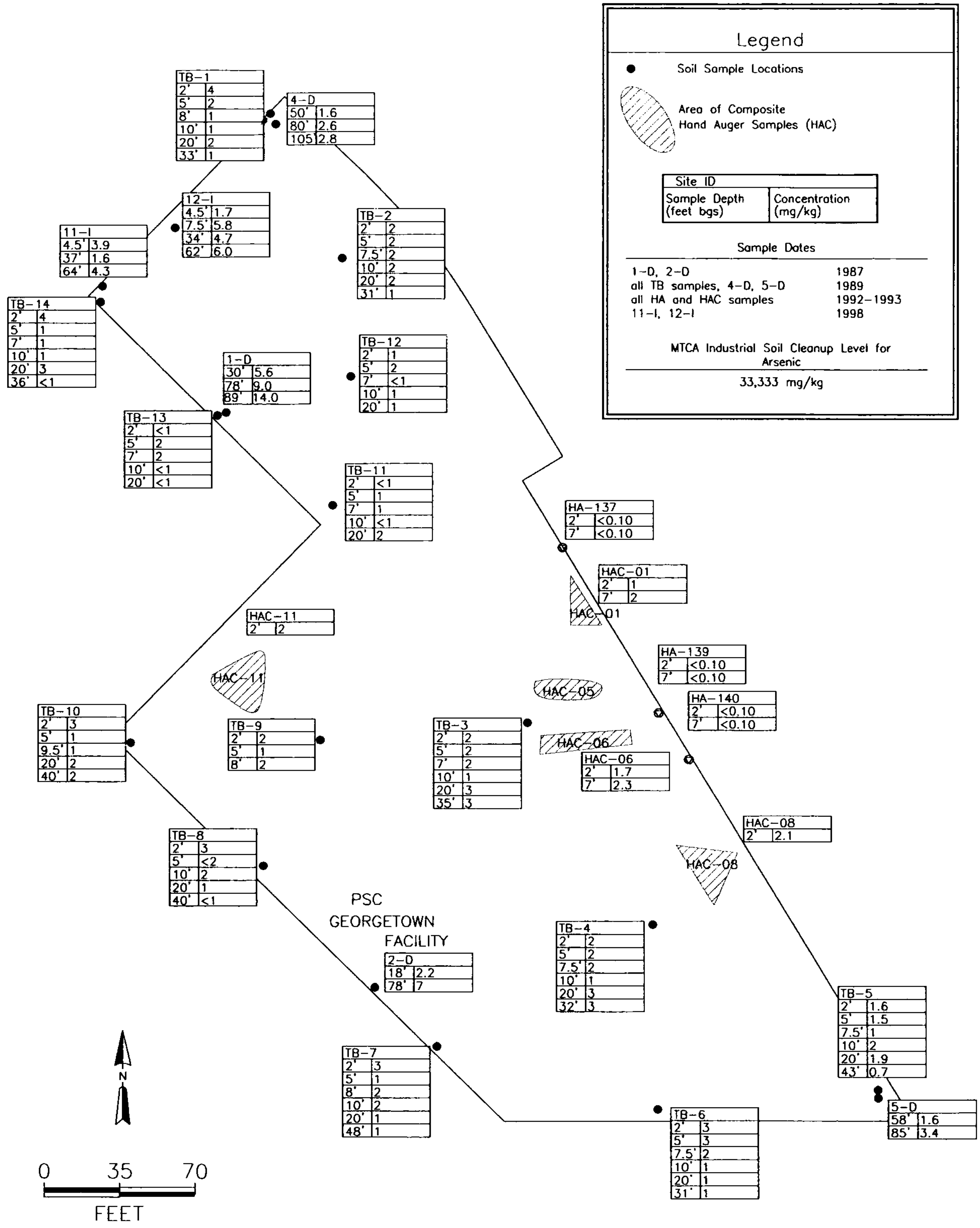
DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 9/17/03	REV.:	FIGURE NO.: 8-8



PSC

TITLE:
Aroclor 1016/1242 Concentrations in Soil, On-site Soil Sample Locations PSC Georgetown Facility

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 9/18/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 8-9



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● Soil Sample Locations

▨ Area of Composite Hand Auger Samples (HAC)

Site ID	
Sample Depth (feet bgs)	Concentration (mg/kg)

Sample Dates

1-D, 2-D	1987
all TB samples, 4-D, 5-D	1989
all HA and HAC samples	1992-1993
11-I, 12-I	1998

MTCA Industrial Soil Cleanup Level for Arsenic

33,333 mg/kg

TB-1	
2'	4
5'	2
8'	1
10'	1
20'	2
33'	1

4-D	
50'	1.6
80'	2.6
105	2.8

12-I	
4.5'	1.7
7.5'	5.8
34'	4.7
62'	6.0

11-I	
4.5'	3.9
37'	1.6
64'	4.3

TB-2	
2'	2
5'	2
7.5'	2
10'	2
20'	2
31'	1

TB-14	
2'	4
5'	1
7'	1
10'	1
20'	3
36'	<1

1-D	
30'	5.6
78'	9.0
89'	14.0

TB-12	
2'	1
5'	2
7'	<1
10'	1
20'	1

TB-13	
2'	<1
5'	2
7'	2
10'	<1
20'	<1

TB-11	
2'	<1
5'	1
7'	1
10'	<1
20'	2

HA-137	
2'	<0.10
7'	<0.10

HAC-01	
2'	1
7'	2

HAC-11	
2'	2

HA-139	
2'	<0.10
7'	<0.10

HA-140	
2'	<0.10
7'	<0.10

TB-10	
2'	3
5'	1
9.5'	1
20'	2
40'	2

TB-9	
2'	2
5'	1
8'	2

TB-3	
2'	2
5'	2
7'	2
10'	1
20'	3
35'	3

HAC-06	
2'	1.7
7'	2.3

HAC-08	
2'	2.1

TB-8	
2'	3
5'	<2
10'	2
20'	1
40'	<1

TB-4	
2'	2
5'	2
7.5'	2
10'	1
20'	3
32'	3

2-D	
18'	2.2
78'	7

TB-5	
2'	1.6
5'	1.5
7.5'	1
10'	2
20'	1.9
43'	0.7

TB-7	
2'	3
5'	1
8'	2
10'	2
20'	1
48'	1

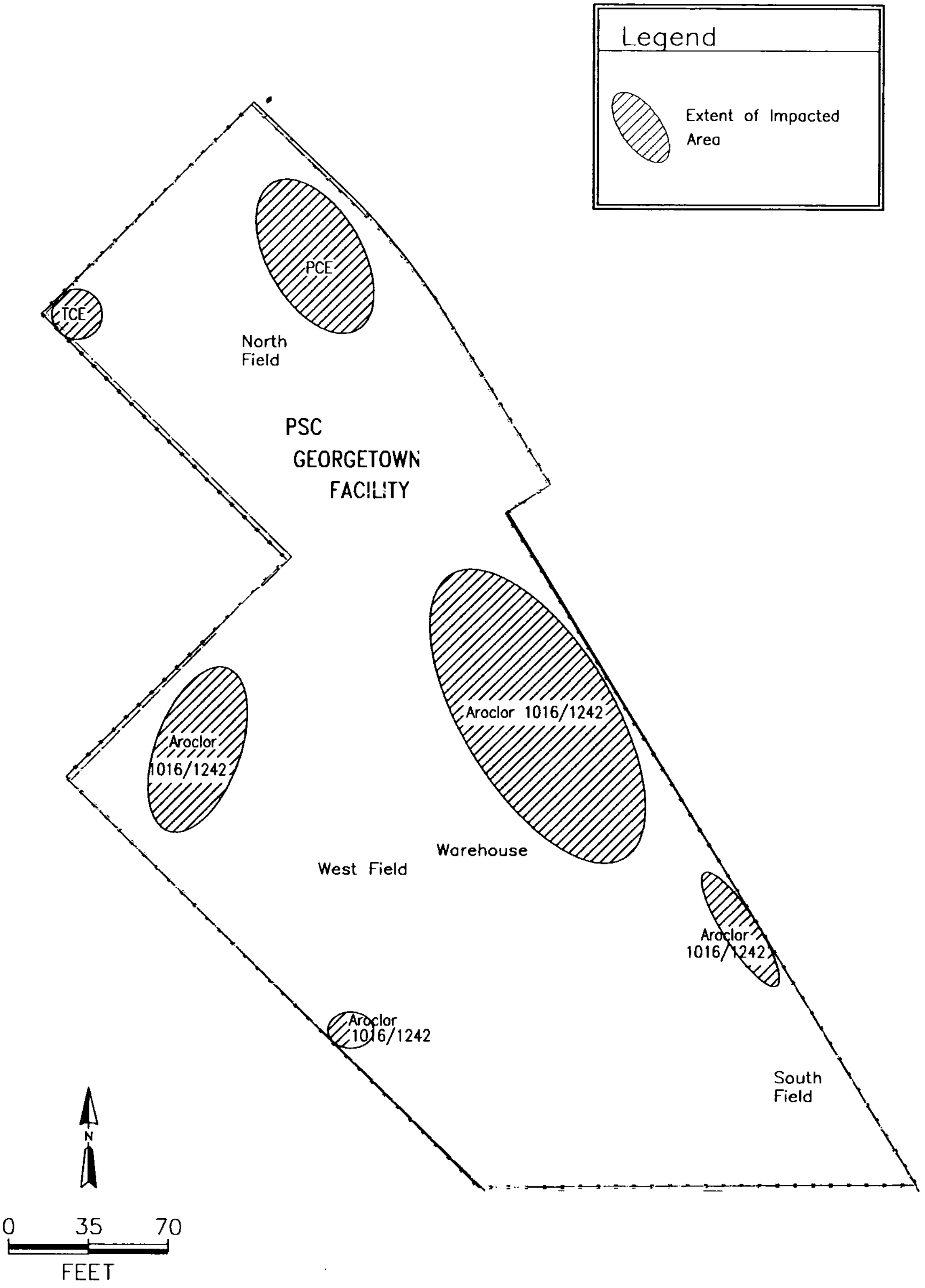
5-D	
58'	1.6
85'	3.4

TB-6	
2'	3
5'	3
7.5'	2
10'	1
20'	1
31'	1

PSC

TITLE:
Arsenic Concentrations in Soil
On-Site Soil Sample Locations
PSC Georgetown Facility

DWN: dtb
DES.:
CHKD:
APPD:
DATE: 9/18/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 8-10



PSC	TITLE: Approximate Extent of Impacted Soil On-site Soil Sample Locations PSC Georgetown Facility	DWN: dtb CHKD: DATE: 10/20/03	DES.: APPD: REV.:	PROJECT NO.: RI2003 FIGURE NO.: 8-11

9.0 NATURE AND EXTENT OF IMPACTED GROUNDWATER

One of the primary objectives of the RI is to characterize the nature and extent of impacted groundwater associated with releases from the facility so that risks to human and environmental receptors can be evaluated in the risk assessment and that necessary remedial alternatives can be evaluated in the FS. PSC has conducted numerous environmental investigations to collect data required to meet this objective. In addition, Ecology required PSC to extend the environmental investigations from the facility west to the Duwamish Waterway, and include locations that the data indicate are not impacted by releases from the PSC facility.

At the request of Ecology, this section presents an overview of the known nature and extent of COPC-impacted groundwater detected during PSC's environmental investigations in the RI Study Area, defined in Section 7. This impacted groundwater has originated from multiple sources in the RI Study Area and these sources are also discussed in this section. This section presents the following topics:

- First, a description of the methods used to evaluate the groundwater analytical results (Section 9.1);
- Second, a general discussion of the nature and extent of COPC-impacted groundwater detected during PSC's environmental investigations in the RI Study Area (Section 9.2);
- Third, a discussion of the potential fate and transport processes affecting the migration of COPC-impacted groundwater (Section 9.3); and
- Fourth, a description of the likely sources of COPC-impacted groundwater in the study area (Section 9.4).

As described in Section 7, the discussion of the nature and extent of impacted groundwater is presented in terms of four evaluation units, Area 1, encompassing the facility; Area 2, encompassing the TASCO and SAD properties; Area 3, encompassing the area downgradient of Areas 1 and 2 extending west to the Duwamish Waterway, and several sampling locations outside Areas 1, 2, and 3.

9.1 *Methods for Evaluation*

As described in Section 4, groundwater samples have been collected at various locations across the RI Study Area since the 1980's. This remedial investigation report focuses on groundwater data collected from 2000 forward because these data meet current regulatory data quality requirements and best represent the current conditions in the RI Study Area. Both historical and current groundwater analytical results are summarized electronically on the attached CD in Appendix 9A and the detected groundwater analytical results used in this report are also summarized in tables presented in Appendix 9B. This discussion of the nature and extent of impacted groundwater focuses on those constituents identified as COPCs in the HHERA and summarized in Section 7.

9.1.1 Sampling Intervals

The groundwater in the RI Study Area exhibits varying fate and transport characteristics owing to differing hydraulic and geochemical conditions with depth, as discussed in Section 3 and described in more detail in Appendices 9C and 9D. Consequently, the groundwater data were considered in four depth intervals for the evaluation of the nature and extent of impacted groundwater:

- The *water table sample interval*, which includes wells screened above 20 feet bgs and groundwater reconnaissance samples collected above 20 feet bgs, and corresponds to the upper 10 feet of the shallow aquifer water-bearing zone;

- The *shallow sample interval*, which includes monitoring wells screened below 20 feet bgs and above 40 feet bgs and groundwater reconnaissance samples collected between 21 feet bgs and 40 feet bgs within the shallow aquifer, or in a few cases, the intermediate aquifer;

- The i*ntermediate sample interval*, which includes all wells screened below 40 feet bgs and above the top of the silt aquitard, as well as groundwater reconnaissance samples collected below 40 feet bgs[1,2] ; and

- The *deep aquifer*, which includes monitoring wells that are screened below the silt aquitard. Wells screened within the deep aquifer are present only close to the facility, including one location upgradient of Area 1, locations within Area 1 and 2, and one location adjacent to and south of Area 2.

These sample intervals do not represent the stratigraphic units described in Section 3.0, as much of the sampling was conducted based on the depth of impacted groundwater rather than the stratigraphic unit. Two wells located east (upgradient) of Area 1 represent exceptions to the sample intervals listed above. Although monitoring well CG-106-I is screened from 26 feet bgs to 36 feet bgs, it is assumed to be screened within the intermediate aquifer based on the geologic properties observed during drilling. Monitoring well CG-106-D is screened from 60 feet bgs to

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[1] Groundwater reconnaissance samples collected within the upper portion of the silt aquitard are considered to be part of the Intermediate Aquifer and were taken into consideration for the description of the nature and extent of contamination surrounding Area 1.

[2] The depth of the interface between the shallow and intermediate aquifer varies across the facility and in Area 3, and thus, the intermediate sample interval may encompass the lower parts of the shallow aquifer in some places. As these aquifers are hydraulically connected, the interface between the two aquifers is marked only by the gradual presence of interbedded silts and no strong vertical hydraulic gradients have been detected between the two aquifers, this should not represent a significant discrepancy in the evaluation of the nature and extent of groundwater.

70 feet bgs but is assumed to be screened within the deep aquifer based on the geologic properties observed during drilling.

9.1.2 Isoconcentration Maps

To aid in the evaluation of the nature and extent of COPC-impacted groundwater throughout the RI Study Area, isoconcentration maps were developed for select COPCs. Isoconcentration maps depict lines of equal concentrations while also taking into consideration the direction of groundwater flow. These are different than isopleth maps which also depict lines of equal concentrations but disregard the direction of groundwater flow. The isoconcentration maps created for this evaluation consider all data from reconnaissance borings completed between January 2000 and May 2003 and the arithmetic average of the detected results from permanent monitoring wells for sampling events from April 2002 through March 2003[3]. These data were selected for depiction on the figures because they are considered most representative of current conditions. In cases where groundwater data were available for both monitoring wells and reconnaissance borings, data from samples collected from monitoring wells were given precedence over data from samples from reconnaissance borings.

Between April 2002 and March 2003, monthly water level measurements were obtained from most of the groundwater monitoring wells. As described in Section 3, the average groundwater level for each well was calculated for these twelve monitoring events, and used to create potentiometric surface maps for each sample interval. A review of the potentiometric surface maps for each monitoring event indicates that the estimated flow direction based on the potentiometric surface gradient does not vary seasonally, and does not appear to have varied over

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[3] Average concentrations were used on the figures, and thus, for consistency across the entire monitoring well network, only the last 4 quarters of monitoring well data were used. However, COPCs were identified based on an evaluation of groundwater monitoring well data collected between January 2000 through the first quarter sampling event 2003. The discussion of nature and extent of groundwater contamination encompasses data collected between January 2000 and the first quarter sampling event 2003.

time, as described in Section 3. Average potentiometric surface maps created for the water table sample interval, shallow sample interval, and intermediate sample interval were used as the basis for development of the corresponding COPC isoconcentration maps.

The depiction of the distribution of COPCs in groundwater within Area 1 is based on a limited number of locations sampled in Area 1 for the RI. Due to the limited number of sample locations within Area 1, the isoconcentration contours may not accurately represent the areal extent of COPCs in Area 1, particularly within the North Field where the majority of the source is thought to be located. However, the isoconcentration contours are likely representative of the distribution of COPCs emanating from Area 1 to Area 2 because there are a number of sample locations near the central portion of Area 2 or at the boundary between Areas 1 and 2, dependent on the sample interval.

9.1.3 Hydrogeologic Cross-Sections

Hydrogeologic cross-sections were created using the lithologic data collected during the installation of selected reconnaissance borings and groundwater monitoring wells. Groundwater levels, COPC concentrations, geology, and sample intervals are depicted on the cross-sections. The hydrogeologic cross-sections help to depict the vertical distribution of COPCs in the subsurface.

The locations of the cross-sections were chosen based on the areal extent of the primary COPCs (Figure 9-1). Most of the cross-sections were oriented along the direction of groundwater flow so that they are representative of the trends and distribution of COPCs along a transport pathway. Cross-section A-A' (Figure 9-2) depicts the north-south distribution of COPCs downgradient of Area 1 along the east side of Denver Avenue South. Cross-section B-B' (Figure 9-3) extends from the eastern edge of the North Field of Area 1 to 5th Avenue South to the west. Cross-section C-C' (Figures 9-4A and 9-4B) extends from the eastern edge of Area 1 to 1st Avenue South to the west. Cross-section D-D' (Figure 9-5) is oriented along the groundwater flow line from 4th Avenue South to 2nd Avenue South. Cross-section E-E' (Figure 9-6) depicts the COPC distribution along South Fidalgo Street near the Duwamish Waterway.

All borings and wells located within approximately 50 feet of the selected cross-section axis were included as part of the cross-section. The sample intervals and analytical results for TCE, cis-1,2-DCE, and vinyl chloride are presented for each boring. For the groundwater monitoring wells, the screened intervals are depicted along with the average values derived for TCE, cis-1,2-DCE, and vinyl chloride. Isoconcentration lines on the cross-sections depict the vertical distribution of COPCs in the subsurface.

9.2 *Regional Distribution of Chemicals of Potential Concern in Groundwater*

This section presents a general description of the nature and extent of COPCs detected in groundwater throughout the RI Study Area, regardless of the source of the COPCs. The discussion has been organized into groups of COPCs related by a common parent compound, or similar physical-chemical properties that might control their fate and transport, as shown in Table 7-1. The discussion for VOCs includes BTEX, chlorinated ethenes, chlorinated ethanes, chlorinated methanes, and other VOCS. The discussion for SVOCs includes PAHs, phenols and other SVOCs while PCBs, and inorganic constituents are discussed as separate groups.

The discussion of the nature and extent of groundwater COPCs is presented with respect to groundwater cleanup levels, as described in Section 7. Groundwater cleanup levels protective of vapor intrusion into indoor air (WAC 173-340-750) were used to evaluate to groundwater concentrations in the water table sample interval and groundwater cleanup levels protective of exposure of humans and ecological receptors to surface water (WAC 173-340-730) were used to evaluate groundwater concentrations in all sampling intervals.

9.2.1 VOCs

9.2.1.1 *BTEX*

BTEX were detected at concentrations exceeding applicable groundwater cleanup levels in the RI Study Area. In general, the distributions of toluene, ethylbenzene, and xylenes were spatially correlated, suggesting a common source for these compounds.

Water Table Sample Interval

In the water table sample interval, BTEX have been detected in groundwater at concentrations exceeding applicable cleanup levels, as presented in Figures 9-7 through 9-10. There appear to be two main areas where BTEX have been detected at concentrations exceeding the applicable cleanup levels. One impacted area is located in the North Field of Area 1 and extends westward across the northern portion of Area 2. Another impacted area is located within the West Field of Area 1 and extends westward across the central portion of Area 2, and for toluene and ethylbenzene, the impacted area extends into Area 3 just beyond Maynard Avenue South.

Outside of the two areas mentioned above, benzene was detected above cleanup levels in the water table sample interval at one sample location, boring I13, near the intersection of 5th Avenue South between South Findlay Street and South Orcas Street. In addition, benzene was also detected at concentrations above applicable cleanup levels in Area 3 between Maynard Avenue South and 5th Avenue South on either side of South Lucile Street. Toluene, ethylbenzene, and xylenes were detected at concentrations exceeding applicable cleanup levels in the water table sample interval near background well CG-107-WT. This area of toluene-, ethylbenzene-, and xylenes-impacted groundwater may extend across the playfield area, based on similar results from a 2002 Ecology groundwater study (Ecology, 2002). Benzene was not detected above cleanup levels at this location.

Shallow Sample Interval

In the shallow sample interval, BTEX have been detected in groundwater at concentrations exceeding applicable cleanup levels, as presented in Figures 9-11 through 9-14. Similar to the water table sample interval, there appear to be two main areas of the shallow sample interval where BTEX have been detected at concentrations exceeding the applicable cleanup levels. One impacted area is located in the North Field of Area 1 and extends westward across the northern portion of Area 2. Another impacted area is located within the West Field of Area 1 and extends westward across the central portion of Area 2. Benzene was also detected above the applicable cleanup level in Area 3 between Denver and 5th Avenues South and South Brandon and South Findlay Streets.

Intermediate Sample Interval

In the intermediate sample interval, BTEX have been detected in groundwater at concentrations exceeding applicable cleanup levels, as presented in Figures 9-15 through 9-17.
Similar to the water table and shallow sample intervals, BTEX were detected in groundwater at concentrations exceeding the applicable cleanup levels in the North Field of Area 1 and extending westward across the northern portion of Area 2, and in the West Field of Area 1, extending westward across the central portion of Area 2. Benzene was also detected at concentrations above the applicable cleanup level at the south end of the South Field.

Deep Aquifer

BTEX were not detected above applicable cleanup levels in the deep aquifer.

9.2.1.2 *Chlorinated Ethenes*

Chlorinated ethenes, tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene isomers (1,2-DCE), and vinyl chloride, were detected at concentrations exceeding applicable groundwater cleanup levels in the RI Study Area. In general, the concentrations of each constituent were spatially correlated suggesting that the presence of 1,2-DCE and vinyl chloride are likely a result of biodegradation of PCE and TCE. The vertical distribution of chlorinated ethenes is depicted in the cross-sections presented in Figures 9-2 through 9-6.

Water Table Sample Interval

In the water table sample interval, the highest concentrations of chlorinated ethenes above applicable cleanup levels were generally detected in two primary locations of Areas 1 and 2 that will be encircled by the HCIM as shown in Figures 9-18 through 9-21 for PCE, TCE, cis-1,2-DCE and vinyl chloride, respectively. Concentrations of chlorinated ethenes exceeding applicable cleanup levels were detected in the North Field extending west across the northern part of Area 2 and in the Process Area extending west and southwest through the Area 2 and into Area 3 to approximately Maynard Avenue South.

There were several locations in the water table sample interval in Area 3 where chlorinated ethenes were detected at concentrations above applicable cleanup levels. These include:

- Sample locations H14/CG-131-WT, near the intersection of 5th Avenue South and South Orcas Street;
- In the vicinity of sample locations CG-137-WT and K19 between 2nd and 4th Avenues South and South Orcas and South Fidalgo Streets;
- Sample locations A8/D13, between the intersection of 7th Avenue South and South Homer Street and the intersection of 6th Avenue South and South Fidalgo Street;
- Sample locations M13/N15, between the intersection of 4th Avenue South and South Lucile Street and the intersection of 3rd Avenue South and South Findlay Street;

- Sample locations P17/CG-138-WT, near the intersection of 2nd Avenue South and South Findlay Street; and

- Sample locations at Q32, west of East Marginal Way along South Fidalgo Street.

Shallow Sample Interval

In the shallow sample interval in Areas 1 and 2, concentrations of chlorinated ethenes exceeding applicable cleanup levels were detected in three primary locations as shown in Figures 9-22 through 9-25 for PCE, TCE, cis-1,2-DCE and vinyl chloride, respectively. Chlorinated ethene concentrations were generally detected above cleanup levels in the northern part of Area 2, in the West Field of Area 1 extending into the central part of Area 2 and in the West field of Area 1 extending through the southern part of Area 2. TCE and vinyl chloride were also detected above applicable cleanup level in the eastern-most part of Area 3 as far as approximately Maynard Avenue South. PCE and 1,2-DCE were not detected above applicable cleanup levels in Area 3. Similar to the water table sample interval, there were several locations in the shallow sample interval in Area 3 where chlorinated ethenes were detected at concentrations that exceeded applicable cleanup levels and that were greater than the surrounding concentrations.

- For TCE:
  - Sample location F13, near the intersection of 6th Avenue South and South Orcas Street
  - Sample location I22, near the intersection of 3rd Avenue South and South Fidalgo Street
  - Sample location L31, near the intersection of 1st Avenue South and East Marginal Way
  - Sample locations at Q32, west of East Marginal Way South along South Fidalgo Street.

- For cis-1,2-DCE:
  - Sample location I17, near the intersection of 4th Avenue South and South Orcas Street
  - Sample location M20, near the intersection of 2nd Avenue South and South Orcas Street
  - Sample location I22, near the intersection of 2nd Avenue South and South Fidalgo Street.

- For vinyl chloride:
  - From 6th Avenue South and South Findlay Street and the intersection of 4th Avenue South and South Lucile Street to approximately East Marginal Way South with hot spots at sample location K23, near the intersection of 2nd Avenue South and South Fidalgo Street and at sample location L30, near the intersection of 1st Avenue South and East Marginal Way S
  - South of South Fidalgo Street between 4th and 6th Avenues South at sample locations CG-132-40 and CG-133-40
  - Sample location D8, near the intersection of Maynard Avenue South and 5th Avenue South.

Intermediate Sample Interval

The distribution of chlorinated ethenes in groundwater in the intermediate sample interval is presented in Figures 9-26 through 9-29 for PCE, TCE, cis-1,2-DCE and vinyl chloride, respectively. In Areas 1 and 2, chlorinated ethenes were detected at concentrations exceeding applicable cleanup levels around three locations: North Field extending west onto the northern portion of Area 2, West Field extending across the central part of Area 2, and at the southern end of Areas 1 and 2. Vinyl chloride appears to be the most widely distributed of the chlorinated ethenes in Areas 1 and 2, but elevated concentrations do not appear to extend much beyond Denver Avenue.

Similar to the water table and shallow sample interval, there are several isolated locations in the intermediate sample interval in Area 3 where chlorinated ethenes were detected above cleanup levels. TCE was detected above the cleanup level at one location, E8, near the intersection of Maynard Avenue South and South Findlay Street while DCE and PCE were not detected above cleanup levels in the intermediate sample interval in Area 3. Downgradient of 5th Avenue South, vinyl chloride was detected above cleanup levels in the area of sample location J23, near the intersection of 2nd Avenue South and South Fidalgo Street and in the area of sample location P17, near the intersection of 2nd Avenue South and South Findlay Street.

Deep Aquifer

PCE and TCE were the only chlorinated ethenes detected in groundwater from the deep aquifer at concentrations exceeding applicable cleanup levels. The concentrations detected in the deep aquifer were significantly lower than those detected in the overlying sample intervals, and the highest concentrations were detected at CG-104-D in Area 2.

9.2.1.3 *Chlorinated Ethanes*

Chlorinated ethanes, 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,1-DCA and chloroethane, were detected at concentrations exceeding applicable groundwater cleanup levels in the RI Study Area. The distribution of chlorinated ethanes in the water table, shallow and intermediate sample intervals and deep aquifer is described below.

Water Table Sample Interval

The distributions of 1,1,1-TCA and 1,1-DCA in the water table sample interval are presented in Figures 9-30 and 9-31. Chlorinated ethanes were detected at concentrations exceeding the applicable cleanup levels in the northwest corner of the North Field extending westward into Area 2 and in the Former West Field extending west and southwest into Area 2 and across Denver Avenue to approximately 6th Avenue South. In addition, 1,1,1-TCA was detected at concentrations just over the cleanup level from a location upgradient of Area 1 across the south end of Areas 1 and 2 and across South Lucile Street into Area 3.

1,1-DCA was also detected above applicable cleanup levels in Area 3 at an isolated sample location, I13, near the intersection of 5th Avenue South and South Orcas Street.

Shallow Sample Interval

In the shallow sample interval, 1,1,1-TCA and 1,1-DCA were detected at concentrations exceeding applicable cleanup levels in the Former West Field extending west and southwest into the middle of Area 2, as shown in Figures 9-32 and 9-33. 1,1-DCA was also detected at concentrations exceeding the applicable cleanup level in the northwest corner of the North Field extending westward into Area 2 and in the southern part of Area 2. Chlorinated ethanes were not detected at concentrations exceeding applicable cleanup levels in the shallow sample interval in Area 3. 1,1-DCA was also detected above cleanup levels at one isolated sample location in Area 3, I17 located at the intersection of 4th Avenue South and South Orcas Street. 1,2-DCA and chloroethane were not detected above applicable cleanup levels in the shallow sample interval.

Intermediate Sample Interval

In the intermediate sample interval, 1,1,1-TCA was detected at concentrations exceeding the applicable cleanup level only in the former west field extending into the southern part of Area 2, as presented in Figure 9-34. 1,1-DCA was detected at concentrations above the applicable cleanup level in the northwest corner of the North Field extending westward into Area 2 and in the West Field extending west into the middle of Area 2 as presented in Figure 9-35. Chlorinated ethanes were not detected above applicable cleanup levels in the intermediate sample interval in Area 3. 1,2-DCA and chloroethane were not detected above applicable cleanup levels in the intermediate sample interval.

Deep Aquifer

In the deep aquifer, 1,1,1-TCA was detected at concentrations just above the cleanup level at monitoring well 2-D during 2001. No other chlorinated ethanes were detected in groundwater from the deep aquifer at concentrations exceeding applicable cleanup levels.

9.2.1.4 *Chlorinated Methanes*

Chloroform was the only chlorinated methane detected at concentrations exceeding applicable cleanup levels in the RI Study Area in the water table sample interval. Chloroform was detected at concentrations exceeding the applicable cleanup levels in the former North Field and northern part of the west field in Area 1 extending into the northern half of Area 2. The majority of this area will be encompassed by the HCIM. Chloroform was also detected at concentrations above cleanup levels in the water table sample interval at one isolated location south of Area 3 at sample location D8 near the intersection of Maynard Avenue South and South Homer Street.

Chloroform was not detected in groundwater from the shallow and intermediate sample intervals and deep aquifer at concentrations exceeding applicable cleanup levels. Methylene chloride was detected at concentrations above applicable cleanup levels in only one sample, CG-104-I, during a single sampling event.

9.2.1.5 *Ketones*

Two ketones, MIBK and 2-hexanone, were detected at concentrations exceeding applicable groundwater cleanup levels. 2-Hexanone was detected at concentrations exceeding the applicable cleanup level at one location in the water table sample interval 9-S-1, along the western edge of the west field and at one location in the shallow sample interval at D21, just downgradient of the North Field in Area 2, within the area that will be enclosed by the HCIM. 2-Hexanone was not detected at concentrations exceeding cleanup levels in the intermediate sample interval or deep aquifer. MIBK was detected at concentrations exceeding applicable cleanup levels in the northern end of the North Field and the western side of the West Field extending into Area 2 in the water table sample interval and the upper portions of the shallow sample interval in Area 2.

9.2.1.6 *Aromatic VOCs*

Several aromatic VOCs, including 1,2,4-trimethybenzene, 1,3,5-trimethylbenzene, 1,2-dichlorobenzene, cumene, n-propylbenzene, sec-butylbenzene, cumene, n-hexane, n-butylbenzene, p-isopropyltoluene and 1,2,4-trichlorobenzene, were identified as COPCs in groundwater. Although identified as COPCs, n-butylbenzene, p-isopropyltoluene, and 1,2,4-trichlorobenzene have not been detected at concentrations exceeding applicable cleanup levels in any sample interval[4]. The highest concentrations of aromatic VOCs are located in an area that will be encircled by the HCIM.

Water Table Sample Interval

1,2,4-Trimethybenzene and 1,3,5-trimethylbenzene were detected at concentrations exceeding applicable cleanup levels in the water table sample interval in the northern end of the North Field and the western side of the West Field extending into Area 2 and Area 3, just across Denver Avenue South, as shown in Figure 9-36. Cumene and n-propylbenzene were detected in the water table sample interval at concentrations exceeding applicable cleanup levels in the North Field extending westward into Area 2 and in the West Field. Sec-butylbenzene and n-hexane were detected at concentrations exceeding the applicable cleanup levels only once in the water table sample interval in the West Field and in the north part of Area 2, respectively.

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[4] COPCs were conservatively identified in the HHERA by comparison with risk-based screening concentrations based on a target risk of 1×10^{-7} and a target hazard quotient of 0.1. MTCA cleanup levels were developed using default MTCA assumptions including a target risk of 1×10^{-6} and a target hazard quotient of 1.

Shallow Sample Interval

n-Propylbenzene was detected at concentrations exceeding applicable cleanup levels in the shallow sample interval in the northern part of Area 2. No other aromatic VOCs were detected at concentrations exceeding applicable cleanup levels in the shallow sample interval.

Intermediate Sample Interval

1,2,4-Trimethylbenzene was also detected above applicable cleanup levels only once in the intermediate sample interval in the West Field while 1,2-dichlorobenzene was detected at concentrations exceeding applicable screening levels in the North Field in the intermediate sample interval. No other aromatic VOCs were detected at concentrations exceeding applicable cleanup levels in the intermediate sample interval.

Deep Aquifer

n-Hexane was detected one time at a concentration exceeding cleanup levels in the deep aquifer background well, upgradient of the facility. No other aromatic VOCs were detected at concentrations exceeding applicable cleanup levels in the deep aquifer.

9.2.1.7 *Other VOCs*

1,1,2-Trichlorotrifluoroethane, cis-1,3-dichloropropene, trans-1,3-dichloropropene and dichlorodifluoromethane have not been detected at concentrations exceeding applicable cleanup levels in any sample interval. Carbon disulfide was also identified as a COPC but no cleanup levels are available for this COPC. The highest concentrations of carbon disulfide detected in the RI Study Area were generally in the intermediate sample interval in Areas 1 and 2.

9.2.2 SVOCs

9.2.2.1 *LPAHs*

LPAHs naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were identified as COPCs in groundwater and were detected above applicable cleanup levels in the RI Study Area. The highest concentrations of LPAHs are located in the area that will be encompassed by the HCIM. LPAHs were detected at concentrations exceeding applicable cleanup levels in the water table sample interval in the northern-most corner of the former North Field extending westward into Area 2 and along the western edge of the former West Field extending westward into Area 2. LPAHs were not detected above cleanup levels in the water table sample interval in Area 3. Only naphthalene was also detected at concentrations exceeding the applicable cleanup level in the shallow sample interval in Area 3 at isolated sample locations: CG-137, near the intersection of 2nd Avenue South and South Fidalgo street, and Q32, west of East Marginal Way South along South Fidalgo Street. LPAHs were not detected above cleanup levels in the shallow sample interval in Areas 1 and 2 .

LPAHs were not detected above cleanup levels in the intermediate sample interval and deep aquifer in Areas 1, 2, and 3.

9.2.2.2 *SVOCS: Phenols*

Phenolic COPCs, including phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol and pentachlorophenol, were detected at concentrations exceeding applicable groundwater cleanup levels in the water table sample interval in the former North Field and northern portion of Area 2. No phenolic COPCs were detected above applicable cleanup levels in the shallow sample interval.

Each of these COPCs were also detected at concentrations exceeding applicable cleanup levels in the intermediate sample interval in the northern part of Area 2.

No phenolic COPCs were detected above applicable cleanup levels in the deep aquifer. The highest concentrations of phenols are located in the area that will be encompassed by the HCIM.

9.2.2.3 *Other SVOCs*

Concentrations of bis(2-ethylhexyl)phthalate, a common laboratory contaminant, exceeded the applicable cleanup levels in groundwater samples collected from wells screened within the water table sample interval, shallow sample interval, intermediate sample interval, and deep aquifer in the northern half of Area 2 and extending west into Area 3 to approximately 6th Avenue South. Concentrations of bis(2-ethylhexyl)phthalate also exceeded the cleanup level in background wells screened in the water table sample interval, shallow sample interval, intermediate sample interval and deep aquifer. Benzoic acid was also identified as a COPC but no cleanup levels are available for this COPC.

1,4-Dioxane[5] was detected in several discrete locations within the water table sample interval in Areas 1, 2, and 3 at concentrations below applicable cleanup levels, as presented in Figure 9-37. In the shallow sample interval, 1,4-dioxane was only detected at concentrations exceeding applicable cleanup levels in several samples collected from the area between 6th Avenue South and 4th Avenue South, as presented in Figure 9-38. In the intermediate sample interval, 1,4-dioxane was detected at a concentration exceeding the applicable MTCA cleanup level at only 2 sample locations, both in Area 3: at CG-122-60 near the intersection of Maynard Avenue South and South Lucile Street and at CG-135-50 near the intersection of 4th Avenue South and South Lucile Street, as presented in Figure 9-39.

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[5] The sampling program for 1,4-dioxane was expanded during the 2nd quarter 2003 sampling event. Consequently, the distribution of 1,4-dioxane was evaluated using data from samples collected during the 2nd quarter 2003 in addition to data from samples collected between January 2000 1st quarter 2003.

9.2.3 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) Aroclor 1016 and Aroclor 1232 were detected at concentrations exceeding applicable cleanup levels in the water table sample interval in the South and West Fields. Neither COPC was detected in groundwater in any shallow interval wells. Aroclor 1016 was also detected at concentrations exceeding applicable cleanup levels one time each in groundwater samples from the intermediate sample interval and deep aquifer at the CG-5 well nest in the southeast corner of Area 1. Aroclor 1016 and Aroclor 1232 were not detected in any samples collected from Areas 2 and 3.

9.2.4 Total Petroleum Hydrocarbons

Several measures of TPH, GRO, DRO, lube oil range organics (LRO) and several extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH) fractions, were identified as groundwater COPCs. However, there are no MTCA Method B cleanup levels for these compounds. In general, these compounds were detected primarily in the water table sample interval in Areas 1 and 2 and in the easternmost portion of Area 3, as presented in Figure 9-40 for GRO.

9.2.5 Inorganic Constituents

Several inorganic constituents were identified as COPCs in groundwater. The source of many of these constituents is uncertain as they may occur in the environment as a result of natural background conditions, changes in geochemical conditions, or a release. The geochemical factors that control the distribution of several of the redox-sensitive constituents (As, Ni, etc.) are discussed in more detail in Section 9.3.2. A discussion of background groundwater concentrations is presented in Appendix 6A. The distribution of each constituent within the RI Study Area is described in this section.

9.2.5.1 *Arsenic*

Arsenic was detected at concentrations exceeding the applicable cleanup level throughout the water table, shallow and intermediate sample intervals, and deep aquifer in and upgradient of Areas 1, 2, and 3 as shown in Figures 9-41, 9-42 and 9-43, for the water table, shallow, and intermediate sample intervals, respectively. Naturally elevated concentrations of arsenic have been detected in both soil and groundwater throughout Western Washington (San Juan, 1994; WDOH, 1999). Reports of groundwater arsenic concentrations exceeding 10 µg/L in public water supply systems throughout Western Washington are numerous (WDOH, 1999), as presented in Figure 7-5. Arsenic mobility in groundwater is usually controlled by redox conditions, pH, biological activity and adsorption/desorption reactions and increases with increasing pH and more reducing conditions (Hinkle and Polette, 1998).

The highest concentrations of arsenic in the water table sample interval were detected in Area 2 extending into the eastern portion of Area 3 to approximately Maynard Avenue South. Ethene and ethane, indicators of the complete biodegradation of chlorinated ethenes, described in detail in Section 9.3.4, were detected in the area of elevated arsenic concentrations. As the complete biodegradation of chlorinated ethenes requires reducing conditions, the arsenic concentrations may be elevated locally as a result of the reducing conditions. Concentrations decreased substantially downgradient of this area in the water table sample interval, outside the ethane and ethane plumes, in an area with only mildly reducing conditions. In addition, the distribution of arsenic detected in the water table sample interval did not indicate any hot spots, supporting the hypothesis that the highest arsenic concentrations were a result of locally reducing conditions rather than a release.

Arsenic concentrations detected in the shallow and intermediate sample intervals and deep aquifer were lower than those detected in the water table sample interval, despite more strongly reducing conditions in these lower sample intervals. However, arsenic can form insoluble sulfides with reduced sulfate. As sulfate concentrations are very low in the shallow and intermediate sample intervals and deep aquifer, sulfides are likely controlling the migration of arsenic under the reducing conditions in these sample intervals. In general, the highest concentrations in each of these sample intervals were detected in and immediately upgradient of Areas 1 and 2. However, arsenic concentrations were typically less than approximately 3 µg/L in these sample intervals in Area 3, indicating that the conditions that may be resulting in the local mobilization of arsenic in Areas 1 and 2, are not present in Area 3. No distinct spatial trends, such as hot spots, were apparent in the distribution of arsenic in groundwater in the shallow and intermediate sample intervals, and deep aquifer in Area 3, suggesting that the arsenic concentrations detected in groundwater in these intervals in Area 3 are associated with naturally occurring arsenic rather than a release from the facility.

9.2.5.2 *Barium*

Concentrations of barium exceeding the applicable cleanup levels were detected in the water table, shallow, and intermediate sample intervals, as shown in Figures 9-44, 9-45 and 9-46, and in the deep aquifer. Barium is generally soluble at all pH and redox conditions, but will form the insoluble barium sulfate or barium phosphate in the presence of sulfate or phosphate (EPA, 2003).

In the water table and shallow sample intervals, the concentrations were generally higher to the west of 6th Avenue South in Area 3, and the highest detected concentrations were greater than those detected in the corresponding background wells. In the intermediate sample interval, barium was detected at sample locations in Areas 1, 2 and the eastern portion of Area 3 at concentrations similar to those detected in intermediate sample interval background wells. Overall, the only trend in the distribution of barium in groundwater in the water table, shallow, and intermediate sample intervals is that concentrations detected in Areas 1 and 2 are generally lower than those detected in Area 3. This trend suggests that the concentrations detected in groundwater throughout the area are not associated with a release but rather with naturally occurring barium.

9.2.5.3 *Chromium*

Chromium was detected at concentrations exceeding the applicable cleanup level in the water table, shallow and intermediate sample intervals, and deep aquifer. Chromium is typically present as the highly toxic Cr (VI) under strongly oxidizing conditions and the much less toxic Cr(III) under moderately oxidizing to reducing conditions (Lyman et al., 1987). Consequently, the chromium detected in groundwater samples collected as part of this RI was likely present primarily as Cr(III). The solubility of Cr (III) is controlled by precipitation as hydroxides and oxides, as well as sorption (Lyman et al., 1987). However, the chromium hydroxy-complexes often form as such fine solid particles that they are often collected with groundwater samples.

Chromium was detected at concentrations exceeding the cleanup level in the water table and shallow sample intervals sporadically in Areas 1 and 2 and in several samples in Area 3 near the intersections of 5th Avenue South and South Orcas Street, and 2nd Avenue South and South Mead Street, as shown in Figure 9-47 for the shallow sample interval. The highest detected concentrations of chromium in groundwater in the intermediate sample interval were detected in Areas 1 and 2. The highest concentrations of chromium were detected in areas where sulfate was detected, suggesting that chromium may be forming soluble complexes with sulfate. As sulfate concentrations decrease by East Marginal Way South, the chromium is expected to precipitate from solution. The high chromium concentrations may also be attributable to solid hydroxy-complexes that were suspended in groundwater samples.

Chromium was also detected in the deep aquifer at concentrations exceeding the cleanup level. These concentrations are also likely slightly elevated as a result of chloro-complexes associated with elevated chloride concentrations naturally occurring in the deep aquifer.

Hexavalent chromium was detected above applicable cleanup levels in several groundwater samples collected in Area 3 and upgradient/crossgradient of Area 1. The limited detection of hexavalent chromium can likely be attributed to the general reducing nature of groundwater in the RI Study Area. In the water table, Cr(VI) was detected at concentrations exceeding the applicable cleanup level at sample locations K21, near the intersection of 2nd Avenue South and South Mead Street, and at I17, near the intersection of 4th Avenue South and South Orcas Street. In the shallow sample interval, Cr(VI) was detected at concentrations above the applicable cleanup level at sample location F13, near the intersection of 6th Avenue South and South Orcas Street. In the intermediate sample interval, Cr(VI) was detected at concentrations exceeding the applicable cleanup level only in the two background monitoring wells. Nearly all of the positive results for hexavalent chromium were reported as estimated and may be an artifact of sampling as Cr(III) is rapidly oxidized to hexavalent chromium when exposed to air.

9.2.5.4 *Copper*

Copper was detected at concentrations exceeding the applicable cleanup level in the water table, shallow, and intermediate sample intervals as presented in Figures 9-48, 9-49 and 9-50. Copper exists in three oxidation states: +2, +1, and 0 and as it has a strong affinity for soil, typically exhibits low mobility in the environment, except at low pHs (<4) (ATSDR, 2002).

There were no apparent trends in detected copper concentration areally or with depth. The copper concentrations detected in Areas 1 and 2 were consistent with the range of concentrations detected in the background wells. The highest detected copper concentrations were associated with direct push samples in Area 3, suggesting that much of the detected copper may be associated with particulate matter suspended in unfiltered groundwater samples, rather than actual dissolved concentrations[6]. Copper concentrations detected in groundwater appear to be associated with naturally occurring copper.

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[6] For example, turbidity ranged between 51.8 and 605 NTU in shallow and intermediate sample interval groundwater samples from location I13, sampled on March 27, 2002.

9.2.5.5 *Cyanide*

Cyanide was detected at concentrations exceeding the applicable cleanup level in the water table sample interval, shallow sample interval and intermediate sample interval. Cyanide occurs most commonly as hydrogen cyanide in water, although it can also occur as the soluble cyanide ion, alkali and alkaline earth metal cyanides or easily decomposable metallo-cyanide complexes (ATSDR, 1997). In groundwater, cyanide can also form strong insoluble complexes with iron, and thus, is often relatively immobile in groundwater.

In the water table sample interval, cyanide was detected at concentrations exceeding the applicable cleanup level in the North Field and West Field extending to the west across Area 2, while in the shallow sample interval, it was detected at concentrations exceeding the cleanup level in the middle portion of Area 2. Cyanide was not detected in the water table and shallow sample intervals in Area 3. In the intermediate sample interval, cyanide was detected at concentrations exceeding the cleanup level in the northern part of Area 2 extending into the eastern portion of Area 3 to approximately Maynard Avenue South. Based on the high availability of iron, the formation of insoluble iron-cyanide complexes is likely limiting the migration of cyanide in the RI Study Area.

9.2.5.6 *Lead*

Lead was detected at concentrations exceeding the applicable cleanup level in groundwater from the water table, shallow and intermediate sample intervals. The mobility of lead is limited by the formation of insoluble lead sulfates, carbonates, hydroxides and phosphates (ATSDR, 1999).

Concentrations of lead exceed the applicable cleanup levels in samples from the water table, shallow and intermediate sample intervals in the northwest corner of the North Field in Area 1 and in the northern portion of Area 2 extending into Area 3. Lead was also detected at concentrations above the cleanup level in the background wells, and in several other unrelated locations within Area 3. Similar to copper, the highest detected concentrations of lead were associated with direct push samples in Area 3, and thus, the lead concentrations detected in groundwater may be, at least in part, attributable to turbid samples. There are no apparent trends in lead concentration areally or with depth, suggesting that the lead detected in groundwater in Areas 1, 2, and 3 is associated with naturally occurring lead.

9.2.5.7 *Nickel*

Nickel was detected at concentrations exceeding the applicable cleanup level in groundwater from the water table and shallow sample intervals in Area 3. Nickel was not detected above applicable cleanup levels in these sample intervals in Areas 1 and 2 or in the intermediate sample interval. Nickel was detected at concentrations exceeding the cleanup level in several direct push groundwater samples collected from the water table and shallow sample intervals in the area between approximately 6th Avenue South and 2nd Avenue South and South Findlay Street and South Fidalgo Street. As nickel strongly sorbs to soil, the elevated concentrations detected at these locations may be associated with particulates suspended in the samples. As a result, the concentrations of nickel detected in groundwater throughout the area are likely associated with naturally occurring nickel.

9.2.5.8 *Silver*

In water, silver is typically found as the monovalent ion in the form of sulfate, bicarbonate, or sulfate salts; as part of more complex ions with chlorides and sulfates; and adsorbed to particulate matter (ATSDR, 1990). Silver was detected in groundwater in concentrations exceeding the cleanup level in the deep aquifer in monitoring wells CG-102-D, located in Area 3, and CG-104-D, located along the western edge of Area 2. Silver was not detected at concentrations above the cleanup level in groundwater in the water table, shallow or intermediate aquifer, and thus, the elevated concentrations detected in the deep aquifer are likely to be associated with naturally occurring silver.

9.2.5.9 *Zinc*

Zinc was detected in groundwater in concentrations exceeding the cleanup level in the shallow sample interval and deep aquifer. Zinc concentrations in the shallow sample interval exceeded the cleanup level at several sampling locations in Area 3 including F13 near the intersection of 6th Avenue South and South Orcas Street and K21 near the intersection of 2nd Avenue South and South Mead Street. Zinc was also detected at concentrations exceeding the cleanup level in several deep aquifer monitoring wells.

9.2.6 Summary of the Extent of COPC-Impacted Groundwater

BTEX, chlorinated ethenes, chlorinated ethanes, chlorinated methanes, ketones, aromatic VOCs, PAHs, phenols, PCBs and inorganics were detected in groundwater at concentrations exceeding applicable cleanup levels. The majority of the exceedances of cleanup levels were limited to Areas 1 and 2 and the eastern-most part of Area 3 in the water table, shallow and intermediate sample intervals and deep aquifer. Chlorinated ethenes were detected at concentrations exceeding the applicable cleanup levels at a number of sample locations across Area 3 in the water table and shallow sample intervals. Similarly, 1,4-dioxane was detected in the shallow sample interval in Area 3 at concentrations exceeding the applicable cleanup level. In the intermediate sample interval in Area 3, only vinyl chloride and 1,4-dioxane were detected at concentrations exceeding the applicable cleanup levels. The concentrations of most inorganic COPCs detected in groundwater in Areas 1, 2, and 3 appear to be associated with naturally occurring sources.

9.3 *Fate and Transport of Dissolved COPCs*

There are a number of factors, including chemical-physical properties, local geochemical conditions, local hydrogeological conditions and natural attenuation processes, that influence the migration of groundwater COPCs within the RI Study Area. Each of these factors is discussed in detail in this section.

9.3.1 Physical Properties of COPCs

The migration of constituents is influenced by their physical properties such as water solubility, affinity for partitioning to vapor phase, and affinity for partitioning to soil. Movement of chemicals through the vadose and saturated zones is primarily a liquid-phase process involving water movement and the dissolved chemical or solute. Sorption is the removal of the solute from a solution through electrostatic or chemical interactions with a solid surface (Srinivasan and Mercer, 1987). Sorption can occur as a result of the affinity of the solute for the solid, or the lack of affinity of the solute for the solution. The lack of a solute's affinity for water is termed *hydrophobicity* and is typified by many non-polar organic compounds. Hydrophobic chemicals adsorb readily to soil organic matter and clay particles and will not migrate significantly from the region of initial introduction into the soil profile until all sorption sites are occupied. The rate of migration of hydrophobic chemicals dissolved in groundwater is also slowed by sorption to soil, retarding the velocity of the chemical in relationship to the groundwater velocity. The adsorption or distribution coefficient (K_d) is the ratio of the adsorbed concentration of a COPC to its dissolved concentration (Dragun, 1988). Thus, chemicals with a large K_d value will be sorbed to a greater extent than chemicals with low K_d values. For organic molecules, K_d is the product of the soil-organic carbon partition coefficient (K_{oc}) and the fraction organic carbon content of the soil (f_{oc}).

Some constituents dissolved in groundwater may also volatilize into soil gas. The tendency of a constituent to exist in vapor phase as opposed to liquid phase is described by the Henry's Law constant. A discussion of COPCs detected in soil gas, indoor air, and ambient air is presented in Section 10.

Table 9-1 presents a summary of the chemical physical properties, including water solubility, Henry's Law constants and K_{oc}, for the COPCs identified in groundwater. Several COPCs, including bis(2-ethylhexyl)phthalate and PCBs, have low water solubilities and high affinities for soil. These COPCs are not expected to migrate beyond their current distribution in groundwater in the RI Study Area.

9.3.2 Geochemical Conditions

The migration and fate of a number of constituents is influenced by the prevailing geochemical conditions in groundwater at different depths in different areas. In particular, changes in pH and redox conditions may result in the mobilization, precipitation or biodegradation of certain constituents. For example, some inorganic constituents can be mobilized under reducing conditions but this mobilization can be limited by precipitation with other ionic species present in natural waters. Copper and nickel are more mobile at low pH while cyanide is more mobile at high pH. In addition, the biodegradation of several key COPCs, such as highly chlorinated ethenes, occurs primarily under reducing conditions.

Microbes are responsible for the series of reactions that affect groundwater geochemistry. Like many organisms, microbes obtain energy required for growth and activity by facilitating a series of coupled oxidation and reduction reactions, collectively described as reduction/oxidation (redox) reactions. Redox reactions involve the transfer of electrons from electron donor compounds to electron acceptor compounds, resulting in the release of energy and can only occur with a sufficient supply of both electron acceptor and electron donor reactions. Dissolved oxygen is the most favored electron acceptor, but a number of other constituents, including nitrate, ferric iron (Fe(III)), manganese (Mn(IV)), sulfate and carbon dioxide can also be utilized as electron acceptors. In the absence of dissolved oxygen or at very low levels of dissolved oxygen (<1 milligrams per liter [mg/L]), other electron acceptors are utilized. First in the sequence is manganese oxide (MnO_2 (s)) where Mn(IV) is reduced to Mn(II), a very soluble species. After this, the ferric/ferrous iron couple (Fe (III)/Fe (II)) is utilized where, typically, an iron hydroxide ($Fe(OH)_3$ (s)) is converted to Fe (II), which is also a very soluble species. In strongly reducing environments, sulfate is then reduced to sulfide. Once the strongly reducing environment imposed by Fe and sulfate reduction occurs, methanogenic (fermentation) conditions are created in which organic matter is converted to methane instead of carbon dioxide and water. If sulfate is reduced to sulfide, metal sulfides can form generally resulting in very low detected concentrations of the metals in question in groundwater. The geochemical environment is often referred to as aerobic, referring to conditions in which dissolved oxygen has not been depleted, or reducing, referring to conditions in which various electron acceptors have been depleted.

Geochemical conditions are of particular importance for the mobility of metals and metalloids. The solubility of metals is typically controlled by sorption reactions on manganese and iron oxides, both of which are redox sensitive solid phases common in all soils and rocks. Under aerobic conditions, Fe and Mn exist almost exclusively as the respective oxides. Iron and manganese oxides are known to be the solids to which most metals sorb. In fact, arsenic and selenium are almost always associated with iron and manganese oxides. When reducing conditions are encountered, Mn and Fe are reduced to the (II) valence state causing the solid phase to effectively dissolve. In doing so, they release the metals sorbed to the former solids. However, if sulfide reduction occurs under very strongly reducing conditions, then metal sulfide can form, which will greatly reduce their solubility.

The geochemical conditions in groundwater in the water table, shallow and intermediate sample intervals and deep aquifer is described in the following subsections. The description of the geochemical environment was based on the evaluation of a number of water quality parameters, the collection of which described in Section 4. These parameters include redox potential, dissolved oxygen, nitrate/nitrite, Fe(III)/Fe(II), Mn(IV)/Mn(II), sulfate/sulfide, carbon dioxide, and methane. Dissolved oxygen levels less than 0.5 mg/L, redox potentials of less than 750 millivolts (mV), and the presence of reduced species such as nitrite, Fe(II), Mn(II), sulfide, and methane indicate an anaerobic or reducing environment (Wiedemeier et al., 1999). Groundwater geochemistry is described in more detail in Appendix 9C.

The description of the geochemical environment was based on the evaluation of a number of water quality parameters rather than consideration of a single analysis/measurement. Groundwater geochemistry is complex and the scale on which the reactions occur is different than that on which samples are collected. For example, the redox potential measured for a groundwater sample presents the average or dominant conditions within the well area, although reactions associated with multiple redox potentials may be occurring within microsites within the area sampled. The biodegradation of organic COPCs is discussed in more detail in Section 9.3.4.

9.3.2.1 *Water Table Sample Interval*

The geochemical data and water quality parameters indicate that the water table sample interval is generally an anaerobic environment with an area of stronger reducing conditions in Areas 1 and 2 and the easternmost part of Area 3 to approximately 6th Avenue South. This area of strong reducing conditions coincides with the areas where the highest concentrations of COPCs are present. In addition, an area of stronger reducing conditions also appears to be present in the westernmost part of Area 3, near the Duwamish Waterway. The strong reducing conditions are indicated by the presence of reduced iron (Fe(II)), sulfide, and methane and the depletion of nitrate, sulfate, and dissolved oxygen. The central portion of Area 3 and the area upgradient, or east, of Area 1 appear to be only mildly anaerobic.

9.3.2.2 *Shallow Sample Interval*

The geochemical data and water quality parameters in the shallow sample interval indicate that anaerobic conditions exist throughout Areas 1, 2, and 3 as supported by average redox potential measurements below 100 mV. The other geochemical data that support a reducing environment include the depletion of nitrate and sulfate, and production of ferrous iron, sulfide and methane. The distribution of methane indicates extremely strong reducing conditions between the facility and approximately 3rd Avenue South, possibly to the Waterway.

9.3.2.3 *Intermediate Sample Interval*

Groundwater geochemical parameters indicate that groundwater in the intermediate sample interval throughout Areas 1, 2 and the eastern portion of Area 3 is strongly anaerobic, with an area of stronger reducing conditions in Areas 1, 2 and in the eastern part of Area 3. The strong reducing conditions are indicated by the depletion of nitrate and sulfate and the production of methane. The highest methane concentrations were detected in the eastern portion of Area 3 between Denver Avenue South and South Maynard Street, beyond the western extent of the PSC plume. The concentrations of other metabolic byproducts, including methane and carbon dioxide, are similar in the plume area and in the background monitoring wells, indicating that the reducing conditions detected in the intermediate sample interval are related at least in part to natural conditions in the interval.

9.3.2.4 *Deep Aquifer*

The geochemical data indicate that the environment appears to be strongly anaerobic based on redox potential measurements and the production of methane. However, the reducing conditions do not appear to be correlated with COPC concentrations, and are likely solely attributable to the degradation of natural organic matter in the aquifer. These reducing conditions result in the reduction and natural mobilization of metals such as arsenic; however, these same metals may also appear to precipitate from solution in areas with sufficient sulfide concentrations. Chloride concentrations in the deep aquifer are higher than those measured in the overlying sample interval as a result of naturally brackish water in this aquifer, as described in Section 6. The elevated chloride concentrations are likely resulting in the formation of soluble chloro-complexes with some metals.

9.3.3 Influence of Local Hydrogeologic Conditions on Plume Migration

As discussed in Section 3, the subsurface aquifer materials consist of fill and sand in the shallow aquifer grading to interbedded sands and silts in the intermediate aquifer. The occurrence of interbedded silts tends to increase with depth. The interbedded silts range from thin stringers

only several inches thick to lenses that may be several feet thick. The stringers and lenses do not appear to be continuous across the facility or area, but still may have a significant impact on the migration of constituents through the subsurface. In addition, as discussed in Section 3, no strong or consistent vertical hydraulic gradients have been observed in the RI Study Area.
As discussed in Section 3, utility corridors are not likely to be significant pathways for preferential migration. In addition, the area of the former river channel is not considered to be a preferential pathway for contaminant migration. The distributions of COPCs in groundwater in the water table sample interval do not suggest that any preferential flow pathways exist in the RI Study Area.

9.3.4 Influence of Natural Attenuation on Plume Migration

Although many COPCs have been detected at concentrations exceeding cleanup levels in groundwater in the water table, shallow, and intermediate sample intervals in Areas 1 and 2, the concentrations of these COPCs detected in Area 3 just downgradient of Areas 1 and 2 are typically significantly lower, or not detected. The downgradient reduction in concentrations of biodegradable COPCs is clearly attributed to natural attenuation. Natural attenuation is defined as "naturally occurring processes in the environment that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants" (Waters et al., 1998) and includes both non-destructive processes, such as dilution, dispersion, sorption, and volatilization and destructive processes such as biodegradation and abiotic transformations. A detailed discussion of natural attenuation processes and the occurrence of natural attenuation in groundwater in Areas 1, 2, and 3 is presented in Appendix 9C. This section presents a brief summary of the influence of natural attenuation on the fate and transport of impacted groundwater.

Non-destructive processes such as dilution, dispersion, sorption to aquifer materials, and at the water table, volatilization, occur as COPCs are transported in groundwater. While the non-destructive natural attenuation processes act to reduce concentrations, they do not reduce the overall COPC mass. Biodegradation, the process by which organic compounds are broken down into simpler compounds by naturally occurring microorganisms, is an important process acting to reduce concentrations of many organic COPCs in the RI Study Area.

Biodegradation is clearly reducing concentrations of BTEX and other petroleum related COPCs and chlorinated ethenes, ethanes, and methanes in groundwater in the water table, shallow, and intermediate sample intervals at the facility, and in the surrounding area, as well. Active biodegradation is indicated by the following evidence:

- Decreases in concentration of a parent COPC over time;
- Geochemical conditions indicating depletion of electron acceptors and reducing conditions;
- Production of breakdown products in the areas where COPCs are present; and
- Confirmation of the presence of microorganisms capable of degrading the COPCs that are present.

Petroleum hydrocarbons degrade into water and carbon dioxide or methane, which are also produced during the biodegradation of other organic COPCs and as a result, the biodegradation of petroleum hydrocarbons cannot be demonstrated through the presence of breakdown products. Chlorinated ethenes, ethanes, and methanes biodegrade as follows:

- PCE → TCE → cis 1,2-DCE, trans 1,2-DCE, and/or 1,1-DCE (collectively referenced as DCE isomers herein) → vinyl chloride → ethene → ethane;
- 1,1,1-TCA →1,1-DCA→ chloroethane → acetic acid or ethane;

- Carbon tetrachloride → chloroform → methylene chloride → chloromethane → methane;
- 1,2-DCA → chloroethane → acetic acid or ethane.

Vinyl chloride can degrade either through direct aerobic oxidation to carbon dioxide or by reductive dechlorination to ethene under sulfate-reducing and methanogenic conditions. Chloroethane has been shown to rapidly degrade abiotically by hydrolysis to acetate, and thus, is not likely to undergo biodegradation (EPA, 1998). Chloroethane may be reductively dechlorinated to ethane under sulfate-reducing and methanogenic conditions but the rate of this reaction is very slow. The more highly chlorinated COPCs degrade more readily under anaerobic conditions while the lesser chlorinated COPCs degrade more quickly under aerobic conditions.

The following subsections describe the natural attenuation processes that are occurring in each sample interval in the RI Study Area.

9.3.4.1 *Water Table Sample Interval*

In Areas 1, 2, and 3, BTEX and other petroleum related COPCs (Figures 9-7 through 9-10 and 9-40) and chlorinated ethenes (Figures 9-18 through 9-21), ethanes (Figures 9-30 and 9-31), and methanes have been detected at concentrations exceeding applicable cleanup levels in groundwater in the water table sample interval. The concentrations of these COPCs have not exhibited any distinct decreasing trends over time, as presented in Appendix 5B, and thus, do not confirm that biodegradation is occurring. However, the isoconcentration maps indicate a general decrease in the concentrations of both parent and degradation products in the direction of groundwater flow away from the assumed sources, discussed in more detail in Section 9.5, throughout the RI Study Area, indicating that the concentrations are attenuating. Furthermore, the presence of degradation products, such as cis-1,2-DCE and vinyl chloride (Figures 9-20 and 9-21), provide clear evidence that biodegradation is one of the natural attenuation processes reducing COPC concentrations.

Groundwater geochemical data from the water table sample interval, summarized and presented graphically in Appendix 9C, indicate moderately reducing conditions in Areas 1 and 2, with an area of stronger reducing conditions in the easternmost part of Area 3, and returning to moderately reducing conditions in most of the remainder of Area 3. Although the biodegradation of petroleum hydrocarbons cannot be demonstrated through the presence of breakdown products, reducing conditions and depletion of nitrate and Fe(III) in areas of elevated concentrations of petroleum hydrocarbons indicates that biodegradation is occurring. The complete biodegradation of chlorinated ethenes, ethanes, and methanes to ethene and ethane is also likely occurring in the water table sample interval as ethene and ethane were detected in groundwater in both Areas 1 and 2 and the eastern portion of Area 3. The distribution of ethene and ethane in the water table sample interval suggests that the northern portion of the chlorinated ethene groundwater plume emanating from Areas 1 and 2 in the water table sample interval has stabilized and may be shrinking. Biodegradation of chlorinated COPCs is likely occurring to the west of 5th Avenue South in Area 3 as the elevated concentrations of vinyl chloride were detected in the same areas as elevated concentrations of TCE.

The presence of halogen-respiring microorganisms in groundwater collected from the water table sample interval was documented using gene-probe assays. The results of these assays, presented in Appendix 9C, provide data in support of the presence of biota capable of driving the reductive dechlorination process. No evaluation of petroleum-degrading biota was performed for the RI; however, numerous studies have reported that petroleum hydrocarbon-degrading microorganisms are ubiquitous in the subsurface environment (Wiedemeier et al., 1999).

These data clearly indicate that natural attenuation processes, including biodegradation, are acting to reduce the concentrations and mass of BTEX and petroleum hydrocarbons, and chlorinated ethenes, ethanes, and methanes in the water table sample interval.

9.3.4.2 *Shallow Sample Interval*

In the shallow sample interval, chlorinated ethenes (Figures 9-22 though 9-25), ethanes (Figures 9-32 and 9-33), and methanes have been detected at concentrations exceeding applicable cleanup levels in groundwater in Areas 1, 2, and 3 while elevated concentrations of BTEX (Figures 9-11 through 9-14) and petroleum hydrocarbons are limited to Areas 1 and 2. As in the water table sample interval, the concentrations of these COPCs have not exhibited any distinct decreasing trends over time, as presented in figures in Appendix 5B, and thus, do not confirm that biodegradation is occurring. However, the isoconcentration maps indicate a general decrease in the concentrations of both parent and degradation products in the direction of groundwater flow throughout the RI Study Area, indicating that the concentrations are attenuating. Furthermore, the presence of degradation products, such as cis-1,2-DCE and vinyl chloride, provide clear evidence that biodegradation is one of the natural attenuation processes reducing COPC concentrations.

Groundwater geochemical data from the shallow sample interval, summarized and presented graphically in Appendix 9C, indicate reducing conditions across Areas 1, 2, and 3. Methane production indicates extremely strong reducing conditions between the facility and approximately 3rd Avenue South. Reducing conditions and depletion of nitrate and Fe(III) in areas of elevated concentrations of petroleum hydrocarbons suggests that biodegradation of petroleum hydrocarbons is occurring. The complete biodegradation of chlorinated ethenes, ethanes, and methanes is also likely occurring in the shallow sample interval as ethene and ethane were detected in groundwater. Ethane was detected in Area 2 west to at least 4th Avenue South in Area 3 while ethene was detected downgradient of 5th Avenue South to East Marginal

Way South. Vinyl chloride was detected in the same area of the shallow sample interval as ethene suggesting that the ethene is directly related to the biodegradation of vinyl chloride. The distribution of vinyl chloride, ethene, and ethane in the shallow sample interval indicate that the area of elevated vinyl chloride concentrations west of 4th Avenue South may be attributed to a different source than that originating in Area 1. The chlorinated ethene plume emanating from Area 1 and 2 has already undergone nearly complete reductive dechlorination to ethane as a result of the strong reducing conditions in this area, confirmed by the co-existence of elevated ethane and methane concentrations in the area between the Area 2 and 3rd Avenue South. The area of elevated vinyl chloride concentrations west of 4th Avenue South is currently undergoing biodegradation based on the co-located occurrence of ethene. However, despite strong reducing conditions indicated by the production of methane, complete reductive dechlorination is just beginning to the west of 4th Avenue South, as indicated by the presence of vinyl chloride and the relatively low concentrations of ethane in this area. These data indicate that the introduction of chlorinated ethenes to the shallow sample interval west of 4th Avenue South may have occurred more recently than the release from Area 1.

Although no gene-probe assays were conducted on groundwater from the shallow sample interval, this interval is hydraulically connected to the water table and intermediate sample intervals where the presence of halogen-respiring microorganisms was confirmed. Therefore, it is assumed that halogen-respiring organisms are also present in groundwater in the shallow sample interval. Petroleum hydrocarbon-degrading microorganisms are also assumed to be present in the intermediate sample interval owing to their ubiquity in subsurface environments. These data clearly indicate that natural attenuation processes, including biodegradation, are acting to reduce the concentrations and mass of BTEX and petroleum hydrocarbons, and chlorinated ethenes, ethanes, and methanes in the shallow sample interval.

9.3.4.3 *Intermediate Sample Interval*

In the intermediate sample interval, chlorinated ethenes (Figures 9-26 through 9-29) have been detected at concentrations exceeding applicable cleanup levels in groundwater in Areas 1, 2, and 3 while elevated concentrations of BTEX (Figures 9-15 through 9-17) and petroleum hydrocarbons and chlorinated ethanes and methanes are limited to Areas 1 and 2. As in the water table sample interval, the concentrations of these COPCs have not exhibited any distinct decreasing trends over time, as presented in figures in Appendix 5B, and thus, do not confirm that biodegradation is occurring. However, the isoconcentration maps indicate a general decrease in the concentrations of both parent and degradation products in the direction of groundwater flow throughout the RI Study Area, indicating that the concentrations are attenuating. Furthermore, the presence of degradation products, such as cis-1,2-DCE and vinyl chloride, provide clear evidence that biodegradation is one of the natural attenuation processes reducing COPC concentrations.

Groundwater geochemical data from the intermediate sample interval, summarized and presented graphically in Appendix 9C, indicate reducing conditions across Areas 1, 2, and 3, with the most reducing conditions centered in Area 2 and the eastern-most edge of Area 3. This most strongly reducing area corresponds to the area where BTEX, TCE and vinyl chloride were detected in the intermediate sample interval and the area of the highest ethene concentrations. Ethane was also detected in this area and also extending westward to at least 6th Avenue South. The highest concentrations of ethane, which coincide with the highest detected concentrations of methane, were located just downgradient of the highest concentrations of ethene suggesting that the ethane is likely a degradation product of the upgradient ethene plume. Ethene, ethane, and methane were detected at elevated concentrations in the eastern part of Area 3 but no data are available for intermediate sample interval wells to the west.

The presence of halogen-respiring microorganisms was confirmed in groundwater in the intermediate sample interval. Petroleum hydrocarbon-degrading microorganisms are also assumed to be present in the intermediate sample interval due to their ubiquity in subsurface environments.

These data clearly indicate that natural attenuation processes, including biodegradation, are acting to reduce the concentrations and mass of BTEX and petroleum hydrocarbons, and chlorinated ethenes, ethanes, and methanes in the shallow sample interval.

9.3.4.4 *Deep Aquifer*

Petroleum hydrocarbons, chlorinated ethanes and chlorinated methanes were detected only sporadically, and thus, natural attenuation evaluations were not performed for these compound classes. Low concentrations of TCE and vinyl chloride have been detected in groundwater samples collected from monitoring wells CG-102-D and CG-104-D, but the available data do not indicate a consistent trends over time. The geochemical data indicate that the environment appears to be strongly reducing as a result of natural conditions, and thus, highly conducive to biodegradation of chlorinated ethenes.

9.3.4.5 *Summary*

Biodegradation of both petroleum related COPCs and chlorinated solvent COPCs, is occurring in the water table, shallow, and intermediate sample intervals in Areas 1, 2, and 3. Biodegradation appears to be limiting the migration of most petroleum hydrocarbons from the area beyond approximately Maynard Avenue South in the water table sample interval and beyond Area 2 in the shallow[7] and intermediate sample intervals. As they are biodegradable under a variety of geochemical conditions, petroleum hydrocarbons in groundwater in the water table, shallow, and intermediate sample intervals will likely continue to biodegrade in the future.

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[7] Benzene was detected above applicable cleanup levels in the shallow sample interval as far west as 5th Avenue S.

Conditions are also conducive to the biodegradation of chlorinated solvent COPCs in the water table, shallow, and intermediate sample intervals in Areas 1, 2, and 3. In the water table and shallow sample intervals, biodegradation is clearly limiting the migration of chlorinated solvent COPCs and their breakdown products into Area 3 at significant concentrations. The conditions for continued COPC biodegradation exist in Area 3. Biodegradation is also limiting the migration of chlorinated ethenes from Area 2 in the intermediate sample interval. Biodegradation products of chlorinated ethenes, ethanes and methanes have also been detected in areas where no petroleum-related compounds have been detected, suggesting that the biodegradation of chlorinated compounds is not dependent upon the presence of petroleum – related compounds.

The chlorinated COPCs detected in the western half of Area 3 are also biodegrading. Cis-1,2-DCE and vinyl chloride have been detected with and just downgradient of most areas where TCE is detected at elevated concentrations. In addition, ethene has been detected in all three sample intervals in the western half of Area 3 suggesting that complete reductive dechlorination is occurring.

9.4 *Groundwater Plumes*

The aerial and vertical distribution of COPCs detected in groundwater and an analysis of fate and transport characteristics of these COPCs indicate that there are a number of sources of COPC-impacted groundwater in the RI Study Area, including but not limited to releases from the facility. These other sources are located upgradient, cross-gradient, and downgradient of the facility and have resulted in groundwater plumes that are either completely separate from or co-mingled with the groundwater plume emanating from the PSC facility. This section describes the areas where additional, non-PSC sources of impacted groundwater and associated groundwater plumes likely exist. These plumes are being identified in this report per WAC 173-340-300 which provides guidelines for reporting a release of hazardous substance. In addition, the presence of additional sources must be considered in order to develop a scientifically defensible conceptual model of the nature and extent of COPC-impacted groundwater associated with releases from the facility.

The approximate areal distribution of the plumes is shown on Figure 9-51. For the purposes of this evaluation, a "source" is defined as the point of release of one or more contaminants and a "plume" is defined as the extent that one or more contaminants exceed their respective cleanup levels in groundwater both areally and vertically. Distinct plumes were identified based on the consideration of a number of factors including the horizontal and vertical distribution of groundwater COPCs, the distribution of parent compounds and degradation products, groundwater geochemistry, and groundwater flow patterns.

9.4.1 PSC Plume

The PSC plume appears to have been well defined and is described in this section. The groundwater plume migrating from Area 1 in the water table sample interval is migrating in 2 parts, referred to as the North and South PSC Plumes, shown in Figure 9-51. The North PSC Plume includes the area west of Denver Avenue that is impacted by COPCs emanating from the northern portion of Area 1. The boundary between the North PSC Plume and the South PSC Plume is approximately the mid-point between monitoring wells CG-112 and CG-113. The part of the North PSC plume that contains COPCs at concentrations exceeding cleanup levels appears to extend to just past 6th Avenue South to the west in the water table sample interval, as shown in Figure 9-5. The COPCs that were detected above their respective cleanup levels in the water table sample interval in the North PSC Plume include the chlorinated ethenes PCE, TCE, and vinyl chloride; benzene, toluene and ethyl benzene; and the alkenes n-propylbenzene, 1-methylnaphthalene, and n-hexane.

The South PSC Plume includes the area west of Denver Avenue that is impacted by COPCs emanating from the southern portion of Area 1. The parts of the South PSC plume that exceed cleanup levels appear to extend just past Maynard Avenue South on the west in the water table sample interval, as shown in Figure 9-4. The COPCs that were detected above their respective cleanup levels in the water table sample interval in the South PSC Plume include the chlorinated ethenes, TCE and vinyl chloride; the chlorinated ethanes 1,1,1-TCA and 1,1-DCA; and naphthalene.

In the shallow and intermediate sample intervals, the PSC plume is thought to extend as far west as approximately Maynard Avenue South, as shown in Figures 9-4 and 9-5. The COPCs that were detected above their respective cleanup levels in the PSC Plume area in the shallow and intermediate sample intervals include chlorinated ethenes, and ethanes, petroleum-related compounds, and several inorganic constituents. The only COPCs in the part of the PSC plume that has migrated into Area 3 include TCE and vinyl chloride in the shallow sample interval and vinyl chloride in the intermediate sample interval.

Natural attenuation appears to be currently limiting the migration of volatile COPCs in groundwater from Areas 1 and 2 and has likely been acting since shortly after the releases to reduce COPC concentrations and limit the migration from these areas. A fate and transport model based on the Domenico analytical solution (EPA, 2002) was used to estimate the likely distribution of volatile COPCs in groundwater in Area 3 based on different confirmed and assumed sources and the biodegradation rates observed at the site and in the surrounding area. Details of the modeling are presented in Appendix 9D.

COPC-impacted groundwater has been detected downgradient of, and separate from, the likely current extent of the groundwater plume associated with releases from the facility., The potential for this area of impacted groundwater to be a detached plume originating at the facility was considered. Typically, VOC concentrations decrease with distance from the original source location. However, under some conditions, it may be possible for higher concentrations of VOCs to be present at a downgradient location within the plume area between the source and the distal portion of the plume. Detached plumes of parent compounds such as TCE and PCE do not arise with a continuous source, such as the DNAPL that is believed to be present in Areas 1 and 2.

The potential for a detached plume to exist in Area 3 from a finite source, such as a pulsed release, was evaluated using the computer model, BIOCHLOR (EPA, 2002), based on the Domenico analytical solution and described in detail in Appendix 9D. The model was used to estimate the concentration of selected VOCs with distance along a flow line downgradient from Area 1. The purpose of this evaluation was to assess the potential that certain discrete plumes present downgradient of Area 1 have developed from non-DNAPL (i.e. non-continuous source) releases from Area 1. This assessment was performed using the maximum detected concentrations of ethenes and ethanes in groundwater in Areas 1 and 2, and varying compound-specific decay rates (half -life).

Results of this evaluation indicate that a detached VOC plume (i.e., a "pulse" of dissolved COPC) will not develop downgradient of the PSC source area unless no biodegradation is occurring. If biodegradation occurs, even at a relatively slow rate, the BIOCHLOR modeling results indicate that a detached plume would not form downgradient of the source. When biodegradation is simulated, the modeling results show a decline in both parent and degradation products downgradient of the source, with no development of a detached plume. The evidence for biodegradation occurring in the RI Study Area is extremely strong, as presented in Appendix 9C, and therefore, the likelihood of a pulsed release is very low.

9.4.2 C7/D8 Plume

PCE and TCE were detected at concentrations above their cleanup levels in the water table sample interval (Figures 9-18 and 9-19) and to a limited extent in the shallow sample interval near sample locations C7 and D8 (Figures 9-22 and 9-23), southeast of the intersection of Maynard Avenue South and South Homer Street. In the water table sample interval, concentrations were approximately an order of magnitude higher than those detected at the closest upgradient sample location, B5B, on 7th Avenue South between South Findlay Street and South Homer Street. The source is located upgradient of borings C7 and D8. Concentrations of TCE and PCE were not detected above the reporting limit at the nearest up-gradient sample location, boring A3, and no confirmed sources of TCE and PCE are located upgradient of boring A3. The distribution of TCE and PCE in the C7/D8 plume is limited to the water table and shallow sample intervals. The limited vertical distribution of TCE and PCE suggests that this source was comprised of dissolved phase PCE and/or TCE, and was not a DNAPL release. However, TCE in this plume appears to extend toward the west into an area that may be impacted by the leading edge of the south arm of the PSC plume. As a result, this plume, referred to in this report as the C7/D8 Plume, is identified as a likely co-mingled plume.

9.4.2.1 *CG-128 Plume*

In the water table sample interval, concentrations of PCE slightly exceed the cleanup level at monitoring well CG-128-WT, as presented in Figure 9-18. PCE was not detected in a number of water table interval sample points upgradient of this location, including monitoring well CG-122-WT (<0.05 µg/L), directly upgradient. The relatively isolated distribution of PCE in this area indicates that a discrete source not related to releases from Area 1 is responsible for the concentrations of PCE detected at this location. The source of the PCE appears to be a nearby shallow release of dissolved-phase PCE, as the low concentrations and limited vertical distribution do not indicate that the source was DNAPL.

The concentrations of TCE in the water table sample interval at sample points upgradient of this plume are slightly lower than concentrations within the plume area, e.g., an average concentration of 0.38 µg/l at monitoring well CG-122-WT upgradient of the plume is less than 0.89 µg/l at monitoring well CG-128-WT. The modest difference between concentrations within the plume and those downgradient of sources in Area 1 is not definitive of a separate release of TCE at the CG-128 Plume area. The source of TCE at the CG-128 Plume could be a release near CG-128-WT, but could also be the result of the biodegradation of PCE at this location.

9.4.2.2 *I13/CG-131 Plume*

The distribution of COPCs in groundwater indicates the presence of plume in the vicinity of monitoring well CG-131-WT and sample location I13, referred in this report to as the I13/CG-131 Plume. The I13/CG-131 Plume in the water table sample interval is characterized by higher concentrations of TCE than those found upgradient of this area, and the presence of vinyl chloride, 1,1-DCA, and benzene at concentrations above applicable cleanup levels between 5th and 6th Avenues, north of South Orcas Street.

The distribution of VOCs in the water table sample interval suggests that at least two discrete sources are contributing VOCs to this plume. Both sources are likely located east of 6th Avenue South north of South Orcas Street. A source contributing benzene, 1,1-DCA, and vinyl chloride (or their parent compounds) is situated more to the north while a source contributing TCE and vinyl chloride is situated more to the southern portion of this area.

The distributions of benzene and 1,1-DCA follow the same pattern in the I13/CG-131 Plume area, which suggests that these two COPCs in the water table sample interval (Figures 9-7 and 9-31) may have originated from a common source. Both benzene and 1,1-DCA exceeded their respective cleanup levels only at borings I13 and SG-15 within the I13/CG-131 plume area. Elevated concentrations of vinyl chloride (Figure 9-21) are also associated with this source. The concentration of vinyl chloride in the water table sample interval at boring I13 was 104 µg/L, while the concentrations at borings upgradient of this boring (G10 and H9) were less than 1 µg/L, suggesting that the source may potentially be located between these sample locations. As a result, monitoring well CG-131-WT and boring H14 may be situated far enough to the south to not be affected by the source of benzene and 1,1-DCA in this area.

A source located upgradient of the monitoring well CG-131-WT area and possibly downgradient of monitoring well CG-127-WT is contributing elevated concentrations of TCE to the water table sample interval (Figure 9-19). As presented in Figure 9-4, the concentrations of breakdown products relative to parent compounds is significantly higher in this plume than in the upgradient C7/D8 plume, suggesting an older release than that from the C7/D8 plume. Higher relative concentrations of the TCE degradation products cis-1,2-DCE and vinyl chloride are associated with TCE released at this source compared to the low concentrations of cis-1,2-DCE and vinyl chloride present in the upgradient C7/D8 Plume (Figures 9-20 and 9-21). For example, the average concentration of vinyl chloride at monitoring well CG-131-WT (26.94 μg/L) and the concentration (93.9 μg/L) at boring SG15 in the I13/CG-131 Plume are one to nearly two orders of magnitude greater than the vinyl chloride concentrations at monitoring well CG-127-WT (1.66 μg/L) and boring F13 (less than 1 μg/L), respectively, in the C7/D8 Plume (Figure 9-21). Concentrations of all of the VOCs associated with this plume decrease vertically between the water table sample interval and shallow sample interval. The limited vertical distribution and relatively low concentrations of these COPCs suggests that the chlorinated ethenes and ethanes are not currently present at the source areas as DNAPL.

9.4.2.3 *CG-136/CG-137 Plume*

Chlorinated ethenes were detected at concentrations exceeding applicable cleanup levels in the water table sample interval at monitoring wells CG-136 and CG-137, and at nearby borings J20, J23, and I22. As shown in Figure 9-4,the concentrations detected in this area are clearly separate from the I13/CG-131 Plume located directly upgradient, and thus, were identified as a separate plume, referred to in this report as the CG-136/137 Plume. This plume appears to be partially co-mingled with another plume located to the north, the K19 plume. The composition of the CG-136/-137 Plume is distinct from the K19 Plume, discussed in Section 9.4.2.4, based primarily on the presence of concentrations of PCE above the cleanup level at monitoring well CG-136-WT, and the substantially lower concentrations of the TCE degradation products cis-1,2-DCE and vinyl chloride in the water table sample interval in the CG-136/137 plume compared with those in the K19 Plume.

The distribution of PCE and TCE in the water table sample interval suggests that two sources are contributing to CG-136/-137 Plume (Figures 9-18 and 9-19). One source appears to be located just upgradient of monitoring well CG-136-WT while the second source appears to be located upgradient of sample location I22 TCE was detected at a higher concentration at boring I22 than at monitoring well CG-137-WT suggesting that the plume center line may be closer to boring I22 than monitoring well CG-137-WT.

Concentrations of PCE above the cleanup level were only reported at monitoring well CG-136-WT in the vicinity of this plume which suggesting that a source of PCE is located at, or just upgradient of this sample point. Concentrations of TCE in the water table sample interval (Figures 9-4 and 9-19) decrease to less than 2 µg/l at borings SG15 and I17 downgradient of the I13/CG-131 Plume, then increase to an average concentration of 31.6 µg/l at monitoring well CG-136-WT. This is evidence that either the PCE released in this area is degrading to TCE, or that PCE and TCE were both released in this area. Concentrations of TCE increase by over an order of magnitude further downgradient to the southwest at monitoring well CG-137-WT and boring I22. The concentration of PCE at these sample points was less than the reporting limit. This substantial increase in the concentration of TCE, and lack of PCE, indicates that a second source is contributing TCE to the CG-136/-137 Plume at or upgradient of monitoring well CG-137-WT and boring I22. Unlike the I13/CG-131 Plume, the concentrations of TCE in the water table sample interval in the CG-136/-137 Plume area have not degraded substantially, based on the detected concentrations of vinyl chloride.

Concentrations of PCE exceeding the applicable cleanup level are limited in vertical and areal extent to the water table sample interval in the vicinity of monitoring well CG-136-WT. This limited distribution indicates that only dissolved phase PCE was released at this source. The vertical distribution of TCE extended into the shallow sample interval at monitoring well CG-136-40, but the low concentration of TCE at depth in the shallow sample interval does not clearly indicate a release of TCE DNAPL. However, in the shallow sample interval, elevated concentrations of cis-1,2-DCE (133 µg/L) were detected at boring I22 and vinyl chloride (58 µg/L) were detected at boring J23, indicating that TCE may have been present at this location or slightly upgradient in the past. Although TCE was not detected in the intermediate sample interval in this location, vinyl chloride was detected at location J23 (692 µg/L) at a concentration significantly greater than that located in the next upgradient sample, suggesting that a hot spot of TCE, and possibly a small amount of DNAPL, could also have been present in the intermediate sample interval at or upgradient of this location at one time.

The vertical distribution of TCE at boring I22 and its persistence at depth suggests that TCE as DNAPL may also have been released at a source upgradient of this sample point (Figure 9-23). Elevated concentrations of TCE were reported in the deepest reconnaissance groundwater sample collected at this boring at 32 feet bgs. The only nearby location sampled in the intermediate sample interval was boring J23 near monitoring well CG-137. The concentration of TCE was less than 1 ug/l at this boring in the intermediate sample interval (Figure 9-27). Because this boring is cross-gradient of the highest concentration of TCE in the shallow sample interval at boring I22, data from boring J23 does not exclude the potential for TCE as DNAPL to have been released at the source upgradient of boring I22.

9.4.2.4 *K19 Plume*

TCE and vinyl chloride were detected at sample locations K19 and K21 in the water table sample interval at concentrations exceeding their applicable cleanup levels. These concentrations are associated with another potential source, and are referred to in this report as the K19 Plume. This distinct plume, illustrated in Figure 9-5, is located south of the M13 Plume and includes borings K19 and K21.

The source of TCE for this plume in the water table sample interval may be located at or upgradient of boring K19 and possibly downgradient of boring J16. Elevated concentrations of TCE and the degradation products cis-1,2-DCE and vinyl chloride were detected in the shallow groundwater sample collected at boring K19 (Figure 9-5). As shown in Figure 9-5, this plume is discrete from the upgradient I13/CG-131 Plume and adjacent, cross-gradient CG-136/-137 Plumes both by chemical composition (e.g. concentrations of 1,1-DCA and PCE were not detected in the K19 Plume) and areal distribution of TCE.

The data indicate that the source consisted of dissolved phase TCE that is degrading to cis-1,2-DCE and vinyl chloride. TCE was only detected in the reconnaissance groundwater sample collected from the water table sample interval (12 ft bgs) at boring K19, which suggests that TCE as DNAPL was not released at this source. However, cis-1,2-DCE was detected at K19 at concentrations greater than the next upgradient sample at J15 and vinyl chloride was detected at both K19 (32.5 µg/L) and the next downgradient sample at K23 (597 µg/L). These data suggest that higher TCE concentrations may have been present in the shallow sample interval at one time. No samples were collected in this area from the intermediate sample interval.

9.4.2.5 *CG-106 Plume*

TCE and vinyl chloride (Figures 9-19 and 9-21) were detected at concentrations exceeding the cleanup levels in the water table sample interval upgradient of Area 1. In addition, concentrations of 1,1,1-TCA exceeded the applicable cleanup level in the water table sample interval at boring HC13 at the southeastern corner of Area 1 (Figure 9-30). These concentrations are clearly associated with another source, and are referred to in this report as the CG-106 Plume. The approximate location of this plume is provided in Figure 9-48.

The horizontal distribution of the chlorinated ethenes and ethanes indicates more than one source is responsible for the constituents in the CG-106 Plume. A source of the chlorinated ethenes in this plume is likely located at or upgradient (northeast) of monitoring well CG-106. Concentrations of 1,1,1-TCA exceeded the cleanup level in boring HC13 at the southeastern corner of Area 1 (Figure 9-31) suggesting that the origin of 1,1,1-TCA is a separate source upgradient of the PSC facility to the east-northeast.

The decrease in concentrations of TCE, vinyl chloride, and 1,1,1-TCA with depth at sample points within the CG-106 Plume area suggest that the release of chlorinated ethenes and ethanes to shallow groundwater was composed of dissolved PCE and/or TCE, and 1,1,1-TCA. The available data do not suggest a DNAPL source.

9.4.2.6 *CG-107 Plume*

Concentrations of GRO, toluene, ethylbenzene, and xylenes (Figures 9-40, 9-8, 9-9, and 9-10) above their respective cleanup levels were reported at monitoring well CG-107-WT. These results were consistent with those from groundwater reconnaissance samples collected from the water table sample interval by Ecology in this area in 2001 that indicated concentrations of ethylbenzene and xylenes were present above the cleanup levels (Ecology, 2002).

Concentrations of 1,2,4-trimethylbenzene (1,2,4-TMB) and 1,3,5-TMB were also detected in groundwater samples at CG-107-WT but at concentrations less than the cleanup levels. Toluene, ethylbenzene, 1,2,4-TMB, and 1,3,5-TMB were detected at concentrations less than 1 μg/L, and xylenes were present at concentrations less than 3 μg/L, in groundwater samples collected from monitoring wells CG-102 and CG-103. These two wells are located south of Areas 1 and 2 and between Area 1 and the CG-107 Plume area. This area is located southeast and cross-gradient of Area 1, and thus, is considered a distinct plume, referred to in this report as the CG-107 Plume.

The source(s) of this plume is located at or upgradient of monitoring well CG-107-WT and cross-gradient (east-southeast) of Area 1. There are limited data to assess the nature of the source of GRO, toluene, ethylbenzene, and xylenes because no samples were collected upgradient of monitoring well CG-107-WT due to limited access resulting from buildings and utilities.

9.4.2.7 *A8 Plume*

Concentrations of TCE and PCE exceeding their cleanup levels were detected in the water table sample interval in at sample location A8, near the intersection of 7th Avenue South and South Homer Street, almost directly south of Area 1, as presented in Figures 9-18 and 9-19. The distribution of TCE near sample location A8 is characterized by low concentrations (less than 10 µg/l) over a relatively large area encompassing the locations of six borings and monitoring well CG-132-WT. These concentrations are located south-southwest of Area 1 and outside Area 3, in an area that is outside of the flow path from Area 1, and thus, are considered to be a separate plume referred to as the A8 Plume.

A source of TCE to this plume is located at or upgradient of boring A8 near the corner of South Homer Street and 7th Avenue South. Also, there is a separate source of PCE located within the A8 Plume area, upgradient of boring D13 and monitoring well CG-132-WT. The source of PCE may also be contributing TCE, either mixed with the release of PCE or through the degradation of PCE. This scenario is suggested by the relatively elevated concentrations of TCE at borings D13 and C14 and monitoring well CG-133-WT compared to the concentrations at upgradient borings A9, B9, and B12.

The vertical distribution of TCE and PCE is limited to the water table sample interval. Samples from 30, 45, and 60 feet bgs were less than 1 µg/l TCE and PCE at borings A8 and D13, respectively. The limited vertical distribution of TCE and PCE suggests that both of these sources were dissolved phase TCE and PCE, and were not DNAPL releases.

9.4.2.8 *SG-13 Plume*

PCE and/or TCE were detected at concentrations exceeding the cleanup level in the water table sample interval at sample locations SG-13 and P17, near the intersection of 2nd Avenue South and South Findlay Street (Figures 9-18 and 9-19). Concentrations of TCE and PCE were not detected above the reporting limit at the nearest upgradient sample locations, borings P15 and

SG10. This area is considered to be a separate plume, referred to in this report as the SG-13 plume.

The SG13 Plume is located west of the M13 Plume, and includes borings P17 and SG13 and monitoring well CG-138 at the intersection of 2nd Avenue South and South Findlay Street. This plume is defined by concentrations of TCE and PCE exceeding their cleanup levels. Because of the limited number of locations sampled in the vicinity of this plume, the areal extent of this plume in the water table sample interval has not been well defined.

The vertical distribution of TCE and PCE is limited to the water table sample interval (samples from 30, 45, 60, and 75 feet bgs at boring P17 were less than 1 µg/L TCE and PCE). PCE and TCE are distributed differently in the water table sample interval in this area suggesting that there may be separate but close sources for each COPC. Since chlorinated ethenes were not detected in the SG-13 Plume area in the shallow sample interval, concentrations of vinyl chloride exceeding the cleanup level in the intermediate sample interval are likely the result of the degradation of TCE within the M13 Plume, discussed in Section 9.4.2.9, and migration downgradient in the intermediate sample interval to the SG-13 Plume area.

The location of the source(s) of this plume is not well defined. Concentrations of PCE above the cleanup level were only detected in one of the three sample locations within this plume, while concentrations of TCE above the cleanup level were reported at all three points (the average concentration of TCE at monitoring well CG-138 was less than the cleanup level, but concentrations exceeded the cleanup level at this monitoring well one of the four quarters sampled for the RI). The different distribution of PCE and TCE suggest that there may be separate, but close, source locations for each COPC. The nearest upgradient sample locations to the affected sample points are borings P15 and SG10, which are located 400 to 600 feet upgradient. PCE and TCE were not detected above the MRL at these borings, which suggests the source of TCE is between these two borings, and boring P17/monitoring well CG-138-WT.

The low to non-detect concentrations of PCE at boring P17 and monitoring well CG-138 suggest that the source of PCE is downgradient of these sampling locations, close to boring SG13. Alternatively, the distribution of PCE may be influenced by the degradation of PCE to TCE in the vicinity of the source, which has resulted in the reduction of concentrations of PCE within some areas of the plume.

The limited vertical distribution of TCE and PCE suggests that this source was dissolved phase TCE and PCE, and was not a DNAPL release. Furthermore, geochemical conditions and the lack of vinyl chloride in the water table interval at this location, suggest that the release is fairly recent, and has not biodegraded significantly.

9.4.2.9 *M13 Plume*

TCE was detected at a concentration of 8.82 µg/L in the water table sample interval at 15 ft bgs at sample location M13 near the intersection of 4th Avenue South and South Lucile Street and increased downgradient to 46 µg/L in the water table sample interval at 9 ft bgs at sample location N15 near the intersection of 3rd Avenue South and South Findlay Street. Concentrations were below detection limits (<1 µg/L) in samples collected from upgradient sample locations M9, J9, and N11 (Figure 9-19). In addition, the concentrations of cis-1,2-DCE in the water table sample interval increased along the flow path from concentrations near 1 µg/L to 6.17 µg/L at boring M13 and again to 27.9 µg/L at boring N15. Vinyl chloride was not detected in water table sample interval groundwater samples at these locations. These data indicate a separate source due to the increase in TCE and cis-1,2-DCE concentrations along the flow path in the water table sample interval, the shallow nature of the higher concentrations of constituents, and the absence of vinyl chloride with the elevated concentrations of TCE and cis-1,2-DCE, and suggest a recent release. This is referred to as the M13 plume in this report.

The data indicate that the source was dissolved phase TCE that has undergone some degradation to cis-1,2-DCE, but has not yet degraded to vinyl chloride since vinyl chloride is not present in the water table sample interval within the plume area. TCE was only detected in the reconnaissance groundwater samples collected from 9 and 15 feet bgs at borings N15 and M13, which suggests that TCE as DNAPL was not released at this source.

9.4.2.10 *Q32 Plume*

TCE, cis-1,2-DCE, and vinyl chloride were detected at concentrations exceeding applicable cleanup levels primarily in the shallow sample interval in the western portion of Area 3 along South Fidalgo Street west of East Marginal Way South, as shown in Figure 9-6. TCE and cis-1,2-DCE were not detected at sample locations directly upgradient, and thus, the concentrations detected in this area are considered to represent a discrete plume, referred to in this report as the Q32 plume.

The areal extent of COPCs in the Q32 Plume area is not well defined to the north and to the south. The nearest sample locations are over 500 feet to the northeast at borings P26, S24, and monitoring well CG-140; and over 700 feet to the north at boring V31 and monitoring well CG-144. Concentrations of TCE, cis-1,2-DCE, and vinyl chloride at these locations were less than their cleanup levels. No borings or monitoring wells were sampled south of the Q32 Plume.

The direction of groundwater flow in the vicinity of the Q32 Plume borings has not been confirmed, but is expected to trend towards the Duwamish Waterway in a slightly southwest direction. This area is tidally influenced, as discussed in Section 3.

The vertical extent of COPCs within the Q32 Plume appears to be limited to a zone between the base of the water table sample interval and the upper portion of the intermediate sample interval. Cross-section E – E' (Figure 9-6) is oriented east – west along South Fidalgo Street. This cross-section depicts the vertical distribution of TCE, cis-1,2-DCE, and vinyl chloride. Generally, groundwater at the top of the water-bearing zone contains COPCs at, and very close to, the source area. Thus, as the two most shallow reconnaissance groundwater samples at each of the

Q32 borings were not contaminated, the source affecting groundwater quality in this area is probably located to the northeast of the Q32 borings, but west of borings P26 and S24 and monitoring well CG-142-WT.

As the conditions for reductive dechlorination exist in the water bearing units in Area 3, the elevated concentrations of parent compounds (TCE) relative to degradation products cis-1,2-DCE and vinyl chloride suggest a relatively recent release located reasonably close to the sample locations. The elevated concentrations of chlorinated ethenes detected at this location clearly indicate a separate source of these compounds.

9.5 *Groundwater Modeling Evaluation*

As described in Section 2, PSC is in the process of installing a hydraulic barrier wall around the source area in Areas 1 and 2. The purpose of the wall is to prevent the further migration of COPC-impacted groundwater into Area 3. However, some COPCs have already migrated beyond the HCIM area, and may continue to migrate toward the Duwamish Waterway. To predict whether natural attenuation processes will reduce groundwater concentrations below groundwater cleanup levels protective of surface water at the groundwater–surface water interface, fate and transport modeling was conducted. The modeling, described in detail in Appendix 9D, addressed groundwater concentrations associated with four plumes:

- the PSC plume;
- the M13 plume;
- the K19 plume; and
- the CG-136/137 plume.

No predictive modeling was conducted to estimate future concentrations at the Q32 sampling location since this area is very close to the waterway and is not likely to be co-mingled with other plumes.

The modeling results for the PSC plume indicated that only arsenic and Aroclor 1016 might reach the groundwater–surface water interface at concentrations exceeding the applicable groundwater cleanup levels protective of surface water. However, the modeling did not take into account any retardation resulting from adsorption to soil; thus, even arsenic and Aroclor 1016 are unlikely to reach the Duwamish Waterway. As discussed in Section 7, PCBs, such as Aroclor 1016, have a strong affinity for soil and are expected to have extremely low mobility in the environment. Consequently, any Aroclor present in groundwater is likely to partition to soil within a short distance downgradient, and would not likely reach the Duwamish Waterway. As discussed in Sections 7 and 9.2.5.1, arsenic is mobile under moderately reducing conditions where sulfate is not being reduced. Since strongly reducing conditions are present in the PSC plume area in the shallow and intermediate sample intervals and deep aquifer, conditions for mobilization of arsenic appear to exist only in the water table sample interval. Even in the water table sample interval, moderately reducing conditions appear to be present only in the eastern part of Area 3. Any arsenic migrating from this area will likely be oxidized and precipitate from solution, and is not likely to reach the Duwamish Waterway. In addition, the prediction based on the concentrations in the PSC plume was based on current groundwater flow patterns and geochemistry, and thus, may not be representative of conditions following the installation of the HCIM.

The modeling results for both the K19 Plume and the CG-136/CG-137 Plume indicated that barium and copper concentrations associated with these plumes may reach the groundwater–surface water interface at concentrations exceeding the applicable groundwater cleanup levels protective of surface water. However, as discussed in Section 9.2, the concentrations of barium and copper may be associated with turbid water samples and naturally occurring metals. The modeling results for the M13 Plume indicated that no COPCs were predicted to reach the groundwater–surface water interface at concentrations exceeding the applicable groundwater cleanup levels protective of surface water.

The HCIM will likely have a significant effect on groundwater flow patterns, and thus, COPC fate and transport, in the area. However, the nature and extent of these effects cannot be estimated without monitoring data collected after the installation of the wall. PSC plans to monitor water levels and COPC concentrations in wells outside the barrier wall following the installation of the HCIM, and will evaluate the effects of the barrier wall on COPC migration based on this data.

9.6 *Uncertainties*

The nature and extent of COPC-impacted groundwater within the RI Study Area have been well defined. However, there are a number of uncertainties associated with the evaluation of the nature and extent of impacted groundwater based on the available groundwater analytical results. These uncertainties include the following.

- The presence or absence of DNAPL in the North Field of Area 1 and in Area 2 has not been confirmed. However, both areas are within the planned HCIM.
- The vertical and horizontal extent of most of the non-PSC plumes identified in the RI Study Area have not been defined.
- A limited number of groundwater samples have been collected from the lower portion of the intermediate sample interval, just above the silt aquitard, in the eastern most part of Area 3 to verify the aerial extent of the PSC plume in the intermediate sample interval.

- The source of the high vinyl chloride detection in shallow groundwater at reconnaissance boring J7 has not been verified. However, the nature and horizontal and vertical extent of the vinyl chloride has been defined in this area.

- Predictions of future groundwater flow patterns, and therefore, groundwater geochemistry and biodegradation processes, are uncertain because the flow patterns will be affected by the installation of the HCIM.

- The sources of the non-PSC plumes identified in this section are not known. Although considerable effort has been made by PSC to characterize these areas, it may not be possible to determine the source of these plumes without access to private properties and buildings for subsurface characterization.

- The assumptions used in the modeling, such as no retardation, are highly conservative and overestimate the concentrations and rate at which COPCs detected in groundwater may reach the Waterway.

These "data gaps" or uncertainties are not likely to have a significant effect on the outcome of the FS and RA. If additional information is needed during the FS, additional work will be conducted at that time. Data gaps are discussed further in Section 13.

9.7 *Summary and Conclusions of Groundwater Nature & Extent*

One of the primary objectives of the RI is to characterize the nature and extent of COPC-impacted groundwater associated with releases from the facility so that risks to human and environmental receptors can be evaluated in the risk assessment and so that remedial alternatives can be evaluated in the FS. The results of the numerous environmental investigations conducted by PSC in the RI Study Area have clearly defined the nature and extent of impacted groundwater associated with the releases from the PSC property.

BTEX, chlorinated ethenes, ethanes, methanes, SVOCs, and metals were identified as groundwater COPCs in the HHERA. However, only chlorinated ethenes, ethanes, methanes, BTEX and metals have been detected at concentrations above cleanup levels in Area 3.

The distribution of metals concentrations detected in groundwater in the RI Study Area indicates that the source of these metals is likely associated with naturally occurring sources, rather than a release from the facility. The mobility of several of the inorganic constituents identified as COPCs in groundwater is strongly influenced by groundwater geochemical conditions as several of these constituents, including arsenic and nickel, are present in more water-soluble species under strongly reducing conditions. Although reducing conditions are present in all of the identified sampling intervals, the strongest reducing conditions appear to be present in Areas 1 and 2 and in the easternmost part of Area 3. The distribution of arsenic indicates that any arsenic mobilized as a result of these strong reducing conditions appears to precipitate from groundwater as it migrates downgradient in Area 3 and before reaching the Duwamish Waterway.

Biodegradation is limiting the downgradient migration of organic COPCs in Areas 1, 2, and 3. Petroleum hydrocarbons, including BTEX, have migrated to approximately 5th Avenue South in the water table sample interval and just beyond area Area 2 in the shallow and intermediate sample intervals. Conditions in the water table sample interval are also conducive to the biodegradation of chlorinated ethenes, ethanes and methanes. In the water table and shallow sample intervals, biodegradation appears to be limiting the migration of chlorinated solvent COPCs and their breakdown products into Area 3. Conditions in Area 3 are conducive to the continued biodegradation of these COPCs. Biodegradation is also limiting the migration of chlorinated ethenes from Area 2 in the intermediate sample interval. Petroleum hydrocarbons and chlorinated VOCs in groundwater in the water table, shallow, and intermediate sample intervals will likely continue to biodegrade in the future.

The aerial and vertical distribution of COPCs detected in groundwater as part of this RI indicates that there may be a number of additional sources of COPC-impacted groundwater upgradient, crossgradient, and downgradient of the PSC Georgetown facility. These other sources have resulted in groundwater plumes that are either completely separate from or co-mingled with the groundwater plume emanating from Area 1. The evaluation of the potential fate and transport also indicates that impacted groundwater associated with releases at the facility does not extend downgradient beyond approximately 6th Avenue South. Furthermore, fate and transport modeling indicates that only arsenic and Aroclor 1016 concentrations associated with Area 1 could potentially reach the Duwamish Waterway at concentrations exceeding applicable cleanup levels based on the protection of surface water. However, the modeling was conducted using very conservative assumptions that likely overestimate the concentrations that may actually reach the Waterway. In addition, there may be impacts to the Duwamish Waterway associated with releases from other sources such as the source located near the sample location Q32.

The installation of the HCIM barrier wall will have a significant effect on groundwater flow patterns proximate to the wall and, therefore, will impact future migration of COPCs located outside and immediately downgradient of the wall.. However, the nature of the effects are not known at this time. PSC plans to monitor groundwater at selected locations outside the barrier wall in order to determine the changes in groundwater flow and COPC migration associated with the installation of the wall.

9.8 *References*

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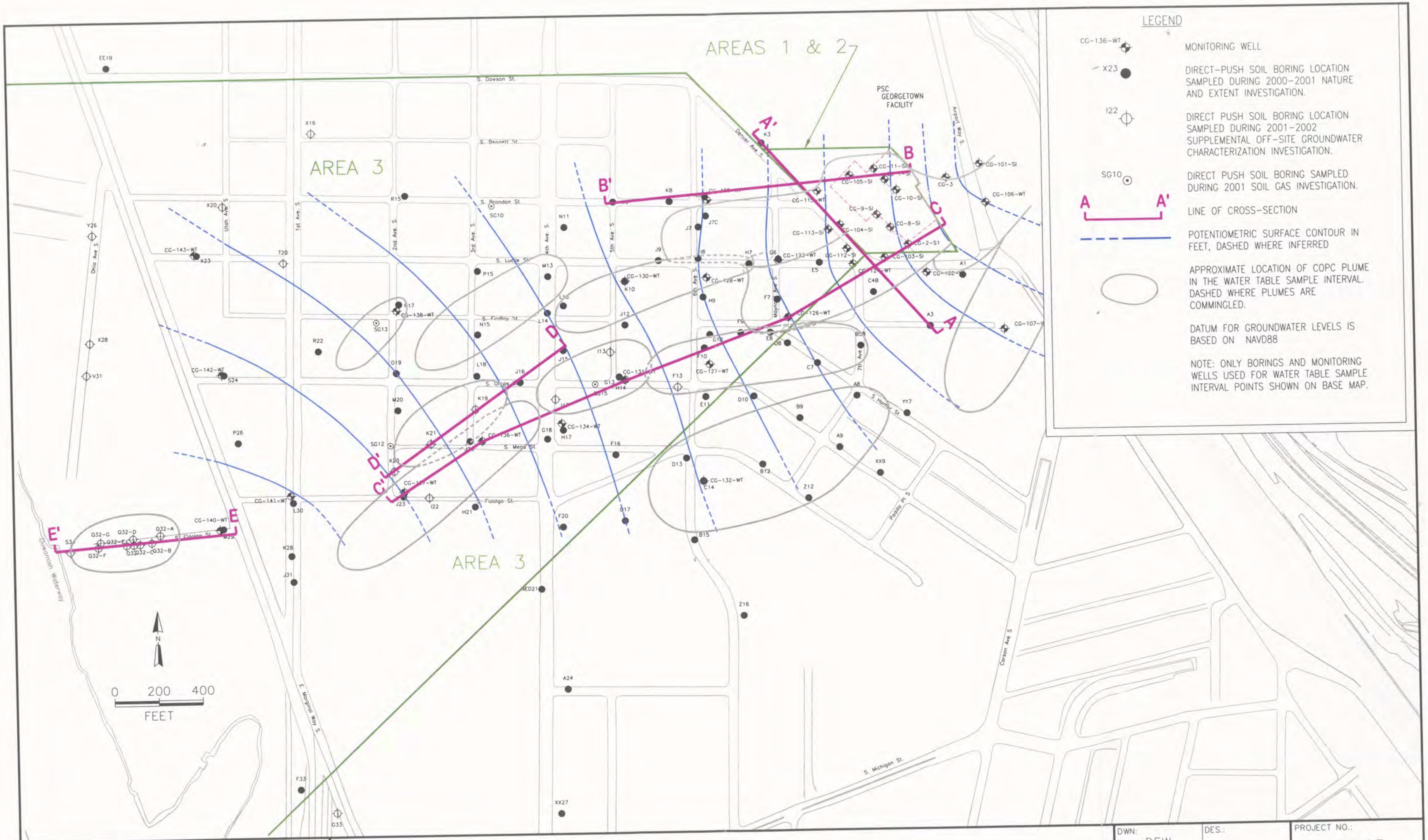


LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
SG10	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
A A'	LINE OF CROSS-SECTION
	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED
	APPROXIMATE LOCATION OF COPC PLUME IN THE WATER TABLE SAMPLE INTERVAL. DASHED WHERE PLUMES ARE COMMINGLED.

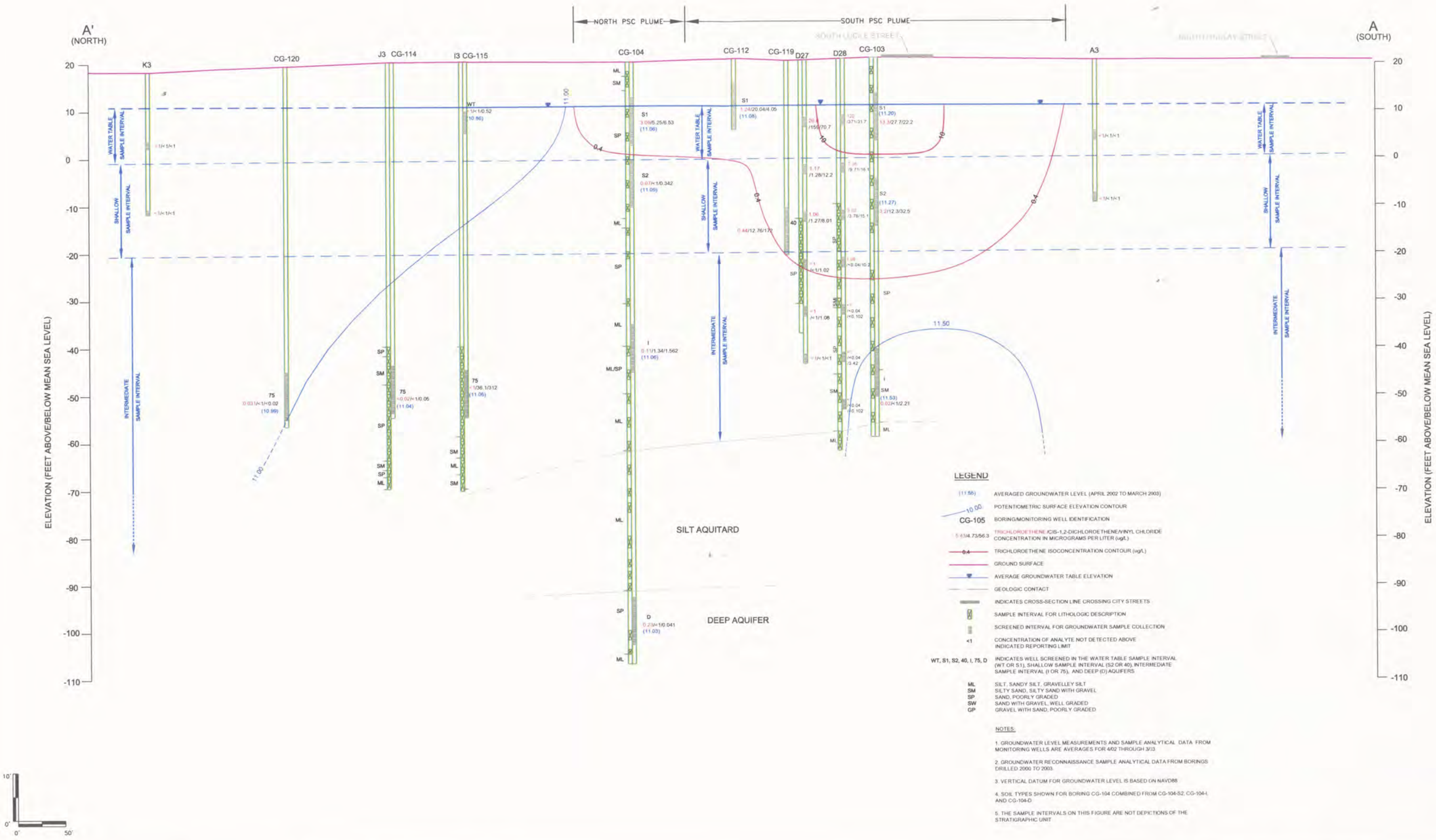
DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

NOTE: ONLY BORINGS AND MONITORING WELLS USED FOR WATER TABLE SAMPLE INTERVAL POINTS SHOWN ON BASE MAP.

PSC

TITLE:
Cross-Section Location Map
With Water Table Sample Interval Points
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.:	RI2003
CHKD:	APPD:		
DATE: 10/21/03	REV.: 1	FIGURE NO.:	9-1



LEGEND

(11.56)	AVERAGED GROUNDWATER LEVEL (APRIL 2002 TO MARCH 2003)
10.00	POTENTIOMETRIC SURFACE ELEVATION CONTOUR
CG-105	BORING/MONITORING WELL IDENTIFICATION
5.43/4.73/56.3	TRICHLOROETHENE /CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR (ug/L)
	GROUND SURFACE
▼	AVERAGE GROUNDWATER TABLE ELEVATION
	GEOLOGIC CONTACT
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
▨	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▮	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
WT, S1, S2, 40, I, 75, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 75), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED
GP	GRAVEL WITH SAND, POORLY GRADED

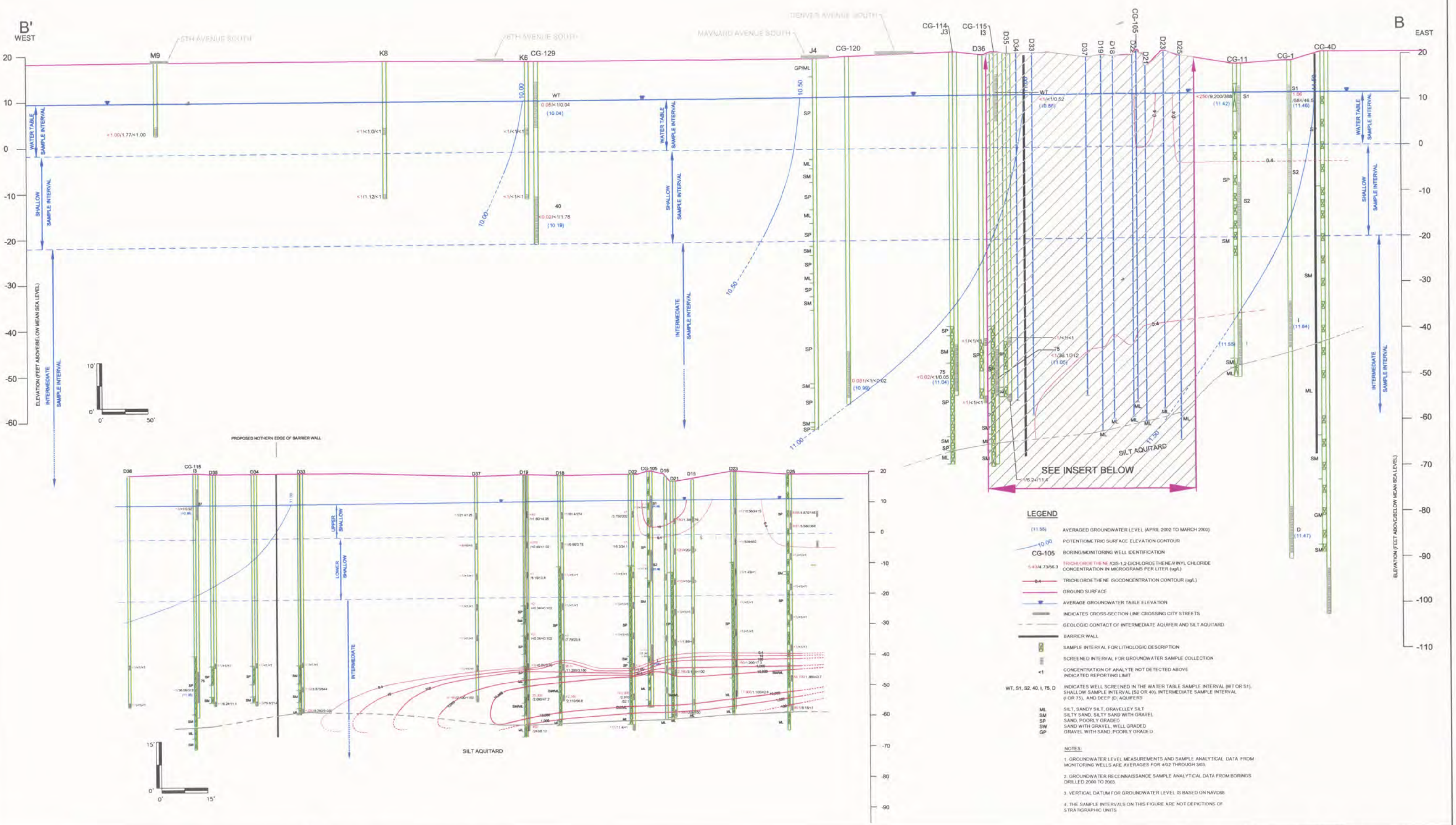
NOTES:

1. GROUNDWATER LEVEL MEASUREMENTS AND SAMPLE ANALYTICAL DATA FROM MONITORING WELLS ARE AVERAGES FOR 4/02 THROUGH 3/03
2. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003
3. VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88
4. SOIL TYPES SHOWN FOR BORING CG-104 COMBINED FROM CG-104-S2, CG-104-I, AND CG-104-D
5. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF THE STRATIGRAPHIC UNIT

PSC

TITLE:
Cross Section A – A'
Remedial Investigation
PSC Georgetown Facility

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: AS	APPD:	
DATE: 10/22/03	REV.:	FIGURE NO.: 9-2



LEGEND

(11.55)	AVERAGED GROUNDWATER LEVEL (APRIL 2002 TO MARCH 2003)
10.00	POTENTIOMETRIC SURFACE ELEVATION CONTOUR
CG-105	BORING/MONITORING WELL IDENTIFICATION
5.43/4.73/56.3	TRICHLOROETHENE /CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR (ug/L)
―	GROUND SURFACE
▼	AVERAGE GROUNDWATER TABLE ELEVATION
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
– – ―	GEOLOGIC CONTACT OF INTERMEDIATE AQUIFER AND SILT AQUITARD
━	BARRIER WALL
☒	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▤	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
WT, S1, S2, 40, I, 75, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 75), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED
GP	GRAVEL WITH SAND, POORLY GRADED

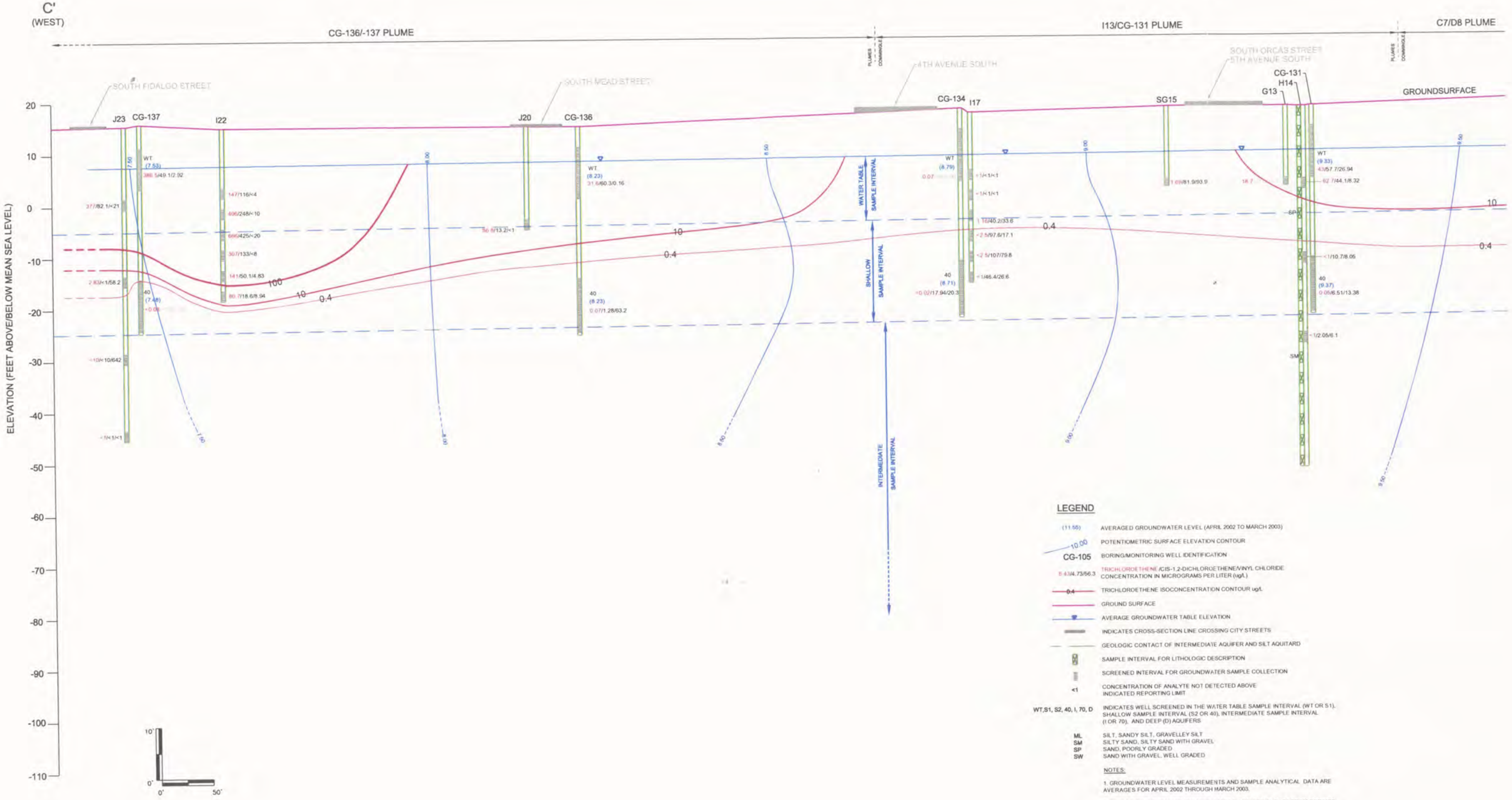
NOTES:

1. GROUNDWATER LEVEL MEASUREMENTS AND SAMPLE ANALYTICAL DATA FROM MONITORING WELLS ARE AVERAGES FOR 4/02 THROUGH 3/03.
2. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003.
3. VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88.
4. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF STRATIGRAPHIC UNITS.

PSC

TITLE:
Cross Section B – B'
Remedial Investigation
PSC Georgetown Facility

DWN: DEW
DES.:
CHKD: AS
APPD:
DATE: 10/23/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-3



LEGEND

(11.55)	AVERAGED GROUNDWATER LEVEL (APRIL 2002 TO MARCH 2003)
10.00	POTENTIOMETRIC SURFACE ELEVATION CONTOUR
CG-105	BORING/MONITORING WELL IDENTIFICATION
5.43/4.73/56.3	TRICHLOROETHENE /CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR ug/L
—	GROUND SURFACE
▽	AVERAGE GROUNDWATER TABLE ELEVATION
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
— —	GEOLOGIC CONTACT OF INTERMEDIATE AQUIFER AND SILT AQUITARD
☒	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▥	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
WT,S1, S2, 40, I, 70, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 70), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED

NOTES:

1. GROUNDWATER LEVEL MEASUREMENTS AND SAMPLE ANALYTICAL DATA ARE AVERAGES FOR APRIL 2002 THROUGH MARCH 2003.

2. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003.

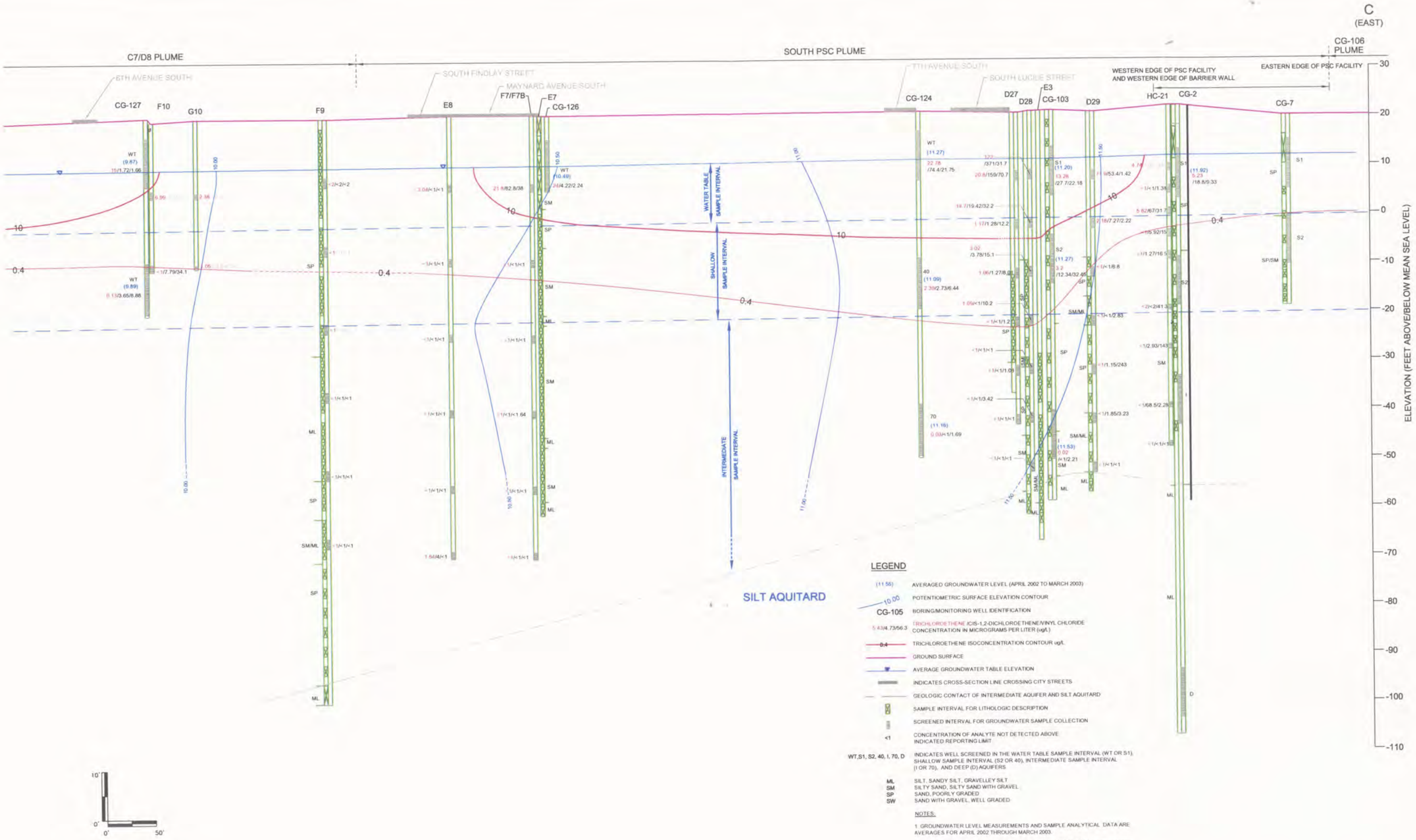
3. VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88

4. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF STRATIGRAPHIC UNITS

PSC

TITLE:
Cross Section C – C' West
Remedial Investigation
PSC Georgetown Facility

DWN: DEW
DES.:
CHKD: AS
APPD:
DATE: 10/23/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-4a



LEGEND

(11.55)	AVERAGED GROUNDWATER LEVEL (APRIL 2002 TO MARCH 2003)
10.00	POTENTIOMETRIC SURFACE ELEVATION CONTOUR
CG-105	BORING/MONITORING WELL IDENTIFICATION
5.43/4.73/56.3	TRICHLOROETHENE /CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR ug/L
	GROUND SURFACE
▼	AVERAGE GROUNDWATER TABLE ELEVATION
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
— —	GEOLOGIC CONTACT OF INTERMEDIATE AQUIFER AND SILT AQUITARD
⊠	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▮	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
WT,S1, S2, 40, I, 70, D	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT OR S1), SHALLOW SAMPLE INTERVAL (S2 OR 40), INTERMEDIATE SAMPLE INTERVAL (I OR 70), AND DEEP (D) AQUIFERS
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED

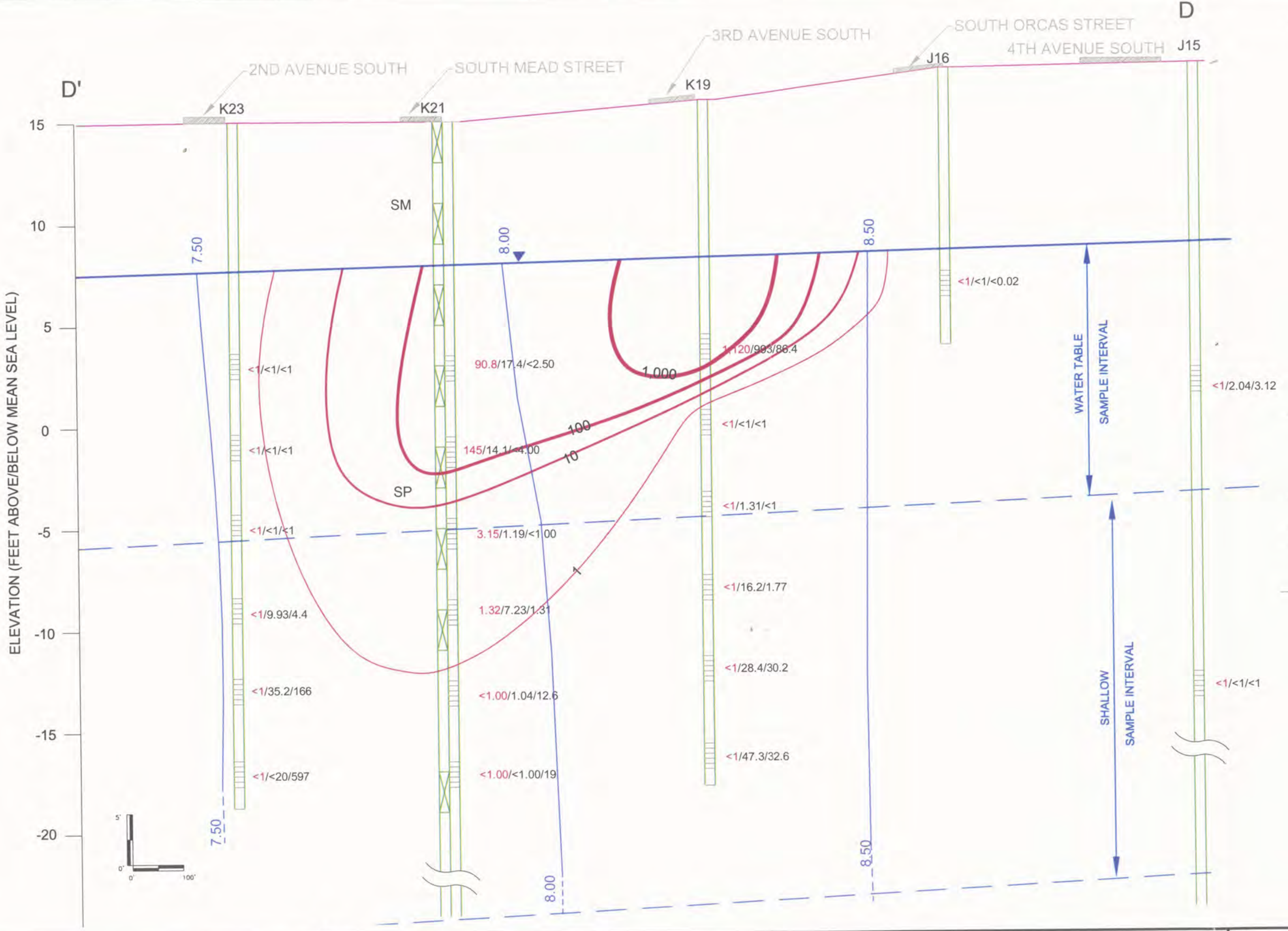
NOTES:

1. GROUNDWATER LEVEL MEASUREMENTS AND SAMPLE ANALYTICAL DATA ARE AVERAGES FOR APRIL 2002 THROUGH MARCH 2003.
2. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003.
3. VERTICAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88
4. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF STRATIGRAPHIC UNITS

PSC

TITLE:
Cross Section C – C' East
Remedial Investigation
PSC Georgetown Facility

DWN: DEW
CHKD: AS
DATE: 10/24/03
DES.:
APPD:
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-4b



LEGEND

8.50	POTENIOMETRIC SURFACE ELEVATION CONTOUR
CG-105	BORING/MONITORING WELL IDENTIFICATION
5.43/4.73/56.3	TRICHLOROETHENE /CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR (ug/L)
	GROUND SURFACE
▼	AVERAGE GROUNDWATER TABLE ELEVATION
	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
	GEOLOGIC CONTACT
☒	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
☰	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
SM SP	SILTY SAND, SILTY SAND WITH GRAVEL SAND, POORLY GRADED

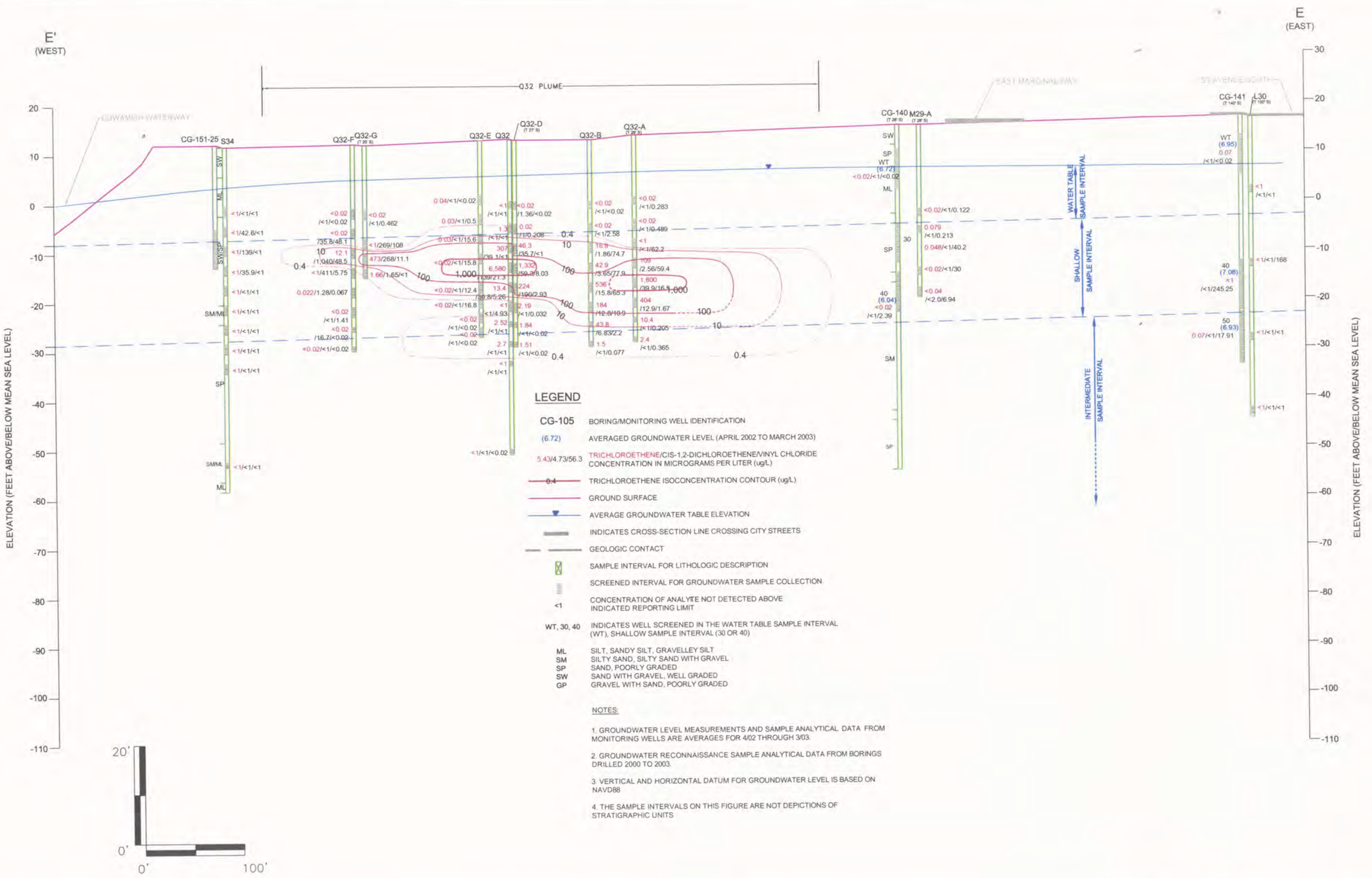
NOTES:

1. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003.
2. BORING K21 DRILLED TO 70 FEET BELOW GROUND SURFACE (bgs) BUT GROUNDWATER QUALITY SAMPLES ONLY COLLECTED TO 32 bgs.
3. BORING J15 DRILLED TO 60 FEET bgs AND SAMPLED AT 15, 30, 45 AND 60 FEET bgs. SAMPLES COLLECTED AT 45 AND 60 FEET bgs NOT SHOWN BUT ANALYTICAL RESULTS WERE <1 ug/L FOR ALL ANALYTES.
4. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF STRATIGRAPHIC UNITS

PSC

TITLE:
Cross Section D – D'
Remedial Investigation
PSC Georgetown Facility

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CTS	APPD:	
DATE: 10/27/03	REV.:	FIGURE NO.: 9–5



LEGEND

CG-105	BORING/MONITORING WELL IDENTIFICATION
(6.72)	AVERAGED GROUNDWATER LEVEL (APRIL 2002 TO MARCH 2003)
5.43/4.73/56.3	TRICHLOROETHENE/CIS-1,2-DICHLOROETHENE/VINYL CHLORIDE CONCENTRATION IN MICROGRAMS PER LITER (ug/L)
0.4	TRICHLOROETHENE ISOCONCENTRATION CONTOUR (ug/L)
—	GROUND SURFACE
▼	AVERAGE GROUNDWATER TABLE ELEVATION
▬	INDICATES CROSS-SECTION LINE CROSSING CITY STREETS
— —	GEOLOGIC CONTACT
▨	SAMPLE INTERVAL FOR LITHOLOGIC DESCRIPTION
▯	SCREENED INTERVAL FOR GROUNDWATER SAMPLE COLLECTION
<1	CONCENTRATION OF ANALYTE NOT DETECTED ABOVE INDICATED REPORTING LIMIT
WT, 30, 40	INDICATES WELL SCREENED IN THE WATER TABLE SAMPLE INTERVAL (WT), SHALLOW SAMPLE INTERVAL (30 OR 40)
ML	SILT, SANDY SILT, GRAVELLEY SILT
SM	SILTY SAND, SILTY SAND WITH GRAVEL
SP	SAND, POORLY GRADED
SW	SAND WITH GRAVEL, WELL GRADED
GP	GRAVEL WITH SAND, POORLY GRADED

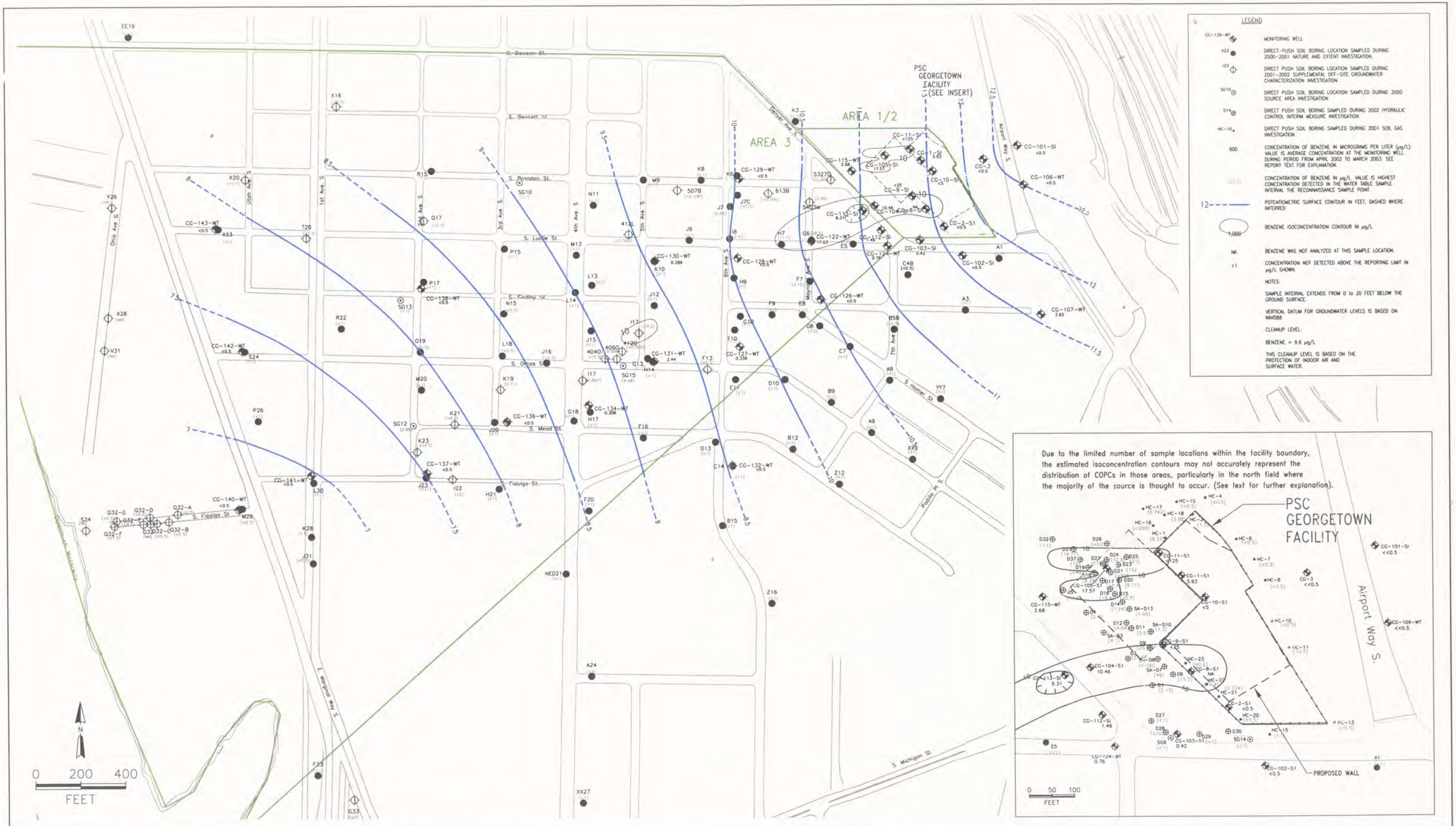
NOTES:

1. GROUNDWATER LEVEL MEASUREMENTS AND SAMPLE ANALYTICAL DATA FROM MONITORING WELLS ARE AVERAGES FOR 4/02 THROUGH 3/03.
2. GROUNDWATER RECONNAISSANCE SAMPLE ANALYTICAL DATA FROM BORINGS DRILLED 2000 TO 2003.
3. VERTICAL AND HORIZONTAL DATUM FOR GROUNDWATER LEVEL IS BASED ON NAVD88
4. THE SAMPLE INTERVALS ON THIS FIGURE ARE NOT DEPICTIONS OF STRATIGRAPHIC UNITS

PSC

TITLE:
Cross Section E – E'
Remedial Investigation
PSC Georgetown Facility

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CTS	APPD:	
DATE: 10/24/03	REV.:	FIGURE NO.: 9–6



	LEGEND
CG-136-WT	MONITORING WELL
K23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF BENZENE IN MICROGRAMS PER LITER (µg/L) VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF BENZENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	BENZENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	BENZENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

BENZENE = 9.6 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

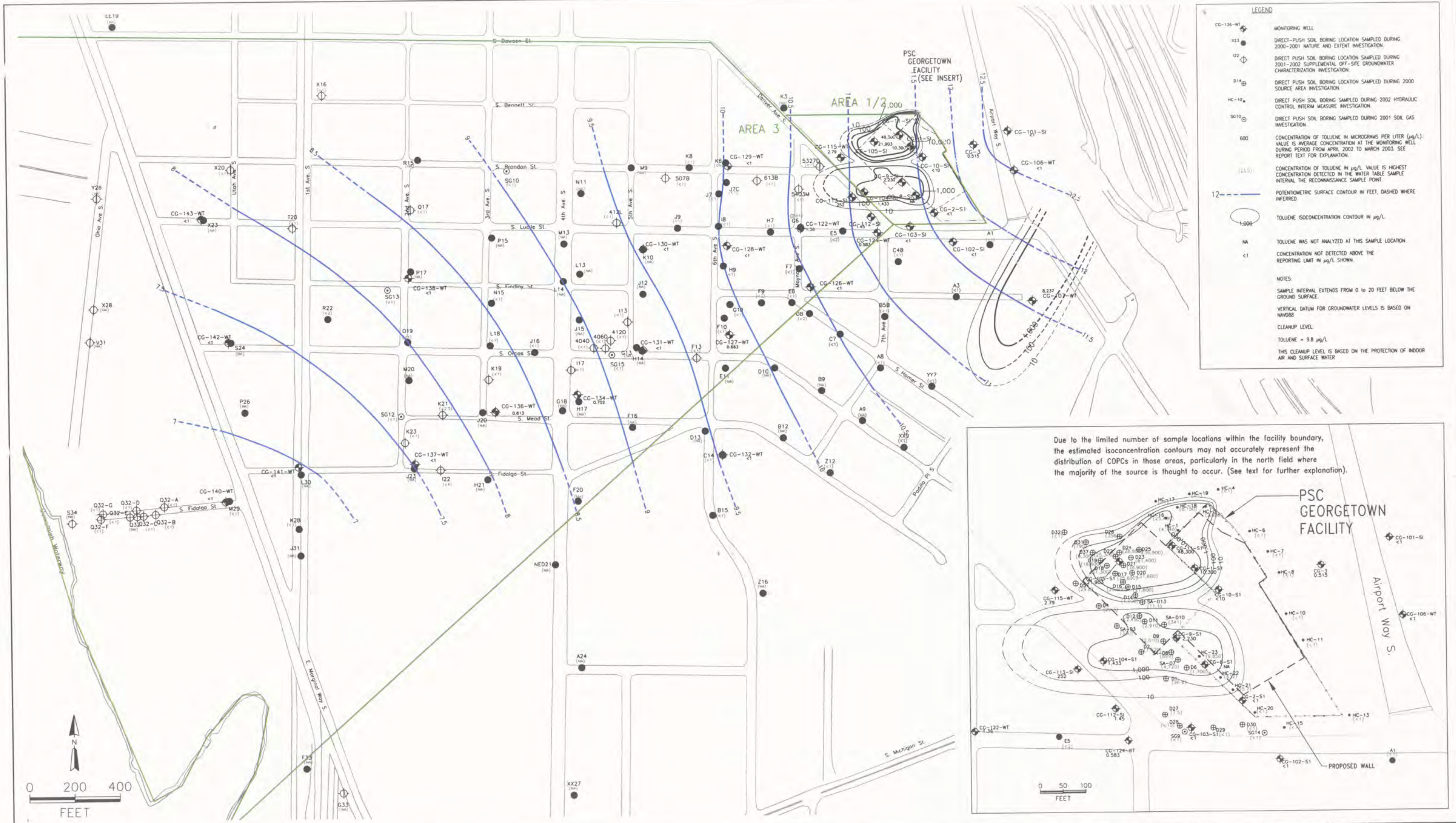
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Benzene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN.: DEW	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	FIGURE NO.: 9-7
DATE: 10/21/03	REV.: 1	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF TOLUENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TOLUENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12 - - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TOLUENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TOLUENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

TOLUENE = 9.8 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER

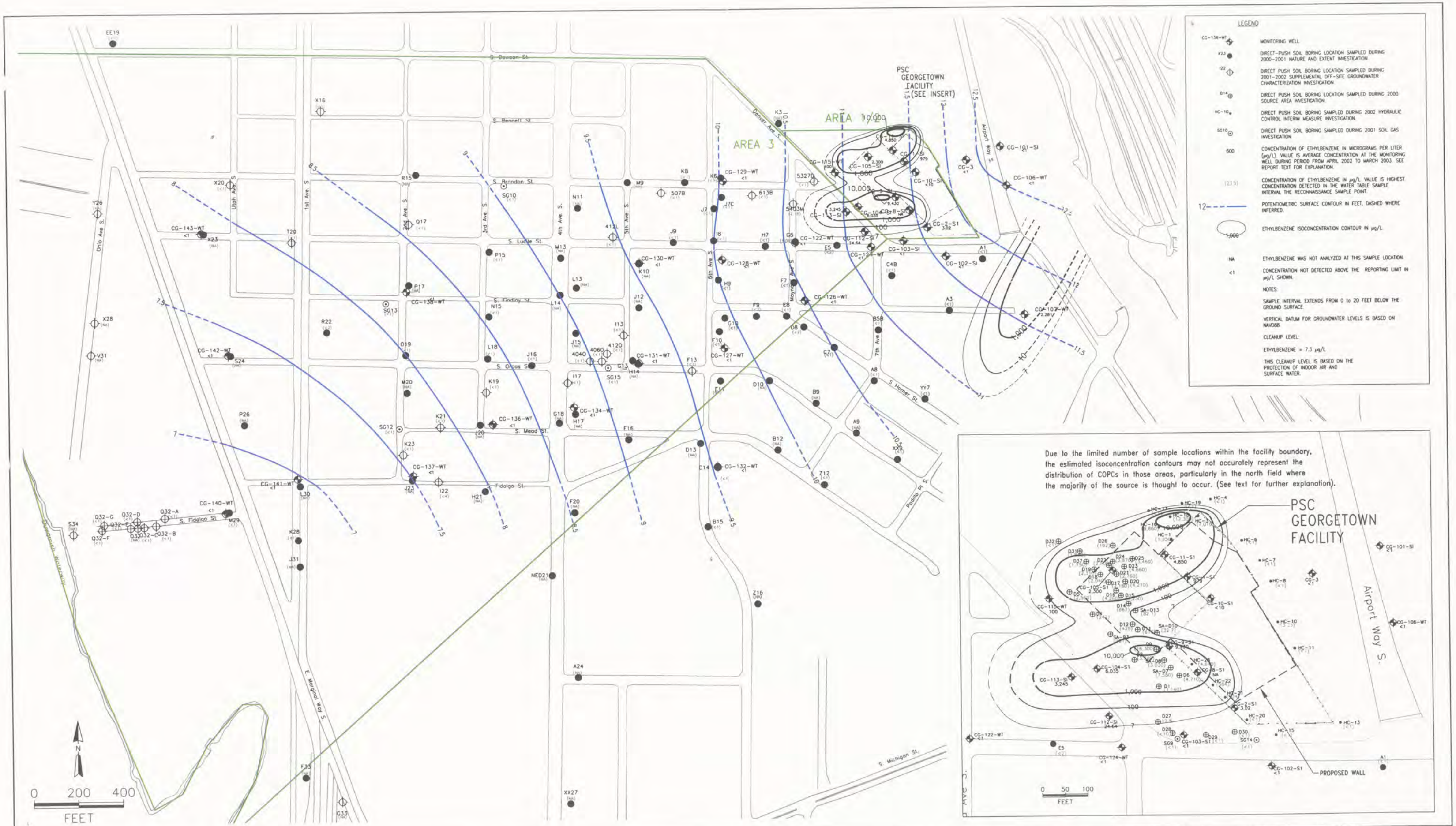
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Toluene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/27/03	REV:	FIGURE NO.: 9-8



LEGEND

CG-136-WT — MONITORING WELL

K23 — DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.

I22 — DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.

D14 — DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.

HC-10 — DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.

SG10 — DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.

600 — CONCENTRATION OF ETHYLBENZENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

(23.5) — CONCENTRATION OF ETHYLBENZENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.

12— — — — POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

1,000 — ETHYLBENZENE ISOCONCENTRATION CONTOUR IN μg/L.

NA — ETHYLBENZENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.

<1 — CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

ETHYLBENZENE = 7.3 μg/L

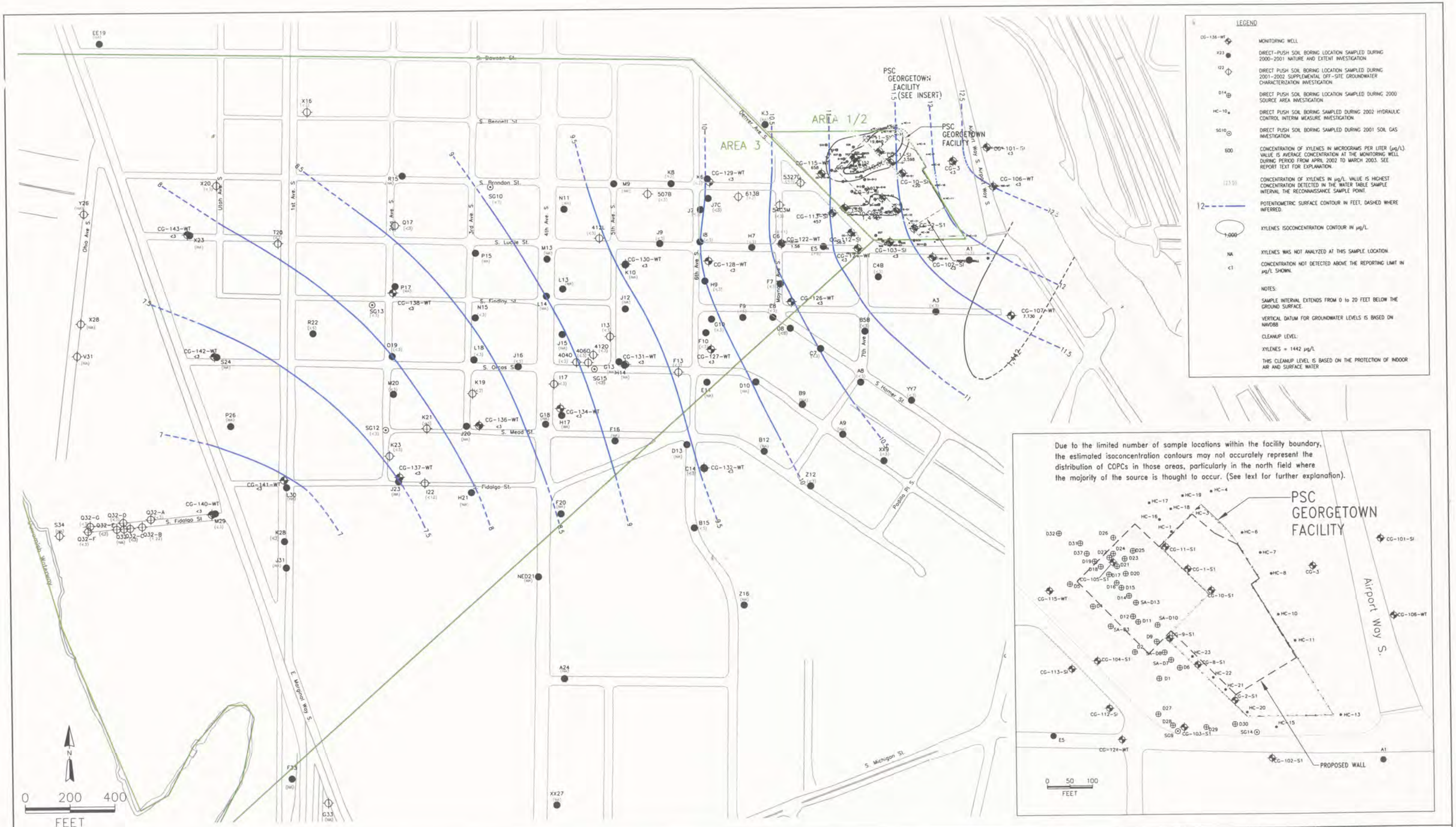
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:
Ethylbenzene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/21/03	REV.: 1	FIGURE NO.: 9-9



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION
I22 ⌽	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF XYLENES IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF XYLENES IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	XYLENES ISOCONCENTRATION CONTOUR IN μg/L.
NA	XYLENES WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

XYLENES = 1442 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER

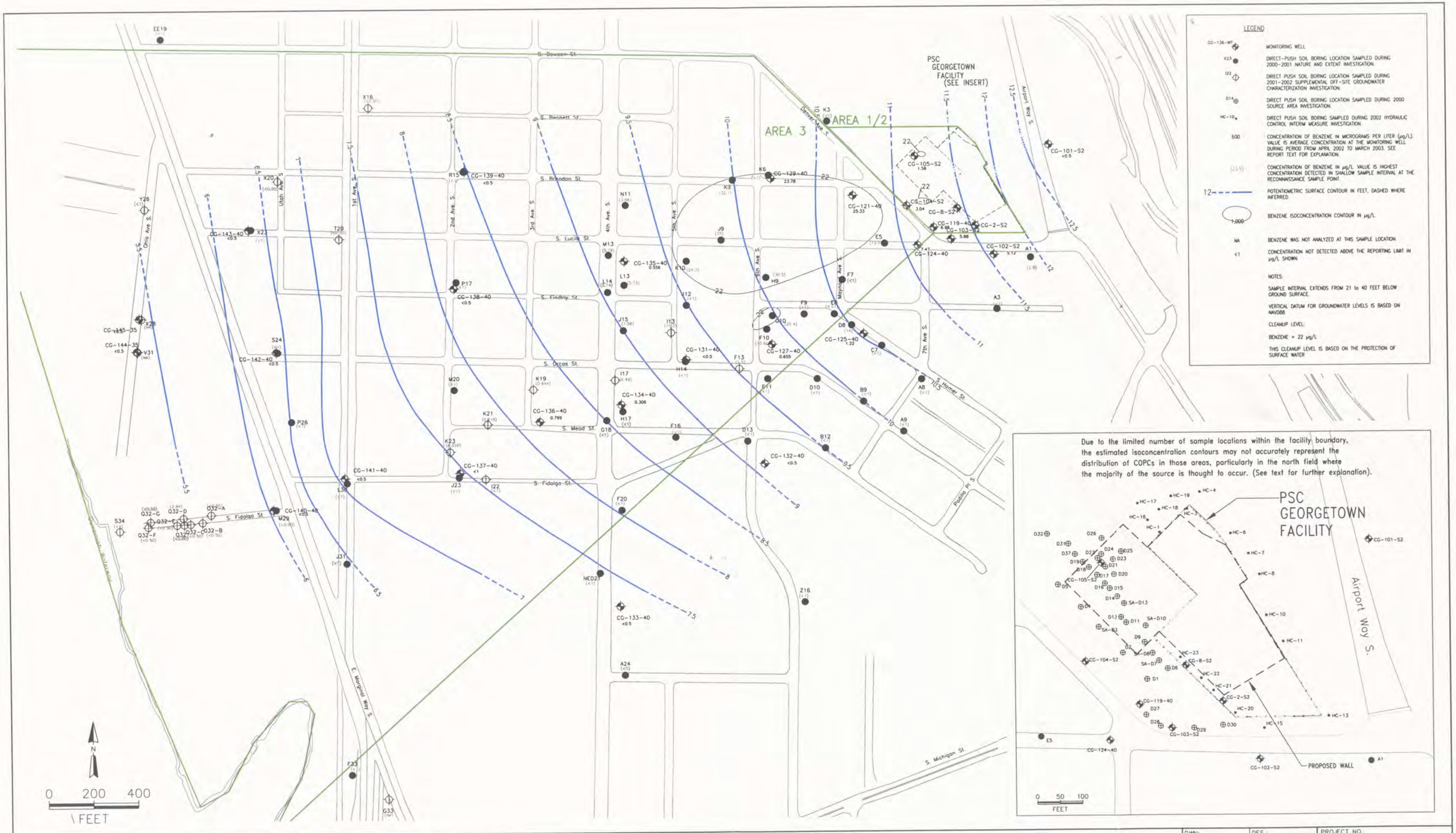
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Xylenes Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO.: 9-10
DATE: 10/27/03	REV.:	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
500	CONCENTRATION OF BENZENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF BENZENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	BENZENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	BENZENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

BENZENE = 22 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

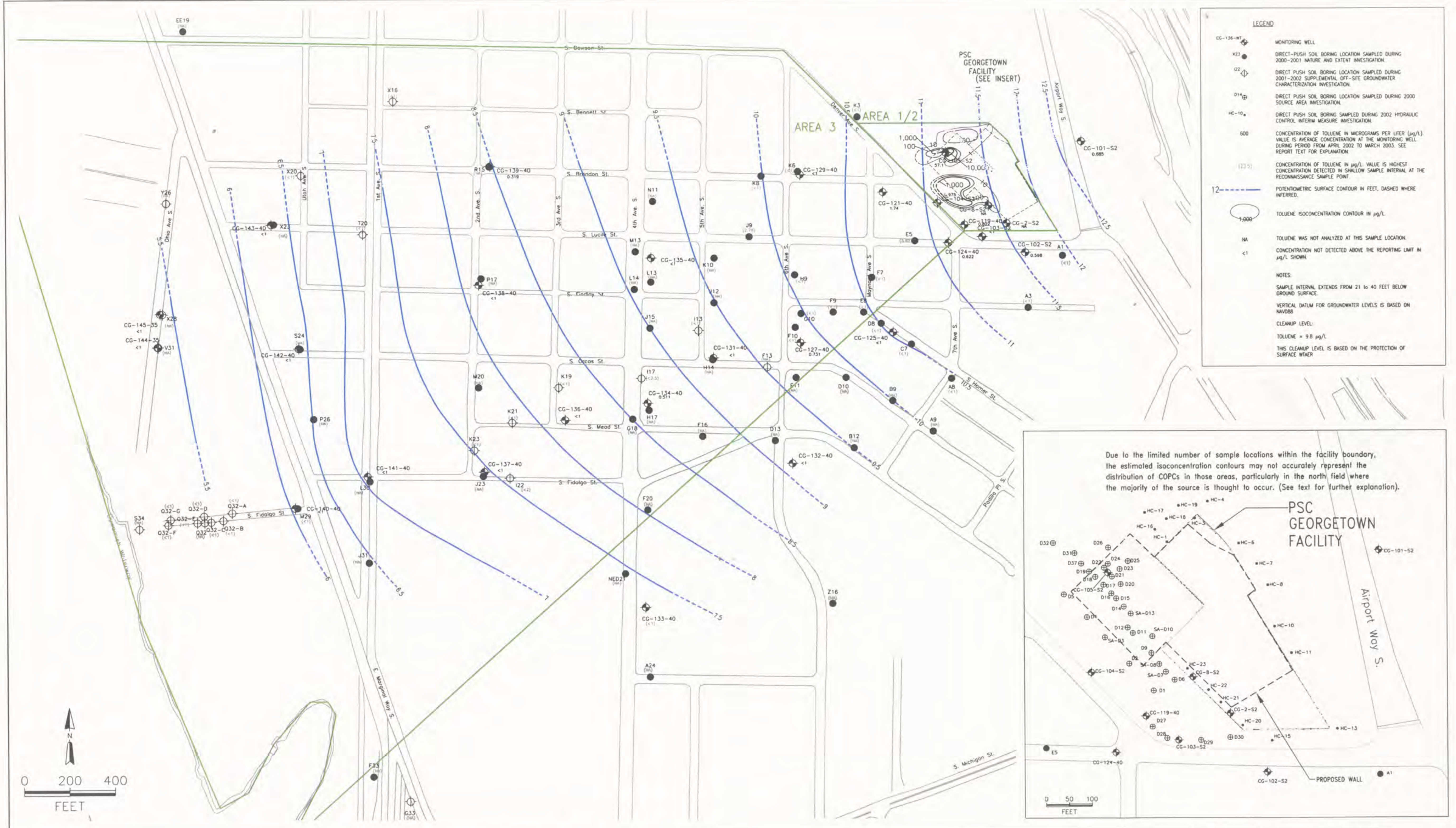
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Benzene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO.: 9-11
DATE: 10/27/03	REV.:	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22 ⏀	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TOLUENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TOLUENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - - -	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TOLUENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	TOLUENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

TOLUENE = 9.8 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WTAER

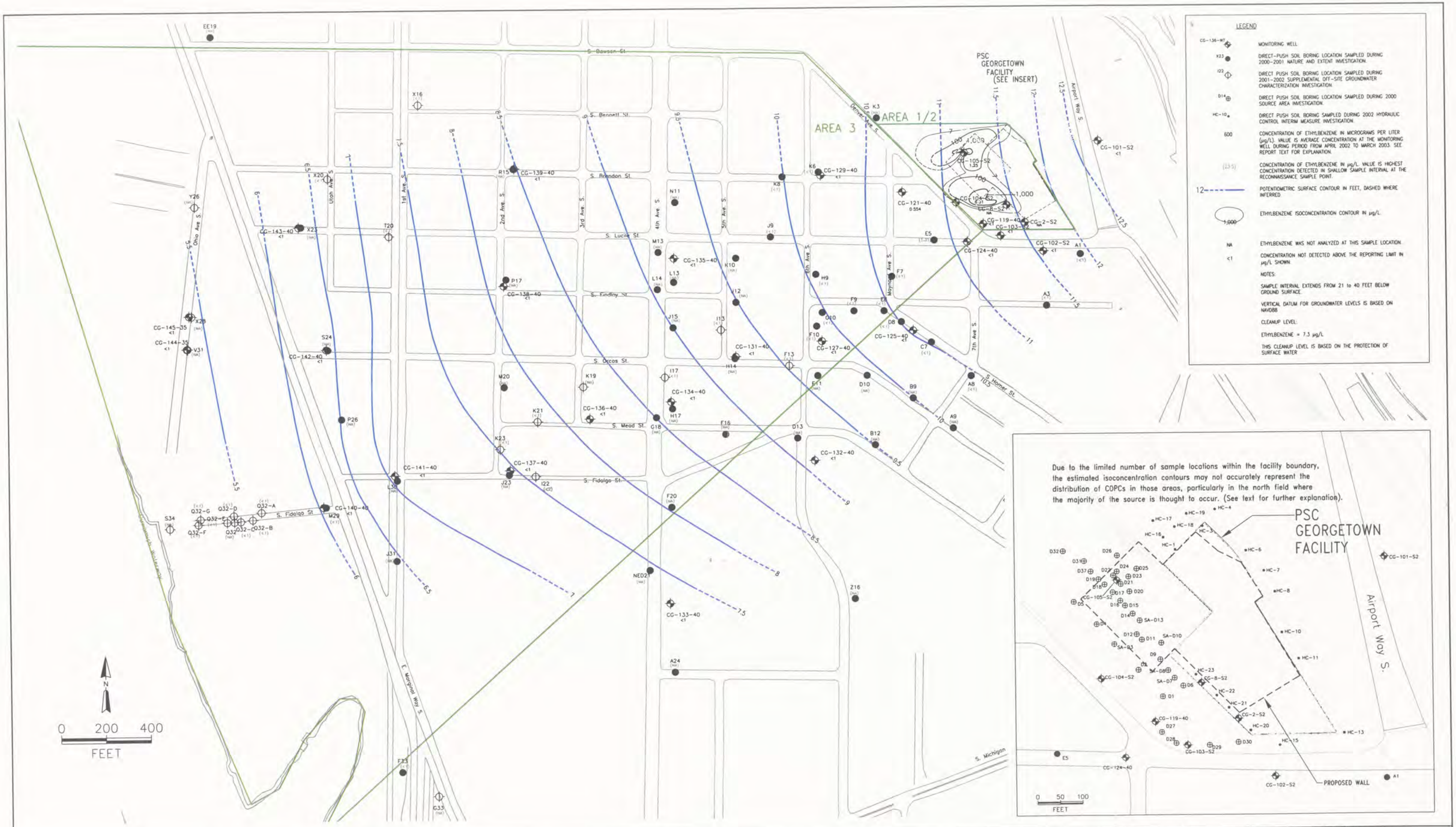
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Toluene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/27/03	REV.:	FIGURE NO.: 9-12



NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

ETHYLBENZENE = 7.3 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

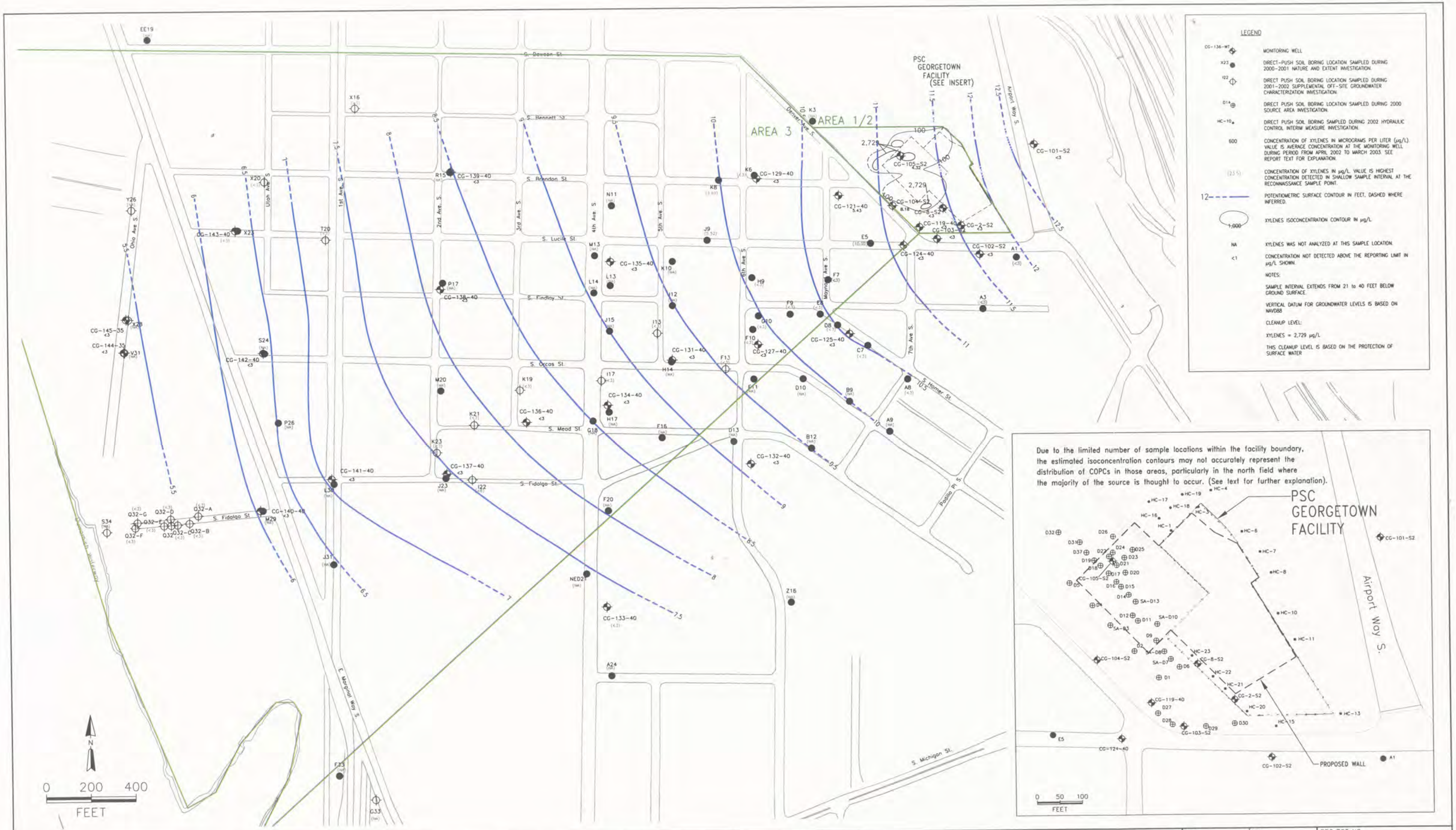
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Ethylbenzene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-13



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF XYLENES IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF XYLENES IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	XYLENES ISOCONCENTRATION CONTOUR IN µg/L.
NA	XYLENES WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

XYLENES = 2,729 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

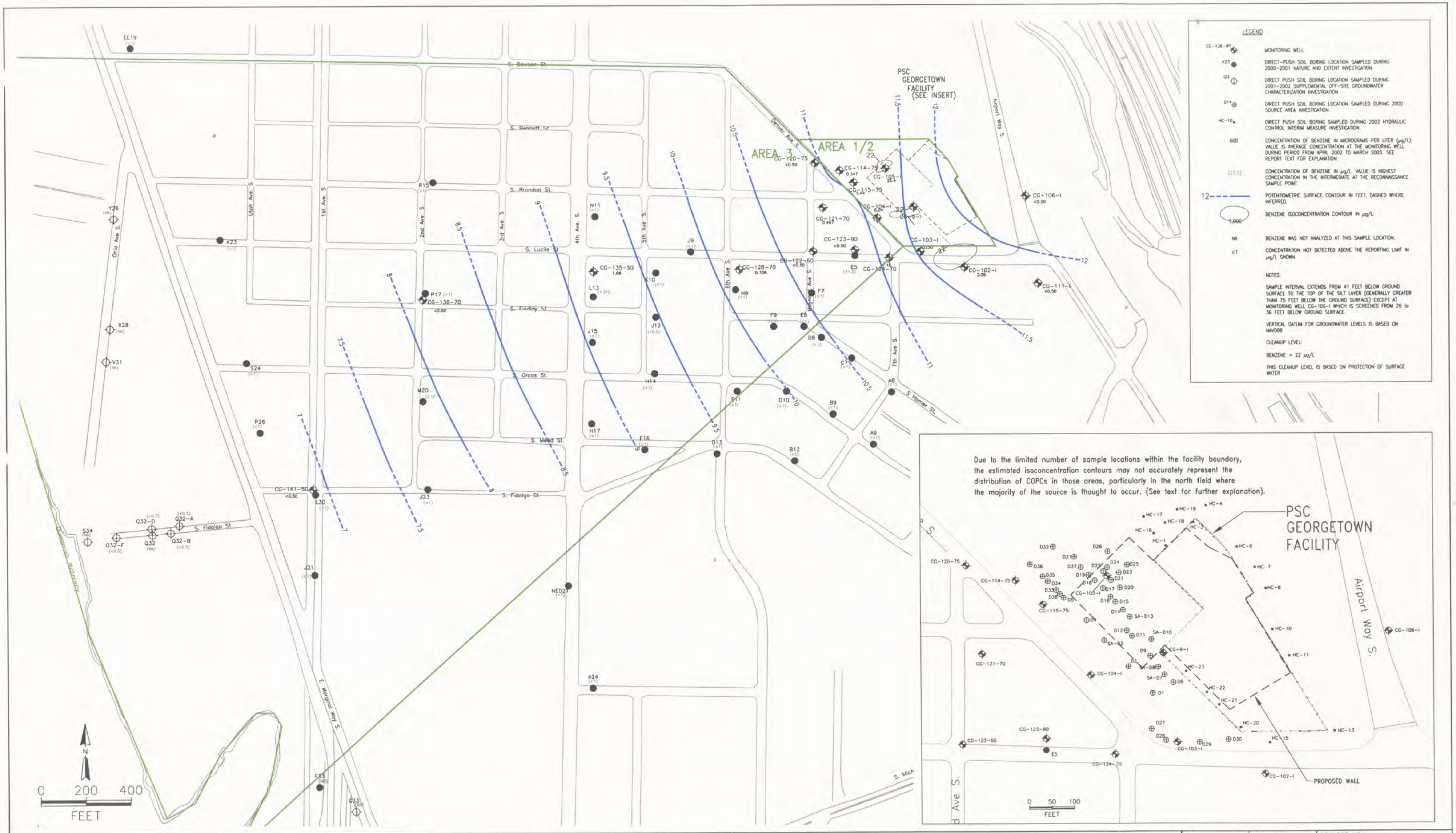
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Xylenes Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-14



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ■	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF BENZENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF BENZENE IN μg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	BENZENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	BENZENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

BENZENE = 22 μg/L

THIS CLEANUP LEVEL IS BASED ON PROTECTION OF SURFACE WATER

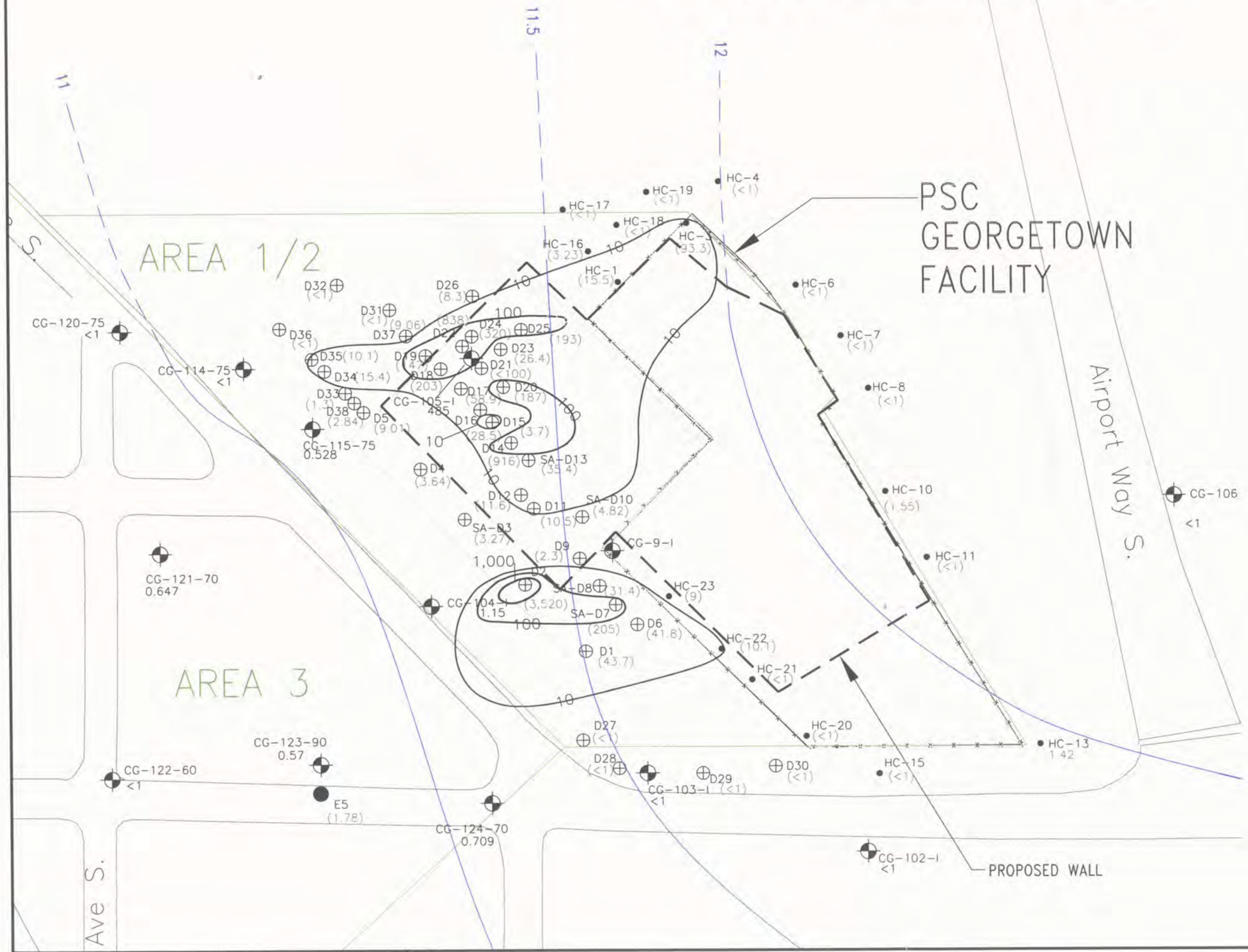
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:
Benzene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW
DES.:
CHKD: CJM
APPD:
DATE: 10/28/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-15

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TOLUENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TOLUENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN INTERMEDIATE SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - -	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TOLUENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	TOLUENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW GROPUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 TO 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

TOLUENE = 9.8 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WTAER

N

0 50 100

FEET

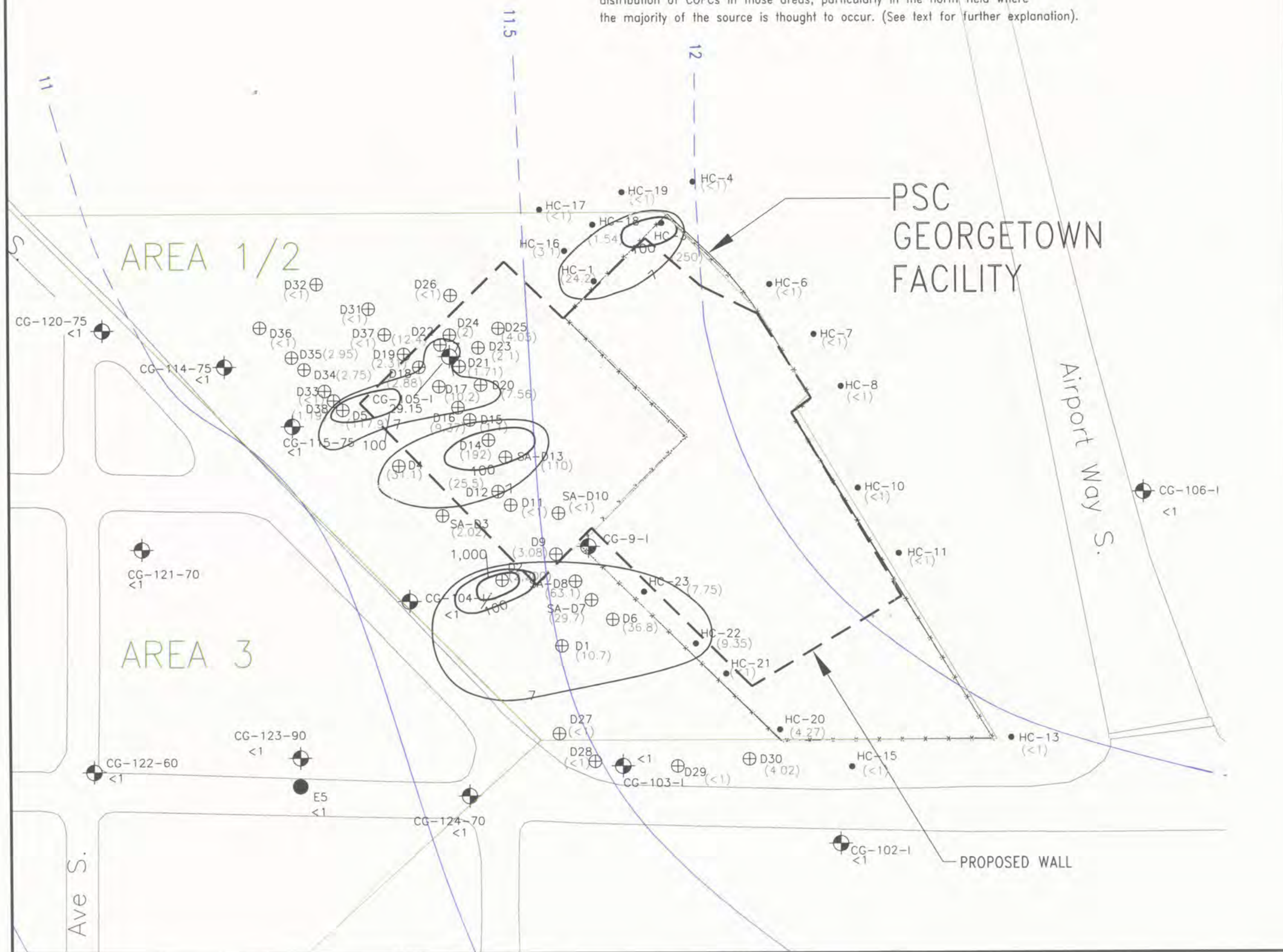
PSC

TITLE:

Toluene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-16

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).



LEGEND

MONITORING WELL

X23 ● DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.

I22 ⊕ DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.

D14 ⊕ DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.

HC-10 ● DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.

600 CONCENTRATION OF ETHYLBENZENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

(23.5) CONCENTRATION OF ETHYLBENZENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN INTERMEDIATE SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.

POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

1,000 ETHYLBENZENE ISOCONCENTRATION CONTOUR IN μg/L.

NA ETHYLBENZENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

ETHYLBENZENE = 7.3 μg/L

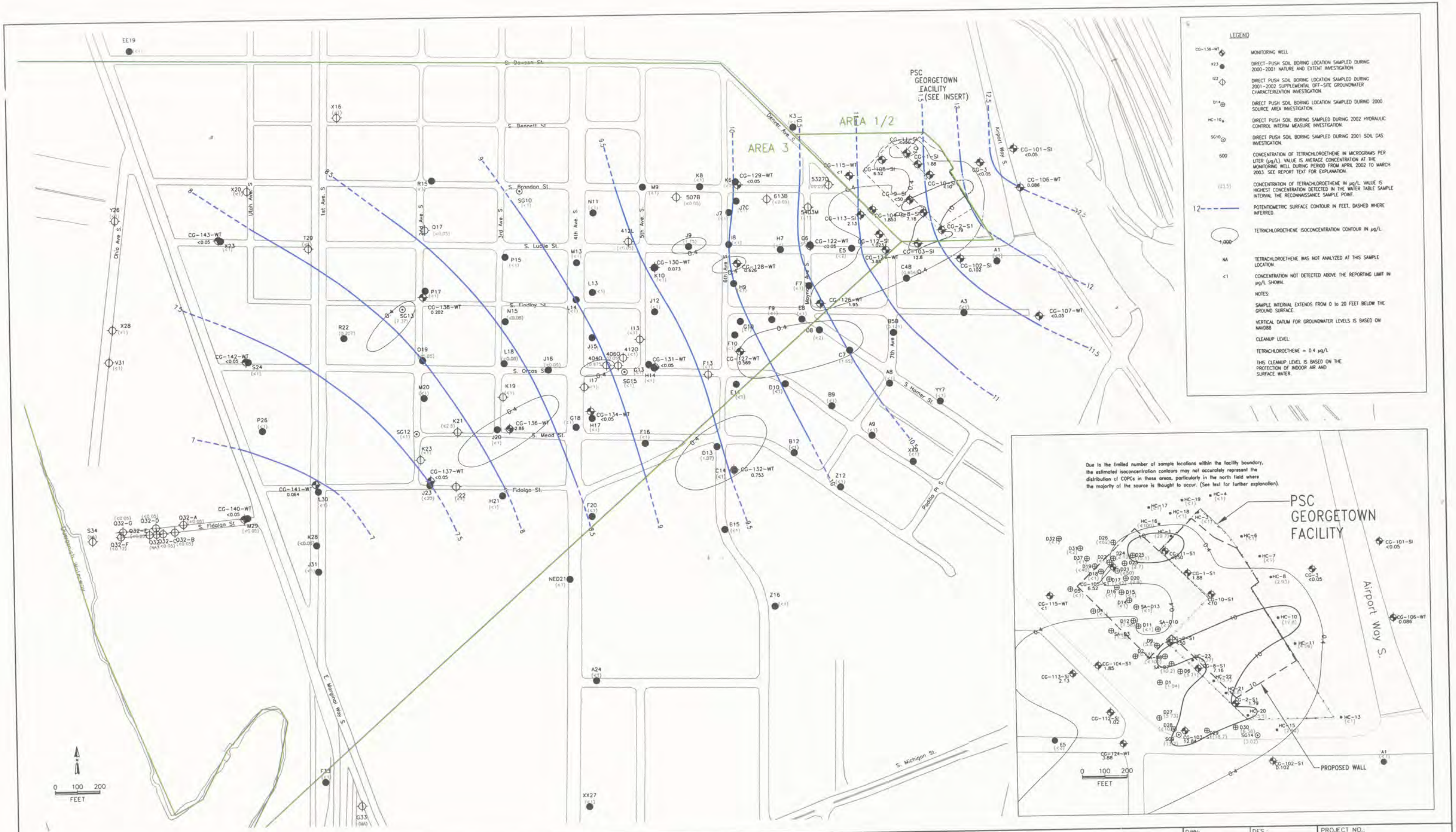
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

Ethylbenzene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-17



Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

LEGEND

CG-136-WT	MONITORING WELL
K23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF TETRACHLOROETHENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TETRACHLOROETHENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12 - - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TETRACHLOROETHENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TETRACHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

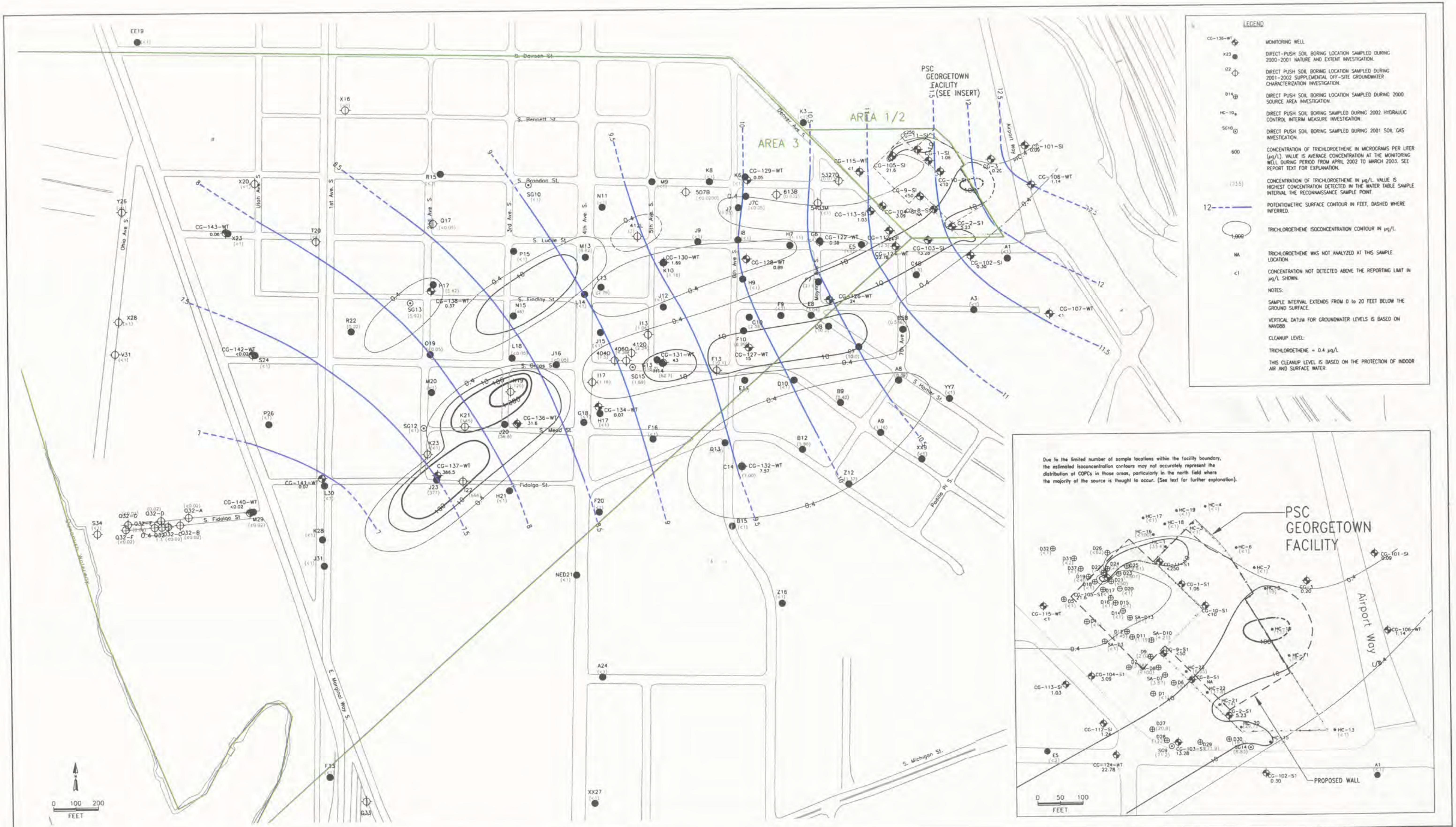
TETRACHLOROETHENE = 0.4 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

PSC

TITLE:
Tetrachloroethene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003	
CHKD: CJM	APPD:	FIGURE NO.: 9-18	
DATE: 10/21/03	REV.: 1		



LEGEND

CG-136-WT ⊕	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22 ⦶	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF TRICHLOROETHENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(255)	CONCENTRATION OF TRICHLOROETHENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12- - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TRICHLOROETHENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TRICHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

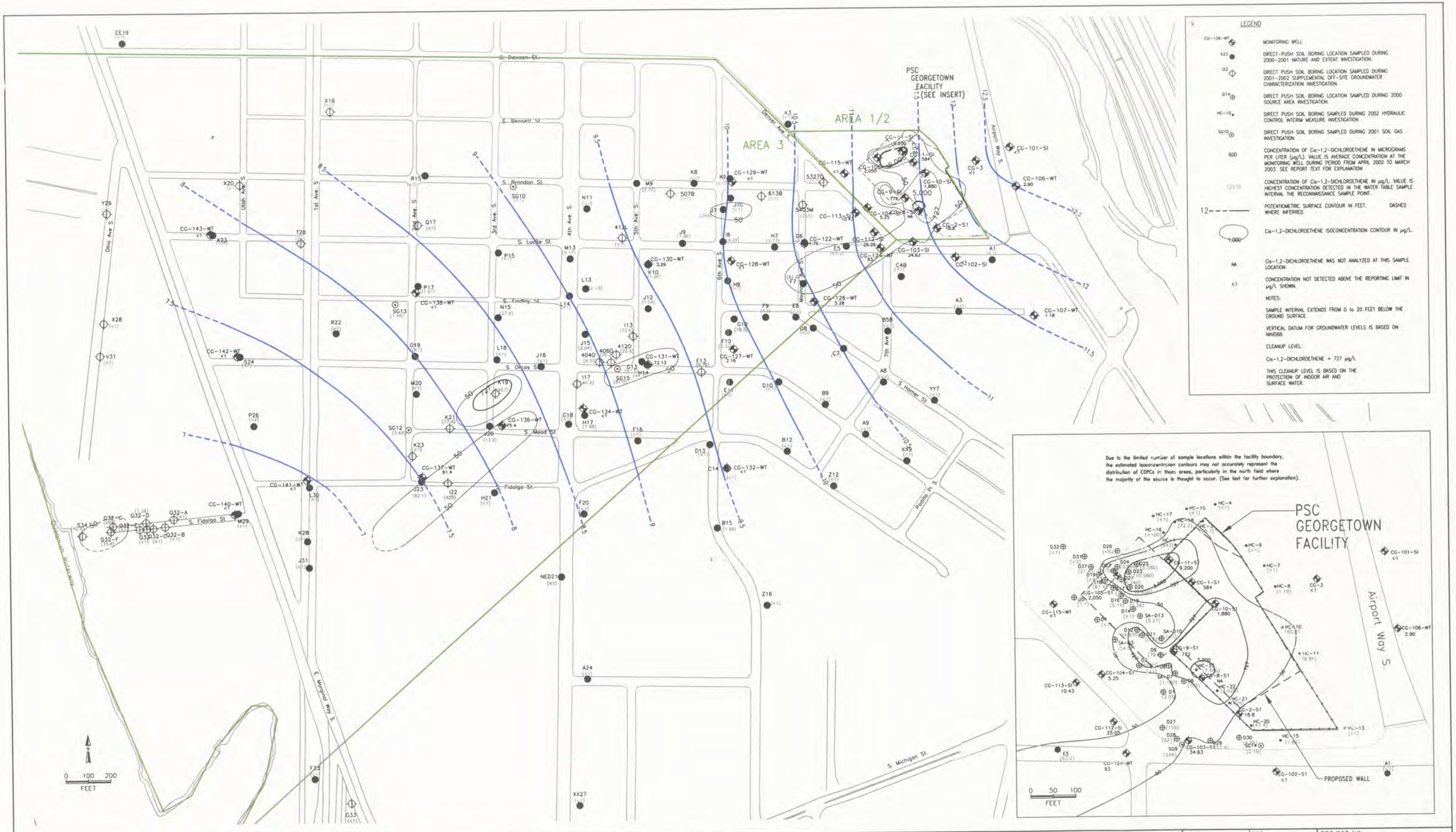
TRICHLOROETHENE = 0.4 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

PSC

TITLE:
Trichloroethene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003	
CHKD: CJM	APPD:	FIGURE NO.: 9-19	
DATE: 10/23/02	REV.: 1		



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF Cis-1,2-DICHLOROETHENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(213)	CONCENTRATION OF Cis-1,2-DICHLOROETHENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET. DASHED WHERE INFERRED.
1,000	Cis-1,2-DICHLOROETHENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	Cis-1,2-DICHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

Cis-1,2-DICHLOROETHENE = 727 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

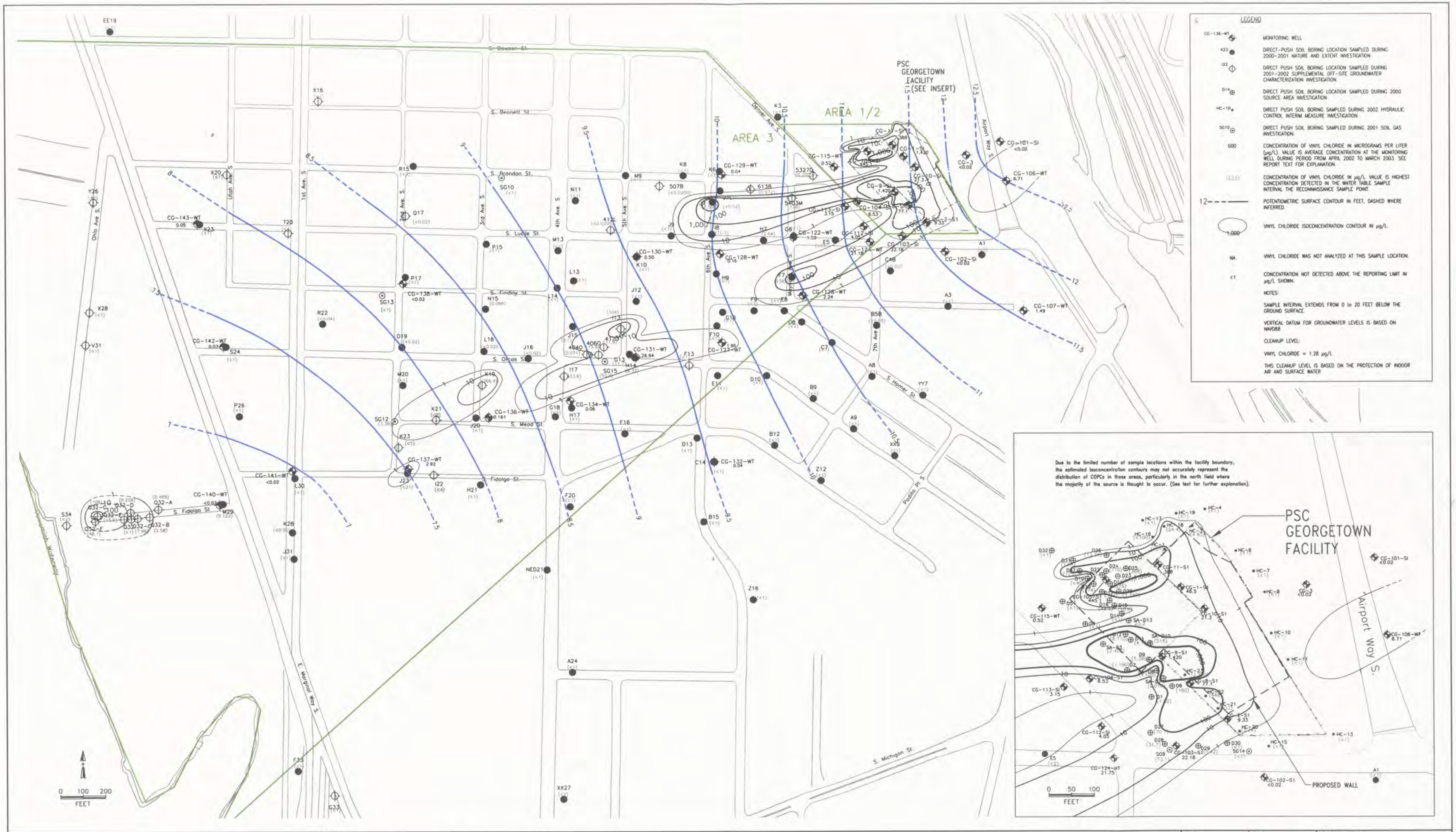
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Cis-1,2-Dichloroethene Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/21/03	REV.: 1	FIGURE NO.: 9-20



Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ■	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF VINYL CHLORIDE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF VINYL CHLORIDE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12– – –——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	VINYL CHLORIDE ISOCONCENTRATION CONTOUR IN µg/L.
NA	VINYL CHLORIDE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

VINYL CHLORIDE = 1.28 µg/L

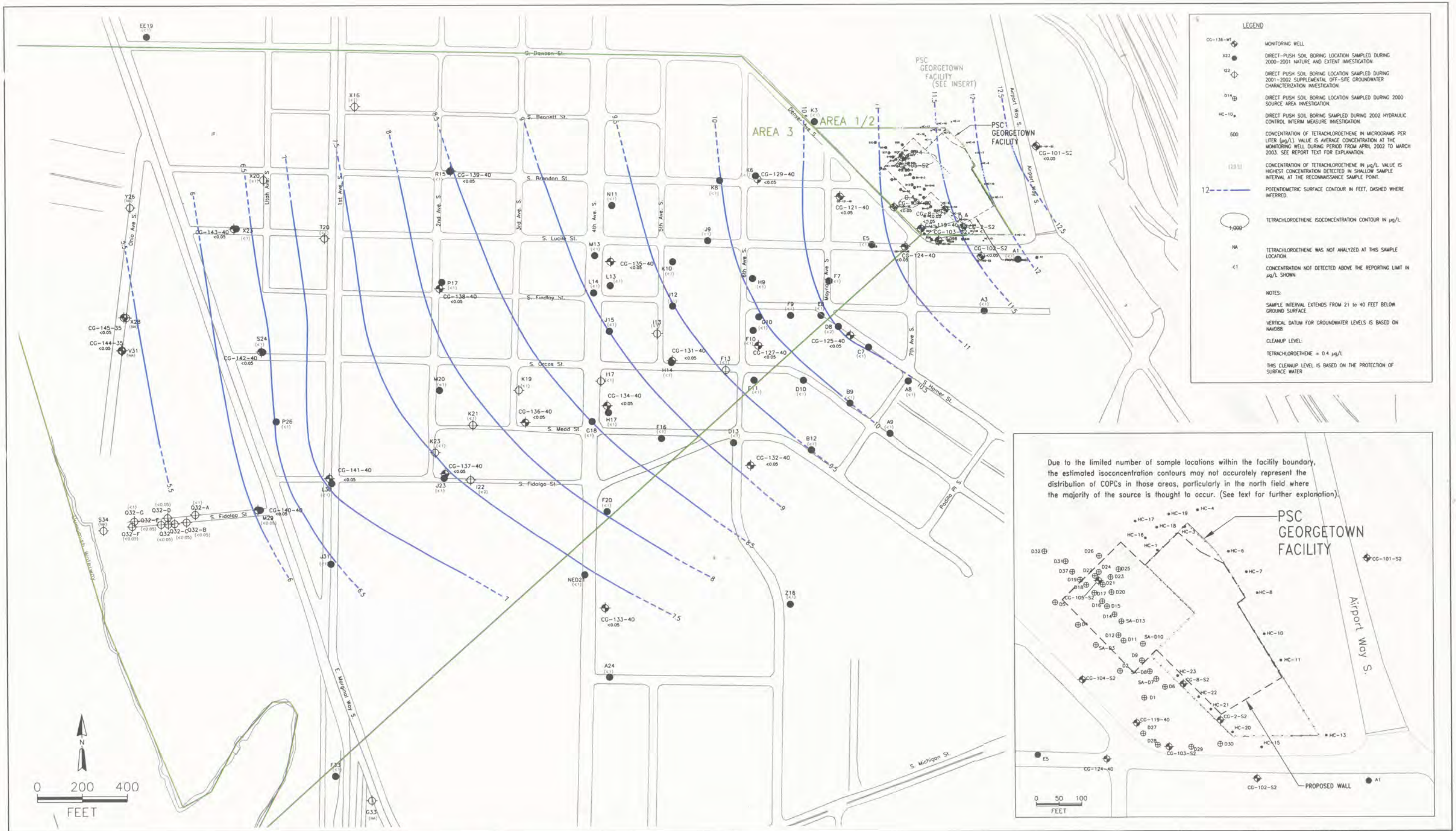
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER

PSC

TITLE:

Vinyl Chloride Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/24/03	REV.: 1	FIGURE NO.: 9-21



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TETRACHLOROETHENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TETRACHLOROETHENE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12– – – ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TETRACHLOROETHENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TETRACHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

TETRACHLOROETHENE = 0.4 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

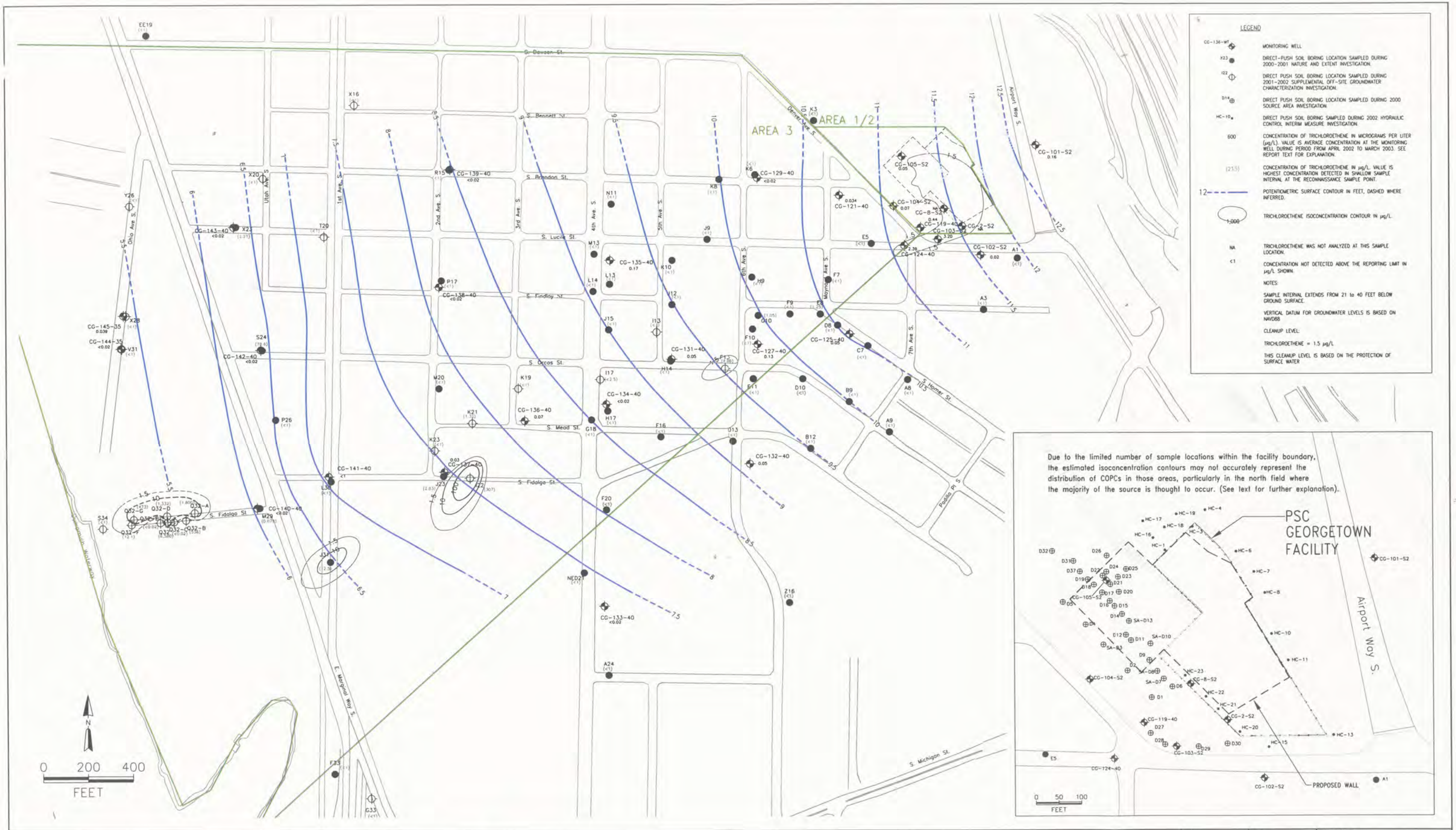
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Tetrachloroethene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW
DES.:
CHKD: CJM
APPD:
DATE: 10/28/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-22



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22 ⌀	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ▪	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TRICHLOROETHENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TRICHLOROETHENE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TRICHLOROETHENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	TRICHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

TRICHLOROETHENE = 1.5 μg/L

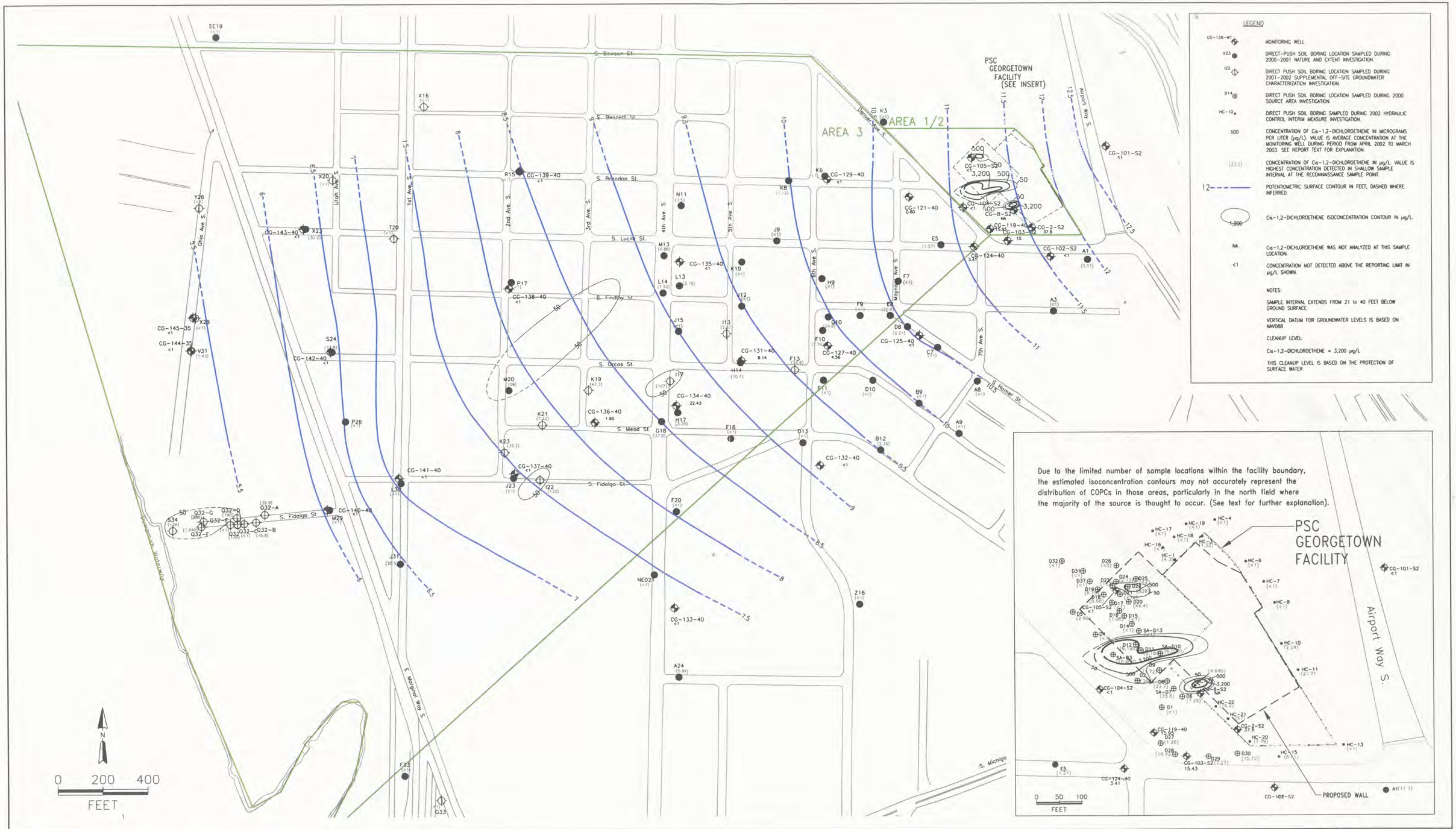
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:
Trichloroethene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-23



NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

Cis-1,2-DICHLOROETHENE = 3,200 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

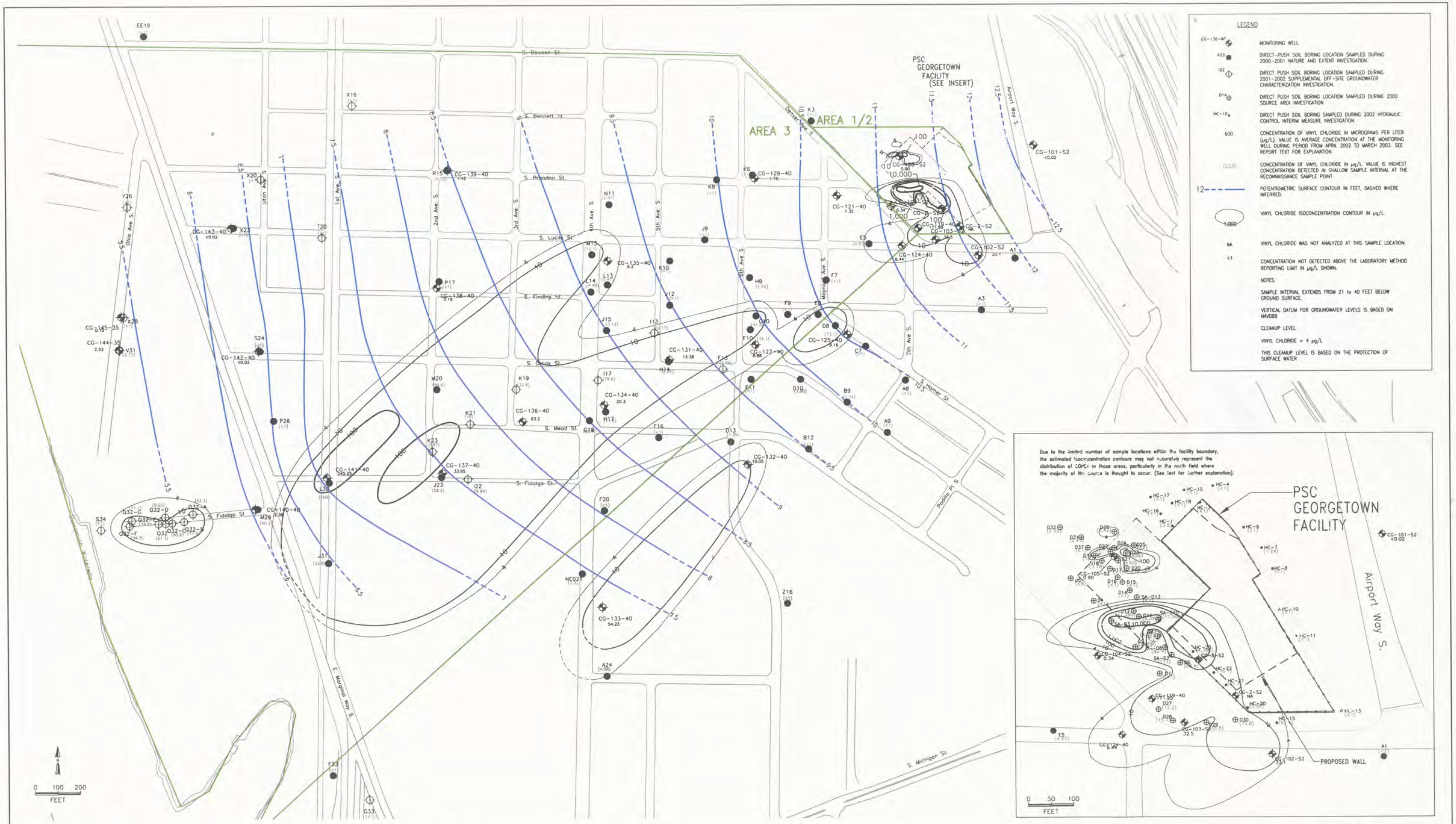
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Cis-1,2-Dichloroethene Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN:	DES.:	PROJECT NO.:
DEW		RI2003
CHKD: CJM	APPD:	FIGURE NO.:
DATE: 10/28/03	REV.:	9-24



LEGEND

CG-138-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF VINYL CHLORIDE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
[23.8]	CONCENTRATION OF VINYL CHLORIDE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12- - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	VINYL CHLORIDE ISOCONCENTRATION CONTOUR IN µg/L.
NA	VINYL CHLORIDE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE LABORATORY METHOD REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

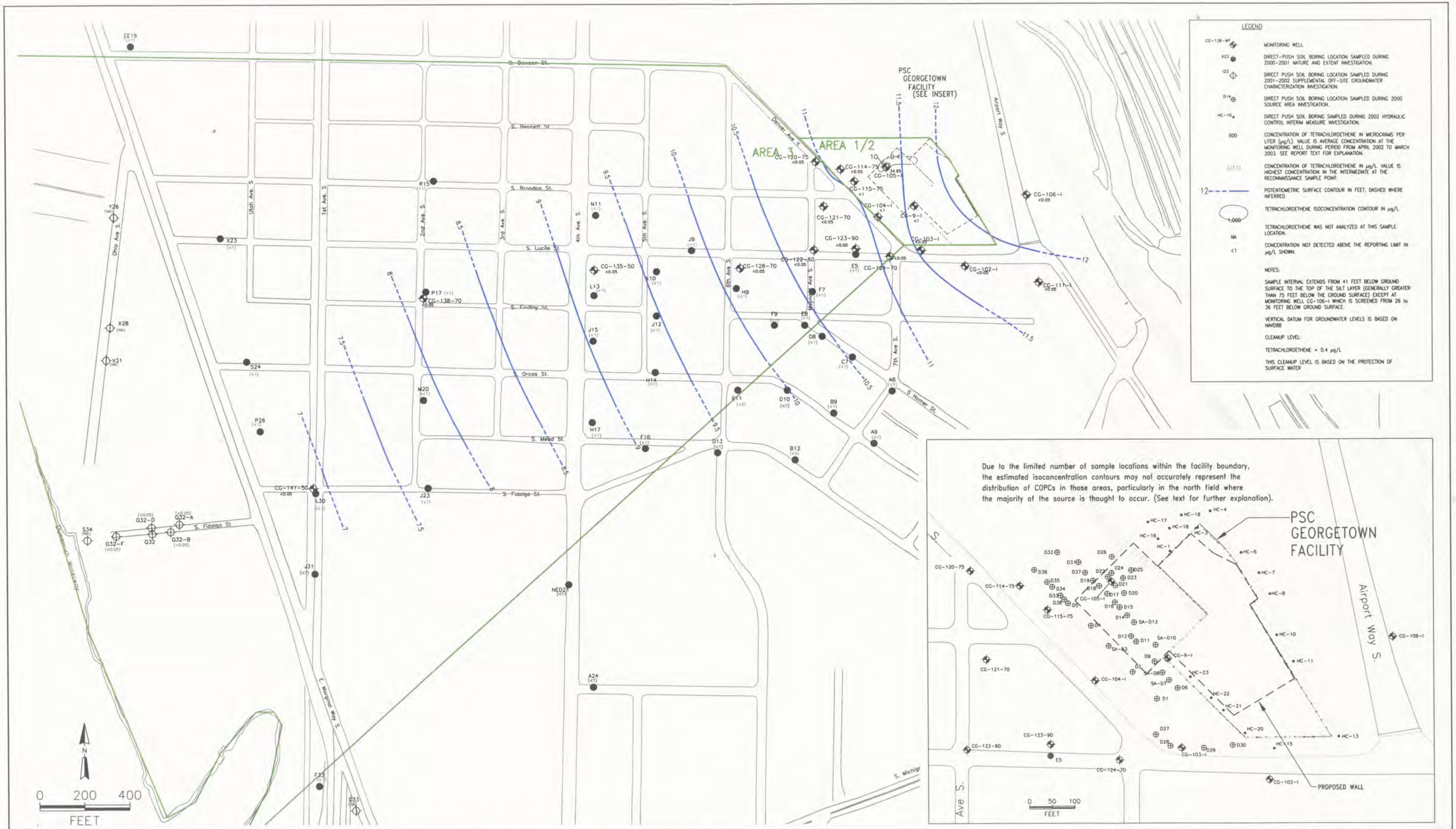
CLEANUP LEVEL

VINYL CHLORIDE = 4 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

TITLE: Vinyl Chloride Isoconcentration Map Shallow Sample Interval PSC Georgetown Facility Remedial Investigation Study Area	DWN: DEW	DES.:	PROJECT NO.: RI2003
	CHKD: CJM	APPD:	FIGURE NO.: 9-25
	DATE: 10/26/03	REV.: 1	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TETRACHLOROETHENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TETRACHLOROETHENE IN µg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TETRACHLOROETHENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TETRACHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

TETRACHLOROETHENE = 0.4 µg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

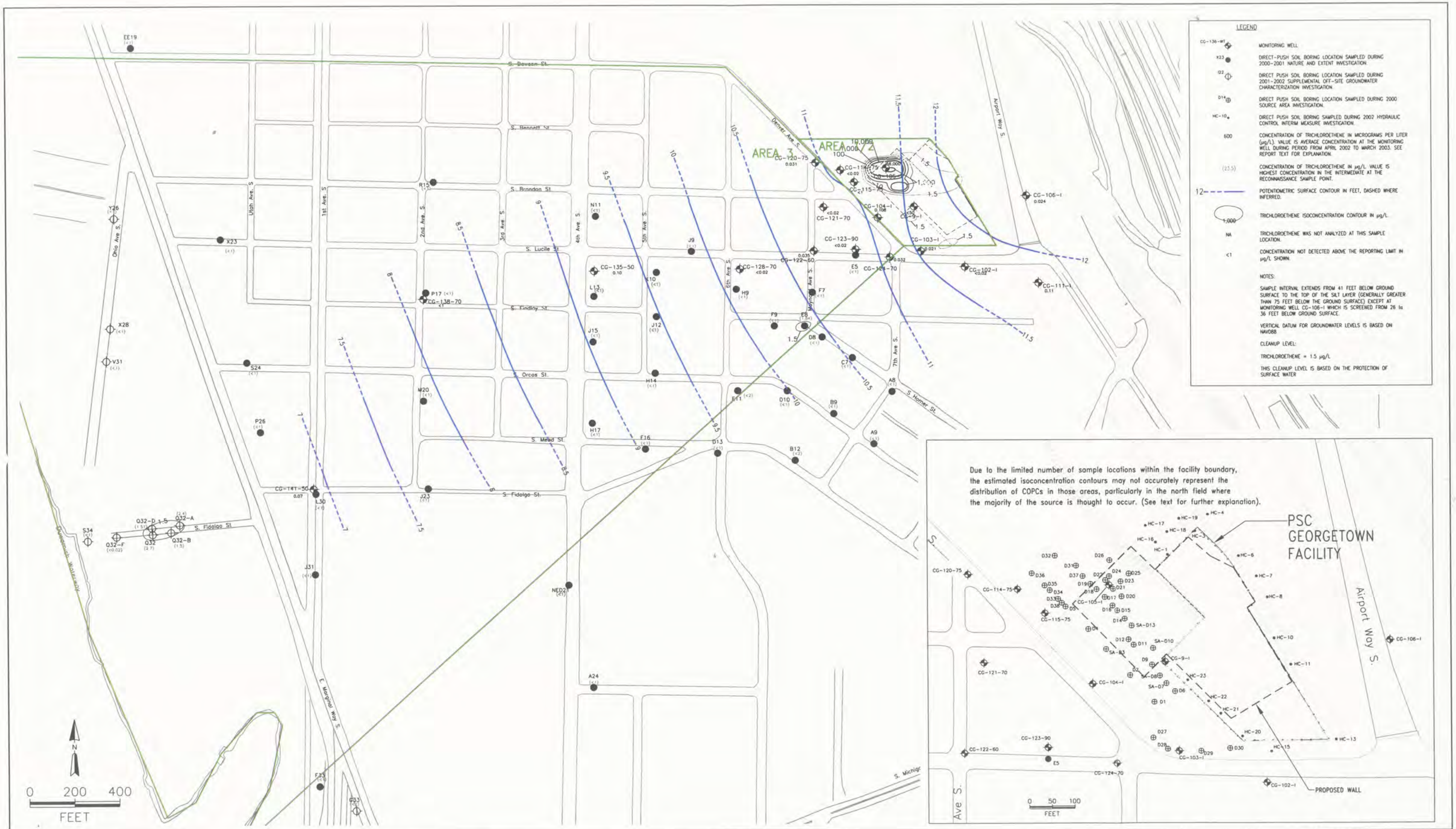
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Tetrachloroethene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-26



Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF TRICHLOROETHENE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF TRICHLOROETHENE IN µg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE AT THE RECONNAISSANCE SAMPLE POINT.
12- - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	TRICHLOROETHENE ISOCONCENTRATION CONTOUR IN µg/L.
NA	TRICHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

TRICHLOROETHENE = 1.5 µg/L

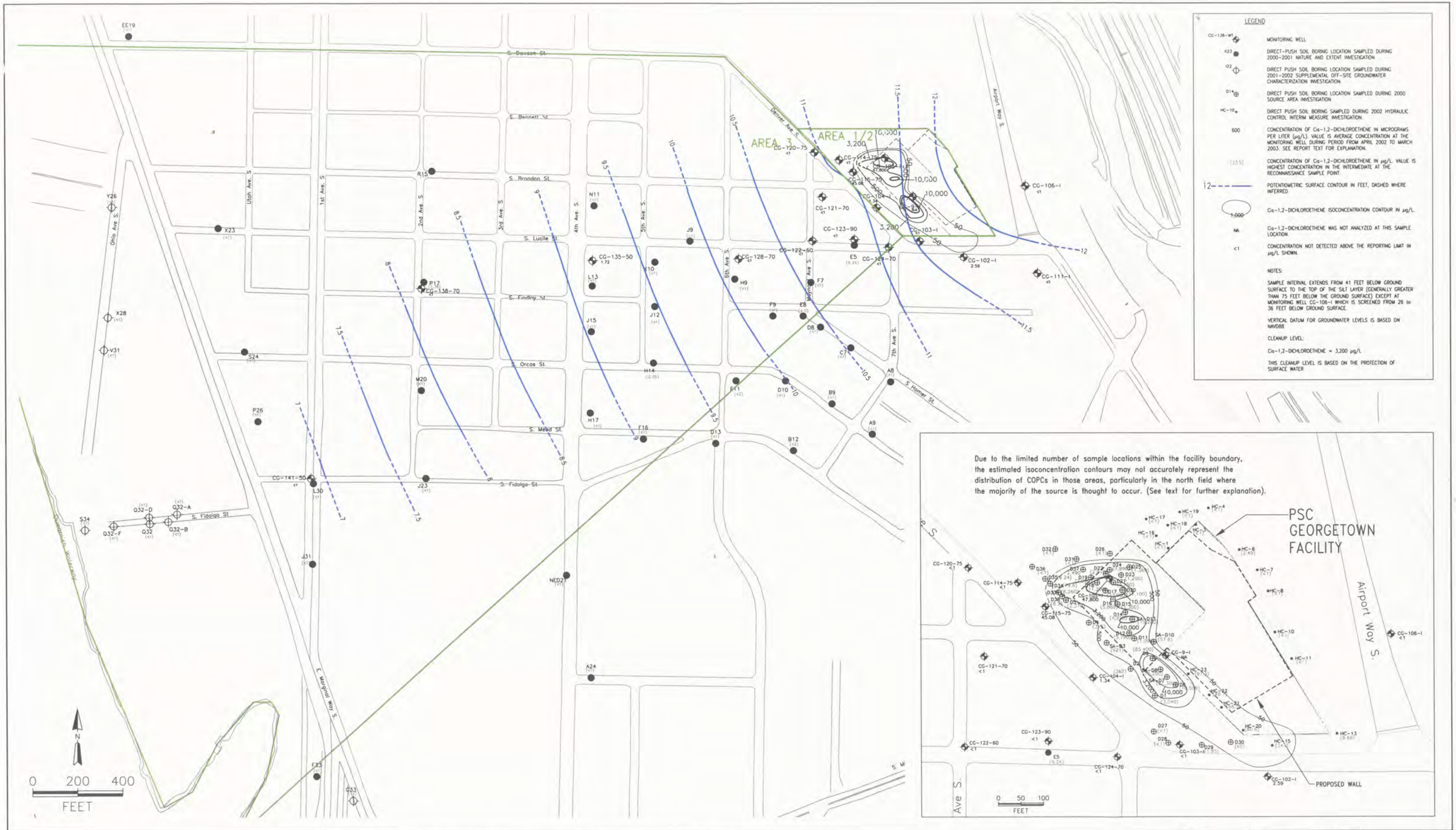
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

Trichloroethene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/28/03	REV.:	FIGURE NO.: 9-27



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF Cis-1,2-DICHLORDETHENE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF Cis-1,2-DICHLORDETHENE IN μg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE AT THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	Cis-1,2-DICHLOROETHENE ISOCONCENTRATION CONTOUR IN μg/L.
NA	Cis-1,2-DICHLOROETHENE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

Cis-1,2-DICHLOROETHENE = 3,200 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

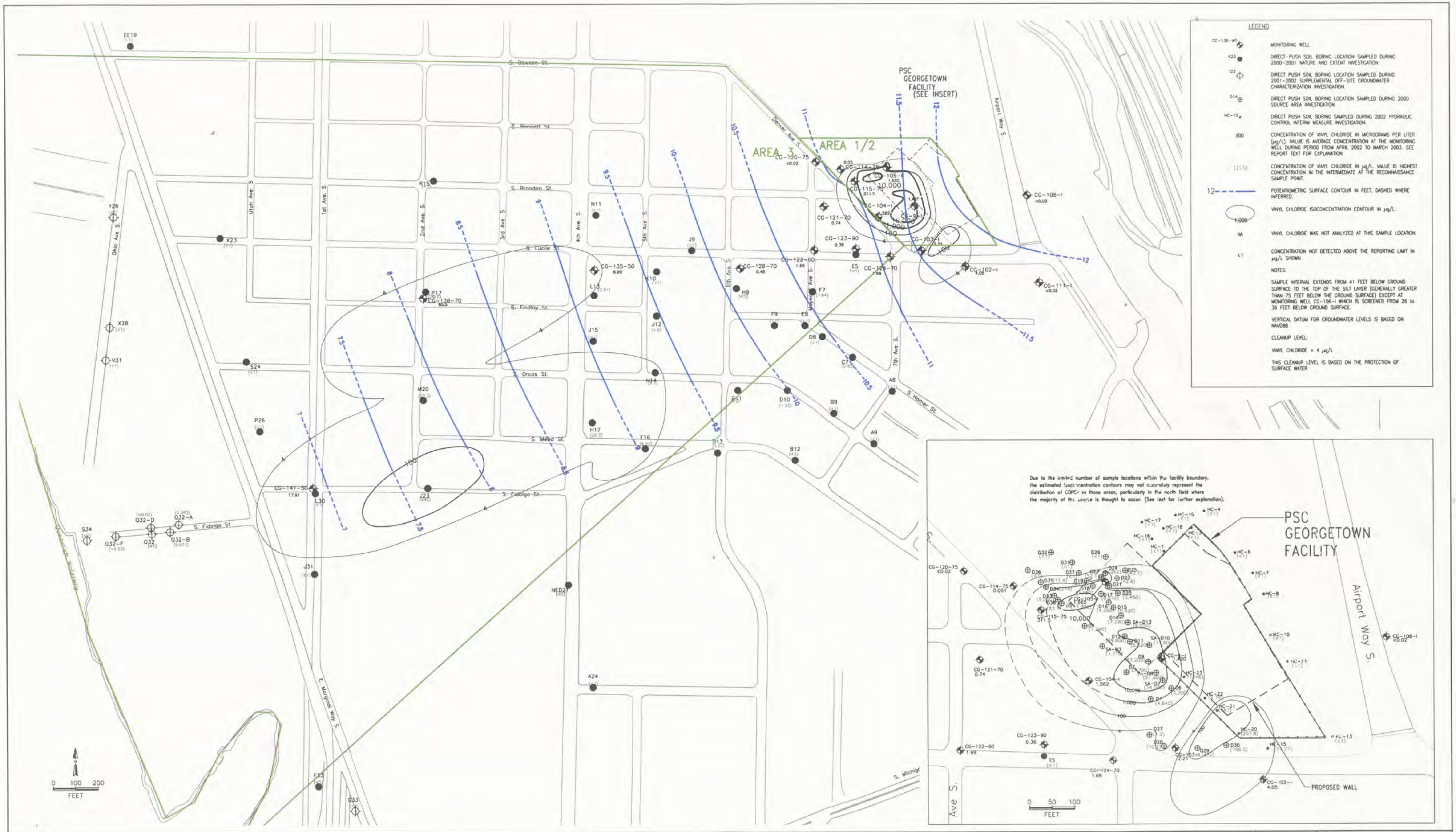
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

Cis-1,2-Dichloroethene Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003	
CHKD: CJM	APPD:	FIGURE NO.: 9-28	
DATE: 10/28/03	REV.:		

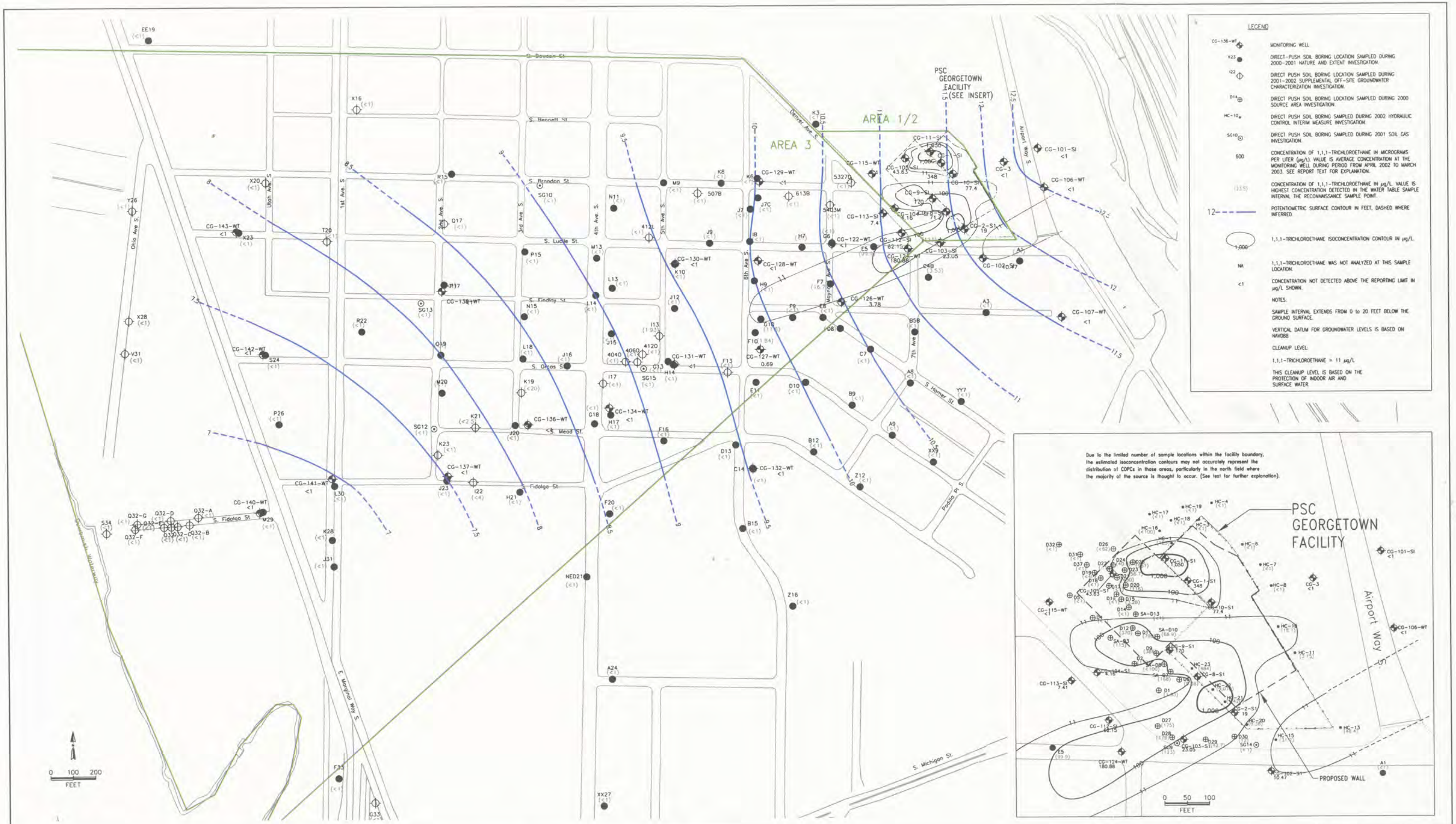


PSC

TITLE:

Vinyl Chloride Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: R12003	
CHKD: CJM	APPD:	FIGURE NO.: 9-29	
DATE: 10/26/03	REV.:		



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(33.5)	CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12- - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	1,1,1-TRICHLORDETHANE ISOCONCENTRATION CONTOUR IN μg/L.
NA	1,1,1-TRICHLORDETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,1,1-TRICHLOROETHANE = 11 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

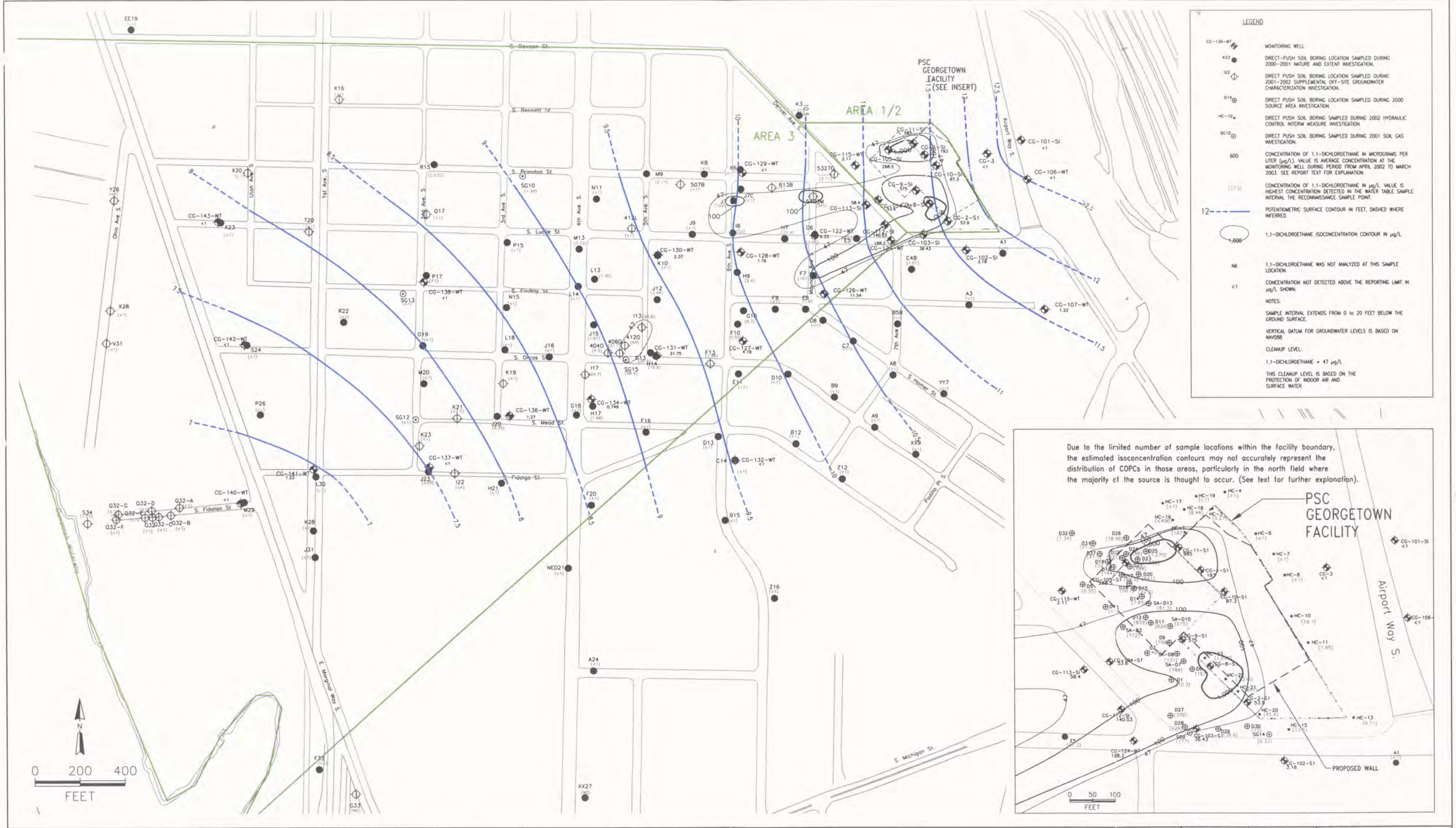
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

1,1,1–Trichloroethane Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003	
CHKD: CJM	APPD:		
DATE: 10/15/03	REV.: 1	FIGURE NO.: 9–30	



Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF 1,1-DICHLOROETHANE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF 1,1-DICHLOROETHANE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL THE RECONNAISSANCE SAMPLE POINT.
12 - - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	1,1-DICHLOROETHANE ISOCONCENTRATION CONTOUR IN µg/L.
NA	1,1-DICHLOROETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88.

CLEANUP LEVEL:

1,1-DICHLOROETHANE = 47 µg/L

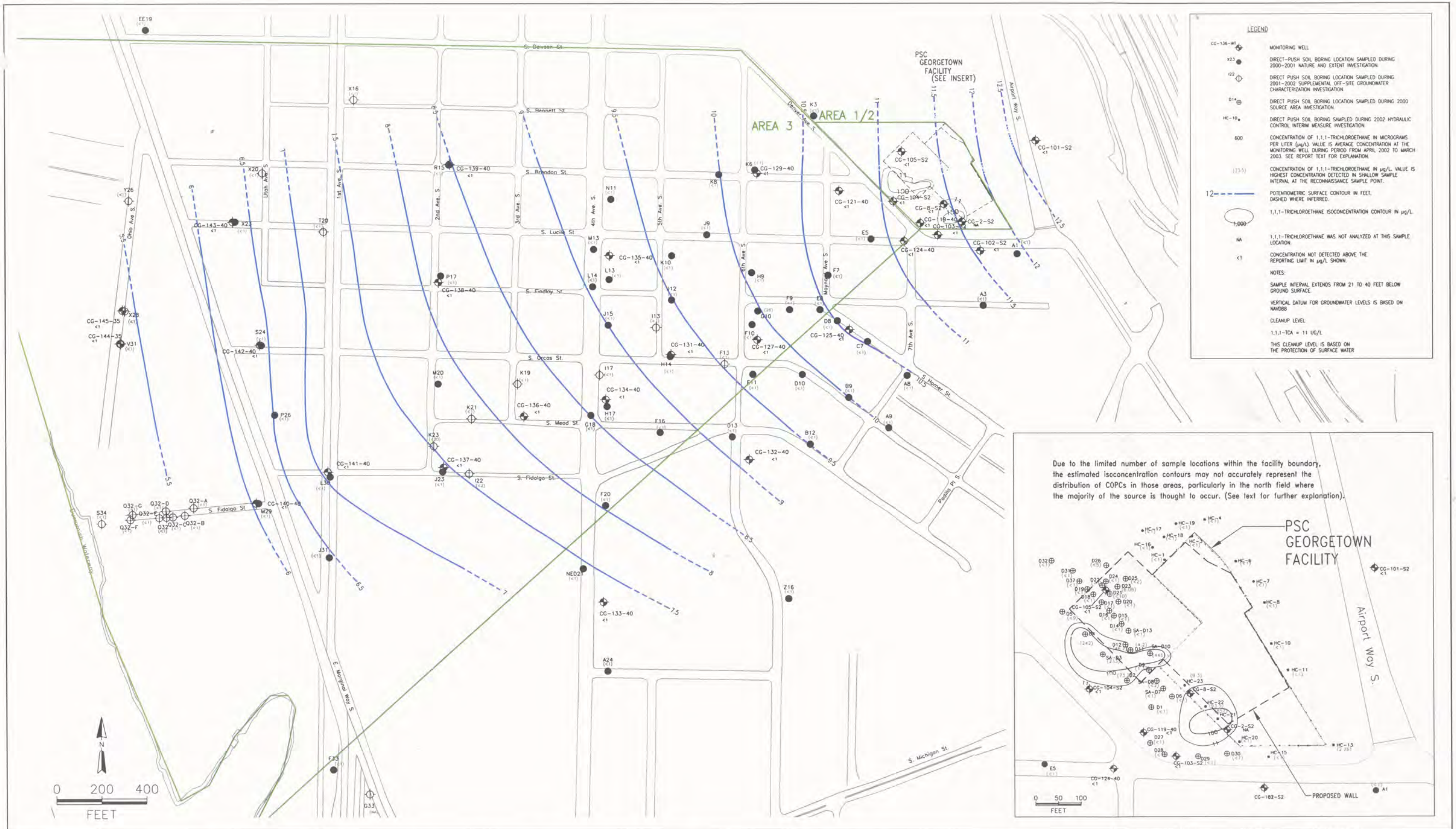
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER.

PSC

TITLE:

1,1-Dichloroethane Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/21/03	REV.: 1	FIGURE NO. 9-31



LEGEND

CG-136-WT MONITORING WELL

X23 DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.

I22 DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.

D14 DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.

HC-10 DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.

600 CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

(23.5) CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN µg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.

12 POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

1,000 1,1,1-TRICHLOROETHANE ISOCONCENTRATION CONTOUR IN µg/L.

NA 1,1,1-TRICHLOROETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 TO 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,1,1-TCA = 11 UG/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

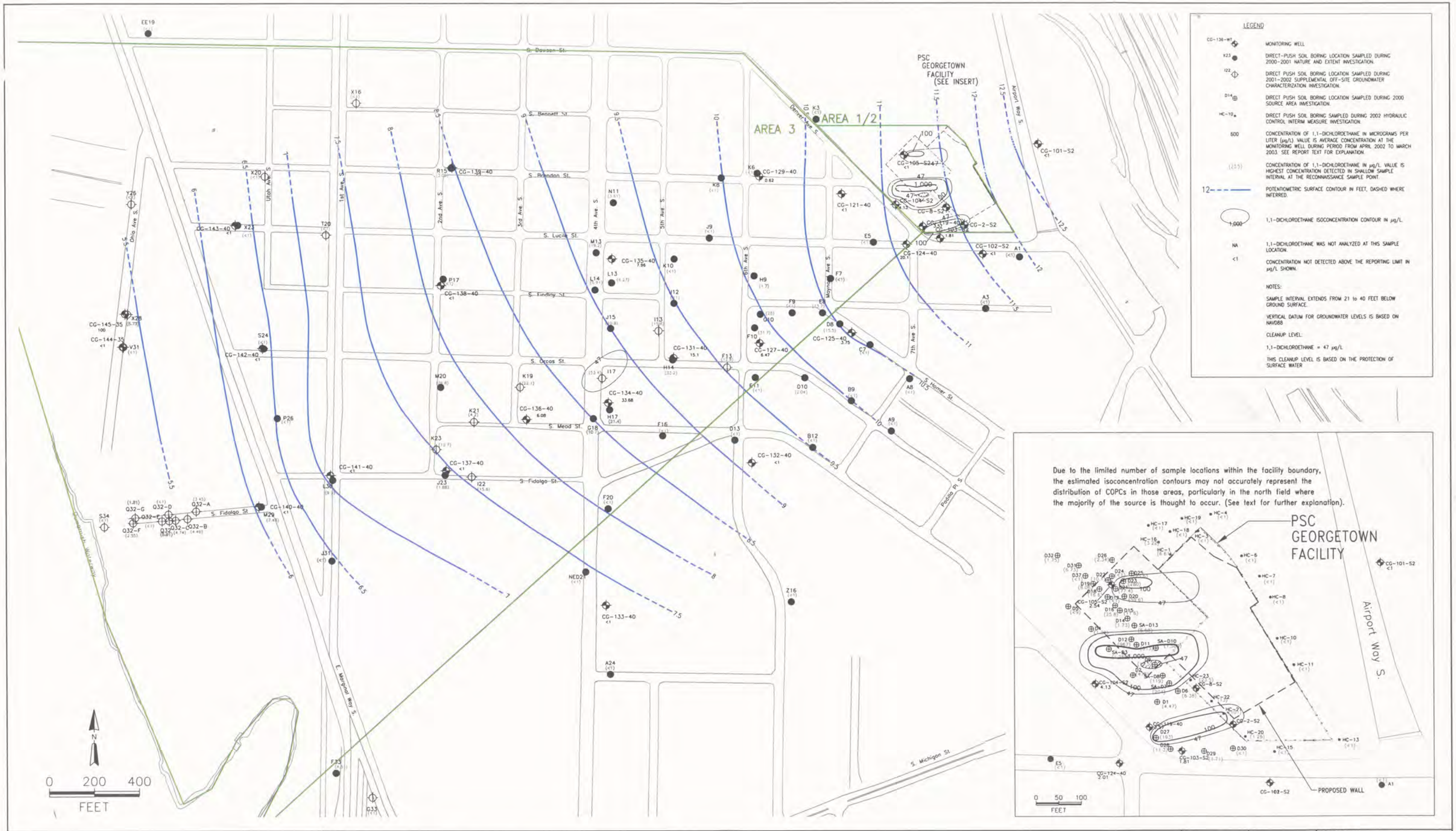
Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

1,1,1–Trichloroethane Isoconcentration Map
Shallow Sample Interval
PSCGeorgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/15/03	REV.: 1	FIGURE NO.: 9–32



LEGEND

CG-136-WT	MONITORING WELL
K23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
500	CONCENTRATION OF 1,1-DICHLOROETHANE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(255)	CONCENTRATION OF 1,1-DICHLOROETHANE IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN SHALLOW SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	1,1-DICHLOROETHANE ISOCONCENTRATION CONTOUR IN μg/L.
NA	1,1-DICHLOROETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,1-DICHLOROETHANE = 47 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

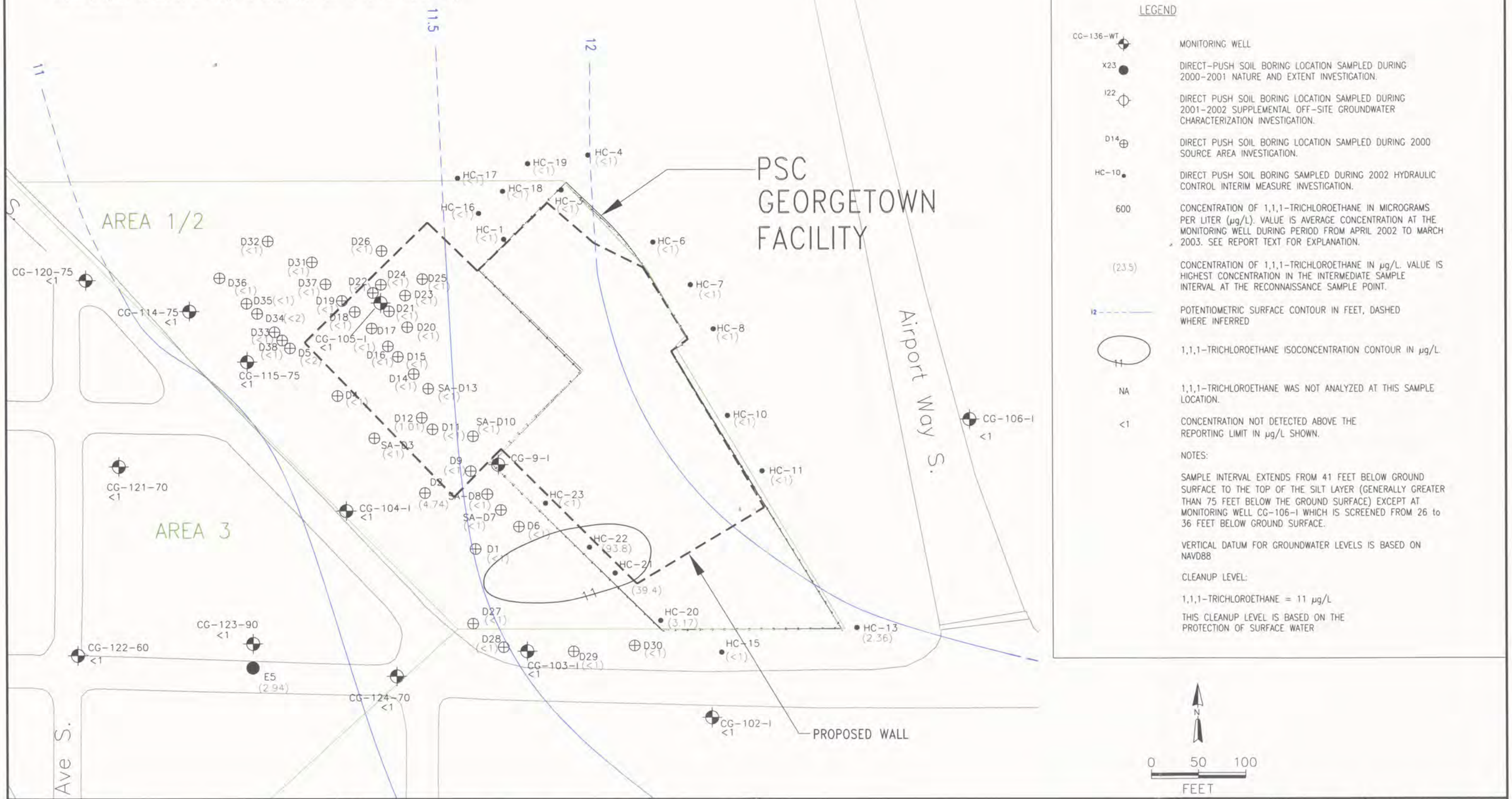
PSC

TITLE:

1,1–Dichloroethane Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 9–33

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN μg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
12	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED
11	1,1,1-TRICHLOROETHANE ISOCONCENTRATION CONTOUR IN μg/L.
NA	1,1,1-TRICHLOROETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

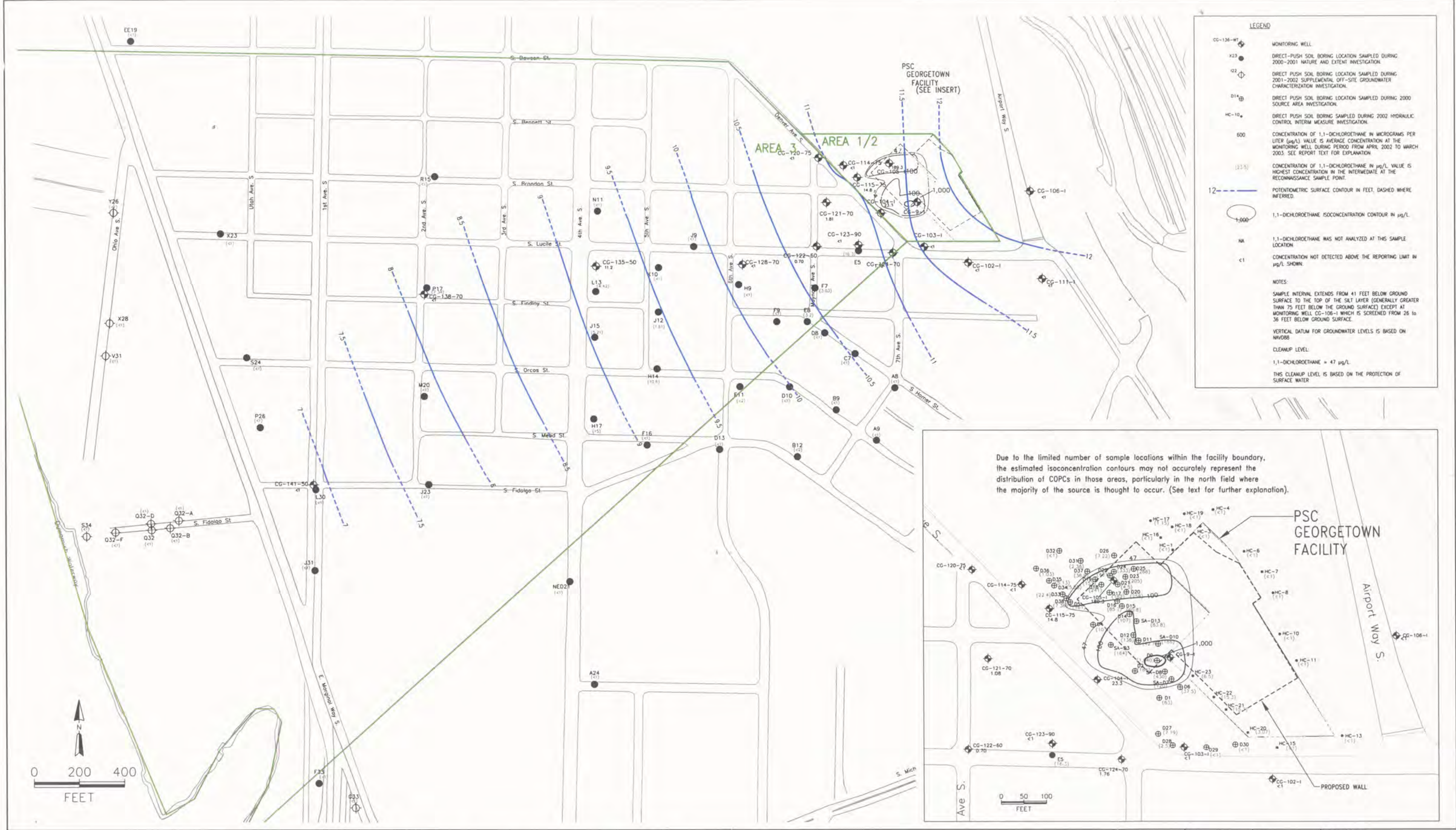
1,1,1-TRICHLOROETHANE = 11 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:
1,1,1-Trichloroethane Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW
DES.:
CHKD: CJM
APPD:
DATE: 10/29/03
REV.:
PROJECT NO.: RI2003
FIGURE NO.: 9-34



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 ●	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
600	CONCENTRATION OF 1,1-DICHLOROETHANE IN MICROGRAMS PER LITER (µg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF 1,1-DICHLOROETHANE IN µg/L. VALUE IS HIGHEST CONCENTRATION IN THE INTERMEDIATE AT THE RECONNAISSANCE SAMPLE POINT.
12- - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
1,000	1,1-DICHLOROETHANE ISOCONCENTRATION CONTOUR IN µg/L.
NA	1,1-DICHLOROETHANE WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN µg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,1-DICHLOROETHANE = 47 µg/L.

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:

1,1-Dichloroethane Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

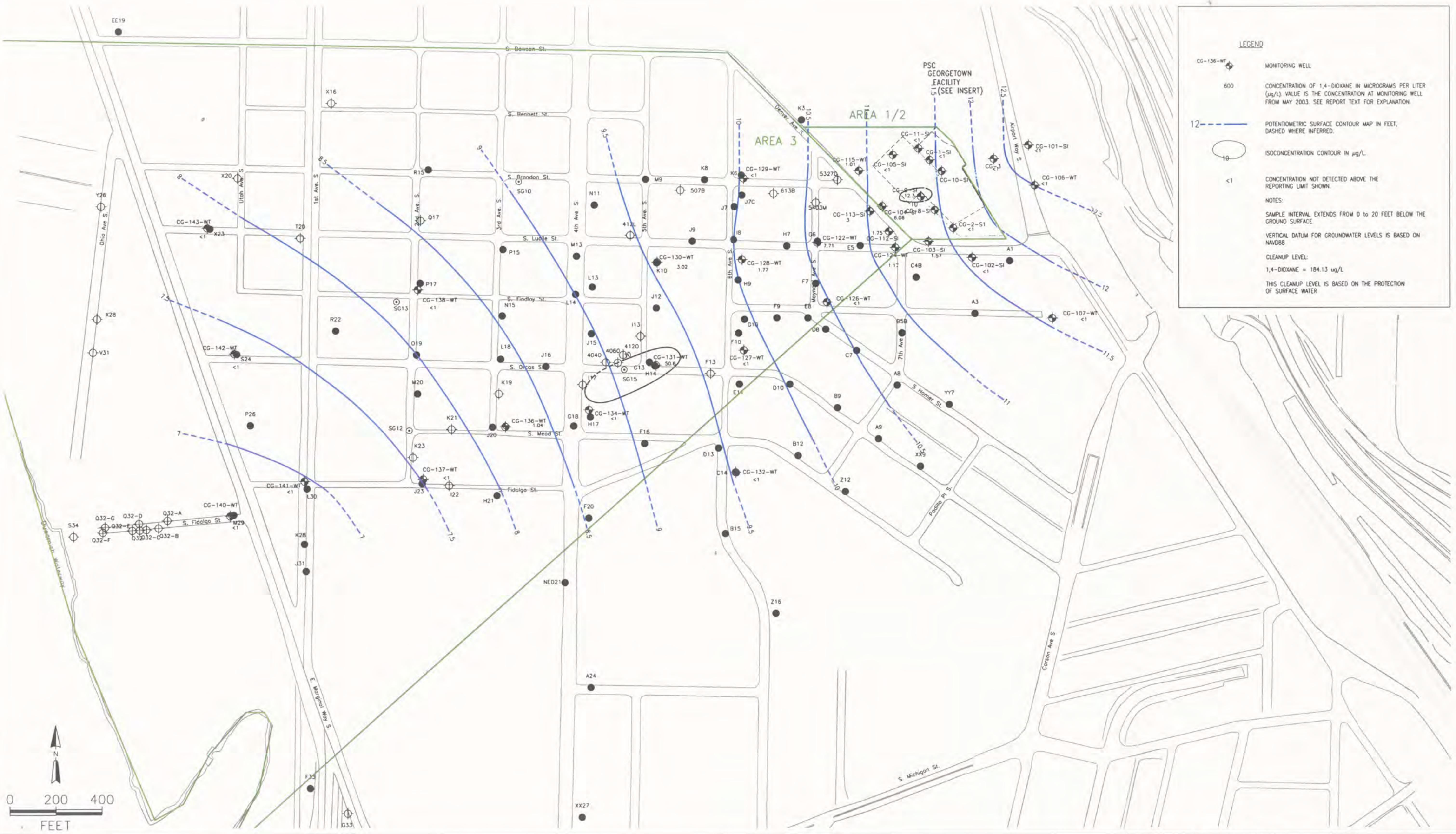
DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 9-35

PSC

TITLE:

Concentrations of 1,2,4–Trimethylbenzene and 1,3,5–Trimethylbenzene in Groundwater
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/15/03	REV.: 1	FIGURE NO.: 9–36



LEGEND

CG-136-WT MONITORING WELL

600 CONCENTRATION OF 1,4-DIOXANE IN MICROGRAMS PER LITER (μg/L). VALUE IS THE CONCENTRATION AT MONITORING WELL FROM MAY 2003. SEE REPORT TEXT FOR EXPLANATION.

12 POTENTIOMETRIC SURFACE CONTOUR MAP IN FEET, DASHED WHERE INFERRED.

10 ISOCONCENTRATION CONTOUR IN μg/L.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,4-DIOXANE = 184.13 ug/L

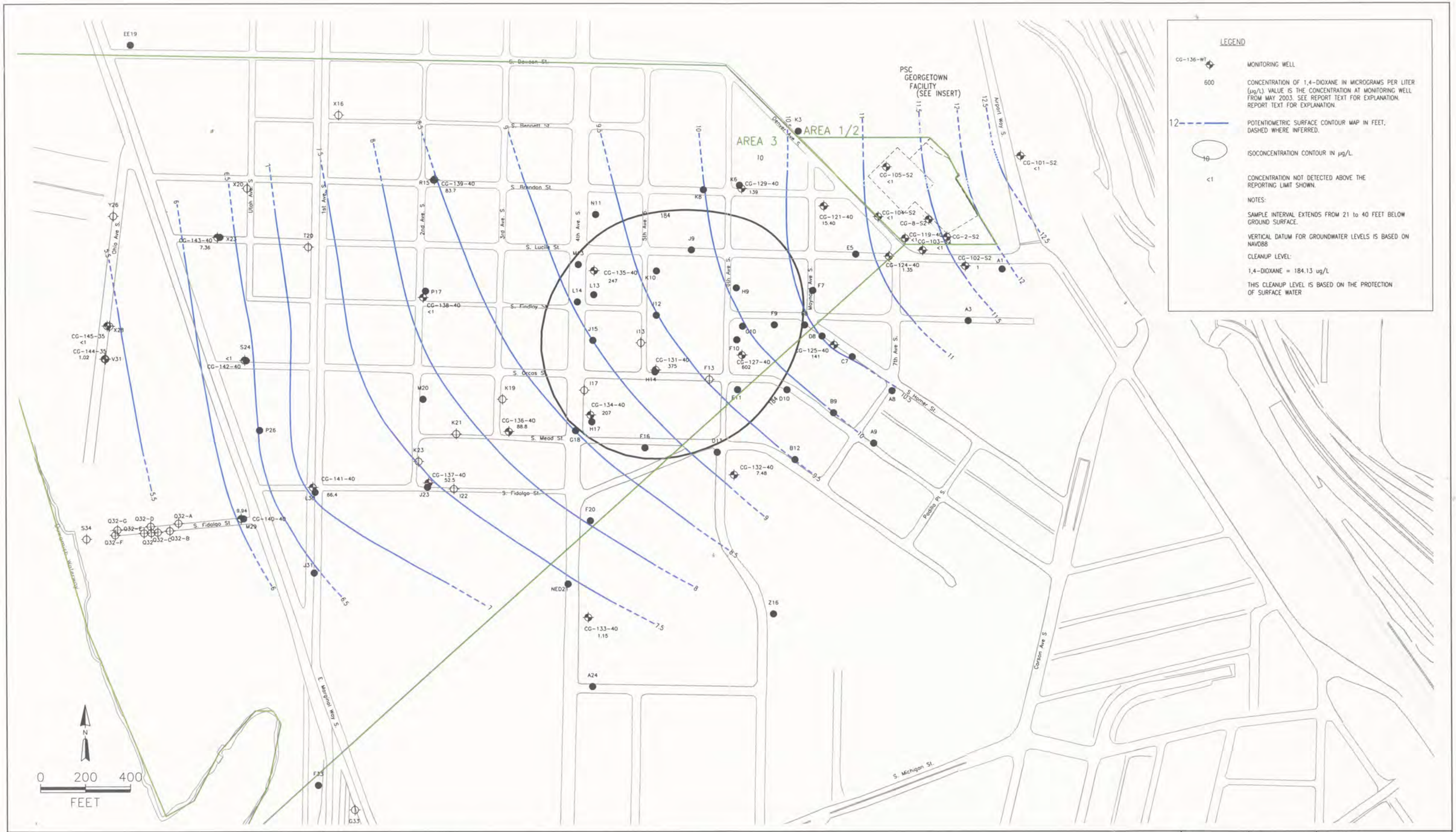
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

1,4-Dioxane Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 9-37



LEGEND

CG-136-WT MONITORING WELL

600 CONCENTRATION OF 1,4-DIOXANE IN MICROGRAMS PER LITER (μg/L). VALUE IS THE CONCENTRATION AT MONITORING WELL FROM MAY 2003. SEE REPORT TEXT FOR EXPLANATION. REPORT TEXT FOR EXPLANATION.

12 POTENTIOMETRIC SURFACE CONTOUR MAP IN FEET, DASHED WHERE INFERRED.

10 ISOCONCENTRATION CONTOUR IN μg/L.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 to 40 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,4-DIOXANE = 184.13 ug/L

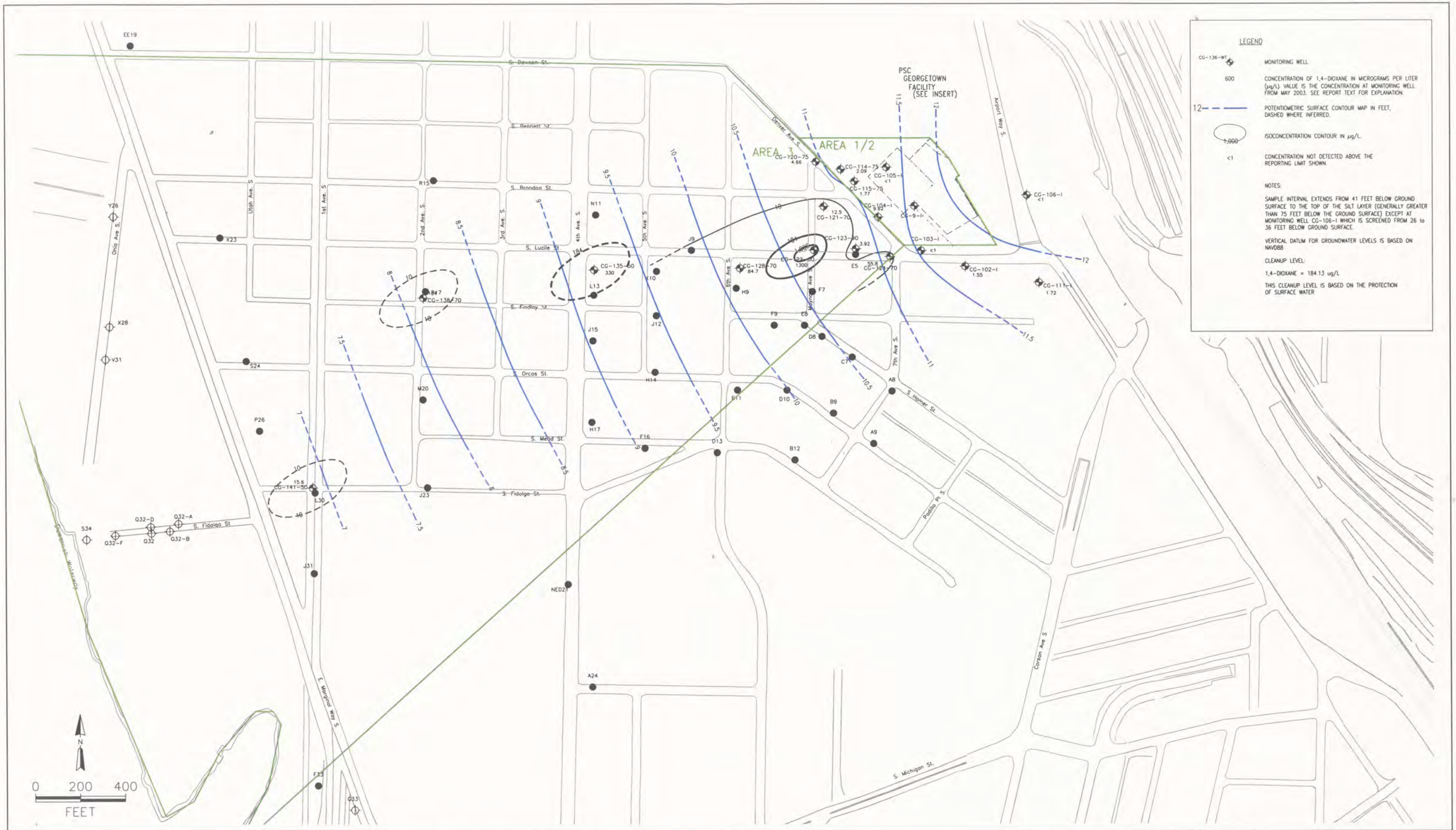
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

1,4–Dioxane Isoconcentration Map
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 9–38



LEGEND

CG-136-WT MONITORING WELL

600 CONCENTRATION OF 1,4-DIOXANE IN MICROGRAMS PER LITER (μg/L). VALUE IS THE CONCENTRATION AT MONITORING WELL FROM MAY 2003. SEE REPORT TEXT FOR EXPLANATION.

12 POTENTIOMETRIC SURFACE CONTOUR MAP IN FEET, DASHED WHERE INFERRED.

1,000 ISOCONCENTRATION CONTOUR IN μg/L.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

1,4-DIOXANE = 184.13 ug/L

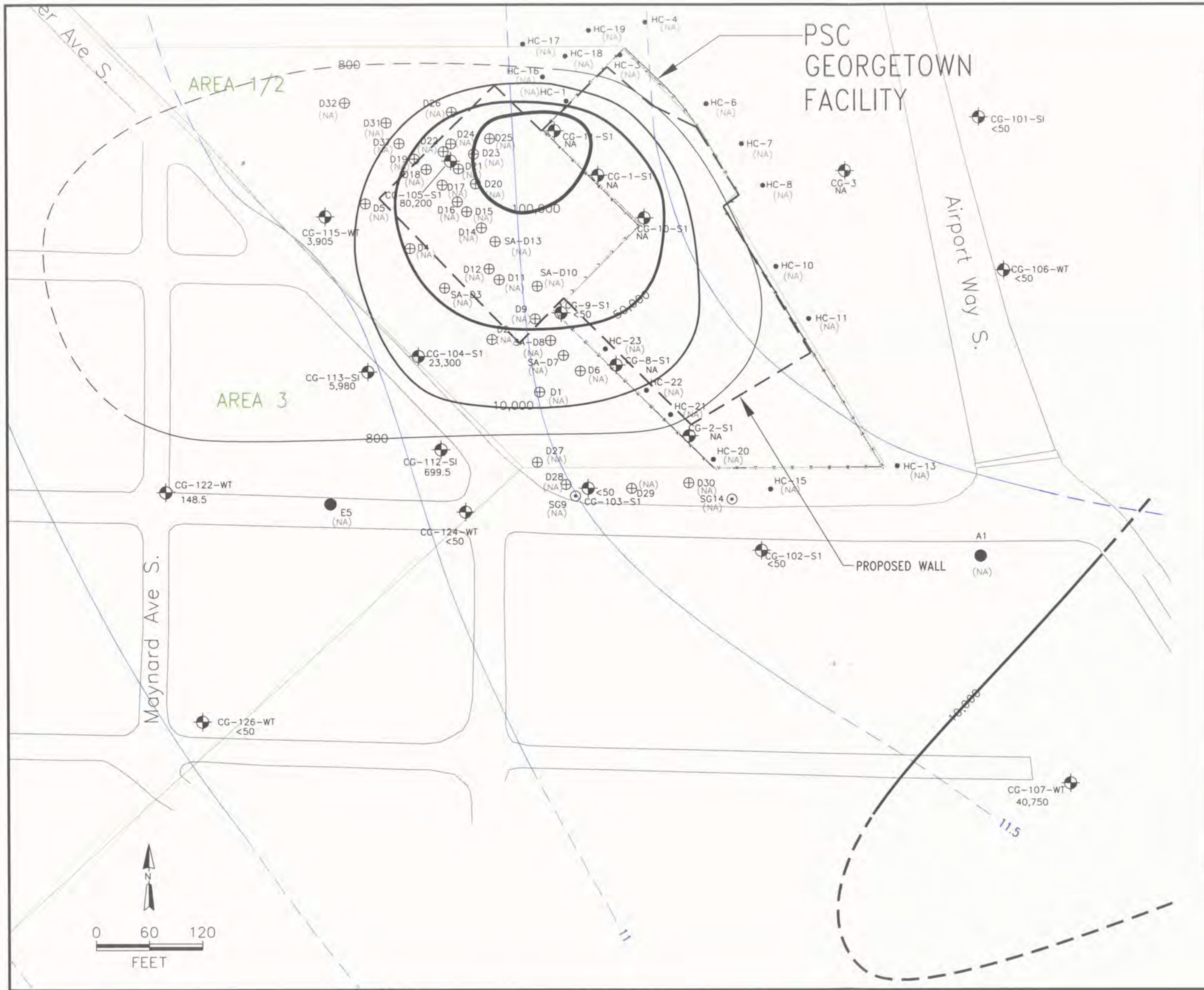
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

1,4-Dioxane Isoconcentration Map
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO. 9-39
DATE: 10/29/03	REV.:	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF GRO IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF GRO IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
— — —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED
1,000	GRO ISOCONCENTRATION CONTOUR IN μg/L. THE CLEANUP
NA	GRO WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

GRO = 1,442 μg/L

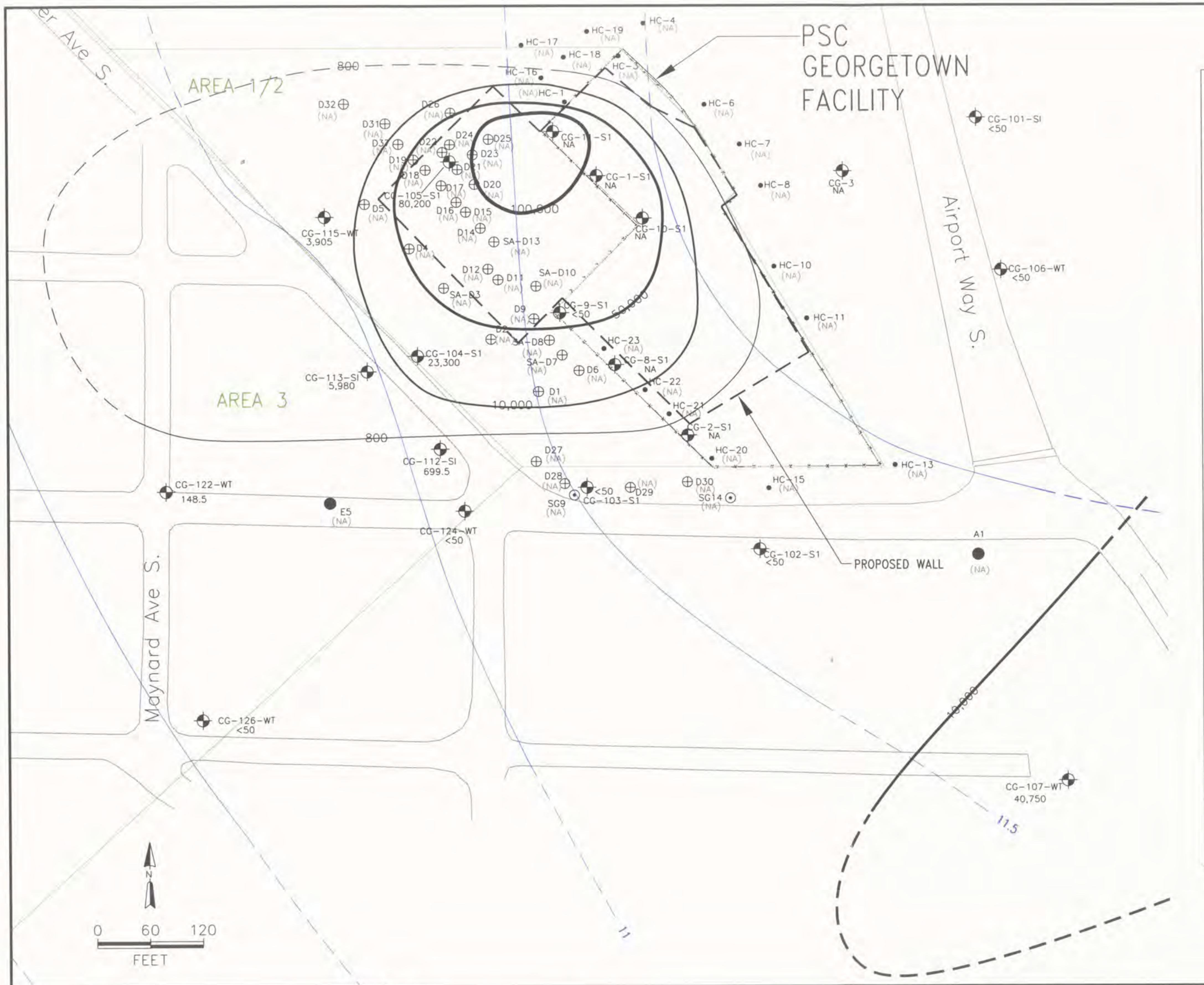
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:
GRO Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO.: 9-40
DATE: 10/29/03	REV.:	



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
D14 ⊕	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2000 SOURCE AREA INVESTIGATION.
HC-10 •	DIRECT PUSH SOIL BORING SAMPLED DURING 2002 HYDRAULIC CONTROL INTERIM MEASURE INVESTIGATION.
SG10 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
600	CONCENTRATION OF GRO IN MICROGRAMS PER LITER (μg/L). VALUE IS AVERAGE CONCENTRATION AT THE MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
(23.5)	CONCENTRATION OF GRO IN μg/L. VALUE IS HIGHEST CONCENTRATION DETECTED IN THE WATER TABLE SAMPLE INTERVAL AT THE RECONNAISSANCE SAMPLE POINT.
— — —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED
1,000	GRO ISOCONCENTRATION CONTOUR IN μg/L. THE CLEANUP
NA	GRO WAS NOT ANALYZED AT THIS SAMPLE LOCATION.
<1	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT IN μg/L SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 to 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

GRO = 1,442 μg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF INDOOR AIR AND SURFACE WATER

Due to the limited number of sample locations within the facility boundary, the estimated isoconcentration contours may not accurately represent the distribution of COPCs in those areas, particularly in the north field where the majority of the source is thought to occur. (See text for further explanation).

PSC

TITLE:
GRO Isoconcentration Map
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: DEW	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 9-40

LEGEND

CG-136-WT ⊕	MONITORING WELL
x23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2002 HYDRAULIC CONTROL INVESTIGATION.
0.01246	CONCENTRATION OF ARSENIC IN MILLIROGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
12 -----——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
NA	ARSENIC NOT ANALYZED AT THIS SAMPLE LOCATION.
<0.01	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 TO 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

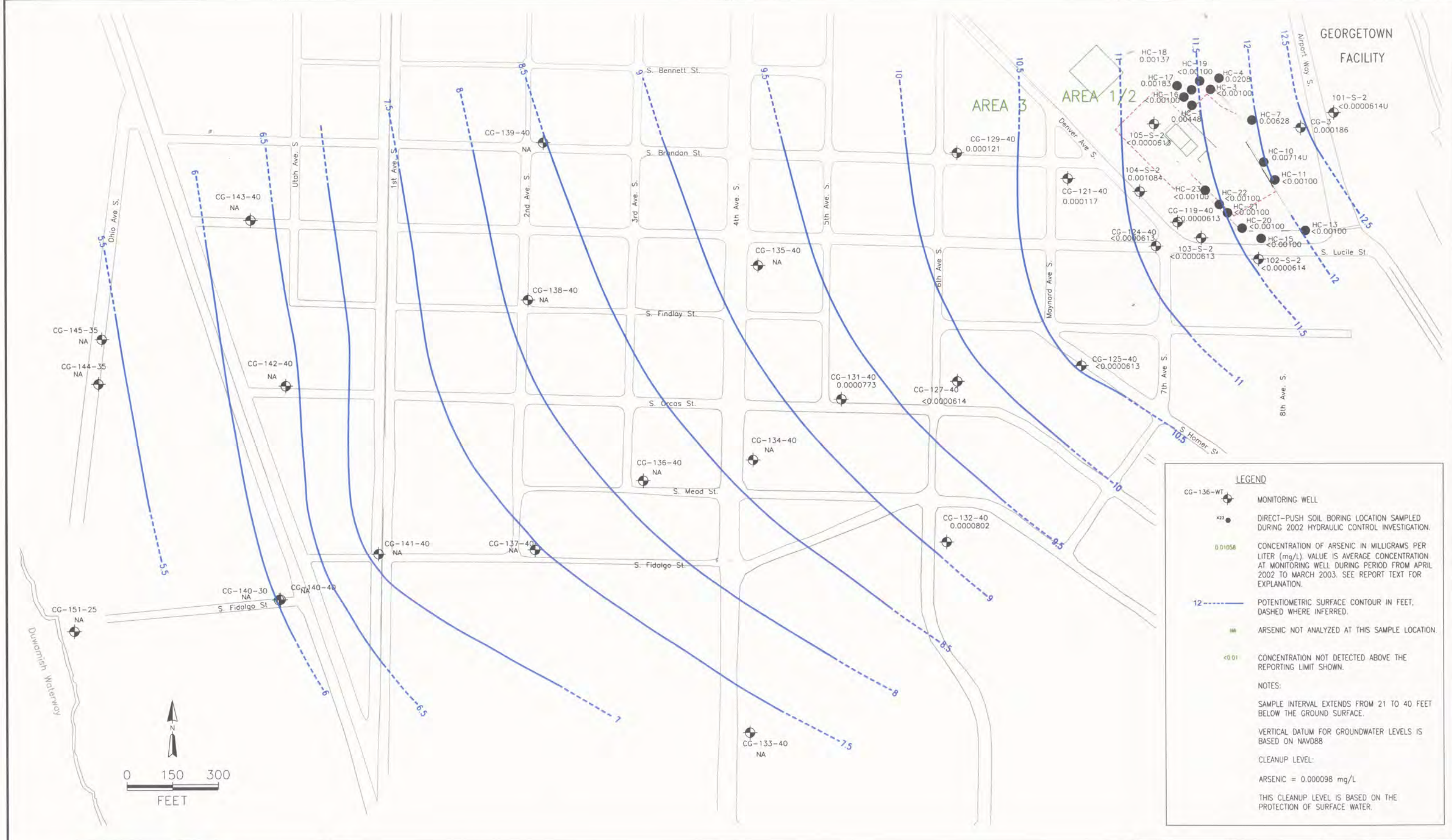
ARSENIC = 0.000098 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:
Concentrations of Arsenic in Groundwater
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 11/11/03	REV.:	FIGURE NO.: 9-41



LEGEND

CG-136-WT ⊕ MONITORING WELL

X23 ● DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2002 HYDRAULIC CONTROL INVESTIGATION.

0.01058 CONCENTRATION OF ARSENIC IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

12 - - - - —— POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

NA ARSENIC NOT ANALYZED AT THIS SAMPLE LOCATION.

<0.01 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 TO 40 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

ARSENIC = 0.000098 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:
Concentrations of Arsenic in Groundwater
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	FIGURE NO.: 9-42
DATE: 11/12/03	REV.:	

LEGEND

MONITORING WELL

CONCENTRATION OF ARSENIC IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2002 HYDRAULIC CONTROL INVESTIGATION.

POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

ARSENIC NOT ANALYZED AT THIS SAMPLE LOCATION.

CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

ARSENIC = 0.000098 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:
Concentrations of Arsenic in Groundwater
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD: cjm	APPD:	
DATE: 11/12/03	REV.:	FIGURE NO.: 9-43

LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
SG15 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
0.01246	CONCENTRATION OF BARIUM IN MILLIROGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
12 - - - ——	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
NA	BARIUM NOT ANALYZED AT THIS SAMPLE LOCATION.
<0.01	CONCENTRATION NOT DETECTED ABOVE THE LABORATORY METHOD REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 TO 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

BARIUM = 0.004 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:

Concentration of Barium in Groundwater
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO.: 9-44
DATE: 10/15/03	REV.: 1	

LEGEND

CG-136-WT MONITORING WELL

X23 DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.

I22 DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.

SG15 DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.

0.01058 CONCENTRATION OF BARIUM IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

12 POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

NA BARIUM NOT ANALYZED AT THIS SAMPLE LOCATION.

<0.01 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 TO 40 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

BARIUM = 0.004 mg/L

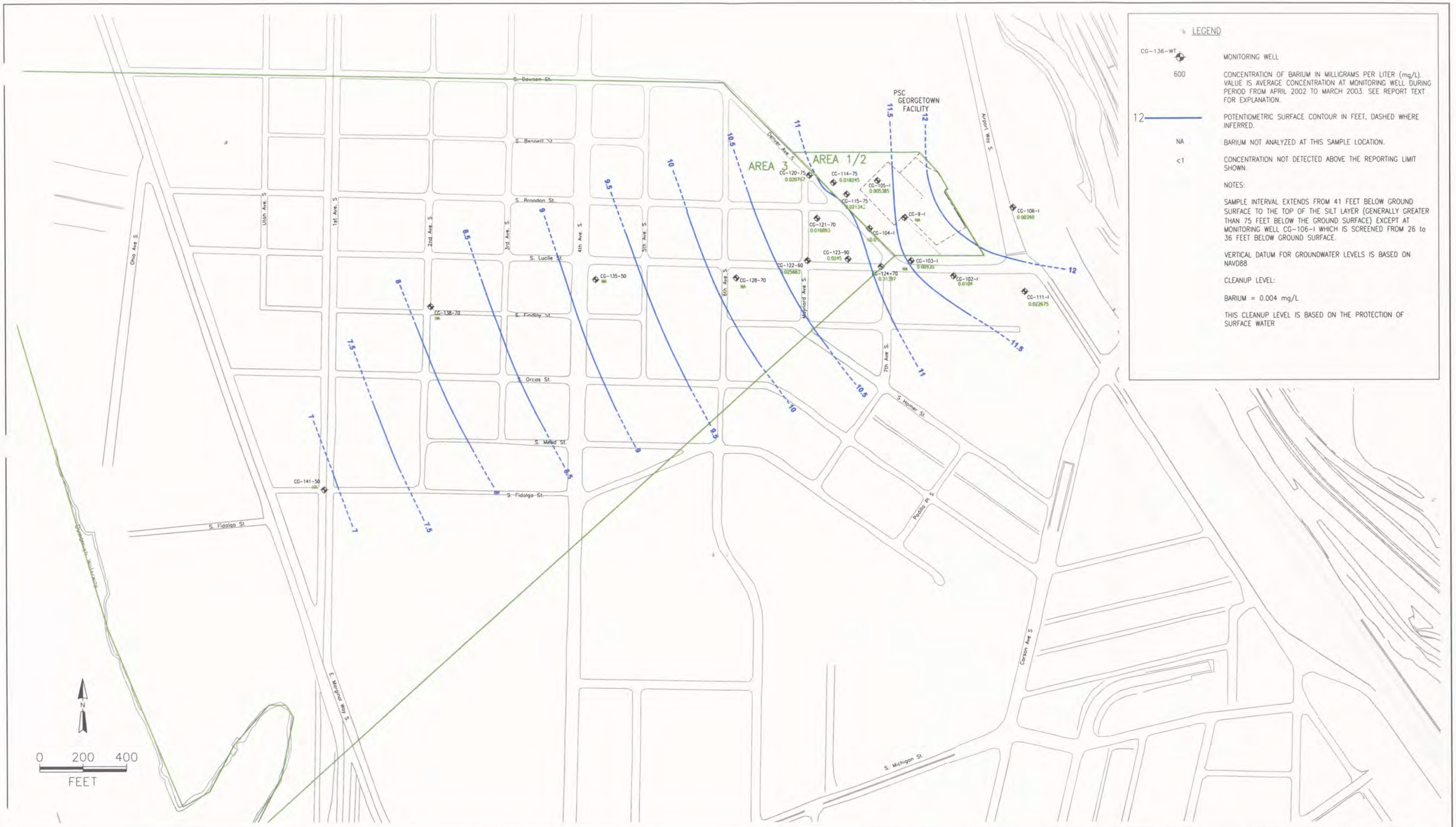
THIS CLEANUP LEVLE IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

Concentration of Barium in Groundwater
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 11/12/03	REV.:	FIGURE NO. 9-45



LEGEND

CG-136-WT MONITORING WELL

600 CONCENTRATION OF BARIUM IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

12 POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

NA BARIUM NOT ANALYZED AT THIS SAMPLE LOCATION.

<1 CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

BARIUM = 0.004 mg/L

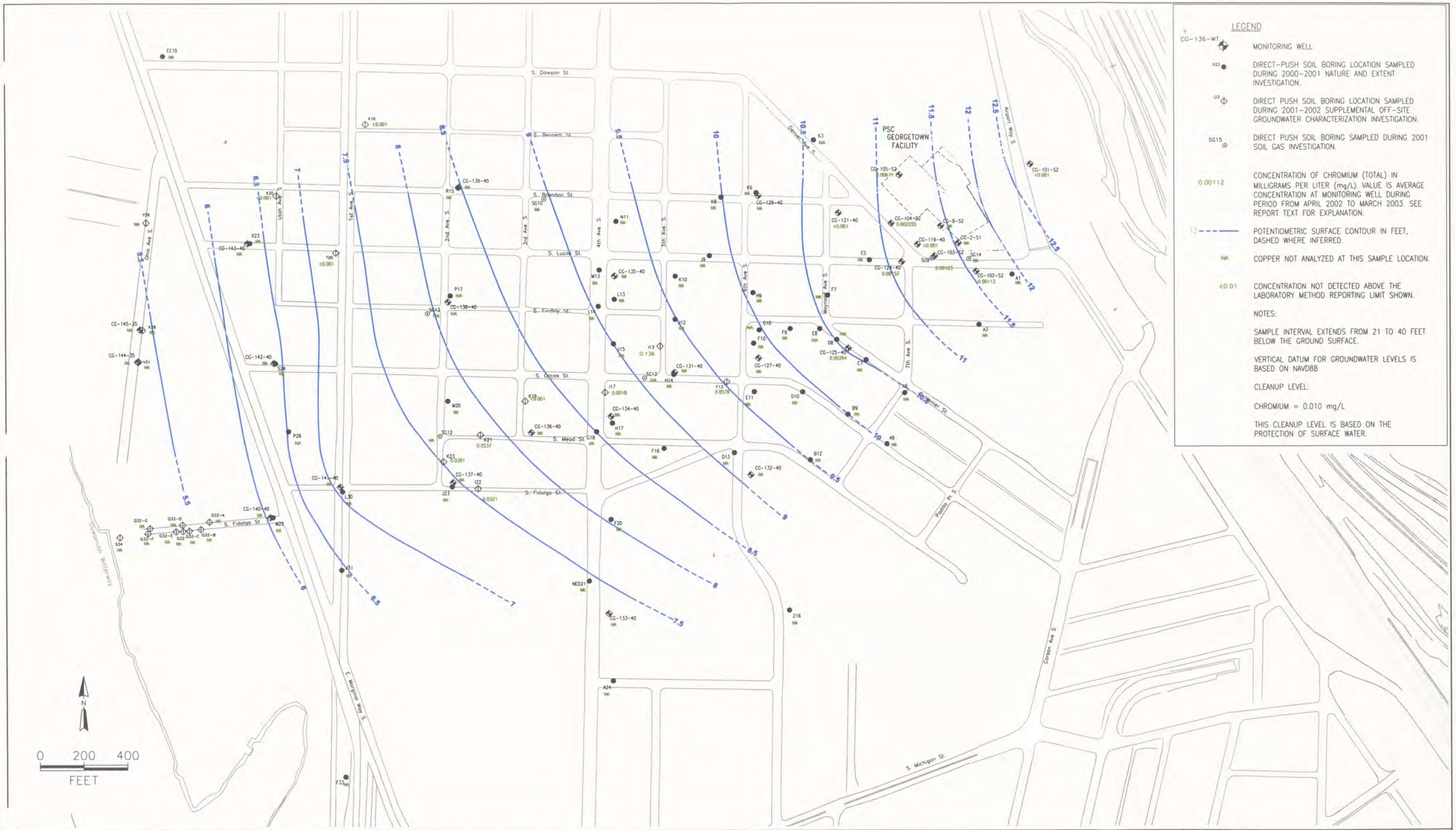
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:

Concentration of Barium in Groundwater
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/15/03	REV.: 1	FIGURE NO.: 9-46



LEGEND

CG-136-WT	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
SG15 ⊙	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
0.00112	CONCENTRATION OF CHROMIUM (TOTAL) IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
12 - - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
NA	COPPER NOT ANALYZED AT THIS SAMPLE LOCATION.
<0.01	CONCENTRATION NOT DETECTED ABOVE THE LABORATORY METHOD REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 TO 40 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

CHROMIUM = 0.010 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:

Concentration of Chromium in Groundwater
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	FIGURE NO.: 9-47
DATE: 10/15/03	REV.: 1	

LEGEND

CG-136-WT ⌖	MONITORING WELL
X23 ●	DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.
I22 ⌖	DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.
SG15 ◎	DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.
0.01246	CONCENTRATION OF COPPER IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.
12 - - - —	POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.
NA	COPPER NOT ANALYZED AT THIS SAMPLE LOCATION.
<0.01	CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 0 TO 20 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

COPPER = 0.031 mg/L

THIS CLEANUP LEVEL LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:

Concentration of Copper in Groundwater
Water Table Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/15/03	REV.: 1	FIGURE NO.: 9-48

LEGEND

CG-136-WT — MONITORING WELL

X23 — DIRECT-PUSH SOIL BORING LOCATION SAMPLED DURING 2000-2001 NATURE AND EXTENT INVESTIGATION.

I22 — DIRECT PUSH SOIL BORING LOCATION SAMPLED DURING 2001-2002 SUPPLEMENTAL OFF-SITE GROUNDWATER CHARACTERIZATION INVESTIGATION.

SG15 — DIRECT PUSH SOIL BORING SAMPLED DURING 2001 SOIL GAS INVESTIGATION.

0.001510 — CONCENTRATION OF COPPER (TOTAL) IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

12 — POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

NA — COPPER NOT ANALYZED AT THIS SAMPLE LOCATION.

<0.01 — CONCENTRATION NOT DETECTED ABOVE THE REPORTING LIMIT SHOWN.

NOTES:

SAMPLE INTERVAL EXTENDS FROM 21 TO 40 FEET BELOW THE GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

CHROMIUM = 0.0031 mg/L

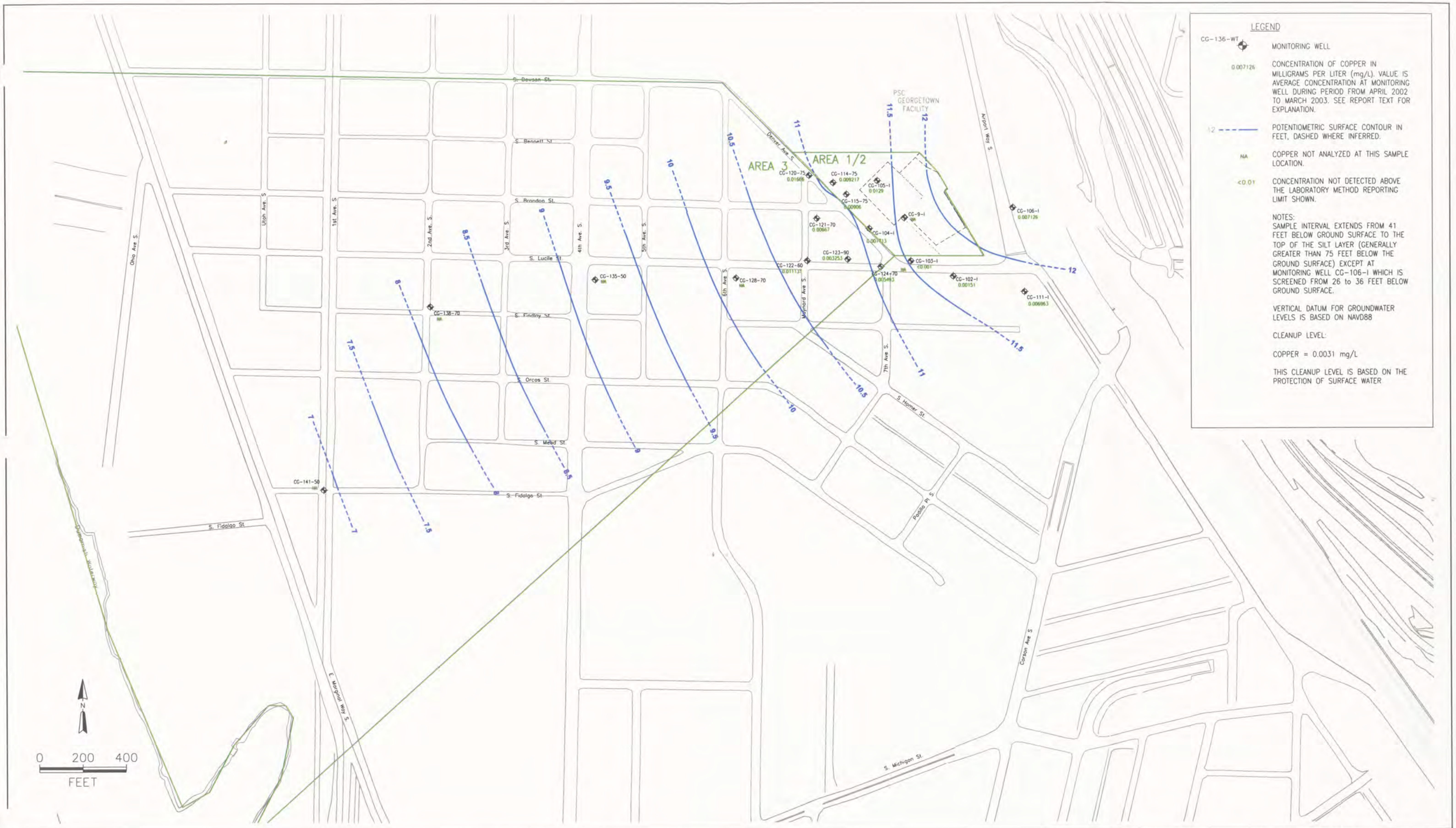
THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER.

PSC

TITLE:

Concentration of Copper in Groundwater
Shallow Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN.: QDD
DES.:
CHKD.: CJM
APPD.:
DATE: 10/15/03
REV.: 1
PROJECT NO.: RI2003
FIGURE NO.: 9-49



LEGEND

CG-136-WT — MONITORING WELL

0.007126 — CONCENTRATION OF COPPER IN MILLIGRAMS PER LITER (mg/L). VALUE IS AVERAGE CONCENTRATION AT MONITORING WELL DURING PERIOD FROM APRIL 2002 TO MARCH 2003. SEE REPORT TEXT FOR EXPLANATION.

12 — POTENTIOMETRIC SURFACE CONTOUR IN FEET, DASHED WHERE INFERRED.

NA — COPPER NOT ANALYZED AT THIS SAMPLE LOCATION.

<0.01 — CONCENTRATION NOT DETECTED ABOVE THE LABORATORY METHOD REPORTING LIMIT SHOWN.

NOTES:
SAMPLE INTERVAL EXTENDS FROM 41 FEET BELOW GROUND SURFACE TO THE TOP OF THE SILT LAYER (GENERALLY GREATER THAN 75 FEET BELOW THE GROUND SURFACE) EXCEPT AT MONITORING WELL CG-106-I WHICH IS SCREENED FROM 26 to 36 FEET BELOW GROUND SURFACE.

VERTICAL DATUM FOR GROUNDWATER LEVELS IS BASED ON NAVD88

CLEANUP LEVEL:

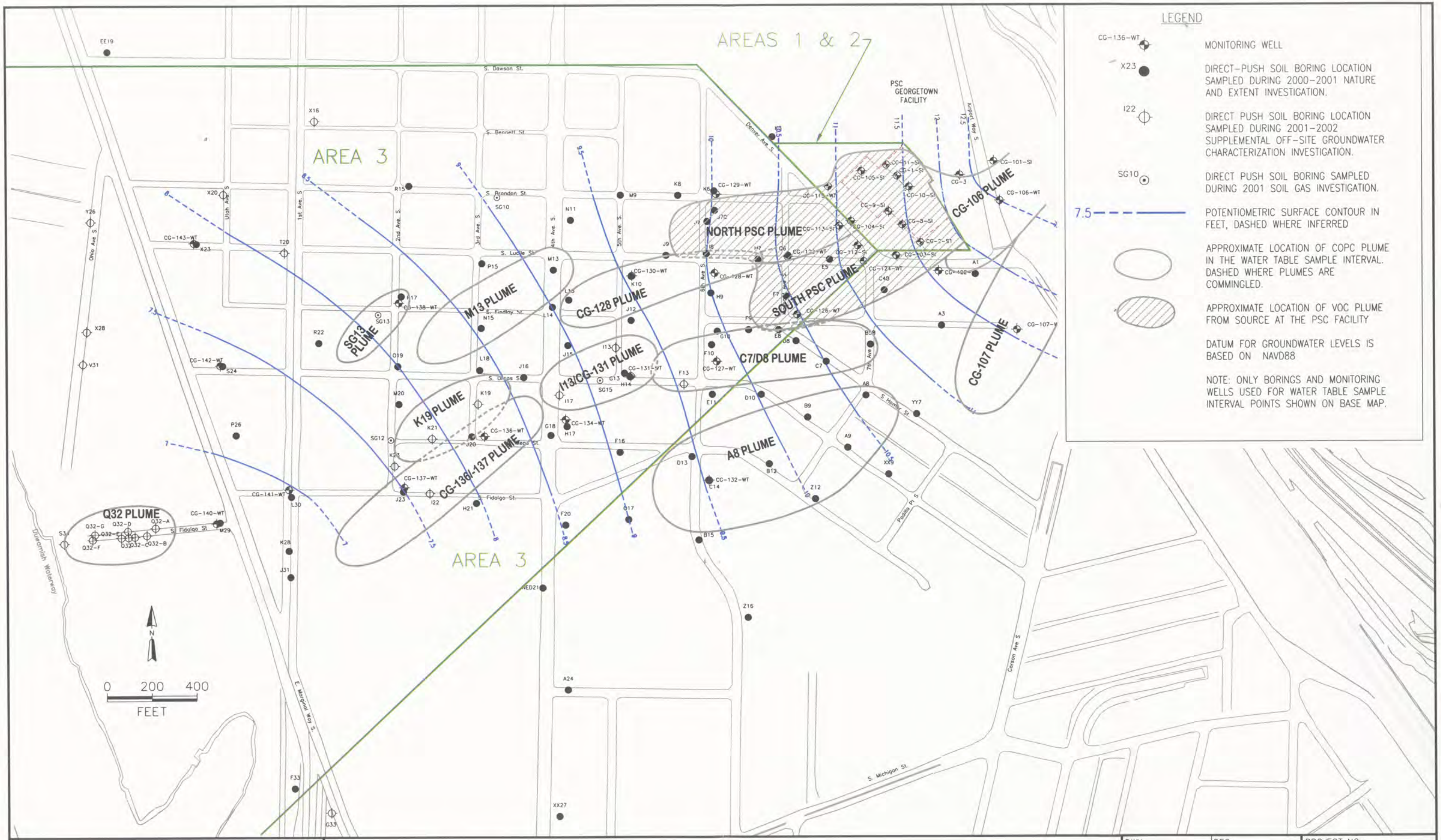
COPPER = 0.0031 mg/L

THIS CLEANUP LEVEL IS BASED ON THE PROTECTION OF SURFACE WATER

PSC

TITLE:
Concentration of Copper in Groundwater
Intermediate Sample Interval
PSC Georgetown Facility Remedial Investigation Study Area

DWN: QDD	DES.:	PROJECT NO.: RI2003
CHKD: CJM	APPD:	
DATE: 10/15/03	REV.:	FIGURE NO.: 9-50



PSC	TITLE: Plume Location Map With Water Table Sample Interval Points PSC Georgetown Facility Remedial Investigation Study Area	DWN: DEW CHKD: AS DATE: 10/21/03	DES.: APPD: REV.: 1

PROJECT NO.: RI2003

FIGURE NO.: 9-51

Table 9-1
Summary of Physical Properties of Organic COPCs
PSC Georgetown Facility Remedial Investigation

Constituent	Reference	Organic Carbon Partition Coefficient K_{oc} (cm3/g)	Water Solubility S (mg/L)	Henry's Law Constant H' (unitless)
Volatile Organic Compounds				
Chlorinated Ethenes				
Tetrachloroethylene	EPA, 2001	155	200	7.54E-01
Trichloroethylene	EPA, 2001	166	1,100	4.22E-01
1,1-Dichloroethylene	EPA, 2001	59	2,250	1.07E+00
cis-1,2-Dichloroethylene	EPA, 2001	36	3,500	1.67E-01
trans-1,2-Dichloroethylene	EPA, 2001	53	6,300	3.85E-01
Vinyl chloride	EPA, 2001	19	2,760	1.11E+00
Ethene	HSDB, 2003	200	131	9.35E+00
Chlorinated Ethanes				
1,1,1-Trichloroethane	EPA, 2001	110	1,330	7.05E-01
1,1-Dichloroethane	EPA, 2001	32	5,060	2.30E-01
1,2-Dichloroethane	EPA, 2001	17	8,520	4.01E-02
Chloroethane	Montgomery, 1996	3	5,710	3.81E-01
Ethane	HSDB, 2003	345	60	2.05E+01
Chlorinated Methanes				
Carbon Tetrachloride	EPA, 2001	174	793	1.25E+00
Methylene chloride	EPA, 2001	12	13,000	8.98E-02
Chloroform	EPA, 2001	40	7,920	1.50E-01
Chloromethane	Montgomery, 1996	25	5,350	3.62E-01
BTEX				
Benzene	EPA, 2001	59	1,750	2.28E-01
Ethylbenzene	EPA, 2001	363	169	3.23E-01
Toluene	EPA, 2001	182	526	2.72E-01
Xylene (total)	EPA, 2001	389	185	3.14E-01
Ketones				
2-Hexanone	Montgomery, 1996	135	35,000	7.18E-02
Methyl isobutyl ketone (MIBK)	Montgomery, 1996	6	19,000	1.60E-02
Chlorinated Volatile Aromatics				
1,2,4-Trimethylbenzene	Montgomery, 1996	3,715	52	2.34E-01
1,3,5-Trimethylbenzene	Montgomery, 1996	661	48	2.76E-01
Cumene	Montgomery, 1996	2,818	48	2.29E-01
n-Butylbenzene	Montgomery, 1996	2,455	12	5.13E-01
n-Hexane	omery, 1996; HSDB	150	13	4.85E+01
p-Isopropyltoluene	HSDB, 2003	4,050	23	0.451
Propylbenzene	Montgomery, 1996	741	60	4.10E-01
sec-Butylbenzene	Montgomery, 1996	891	18	4.67E-01
Other VOCs				
1,1,2-Trichlorotrifluoroethane	Montgomery, 1996	389	136	1.31E+01
Carbon disulfide	EPA, 2001	46	1,190	1.24E+00
Dichlorodifluoromethane	Montgomery, 1996	363	280	1.23E+02
Styrene	EPA, 2001	776	310	1.13E-01
Semi-volatile Organic Compounds				
Polycyclic Aromatic Hydrocarbons (PAHs)				
1-Methyl naphthalene	HSDB, 2003	1,885	26	1.07E-02
2-Methylnaphthalene	Montgomery, 1996	8,511	25	1.30E-02
Naphthalene	EPA, 2001	2,000	31	1.98E-02
Phenols				
2,4-Dimethylphenol	EPA, 2001	209	7,870	8.20E-05
2-Methylphenol	EPA, 2001	91	26,000	4.92E-05
4-Methylphenol	Montgomery, 1996	49	24,000	3.25E-05
Pentachlorophenol	EPA, 2001	592	1,950	1.00E-06
Phenol	EPA, 2001	29	82,800	1.63E-05
Chlorinated Semi- Volatile Aromatics				
1,2-Dichlorobenzene	EPA, 2001	617	156	7.79E-02
Phthalates				
Bis(2-ethylhexyl) phthalate	EPA, 2001	15,100,000	0.3	4.18E-06
Di-n-butylphthalate	EPA, 2001	33,900	11	3.85E-08
Other SVOCs				
Benzoic acid	EPA, 2001	1	3,500	6.31E-05
1,4-Dioxane	Montgomery, 1996	3	miscible	2.00E-04
PCBS				
Aroclor 1016	Montgomery, 1996	323,594	0.4	9.43E-03
Aroclor 1232	Montgomery, 1996	676	1.5	3.54E-02
Total Petroleum Hydrocarbons				
C10-C12 (EPH) Aromatics	Ecology, 2001	2,510	25.00	0.14
C8-C10 (EPH) Aliphatics	Ecology, 2001	30,200	0.4	80
C8-C10 (EPH) Aromatics	Ecology, 2001	1,580	65	0.48
C8-C10 (VPH) Aromatics	Ecology, 2001	1,580	65	0.48
Diesel		---	---	---
Gasoline		---	---	---
Lube Oil Hydrocarbons		---	---	---
TotalExtractablePetroleum HC		---	---	---
TotalVolatilePetroleum HC		---	---	---

Notes:

cm3/g = cubic centimeters per gram

mg/L = milligrams per liter = parts per million (ppm)

10.0 DESCRIPTION OF SOIL GAS AND INDOOR AIR SAMPLING RESULTS

COPC-impacted groundwater has been detected in the water table sample interval downgradient of the facility. Volatile constituents can be transferred from contaminated groundwater or soil by volatilization to soil gas. Soil gas is the air residing in the interstitial spaces of the porous granular soil, below ground surface and above the saturated soil zone. Once volatilized, the constituents in soil gas can migrate in the vadose zone via diffusion and/or gas-phase advection to the ground surface or into overlying buildings. Gas-phase advection results primarily from differences in air pressure in the subsurface and above ground or in buildings. Cracks or other openings in a building's foundation may serve as entry points for impacted soil gas via diffusion or pressure-gradient driven advection. Similar to the differences in pressure above and below ground, pressure differentials often exist between the inside and outside of buildings due to wind, building ventilation systems (including heating and air conditioning, bathroom and kitchen fans), and household appliances (e.g., clothes dryers, cooling fans). These pressure differentials also result in ambient air being drawn into buildings.

Because exposure to volatile COPCs in indoor air has been identified as a potentially complete exposure pathway, the indoor air concentrations that may result from migration from impacted groundwater are of interest. However, the concentration of a compound detected in indoor air may be attributed to a number of sources, including unrelated contamination in soil gas, ambient air, and other household or industrial sources. For instance, household products containing the same VOCs as those that constitute the PSC groundwater plume (e.g., solvents) are ubiquitous, as described in Table 10-1. As a result, concentrations detected in indoor air samples should be considered in conjunction with groundwater, soil gas, and ambient air concentrations to determine the likely source of the constituents in indoor air.

A number of indoor air, ambient air, and soil gas sampling events have been conducted to assess the potential for VOCs to migrate from the subsurface into buildings. The sampling events are summarized in Table 10-2 and discussed in detail in Section 4. Analytical results from these investigations are presented in Appendix 10A. Only samples collected since 2000 will be evaluated in this discussion as these are most representative of current conditions.

10.1 *Available Data*

Locations where soil gas, indoor air, and ambient air samples have been collected since 2000 are shown in Figure 10-1. Table 10-3 presents a summary of the compounds detected in indoor air, soil gas, and ambient air samples collected since the beginning of 2000. The chemical concentrations detected in indoor and ambient air were screened against MTCA Method B Residential Air Cleanup Levels (WAC 173-340-750) and typical residential indoor air concentrations reported in literature. These screening levels are protective of both residential, commercial, and industrial exposures to impacted indoor air. These standards to which the data have been compared are referred to in this section as MTCA screening levels. Chlorinated ethenes (tetrachloroethene and trichloroethene), chlorinated ethanes (1,2-dichloroethane), chlorinated methanes (carbon tetrachloride, chloroform, chloromethane, methylene chloride), ketones (2-hexanone), and aromatic VOCs (1,2,4-Trimethylbenzene, , 1,3,5-trimethylbenzene, 1,4-dichlorobenzene, , benzene) were detected in indoor air at concentrations exceeding the cleanup level, identified in Section 7. The potential for these detections to be associated with groundwater contamination is discussed in the following sections.

Chlorinated ethenes (tetrachloroethene, trichloroethene and vinyl chloride), chlorinated ethanes (1,2-dichloroethane), chlorinated methanes (carbon tetrachloride, chloroform, chloromethane), benzene, and ethylene dibromide were detected in ambient air at concentrations exceeding the MTCA cleanup level. It is highly unlikely that the detected concentrations in ambient air are the result of volatilization from groundwater because the concentrations detected in groundwater would need to be several orders of magnitude higher to result in the ambient air concentrations on the order of those detected, as indicated by screening level modeling. The detected concentrations in ambient air are more likely attributable to vapor releases from normal traffic and business and industrial operations in the area. The ambient air concentrations are within the range of typical urban air concentrations as presented in Table 10-1.

10.1.1 Chlorinated Ethenes

PCE and TCE were detected in both indoor and ambient air at concentrations exceeding the MTCA cleanup levels. The highest PCE concentrations in indoor air were detected at sampling locations 672L and 5409D during the August 2000 sampling event; however, when these two locations were re-sampled in August 2002, the concentrations were significantly lower. The highest TCE concentrations in indoor air were detected at sampling location 406 O. The TCE concentration detected in a soil gas sample collected from the same location was half that detected in indoor air, suggesting that the concentration detected in indoor air is not likely to be completely attributable to volatilization from groundwater. TCE was detected in groundwater at this location. In cases where paired ambient air and indoor air samples were collected, the PCE and TCE concentrations detected in indoor air were typically similar to the concentrations detected in ambient air as presented in Table 10-4. In addition, the detected concentrations of PCE and TCE in indoor air did not generally correlate well with the concentrations detected in soil gas and groundwater samples collected from the same area.

10.1.2 Chlorinated Ethanes

1,2-Dichloroethane was detected in both indoor air and ambient air at concentrations exceeding the MTCA cleanup level. The highest 1,2-DCA concentrations in indoor air were detected at sampling location 5409D where the compound was detected in groundwater but was not detected in soil gas or ambient air, suggesting that there may be a household source of 1,2-DCA in this home.

10.1.3 Chlorinated Methanes

Carbon tetrachloride, chloroform, chloromethane, and methylene chloride were detected in both indoor air and ambient air at concentrations exceeding MTCA cleanup levels. The concentrations of chloroform in indoor air were not well correlated with the concentrations detected in soil gas, ambient air, or groundwater. The highest detected concentration of chloroform in indoor air was at sampling location 613B where the compound was detected in soil gas at a concentration nearly an order of magnitude lower than that in indoor air and where the compound was not detected in groundwater. Carbon tetrachloride, chloromethane, and methylene chloride analyses were performed on samples collected during the August 2000 sampling event only. Carbon tetrachloride and chloromethane were detected in indoor air at concentrations similar to that detected in a co-located and concurrently collected ambient air sample. Methylene chloride was detected at elevated concentrations in all indoor air samples but at significantly lower concentrations in co-located soil gas samples, and not at all in co-located groundwater samples. These data suggest that the concentrations of chlorinated methanes detected in indoor air are attributable to ambient background conditions.

10.1.4 Ketones

2-Hexanone was detected in one indoor air sample at location 613B at a concentration just above the MTCA cleanup level. 2-Hexanone was not detected in the three other indoor air samples collected from the same sampling location. The detected concentrations of 2-hexanone in indoor air are not well correlated with the detected concentrations in soil gas, ambient air, and groundwater, suggesting that there may be a household source of the chemical.

10.1.5 Aromatic VOCs

Benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and 1,4-dichlorobenzene were detected in indoor air samples at concentrations exceeding the MTCA cleanup levels. Benzene concentrations detected in indoor air samples were well correlated with the concentrations detected in both soil gas and ambient air but not with concentrations detected in groundwater. As the concentrations of benzene in indoor air were very similar to those detected in ambient air throughout the sampling area, it is likely that the benzene concentrations detected in indoor air can be attributed to ambient background conditions. The concentrations of the trimethylbenzenes and 1,4-dichlorobenzene in indoor air were not well correlated with the concentrations detected in soil gas or groundwater. The trimethylbenzenes were not detected in groundwater at any of the locations where the 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene concentrations detected in indoor air exceeded MTCA cleanup levels. The trimethylbenzenes were detected consistently at low concentrations in ambient air and were also detected somewhat consistently in soil gas, although not at the location where the highest indoor air concentrations were detected, sampling location 404O. 1,4-Dichlorobenzene was detected in indoor air samples from location 672 L where it was not detected in soil gas or groundwater.

10.2 *Uncertainties*

A number of soil gas, indoor air, and ambient air samples were collected in an effort to determine whether groundwater contamination downgradient of the facility may be adversely impacting the indoor air of overlying buildings. However, there are a number of uncertainties associated with the collection of soil gas, indoor air, and ambient air samples; the evaluation of analytical results reported for these samples; and any potential conclusions drawn from this evaluation. The uncertainties associated with sampling methodology, natural conditions, and sources of chemicals are discussed below.

10.2.1 Uncertainty with Sampling and Analysis

The samples included in this evaluation were collected during multiple sampling events. Although the more recent sampling events have been conducted following a consistent protocol, the differences in methodologies between the earlier and recent sampling events may have affected the sample results, and thus, are sources of uncertainty. The following are differences in methodologies:

- Soil gas stabilized over a 24-hour period during the August 2000 Investigation. Soil gas stabilization was not reached for March 2001 Investigation. However, air was purged during the March 2001 investigation as a method of stabilization.

- Soil gas and ambient air samples were collected for 24 hour periods in 2000 and 2002; however, in 2001, these samples were only collected for a 30 minute period, which may not have been representative of concentrations over a 24 hour period.

- Individual Summa® canisters fill at slightly different rates, and thus, the differences between sampling apparatus is a source of uncertainty. However, the sampling period for each canister is used in the calculation of concentration.

Analytical detection limits varied not only between different investigations, but also between different samples collected for the same investigation. The detection limits for some constituents and some indoor air samples exceeded the corresponding indoor air MTCA Method B levels. Thus, it is possible that there are some correlations that cannot be determined from the data. However, only the data from 2002 were used in the HHERA, and thus, the uncertainties identified here are applicable only to the evaluation provided in this section.

10.2.2 Uncertainty due to Natural Conditions

The results of the indoor air and soil gas investigations conducted since 2000 exhibit substantial variability, which may be a result of the following factors:

- Spatial and temporal variation of the vertical extent of the vadose zone, due to changes in the water table elevation

- Spatial and temporal variation of contaminant levels in shallow-aquifer groundwater

- Spatial and temporal variation of the rate of air advection from ambient air to soil gas, and vice versa, because of variation in the vertical pressure gradient in the shallow vadose zone. The gradient depends in part on the temporal variation of barometric pressure and local micrometeorological conditions, and on the spatial variation of geological characteristics and land use (e.g., surface paving and development).

- Physical properties of the dwellings at which indoor air was sampled. The most important physical properties include the type of foundation and the air exchange rate of the dwelling.

10.2.3 Uncertainty Associated with Chemical Sources

There are a number of potential sources of the chemicals detected in soil gas and indoor air samples; these sources include:

- COPCs in shallow-aquifer groundwater emanating from the facility;

- Potential areas of locally-contaminated soil and/or groundwater that are not associated with releases at the facility;

- Potential residual levels of interior contamination (e.g., from household products that were stored or used inside dwellings, or human activities [e.g., smoking]); and

- Potential ambient air contaminants that migrate to indoor air via advection and/or diffusion.

During more recent sampling events, attempts were made to reduce the uncertainty associated with the potential sources of chemicals by removing obvious indoor chemical sources and collecting co-located ambient air, soil gas and groundwater samples.

10.3 *Summary of Results*

Indoor air, ambient air, and soil gas samples were collected as part of several investigations conducted since 2000. Several compounds were detected in the indoor air of local buildings at concentrations exceeding the applicable MTCA Method B air screening levels. Many uncertainties exist in indoor air data collection resulting in difficulties interpreting data. For this reason, the concentrations of these compounds detected in indoor air may be attributed, at least in part, if not entirely, to sources other than the groundwater plume emanating from the PSC facility. Regardless of the source of the detected concentrations, PSC is currently conducting interim measures to prevent unacceptable human exposure to compounds migrating from groundwater into the indoor air of area buildings.

10.4 *References*

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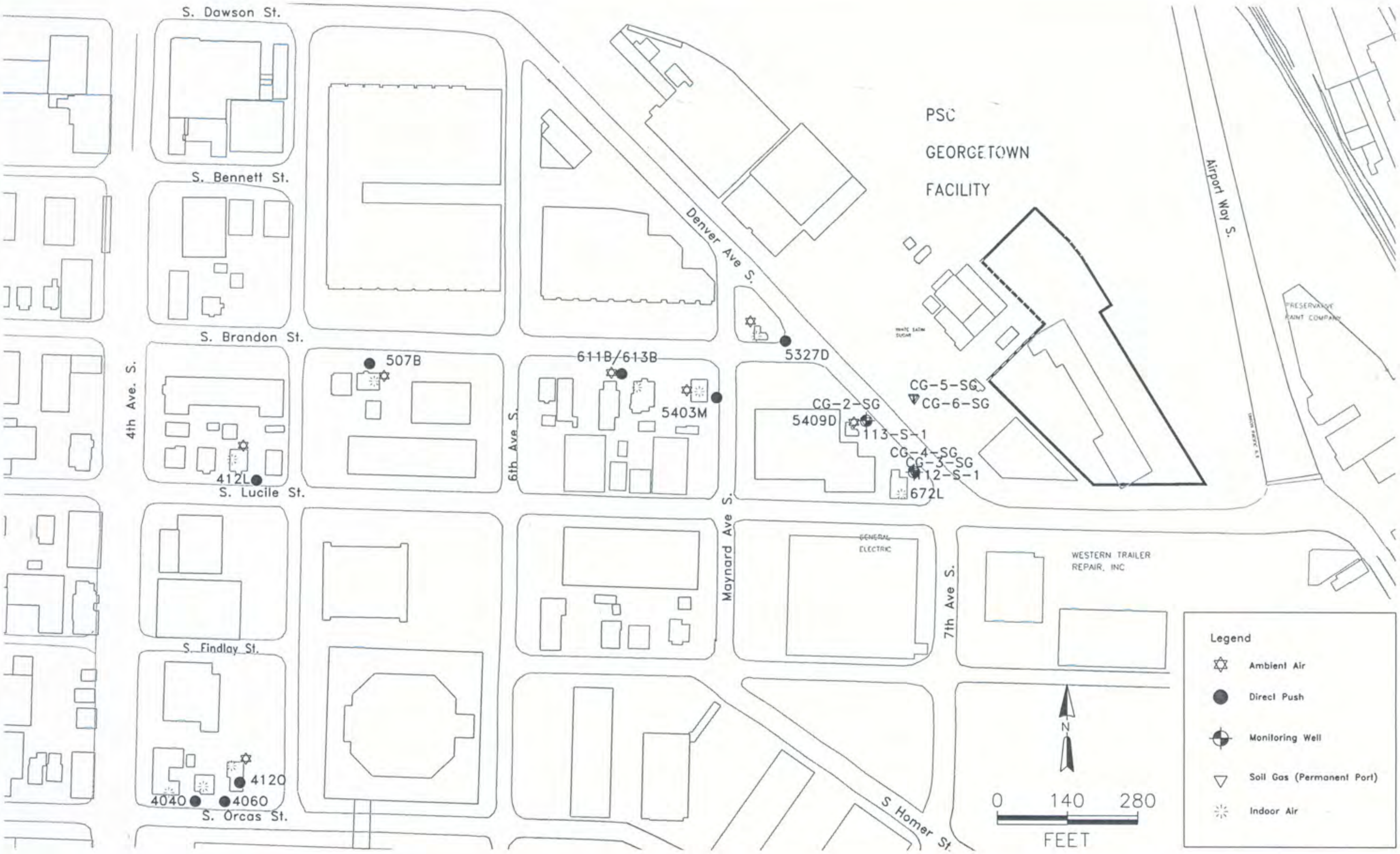

PSC

TITLE:

Location of Indoor Air, Ambient Air, and Soil Gas Sampling Points

PSC Georgetown Remedial Investigation Study Area

DWN: dtb	DES.:	PROJECT NO.: RI2003
CHKD:	APPD:	
DATE: 10/29/03	REV.:	FIGURE NO.: 10-1

Table 10-1
Typical Household Chemical Sources and Concentrations
PSC Georgetown Facility Remedial Investigation

Compound	Household source (c,d)	Typical Household Indoor Air Concentrations (ug/m^3)		Typical Urban Ambient Air Concentrations (ug/m^3) ©
Acetone	rubber cement, cleaning fluids, nail polish remover	---		2.41-83.3
Benzene	automobile exhausts, gasoline, cigarette smoke, scatter rugs, carpet glue	0.75-156.3	a	0.19-347
Bromomethane	soil fumigant	---		---
Carbon tetrachloride	rubber cement, degreasing agent	---		---
Chlorobenzene	plastic foam insulation, paint-related products	---		0.3-3
Chloroethane	refrigerant	---		0.23-0.59
Chloroform	generated from chlorinated water	34.02	a	0.1-11.5
Chloromethane	herbicide, in foams	---		1.5-2.1
1,4-Dichlorobenzene	moth balls, insecticdes, air deodorant, toilet disinfectant	---		1.2-24
1,1-Dichloroethane	plastic packaging material (including food packaging), flame retardant fabrics	---		0.45
1,2-Dichloroethane	carpet cleaners, fumigant, nail polish	0.1-0.75	a	0.06-0.5
Ethylbenzene	paint thinners, insecticides, wood office furniture, gasoline	0.63-24.12	a	0.44-122.5
2-Hexanone		---		---
Methylene chloride	hairspray, paint stripper, rug cleaners, insecticdes, furniture polish	4-5	b	1.02-5.72
MTBE	gasoline	---		---
Styrene	cigarette smoke, automobile exhaust, fiberglass, rubber & epoxy adhesives, naturally in some fruits & vegetables	---		0.3-64.94
1,1,2,2-Tetrachoroethane	solvent, paint and rust removers, varnishes, lacquers	---		---
Tetrachloroethene	dry cleaning, metal degreaing, adhesives & glue, insecticide, rug cleaner	0.03-659.6	a	1.38-67
Toluene	gasoline, automobile exhaust, polishes, nail polish, paint thinner, cigarette smoke	4.24-1885	a	3.06-4,251
1,1,1-Trichloroethane	spot cleaners, glues, insecticides, drain cleaners, shoe polish	0.09-816.5		2.22-55
Trichloroethene	scented candles, automotive cleaning and degreasing products	0.001-720.4	a	0.28-6
1,2,4-Trimethylbenzene	gasoline, solvent, paint thinner	059-3.96	a	2.5-2.9
1,3,5-Trimethylbenzene	gasoline, solvent, paint thinner	1.43-5.41	a	1.5-2
Xylenes	water sealer, gasoline, automobile exhaust, markers, floor polish, cigarette smoke	---		4.43-168

References

a) PSC, 2003
b) CARB, 2001.
c) HSDB, 2003.

Table 10-2
Summary of Soil Gas and Indoor Air Sampling Conducted Since 2000
PSC Georgetown Facility Remedial Investigation

Date	Sample Location	Soil Gas Samples	Indoor Air Samples	Ambient AirSamples
August 2000	672 S. Lucile St.	CSG-672L-1 CSG-672L-2 CSG-672L-3 CSG-672L-4 CSG-672L-5	IA-672L-1 IA-672L-2	
	5409 Denver Ave. S.	ISG-5409D-1 CSG-5409D-1 CSG-5409D-2 CSG-5409D-3	IA-5409D-1	AA1-0800 AA2-0800
March 2001	Georgetown Area	SG-9 SG-10 SG-12 SG-13 SG-14 SG-15		SG-9-0301 SG-13-0301
August 2002	613 S. Brandon St.	613B-SG1-0802	613B-IA1-0802 613B-IA2-0802	
	672 S. Lucile St.		672L-IA1-0802 672L-IA2-0802 672L-IA1-0802 672L-IA2-0802 672L-IA3-0803	
	5403 Maynard Ave. S.	5403M-SG1-0802	5403M-IA1-0802 5403M-IA2-0802	5403M-AA-0802
	412 S. Orcas St.	412O-SG1-0802	412O-IA1-0802 412O-IA2-0802	412O-AA-0802
	406 S. Orcas St.	406O-SG1-0802	406O-IA1-0802 406O-IA2-0802	
	404 S. Orcas St.	404O-SG1-0802	404O-IA1-0802 404O-IA2-0802	
	412 S. Lucile St.	412L-SG1-0802		412L-AA-0802
	507 S. Brandon St.	507B-SG1-0802	507B-IA1-0802 507B-IA2-0802	
	5327 Denver Ave. S.	5327D-SG1-0802	5327D-IA1-0802 5327DC-IA1-0802	
	5409 Denver Ave. S.		5409D-IA1-0802 5409D-IA2-0802	5409D-AA-0802
	611 S. Brandon St.		611BC-IA1-0802	
	727 S. Homer St.			727H-AA-0802
December 2002	406 S. Orcas St.			406O-AA-1202
	5409 Denver Ave. S.			5409D-AA-1202
	611 S. Brandon St.			611B-AA-1202
	735 S. Homer St.			735H-AA-1202

Table 10-3
Summary of Indoor Air, Soil Gas and Ambient Air Analytical Results
PSC Georgetown Facility Remedial Investigation

		Indoor Air (ug/m^3)							Ambient Air (ug/m^3)						Soil Gas (ug/m^3)				
Compound	MTCA Method B CL	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Maximum Exceeds MTCA B?	Typical Residential Indoor Air Concentration	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Maximum Exceeds MTCA B?	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration
1,1,1-Trichloroethane	1008	39	48	81%	0.19	19	no	0.09-816.5	8	16	50%	0.18	2.4	no	84	95	88%	0.1	84000
1,1,1,2-Tetrachloroethane															3	80	4%	0.46	7.7
1,1,1,2-Tetrafluoroethane															18	26	69%	0.69	11000
1,1,2-Trichloro-1,2,2-trifluoroethane	13714.286	6	6	100%	0.61	340	no	---	1	4	25%	1	1	no	51	54	94%	0.1	11000
1,1,2-Trichloroethane		0	4	0%	---	---	---	---	0	4	0%	---	---	---	1	80	1%	8.9	8.9
1,1-Dichloroethane	228.571	2	46	4%	0.2	0.22	no	---	2	16	13%	0.26	0.42	no	61	95	64%	0.17	42000
1,1-Dichloroethylene	91.429	0	46	0%	---	---	---	---	0	16	0%	---	---	---	21	94	22%	0.2	28
1,2,4-Trichlorobenzene															1	26	4%	1.2	1.2
1,2,4-Trimethylbenzene	2.72	42	42	100%	0.46	190	Yes	059-3.96	11	14	79%	0.35	2.1	no	28	61	46%	0.49	69
1,2-Dichlorobenzene		0	4	0%	---	---	---	---	0	4	0%	---	---	---	3	61	5%	0.64	1.1
1,2-Dichloroethane	0.0962	20	48	42%	0.13	4.1	Yes	0.1-0.75	2	16	13%	0.18	17	Yes	9	94	10%	0.12	130
1,2-Dichloroethene															7	11	64%	44	220000
1,2-Dichloropropane		0	4	0%	---	---	---	---	0	4	0%	---	---	---	1	80	1%	11	11
1,3,5-Trimethylbenzene	2.72	40	43	93%	0.21	89	Yes	1.43-5.41	6	12	50%	0.18	0.73	no	22	41	54%	0.41	53
1,3-Butadiene															9	26	35%	0.47	2
1,3-Dichlorobenzene		0	4	0%	---	---	---	---	0	4	0%	---	---	---	8	61	13%	0.98	5.8
1,4-Dichlorobenzene	0.0962	3	5	60%	0.35	0.37	Yes	---	0	4	0%	---	---	---	7	61	11%	0.19	1.7
2-Hexanone	8	3	42	7%	0.8	8.6	Yes	---	4	12	33%	1.3	3.2	no	10	43	23%	2.3	19
Acetone	---	6	6	100%	32	66	no	---	4	4	100%	27	48	no CL	35	80	44%	1.4	440
Acrolein															1	10	10%	150	150
Benzene	0.321	48	48	100%	0.93	11	Yes	0.75-156.3	16	16	100%	0.95	8.2	Yes	49	94	52%	0.32	19
Bromodichloromethane															15	45	33%	2	8.8
Bromomethane															1	45	2%	0.88	0.88
Carbon disulfide															8	29	28%	6.8	640
Carbon Tetrachloride	0.321	5	6	83%	0.67	1	Yes	---	4	4	100%	0.54	0.86	Yes	22	80	28%	0.33	320
Chlorobenzene	0.321	1	5	20%	0.14	0.14	no	---	0	4	0%	---	---	---	16	80	20%	0.15	250
Chloroethane	4571.429	2	42	5%	0.28	0.38	no	---	2	12	17%	0.55	0.56	no	17	59	29%	0.11	160
Chloroform	0.109	34	48	71%	0.22	4.6	Yes	34.02	3	16	19%	0.19	2.4	Yes	61	94	65%	0.26	210
Chloromethane	0.109	6	6	100%	0.49	2	Yes	---	3	4	75%	1.1	1.5	Yes	22	80	28%	0.26	9.1
cis-1,2-Dichloroethylene	16	0	46	0%	---	---	---	---	1	16	6%	0.63	0.63	no	52	95	55%	0.25	220000
cis-1,3-Dichloropropene		0	4	0%	---	---	---	---	0	4	0%	---	---	---	1	80	1%	13	13
Cumene	182.857	2	42	5%	18	20	no	---	0	8	0%	---	---	---	0	13	0%	---	---
Dichlorofluoromethane	---								2	2	100%	1	3.5	no CL	10	31	32%	3.6	9.1
Ethylbenzene	457.143	47	48	98%	0.48	7.8	no	0.63-24.12	12	16	75%	0.49	19	no	51	95	54%	0.21	140000
Ethylene Dibromide	0.0114								1	2	50%	3.4	3.4	Yes	1	31	3%	0.64	0.64
m,p-Xylenes	16	6	6	100%	0.66	6	no	---	4	4	100%	2.1	5.1	no	45	81	56%	0.41	22000
Methylene chloride	5.319	6	6	100%	3.8	330	Yes	4-5	4	4	100%	0.78	43	no	28	74	38%	0.35	380
n-Hexane															2	10	20%	91	220
o-Xylenes	16	5	6	83%	0.69	1.7	no	---	4	4	100%	0.57	2	no	30	61	49%	0.16	260
Propylbenzene	16	2	42	5%	45	48	Yes	---	0	12	0%	---	---	---	0	13	0%	---	---
Styrene	457.14	5	6	83%	0.34	0.62	no	---	4	4	100%	0.17	0.38	no	22	80	28%	0.2	14000
Tetrachloroethene	0.417	29	48	60%	0.23	21	Yes	0.03-659.6	8	16	50%	0.24	2.7	Yes	80	94	85%	0.2	840
Toluene	182.857	48	48	100%	1.5	83	no	4.24-1885	16	16	100%	11	9.5	no	67	95	71%	0.22	98000
trans-1,2-Dichloroethylene	32	0	46	0%	---	---	---	---	1	16	6%	1.5	1.5	no	6	94	6%	1.9	650
trans-1,3-Dichloropropene		0	4	0%	---	---	---	---	0	4	0%	---	---	---	1	80	1%	8.3	8.3
Trichloroethylene	0.0219	47	48	98%	0.23	7.5	Yes	0.001-720.4	14	16	88%	0.39	8.2	Yes	68	95	72%	0.17	5600
Trichlorofluoromethane															6	19	32%	0.1	430
Vinyl chloride	0.284	9	47	19%	0.049	0.15	no	---	5	16	31%	0.19	2.0	Yes	31	95	33%	0.044	27000

Notes:

CL = cleanup level

ug/m^3 = micrograms per cubic meter

Table 10-4
Summary of Results for Co-located Indoor Air, Ambient Air, Soil Gas and Groundwater Samples Collected Since 2000
PSC Georgetown Facility Remedial Investigation

Date	Sample Location	Media	Compound ->	1,2,4-Trimethylbenzene	1,2-Dichloroethane	1,3,5-Trimethylbenzene	1,4-Dichlorobenzene	2-Hexanone	Benzene	Carbon tetrachloride	Chloroform	Chloromethane	Methylene chloride	Tetrachloroethylene	Trichloroethylene
			Samples | MTCA B Air CL ->	2.72	0.0962	2.72	0.0962	8	0.321	0.321	0.109	0.109	5.319	0.417	0.0219
August 2000	672L	Indoor Air	IA-672L-1		**0.2**	<0.12	**0.35**		**3.9**	**1**	**0.73**	**1.9**	**120**	**2.1**	**0.44**
			IA-672L-2		**0.17**		**0.36**		**3.2**	**1**	**0.83**	**1.6**	**130**	**2.3**	**3.3**
			IA-672L-2 (dup)		**0.17**		**0.37**		**3.8**	**1**	**0.73**	**2**	**130**	**2.6**	**0.6**
		Soil Gas	CSG-672L-1		<0.17		<0.25		1.9	61	160	<0.085	0.96	33	8.9
			CSG-672L-2		<1.2		<1.8		2.8	320	14	0.78	<5.4	10	3.9
			CSG-672L-3		<0.61		<0.91		4.4	120	5.7	<0.31	<2.6	5.3	22
			CSG-672L-4		<0.49		<0.73		4.2	<0.76	5.6	1.2	<2.1	39	3.8
			CSG-672L-5		<0.33		<0.49		4.1	<0.51	3.6	0.44	<1.4	61	<0.44
		Ambient Air	---												
		Groundwater	W-672L-1		3.69		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-672L-2		<1		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-672L-3		3.50		<1	<10	<1	<1	3.30	<5	<5	<1	16.5
			W-672L-4		2.45		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-672L-5		<1		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-672L-6		4.43		<1	<10	<1	<1	4.56	<5	<5	1.73	45.8
			W-672L-7		4.63		<1	<10	<1	<1	2.63	<5	<5	<1	3.33
	5409D	Indoor Air	IA-5409D-1		**4**		<0.41		**1.6**	**0.67**	**0.37**	**1.5**	**330**	**1.4**	**4.4**
			IA-5409D-1 dup		**4.1**				**1.6**	**0.69**	**0.37**	**1.4**	**320**	**1.3**	**4.5**
		Soil Gas	ISG-5409D-1		<0.12	<0.37	<0.18		2.2	<0.19	<0.15	0.49	3.8	21	2.7
			CSG-5409D-1		<0.13		<0.19		2.4	6.9	<0.15	<0.065	<0.55	75	0.5
			CSG-5409D-2		<0.13		<0.20		2.9	<0.20	0.3	<0.068	<0.57	63	1.1
			CSG-5409D-3		<0.12		<0.18		2.2	<0.19	0.26	<0.062	0.65	61	0.29
		Ambient Air	AA1-0800		**<0.16**		**<0.23**		**2.2**	**0.86**	**<0.19**	**1.5**	**0.8**	**0.42**	**0.39**
			AA2-0800		0.18		**<0.18**		**5.4**	**0.8**	**0.27**	**<0.06**	**1.7**	**2.7**	**6.7**
		Groundwater	W-5409D-1		<1		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-5409D-2		<1		<1	<10	<1	<1	<1	<5	<5	<1	1.16
			W-5409D-3		<1		<1	<10	<1	<1	<1	<5	<5	<1	<1
			W-5409D-4		7.45		<1	<10	<1	<1	1.90	<5	<5	<1	1.15
August 2002	404O	Indoor Air	404O-IA1	**120**	**0.22**	**51**		**<0.76**	**1.7**		**0.25**			0.32	**4.9**
			4040-9-IA1-0802	**170**	<0.14	**78**		**<0.73**	**1.4**		**0.22**			0.3	**5.8**
			404O-IA2-0802	**190**	<0.29	**89**		**<1.5**	**1.5**		**<0.36**			<0.49	**7.4**
		Soil Gas	404O-SG1-0802	<5.4	<4.5	<5.4		<18	6.6		<5.4			280	<5.9
		Ambient Air	---												
		Groundwater	404O-GW1-0802	<1.00	0.172	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	0.097	1.5
	406O	Indoor Air	406O-IA1-0802	**3.3**	<0.15	1.1		0.8	**3.7**		**0.26**			<0.25	**7.1**
			4060-9-IA1-0802	**3.2**	<0.15	1		**<0.74**	**3.6**		**0.27**			<0.25	**7.4**
			406O-IA2-0802	2.3	<0.15	0.76		**<0.74**	**2.4**		**0.28**			<0.25	**7.5**
		Soil Gas	406O-SG1-0802	14	<0.17	3.6		9.9	3		0.62			8.2	3.4
		Ambient Air	---												
		Groundwater	406O-GW1-0802	<1.00	0.535	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	0.06	4.38
	412L	Indoor Air	412L-IA1-0802	2.7	<0.14	0.91		2.8	**1.1**		**0.34**			<0.24	**1.7**
			412L-9-IA1-0802	**3**	**0.16**	0.97		**<0.78**	**1.1**		**0.3**			<0.26	**2**
			412L-IA2-0802	0.99	<0.15	0.35		**<0.76**	**1.2**		**1.4**			<0.25	**2.1**
			412L-IA3-0802	2	<0.14	0.55		**<0.70**	**1.4**		**1.3**			0.26	**2.2**
		Soil Gas	412L-SG1-0802	28	<4.4	<5.3		<18	4.2		<5.3			<7.3	<5.8
		Ambient Air	412L-AA-0802	**0.52**	**<0.16**	**<0.19**		**<0.80**	**1.2**		**<0.038**			**<0.26**	**2.3**
		Groundwater	412L-GW1-0802	<1.00	<0.100	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	<0.0500	3
			CG-130-WT-0802	<1.00	<0.100	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	0.052	1.54
	412O	Indoor Air	412O-IA1-0802	0.7	**0.14**	0.23		**<0.70**	**1.3**		**0.75**			<0.23	**3.8**
			4120-9-IA1-0802	0.73	<0.15	0.26		**<0.74**	**1.5**		**0.79**			<0.25	**4**
			412O-IA2-0802	0.98	**0.19**	0.3		**<0.74**	**1.5**		**0.83**			<0.25	**4.6**
		Soil Gas	412O-SG1-0802	7.2	<0.16	2.1		7.2	4		0.74			1.4	7.5
		Ambient Air	412O-AA-0802	**0.94**	**<0.16**	**0.73**		**3.2**	**1.2**		**<0.19**			**<0.27**	**4.1**
		Groundwater	412O-GW1-0802	<1.00	1.82	<1.00	<1.00	<10.0	<0.500	<1.00	<1.00	<2.50	<5.00	<1.00	2.54
			CG131-WT-0802	<1.00	1.87	<1.00	<0.100	<10.0	3.46	<0.0500	<1.00	<2.50	<5.00	<0.0500	44.1
	507B	Indoor Air	507B-IA1-0802	1.3	**0.13**	0.38		**<0.66**	**2**		**0.41**			**1.4**	**1.4**
			507B-9-IA1-0802	1.1	**0.17**	0.3		**<0.70**	**1.9**		**0.44**			**1.4**	**1.4**
			507B-IA2-0802	1	<0.15	0.29		**<0.74**	**1.8**		**0.44**			**1.4**	**1.2**
		Soil Gas	507B-SG1-0802	5.3	<1.3	1.6		<6.7	4.8		<1.6			<2.2	2
		Ambient Air	507B-AG-0802_AA	**0.46**	**<0.14**	0.18		**<0.73**	**1.3**		**<0.17**			**0.36**	**3.2**
		Groundwater	507B-GW1-0802	<1.00	<0.100	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	<0.0500	<0.0200
	5327D	Indoor Air	5327D-IA1-0802	0.93	<0.16	0.35		**<0.82**	**1.8**		<0.19			0.28	**0.37**
			5327D-9-IA1-0802	**3.2**	<0.18	1		**<0.90**	**1.7**		<0.22			<0.30	**0.3**
			5327DC-IA1-0802	1.6	<0.15	0.52		**<0.74**	**1.3**		<0.18			0.26	**0.38**
			5327DC-9-IA1-0802	0.46	0.21	<0.18		**<0.74**	**1.2**		<0.18			<0.25	**0.32**
		Soil Gas	5327D-SG1-0802	9.4	<0.16	2.1		5.7	2.9		1.4			3.6	0.89
		Ambient Air	5327D-A1-0802_AA	**0.98**	**<0.14**	0.34		**2**	**1.8**		**<0.17**			**0.39**	**0.41**
			5327D-9-A1-0802_AA	**2.1**	**<0.21**	**0.71**		**<1.1**	**1.8**		**<0.25**			**0.41**	**0.41**
		Groundwater	5327D-GW1-0802	<1.00	<0.100	<1.00	<0.100	<10.0	1.32	<0.0500	<1.00	<2.50	<5.00	<0.0500	0.073

Table 10-4

Summary of Results for Co-located Indoor Air, Ambient Air, Soil Gas and Groundwater Samples Collected Since 2000

PSC Georgetown Facility Remedial Investigation

Date	Sample Location	Media	Compound -> Samples | MTCA B Air CL ->	1,2,4-Trimethylbenzene	1,2-Dichloroethane	1,3,5-Trimethylbenzene	1,4-Dichlorobenzene	2-Hexanone	Benzene	Carbon tetrachloride	Chloroform	Chloromethane	Methylene chloride	Tetrachloroethylene	Trichloroethylene
				2.72	0.0962	2.72	0.0962	8	0.321	0.321	0.109	0.109	5.319	0.417	0.0219
	5403M	Indoor Air	5403M-IA1-0802	0.94	<0.15	0.27		<0.78	**1.2**		**2.3**			**0.61**	**0.29**
			5403M-9-IA1-0802	0.87	<0.16	0.21		<0.82	**1.2**		**2**			**0.6**	**0.41**
			5403M-IA2-0802	0.7	<0.16	0.22		<0.80	**1.3**		**3.8**			**0.44**	**0.38**
		Soil Gas	5403M-SG1-0802	<20	<16	<20		<67	<13		<20			<28	<22
		Ambient Air	5403M-AA-0802	1.2	<0.12	0.56		1.3	1.1		<0.15			<0.20	**0.42**
		Groundwater	5403-GW1-0802	2.68	<1.00	<1.00	<1.00	<10.0	2.48	<1.00	<1.00	<2.50	<5.00	<1.00	<1.00
	5409D	Indoor Air	5409D-IA1-0802	0.74	**2.2**	0.29		<0.71	**0.98**		<0.17			0.25	**0.5**
			5409D-9-IA1-0802	0.76	**2.1**	0.3		<0.74	**0.93**		<0.18			<0.25	**0.49**
			5409D-IA2-0802	0.9	**0.87**	0.3		<0.70	**1.2**		**0.27**			0.68	**0.83**
		Soil Gas	CG-2-SG-0802	0.71	<0.16	0.44		5.2	0.51		<0.19			40	<0.21
		Ambient Air	5409D-AA-0802	0.35	<0.15	<0.19		<0.78	**0.95**		<0.18			<0.26	**0.48**
		Groundwater	CG-113-S1-0802	48.6	1.92	10.3	0.237	<10.0	5.76	<0.0500	<1.00	<2.50	<5.00	1.76	0.943
	611B/613B	Indoor Air	613B-IA1-0802	0.71	<0.12	0.24		<0.63	**1.4**		**4.4**			**0.55**	**0.45**
			613B-9-IA1-0802	0.75	**0.14**	0.23		<0.64	**1.5**		**4.4**			**0.58**	**0.53**
			613B-IA2-0802	0.76	<0.13	0.24		<0.66	**1.4**		**4.6**			**0.57**	**0.5**
			613B-IA1-0802_08/26/02	0.97	**0.14**	0.29		**8.6**	**2.5**		**4**			**0.68**	**0.47**
			613B-IA2-0802_08/26/02	1.8	<0.16	0.54		<0.82	**2.8**		**3.1**			**0.82**	**0.72**
		Soil Gas	613B-SG1-0802	<4.7	<3.8	<4.7		19	4.6		<4.6			<6.4	<5.1
			613B-SG1-0802_08/27/02	1.6	<0.16	0.81		5.2	4.6		0.52			1.7	1.5
		Crawlspace air	611BC-IA1-0802	1	<0.12	0.35		<0.59	3.2		<0.14			0.23	0.45
			611BC-9-IA1-0802_08/19/02	1	<0.13	0.34		<0.66	3.3		<0.16			<0.22	0.38
			611BC-IA1-0802_08/26/02	0.48	<0.16	<0.20		<0.82	1.2		<0.19			<0.27	<0.21
			611BC-9-IA1-0802_08/26/02	0.99	0.17	0.31		<0.86	1.1		<0.20			<0.28	0.23
		Ambient Air	---												
		Groundwater	613B-GW1-0802	<1.00	<0.100	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	<0.0500	<0.0200
			613B-GW1-0802	<1.00	<0.100	<1.00	<0.100	<10.0	<0.500	<0.0500	<1.00	<2.50	<5.00	<0.0500	0.032
	672L	Indoor Air	672L-IA1-0802	0.94	<0.14	0.44		<0.71	**1.2**		**0.33**			<0.24	**0.52**
			672L-9-IA1-0802_08/19/02	0.8	<0.14	0.29		<0.71	**1.2**		**0.39**			<0.24	**0.58**
			672L-IA2-0802	0.8	<0.14	0.35		<0.73	**1.2**		**0.4**			<0.24	**0.52**
			672L-IA1-0802	0.83	<0.18	0.34		<0.90	**1.5**		**0.23**			0.3	**1.2**
			672L-9-IA1-0802_08/27/02	2	0.28	0.74		<1.2	**2.4**		**0.31**			**0.52**	**1.3**
			672L-IA2-0802	1.3	<0.18	0.49		<0.93	**2**		<0.22			0.31	**1.4**
			672L-IA3-0803	2.2	0.35	0.85		<0.99	**11**		<0.24			**0.47**	**1.2**
		Soil Gas	CG-3-SG-0802_08/22/02	0.62	<0.31	0.41		2.3	<0.62		1.7			9.7	2.4
			CG-4-SG-0802_08/21/02	<0.61	<0.50	<0.61		4	<0.99		3.2			21	4.9
			CG-3-SG-0802_08/28/02	1.1	<0.36	0.67		7.1	0.92		2.5			13	3.9
			CG-4-SG-0802_08/28/02	0.72	<0.48	<0.58		5.2	<0.95		3.2			21	5.3
		Ambient Air	---												
		Groundwater	CG-112-S1-082202	21	0.357	1.52	1.13	<10.0	1.03	<0.0500	<1.00	<2.50	<5.00	0.896	1.64
			CG-112-S1-082802	29.2	<1.00	2.51	1.46	<10.0	1.05	<1.00	<1.00	<2.50	<5.00	<1.00	1.37

Notes:

CL = cleanup level

ug/m^3 = micrograms per cubic meter

ug/L = micrograms per liter

Indoor air, ambient air and soil gas results are in ug/m^3.

Groundwater results are in ug/L.

Bold text indicates air result exceeds MTCA Air CL.

11.0 ENVIRONMENTAL INDICATOR STATUS

One initiative in EPA's RCRA Corrective Action Program tracks the progress of site cleanups in meeting two Environmental Indicators (EIs). The two EIs, *Current Human Exposures Under Control* and *Migration of Contaminated Groundwater Under Control*, track the progress of cleanups in protecting human health from unacceptable exposure to contaminated groundwater and in preventing the further migration of groundwater contaminant plumes. EPA and Ecology have completed the EI evaluations for the facility in the past. However, as remedial activities at the facility continue, the EI should be periodically re-evaluated. Consistent with the permit requirement VII.A.4 for the Final RI, the EI evaluations for the facility have been updated and are presented in this section.

11.1 *Migration of Contaminated Groundwater Under Control*

The *Migration of Contaminated Groundwater Under Control* EI tracks the progress of sites in stabilizing contaminated groundwater plumes, or controlling the further migration of contaminated groundwater, and preventing the discharge of contaminated groundwater to surface water. The evaluation for the facility indicates that the groundwater plume associated with releases from the PSC property does not extend beyond approximately 5th Avenue South and COPC-impacted groundwater associated with releases from the facility is not discharging to surface water, as discussed in Section 9. In addition, PSC is currently in the process of installing a hydraulic control barrier wall and associated pump and treat system around the source of impacted groundwater emanating from the facility, thus preventing the further migration of COPCs from the facility. Groundwater monitoring will be conducted at wells both inside and outside the HCIM barrier wall to verify that that the hydraulic control is achieved and maintained. The installation of the HCIM barrier wall is expected to be completed by the end of 2003. Following the completion of the installation, the migration of COPCs from the facility can be considered under control. The EI form for the *Migration of Contaminated Groundwater Under Control* was completed by PSC and is presented in Appendix 11A.

11.2 *Current Human Exposures Under Control*

The *Current Human Exposures Under Control* EI tracks the progress of sites in controlling unacceptable exposures to contamination that can be reasonably expected under current land and groundwater use conditions. The evaluation for the facility indicates that all current human exposures are under control and do not pose unacceptable risks to human health, as discussed in the Human Health and Ecological Risk Assessment (HHERA) presented Part II of this report. Under current land use at the facility and in the surrounding area, there are three potential human exposures:

- Exposure of residents and workers to volatile COPCs migrating from groundwater into the indoor air of overlying buildings;
- Exposure of on-site and off-site construction workers to volatile COPCs migrating from groundwater into trenches during excavation activities; and
- Exposure of on-site construction workers to COPCs in surface and subsurface soil at the facility.

Construction worker exposure to COPCs in soil during on-site excavation activities will be controlled by personal protective equipment (PPE) requirements outlined in the PSC Health and Safety Plan. Construction worker exposure to COPCs in groundwater downgradient of the facility is not likely to result in unacceptable risk to human health, as discussed in the HHERA. Interim measures are currently being conducted to limit exposures to COPCs migrating from groundwater into indoor air. Additional information regarding these measures is presented in the *Inhalation Pathway Interim Measures Work Plan* (November, 2002). The EI form for the *Current Human Exposures Under Control* was completed by PSC and is presented in Appendix 11A.

11.3 *Summary of Corrective Action Progress*

EPA's RCRA Corrective Action Program tracks the progress of site cleanups in meeting two Environmental Indicators (EIs), *Current Human Exposures Under Control* and *Migration of Contaminated Groundwater Under Control.* The EI evaluations for the PSC Georgetown facility were updated as part of this report and indicate that current human exposures and migration of contaminated groundwater are both under control.

11.4 *References*

United States Environmental Protection Agency (EPA). 1999a. *Documentation of Environmental Indicator Determination, Interim Final. RCRA Corrective Action, Environmental Indicator (EI) RCRIS Code (CA750), Migration of Contamination Groundwater Under Control*, US Environmental Protection agency, February 1999.

United States Environmental Protection Agency (EPA). 1999b. *Documentation of Environmental Indicator Determination, Interim Final. RCRA Corrective Action, Environmental Indicator (EI) RCRIS Code (CA725), Current Human Exposures Under Control*, US Environmental Protection agency, February 1999.

12.0 IDENTIFICATION OF CHEMICALS OF CONCERN AND PRELIMINARY REMEDIAL ACTION OBJECTIVES

Section VII.A.4.a.8 of the Part B Permit for the facility requires the proposal of preliminary remedial objectives (PRAOs) [1] and preliminary remedial action levels (PRALs) in the RI. PRAOs and PRALs are identified in the RI to focus the efforts of the feasibility study on the areas of the facility and the RI Study Area where a remedy may be required to protect human health and the environment. PRALs are risk-based values that provide an estimate of the concentrations to which exposures must be controlled to protect human health and the environment. PRALs are used to identify the chemicals of concern (COCs) which will be further evaluated in the FS. MTCA Cleanup Levels (CLs) developed in the HHERA were adopted as PRALs. PRAOs use the results of a comparison of COPC concentrations and CLs to identify areas where a remedy is required. PRAOs will be used as the basis of the FS. The PRAOs and CLs for the facility are summarized in this section.

12.1 *Three-fold MTCA criteria*

In order to determine the areas where a remedy is required, COPC concentrations in soil and groundwater were compared with CLs developed in accordance with MTCA (WAC 173-340). The CLs were compared with the reasonable maximum exposure (RME) soil and groundwater concentrations within the framework of MTCA's compliance criteria [WAC 173-340-740 (7)(d) and (e), and WAC 173-340-720 (9)], referred to herein as the three-fold MTCA criteria. The three-fold MTCA criteria are:

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[1] The PRAOs presented in this section are preliminary and may be modified in the FS based discussions between PSC, Ecology, and stakeholders. Additional objectives may be proposed to Ecology, if appropriate, to address specific issues identified as the FS is performed. Modifications or additions to the remedial objectives will be discussed with Ecology at the regular progress meetings conducted during performance of the FS.

1. The maximum concentration for a COPC must be less than or equal to two times the site-specific COPC cleanup or remediation level.
2. The 95% upper confidence limit (95%UCL) on the mean concentration must be less than the site-specific cleanup or remediation level.
3. Less than 10% of individual soil concentrations shall exceed the site-specific cleanup or remediation level.

The comparison of COPC concentrations to the CLs within the framework of the three-fold MTCA criteria is presented in the following sections for soil and groundwater.

12.2 *Soil*

Soil CLs were calculated based on MTCA equations 745-4 and 745-5 and are protective of occupational exposure to COPCs in soil. The CLs were compared to RME soil concentrations from samples collected in Area 1[2] from zero to 15 feet bgs. The RME soil concentration was calculated as the lower of the 95% UCL concentration or the maximum detected concentration, as described in detail in Section 3.3.2 of the HHERA.

The results of the evaluation, presented in Table 12-1, indicate that PCB Aroclor 1016/1242, PCE, and TCE detected in soil in Area 1 fail one or more of the criteria, and thus, are identified as COCs and require further evaluation in the FS. Exposure to soil in Area 1 is and will continue to be restricted by a concrete or asphalt cap.

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[2] The only soil impacted from operations at the facility is in Area 1 with the exception of HA-151 and HAC-17, which are located in Area 2 just across the fenceline from Area 1. These samples were also included in the evaluation of soil because they are considered to be part of the same area of COPC-impacted soil just inside the facility fenceline.

12.3 *Groundwater*

Groundwater CLs were calculated based on protection of indoor air and protection of surface water. The development of the groundwater CLs and the comparison of COPC concentrations to each of the CLs is described in this section.

12.3.1 Groundwater Protection of Indoor Air

The CLs based on the protection of indoor air were calculated by developing air CLs based on MTCA equations 750-1 and 750-2 and dividing them by the appropriate groundwater-to-indoor air volatilization factor (GIVF). These CLs were compared with separate RME groundwater concentrations for groundwater located within the water table sample interval[3] in Area 1, Area 2, Area 3, and outside Areas 1, 2, and 3. Similar to soil, the RME groundwater concentrations were calculated as the lower of the 95% UCL concentration or the maximum detected concentration, as described in detail in Section 3.3.2 of the HHERA.

The results of the comparison, presented in Table 12-2, indicate that the following constituents failed one or more of the three-fold MTCA criteria, and thus, are identified as COCs and require further evaluation in the FS.

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[3] The water table sample interval includes all groundwater samples collected from wells and borings with screened intervals at depths <20 feet bgs.

Groundwater COCs Based on Protection of Indoor Air

Area 1	Area 2	Area 3
1,2-Dichloroethane	1,2-Dichloroethane	Benzene
Benzene	Benzene	Trichloroethene
Chloroform	Chloroform	Vinyl chloride
Cis-1,2-Dichloroethene	Cis-1,2-Dichloroethene	C8-C10 Aliphatics (EPH)
trans-1,2-Dichloroethene	Ethylbenzene	C8-C10 Aromatics (VPH)
Ethylbenzene	Tetrachloroethene	
Tetrachloroethene	Trichloroethene	
Trichloroethene	Toluene	
Toluene	Vinyl chloride	
Vinyl chloride	Xylenes	
Xylenes	1,2,4-& 1,3,5-Trimethylbenzenes	
1,2,4-& 1,3,5-Trimethylbenzenes	C8-C10 Aliphatics (EPH)	
C8-C10 Aliphatics (EPH)	C8-C10 Aromatics (EPH)	
C8-C10 Aromatics (VPH)	C8-C10 Aromatics (VPH)	

In addition, a number of COPCs, including 1,2-dichloroethane, benzene, chloroform, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, tetrachloroethene, trichloroethene, toluene, vinyl chloride, xylenes, 1,2,4-& 1,3,5-trimethylbenzenes, C8-C10 aliphatics (EPH), C8-C10 aromatics (EPH), and C8-C10 Aromatics (VPH) were detected in groundwater in the water table sample interval outside Areas 1, 2, and 3 at concentrations that failed one or more of the criteria. As discussed in Section 9, groundwater COPCs detected in the areas outside of Areas 1, 2, and 3 are not related to releases from the PSC facility, and thus, will not be evaluated in the

FS. However, this evaluation does indicate that remedial action undertaken by another responsible party may be required in these areas.

12.3.2 Groundwater Protection of Surface Water

Two groundwater CLs based on the protection of surface water were calculated: one for the protection of human exposures to surface water and another based on the protection of ecological receptors. The groundwater CLs based on the protection of human exposures to surface water were calculated based on MTCA equations 730-1 and 730-2 and are protective of ingestion of aquatic organisms. The groundwater CLs based on the protection of ecological receptors were based on the ecological screening levels defined in the HHERA. The DAFs used to estimate the concentrations at the groundwater-to-surface-water interface were based on the peak concentrations at the groundwater-to-surface-water interface estimated assuming a finite source groundwater model that incorporated site-specific biodegradation constants and no retardation, and are described in more detail in Appendix 9D. These CLs were compared with separate RME groundwater concentrations for groundwater from all sample intervals[4] within the PSC plume area, as defined in Section 9.0, but outside the HCIM.

The results of the comparison, presented in Table 12-3, indicate that the following constituents failed one or more of the criteria, and thus, are identified as COCs and require further evaluation in the FS.

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[4] All sample intervals include the water table, shallow, and intermediate sample intervals, and the deep aquifer, as defined in Section 9.

Groundwater COCs Based on Protection of Surface Water
Arsenic
Manganese
Aroclor 1016
Ethylbenzene
Trichloroethene
Vinyl chloride

Although these COPCs were identified as requiring further evaluation, the fate and transport evaluation presented in Section 9 indicates that none of these COPCs are likely to reach the groundwater-to-surface-water interface at concentrations exceeding the applicable groundwater cleanup levels protective of surface water.

12.4 *Preliminary Remedial Action Objectives*

PRAOs were developed based on the results of the RI, HHERA, and evaluation of the three-fold MTCA criteria. These objectives will be used as the basis of the FS, as described in Part IV of this report. Three PRAOs were developed for the area that has been impacted by releases from the facility:

- Prevent direct contact with surface or subsurface soils and inhalation of dusts from surface soils with COCs that exceed cleanup levels in Area 1;
- Reduce risks associated with exposure to vapors from affected soil or groundwater to acceptable levels established in accordance with MTCA regulations; and
- Protect human and ecological receptors by reducing COC concentrations in affected groundwater to cleanup levels based on protection of surface water to ensure continued protection of surface water in the future.

These objectives may be modified or additional objectives may be proposed to Ecology, if appropriate, to address specific issues identified as the FS is performed. Modifications or additions to the PRAOs will be discussed with Ecology at the regular progress meetings conducted during performance of the FS.

12.5 *Summary*

MTCA CLs were identified as PRALs for the facility and were compared with site concentrations to identify the COCs in soil and groundwater which will be further evaluated in the FS. The results of the comparison indicated that several COPCs in soil and groundwater require further evaluation in order to protect human health and the environment. These results were used to develop PRAOs that will form the basis of the FS.

Table 12-1
Identification of COCs in Area 1 Soil
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/kg)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/kg)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/kg)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion? (Maximum/CL > 2)	COC?
Arsenic	65	91	33,333	0	No	2,031	0.06	No	5,810	0.2	No	No
Barium	11	100	93,333,333	0	No	198,631	0.002	No	880,000	0.009	No	No
Cadmium	65	9	---	0	No	548	---	No	1,100		No	No
Chromium	65	100	---	0	No	25,235	---	No	257,000		No	No
Copper	65	100	49,333,333	0	No	15,095	0.0003	No	81,000	0.002	No	No
Cyanide	54	35	26,666,667	0	No	2,157	0.00010	No	25,000	0.0009	No	No
Lead	65	52	---	0	No	163,250	---	No	1,900,000		No	No
Mercury	65	17	---	0	No	196	---	No	2,400		No	No
Nickel	65	100	26,666,667	0	No	7,525	0.0003	No	13,000	0.0005	No	No
Silver	6	17	6,666,667	0	No	36,300	0.005	No	36,300	0.005	No	No
Zinc	65	100	400,000,000	0	No	54,426	0.00010	No	226,000	0.0006	No	No
Aroclor 1016/1242	**42**	**83**	**12,500**	**40.5**	**Yes**	**1,305,581**	**104.4**	**Yes**	**2,200,000**	**176.0**	**Yes**	**Yes**
Aroclor 1254	32	19	12,500	0	No	3,600	0.3	No	3,600	0.3	No	No
Aroclor 1260	32	28	12,500	0	No	3,115	0.2	No	5,500	0.4	No	No
1,2,4-Trichlorobenzene	69	10	14,545,455	0	No	301	0	No	8,800	0.0006	No	No
1,2-Dichlorobenzene	70	29	130,909,091	0	No	853	0	No	9,400	0.00010	No	No
2,4-Dimethylphenol	65	12	13,333,333	0	No	532	0	No	12,000	0.0009	No	No
2-Methylphenol	65	26	33,333,333	0	No	299	0	No	1,000	0	No	No
4-Methylphenol	65	40	3,333,333	0	No	2,051	0.0006	No	41,000	0.01	No	No
Acenaphthene	65	26	40,000,000	0	No	359	0	No	2,100	0.00010	No	No
Benzo(a)anthracene	65	32	102,740	0	No	235	0.002	No	1,200	0.01	No	No
Benzo(a)pyrene	65	20	10,274	0	No	202	0.02	No	920	0.09	No	No
Benzo(b)fluoranthene	65	34	102,740	0	No	318	0.003	No	1,200	0.01	No	No
Benzo(ghi)perylene	65	22	---	0	No	188	---	No	660		No	No
Benzo(k)fluoranthene	65	34	102,740	0	No	306	0.003	No	1,200	0.01	No	No
Bis(2-ethylhexyl) phthalate	65	59	1,785,714	0	No	1,429	0.0008	No	40,000	0.02	No	No
Carbazole	9	11	1,250,000	0	No	92	0.00010	No	92	0.00010	No	No
Chrysene	65	40	1,027,397	0	No	308	0.0003	No	1,500	0.002	No	No
Di-n-butyl phthalate	65	34	66,666,667	0	No	465	0	No	5,300	0.00010	No	No
Dibenzo(a,h)anthracene	65	6	25,685	0	No	76	0.003	No	76	0.003	No	No
Dibenzofuran	65	23	---	0	No	255	---	No	1,400		No	No
Fluoranthene	65	40	26,666,667	0	No	453	0	No	3,300	0.00010	No	No
Fluorene	65	32	58,181,818	0	No	427	0	No	2,600	0	No	No
Indeno(1,2,3-cd)pyrene	65	22	102,740	0	No	197	0.002	No	810	0.008	No	No
Methyl isobutyl ketone (MIBK)	74	34	116,363,636	0	No	40,350	0.0003	No	43,000	0.0004	No	No
Naphthalene	69	62	29,090,909	0	No	17,462	0.0006	No	84,000	0.003	No	No
Pentachlorophenol	65	19	208,333	0	No	940	0.005	No	1,800	0.009	No	No
Phenanthrene	65	57	---	0	No	1,330	---	No	7,400		No	No
Phenol	65	52	200,000,000	0	No	2,698	0	No	50,000	0.0003	No	No
Pyrene	65	46	20,000,000	0	No	589	0	No	12,000	0.0006	No	No
1,1,1-Trichloroethane	74	73	556,521,739	0	No	570,000	0.0010	No	570,000	0.0010	No	No
1,1,2-Trichloroethane	74	10	956,938	0	No	390	0.0004	No	390	0.0004	No	No

Table 12-1
Identification of COCs in Area 1 Soil
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/kg)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/kg)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/kg)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion? (Maximum/CL > 2)	COC?
1,1-Dichloroethane	73	36	198,757,764	0	No	3,100	0	No	3,100	0	No	No
1,1-Dichloroethylene	73	4	99,378,882	0	No	2,000	0	No	2,000	0	No	No
1,2-Dichloroethane	73	26	599,401	0	No	23,000	0.04	No	23,000	0.04	No	No
1,2-Dichloroethene	42	67	17,888,199	0	No	47,000	0.003	No	47,000	0.003	No	No
2-Hexanone	73	6	58,181,818	0	No	40,000	0.0007	No	40,000	0.0007	No	No
Acetone	74	62	66,666,667	0	No	16,000	0.0002	No	16,000	0.0002	No	No
Benzene	74	27	1,355,167	0	No	2,600	0.002	No	2,600	0.002	No	No
Chloroform	73	21	19,875,776	0	No	4,200	0.0002	No	4,200	0.0002	No	No
Ethylbenzene	74	85	145,454,545	0	No	3,400,000	0.02	No	3,400,000	0.02	No	No
Methylene chloride	74	92	9,937,888	0	No	680,000	0.07	No	680,000	0.07	No	No
Tetrachloroethylene	74	72	101,010	2.7	No	290,000	2.9	**Yes**	290,000	2.9	**Yes**	**Yes**
Toluene	74	97	290,909,091	0	No	3,300,000	0.01	No	3,300,000	0.01	No	No
Trichloroethylene	74	61	136,364	4.1	No	460,000	3.4	**Yes**	460,000	3.4	**Yes**	**Yes**
Vinyl chloride	73	7	53,239	0	No	96	0.002	No	96	0.002	No	No
Xylenes (Total)	66	94	290,909,091	0	No	2,800,000	0.010	No	2,800,000	0.010	No	No
cis-1,2-Dichloroethylene	32	63	19,875,776	0	No	47,000	0.002	No	47,000	0.002	No	No
trans-1,2-Dichloroethylene	32	9	39,751,553	0	No	8.40	0	No	8.40	0	No	No
1,1,2-Trichlorotrifluoroethane	55	44	43,636,363,636	0	No	330,000	0	No	330,000	0	No	No
1,2,4-Trimethylbenzene	4	100	72,727,273	0	No	27,000	0.0004	No	27,000	0.0004	No	No
1,3,5-Trimethylbenzene	4	100	72,727,273	0	No	18,000	0.0002	No	18,000	0.0002	No	No
2-Methylnaphthalene	65	52	13,090,909	0	No	6,459	0.0005	No	23,000	0.002	No	No
Cumene	4	100	145,454,545	0	No	1,800	0	No	1,800	0	No	No
Propylbenzene	4	100	14,545,455	0	No	5,900	0.0004	No	5,900	0.0004	No	No
n-Butylbenzene	4	100	58,181,818	0	No	1,200	0	No	1,200	0	No	No
p-Isopropyltoluene	4	100	—	0	No	1,900	—	No	1,900		No	No
sec-Butylbenzene	4	100	14,545,455	0	No	960	0.00010	No	960	0.00010	No	No

Notes:

ug/kg = micrograms per kilogram = parts per billion (ppb)

RME = reasonable maximum exposure

CL = cleanup level

COC = chemical of concern

COPC = chemical of potential concern

Per MTCA, only soil samples starting in the from 0 to 15 feet below ground surface interval were included.

The three-fold MTCA criteria are:

1. The maximum concentration for a COPC must be less than or equal to two times the site-specific COPC cleanup or remediation level.
2. The 95% upper confidence limit (95%UCL) on the mean concentration must be less than the site-specific cleanup or remediation level.
3. Less than 10% of individual soil concentrations shall exceed the site-specific cleanup or remediation level.

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
Area 1												
Arsenic	44	98	---		No	7.85		No	17.40		No	No
Barium	25	24	---	0	No	10.39		No	32.90		No	No
Chromium	25	72	---	0	No	4.40		No	12.50		No	No
Copper	25	44	---	0	No	1.81		No	7.35		No	No
Cyanide	69	38	---	0	No	10.28		No	48.90		No	No
Lead	44	27	---	0	No	1.43		No	10.10		No	No
Manganese	11	100	---	0	No	1735.48		No	1990.00		No	No
Nickel	25	72	---	0	No	3.58		No	9.14		No	No
Selenium	25	8	---	--	No	0.58	--	No Std	1.08	--	No Std	No
Vanadium	21	91	---	--	No	4.86	--	No Std	10.40	--	No Std	No
Zinc	25	28	---	0	No	9.99		No	31.70		No	No
C10-C12 (EPH) Aromatics	5	60	5,284	0	No	2160.00	0.4	No	2160.00	0.4	No	No
C8-C10 (EPH) Aliphatics	5	60	11	60	Yes	2360.00	217.6	Yes	2360.00	217.6	Yes	Yes
TotalExtractablePetroleum HC	5	60	---	0	No	2660.00		No	2660.00		No	No
C8-C10 (VPH) Aromatics	5	60	1,205	40	Yes	28600.00	23.7	Yes	28600.00	23.7	Yes	Yes
TotalVolatilePetroleum HC	5	80	---	0	No	28600.00		No	28600.00		No	No
Aroclor 1016	44	14	176	0	No	1.06	0.006	No	15.40	0.09	No	No
Aroclor 1232	44	21	---	0	No	4.10		No	25.90		No	No
1,2-Dichlorobenzene	95	36	11,188	0	No	16.76	0.002	No	51.50	0.005	No	No
2,4-Dimethylphenol	56	36	---	0	No	109.81		No	921.00		No	No
2-Methylphenol	63	32	---	0	No	52.57		No	282.00		No	No
4-Methylphenol	20	45	---	0	No	1451.82		No	1930.00		No	No
Bis(2-ethylhexyl) phthalate	48	2	---	0	No	1.70		No	1.70		No	No
Methyl isobutyl ketone (MIBK)	101	28	1,043,973	0	No	467.39	0.0004	No	2790.00	0.003	No	No
Naphthalene	99	56	592	1	No	312.56	0.5	No	652.00	1.1	No	No
Pentachlorophenol	63	11	---	0	No	22.62		No	48.70		No	No
Phenol	63	35	---	0	No	676.19		No	6630.00		No	No
Diesel	64	72	---	0	No	5809.57		No	19300.00		No	No
Gasoline	64	84	---	0	No	161000.00		No	161000.00		No	No
Lube Oil Hydrocarbons	64	34	---	0	No	559.29		No	5500.00		No	No
1,1,1-Trichloroethane	101	87	10,949	0	No	2186.22	0.2	No	9010.00	0.8	No	No
1,1-Dichloroethane	101	95	7,516	0	No	1836.92	0.2	No	3210.00	0.4	No	No
1,1-Dichloroethylene	101	32	532	0	No	36.93	0.07	No	106.00	0.2	No	No
1,2-Dichloroethane	101	37	13	20	Yes	148.16	11.5	Yes	1100.00	85.4	Yes	Yes
2-Hexanone	101	5	6,090	0	No	70.79	0.01	No	523.00	0.09	No	No
Benzene	101	34	10	17	Yes	25.99	2.7	Yes	103.00	10.7	Yes	Yes
Carbon disulfide	101	10	---	--	No	9.76	--	No Std	9.76	--	No Std	No
Chloroethane	101	42	54,374	0	No	251.83	0.005	No	896.00	0.02	No	No
Chloroform	101	10	4	5	No	11.58	2.8	Yes	82.00	20.0	Yes	Yes
Ethylbenzene	101	78	12,624	6	No	21900.00	1.7	Yes	21900.00	1.7	No	Yes
Methylene chloride	101	21	321	0	No	66.15	0.2	No	236.00	0.7	No	No
Styrene	101	3	---	--	No	6.67	--	No Std	47.40	--	No Std	No

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
Tetrachloroethylene	101	57	5	26	Yes	26.45	5.3	Yes	282.00	56.3	Yes	Yes
Toluene	101	69	4,961	24	Yes	66900.00	13.5	Yes	66900.00	13.5	Yes	Yes
Trichloroethylene	101	66	0.4	65	Yes	24.07	59.5	Yes	612.00	1513.7	Yes	Yes
Vinyl chloride	101	87	1	86	Yes	1928.68	1504.8	Yes	5590.00	4361.3	Yes	Yes
Xylenes (Total)	101	74	1,442	37	Yes	24850.00	17.2	Yes	24850.00	17.2	Yes	Yes
cis-1,2-Dichloroethylene	101	88	727	33	Yes	14500.00	19.9	Yes	14500.00	19.9	Yes	Yes
trans-1,2-Dichloroethylene	101	38	653	1	No	99.57	0.2	No	7120.00	10.9	Yes	Yes
1,1,2-Trichlorotrifluoroethane	82	52	12,088	0	No	1426.49	0.1	No	2170.00	0.2	No	No
1,2,4-Trimethylbenzene	82	72	130	37	Yes	3080.00	23.7	Yes	3080.00	23.7	Yes	Yes
1,3,5-Trimethylbenzene	40	70	98	30	Yes	755.00	7.7	Yes	755.00	7.7	Yes	Yes
1,4-Dioxane	5	20	—	0	No	12.30		No	12.30		No	No
2-Methylnaphthalene	48	21	—	0	No	21.70		No	21.70		No	No
Benzoic acid	46	13	—	--	No	38.82	--	No Std	649.00	--	No Std	No
Cumene	19	74	749	0	No	76.00	0.1	No	76.00	0.1	No	No
Dichlorodifluoromethane	56	7	64	0	No	6.67	0.1	No	15.00	0.2	No	No
Ethene	19	84	—	0	No	351.80		No	402.00		No	No
Methane	20	100	—	0	No	3680.00		No	3680.00		No	No
Methylphenol	36	42	—	0	No	672.67		No	2680.00		No	No
Propylbenzene	19	74	269	0	No	172.00	0.6	No	172.00	0.6	No	No
n-Butylbenzene	19	11	—	0	No	1.53		No	11.20		No	No
n-Hexane	6	17	—	0	No	4.21		No	4.21		No	No
p-Isopropyltoluene	19	63	749	0	No	58.10	0.08	No	58.10	0.08	No	No
sec-Butylbenzene	19	32	231	0	No	192.03	0.8	No	202.00	0.9	No	No
Area 2												
Arsenic	14	93	—	0	No	13.37		No	20.90		No	No
Barium	19	47	—	0	No	8.52		No	13.90		No	No
Chromium	14	100	—	0	No	17.90		No	17.90		No	No
Copper	19	79	—	0	No	3.94		No	7.98		No	No
Cyanide	30	33	—	0	No	7.94		No	14.10		No	No
Lead	13	54	—	0	No	5.18		No	6.82		No	No
Manganese	19	100	—	0	No	549.78		No	702.00		No	No
Nickel	19	95	—	0	No	4.20		No	5.43		No	No
Selenium	19	16	—	--	No	0.79	--	No Std	1.77	--	No Std	No
Vanadium	7	100	—	--	No	36.30	--	No Std	36.30	--	No Std	No
Zinc	7	14	—	0	No	9.62		No	15.40		No	No
C10-C12 (EPH) Aromatics	10	80	5,284	0	No	2300.00	0.4	No	2300.00	0.4	No	No
C8-C10 (EPH) Aliphatics	10	70	11	70	Yes	2910.00	268.3	Yes	2910.00	268.3	Yes	Yes
C8-C10 (EPH) Aromatics	4	75	1,205	25	Yes	10700.00	8.9	Yes	10700.00	8.9	Yes	Yes
TotalExtractablePetroleum HC	10	90	—	0	No	5530.00		No	5530.00		No	No
C8-C10 (VPH) Aromatics	7	86	1,205	71	Yes	22255.28	18.5	Yes	36800.00	30.5	Yes	Yes
TotalVolatilePetroleum HC	10	80	—	0	No	36800.00		No	36800.00		No	No
1,2-Dichlorobenzene	38	50	11,188	0	No	75.20	0.007	No	75.20	0.007	No	No
2,4-Dimethylphenol	26	81	—	0	No	972.00		No	972.00		No	No

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
2-Methylphenol	27	56	---	0	No	360.85		No	491.00		No	No
4-Methylphenol	6	67	---	0	No	1550.00		No	1550.00		No	No
Methyl isobutyl ketone (MIBK)	71	34	1,043,973	0	No	1290.00	0.001	No	1290.00	0.001	No	No
Naphthalene	40	80	592	0	No	124.31	0.2	No	154.00	0.3	No	No
Pentachlorophenol	27	19	---	0	No	10.80		No	10.80		No	No
Phenol	27	63	---	0	No	3190.00		No	3190.00		No	No
Diesel	22	82	---	0	No	24700.00		No	24700.00		No	No
Gasoline	22	100	---	0	No	52839.23		No	102000.00		No	No
Lube Oil Hydrocarbons	22	27	---	0	No	1613.08		No	5500.00		No	No
1,1,1-Trichloroethane	73	51	10,949	0	No	967.00	0.09	No	967.00	0.09	No	No
1,1-Dichloroethane	73	82	7,516	0	No	1270.00	0.2	No	1270.00	0.2	No	No
1,1-Dichloroethylene	73	32	532	0	No	90.76	0.2	No	391.00	0.7	No	No
1,2-Dichloroethane	73	45	13	30	Yes	387.21	30.1	Yes	465.00	36.1	Yes	Yes
2-Hexanone	71	7	6,090	0	No	28.30	0.005	No	28.30	0.005	No	No
Benzene	73	69	10	41	Yes	44.73	4.7	Yes	48.00	5.0	Yes	Yes
Carbon disulfide	71	1	---	--	No	1.06	--	No Std	1.06	--	No Std	No
Chloroethane	71	80	54,374	0	No	502.95	0.009	No	1830.00	0.03	No	No
Chloroform	71	14	4	10	No	25.05	6.1	Yes	29.60	7.2	Yes	Yes
Ethylbenzene	71	96	12,624	6	No	16300.00	1.3	Yes	16300.00	1.3	No	Yes
Methylene chloride	73	41	321	0	No	80.70	0.3	No	80.70	0.3	No	No
Tetrachloroethylene	73	45	5	21	Yes	28.77	5.7	Yes	29.70	5.9	Yes	Yes
Toluene	71	97	4,961	42	Yes	43200.00	8.7	Yes	43200.00	8.7	Yes	Yes
Trichloroethylene	73	34	0	34	Yes	31.72	78.5	Yes	61.60	152.4	Yes	Yes
Vinyl chloride	73	74	1	73	Yes	8710.00	6795.5	Yes	8710.00	6795.5	Yes	Yes
Xylenes (Total)	71	97	1,442	72	Yes	36960.02	25.6	Yes	39430.00	27.3	Yes	Yes
cis-1,2-Dichloroethylene	73	67	727	33	Yes	8430.00	11.6	Yes	8430.00	11.6	Yes	Yes
trans-1,2-Dichloroethylene	73	62	653	0	No	62.45	0.10	No	173.00	0.3	No	No
1,1,2-Trichlorotrifluoroethane	67	52	12,088	0	No	466.00	0.04	No	466.00	0.04	No	No
1,2,4-Trimethylbenzene	36	86	130	69	Yes	1402.85	10.8	Yes	1910.00	14.7	Yes	Yes
1,3,5-Trimethylbenzene	26	81	98	46	Yes	1160.00	11.9	Yes	1160.00	11.9	Yes	Yes
1,4-Dioxane	3	33	---	0	No	5.28		No	5.28		No	No
1-Methyl naphthalene	4	50	---	0	No	7.03		No	7.03		No	No
2-Methylnaphthalene	18	28	---	0	No	10.50		No	10.50		No	No
Benzoic acid	15	40	---	--	No	6420.00	--	No Std	6420.00	--	No Std	No
Cumene	4	100	749	0	No	78.10	0.1	No	78.10	0.1	No	No
Dichlorodifluoromethane	12	17	64	0	No	52.60	0.8	No	52.60	0.8	No	No
Ethane	34	53	---	0	No	285.16		No	298.00		No	No
Ethene	34	85	---	0	No	2340.00		No	2340.00		No	No
Methane	34	100	---	0	No	5536.64		No	9980.00		No	No
Methylphenol	20	40	---	0	No	1500.00		No	1500.00		No	No
Propylbenzene	4	50	269	0	No	167.00	0.6	No	167.00	0.6	No	No
n-Butylbenzene	16	44	---	0	No	38.70		No	38.70		No	No
n-Hexane	9	33	---	0	No	7.92		No	7.92		No	No

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
p-Isopropyltoluene	4	75	749	0	No	50.70	0.07	No	50.70	0.07	No	No
sec-Butylbenzene	4	25	231	0	No	15.60	0.07	No	15.60	0.07	No	No
Area 3												
Arsenic	20	100	---	0	No	29.50		No	29.50		No	No
Barium	55	26	---	0	No	8.93		No	43.70		No	No
Chromium	46	26	---	0	No	2.23		No	18.60		No	No
Copper	55	33	---	0	No	2.34		No	14.40		No	No
Hexavalent Chromium	35	51	---	0	No	7.62		No	17.90		No	No
Manganese	45	100	---	0	No	329.40		No	903.00		No	No
Nickel	55	66	---	0	No	5.46		No	19.20		No	No
Selenium	55	13	---	--	No	0.79	--	No Std	13.20	--	No Std	No
Vanadium	10	90	---	--	No	5.23	--	No Std	6.36	--	No Std	No
C10-C12 (EPH) Aromatics	23	17	5,284	0	No	45.26	0.009	No	103.00	0.02	No	No
C8-C10 (EPH) Aliphatics	23	22	11	22	Yes	154.67	14.3	Yes	737.00	68.0	Yes	Yes
C8-C10 (EPH) Aromatics	17	24	1,205	6	No	1105.62	0.9	No	1920.00	1.6	No	No
TotalExtractablePetroleum HC	23	26	---	0	No	331.56		No	1970.00		No	No
C8-C10 (VPH) Aromatics	13	39	1,205	31	Yes	6070.00	5.0	Yes	6070.00	5.0	Yes	Yes
TotalVolatilePetroleum HC	23	35	---	0	No	6070.00		No	6070.00		No	No
1,2-Dichlorobenzene	173	13	11,188	0	No	1.32	0.00010	No	11.70	0.0010	No	No
2,4-Dimethylphenol	38	11	---	0	No	6.78		No	27.20		No	No
2-Methylphenol	38	5	---	0	No	5.85		No	16.90		No	No
Bis(2-ethylhexyl) phthalate	19	16	---	0	No	24.70		No	24.70		No	No
Methyl isobutyl ketone (MIBK)	188	6	1,043,973	0	No	8.65	0	No	10.00	0	No	No
Naphthalene	171	19	592	0	No	2.40	0.004	No	58.60	0.10	No	No
Pentachlorophenol	38	11	---	0	No	3.37		No	3.37		No	No
Phenol	38	5	---	0	No	5.77		No	24.60		No	No
Diesel	20	45	---	0	No	3440.00		No	3440.00		No	No
Gasoline	20	80	---	0	No	22200.00		No	22200.00		No	No
1,1,1-Trichloroethane	220	21	10,949	0	No	8.31	0.0008	No	874.00	0.08	No	No
1,1-Dichloroethane	230	44	7,516	0	No	42.20	0.006	No	815.00	0.1	No	No
1,1-Dichloroethylene	220	27	532	0	No	2.34	0.004	No	12.90	0.02	No	No
1,2-Dichloroethane	220	18	13	0	No	1.29	0.1	No	9.95	0.8	No	No
2-Hexanone	188	6	6,090	0	No	8.65	0.001	No	10.00	0.002	No	No
Benzene	220	27	10	5	No	1.56	0.2	No	38.20	4.0	Yes	Yes
Carbon disulfide	188	6	---	--	No	0.68	--	No Std	1.00	--	No Std	No
Chloroethane	188	23	54,374	0	No	28.50	0.0005	No	552.00	0.01	No	No
Chloroform	192	8	4	0.5	No	0.93	0.2	No	4.56	1.1	No	No
Ethylbenzene	191	18	12,624	0.5	No	19.60	0.002	No	15700.00	1.2	No	No
Methylene chloride	220	6	321	0	No	4.04	0.01	No	10.20	0.03	No	No
Styrene	192	6	---	--	No	0.86	--	No Std	1.00	--	No Std	No
Tetrachloroethylene	220	26	5	1.4	No	1.78	0.4	No	7.37	1.5	No	No
Toluene	192	19	4,961	0	No	5.22	0.001	No	4060.00	0.8	No	No
Trichloroethylene	230	53	0	42	Yes	50.66	125.3	Yes	1120.00	2770.3	Yes	Yes

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
Vinyl chloride	230	45	1	30	Yes	32.34	25.2	Yes	2500.00	1950.5	Yes	Yes
Xylenes (Total)	192	21	1,442	1.0	No	15.15	0.01	No	1795.00	1.2	No	No
cis-1,2-Dichloroethylene	230	51	727	0.9	No	49.79	0.07	No	993.00	1.4	No	No
trans-1,2-Dichloroethylene	230	22	653	0	No	1.23	0.002	No	9.97	0.02	No	No
1,1,2-Trichlorotrifluoroethane	192	18	12,088	0	No	3.85	0.0003	No	68.70	0.006	No	No
1,2,4-Trimethylbenzene	164	14	130	1.8	No	5.72	0.04	No	188.00	1.4	No	No
1,3,5-Trimethylbenzene	150	7	98	0	No	1.18	0.01	No	28.40	0.3	No	No
1,4-Dioxane	10	70	—	0	No	26.18		No	30.90		No	No
1-Methyl naphthalene	5	40	—	0	No	0.36		No	0.36		No	No
2-Methylnaphthalene	21	10	—	0	No	0.47		No	0.47		No	No
Benzoic acid	19	5	—	--	No	11.14	--	No Std	21.90	--	No Std	No
Dichlorodifluoromethane	45	24	64	0	No	1.00	0.02	No	1.00	0.02	No	No
Ethane	41	37	—	0	No	312.13		No	782.00		No	No
Ethene	41	27	—	0	No	570.45		No	1740.00		No	No
Methane	41	90	—	0	No	25400.00		No	25400.00		No	No
Propylbenzene	45	4	269	0	No	1.69	0.006	No	16.30	0.06	No	No
n-Butylbenzene	62	5	—	0	No	1.29		No	1.61		No	No
n-Hexane	38	3	—	0	No	1.06		No	1.06		No	No
p-Isopropyltoluene	45	4	749	0	No	1.27	0.002	No	1.92	0.003	No	No
sec-Butylbenzene	15	13	231	0	No	0.87	0.004	No	2.48	0.01	No	No
Outside Area 1, Area 2, and Area 3												
Arsenic	113	87	—	0	No	9.95		No	29.50		No	No
Barium	132	27	—	0	No	7.67		No	43.70		No	No
Chromium	106	52	—	0	No	3.46		No	18.60		No	No
Copper	132	44	—	0	No	1.98		No	14.40		No	No
Cyanide	180	23	—	0	No	7.25		No	48.90		No	No
Hexavalent Chromium	45	40	—	0	No	6.30		No	17.90		No	No
Lead	143	14	—	0	No	0.86		No	10.10		No	No
Manganese	102	95	—	0	No	751.01		No	1990.00		No	No
Nickel	131	71	—	0	No	3.43		No	19.20		No	No
Selenium	132	13	—	--	No	0.72	--	No Std	13.20	--	No Std	No
Vanadium	50	90	—	--	No	6.36	--	No Std	36.30	--	No Std	No
Zinc	76	11	—	0	No	6.70		No	31.70		No	No
C10-C12 (EPH) Aromatics	63	24	5,284	0	No	164.56	0.03	No	2300.00	0.4	No	No
C8-C10 (EPH) Aliphatics	63	27	11	27	Yes	297.13	27.4	Yes	4070.00	375.3	Yes	Yes
C8-C10 (EPH) Aromatics	35	26	1,205	11	Yes	3624.09	3.0	Yes	13700.00	11.4	Yes	Yes
TotalExtractablePetroleum HC	63	33	—	0	No	858.97		No	8170.00		No	No
C8-C10 (VPH) Aromatics	42	38	1,205	31	Yes	36800.00	30.5	Yes	36800.00	30.5	Yes	Yes
TotalVolatilePetroleum HC	63	37	—	0	No	36800.00		No	36800.00		No	No
Aroclor 1016	101	6	176	0	No	0.31	0.002	No	15.40	0.09	No	No
Aroclor 1232	101	9	—	0	No	0.59		No	25.90		No	No
1,2-Dichlorobenzene	379	20	11,188	0	No	4.46	0.0004	No	75.20	0.007	No	No
2,4-Dimethylphenol	169	28	—	0	No	44.50		No	972.00		No	No

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
2-Methylphenol	180	21	—	0	No	23.08		No	491.00		No	No
4-Methylphenol	37	35	—	0	No	391.33		No	1930.00		No	No
Bis(2-ethylhexyl) phthalate	116	4	—	0	No	24.70		No	24.70		No	No
Methyl isobutyl ketone (MIBK)	447	14	1,043,973	0	No	62.72	0.00010	No	2790.00	0.003	No	No
Naphthalene	384	32	592	0.3	No	30.72	0.05	No	652.00	1.1	No	No
Pentachlorophenol	180	10	—	0	No	12.75		No	48.70		No	No
Phenol	180	23	—	0	No	92.90		No	6630.00		No	No
Diesel	146	56	—	0	No	3644.60		No	24700.00		No	No
Gasoline	146	66	—	0	No	161000.00		No	161000.00		No	No
Lube Oil Hydrocarbons	146	23	—	0	No	472.90		No	5500.00		No	No
1,1,1-Trichloroethane	492	42	10,949	0	No	122.82	0.01	No	9010.00	0.8	No	No
1,1-Dichloroethane	504	59	7,516	0	No	342.99	0.05	No	3210.00	0.4	No	No
1,1-Dichloroethylene	492	25	532	0	No	8.46	0.02	No	391.00	0.7	No	No
1,2-Dichloroethane	492	24	13	9	No	12.89	1.0	Yes	1100.00	85.4	Yes	Yes
2-Hexanone	447	5	6,090	0	No	19.82	0.003	No	523.00	0.09	No	No
Benzene	492	30	10	12	Yes	5.62	0.6	No	103.00	10.7	Yes	Yes
Carbon disulfide	447	5	—	–	No	2.35	–	No Std	9.76	–	No Std	No
Chloroethane	447	32	54,374	0	No	204.28	0.004	No	1830.00	0.03	No	No
Chloroform	453	14	4	7	No	3.41	0.8	No	82.00	20.0	Yes	Yes
Ethylbenzene	452	42	12,624	2	No	21900.00	1.7	Yes	21900.00	1.7	No	Yes
Methylene chloride	492	13	321	0	No	12.59	0.04	No	236.00	0.7	No	No
Styrene	453	3	—	–	No	1.84	–	No Std	47.40	–	No Std	No
Tetrachloroethylene	492	37	5	12	Yes	8.88	1.8	Yes	282.00	56.3	Yes	Yes
Toluene	453	41	4,961	12	Yes	61872.62	12.5	Yes	66900.00	13.5	Yes	Yes
Trichloroethylene	504	53	0	46	Yes	27.87	68.9	Yes	1120.00	2770.3	Yes	Yes
Vinyl chloride	504	53	1	45	Yes	814.48	635.5	Yes	8710.00	6795.5	Yes	Yes
Xylenes (Total)	453	42	1,442	21	Yes	18871.68	13.1	Yes	39430.00	27.3	Yes	Yes
cis-1,2-Dichloroethylene	504	57	727	12	Yes	1655.54	2.3	Yes	14500.00	19.9	Yes	Yes
trans-1,2-Dichloroethylene	504	28	653	0.2	No	6.28	0.010	No	7120.00	10.9	Yes	Yes
1,1,2-Trichlorotrifluoroethane	424	30	12,088	0	No	39.94	0.003	No	2170.00	0.2	No	No
1,2,4-Trimethylbenzene	352	34	130	17	Yes	307.55	2.4	Yes	3080.00	23.7	Yes	Yes
1,3,5-Trimethylbenzene	269	24	98	9	No	29.72	0.3	No	1160.00	11.9	Yes	Yes
1,4-Dioxane	30	30	—	0	No	3.25		No	30.90		No	No
1-Methyl naphthalene	23	17	—	0	No	7.03		No	7.03		No	No
2-Methylnaphthalene	122	14	—	0	No	21.70		No	21.70		No	No
Benzoic acid	113	12	—	–	No	50.57	–	No Std	6420.00	–	No Std	No
Cumene	59	31	749	0	No	27.69	0.04	No	78.10	0.1	No	No
Dichlorodifluoromethane	131	13	64	0	No	3.81	0.06	No	52.60	0.8	No	No
Ethane	115	29	—	0	No	90.19		No	782.00		No	No
Ethene	114	49	—	0	No	1051.28		No	2340.00		No	No
Methane	115	90	—	0	No	25400.00		No	25400.00		No	No
Methylphenol	132	20	—	0	No	60.65		No	2680.00		No	No
Propylbenzene	74	24	269	0	No	45.47	0.2	No	172.00	0.6	No	No

Table 12-2
Identification of Groundwater COCs Based on Protection of Indoor Air
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Concentration (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (Maximum/CL > 2)	COC?
n-Butylbenzene	129	9	---	0	No	1.58		No	38.70		No	No
n-Hexane	82	6	---	0	No	3.67		No	7.92		No	No
p-Isopropyltoluene	74	23	749	0	No	5.90	0.008	No	58.10	0.08	No	No
sec-Butylbenzene	44	21	231	0	No	7.98	0.03	No	202.00	0.9	No	No

Notes:

ug/L = micrograms per liter= parts per billion (ppb)

RME = reasonable maximum exposure

CL = cleanup level

COC = chemical of concern

COPC = chemical of potential concern

Evaluation included only data from water table and shallow sample interval wells (I.e., screen interval < 20 feet below ground surface) collected after 01/01/2000.

The three-fold MTCA criteria are:

1. The maximum concentration for a COPC must be less than or equal to two times the site-specific COPC cleanup or remediation level.
2. The 95% upper confidence limit (95%UCL) on the mean concentration must be less than the site-specific cleanup or remediation level.
3. Less than 10% of individual soil concentrations shall exceed the site-specific cleanup or remediation level.

Table 12-3
Identification of Groundwater COCs Based on Protection of Surface Water
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Dilution Attenuation Factor	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Groundwater Concentration at Surface Water Interface (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion ? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (MAX/CL > 2)	COC?
Arsenic	145	57	0.1	37	29.7	Yes	0.21	2.1	Yes	0.80	8.1	Yes	Yes
Barium	160	31	4	37	0	No	0.21	0.05	No	1.31	0.3	No	No
Chromium	106	75	---	1,000,000	0	No	0.000004		No	0.00008		No	No
Copper	160	53	3	1,000,000	0	No	0.000002	0	No	0.00003	0	No	No
Cyanide	241	20	1	37	2.1	No	0.20	0.2	No	1.76	1.8	No	No
Hexavalent Chromium	32	6	10	1,000,000	0	No	0.000004	0	No	0.00002	0	No	No
Lead	140	10	---	1,000,000	0	No	0.0000007		No	0.000006		No	No
Manganese	140	96	120	37	0.7	No	29.43	0.2	No	173076.92	1442.3	Yes	Yes
Nickel	158	67	8	1,000,000	0	No	0.000003	0	No	0.00007	0	No	No
Selenium	159	3	---	1,000,000	--	No	0.0000005	--	No Std	0.000002	--	No Std	No
Vanadium	64	84	---	1,000,000	--	No	0.000006	--	No Std	0.00003	--	No Std	No
Zinc	49	18	81	1,000,000	0	No	0.000009	0	No	0.00006	0	No	No
C10-C12 (EPH) Aromatics	79	10	---	1,000,000	0	No	0.00004		No	0.0003		No	No
C8-C10 (EPH) Aliphatics	79	10	---	1,000,000	0	No	0.00009		No	0.003		No	No
C8-C10 (EPH) Aromatics	46	13	---	1,000,000	0	No	0.0002		No	0.01		No	No
TotalExtractablePetroleum HC	79	15	---	1,000,000	0	No	0.0001		No	0.003		No	No
C8-C10 (VPH) Aromatics	49	16	---	1,000,000	0	No	0.001		No	0.01		No	No
TotalVolatilePetroleum HC	79	17	---	1,000,000	0	No	0.0005		No	0.01		No	No
Aroclor 1016	129	2	0.003	35	1.6	No	0.005	1.8	Yes	0.44	148.4	Yes	Yes
Aroclor 1232	129	5	0.0001	1,000,000	0	No	0.0000003	0.003	No	0.00003	0.2	No	No
1,2-Dichlorobenzene	387	10	14	1,000,000	0	No	0.000002	0	No	0.00008	0	No	No
2,4-Dimethylphenol	219	12	131	1,000,000	0	No	0.000008	0	No	0.0002	0	No	No
2-Methylphenol	231	7	13	1,000,000	0	No	0.000006	0	No	0.0001	0	No	No
4-Methylphenol	44	16	1,000	1,000,000	0	No	0.00002	0	No	0.0007	0	No	No
Bis(2-ethylhexyl) phthalate	143	3	3	37	0	No	0.67	0.2	No	0.67	0.2	No	No
Methyl isobutyl ketone (MIBK)	537	5	170	1,000,000	0	No	0.00002	0	No	0.0005	0	No	No
Naphthalene	398	23	12	1,000,000	0	No	0.000009	0	No	0.0007	0.00010	No	No
Pentachlorophenol	231	7	5	34	0	No	0.20	0.04	No	0.22	0.04	No	No
Phenol	231	7	118	1,000,000	0	No	0.000007	0	No	0.0003	0	No	No
Diesel	182	33	---	1,000,000	0	No	0.0007		No	0.01		No	No
Gasoline	182	39	---	1,000,000	0	No	0.007		No	0.08		No	No
Lube Oil Hydrocarbons	181	14	---	1,000,000	0	No	0.0003		No	0.002		No	No
1,1,1-Trichloroethane	539	25	11	1,000,000	0	No	0.00001	0	No	0.009	0.0008	No	No
1,1-Dichloroethane	539	50	47	1,000,000	0	No	0.00007	0	No	0.003	0.00010	No	No
1,1-Dichloroethylene	539	10	25	1,000,000	0	No	0.000003	0	No	0.0002	0	No	No
1,2-Dichloroethane	539	13	59	1,000,000	0	No	0.000002	0	No	0.0002	0	No	No
2-Hexanone	537	2	99	1,000,000	0	No	0.00001	0	No	0.0005	0	No	No
Benzene	539	41	23	1,000,000	0	No	0.000007	0	No	0.0001	0	No	No
Carbon disulfide	537	6	---	1,000,000	--	No	0.000002	--	No Std	0.000010	--	No Std	No
Chloroethane	537	32	894	1,000,000	0	No	0.00009	0	No	0.002	0	No	No
Chloroform	539	7	28	1,000,000	0	No	0.000002	0	No	0.00002	0	No	No
Ethylbenzene	538	37	7	102	12.3	Yes	9.65	1.3	Yes	215.74	29.6	Yes	Yes

Table 12-3
Identification of Groundwater COCs Based on Protection of Surface Water
PSC Georgetown Facility Remedial Investigation

COPC	Number of Samples Analyzed	Frequency of Detection (%)	MTCA Cleanup Level (ug/L)	Dilution Attenuation Factor	Frequency of Exceedence of CL (%)	Fail MTCA Frequency of Exceedance Criterion?	RME Groundwater Concentration at Surface Water Interface (ug/L)	Ratio of RME to CL	FAIL MTCA RME Criterion ? (RME/CL > 1)	Maximum Detected Concentration (ug/L)	Ratio of Maximum to CL	FAIL MTCA Maximum Criterion ? (MAX/CL > 2)	COC?
Methylene chloride	539	7	960	1,000,000	0	No	0.000007	0	No	0.0004	0	No	No
Styrene	539	1	---	1,000,000	--	No	0.000001	--	No Std	0.00005	--	No Std	No
Tetrachloroethylene	539	17	0.4	916	0	No	0.004	0.009	No	0.31	0.8	No	No
Toluene	539	37	10	1,960	0.2	No	0.16	0.02	No	12.96	1.3	No	No
Trichloroethylene	539	28	2	970	0.4	No	0.006	0.004	No	26.07	17.1	Yes	Yes
Vinyl chloride	539	51	4	4,514	0.4	No	0.14	0.04	No	11.37	2.9	Yes	Yes
Xylenes (Total)	539	38	2,729	1,000,000	0	No	0.0005	0	No	0.04	0	No	No
cis-1,2-Dichloroethylene	539	45	3,201	1,000,000	0	No	0.0001	0	No	0.02	0	No	No
trans-1,2-Dichloroethylene	539	25	11,600	1,000,000	0	No	0.00001	0	No	0.007	0	No	No
1,1,2-Trichlorotrifluoroethane	511	19	11,000	1,000,000	0	No	0.00001	0	No	0.002	0	No	No
1,2,4-Trimethylbenzene	373	31	400	1,000,000	0	No	0.00005	0	No	0.003	0	No	No
1,3,5-Trimethylbenzene	293	22	400	1,000,000	0	No	0.000008	0	No	0.0008	0	No	No
1,4-Dioxane	40	43	---	1,000,000	0	No	0.00001		No	0.001		No	No
1-Methyl naphthalene	28	7	---	1,000,000	0	No	0.0000004		No	0.0000004		No	No
2-Methylnaphthalene	152	5	2	432	0	No	0.04	0.02	No	0.05	0.02	No	No
Benzoic acid	141	2	---	1,000,000	--	No	0.000009	--	No Std	0.00003	--	No Std	No
Cumene	28	29	7	1,000,000	0	No	0.00003	0	No	0.00005	0	No	No
Dichlorodifluoromethane	88	1	---	1,000,000	0	No	0.000002		No	0.000009		No	No
Ethane	168	46	---	1,000,000	0	No	0.0008		No	0.02		No	No
Ethene	167	43	---	1,000,000	0	No	0.001		No	0.01		No	No
Methane	168	96	---	1,000,000	0	No	0.05		No	0.05		No	No
Methylphenol	176	4	---	1,000,000	0	No	0.000006		No	0.0003		No	No
Propylbenzene	31	29	7	408	0	No	0.23	0.03	No	0.23	0.03	No	No
n-Butylbenzene	134	5	356	1,000,000	0	No	0.0000009	0	No	0.000006	0	No	No
n-Hexane	77	3	1	383	0	No	0.006	0.01	No	0.009	0.02	No	No
p-Isopropyltoluene	31	26	---	1,000,000	0	No	0.000004		No	0.00006		No	No
sec-Butylbenzene	31	19	89	1,000,000	0	No	0.000005	0	No	0.0002	0	No	No

Notes:

ug/L = micrograms per liter= parts per billion (ppb)

RME = reasonable maximum exposure

CL = cleanup level

COC = chemical of concern

COPC = chemical of potential concern

Evaluation included all monitoring wells and direct push results collected after 01/01/2000 for Areas 1, 2, and eastern edge of Area 3 outside the HCIM.

The three-fold MTCA criteria are:

1. The maximum concentration for a COPC must be less than or equal to two times the site-specific COPC cleanup or remediation level.
2. The 95% upper confidence limit (95%UCL) on the mean concentration must be less than the site-specific cleanup or remediation level.
3. Less than 10% of individual soil concentrations shall exceed the site-specific cleanup or remediation level.

13 SUMMARY AND CONCLUSIONS

This section presents a summary of the key RI findings.

13.1 *Summary of RI Objectives & Findings of the RI*

Section VII of the Part B permit defines the scope of the RI, which is summarized in Section 1 of this report. The objective of an RI under MTCA is to collect, develop, and evaluate sufficient information regarding a site to select a cleanup action (WAC 173-340-350). The information presented in the RI will be used in the feasibility study to evaluate potential remedies for the site. This RI has fulfilled the requirements of the scope of work identified in the permit and the objective of an RI under MTCA. The RI was conducted with the following specific objectives:

- Characterization of the hydrogeological conditions of the RI Study Area;
- Determination of the highest beneficial use of groundwater consistent with the MTCA regulation;
- Characterization of the nature and extent of COCs emanating from the facility;
- Assessment of the fate and transport mechanisms for COCs throughout the RI Study Area; and
- Completion of quantitative human health and ecological risk assessments that assess current and future exposure pathways.

PSC has collected a considerable amount of data during remedial investigation activities. These activities have included:

- Installation of 103 monitoring wells and quarterly groundwater monitoring of these wells;
- Installation of 260 sample reconnaissance borings from which more than 976 groundwater samples were collected and analyzed;
- Installation of 64 soil borings from which more than 215 soil samples were collected and analyzed;
- Installation of 76 reconnaissance borings from which 84 soil gas samples were collected and analyzed;
- Installation of 5 permanent soil gas ports that were sampled and analyzed between four and six times each; and
- Collection of 35 indoor air samples and 16 ambient air samples.

The discussion of the nature and extent of these constituents is presented in terms of three evaluation units, based on different types of current and plausible future land uses in each area:

Area 1 – is the facility;

Area 2 –comprises two properties, the TASCO and the SAD property located immediately hydraulically downgradient of the facility (east of Denver Avenue and north of South Lucile Street); and

Area 3 – comprises mixed used residential/industrial/commercial properties located hydraulically downgradient from the facility (west of Denver Avenue and south of South Lucile Street extending to the Duwamish Waterway).

These three areas are collectively referred to as the RI Study Area. A number of constituents have been detected in soil, groundwater, indoor air, soil gas, and ambient air during the investigations conducted by PSC in the RI Study Area. The remainder of this section summarizes the findings and conclusions of the RI under each of the objectives listed above.

Objective: Characterization of the hydrogeological conditions of the RI Study Area

Data from monitoring well borings, reconnaissance borings, and soil borings have provided information about the hydrogeological characteristics of the RI Study Area. The following five geologic units, listed in order of increasing depth, have been identified from logs of the borings:

- Shallow Sand Unit;
- Intermediate Sand and Silt Unit;
- Silt Unit;

- Deep Sand and Silt Unit; and
- Bedrock.

The upper four units are part of the Duwamish Valley alluvium regional geologic unit.

Five hydrogeologic units have been defined in the RI Study Area. These units are listed below in order of increasing depth:

- Shallow aquifer;
- Intermediate aquifer;
- Silt aquitard;
- Deep aquifer; and
- Basement confining unit.

These units are directly correlated with the local geologic units described above.

The shallow aquifer corresponds to the shallow sand geologic unit, which includes surface fill. This unit is horizontally continuous, having been encountered at all of the borings in the area. The thickness generally increases from the area east of the facility, to the west, ranging between approximately 21 and 46 feet. The shallow aquifer is unconfined.

The intermediate aquifer corresponds to the intermediate sand and silt geologic unit. The intermediate aquifer is horizontally continuous across the RI Study Area, where its thickness varies from approximately 13 feet to 68 feet. This aquifer is bounded above by the shallow aquifer, to which it is hydraulically connected. The contact between the shallow and intermediate aquifers is consistent with the study area subsurface topography, dipping to the west-southwest. The intermediate aquifer is considered semi-confined.

The silt aquitard corresponds to the silt geologic unit. This unit is continuous across Areas 1 and 2 and approximately 1200 feet into Area 3.Where penetrated by the PSC borings, the total thickness of the silt aquitard varied from approximately 14 feet to 50 feet. The depth of its upper surface of the aquitard ranged from approximately 30 to 112 feet bgs. The available data indicate that the upper surface is highest in the area east of the facility footprint and slopes westward. The silt aquitard hydraulically confines the underlying deep aquifer.

The deep aquifer corresponds to the deep sand and silt geologic unit and is located below the silt aquitard. This unit is horizontally continuous throughout the well network in Areas 1 and 2. The depth of the deep aquifer's upper surface varies from approximately 84 feet bgs to over 128 feet bgs. The unit's thickness is greater than 34 feet in some locations. The depth to bedrock appears to increase rapidly with distance west of the facility, to about 330 to 660 feet bgs near the Duwamish Waterway.

The basement confining unit corresponds to the bedrock geologic unit. The upper surface of the bedrock may be weathered and fractured. The base of the weathered zone forms a boundary between the relatively permeable overlying materials (i.e., unconsolidated sediments and weathered bedrock) and the relatively impermeable, underlying, unweathered bedrock. Based on its relatively low permeability and low recharge in the east upland area, the bedrock basement is classified as a confining unit.

Objective: Determination of the highest beneficial use of groundwater consistent with the MTCA regulation

Background groundwater analytical results and current regulations were researched and evaluated to determine the highest beneficial use of groundwater at and near the PSC Georgetown facility. This evaluation resulted in the following findings:

- The shallow aquifer and intermediate aquifer do not meet the definition of potability because the following concentrations of natural background inorganics exceed MCLs: ferric iron, ferrous iron, total iron, total dissolved solids, turbidity, manganese, coliform bacteria, and color. These exceedances are consistent with other background concentrations in the Duwamish area.

- The deep aquifer does not meet the definition of potability because the following concentrations of natural background inorganics exceed MCLs: arsenic, chloride, ferric iron, total iron, manganese, total dissolved solids, turbidity, and color. These exceedances are consistent with other background concentrations in the Duwamish area.

- Before using groundwater from the shallow/intermediate aquifer or the deep aquifer for drinking water, it would need to be treated to reduce concentrations of turbidity, coliform bacteria, iron, manganese, total dissolved solids, and color to meet MCL and public waste supply requirements. Groundwater from the deep aquifer would also need to be treated to reduce arsenic concentrations. The costs required to install and maintain a well and the required water treatment equipment are many times greater than those associated with obtaining water from Seattle Public Utilities. In addition, the quality of the treated groundwater is still likely to be inferior to that available to Seattle Public Utilities customers from the region's multiple surface water and groundwater sources. The cost of treating groundwater from any of the three area aquifers compared with the costs associated with obtaining water from the public utilities renders the use of area groundwater as a source of drinking water not practicable under WAC 173-340-720(2)(ii).

- The evaluation of background groundwater analytical results and current regulations indicates that the highest beneficial use of groundwater at and near the PSC Georgetown facility is not as a source of drinking water. The highest beneficial use of groundwater in the vicinity of the facility is the protection of surface water in the Duwamish Waterway. Consequently, groundwater cleanup levels that are protective of surface water pathways were developed and applied in the RI.

Objective: Characterization of the nature and extent of COCs emanating from the facility

In order to determine the areas where remedies should be evaluated, RME soil and groundwater concentrations were compared to MTCA cleanup levels within the framework of the three-fold MTCA criteria [WAC 173-340-740 (7)(d) and (e), WAC 173-340-720 (9)], which are:

1. The maximum concentration must be less than or equal to two times the cleanup level.
2. The upper one-sided ninety-five percent confidence limit on the true mean concentration must be less than the cleanup level.
3. Less than 10% of the concentrations shall exceed the cleanup level.

The following description of this objective summarizes the results of this evaluation as a method of identifying the nature and extent of contamination. This evaluation resulted in the following findings regarding the nature and extent of COC-affected media in the RI Study Area:

- The COCs for soil as identified by comparison of soil data to the three-fold MTCA criteria are PCB Aroclor 1016/1242, tetrachloroethene, and trichloroethene. These COCs will be evaluated further in the FS. COCs in soil are limited to the facility property and may potentially leach to groundwater. Most of the soil samples were collected before the SVE system was installed so it is likely that the SVE has reduced VOC concentrations further, possibly below cleanup levels.

- Groundwater chemical data from the water table sample interval throughout the RI Study Area indicate that VOC concentrations exceed cleanup levels protective of indoor air at some locations. The groundwater COCs based on protection of indoor air were identified using the three-fold MTCA criteria and include 1,2-dichloroethane, benzene, chloroform, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, tetrachloroethene, trichloroethene, toluene, vinyl chloride, xylenes, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, C8-C10 Aliphatics (EPH), and C8-C10 Aromatics (VPH).[1]

- The groundwater COCs based on the protection of surface water were identified using the three-fold MTCA criteria and include: arsenic, PCB Aroclor 1016, manganese, ethylbenzene, trichloroethene, and vinyl chloride.[2] However, none of these COCs have reached the groundwater-to-surface-water interface as the PSC plume ends approximately 3000 feet east of the Duwamish Waterway.

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[1] These COCs are not pertinent to the entire RI Study Area, there are only five COCs for Area 3. See Section 12 for more details.

[2] Modeling did not predict that ethylbenzene, manganese, trichloroethene, and vinyl chloride would reach the Duwamish Waterway.

- The COC concentrations in groundwater detected at the facility, and property immediately to the west and northwest of the facility, exceed MTCA cleanup levels and indicate that DNAPL may be present.

- COCs in groundwater from the facility have migrated past the property boundary. COC concentrations in groundwater migrating downgradient from the Area 1 and Area 2 diminish to below cleanup levels by approximately South Brandon Street to the north, between South Maynard Street and Fifth Avenue South to the west and between South Lucile Street and South Findlay Street to the south. This area is referred to generally as the PSC plume area.

- PSC identified at least eleven other groundwater plumes upgradient, crossgradient, and downgradient of the facility. These other plumes were identified based on the distribution of groundwater COCs and geochemical parameters and are associated with sources unrelated to the facility. A number of businesses in the RI Study Area use or have used constituents identified as COCs in this RI.

- Empirical data and modeling of groundwater data proximate to the Duwamish Waterway[3] indicate that TCE and vinyl chloride exceed cleanup levels based on protection of surface water. However, these exceedances were limited to groundwater data collected near reconnaissance boring Q32, which is associated with a non-PSC related source of contamination in the area.

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[3] Modeling via the Current Alternate Case.

Objective: Assessment of the fate and transport mechanisms for COCs throughout the RI Study Area

Modeling and monitoring were conducted to assess the fate and transport of COCs. An evaluation of the modeling and monitoring results produced the following conclusions:

- A natural attenuation assessment demonstrates that the non-destructive processes of dispersion and dilution are occurring in all areas.

- Changes in geochemistry within the areas of elevated petroleum hydrocarbon concentrations along with a decreasing concentration along flow lines and limited extent of petroleum-related hydrocarbons and BTEX compounds in the water table, shallow, and intermediate sample intervals indicate that biodegradation of petroleum related hydrocarbons is occurring.

- The distribution of chlorinated constituents, their biodegradation products, and groundwater geochemical parameters indicate that biodegradation of chlorinated ethenes, ethanes, and methanes is likely occurring in the water table, shallow, and intermediate sample intervals in Areas 1, 2, and 3. In addition, the presence of ethene and ethane in areas of reducing conditions indicates that complete reductive dechlorination is occurring.

- The distribution of ethene and ethane in the water table and shallow sample intervals suggests that the northern portion of the chlorinated ethene groundwater plume emanating from Areas 1 and 2 may be shrinking due to biodegradation. The distribution of ethane detected in the intermediate sample interval indicates that complete reductive dechlorination has occurred by the time the plume has reached approximately 6th Avenue

South. Biodegradation appears to be limiting the extent of chlorinated hydrocarbons in the shallow and intermediate aquifers.

- The presence of halogen-respiring microorganisms in groundwater collected from the water table sample interval of the shallow aquifer and the intermediate aquifer was documented using gene-probe assays. The results of these assays provide data in support of the presence of biota capable of driving the reductive dechlorination process.

- Conditions exist for continued biodegradation of COCs in Areas 1, 2, and 3.

- The distribution of metals concentrations detected in groundwater in the RI Study Area indicate that the source of most of these metals are likely associated with background conditions, rather than a release from the PSC property. The mobility of several of the metals identified as COCs in groundwater appears to be controlled by groundwater geochemical conditions because several of these metals, including arsenic and nickel, are present in more water soluble species under strongly reducing conditions. While reducing conditions are present in all of the identified sampling intervals, the strongest reducing conditions appear to be present in Areas 1 and 2 and in the eastern most part of Area 3. Any metals mobilized as a result of these strong reducing conditions are likely to precipitate from groundwater as they migrate downgradient and before they reach the Duwamish Waterway. In addition, while enhanced in some areas by biodegradation, the reducing conditions in the RI Study Area appear to be a result of natural conditions.

- Predictive groundwater modeling was performed for COC concentrations detected within the PSC plume area, but outside the footprint of the subsurface barrier wall. The results of the modeling and fate and transport evaluation indicated some of the COCs (arsenic and Aroclor 1016) within the PSC plume could potentially reach the groundwater-to-surface-water interface at the Duwamish Waterway at concentrations exceeding cleanup levels based on the protection of surface water. However, groundwater concentrations indicate that Aroclor 1016 has not migrated from the facility and that arsenic concentrations are related to natural background concentrations.

- Predictive groundwater modeling was conducted for several non-PSC sources located between the PSC facility and First Avenue South. The results of the modeling indicate that no COCs associated with these source areas are likely to reach the groundwater-to-surface-water interface at concentrations that exceed applicable cleanup levels.

Objective: Completion of quantitative human health and ecological risk assessments that assess current and future exposure pathways

The human health risk assessment (HHRA) evaluated exposures to the following receptors:

- Industrial/Commercial workers;
- Trench workers;
- Residents; and
- Fishermen.

Based on the results of the HHRA, excess cancer risks associated with exposure to COCs were greater than MTCA regulatory benchmarks of a cumulative cancer risk of 1E-05 and a non-cancer hazard index of 1. The primary exposure pathways of concern considered relevant for the HHRA were:

- Direct contact with soil (Area 1 only);

- Inhalation of vapors in indoor air from soil (Area 1 and Area 2 only); and

- Inhalation of vapors in indoor air from groundwater (Areas 1, 2, and 3).

The COCs for soil and groundwater were benzene, TCE, and vinyl chloride.

The ecological risk assessment (ERA) evaluated terrestrial and aquatic receptors. The results of the ERA indicated that a terrestrial ecological risk assessment is not required for the site because there is no suitable habitat (WAC 173-340-7491). The results of the evaluation of aquatic receptors indicated that is unlikely that there are deleterious effects associated with COCs in groundwater. This was based on a comparison of modeled surface water concentrations with aquatic screening levels.

13.2 *Identification of Data Gaps*

PSC has identified the following data gaps and follow-up actions relating to the RI.

- COCs in the lower portion of the intermediate sampling interval emanating from the northern portion of Area 2 have not been characterized thoroughly. PSC will propose new monitoring wells, downgradient of the barrier wall, to monitor the effectiveness of the HCIM barrier wall at depth. This data gap will be addressed in the long term monitoring plan for the HCIM.

- PSC cannot verify the source of the vinyl chloride present in shallow groundwater at reconnaissance boring J7b. Although this is a data gap, it is not critical data for completion of either the RI or the FS. Reconnaissance borings around the J7 area demonstrate that the horizontal and vertical nature and extent (downgradient via groundwater) of the COCs, including vinyl chloride, in groundwater have been adequately characterized.

- Data gaps may arise after the barrier wall is completed. Local groundwater flow patterns in the vicinity of the wall will change as a result of the barrier wall; however, the regional groundwater flow patterns will not change. Therefore, PSC will need to monitor the groundwater to assess how the barrier wall will affect local groundwater flow patterns, chemical transport, and natural attenuation. This will be addressed by the long-term monitoring plan for the HCIM.

- Sources of contamination have not been identified for all of the non-PSC plumes. At the request of Ecology, considerable effort has been made by PSC to characterize these areas, especially in the water table sample interval, for the purpose of evaluating risks for the inhalation pathway. However, without access to private properties it may not be possible to determine the source of these plumes. PSC does not believe this is a data gap that needs to be addressed for the RI, or by PSC.

13.3 *Summary and Path Forward*

PSC has completed the Final Comprehensive Remedial Investigation Report, the Human Health and Ecological Risk Assessment, the revised Public Participation Plan and the Feasibility Study Scope of Work Technical Memorandum in accordance with permit requirement VII.A.4 and MTCA (WAC 173-340-750).

Upon approval of these documents by Ecology, PSC will prepare the Draft Feasibility Study, based on the PRAOs identified in this report. These PRAOs are currently being addressed by the ongoing interim measures, as summarized below. However, analysis in the feasibility study is still required to determine whether additional actions will be necessary.

PRAO 1 – Prevent direct contact with surface or subsurface soils and inhalation of dusts from surface soils with COCs that exceed cleanup levels in Area 1.

Summary of Conditions Related to PRAO 1 – COCs in soil are limited to the vadose zone within the facility property. The COCs for soil based on the three-fold MTCA criteria are Aroclor 1016/ 1242, tetrachloroethene, and trichloroethene. COCs in soil may potentially leach to groundwater via infiltration of precipitation. PSC has operated an SVE system in the north field of the facility since 1994, which has removed over 19,000 pounds of VOCs from the subsurface. The facility property is completely covered with a concrete cap, which prevents direct contact with soil and also prevents leaching of COCs from soil to groundwater. PSC plans on maintaining this concrete cap, or a similar protective barrier, as part of the overall remedy for the facility. In addition, a subsurface barrier wall, which is currently under construction as part of the HCIM and is scheduled for completion by the end of 2003, will enclose all affected soil and the highest concentrations of COCs in groundwater on the facility and neighboring properties. The barrier wall, combined with a groundwater withdrawal system to induce an inward groundwater gradient, will prevent further migration of groundwater impacted by COCs from the facility.

PRAO 2 – Reduce risks associated with exposure to vapors from affected soil or groundwater to acceptable levels established in accordance with MTCA regulations.

Summary of Conditions Related to PRAO 2 – Groundwater at the water table sample interval throughout the RI Study Area indicates that VOC concentrations exceed cleanup levels protective of indoor air at some locations. However, this pathway is currently being addressed by implementation of IPIMs in buildings above groundwater where VOC concentrations exceed these cleanup levels. In addition, PSC has either purchased or obtained easements to much of the property that contains the highest concentrations of TCE and other COCs including those areas where DNAPL is likely present, and PSC is installing an HCIM in the form of a subsurface barrier wall around that property. Therefore, by the end of 2003, the majority of the impacted groundwater, soil, and potential DNAPL will be contained within this barrier wall, which will prohibit future migration of COCs from the facility.

PRAO 3 - Protect human and ecological receptors by reducing COC concentrations in affected groundwater to cleanup levels based on protection of surface water to ensure continued protection of surface water in the future.

Summary of Conditions Related to PRAO 3 - Impacted groundwater emanating from the facility does not currently reach the surface water. In order to prevent impacted groundwater from migrating toward surface water, PSC is installing the HCIM around the areas where soil and groundwater is severely impacted.

The Draft Feasibility Study will address the progress on meeting these PRAOs, and identify any requirements for additional action. The Draft Feasibility Study is due within 60 days of Ecology's approval of the RI. In the meantime, PSC will continue implementing its three interim measures, the SVE system, the IPIMs, and the HCIM to protect human health and the environment.