HARTCROWSER

Earth and Environmental Technologies

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J-4422-02

December 12, 1995

Mr. Mike Gallagher
Washington State Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

RE: Proposed Cleanup Action
Former Tux Shop Site
5409 15th Avenue Northwest
Seattle, Washington

Dear Mike:

On behalf of our client, The Tux Shops, we are submitting this letter requesting your thoughts regarding planned cleanup actions at the former Tux Shop facility located in the Ballard area of Seattle. This independent cleanup action has been initiated by The Tux Shops and the FN&F Investment Company. At this time, our client has not decided whether it will seek a No Further Action (NFA) Letter under the Independent Remedial Action Program (IRAP).

Your willingness in the past to provide technical input on independent cleanup actions has been extremely helpful. We are asking that you take a few minutes to review this information and provide your opinion as to whether this is consistent with the MTCA. If you have concerns regarding our plans, we will consider them before implementing the Cleanup Action Plan (CAP). We have found this informal comment process very useful and feel it provides for a better independent cleanup action with a minimum amount of agency effort.

PURPOSE AND OVERVIEW

Issues related to groundwater contamination from the Tux Shop facility came to light in 1990 during groundwater investigations being conducted at the adjacent Unocal facility. At that time Unocal notified The Tux Shops and Ecology (Mr. Joe Hickey) that groundwater under the Unocal site contained elevated concentrations of tetrachloroethene (PCE). Mr. Hickey also met at the site with Mr. Martin Nudelman, of The Tux Shops. Since the initial notification to Ecology, The Tux Shops has voluntarily investigated site conditions, screened feasible cleanup alternatives, conducted pilot tests, and developed a CAP.

The site is in the process of being leased to Walgreens for construction of a retail drug store. These redevelopment activities will coincide with implementation of the CAP. This is consistent with our understanding of the State Legislature's intent when they revised the MTCA statute last year to encourage "brownfield" development. We have advised our client to submit investigation and remediation information to Ecology to keep you informed and to take advantage of agency input prior to initiating an expensive cleanup action at the site. Primary considerations are to reduce the potential for construction delays when redevelopment activities start in the early spring and to reduce the likelihood of additional agency requirements after the building is constructed.

To facilitate your review, we have summarized in this letter results of the investigation and feasibility study. We also provide a summary remedial design for the CAP. We have pulled together key information in a concise, visual format to make your review easier. Detailed documentation of this work will be submitted to Ecology at the completion of the cleanup action, as required by the MTCA.

The **SITE CHARACTERIZATION** section presents summaries of the site history, investigation activities, chemicals of concern, nature and extent of affected media, and potential migration and exposure pathways; in the **REMEDIAL STRATEGY** section we present summaries of our feasibility study, on-site pilot test, remediation approach, implementation schedule, and post-implementation monitoring; and closing remarks and the limitations of our work are presented in the **SUMMARY** and **LIMITATIONS** sections, respectively. Site data are summarized in Tables 1 through 7. Figures 1 through 7 present visual representations of site information and CAP design. Attachment A presents boring logs for site explorations.

SUMMARY OF SITE CHARACTERIZATION DATA

Site Description

The Tux Shop site is located on the corner of Northwest Market Street and 15th Avenue NW in the Ballard section of Seattle, Washington. The property is bounded on three sides by public streets and to the west by a Seattle Fire Department station. Properties surrounding the Tux Shop site are generally used for commercial purposes with some residential properties located to the southwest of the site along NW 54th Street (Figure 1). The eastern portion of the site formerly contained a Unocal service station, which was decommissioned in 1993. A dry cleaning facility operated on the western portion of the site from the early 1950s until 1993 when the facility was shut down because of a fire. All of the structures that were formerly present on both portions of the site have been demolished. The eastern portion of the site is currently paved.

Unocal and GeoEngineers initiated a site investigation and cleanup program to address petroleum-containing soils. Approximately 4,400 cubic yards of soil were excavated and removed from the site. Details of the Unocal site characterization and remediation program were documented in several reports submitted to Ecology including the final cleanup report "Report of Environmental Services UST Removal Monitoring, Remediation Excavation Monitoring, and Supplemental Subsurface Exploration, Former Service Station 5479," GeoEngineers, February 3, 1995.

During site characterization activities conducted by Unocal in 1990, tetrachloroethene (PCE) and several other chlorinated solvents were detected in shallow groundwater beneath the property. Unocal notified Ecology and the operators of the dry cleaning facility, The Tux Shops, of the PCE occurrence. The Tux Shops and the FN&F Investment Company initiated a site characterization program to evaluate the source and extent of PCE-containing soils and groundwater. Data generated from these investigations are summarized below.

Chemicals of Concern

Specific documented releases that have contributed to elevated chlorinated solvent concentrations in groundwater have not been identified. The presence of chlorinated solvents at the site appears to be associated primarily with dry cleaning operations that were formerly conducted on the western portion of the property. PCE is the predominant chlorinated solvent detected at the site. PCE had the highest concentrations in both soil

(6.9 mg/kg) and groundwater (100 mg/L) and is likely responsible for the majority of the risk associated with the site. Of the chlorinated solvents detected at the site, only PCE has been detected in both soil and groundwater at concentrations of potential concern relative to MTCA cleanup levels. Therefore, the screening of remedial alternatives was conducted with PCE as the primary chemical of concern.

The highest PCE concentrations in soil and groundwater occur in the vicinity of a sump (sewer drain) located immediately south of the former Tux Shop building (Figure 1). PCE concentrations in soil samples collected in this area are typically below 1 mg/kg with maximum concentrations (up to 6.9 mg/kg) generally occurring at depths of approximately 20 feet below ground surface (Tables 1 and 2). As shown in Table 3, PCE concentrations in site groundwater have ranged from not detected (MW-4A) to 100 mg/L in well KMW-5 formerly located next to the sump area.

PCE concentrations in groundwater decrease from approximately 50 percent of the solubility limit at a depth of 5 feet below the water table to approximately 10 percent of the solubility limit at a depth of 25 feet below the water table, to almost non-detect at the bottom of the aquifer, approximately 75 feet below. No free-phase product has been detected in any of the site wells.

Trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and vinyl chloride (VC) were observed in groundwater at much lower concentrations than PCE (up to 1.1, 0.32, and 0.06 mg/L, respectively) and appear to be biotransformation products resulting from a release of PCE. These constituents were generally not detected in site soils. Two other halogenated volatile compounds were detected at the site at trace concentrations. Methylene chloride was detected in two soil samples at an approximate concentration of 0.04 mg/kg and carbon tetrachloride was detected in two groundwater samples at an approximate concentration of 0.005 mg/L. These compounds are not common biotransformation products of PCE and are often associated with sample handling or laboratory contamination. Methylene chloride and carbon tetrachloride are not of concern with respect to remediation at the site, because of their low concentrations which pose a very low percentage of the overall site risk. Regardless, the planned CAP for the site should effectively remove these two trace chlorinated solvents.

Source Areas

Based on the observed distribution of PCE in site soil and groundwater as well as the results of headspace organic vapor screening performed on site borings and test pits (see

Attachment A), the primary source of PCE appears to be related to a former sump located immediately south of the main Tux Shop building (Figures 1 and 2). However, no historical records exist regarding the discharge of solvents into the sump. A secondary source area may have been the central driveway for the former facility, which may reflect spillage of solvents during transfer operations. No records exist documenting a spill along the central driveway but organic vapors and asphalt deterioration were observed in the area by Hart Crowser field representatives.

Soil quality data indicate that the soils above the water table (from 0 to 15 feet deep) contain relatively low concentrations of PCE relative to the MTCA soil cleanup level (0.5 mg/kg). Furthermore, PCE in the form of pooled free product or dense nonaqueous-phase liquid (DNAPL) has not been observed at the site, including in a well installed at the bottom of the aquifer. Therefore, it appears that a discrete DNAPL source area is not present at the site and a DNAPL source removal action is not necessary as a remedial alternative.

Migration and Exposure Pathways

Site characterization data indicate that pooled DNAPL is not present at the site but that residual DNAPL, present as non-continuous droplets or ganglia, is probably present in the upper 15-foot groundwater zone (15 to 30 feet below ground surface). The presence of residual DNAPL in the subsurface could continue to leach PCE to site groundwater and will be addressed by the proposed remedial action for the site.

The current pathways of contaminant migration are volatilization to the atmosphere and advection in the groundwater. The relatively low soil PCE concentrations and the lack of free-phased product in the vadose zone will limit volatilization from soils, and volatilization of PCE from groundwater is expected to be relatively low because of mass transfer limitations. Nevertheless, the potential exists for PCE vapor concentrations to exceed permissible limits in future developments on site, especially in subsurface structures. Vapor control will also be addressed by the remedial action to be implemented.

Groundwater flow at the site is generally southeast toward the former Unocal portion of the site. Groundwater appears to move very slowly within the very dense, till-like material that comprises the shallow aquifer. The groundwater flow rate was estimated at 0.02 to 0.04 feet per day based on a permeability of 10^{-4} cm/sec (estimated from a water level recovery test and soil characteristics). Many of the wells pump dry during sampling. The presence of PCE and PCE biotransformation products in the monitoring wells located downgradient of the former sump area indicate that some contaminant migration through advection in the groundwater has occurred. However, migration of PCE from the source area is likely to be limited based on the low groundwater flow rate and the lack of an on-going source to soil.

REMEDIAL STRATEGY

Screening of Remedial Alternatives

Based on the available site characterization data, an evaluation of remedial alternatives was conducted for the former Tux Shop property in Ballard. The primary purpose of the evaluation was to identify and compare the most applicable remedial alternatives for the site based on demonstrated effectiveness, technical implementability, and cost.

Based on the screening process, the remedial technologies retained for further consideration were developed into the following remedial alternatives for the site:

- Alternative 1—Capping/Passive Venting/Institutional Controls;
- Alternative 2—Capping/Passive Venting/Hydraulic Containment with On-Site Treatment of Groundwater; and
- Alternative 3—*In Situ* Treatment with Soil Vapor Extraction and Groundwater Air Sparging.

Alternative 3 would treat and ultimately reduce PCE concentrations at the site, resulting in the shortest duration of cleanup, lowest long-term liability, and greatest regulatory acceptance of the three alternatives. Alternative 2 would merely contain the contaminated groundwater plume without taking active measures to reduce the amount of contamination on site. Alternative 1 is the least protective of the alternatives evaluated, as it would only provide a safeguard against contaminant vapors without adequately containing or reducing the amount of contamination on site.

Although Alternative 3 had the highest estimated cost of the three alternatives, the evaluation of remedial alternatives indicated that *in situ* treatment of groundwater using air sparging would be the most effective method to cleanup the site. To capture contaminant vapors stripped from the groundwater through air sparging and to remove residual volatile organics in the vadose zone soil, the system would be installed in conjunction with a soil vapor extraction system. A pilot study was recommended to evaluate potential effectiveness and provide a basis of design prior to implementation of a full-scale system.

Pilot Study Approach

The Air Sparging Pilot Study was conducted to meet the following objectives:

- Determine the effective "treatment zone" of an *in situ* air sparging (IAS) well;
- Evaluate the effectiveness of a soil vapor extraction (SVE) vent in capturing the injected air;
- Estimate the concentration and mass of tetrachloroethene (PCE) in the extracted soil vapor; and
- Estimate the removal rate of PCE from the saturated zone.

Test wells and monitoring points for the Air Sparging Pilot Test were installed under Hart Crowser's direction on October 9, 10, and 11, 1995. The pilot test layout is shown on Figure 3. The generalized cross section for the test layout is shown on Figure 4.

The test was conducted using one air sparging test well (AS-1), one vapor extraction test well (VE-1), three groundwater monitoring points (GM-1 through GM-3), one existing groundwater monitoring well (HC-1W) and three vapor monitoring points (VM-1 through VM-3).

Field testing for the Air Sparging Pilot Study was conducted by Hart Crowser on October 16, 17, and 18, 1995. The scope of the field test consisted of the following tasks:

- Equipment mobilization and test setup;
- Baseline monitoring;
- Conduct 2-hour SVE test;
- Conduct 24-hour IAS/SVE test; and
- Conduct post-test groundwater sampling.

During the SVE and the IAS/SVE tests, the vapor extraction system was operated at a vacuum of 60 inches of water, and an average flow rate of about 6 scfm. During the IAS/SVE test, the air sparging system was operated at a pressure of approximately 13 psi, with a flow rate of approximately 0.5 scfm.

Helium was introduced into the air sparging well as a tracer gas, to help evaluate the effectiveness of the vapor extraction well in capturing sparged air.

Samples were labeled to indicate the time during the pilot test at which they were collected. These are described as follows:

- T0 - Time zero, pre-test baseline samples collected;
- T4 - Four hours into test, during sparging, soil vapor samples collected;
- T24 - Twenty-four hours into test, soil vapor samples collected before sparging is shut down;
- T26 - Immediately after sparging was shut down, post-sparging groundwater samples collected and field parameters measured; and
- T100 - Five days after test, post-test groundwater samples collected, and field parameters measured.

Pilot Study Results

Based on the pilot test results, it appears that air sparging would be effective at transferring PCE into the vapor phase and that vapor extraction would be effective in capturing the transferred vapors. Parameters monitored for air sparging effectiveness included groundwater elevation, dissolved oxygen, and dissolved PCE.

- **Groundwater elevation** was monitored with transducers in conjunction with interface probes. As shown on Figure 5, there was a substantial increase in groundwater elevation observed up to a distance of 17 feet from the sparging well AS-1 and probably beyond.
- **Dissolved oxygen** was increased up to 17 feet away from the sparging well (Table 4).

- **PCE in groundwater** (Table 5) was reduced in the sparging well (AS-1) by about an order of magnitude. There was also a significant reduction in PCE concentrations in HC-1W and GM-3. These wells are 15 and 17 feet away from the sparging well, respectively. PCE concentrations in wells GM-1 and GM-2 were essentially unchanged. One possible explanation for the unchanged concentrations in GM-1 and GM-2 is that additional mass may have dissolved from residual PCE that may have been adsorbed to the soil. Over a longer period of operation a decline in PCE concentrations would be expected.

Parameters monitored for vapor extraction included vacuum, oxygen, vapor-phase PCE, and helium.

- **Vacuum** was monitored in the vapor extraction well (VE-1), and in VM-1, VM-2, and VM-3. The vacuum data indicate significant influence up to about 20 feet from the extraction well VE-1 (Figure 6).

- **Oxygen** data indicate the vapor extraction system was drawing atmospheric air through the subsurface into the vapor monitoring wells, thereby increasing the oxygen concentrations.

- **Vapor phase PCE** increased dramatically in VM-3, approximately 5 feet away from the sparging well AS-1, during air sparging (Table 6).

- **Helium** data at the vapor extraction well (VE-1) indicate capture of the sparged air.

Remedial Approach

A conceptual design of a full-scale air sparging/vapor extraction system was developed based on the results of the pilot test. The full-scale system would consist of two subsystems: (1) a source area sparging/extraction system to address elevated concentrations of PCE (greater than 1 mg/L) present in the area of the former sump, and (2) an optional downgradient sparging/extraction system to address lower concentrations of PCE (greater than 0.005 mg/L) at the downgradient boundary of the site. The sparging/extraction system, and the associated piping, air supply, and vapor control and treatment equipment, would be installed in coordination with the planned construction and operation of Walgreens drug store at the site.

Conceptual design criteria are presented in Table 7 and a conceptual plan and profile are shown on Figure 7.

The source area sparging/extraction system would include:

- Fifteen air sparging wells located on 20-foot centers injecting air 20 feet below the water table at rates of 0.5 scfm.
- Four horizontal vapor extraction vents located on 30-foot centers extracting air from a 1-foot-deep sand capture layer below the floor slab of the proposed drug store.
- Eight vertical vapor capture/extraction vents located on 40-foot centers capturing and extracting vapors from around the perimeter of the source area sparging area.

The downgradient sparging/extraction system would include:

- Fifteen air sparging wells located on 5-foot centers injecting air 20 feet below the water table at rates of 1 scfm.
- One horizontal vapor extraction vent located directly above the downgradient sparging vents within a 80-foot-long, 3-foot-deep sand extraction trench along the east boundary of the site.

The air supply and vapor control and treatment equipment would include:

- One air supply blower to supply 25 scfm at 10 to 15 psig.
- One vapor extraction blower to extract 140 scfm at 60 to 80 inches of water column.
- One catalytic oxidizer (CATOX) rated at 140 scfm to destroy PCE vapors prior to discharge of the off-gas to the atmosphere.

Preliminary Implementation Schedule

Assuming reasonable review periods and permitting requirements, the preliminary implementation schedule is as follows:

Schedule Milestone	Date
Complete Remedial Design	April 1, 1996
Complete Permitting	May 1, 1996
Begin Construction	June 1, 1996
Complete Construction	Sept. 1, 1996
Complete Startup	Oct. 1, 1996

POST-IMPLEMENTATION MONITORING

Post-implementation monitoring will be conducted to document system performance and regulatory compliance. The following monitoring activities will be conducted:

- Weekly monitoring of process variables including flow rates, pressures, and organic vapor concentration in perimeter monitoring wells and the extracted soil gas.
- Monthly monitoring of water table elevations and PCE concentration in the extracted soil gas.
- Quarterly sampling and analysis of groundwater from perimeter monitoring wells.

SUMMARY

The preferred alternative will effectively treat contaminated groundwater, based on the results of the pilot test. It has an added advantage of treating any residual petroleum constituents in groundwater resulting from the former Unocal site (now owned by The Tux Shops). This alternative is also a preferred alternative under the MTCA (i.e., removal and destruction). As an added benefit, it allows an otherwise vacant site to be put back into productive use. Ongoing monitoring will document the effectiveness of the cleanup action to ensure protection of human health and the environment.

We will call you during the week before Christmas to discuss your opinions regarding our plans. A meeting could also be arranged, if you desire. We understand that your opinions are in no way binding and do not represent a settlement under the MTCA.

We look forward to your favorable consideration of our request. If you have any questions, please call.

Sincerely,

HART CROWSER, INC.

BARRY L. KELLEMS, P.E.
Associate

WILLIAM B. ABERCROMBIE
Senior Associate

BLK/WBA:sde
TUXSHOP.lr

Attachments:

Table 1 - Soil Quality Data Collected from Well HC-1D
Table 2 - Soil Quality Data Collected During Previous Investigations
Table 3 - Groundwater Quality Data Collected during Previous Investigations
Table 4 - Groundwater Field Data Collected During Field Test
Table 5 - Groundwater Analytical Laboratory Field Data Collected During Pilot Test
Table 6 - Soil Vapor Analytical Laboratory Data Collected During Pilot Test
Table 7 - Conceptual Design Criteria
Figure 1 - Site Plan
Figure 2 - Test Pit Location Plan
Figure 3 - Pilot Test Layout
Figure 4 - Pilot Test Conceptual Cross Section
Figure 5 - Hydrographs for Sparging Monitoring Points
Figure 6 - Plot of Soil Vapor Extraction Steady State Vacuum Data
Figure 7 - Conceptual Layout of Air Sparging/Soil Vapor Extraction System
Attachment A - Boring and Test Pit Logs

Table 1 - Soil Quality Data Collected from Well HC-1D

Sample Number	Depth Interval in Feet	PCE Concentration in mg/kg (ppm)
S-1	10 to 11.5	1.2
S-2	20 to 21.5	6.9
S-3	30 to 31.5	0.48
S-4	40 to 41.5	ND
S-5	45 to 46.5	0.045 J
S-6	50 to 51.5	ND
S-7	55 to 56.5	ND
S-8	60 to 61.5	ND
S-9	65 to 66.5	ND
S-10	70 to 71.5	ND
S-11	75 to 76.5	ND
S-12	80 to 81.5	ND
S-13	85 to 86.5	ND
S-14	90 to 91.5	0.088
S-15	92 to 95(a)	ND

Notes:

Tetrachloroethylene was the only halogenated volatile compound detected in Well HC-1D soil samples.

ND Not detected at a detection limit of 0.050 mg/kg.
J Estimated value.
(a) Sample collected from soil cuttings.

Table 2 - Soil Quality Data Collected during Previous Investigations

Sample ID	Sample Date	Depth in ft	Concentration in mg/kg (ppm) PCE	TCE	1,2-DCE	MeCl
MW-Tux-1 (3.5)	Feb-91	3.5 - 5	ND	ND	ND	ND
MW-Tux-1 (13.5)	Feb-91	13.5 - 13.9	ND	ND	ND	ND
MW-Tux-2 (5.5)	Feb-91	5.5 - 6.5	ND	ND	ND	ND
MW-Tux-2 (11)	Feb-91	11 - 11.6	ND	ND	ND	ND
MW-Tux-3 (8.5)	Feb-91	8.5 - 10	ND	ND	ND	ND
MW-Tux-3 (11)	Feb-91	11 - 11.8	ND	ND	ND	ND
KMW-01 (02-A)	Feb-94	5 - 6.5	0.037	ND	ND	ND
KMW-01 (02-B)	Feb-94	10 - 11.5	0.028	ND	ND	ND
KMW-02 (03-B)	Feb-94	10 - 11.5	ND	ND	ND	ND
KMW-03 (04-A)	Feb-94	5 - 6.5	0.36	ND	ND	ND
KSB-02 (05-A)	Feb-94	5 - 6.5	1.5	ND	ND	ND
KMW-04 (06-B)	Feb-94	10 - 11.5	0.25	ND	ND	ND
KMW-05 (07-A)	Feb-94	5 - 6.5	0.8	ND	ND	0.037
KMW-05 (07-B)	Feb-94	10 - 11.5	0.32	ND	ND	0.038
HC-1/S-6	Dec-94	18.5 - 20	0.71	ND	ND	ND
HC-1/S-12	Dec-94	27.5 - 28.5	0.23	ND	ND	ND
HC-1/S-16	Dec-94	33.5 - 34.5	ND	ND	ND	ND
HC-1/S-20	Dec-94	39.5 - 40	0.085	ND	ND	ND
HC-2/S-4	Dec-94	14.5 - 16	0.59	ND	ND	ND
HC-2/S-8	Dec-94	24.5 - 26	0.19	ND	ND	ND
HC-2/S-11	Dec-94	32 - 32.5	ND	ND	ND	ND

Notes:
Samples analyzed using EPA Method 8010 - no other purgeable halocarbons detected in site soil samples.
PCE - Tetrachloroethylene
TCE - Trichloroethylene
DCE - Dichloroethylene
MeCl - Methylene Chloride
ND - Not Detected

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Table 3 - Groundwater Quality Data Collected during Previous Investigations

Well ID	Screen Interval in ft.	Sample Date	Concentration in mg/L (ppm) PCE	TCE	1,2-DCE	1,1-DCE	CTet	VC
MW-Tux-1	6.5 - 18	Mar-91	0.0014	ND	ND	ND	ND	ND
		May-91	0.00071	ND	ND	ND	ND	ND
		Sep-94	0.081	ND	ND	ND	ND	ND
MW-Tux-2	8 - 13.5	Mar-91	32	0.052	0.026	ND	ND	ND
		May-91	Dry	Dry	Dry	Dry	Dry	Dry
		Sep-94	Dry	Dry	Dry	Dry	Dry	Dry
MW-Tux-3	6 - 16	Mar-91	17	ND	ND	ND	ND	ND
		May-91	30	ND	ND	ND	ND	ND
		Sep-94	7.6	0.16	ND	ND	ND	ND
KMW-1	10 - 20	Feb-94	1.2	0.01	ND	ND	ND	ND
		Sep-94	1.2	ND	ND	ND	ND	ND
KMW-2	10 - 20	Mar-94	0.69	0.001	ND	ND	ND	ND
		Sep-94	0.31	ND	ND	ND	ND	ND
KMW-3	10 - 20	Mar-94	1.8	0.003	ND	ND	0.005	ND
		Sep-94	13	ND	ND	ND	ND	ND
KMW-4	10 - 20	Mar-94	41	0.028	ND	ND	0.004	ND
		Sep-94	20	ND	ND	ND	ND	ND
KMW-5	10 - 20	Mar-94	62	0.18	ND	ND	ND	ND
		Sep-94	100	1.1	ND	ND	ND	ND
MW-1A	8-18	Sep-94	0.21	0.077	0.15	ND	ND	0.058
MW-2A	8-18	Sep-94	0.88	0.0044	0.016	ND	ND	ND
MW-3A	8-18	Sep-94	0.37	0.079	0.18	ND	ND	ND
MW-4A	8-18	Sep-94	ND	ND	ND	ND	ND	ND
MW-5A	8-18	Sep-94	0.012	0.0047	0.056	ND	ND	ND
HC-1W	38 - 43	Dec-94	21	0.1	0.004	ND	ND	ND
		Jun-95	13	1.0	0.053	0.0034	ND	ND
		Jul-95	20	0.49	ND	ND	ND	ND
HC-1D	86.5 - 91.5	Jul-95	0.034	ND	ND	ND	ND	ND

Notes:

Samples analyzed using EPA Method 8010/8240.
PCE - Tetrachloroethylene
TCE - Trichloroethylene
DCE - Dichloroethylene
CTet - Carbon Tetrachloride
VC - Vinyl Chloride
ND - Not Detected

Table 4 - Groundwater Field Data Collected during Pilot Test

Dissolved Oxygen

Well Location	Depth of Screen Interval in Feet	Dissolved Oxygen in mg/L Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29-31	4.6	10.2	7.3
GM-1	24-25	5.9	10.2	10.0
GM-2	24-25	3.8	11.2	9.2
GM-3	19.5-20.5	5.1	6.0	8.4
HC-1W	38-43	6.0	7.7	2.4

Groundwater Temperatures

Well Location	Depth of Screen Interval in Feet	Groundwater Temperature in °C Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29-31	15.6	15.5	15.7
GM-1	24-25	16.0	17.1	16.2
GM-2	24-25	15.8	17.2	16.2
GM-3	19.5-20.5	16.0	16.5	16.7
HC-1W	38-43	15.3	15.4	15.4

Groundwater pH

Well Location	Depth of Screen Interval in Feet	Groundwater pH Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29-31	7.5	7.4	7.4
GM-1	24-25	7.6	7.1	7.0
GM-2	24-25	7.6	7.0	6.9
GM-3	19.5-20.5	7.5	7.5	6.5
HC-1W	38-43	7.6	7.4	7.8

Groundwater Oxydation Reduction Potential

Well Location	Depth of Screen Interval in Feet	Groundwater ORP in millivolts Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29-31	157	182	178
GM-1	24-25	133	214	224
GM-2	24-25	129	164	193
GM-3	19.5-20.5	129	104	133
HC-1W	38-43	150	131*	86*

* HC-1W run dry, meter readings suspect.

Groundwater Conductivity

Well Location	Depth of Screen Interval in Feet	Groundwater Conductivity in µS Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29-31	0.084	0.068	0.282
GM-1	24-25	0.115	0.077	0.115
GM-2	24-25	0.128	0.445	0.099
GM-3	19.5-20.5	0.612	0.558	0.560
HC-1W	38-43	0.011	0.060	0.036

Table 5 - Groundwater Analytical Laboratory Data Collected during Pilot Test

Well Location	Depth of Screen Interval in Feet	Tetrachloroethene in µg/L		
		Pre-Test (T0)	Post-Sparging (T26)	Post-Test (T100)
AS-1	29 to 31	2,700	451	350
GM-1	24 to 25	3,800	3,850	4,600
GM-2	24 to 25	3,900	3,850	5,000
GM-3	19.5 to 20.5	3,500	1,500	2,700
HC-1W	38 to 43	9,200	7,500	4,200
Duplicate of GM-2		--	3,540	--

Table 6 - Soil Vapor Analytical Laboratory Data Collected during Pilot Test

Well Location	Depth of Screen Interval in Feet	Tetrachloroethene in ppmv		
		Pre-Test (T0)	During Sparging (T4)	End of Sparging (T24)
VE-1	8 to 10	8	2100	1600
VE-1*	8 to 10		2100	
VM-1	9 to 10	740	2.9	15
VM-2	9 to 10	38	320	NA
VM-3	9 to 10	100	5300	6600

*Field duplicate - QA/QC sample.

42202\table5&6.xls

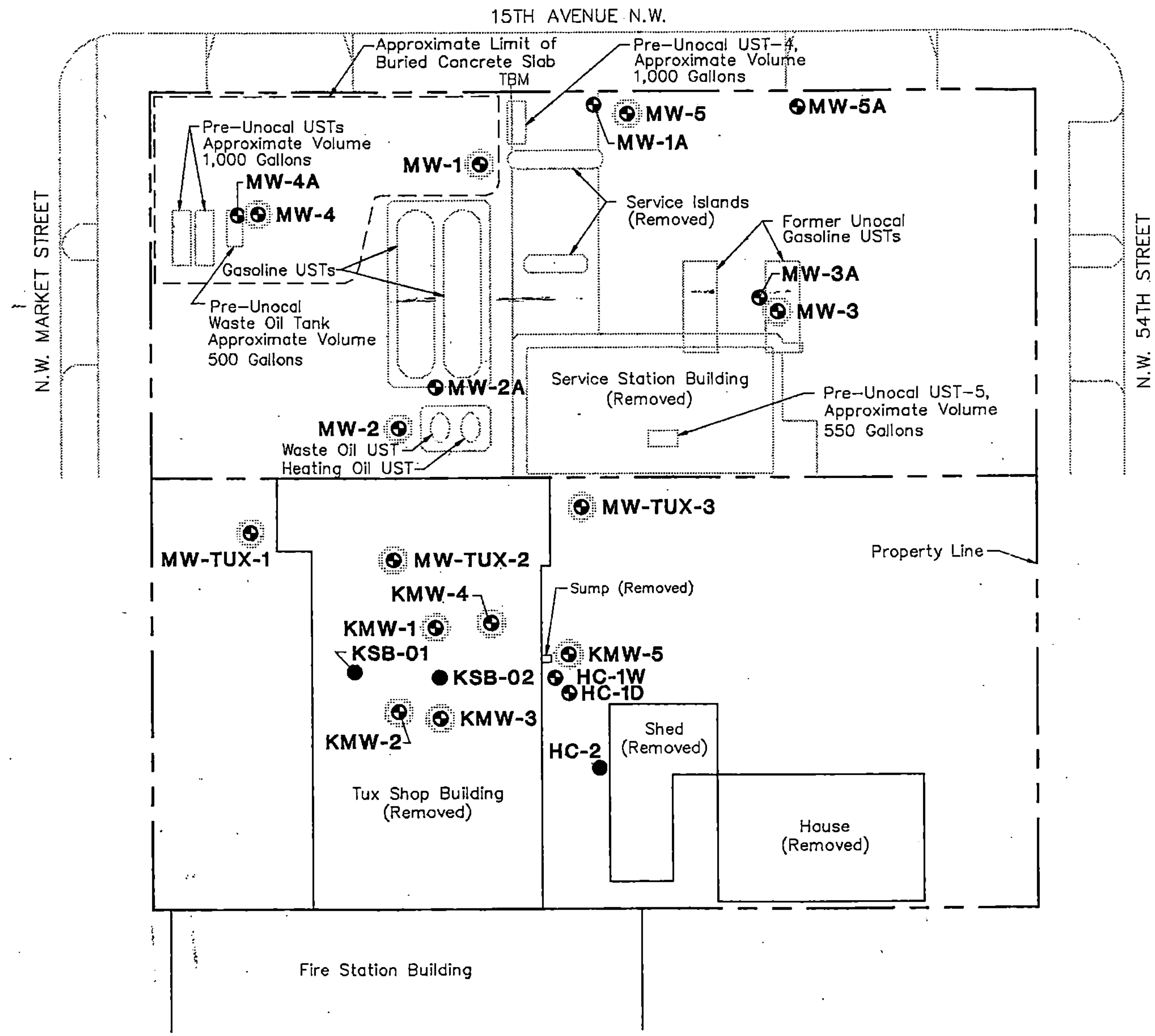
Table 7 - Conceptual Design Criteria

Parameter	Value	Units
Source Area Air Sparge System		
(Veritical sparge wells installed below water table)		
Sparge well spacing	20	feet
Number of vertical wells	15	wells
Depth to water table	15	feet
Depth of well	35	feet
Screen length at bottom of well	5	feet
Well diameter	2	inches
Air flow per well	0.5	scfm
Total sparge air requirement	10	scfm
Well minimum pressure	10	psig
Total length of header pipe	400	feet
Header pipe diameter	3	inch
Well installation method	Hollow-Stem Auger	
Well and header pipe material	PVC	
Source Area/Building Vapor Extraction System		
(Horizontal vents installed in sand layer below building foundation)		
Extraction vent spacing	30	feet
Number of horizontal vents	4	vents
Total length of vent	300	feet
Depth of vent	3	feet
Vent diameter	3	inches
Air flow per vent	10	scfm
Total vapor extraction air requirement	40	scfm
Vent minimum vacuum	10	inches H2O
Thickness of sand layer	1	foot
Area of sand layer	10,000	square feet
Volume of sand layer	370	cubic yards
Total length of header pipe	150	feet
Header pipe diameter	3	inch
Well and header pipe material	PVC	
Source Area/Perimeter Vapor Extraction System		
(Vertical wells/vents installed below water table on edge of source area)		
Extraction vent spacing	40	feet
Number of vertical vents	8	vents
Depth of vent	25	feet
Vent diameter	12	inches
Air flow per vent	5	scfm
Total vapor extraction air requirement	40	scfm
Vent minimum vacuum	10	inches H2O
Total length of header pipe	200	feet
Header pipe diameter	3	inch

Table 7 - Conceptual Design Criteria

Parameter	Value	Units
Well installation method	Hollow-stem auger	
Well packing	8/12 sand	
Header pipe material	PVC	
Downgradient Air Sparge System (Option 1)		
(Vertical sparge wells in cable tool installed sand curtain trench)		
Sparge well spacing	5	feet
Number of vertical wells	15	wells
Depth to water table	15	feet
Depth of well	35	feet
Screen length at bottom of well	10	feet
Well diameter	2	inches
Air flow per well	1	scfm
Total sparge air requirement	15	scfm
Well minimum pressure	5	psig
Total length of header pipe	200	feet
Header pipe diameter	3	inch
Well installation method	Hollow stem auger	
Well packing	8/12 sand	
Header pipe material	PVC	
Downgradient Vapor Extraction System (Option 1).		
(Horizontal vent installed in sand layer at top of sparge trench , option 2a)		
Number of horizontal vents	1	vent
Length of vent	80	feet
Depth of vent	3	feet
Vent diameter	3	inches
Total vapor extraction air requirement	60	scfm
Vent minimum vacuum	10	inches H2O
Thickness of sand layer	3	feet
Volume of sand layer	10	cubic yards
Total length of header pipe	100	feet
Header pipe diameter	3	inch
Well and header pipe material	PVC	
Blower Flow Capacity		
Baseline Air Injection	10	scfm
Baseline Vapor Extraction	80	scfm
Total Air Injection under Baseline plus Option 1	25	scfm
Total Vapor Extraction under Baseline plus Option 1	140	scfm

Site Plan



Notes: 1. Base map prepared from drawing provided by GeoEngineers entitled "Site Plan", dated October 19, 1994.

2. The locations of all features shown are approximate.

3. All aboveground and underground facilities shown on the Site Plan have been removed.

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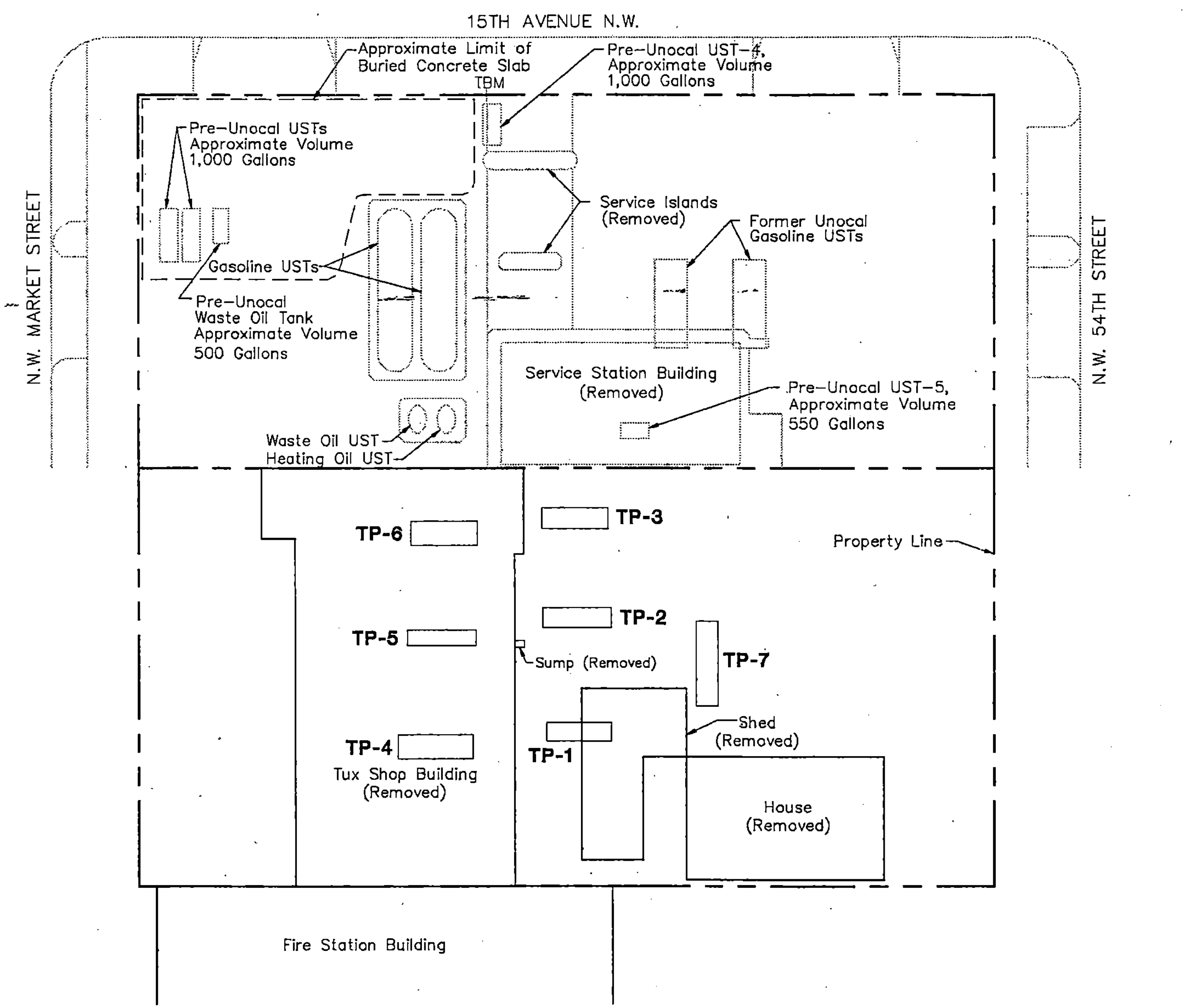
Figure 1

JCH 12/7/95 1=30 HC.pcp
44220203

Test Pit Location Plan



TP-1 Test Pit Location and Number

TBM Temporary Benchmark on N.E. corner of Catch Basin; assumed elevation of 100.00 feet

Notes:
1. Base map prepared from drawing provided by GeoEngineers entitled "Site Plan", dated October 19, 1994.
2. The locations of all features shown are approximate.
3. All aboveground and underground facilities shown on the Site Plan have been removed.
4. Test pits were installed to observe the physical nature of subsurface soils. No soil samples from the test pits were submitted for chemical analysis.

N

0 30 60
Scale in Feet

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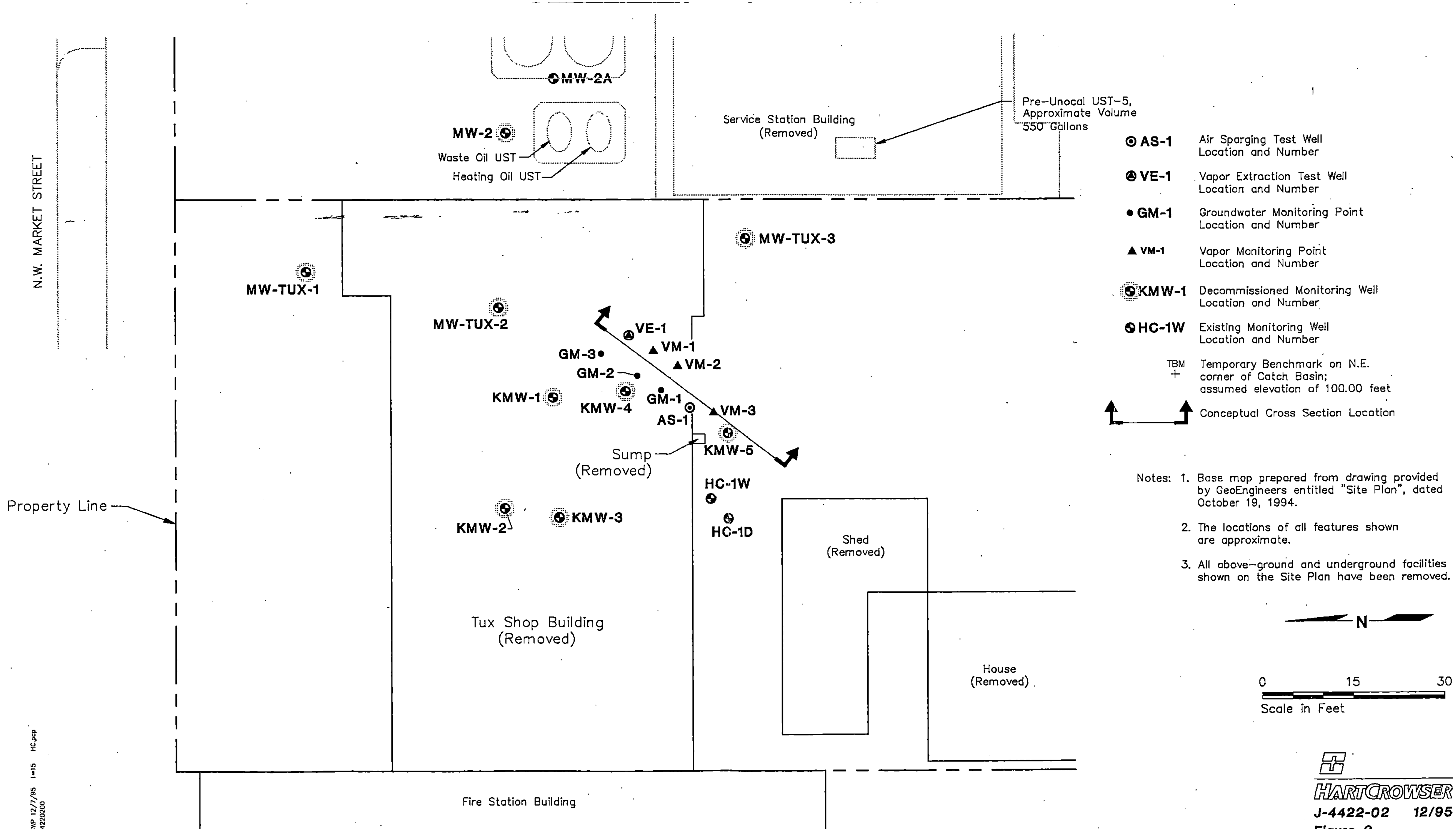
Figure 2

JCH 12/7/95 1=30 HC.pcp
44220204

Pilot Test Layout



Notes:
1. Base map prepared from drawing provided by GeoEngineers entitled "Site Plan", dated October 19, 1994.
2. The locations of all features shown are approximate.
3. All above-ground and underground facilities shown on the Site Plan have been removed.

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Figure 3

JCH 12/7/95 1=5 HC.pcp
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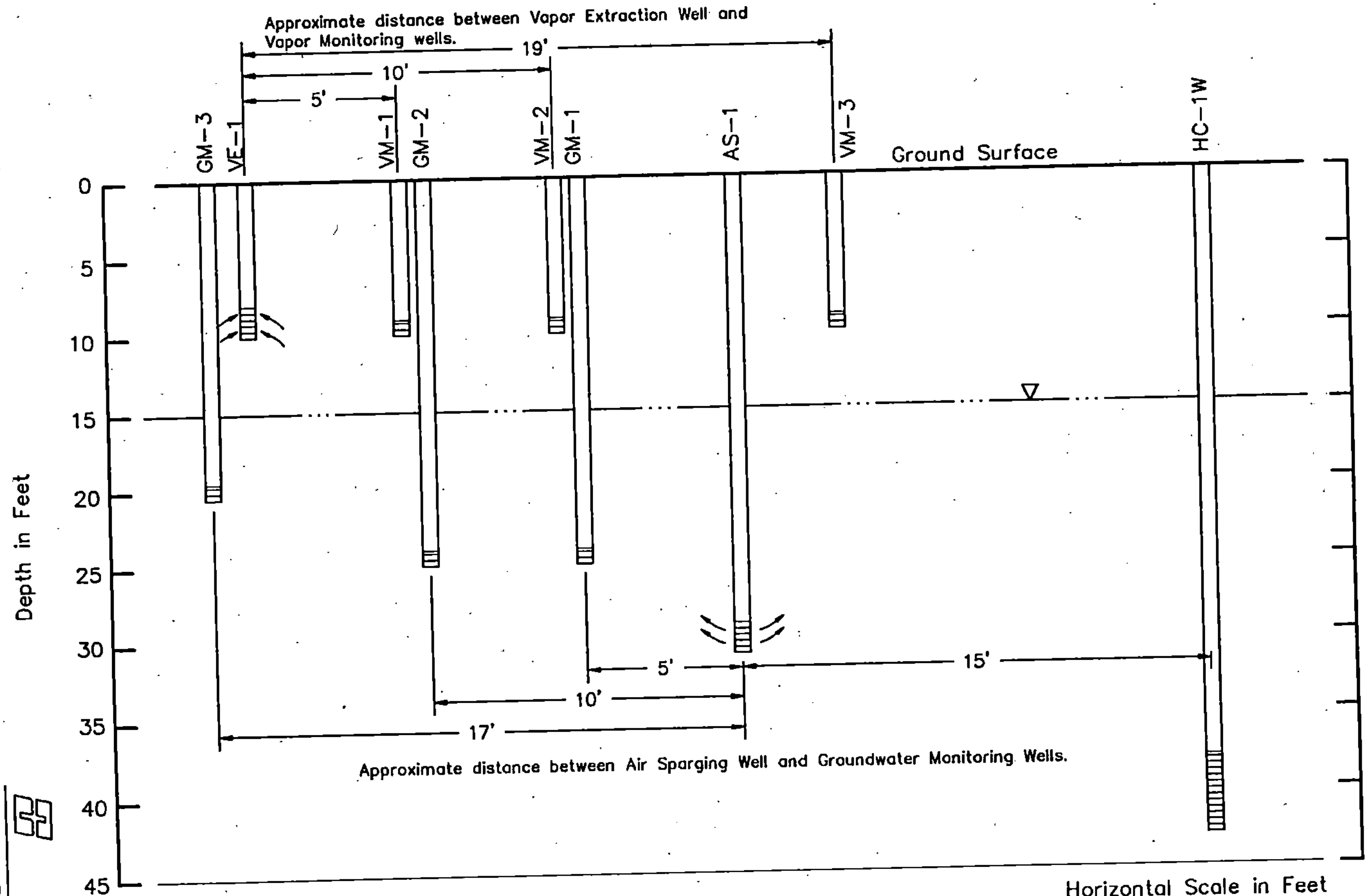
Pilot Test Conceptual Cross Section



Well Designation

AS	Air Sparging Well
VE	Vapor Extraction Well
GM	Groundwater Monitoring Well
VM	Vapor Monitoring Well
HC	Existing Groundwater Monitoring Well

Note: The approximate distance between the air sparging well and the vapor extraction well is 16 feet.

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Figure 4

Hydrographs for Sparging Monitoring Points

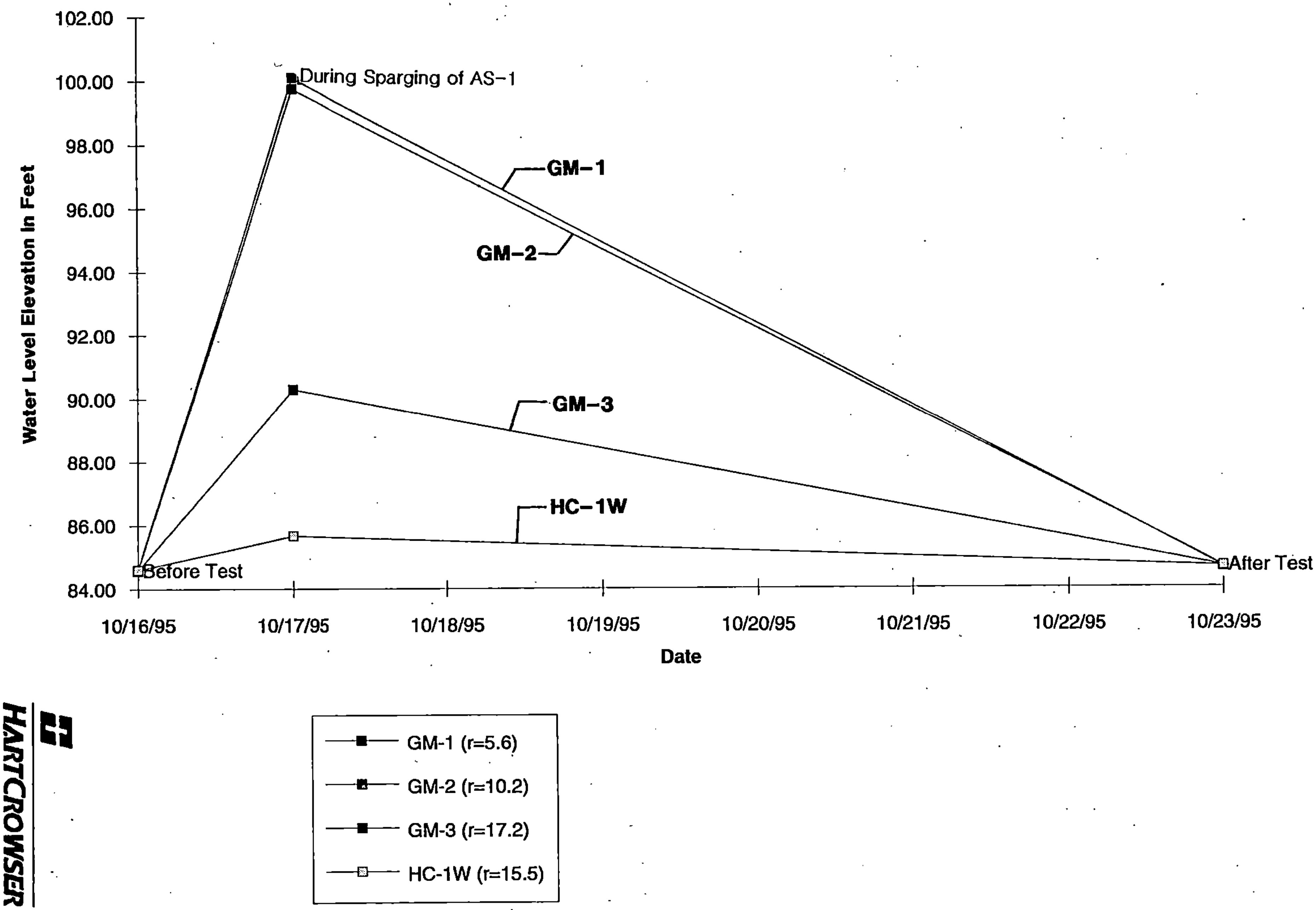

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Figure 5

Plot of Soil Vapor Extraction Steady State Vacuum Data

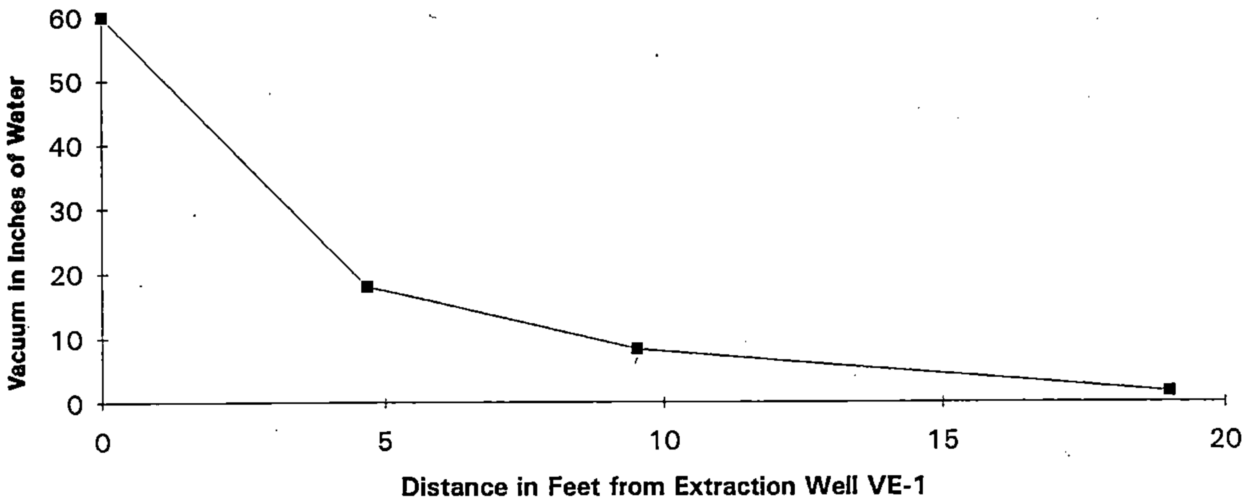

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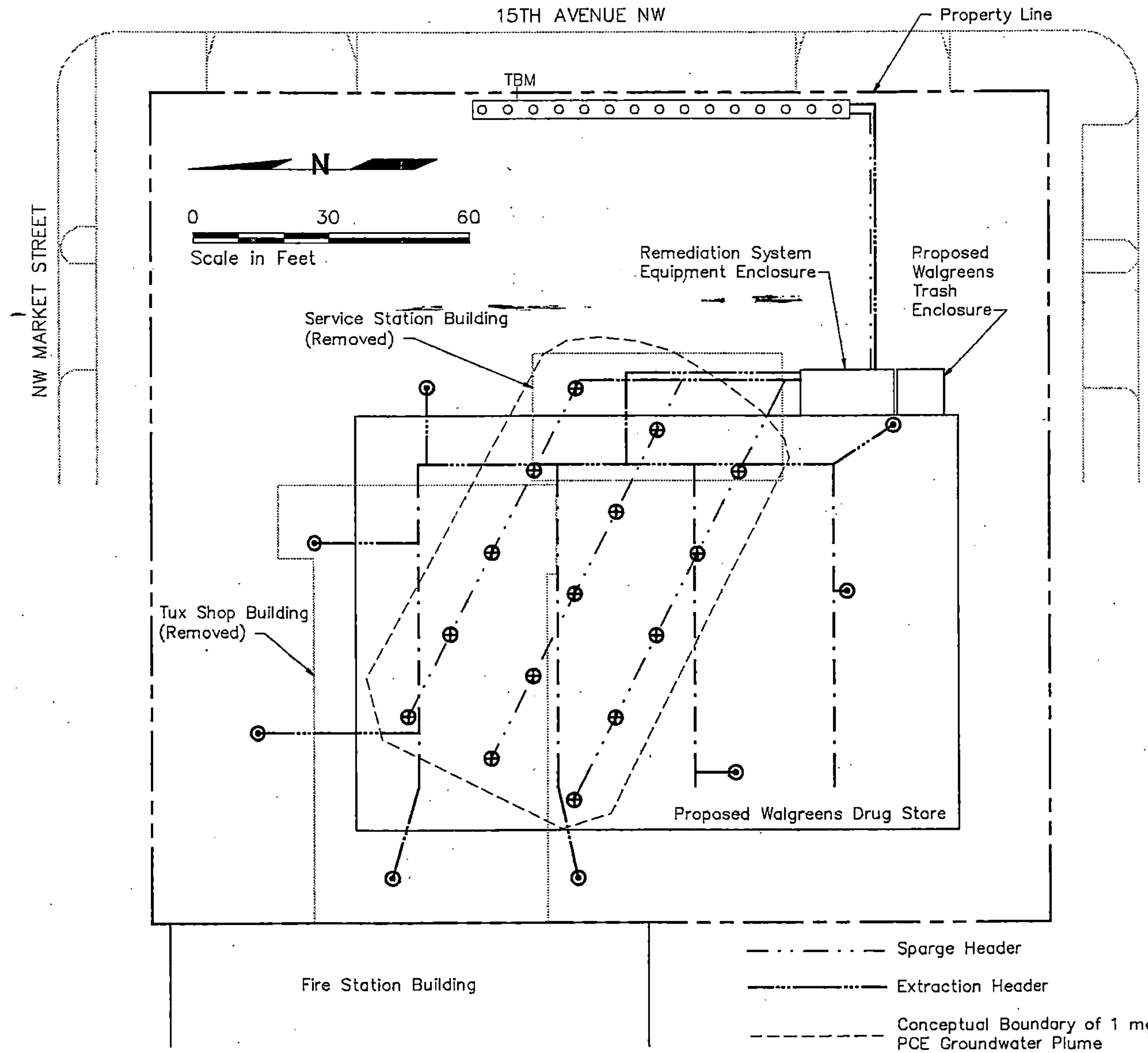
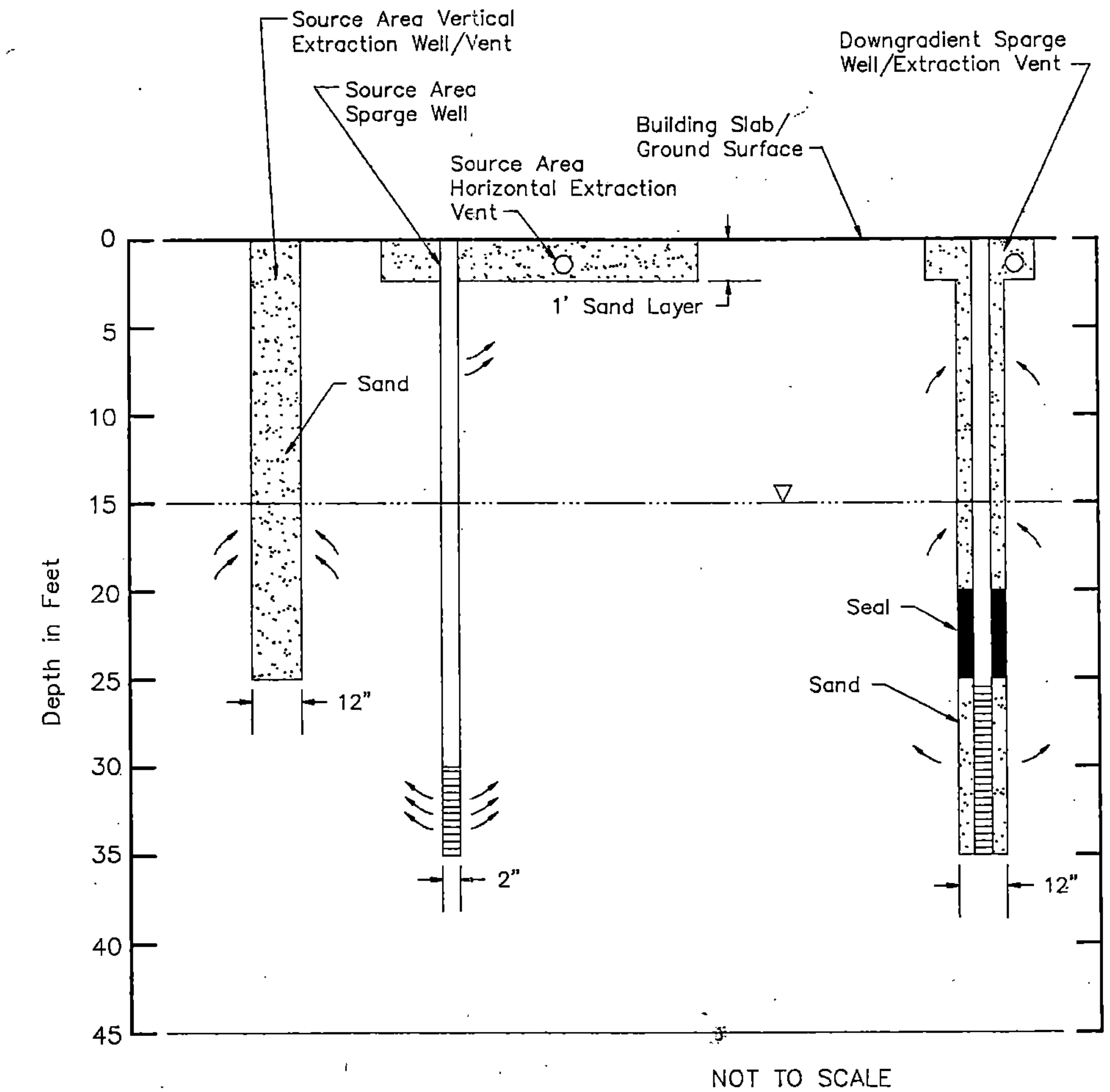
Figure 6

Conceptual Layout of Air Sparging/Soil Vapor Extraction System

Plan



Conceptual Cross Section



Sparge Header

Extraction Header

Conceptual Boundary of 1 mg/L PCE Groundwater Plume

⊕ Source Area Sparge Well (15)

Source Area Horizontal Extraction Vent (4)

⊙ Source Area Vertical Extraction Well/Vent (8)

○ Downgradient Sparge Well (15)

Downgradient Horizontal Extraction Vent (1)

TBM Temporary Benchmark on N.E. corner of Catch Basin; assumed elevation of 100.00 feet

Notes:
1. The locations of all features shown are approximate.
2. All above-ground and underground facilities were removed on or before September 1993.
3. Base map prepared from drawing provided by client entitled "Site Plan", dated October 19, 1994.
4. Proposed Walgreens Drug Store from drawing prepared by Mithun Partners entitled "Project Data and Site Plan", dated April 10, 1995.

JCH 12/7/95 1=30 HC.pcp
4422020Z

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Figure 7

ATTACHMENT A
BORING & TEST PIT LOGS

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 – 4	Very soft	0 – 2	<0.125
Loose	4 – 10	Soft	2 – 4	0.125 – 0.25
Medium dense	10 – 30	Medium stiff	4 – 8	0.25 – 0.5
Dense	30 – 50	Stiff	8 – 15	0.5 – 1.0
Very dense	>50	Very stiff	15 – 30	1.0 – 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 – 5
Slightly (clayey, silty, etc.)	5 – 12
Clayey, silty, sandy, gravelly	12 – 30
Very (clayey, silty, etc.)	30 – 50

Legends

Sampling Test Symbols

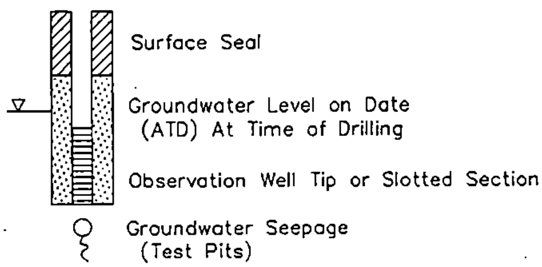
BORING SAMPLES

- ⊠ Split Spoon
- ⧅ Shelby Tube
- Ⅲ Cuttings
- ◫ Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- ⊠ Grab (Jar)
- ⧄ Bag
- ⧅ Shelby Tube

Groundwater Observations



Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
PID	Photoionization Reading
CA	Chemical Analysis

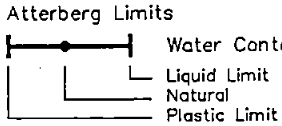


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Figure A-1

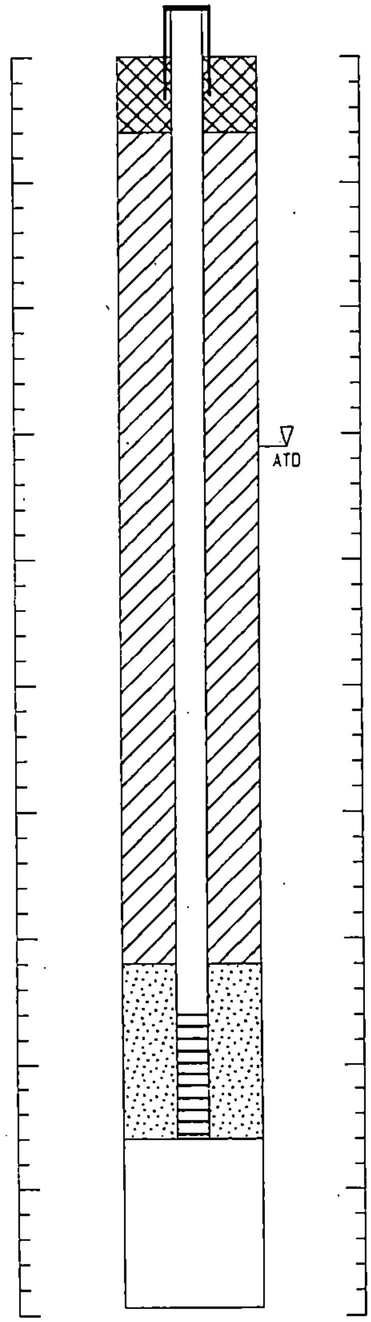
Boring Log and Construction Data for Monitoring Well HC-1W

Geologic Log

Depth in Feet	
0	(Loose), moist, dark brown, silty, gravelly SAND. Loose, damp to moist, grayish brown, slightly silty SAND.
	Becomes medium dense with trace gravel.
	Becomes dense to very dense.
15	Becomes wet.
20	Very dense, wet, grayish brown, slightly silty, gravelly SAND.
	Very dense, moist, grayish brown, trace to slightly silty SAND.
	0.5-inch silt lens.
	1- to 2-inch silt lens.
35	Very dense damp, gray, slightly sandy SILT.
	Very dense, damp, gray, silty to slightly silty SAND with trace gravel.
50	Bottom of Boring at 49.7 Feet. Completed 12/14/94.

Sample	N	PID
S-1	5	(173)
S-2	10	(1428)
S-3	42	(1890)
S-4	51	(2000)
S-5	53	(1725)
S-6	60	(783)
S-7	85/9	(619)
S-8	74/6	(548)
S-9	85/6	(614)
S-10	50/5	(1098)
S-11	50/3	(580)
S-12	50/3	(202)
S-13	25/1	(134)
S-14	82/6	(250)
S-15	80/9	(270)
S-16	50/3	(10)
S-17	81/5	(13)
S-18	100/5	(27)
S-19	100/6	(32)
S-20	75/5	(47)
S-21	50/2	(1)
S-22	80/5	(32)
S-23	85/3	(7)
S-24	62/3	(3)
S-25	75/3	(44)

Monitoring Well Design



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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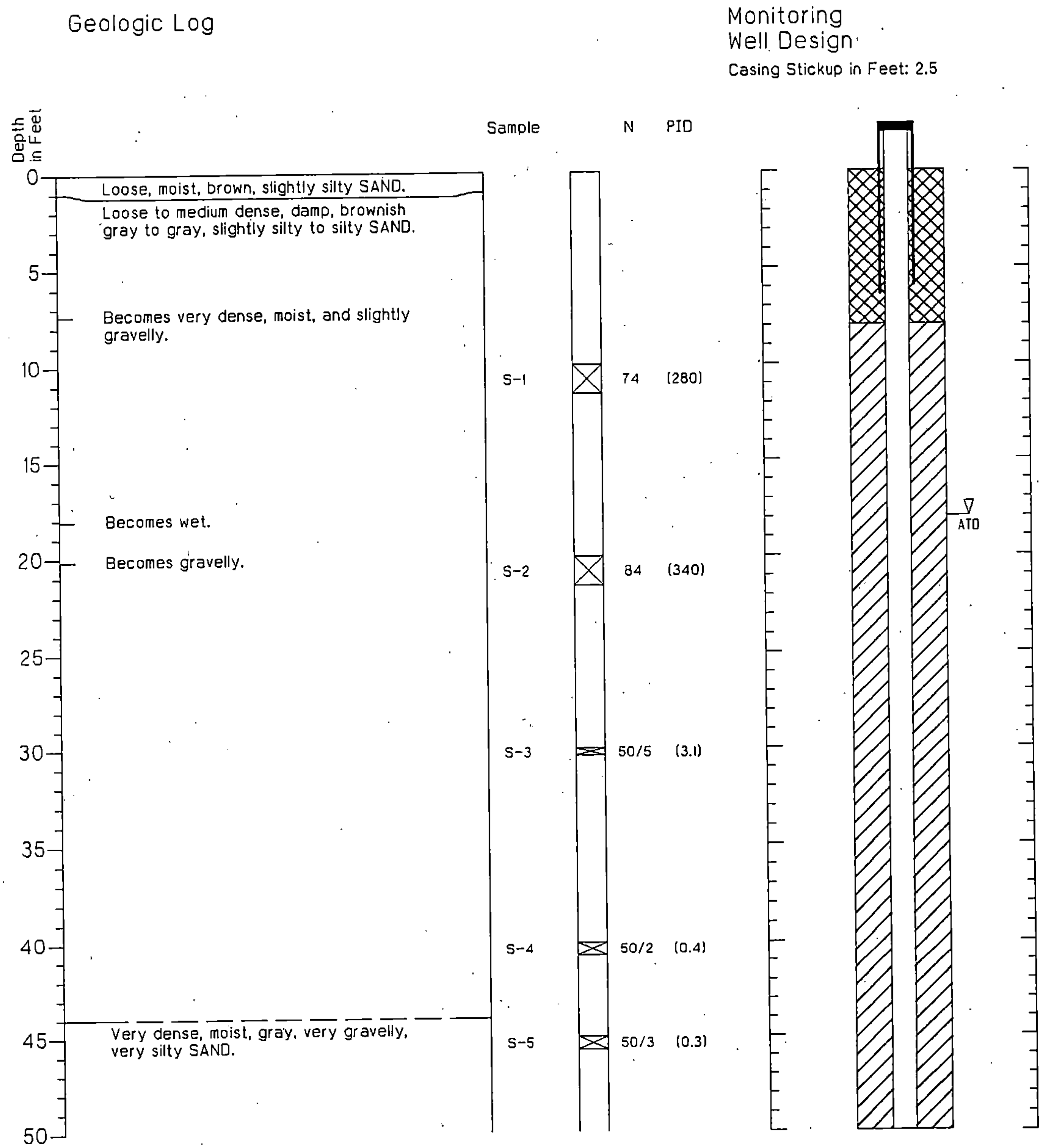
Figure A-2

Boring Log and Construction Data for Monitoring Well HC-1D



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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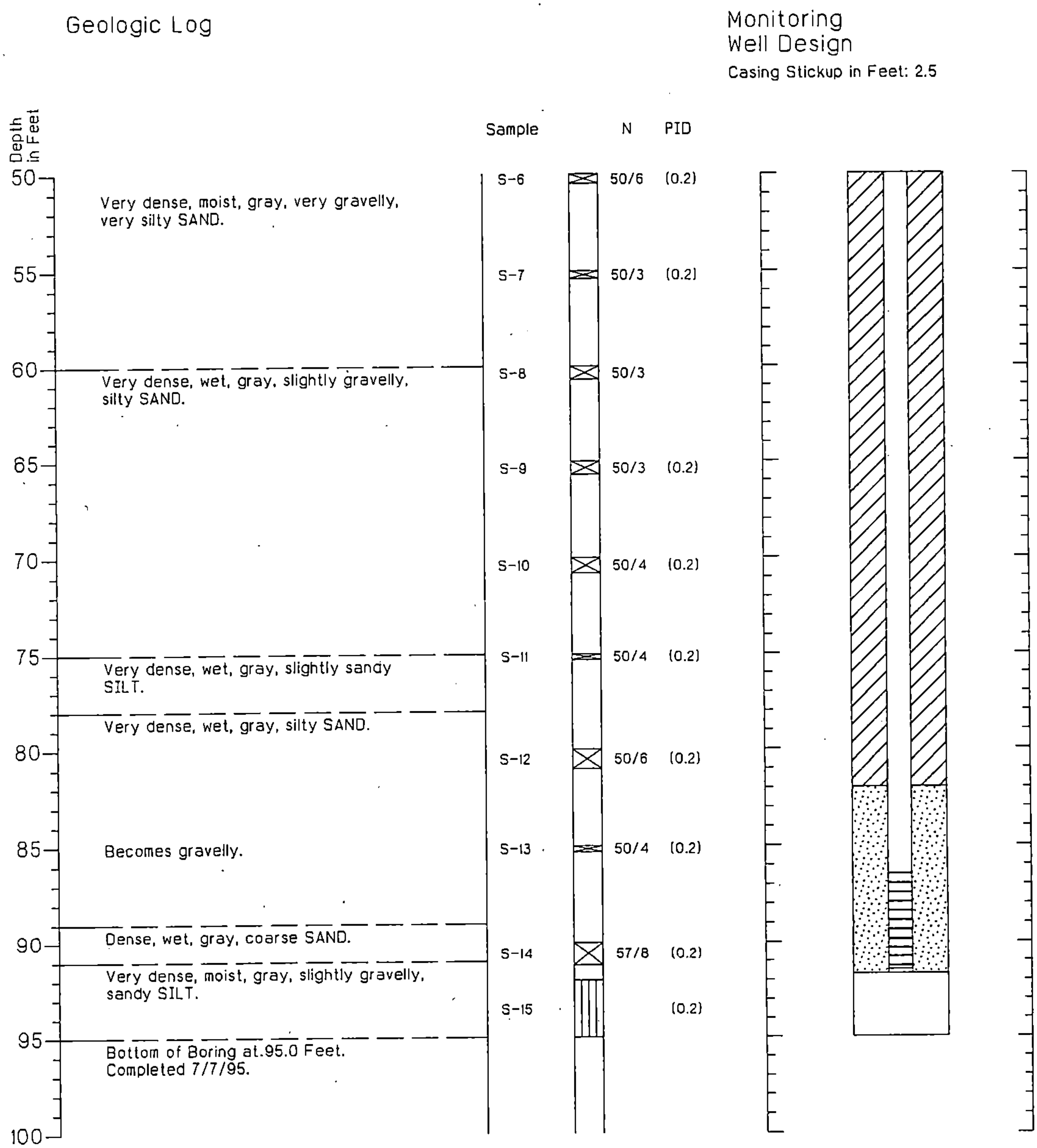
Figure A-3 1/2

Boring Log and Construction Data for Monitoring Well HC-1D



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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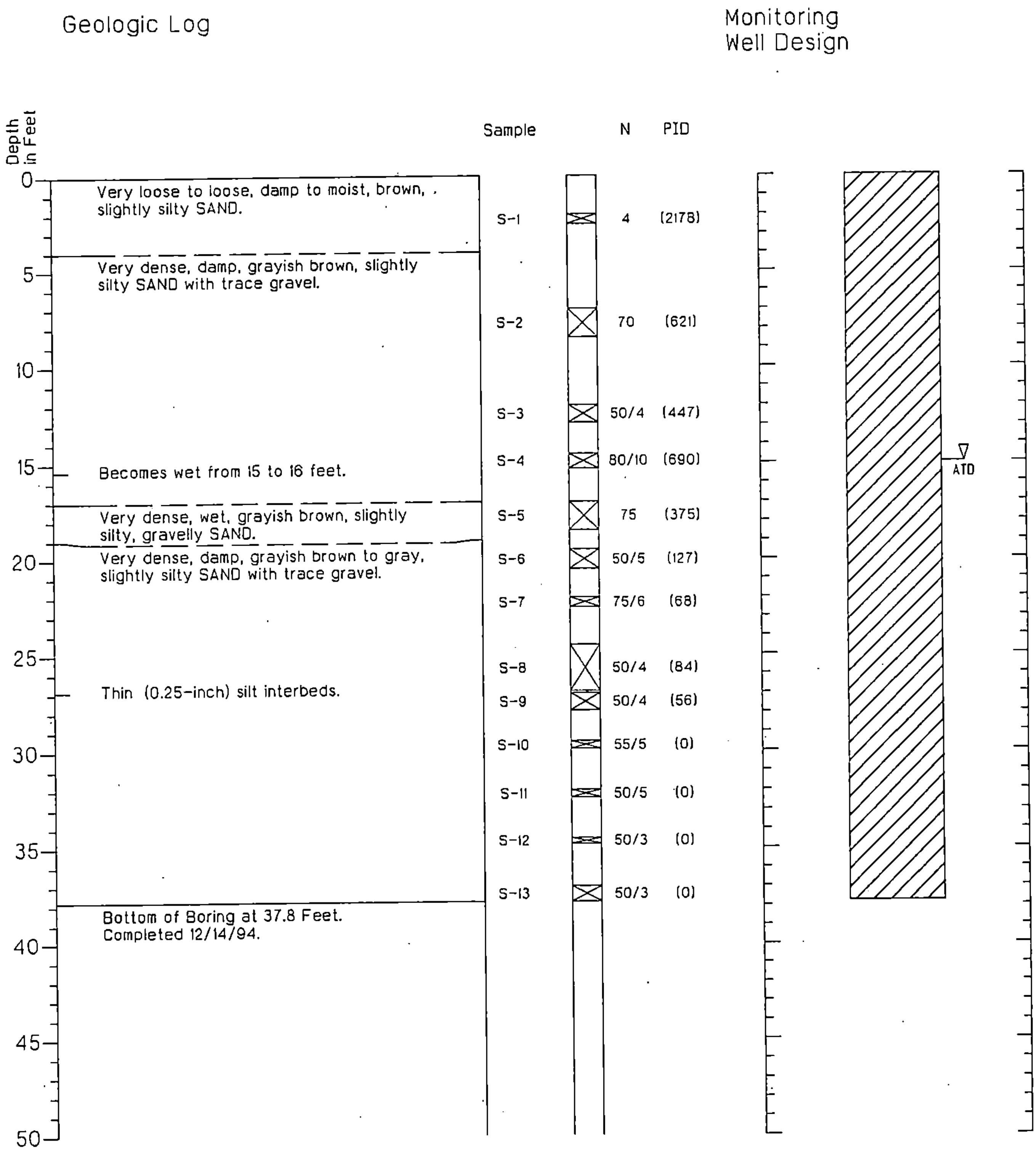
Figure A-3 2/2

Boring Log and Construction Data for Monitoring Well HC-2



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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Figure A-4

Test Pit Log TP-1

Sample	PID	Depth in Feet	SOIL DESCRIPTIONS
		0–1	(Loose), moist, dark brown and gray, silty, gravelly, fine SAND.
		1–12	(Dense), moist to wet, gray, slightly silty to silty, slightly gravelly SAND.
	5	3	
	8	5	Less silty. Concrete pipe, possible trench line.
	50	9	
	200	11	
		12–17	(Very dense), moist, gray, slightly silty, slightly gravelly, fine SAND.
	300	13	
	300	15	
		17	Bottom of Test Pit at 17 Feet. Completed 10/31/94.

Test Pit Log TP-2

Sample	PID	Depth in Feet	SOIL DESCRIPTIONS
		0–1	(Loose), moist, dark brown and gray, silty, gravelly, fine SAND.
		1–12	(Dense), moist, gray, slightly silty to silty, slightly gravelly, fine SAND with iron staining at 1- to 1½-foot-depth.
	0	1	
	5	2	
	10	4.5	
	20	9	
	120	11	
		12–15	(Very dense), moist, gray, slightly gravelly, silty, fine SAND.
	300	13.5	
	300	15	
		15	Bottom of Test Pit at 15 Feet. Completed 10/31/94.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

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Figure A-5

Test Pit Log TP-3

Sample | PID | Depth in Feet | SOIL DESCRIPTIONS

PID	Depth in Feet
0	2
0	3
0	4–5
0	7–8
0	10–11
0	13

(Loose), moist, brown and gray, slightly silty, gravelly SAND.

(Dense), moist, gray to light brown, slightly gravelly SAND with some iron staining at 1- to 1½-foot-depth and a thin lens of concrete debris at 2-foot-depth.

(Very dense), moist, gray, slightly silty, slightly gravelly, fine SAND.

Bottom of Test Pit at 13 Feet.
Completed 11/1/94.

Test Pit Log TP-4

Sample | PID | Depth in Feet | SOIL DESCRIPTIONS

PID	Depth in Feet
0	1–2
5	2–3
20	5
30	6–7
30	8
30	10
5	12
5	14
3	17

(Loose), moist, dark brown, silty, gravelly SAND with 1 ft. x 2 ft lens of pea gravel.

(Loose), moist, light brown, slightly clayey, slightly sandy SILT.

(Dense), moist, gray, slightly silty, slightly gravelly, fine SAND.

(Very dense), moist, gray, slightly silty, slightly gravelly, fine SAND.

Bottom of Test Pit at 17 Feet.
Completed 11/1/94.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

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Figure A-6

Test Pit Log TP-5

PID	Depth in Feet	SOIL DESCRIPTIONS
	0–2	(Loose), moist, dark brown, silty, gravelly SAND with pea gravel, logs, asphalt, metal, and concrete debris.
	2–4.5	(Dense), moist, light brown and gray mottling, slightly gravelly, slightly sandy SILT grading to very sandy SILT.
20	5	(Dense), moist, gray, slightly gravelly, fine SAND.
150, 500	6	
200	7	
100	8	
50	9	
300	11	
20	13	(Very dense), moist, gray, slightly gravelly, fine SAND.
5	15	Bottom of Test Pit at 15 Feet. Completed 11/1/94.

Test Pit Log TP-6

PID	Depth in Feet	SOIL DESCRIPTIONS
0	0–1.5	(Loose), moist, dark brown, very silty, very gravelly SAND with asphalt and concrete debris.
2	3	(Loose), moist, light brown, slightly sandy to sandy, slightly gravelly SILT with some iron staining.
3	4	
20	5	(Dense), moist, gray, slightly gravelly SAND.
10	6	
5	7	
3	8	
7	9	
5	11	
7	14	(Very dense), moist, gray, slightly gravelly SAND.
	15	Bottom of Test Pit at 15 Feet. Completed 11/1/94.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

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Figure A-7

Test Pit Log TP-7

Sample	PID	Depth in Feet	SOIL DESCRIPTIONS
	0	0	(Loose), moist, dark gray and black, silty, gravelly SAND with seam of black coal-like layer with pieces of slag-like material and bricks.
		1	
	1	2	(Loose), moist, light brown, slightly sandy to sandy, slightly gravelly SILT with iron staining, hit abandoned sewer line at 2½-foot-depth.
		3	
	1	4	(Dense), moist, gray, slightly gravelly SAND.
		5	
		6	
	1	7	
		8	
	10	9	
	20	10	
	10	11	
	40	12	(Very dense), moist, gray, slightly gravelly SAND. Very difficult digging.
	40	13	
	20	14	Bottom of Test Pit at 14 Feet. Completed 11/1/94.
		15	
		16	
		17	
		18	
		19	
		20	

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

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Figure A-8