RECEIVED

APR 02 1999

DEPT OF ECOLOGY

HARTCROWSER

Earth and Environmental Technologies

Summary of Site Investigations
Spencer Industries, Inc.
8410 Dallas Avenue South
Seattle, Washington

Volume I

Prepared for
Spencer Industries, Inc.

April 1, 1999
J-4686-02

CONTENTS

CONTENTS (Continued)

Page

FIGURES

CONTENTS (Continued)

Page

SUMMARY OF SITE INVESTIGATIONS
SPENCER INDUSTRIES, INC.
8410 DALLAS AVENUE SOUTH
SEATTLE, WASHINGTON

SUMMARY

This report presents the results of a series of soil and groundwater investigations performed between November 1996 and February 1999 at Spencer Industries, located at 8410 Dallas Avenue South in Seattle, Washington (Figure 1). Spencer Industries manufactures aircraft parts and equipment. Historically, solvent use at the site has been very limited. The investigations summarized in this report identified and delineated two adjacent plumes of chlorinated solvents (a perchlorethylene (PCE)/trichlorethylene (TCE) plume, and a TCE plume). The plumes are limited to the north end of the property and do not extend more than 40 feet below ground surface. Investigations did not suggest the presence of residual dense non-aqueous phase liquid (DNAPL) or a significant soil source area at the site.

Spencer Industries is located in close proximity to the Duwamish Waterway. Groundwater near the site is generally of low quality and is not used as drinking water supply. MTCA Method A soil and groundwater levels were assumed to be applicable during preparation of this report.

The suitability of natural attenuation as the mechanism for remediation of the solvent plumes was assessed. Physical attenuation is significant at the site, as a result of relatively low maximum concentrations of TCE and PCE combined with tidally induced dispersion and mixing. Geochemical measurements at the site indicate iron- and sulfate-reducing conditions dominate, leading to natural attenuation of chlorinated solvents through reductive dechlorination.

1.0 PROJECT BACKGROUND

1.1 Location

The Spencer Industries site is located between South Dallas Street and South Orr Street, east of 12th Avenue South near the Duwamish Waterway in Seattle, Washington (Figure 2). Spencer Industries distributes aircraft hydraulic components and fasteners, and conducts light assembly at its facility. The surrounding neighborhood is mixed-use light industrial, commercial, and residential.

1.2 Site History

The facility was initially developed as Spencer Industries in 1946. Historically, solvent use at the site has been limited. According to a Level I Environmental Site Assessment prepared by Converse Consultants NW in 1991 (Appendix B), the only known use of chlorinated solvents was as trichloroethylene (TCE), a component in Zep Hydro-Clean and Zep Sof-Safe (degreasers).

Currently, Spencer Industries has a small assembly operation at the site, with the remainder of the site devoted to storage and distribution facilities. No known spills or disposal of chlorinated solvents have been recorded from this operation. Degreasers currently used at the site do not contain chlorinated solvents.

1.3 Correspondence

Correspondence or inquiries concerning the site should be directed to:

Mr. Carl Einberger
Hart Crowser, Inc.
1910 Fairview Avenue East
Seattle, WA 98102
(206) 324-9530

or

Mr. John Hoyt
HMH, L.L.C.
221 SW 153rd Street, Suite 224
Burien, WA 98166
(206) 849-9000

1.4 Report Organization

The remaining sections of this report are organized as follows:

- **SITE PHYSICAL CHARACTERISTICS**;
- **INTERPRETATION OF APPLICABLE CLEANUP LEVELS**;
- **SITE INVESTIGATIONS**;
- **CONCLUSIONS**;
- **LIMITATIONS**; and
- **REFERENCES**.

Supporting tables and figures are provided at the end of the text. Appendix A describes field procedures and contains logs of explorations and well installations performed by Hart Crowser. Appendix B presents a copy of the Level I Environmental Site Assessment prepared by Converse Consultants NW. Appendix C presents a series of letter reports prepared by Pacific Testing Laboratories concerning samples collected from the property. Appendix D presents the Supplemental Groundwater Investigation report prepared by Conestoga-Rovers & Associates Limited. Appendix E presents electronic disks containing the Slug Test and Tidal Response Monitoring Data. Appendix F (presented in Volume II) contains soil and groundwater analytic data for samples collected by Hart Crowser.

2.0 SITE PHYSICAL CHARACTERISTICS

The Spencer Manufacturing and Spencer Fluid Power buildings are located on South Orr Street approximately 300 feet south of the Duwamish Waterway. Figure 2 shows relevant site features and exploration locations. Figures 3, 4, and 5 present geologic cross sections through the site area.

Soil data collected by Conestoga-Rovers & Associates, Limited (CRA, Appendix D) and Hart Crowser during a series of site investigations indicate that approximately the upper 60 feet of sediments are Duwamish River alluvial deposits. These deposits consist of brown to gray-black, fine to medium Sand with lenses of sandy silt and occasional small rootlets and wood debris.

Underlying the alluvial deposits, marine deposits were encountered at a depth of about 60 feet, and extend to a depth of at least 90 feet. These deposits consist of interbedded sandy Silt and silty Clay.

Depth to groundwater at the site is approximately 10 feet. Water level elevations in the nearby Duwamish Waterway show considerable variability due to tidal fluctuations. Changes in groundwater levels at the site of approximately 1 foot are associated with the tidal cycle. Based on a tidal monitoring study performed by Hart Crowser (discussed below), the average groundwater flow direction is about six degrees west of north with a gradient of 0.002 ft/ft. Groundwater velocity is approximately 50 feet/year.

3.0 INTERPRETATION OF APPLICABLE CLEANUP LEVELS

Spencer Industries is located in close proximity to the Duwamish Waterway. Because groundwater in the area is of generally low quality, with high salinity at depths of as little as 60 feet, future development as a drinking water source is unlikely. MTCA Method A soil and groundwater levels were assumed to be applicable during preparation of this report. Method A cleanup levels are appropriate for "routine" sites with a limited number of contaminants. Based on analytical data, Method A cleanup levels are met before contaminants migrate off site or discharge to the Duwamish Waterway. These cleanup levels, along with federal Maximum Contaminant Levels (MCLs), are included in Table 2. We have also assumed MTCA Method A soil cleanup levels are applicable. These cleanup levels are included in Table 1.

4.0 SITE INVESTIGATIONS

4.1 Converse Consultants Level I Environmental Site Assessment

In 1991, Converse Consultants NW performed a Level I Environmental Site Assessment at Spencer Industries. A copy of the assessment report prepared by Converse is presented in Appendix B. The objective of this assessment was to determine the potential for site contamination. The assessment included review of historical aerial photos, property title history, and Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) files for indications of contaminated sites in the vicinity, and a site visit.

During the site visit, a 200-gallon above-ground waste oil tank and a 200-gallon above-ground fuel oil tank were documented (Figure 2). These tanks have since been removed, and underlying soils excavated and disposed of. Heavy oil staining was observed on the ground beneath the tanks. The usage of a Zep cleaner (a solvent containing a component of TCE) was noted. No visible stains or odors were discovered in association with the Zep cleaner. It was also noted that several empty 20-gallon Zep barrels were stored outside at the site.

Based on this site assessment, it was recommended that soil samples be collected to determine the extent of contamination due to releases from the oil storage tanks.

4.2 Pacific Testing Laboratories Soil Sampling and Analysis

On May 5, 1992, in response to the Level I assessment, Pacific Testing Laboratories collected one soil sample in the vicinity of the oil tanks. This sample (designated as PTL-sandy soil) was analyzed for diesel-range hydrocarbons (TPH-D), with a detection of 221 mg/kg. This is slightly above the MTCA Method A soil cleanup level for TPH of 200 mg/kg. Three additional samples were collected near the oil tanks on June 30, 1992 (TPL-A, TPL-B, and TPL-C) and analyzed for TPH. These three samples had no TPH detected, with a detection limit of 200 mg/kg. Specific sample locations and depth intervals are unknown, therefore sample locations are not shown on Figure 2. Analytical results are summarized in Table 1. Appendix C presents the Pacific Testing Laboratories reports for these and related site activities.

4.3 CRA Site Investigation

CRA performed a limited soil and groundwater investigation at the subject property in 1996 (Appendix D). During this investigation, borings CB-1 through CB-3 were drilled, and monitoring wells MW-1, MW-2, and MW-3 were drilled and installed, at the locations shown on Figure 2.

Soil samples were collected from three borings (CB-1, CB-2, and CB-3). The soil samples were analyzed for metals. Soil samples from CB-1 and CB-2 (located near the former oil tanks) were analyzed for diesel-range hydrocarbons (TPH-D), and samples from CB-2 and CB-3 were analyzed for PCBs. The sample from CB-3 was also analyzed for volatile organic compounds (VOCs). Analyses of these samples did not result in a detection above the applicable MTCA Method A soil cleanup levels. Analytical data from the site investigations are summarized in Table 1.

Groundwater samples were also collected by CRA in 1996 from monitoring wells MW-1, MW-2, and MW-3 and analyzed for TPH-D, metals, and VOCs. TPH-D was not detected in the groundwater samples. Lead was detected at concentrations of 10.3 and 6.9 µg/L at MW-1 and MW-3, respectively, which are above the MTCA Method A cleanup level of 5 µg/L. Arsenic was detected at concentrations of 5.4 and 7.1 µg/L at MW-1 and MW-3, respectively. These detections exceed the Method A arsenic cleanup level of 5 µg/L. Because lead and arsenic concentrations are also elevated in the upgradient well, they likely represent background conditions, and are not necessarily indicative of a release on site.

VOCs were not detected above the detection limit of 1 µg/L at MW-3, the upgradient well. PCE, TCE, and TCA were detected in the groundwater sample from MW-1 at concentrations of 48.8, 16.9, and 41.5 µg/L, respectively. Lower concentrations of dichloroethylene (DCE) and dichloroethane (DCA) were also detected. PCE and DCE were detected in the sample from MW-2 at concentrations of 54 and 15.3 µg/L, respectively. Of these detections, TCE concentrations at MW-1 and MW-2 exceed the Method A TCE cleanup level of 5 µg/L, and PCE at MW-1 exceeds the Method A PCE cleanup level of 5 µg/L. Groundwater analytic data from this and subsequent sampling rounds are summarized in Table 2.

The CRA report concluded that based on the absence of VOCs in the upgradient well (MW-3), the VOC-impacted groundwater areas at the site were likely related to an on-site source. Based on this conclusion, further site investigation was recommended.

4.4 Hart Crowser Site Investigation

In 1996, Hart Crowser performed a soil and groundwater investigation at the site to determine the lateral and vertical extent of groundwater impacted by chlorinated VOCs, and to identify potential on-site VOC source areas. This investigation included soil and groundwater sampling at 14 locations (SP-1 through SP-14 on Figure 2) using a direct-push Strataprobe drill rig, and groundwater sampling at two locations (deep borings D-1 and D-2 on Figure 2) using a hollow-stem auger. No soil samples were collected from D-1 and D-2 nor were logs developed for these groundwater sampling explorations. Groundwater samples were also collected from existing wells MW-1, MW-2, and MW-3.

Ten soil samples and fifteen groundwater samples (twelve from borings, and three from monitoring wells) were submitted for analysis of VOCs. Soil analytical data are summarized in Table 1, groundwater analytical data from the monitoring wells are summarized in Table 2, and groundwater analytical data from the auger and Strataprobe borings are summarized in Table 3.

Based on these data, the following observations were made:

- There does not appear to be an upgradient VOC source. VOCs were not detected in soil or groundwater samples (SP-8, SP-9, SP-10, SP-14, and MW-3) collected from the upgradient portions of the property.

- The lateral extent of impacted groundwater is limited, as shown on Figure 6. Groundwater with elevated VOCs is located in two areas, near the northeast and northwest corners of the Spencer Fluid Power building. VOCs in groundwater appear to be limited to the northern portion of the property, based on non-detect results obtained at SP-4 and SP-5 in the central area of operations. Based on non-detect results at SP-12 and SP-13, impacted groundwater does not appear to have migrated off site across South Orr Street.

- There are two chemically distinct plumes, as shown on Figure 6, indicating that separate sources were likely. The plume around MW-1 has elevated concentrations of PCE and TCE, and detections of TCE below the MTCA

Method A groundwater cleanup level. The plume around MW-2 has elevated concentrations of TCE, with detections of cis-1,2-DCE below the federal MCL (no MTCA Method A cleanup level exists for DCE).

- In the deep borings, TCE was detected at low concentrations. PCE detections in D-1 are at lower concentrations than those detected at the water table in MW-1, indicating a decrease in concentration with depth. DCE concentrations at D-2 increased slightly with depth, but remain below federal MCLs.

- The detected concentrations of VOCs at the site are significantly lower than would be expected in conjunction with a DNAPL source (generally considered to be greater than 1% of the solubility of the VOC compound).

Based on the sampling methodology, groundwater samples collected from within the auger during drilling of deep hollow-stem auger borings are not considered to be representative of actual site groundwater concentrations at depth. During sampling from a hollow-stem auger, there is the potential for movement of water and soils from upper zones of the aquifer, resulting in non-representative samples from deeper zones. For this reason, these data are presented in Table 3, but are not shown on the cross sections on Figures 3, 4, and 5. A more precise and representative method for groundwater sampling using a cone penetrometer (CPT) was used in a subsequent investigation round, as described in the next section.

In summary, during this phase of investigation, it was determined that there is a relatively limited extent of low concentration VOCs in groundwater, and no evidence of off-site migration of VOCs. There is no evidence indicating a DNAPL source area is present at the site. Based on these findings, further investigations were planned to determine potential source areas, and evaluate whether monitored natural attenuation would be a feasible remedial alternative for this site.

4.5 Hart Crowser Source Area Assessment

In spring of 1997, Hart Crowser performed additional site investigation activities. Objectives of this work were to:

- Assess the presence/absence of residual solvent sources in site soils; and

- Accurately determine the depth of solvent-impacted groundwater within the two plume areas.

Based on the observed distribution of solvents in groundwater (i.e., a PCE/TCE plume and a TCE plume), the potential for two source areas was considered. The repair shop area was investigated as a potential source for the TCE plume, and the septic tank was investigated as a potential source for the PCE/TCE plume.

Hart Crowser completed six Strataprobe borings (B-1 through B-6 on Figure 7) around the perimeter of the septic tank and in the drainfield. Soil samples were screened using a photoionization detector (PID), and twelve samples from a range of depths were submitted for analysis of VOCs (see Table 1). No solvents were detected in any of these soil samples, and there did not appear to be a residual solvent source in the soils around the septic tank and drainfield.

Hart Crowser completed ten hand-auger soil borings (B-7 through B-16 on Figure 7) in the repair shop area using a rotohammer and split-spoon sampler. These borings were located in areas with joints, cracks, and staining on the concrete floor. Each boring was driven to a depth of 2 feet, except B-10, B-11, B-14, and B-16. These borings were driven to depths of between 8 and 14 feet to assess deeper soil conditions near the water table. Following screening using a PID, twelve soil samples were submitted for analysis of VOCs. PCE was detected in the soil samples collected from the 0- to 2-foot-depth interval. Concentrations ranged from 0.085 to 0.31 mg/kg (Table 1), below the MTCA Method A cleanup level for soil of 0.5 mg/kg. Soil samples from deeper intervals, closer to the water table, were non-detect for chlorinated solvents. Based on these results, the soil under the repair shop is not considered to be a significant ongoing source of solvents to groundwater.

The potential for a DNAPL solvent plume was evaluated by Hart Crowser using cone penetrometer (CPT) equipment. CPT equipment provides real-time measurements of soil physical properties, allowing for the interpretation of hydrogeologic conditions as drilling proceeds. Groundwater samples were collected from above fine-grained silty deposits, where a sinking DNAPL plume would be expected to pool.

Five groundwater samples were collected from two CPT explorations (CPT-1 and CPT-2 on Figures 2 and 7) above silt or clay contacts and analyzed for VOCs. Results are summarized in Table 3. Low concentrations of TCE were detected at a depth of 23 feet in CPT-1. No other chlorinated solvents were detected deeper in CPT-1 or at any depth in CPT-2.

Based on the results of this phase of investigation, the following conclusions were made:

- Maximum concentrations of residual solvents in soils were low or below detection limits in areas associated with impacted groundwater. Where solvents were detected, they were only present near the ground surface and not at greater depths. No significant soil source area for chlorinated solvents appears to exist at the site.

- The vertical extent of impacted groundwater is less than 50 feet. Detected concentrations of TCE at a depth of 23 feet were below MTCA Method A groundwater cleanup levels.

4.6 Hart Crowser Tidal Monitoring and Slug Testing

To determine the average direction of groundwater flow, and the variability associated with tidal influences on groundwater, Hart Crowser monitored water levels in MW-1, MW-2, MW-3, and the Duwamish Waterway between October 7 and 12, 1998. These results were used to site additional monitoring wells along the identified groundwater flow direction.

The Duwamish Waterway and monitoring wells MW-1, MW-2, and MW-3 were equipped with pressure transducers for the duration of the monitoring study. Each transducer was programmed to record water levels at 15-minute intervals. Following the monitoring period, the magnitude and direction of the hydraulic gradient were calculated at each measurement time by the three-point method. The gradient magnitude ranged between 0.0002 and 0.004 ft/ft, while the gradient direction ranged between 37 degrees east of north and 14 degrees west of north (Figure 8). Although there is a wide range in hydraulic gradient direction, the hydraulic gradient magnitude is negligible at the outer bounds of the range.

An electronic version of the data used to determine the hydraulic gradient and tidal fluctuations are presented in Appendix E. The average magnitude and direction of the hydraulic gradient were calculated using the following equations:

$$\bar{I} = \sum_{n} \frac{I_n}{n};$$

$$\bar{\alpha} = \frac{\sum_{n} (\alpha_n \times I_n)}{\sum_{n} I_n}$$

Where:

$\bar{I}$ is the average magnitude;

I_n is the magnitude at a given time;

n is the number of data points;

$\bar{\alpha}$ is the weighted average gradient direction; and

α_n is the gradient direction at a given time.

Based on the data collected between October 7 and 12, a weighted average direction of 6 degrees west of north and an average magnitude of 0.002 ft/ft were calculated. This information was used to site monitoring wells HC-1, HC-2, and HC-3 along flow paths downgradient from the areas of known PCE- and TCE-impacted groundwater (Figure 2). Appendix A presents logs for these wells.

Based on slug tests performed by Hart Crowser, the hydraulic conductivity near the water table at the site ranges from 8.8×10^{-4} to 4.8×10^{-2} cm/sec, with a geometric mean of 6.5×10^{-3} cm/sec. An electronic version of the slug test data is presented in Appendix E. Assuming a porosity of 0.25, the average groundwater flow velocity is estimated to be on the order of 50 feet/year. As a result of interaction with the surrounding soils through sorption and desorption processes, the transport velocity of the dissolved constituents will be lower than the average groundwater flow velocity. Cohen, Mercer, and Matthews (1993) give a retardation factor of 14.2 for PCE, which results in a transport velocity on the order of 4 feet/year. This is only an approximation, as the retardation factor is site-specific and controlled by the amount of organic matter present, among other factors.

4.7 Groundwater Sampling and Analysis for Natural Attenuation Demonstration

The U.S. Environmental Protection Agency (EPA) defines natural attenuation as "naturally occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media. These *in situ* processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants (EPA, 1997)." Based on the tidal study, dispersion and dilution caused by variable flow directions are likely significant processes for natural attenuation at this site. Evidence for biological and chemical processes were evaluated through groundwater sampling and analysis.

In October 1998, January 1999, and February 1999, groundwater samples were collected from the six on-site monitoring wells. Samples were submitted to the laboratory for the following analyses: VOCs by EPA Method 8260 with low detection limit (i.e., 0.2 µg/L); dissolved iron; nitrate and nitrite; and sulfate. In addition to the laboratory analyses, pH, redox potential (eH), dissolved oxygen, temperature, and electrical conductivity were measured in the field at the time of sampling.

Laboratory analytic data and field parameter measurements are summarized in Table 2. The January 1999 sampling round detected high concentrations of TCE and low concentrations of other solvents in the wells, including the upgradient well. These data are inconsistent with previous and subsequent sampling rounds, when significant concentrations of TCE were only detected in MW-1 and MW-2. Immediately upon receipt of these anomalous results, another sampling round was planned and mobilized, and results from this next round (approximately three weeks later) were consistent with other sampling events. We subsequently determined that the anomalous results were likely caused by previous use of the equipment at a site with high concentrations of VOCs, followed by inadequate decontamination of the sampling equipment (a Grundfos submersible pump). The data from the January 1999 sampling round are presented in Table 2, but are not considered further in this discussion.

PCE and TCE concentrations in groundwater are shown on the cross sections on Figures 3, 4, and 5 to illustrate the extent of these chemicals in groundwater in the site vicinity. The maximum detected concentrations (other than spurious January 1999 data) in the monitoring wells are shown on the cross sections. Figure 9 shows groundwater sampling locations with selected analytic data and field measurements for the October 1998 and February 1999 sampling rounds, along with the average groundwater flow direction. Based on these data, the following observations were made:

- With the exception of one low concentration of TCE, no chlorinated solvents were detected at the upgradient well MW-3. As previously observed, MW-1 has elevated PCE and TCE concentrations, while MW-2 has elevated TCE concentrations.

- The downgradient wells (HC-1, HC-2, and HC-3) show low concentrations of PCE and TCE. Vinyl chloride was not detected in any well.

- Dissolved oxygen concentrations are very low throughout the entire site. Measurements of eH were between 13 and -76 mV during the first round, indicating reducing conditions. During the third round, eH was in the 100 to 300 mV range, values that are assumed to be the result of instrument error.

- A decrease in nitrate and an increase in dissolved iron concentrations were noted across the site, indicating nitrate- and iron-reducing conditions exist. There is a decrease in sulfate concentrations in the northern and eastern portions of the site (between MW-2 and HC-2, and between HC-1 and HC-3), indicating sulfate-reducing conditions exist in these areas. The high nitrate and sulfate concentrations at MW-2 are associated with the septic system leach field.

The chemical conditions at the site (low dissolved oxygen, low eH, and iron- and sulfate-reducing conditions) are favorable for reductive dechlorination of PCE and TCE. These conditions, coupled with the low VOC concentrations at the downgradient wells, indicate that the contaminants are naturally degrading and dispersing before they migrate off the site.

5.0 CONCLUSIONS

Based on the investigations discussed above, we make the following conclusions:

- There are two chemically distinct chlorinated solvent plumes. Near MW-1, a PCE/TCE plume is present, and near MW-2, a TCE plume is present;

- Lead and arsenic concentrations in groundwater exceed MTCA Method A groundwater cleanup levels. Concentrations are elevated at the upgradient well, and these concentrations appear to represent background conditions. No use or release of lead or arsenic is known at the site;

- Based on groundwater samples from deep CPT explorations, shallow strataprobe borings, and the six monitoring wells, the lateral and vertical extent of the solvent plumes are limited. Groundwater with detections of VOCs does not extend to depths greater than 50 feet, and is limited to the northern portion of the property. The plumes have not migrated off site across South Orr Street. There is no indication of any DNAPL presence in the subsurface, based on detected dissolved concentrations;

- Soils beneath the site do not contain a significant source area of chlorinated solvents. The concentrations detected in soil samples analyzed are below MTCA Method A cleanup levels of 0.5 mg/kg for TCE and PCE. This conclusion is based on results of extensive site-wide soil sampling, and focused sampling in the two plume areas where solvents were potentially used or discarded in the past. Active soil cleanup or source control is not considered necessary based on these results;

- Conditions are favorable for natural attenuation of the existing plumes. Physical mixing and dispersion are high at the site, as a result of tidally varying groundwater flow velocities and directions. Groundwater chemistry indicates that iron- and sulfate-reducing conditions exist, which are suitable for reductive dechlorination of chlorinated solvents; and
- Based on the MTCA Method A groundwater cleanup levels, constituents do not exceed these cleanup levels, with the exception of PCE at MW-1 and TCE at MW-1 and MW-2. Concentrations of PCE and TCE in the three downgradient wells (HC-1, HC-2, and HC-3) are significantly below Method A cleanup levels.

6.0 LIMITATIONS

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

Any questions regarding our work and this letter report, the presentation of the information, and the interpretation of the data are welcome and should be referred to the undersigned.

Sincerely,

HART CROWSER, INC.

Carl Einberger

CARL EINBERGER
Senior Associate Hydrogeologist

JOSEPH N. MORRICE
Staff Hydrogeologist

468602\spencer(rpt).doc

7.0 REFERENCES

Cohen, R. M., J. W. Mercer, and J. Matthews, 1993. DNAPL Site Evaluation. CRC Press, Inc. CRC Press, Boca Raton , Florida.

EPA, 1997. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Office of Solid Waste and Emergency Response Directive 9200.4-17.

Table 1 - Summary of Soil Quality Data

			Detected VOCs in mg/kg	TPH in mg/kg		Metals in mg/kg					PCBs in mg/kg
Sample ID	Sample Interval	Sample Date	PCE	Diesel Range	Oil Range	Barium	Cadmium	Chromium	Vanadium	Lead	Total PCBs
Soil Standards:											
MTCA Method A (1)			0.5	200	200	-	2	100	-	-	1
MTCA Method B (1)			19.6	-	-	560	80	-	560	-	0.13
TPL-sandy soil	unknown	5/5/1992	NA	**221**	NA	NA	NA	NA	NA	NA	NA
TPL-A	unknown	6/30/1992	NA	30 U (2)	(2)	NA	NA	NA	NA	NA	NA
TPL-B	unknown	6/30/1992	NA	30 U (2)	(2)	NA	NA	NA	NA	NA	NA
TPL-C	unknown	6/30/1992	NA	30 U (2)	(2)	NA	NA	NA	NA	NA	NA
CB-1	3.0 - 5.0	11/12/1996	0.2 U	10 U	25 U	15.6	0.92	5.91	24.9	10 U	NA
CB-2	3.0 - 5.0	11/12/1996	0.2 U	10 U	40.7	25.7	0.52	9.23	28.5	39.4	50 U
CB-3	0 - 2.5	11/12/1996	0.2 U	NA	NA	21.3	1.00	8.72	28.5	19.8	50 U
SP-1	6.0 - 8.0	11/25/1996	0.110	NA	NA	NA	NA	NA	NA	NA	NA
SP-3	6.0 - 8.0	11/25/1996	0.190	NA	NA	NA	NA	NA	NA	NA	NA
SP-3	10.0 - 12.0	11/25/1996	0.100	NA	NA	NA	NA	NA	NA	NA	NA
SP-4	6.0 - 8.0	11/25/1996	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
SP-5	6.0 - 8.0	11/25/1996	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
SP-6	6.0 - 8.0	11/25/1996	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
SP-6 Dup	6.0 - 8.0	11/25/1996	0.060	NA	NA	NA	NA	NA	NA	NA	NA
SP-10	10.0 - 12.0	11/26/1996	.050 U	20 U	50 U	NA	NA	NA	NA	NA	NA
SP-10 Dup	10.0 - 12.0	11/26/1996	.050 U	20 U	50 U	NA	NA	NA	NA	NA	NA
SP-12	6.0 - 8.0	11/25/1996	.050 U	20 U	**490**	NA	NA	NA	NA	NA	NA
SP-13	6.0 - 8.0	11/26/1996	.050 U	20 U	50 U	NA	NA	NA	NA	NA	NA
SP-14	6.0 - 8.0	11/26/1996	.050 U	20 U	50 U	NA	NA	NA	NA	NA	NA
B-1-S1	2.0 - 4.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-1-S3	6.0 - 8.25	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-2-S1	1.5 - 3.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-2-S3	4.0 - 6.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-3-S1	1.5 - 3.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-3-S4	7.5 - 9.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-4-S1	1.5 - 3.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-4-S4	8.25 - 9.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-5-S1	1.0 - 3.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-5-S4	7.5 - 8.5	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-6-S1	1.5 - 3.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-6-S3	7.0 - 8.5	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-7-S1	0.0 - 2.0	4/11/1997	0.310	NA	NA	NA	NA	NA	NA	NA	NA
B-8-S1	0.0 - 2.0	4/11/1997	0.150	NA	NA	NA	NA	NA	NA	NA	NA
B-9-S1	0.0 - 2.0	4/11/1997	0.190	NA	NA	NA	NA	NA	NA	NA	NA
B-10-S1	0.0 - 2.0	4/11/1997	0.310	NA	NA	NA	NA	NA	NA	NA	NA
B10-S3	9.0 - 10.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-11-S1	0.0 - 2.0	4/11/1997	0.085	NA	NA	NA	NA	NA	NA	NA	NA
B-12-S1	0.0 - 2.0	4/11/1997	0.190	NA	NA	NA	NA	NA	NA	NA	NA
B-13-S1	0.0 - 2.0	4/11/1997	0.110	NA	NA	NA	NA	NA	NA	NA	NA
B-14-S1	0.0 - 2.0	4/11/1997	0.310	NA	NA	NA	NA	NA	NA	NA	NA
B-14-S3	7.0 - 8.0	4/11/1997	.050 U	NA	NA	NA	NA	NA	NA	NA	NA
B-15-S1	0.0 - 2.0	4/11/1997	0.190	NA	NA	NA	NA	NA	NA	NA	NA
B-16-S1	0.0 - 2.0	4/11/1997	0.100	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
(1) per CLARC II database (February 1996).
(2) Analyzed for total TPH only.
U: Not detected above the laboratory detection limit indicated.
Dup: Field duplicate sample.
NA: Not analyzed
Exceedances of cleanup standards are shown in bold type.

468602/spencer(tables).xls - Table 1

Table 2 - Summary of Groundwater Quality Data from Monitoring Wells

		Detected VOCs in µg/L							TPH in mg/L		Metals in µg/L				
Sample ID	Sample Date	cis-1,2-DCE	1,1-DCE	trans 1,2-DCE	1,1-DCA	1,1,1-TCA	TCE	PCE	Diesel Range	Oil Range	Arsenic	Barium	Chromium	Lead	Vanadium
Groundwater Standards:															
MTCA Method A (1)		-	-	-	-	200	5	5	1,000	1,000	5	-	50	5	-
Federal MCL (1)		70	7	100	-	200	5	5	-	-	50	2,000	100	15	-
MW-1	11/11/1996	4.7	2.8	1.0 U	11.8	41.5	**16.9**	**48.8**	0.25 U	0.75 U	**5.4**	92.4	18.8	**10.3**	42.6
MW-1 Dup	11/11/1996	4.8	2.7	1.0 U	11.8	42.1	**16.7**	**48.0**	0.25 U	0.75 U	4.0 U	107.0	24.1	**10.1**	107.0
MW-1	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	55	**14**	**41**	NA	NA	NA	NA	NA	NA	NA
MW-1	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	42	**12**	**47**	NA	NA	NA	NA	NA	NA	NA
MW-1 Dup	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	42	**12**	**44**	NA	NA	NA	NA	NA	NA	NA
MW-1	11/11/1997	5.0 U	5.0 U	5.0 U	5.0 U	47	**15**	**47**	NA	NA	NA	NA	NA	NA	NA
MW-1	10/30/1998	0.3	0.3	0.2 U	3.1	45	**16**	**39**	NA	NA	NA	NA	NA	NA	NA
MW-1 *	1/22/1999	1.1	0.2 U	0.2 U	1.3	24	**39**	**26**	NA	NA	NA	NA	NA	NA	NA
MW-1	2/15/1999	0.2 U	0.2 U	0.2 U	1.5	28	**10**	**32**	NA	NA	NA	NA	NA	NA	NA
MW- 2	11/11/1996	15.3	1.0 U	1.0 U	1.0 U	1.0 U	**54**	1.0 U	0.25 U	0.75 U	4.0 U	81.4	10.0 U	2.0 U	29.1
MW-2	4/18/1997	4.5 J	5.0 U	5.0 U	5.0 U	1.0 U	**34**	1.0 U	NA	NA	NA	NA	NA	NA	NA
MW-2	11/11/1997	11	5.0 U	5.0 U	5.0 U	1.0 U	**50**	1.0 U	NA	NA	NA	NA	NA	NA	NA
MW-2	10/30/1998	4.4	0.2 U	0.6	0.2 U	0.2 U	**24**	0.2 U	NA	NA	NA	NA	NA	NA	NA
MW-2 Dup	10/30/1998	4.3	0.2 U	0.6	0.2 U	0.2 U	**24**	0.2 U	NA	NA	NA	NA	NA	NA	NA
MW-2 *	1/22/1999	4.2	0.2 U	0.3	0.2 U	0.2 U	**70**	1.0	NA	NA	NA	NA	NA	NA	NA
MW-2 Dup *	1/22/1999	3.7	0.2 U	0.3	0.2 U	0.2 U	**60**	0.8	NA	NA	NA	NA	NA	NA	NA
MW-2	2/15/1999	1.6	0.2 U	0.3	0.2 U	0.2 U	**22**	0.2 U	NA	NA	NA	NA	NA	NA	NA
MW-3	11/13/1996	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.25 U	0.75 U	**7.1**	109.0	26.8	**6.9**	59.5
MW-3	11/11/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	5.0 U	1.0 U	NA	NA	NA	NA	NA	NA	NA
MW-3	10/30/1998	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.4	0.2 U	NA	NA	NA	NA	NA	NA	NA
MW-3 *	1/22/1999	2.5	0.2 U	0.2 U	0.2 U	0.2 U	**39**	0.6	NA	NA	NA	NA	NA	NA	NA
MW-3	2/15/1999	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-1	10/30/1998	0.2 U	0.2 U	0.2 U	0.5	0.2 U	0.3	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-1 *	1/22/1999	2.0	0.2 U	0.2 U	0.3	0.2 U	**49**	0.8	NA	NA	NA	NA	NA	NA	NA
HC-1	2/15/1999	0.2 U	0.2 U	0.2 U	0.2 U	0.5	0.2 U	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-1 DUP	2/15/1999	0.2 U	0.2 U	0.2 U	0.2 U	0.5	0.2 U	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-2	10/30/1998	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.3	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-2 *	1/22/1999	1.9	0.2 U	0.2 U	0.2 U	0.2 U	**45**	0.7	NA	NA	NA	NA	NA	NA	NA
HC-2	2/15/1999	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	NA	NA	NA	NA	NA	NA	NA
HC-3	10/30/1998	0.5	0.2 U	0.2 U	1.4	0.2	0.7	0.3	NA	NA	NA	NA	NA	NA	NA
HC-3 *	1/22/1999	1.9	0.2 U	0.2 U	1.4	0.2 U	**38**	0.9	NA	NA	NA	NA	NA	NA	NA
HC-3	2/15/1999	0.2	0.2 U	0.2 U	1.0	0.2	0.4	0.4	NA	NA	NA	NA	NA	NA	NA

Table 2 - Summary of Groundwater Quality Data from Monitoring Wells

		Conventionals in mg/L				Field Parameters				
Sample ID	Sample Date	Dissolved Iron	Nitrate	Nitrite	Sulfate	pH	eH in mV	Dissolved Oxygen in mg/L	Temperature in Celsius	Conductivity in mmhos
Groundwater Standards:										
MTCA Method A (1)		-	-	-	-					
Federal MCL (1)		-	10	1	-					
MW-1	11/11/1996	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-1 Dup	11/11/1996	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-1	11/26/1996	NA	NA	NA	NA	6.1	NA	NA	14.3	NA
MW-1	4/18/1997	NA	NA	NA	NA	6.5	NA	NA	12.6	NA
MW-1 Dup	4/18/1997	NA	NA	NA	NA					
MW-1	11/11/1997	NA	NA	NA	NA	6.9	NA	2.0	15.0	NA
MW-1	10/30/1998	0.03	1.8	0.01 U	27	6.4	13	0.4	16.9	0.150
MW-1 *	1/22/1999	0.02 U	4.6	0.012	18	6.8	-70	0.5	15.4	0.146
MW-1	2/15/1999	0.02 U	8.0	0.018	31	5.8	366	0.1	14.0	0.165
MW- 2	11/11/1996	NA	NA	NA	NA	6.4	NA	NA	15.1	NA
MW-2	4/18/1997	NA	NA	NA	NA	6.7	NA	NA	13.5	NA
MW-2	11/11/1997	NA	NA	NA	NA	6.9	NA	1.9	15.3	NA
MW-2	10/30/1998	0.08	40	0.047	160	7.1	-20	0.4	16.9	0.729
MW-2 Dup	10/30/1998	0.08	40	0.047	160					
MW-2 *	1/22/1999	0.05	52	0.016	120	6.9	-96	1.9	14.4	0.665
MW-2 Dup *	1/22/1999	0.05	52	0.021	140					
MW-2	2/15/1999	0.02 U	59	0.034	160	5.9	328	1.6	14.7	0.678
MW-3	11/13/1996	NA	NA	NA	NA	6.2	NA	NA	13.8	NA
MW-3	11/11/1997	NA	NA	NA	NA	7.2	NA	1.5	14.4	NA
MW-3	10/30/1998	0.02 U	4.6	0.028	35	6.6	-42	0.2	15.7	0.202
MW-3 *	1/22/1999	0.02 U	11	0.010 U	66	6.9	-33	2.1	13.7	0.274
MW-3	2/15/1999	0.02 U	6.3	0.011	49	5.3	329	4.5	13.5	0.212
HC-1	10/30/1998	9.33	0.070	0.10	32	7.4	-72	0.1	14.8	0.279
HC-1 *	1/22/1999	6.29	0.010 U	0.027	24	6.8	-50	0.4	15.6	0.197
HC-1	2/15/1999	0.14	0.020	.010 U	38	5.8	207	0.1	14.7	0.262
HC-1 DUP	2/15/1999	0.16	0.020	0.024	38					
HC-2	10/30/1998	1.77	0.010 U	0.010	9.3	7.4	-37	0.1	15.6	0.096
HC-2 *	1/22/1999	0.70	0.058	0.010 U	9.0	6.8	-64	1.6	14.3	0.063
HC-2	2/15/1999	0.70	0.020	0.015	13	5.6	259	0.1	13.5	0.091
HC-3	10/30/1998	13.6	0.010 U	0.012	18	7.3	-76	0.2	15.4	0.209
HC-3 *	1/22/1999	18.8	0.038	0.010 U	24	6.7	-75	0.4	14.8	0.185
HC-3	2/15/1999	11.8	0.010 U	0.052	26	5.6	103	0.2	14.0	0.222

Notes:
(1) per CLARC II database (February 1996).
U: Not detected above the laboratory detection limit indicated.
DUP: Field duplicate sample.
NA: Not analyzed.
J: Estimated Concentration.
*: Data from January 22, 1999, sampling round are anamolous, and are likely the result of a sampling or analysis error.
Exceedences of cleanup levels are shown in bold type.

Table 3 - Summary of Groundwater Quality Data from Borings

			Detected Volatile Organics in µg/L							TPH in mg/L
Sample ID	Sample Depth	Sampling Date	cis-1,2-DCE	1,1-DCE	trans 1,2-DCE	1,1-DCA	1,1,1-TCA	TCE	PCE	Total TPH
SP-1	10.0 - 12.0	11/25/1996	5.0 U	5.0 U	5.0 U	7.8	30	4.9	**20**	NA
SP-2	12.0 - 14.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-4	12.0 - 14.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-5	10.0 - 12.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-6	10.0 - 12.0	11/25/1996	6.8	5.0 U	5.0 U	5.0 U	5.0 U	1.5	5.0 U	NA
SP-6 Dup	10.0 - 12.0	11/25/1996	6.9	5.0 U	5.0 U	5.0 U	5.0 U	1.6	5.0 U	NA
SP-7	12.0 - 14.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-8	10.0 - 12.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-8 Dup	10.0 - 12.0	11/25/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-9	10.0 - 12.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-9 Dup	10.0 - 12.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.0 U
SP-10	10.0 - 12.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	NA
SP-11	10.0 - 12.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.0 U
SP-12	12.0 - 14.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.0 U
SP-13	10.0 - 12.0	11/26/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.0 U
D-1	25.0 - 28.5	12/6/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	3.1	**18**	NA
D-1	37.5 - 39.0	12/6/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.7	**15**	NA
D-1 Dup	37.5 - 39.0	12/6/1996	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	2.7	**16**	NA
D-2	28.0 - 30.0	12/6/1996	13.0	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	1.0 U	NA
D-2	40.0 - 44.0	12/6/1996	36.0	5.0 U	5.0 U	5.0 U	5.0 U	1.8	1.0 U	NA
D-2 Dup	40.0 - 44.0	12/6/1996	40.0	5.0 U	5.0 U	5.0 U	5.0 U	1.9	1.0 U	NA
CPT-1	23.0	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	2.1	1.0 U	NA
CPT-1	62.0	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	1.0 U	1.0 U	NA
CPT-2	41.0	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	1.0 U	1.0 U	NA
CPT-2	52.5	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	1.0 U	1.0 U	NA
CPT-2	57.5	4/18/1997	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	1.0 U	1.0 U	NA

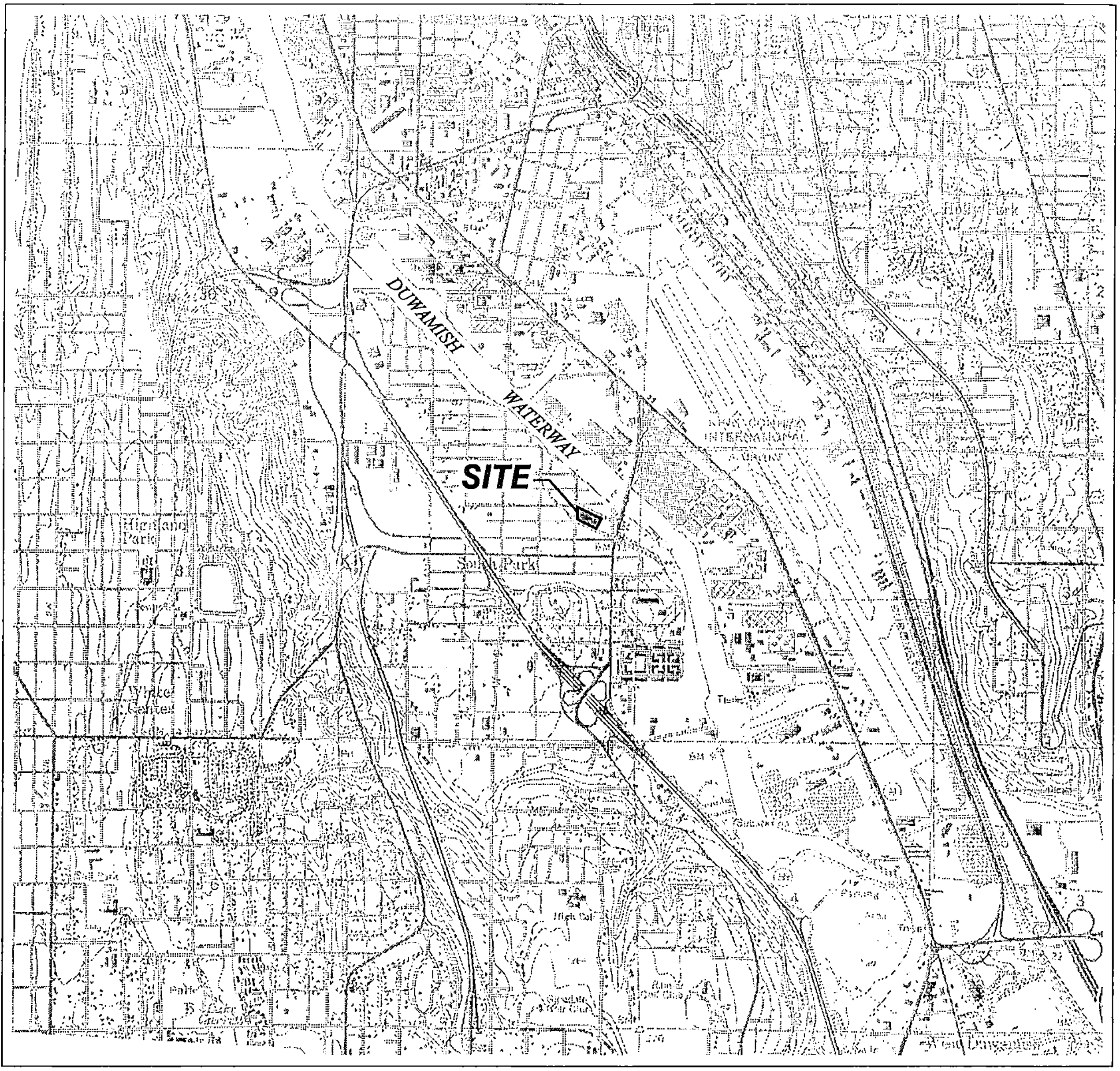
U: Not detected above the laboratory detection limit indicated.

Dup: Field duplicate sample.

NA: Not analyzed

Exceedences of cleanup levels are shown in bold type.

Vicinity Map



COREL\468602\VMAP468602

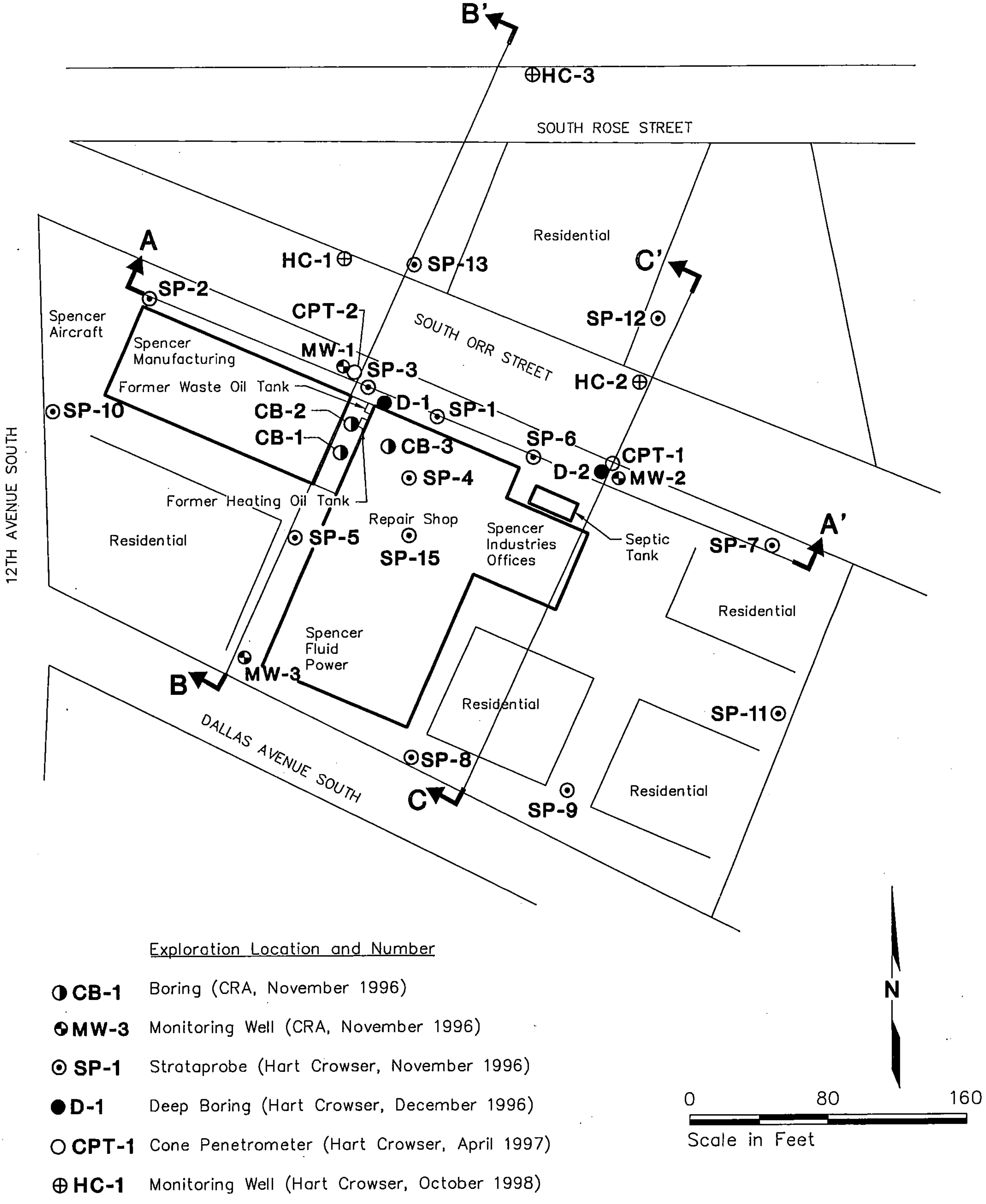
Note: Base map prepared from USGS 7.5 minute quadrangle map or Seattle South, Washington, dated 1973.

HARTCROWSER

J-4686-02 **3/99**

Figure 1

Site and Exploration Plan



Exploration Location and Number

◑ CB-1	Boring (CRA, November 1996)
⊕ MW-3	Monitoring Well (CRA, November 1996)
⊙ SP-1	Strataprobe (Hart Crowser, November 1996)
● D-1	Deep Boring (Hart Crowser, December 1996)
○ CPT-1	Cone Penetrometer (Hart Crowser, April 1997)
⊕ HC-1	Monitoring Well (Hart Crowser, October 1998)
AA'	Cross Section Location and Designation (See Figure 3 through 5)

Note: Additional boring locations from potential solvent source area investigation are shown on Figure 7.

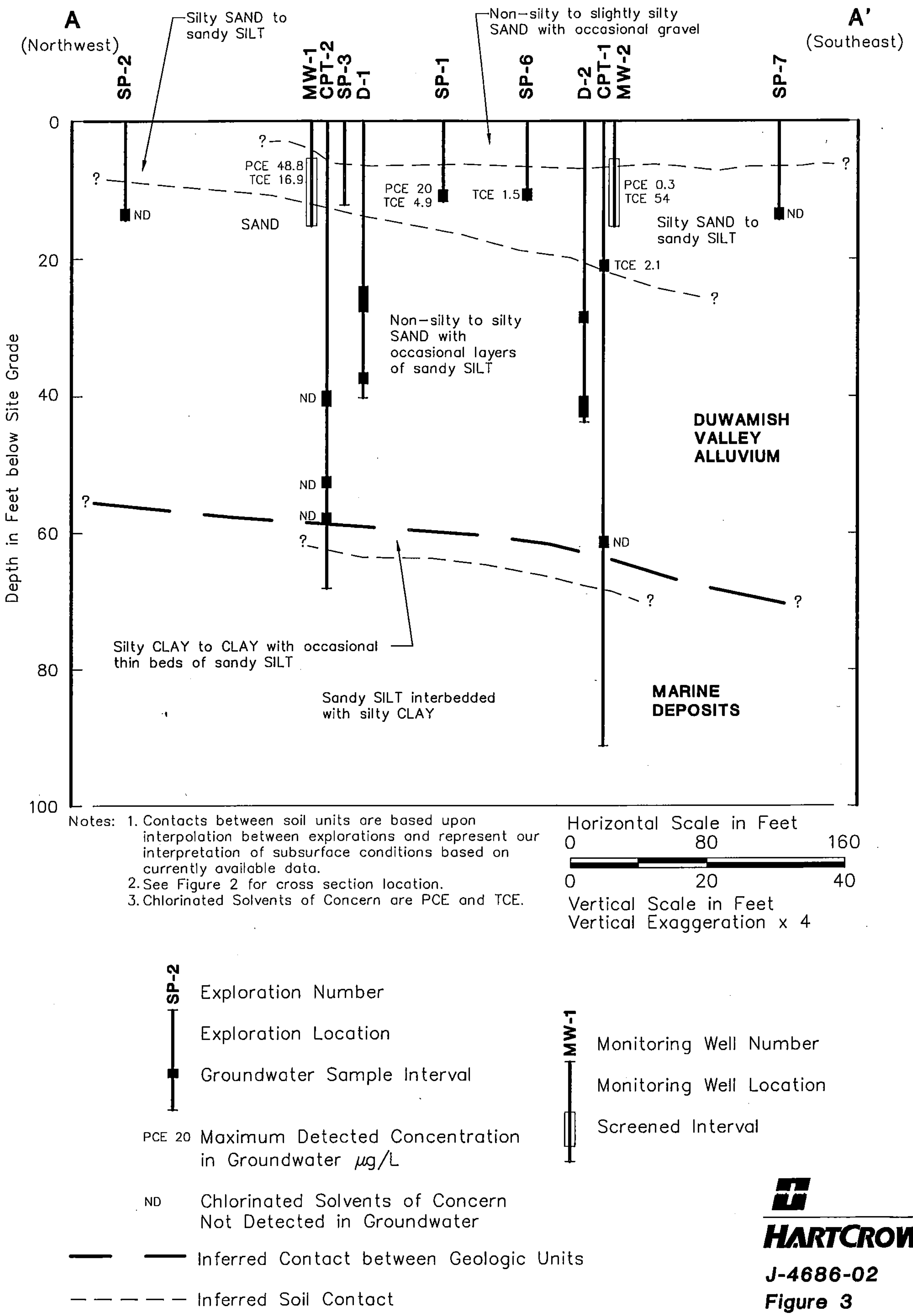
HARTCROWSER

J-4686-02 3/99

Figure 2

CVD 3/31/99 1=80 wdstk-8.pc2
46860204

Geologic Cross Section A-A'



Notes:
1. Contacts between soil units are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 2 for cross section location.
3. Chlorinated Solvents of Concern are PCE and TCE.

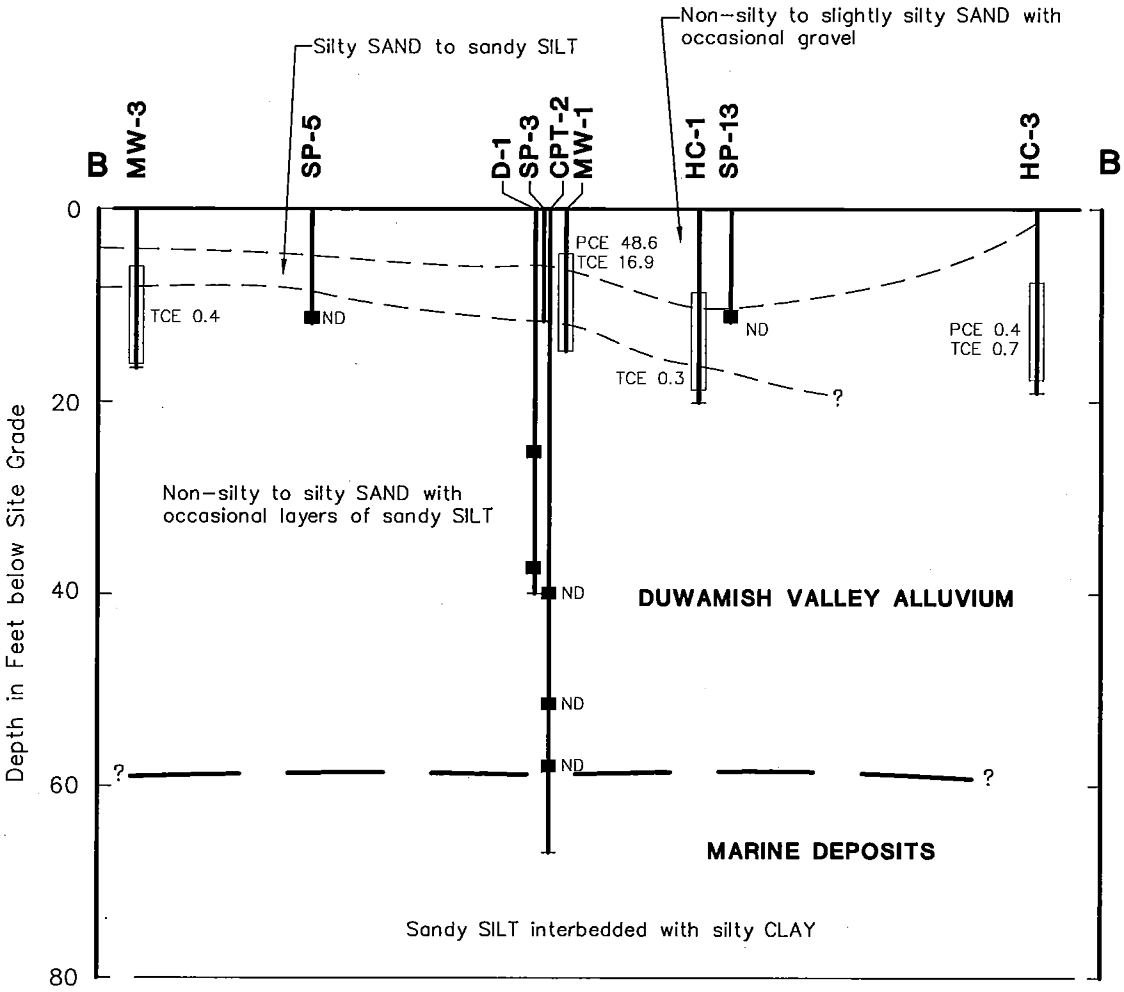
HARTCROWSER

J-4686-02 3/99

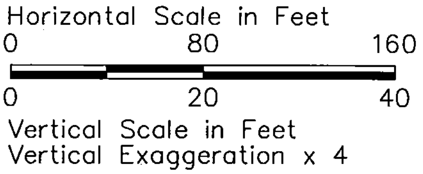
Figure 3

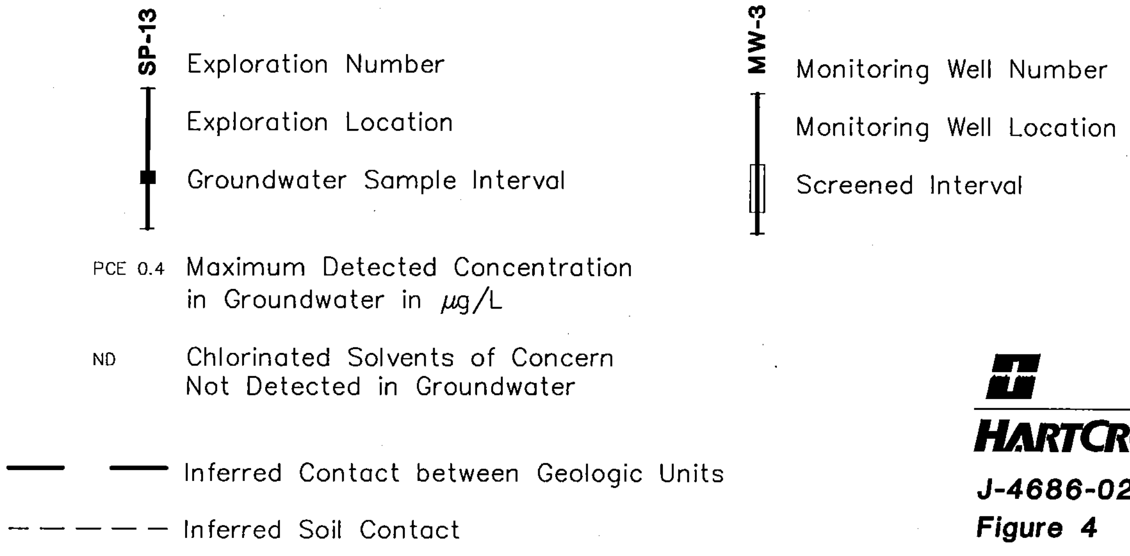
CVD 3/31/99 1=80 WDSTK-8.PC2
4686026

Geologic Cross Section B-B'



Notes:
1. Contacts between soil units are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 2 for cross section location.
3. Chlorinated Solvents of Concern are PCE and TCE.

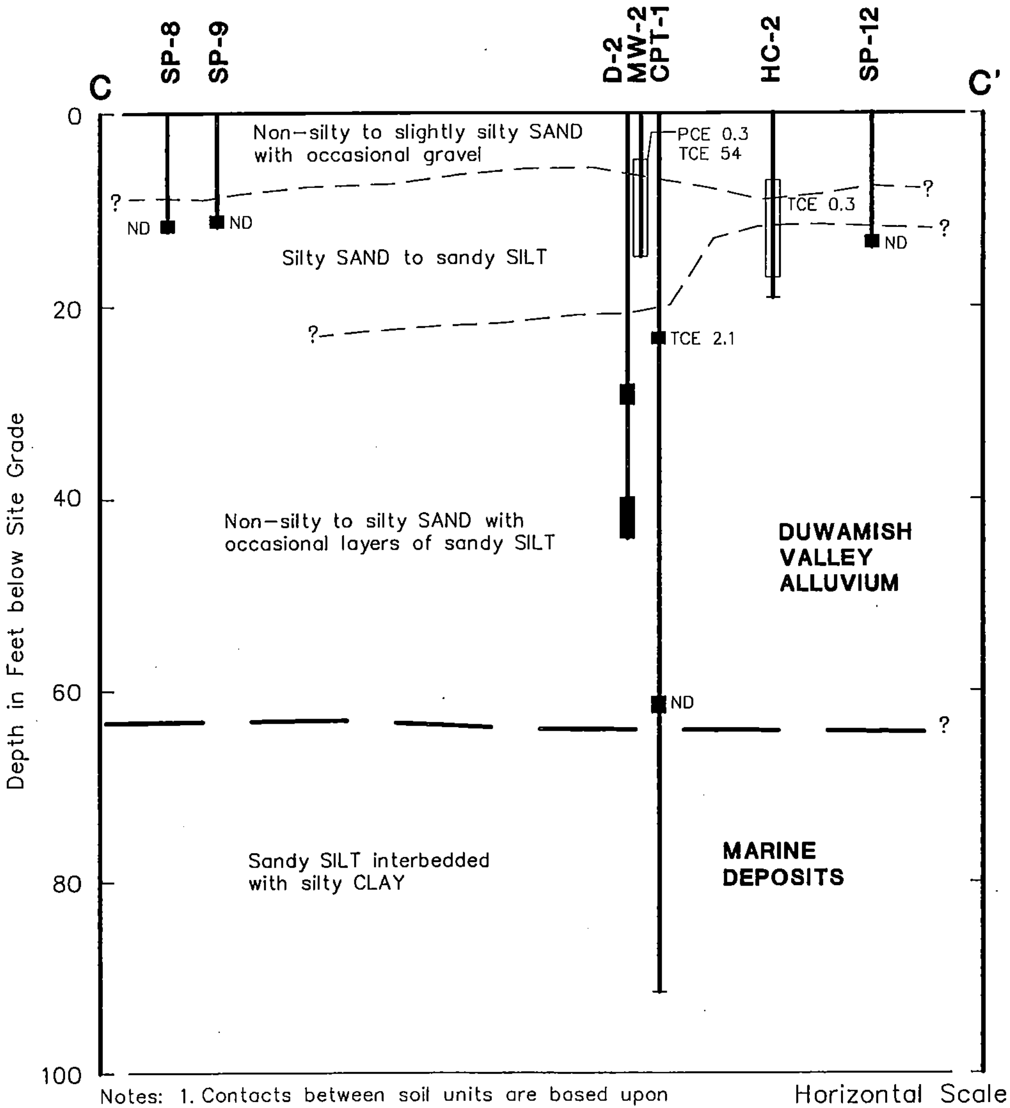




HARTCROWSER

J-4686-02 3/99
Figure 4

Geologic Cross Section C-C'



Notes:
1. Contacts between soil units are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 2 for cross section location.
3. Chlorinated Solvents of Concern are PCE and TCE.

Horizontal Scale in Feet
0 80 160

0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 4

SP-13 Exploration Number

Exploration Location

Groundwater Sample Interval

PCE 00.3 Maximum Detected Concentration in Groundwater in μg/L

ND Chlorinated Solvents of Concern Not Detected in Groundwater

MW-2 Monitoring Well Number

Monitoring Well Location

Screened Interval

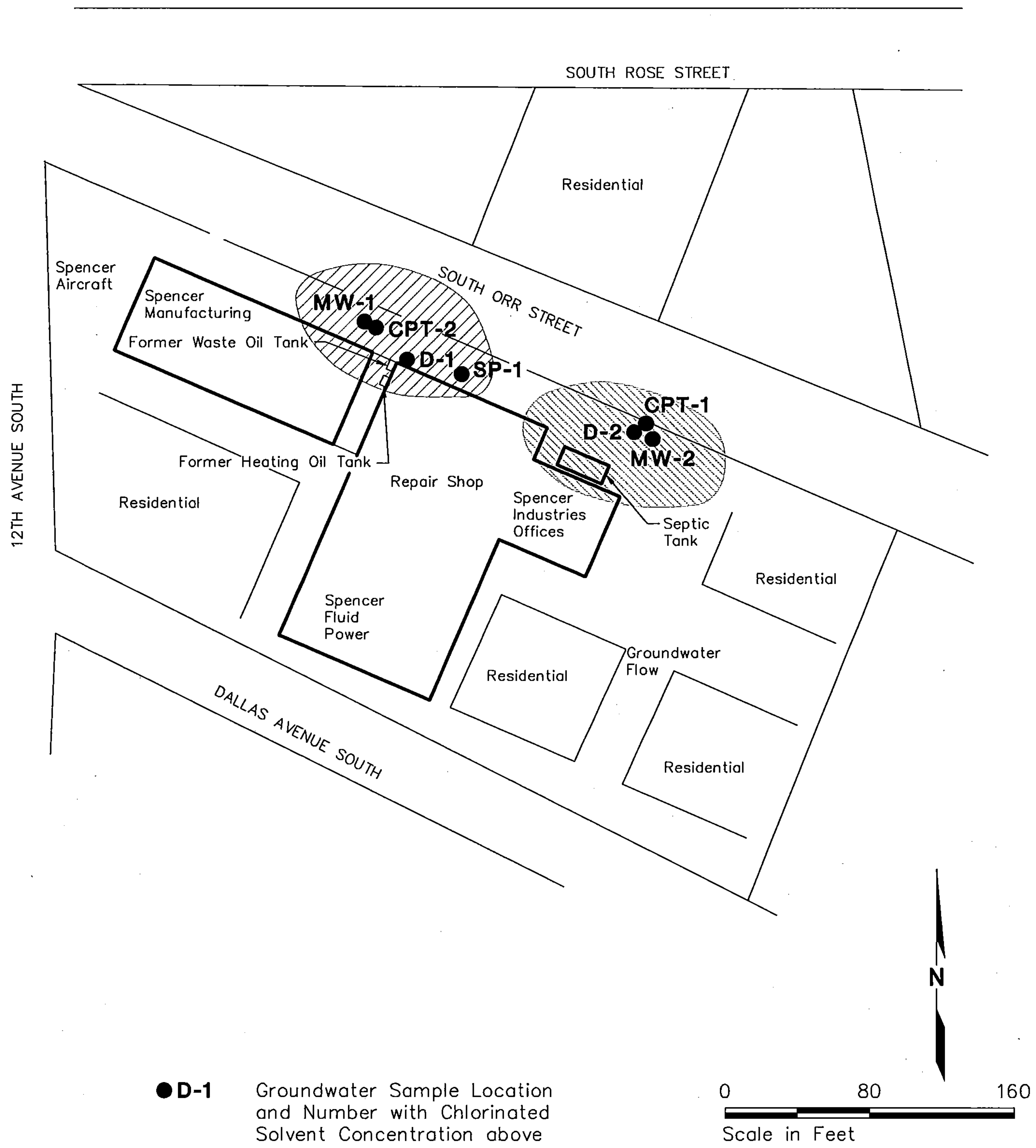
— — Inferred Contact between Geologic Units

– – – – – Inferred Soil Contact

CVD 3/31/99 1=80 WDSTK-8.PC2
46860208

HARTCROWSER
J-4686-02 3/99
Figure 5

Extent of Solvent-Impacted Groundwater



● **D-1** Groundwater Sample Location and Number with Chlorinated Solvent Concentration above MTCA Method A Cleanup Levels

▨ Approximate Extent of PCE/TCE–Impacted Groundwater

▨ Approximate Extent of TCE–Impacted Groundwater

HARTCROWSER

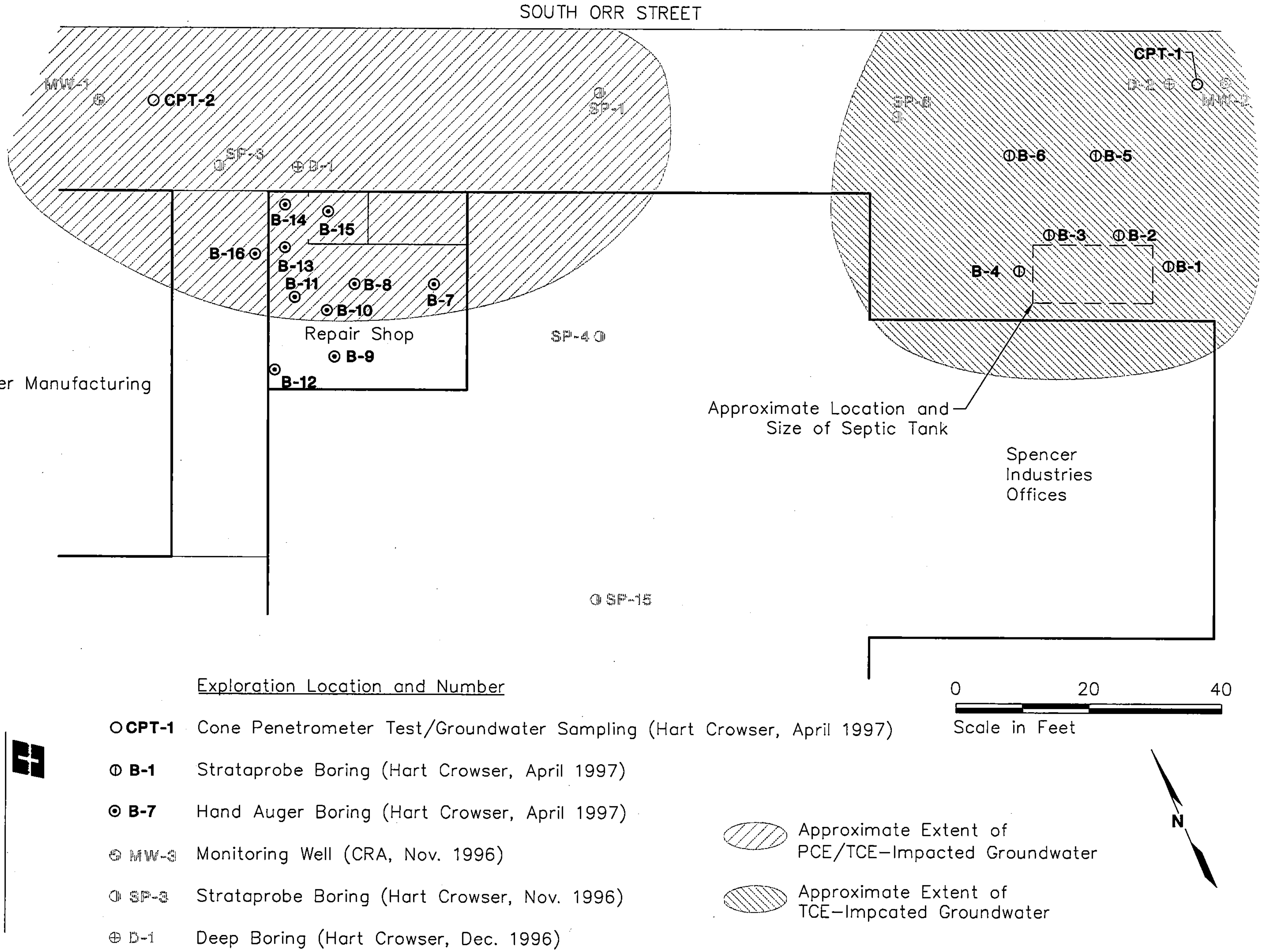
J-4686-02 3/99

Figure 6

CVD 3/23/99 1=80 wdstk-8.pc2
46860205

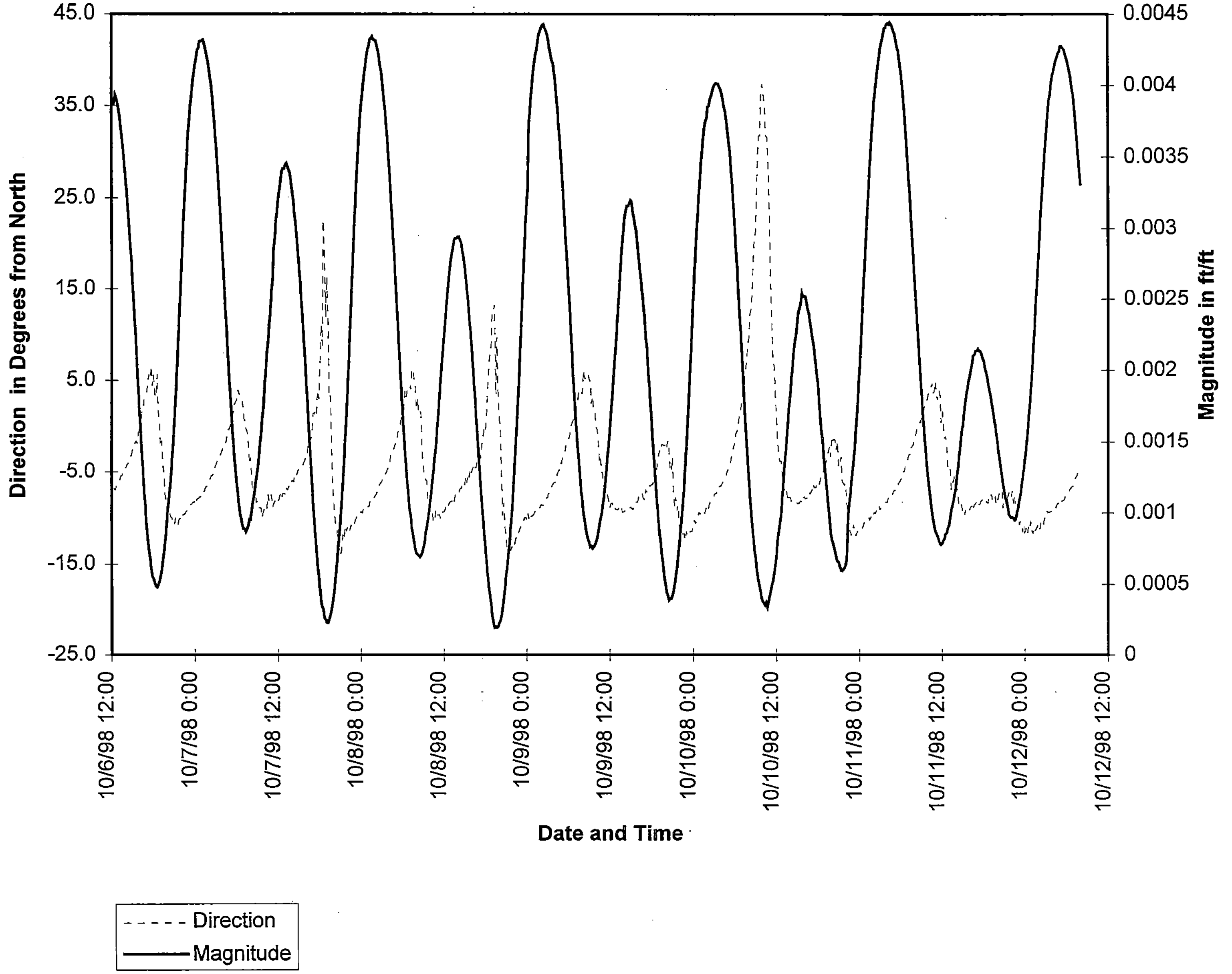
Potential Source Area Exploration Plan

CVD 3/31/99 1=20 wdstk-8.pc2
46860203



HARTCROWSER
J-4686-02 3/99
Figure 7

Magnitude and Direction of Hydraulic Gradient at Spencer Industries



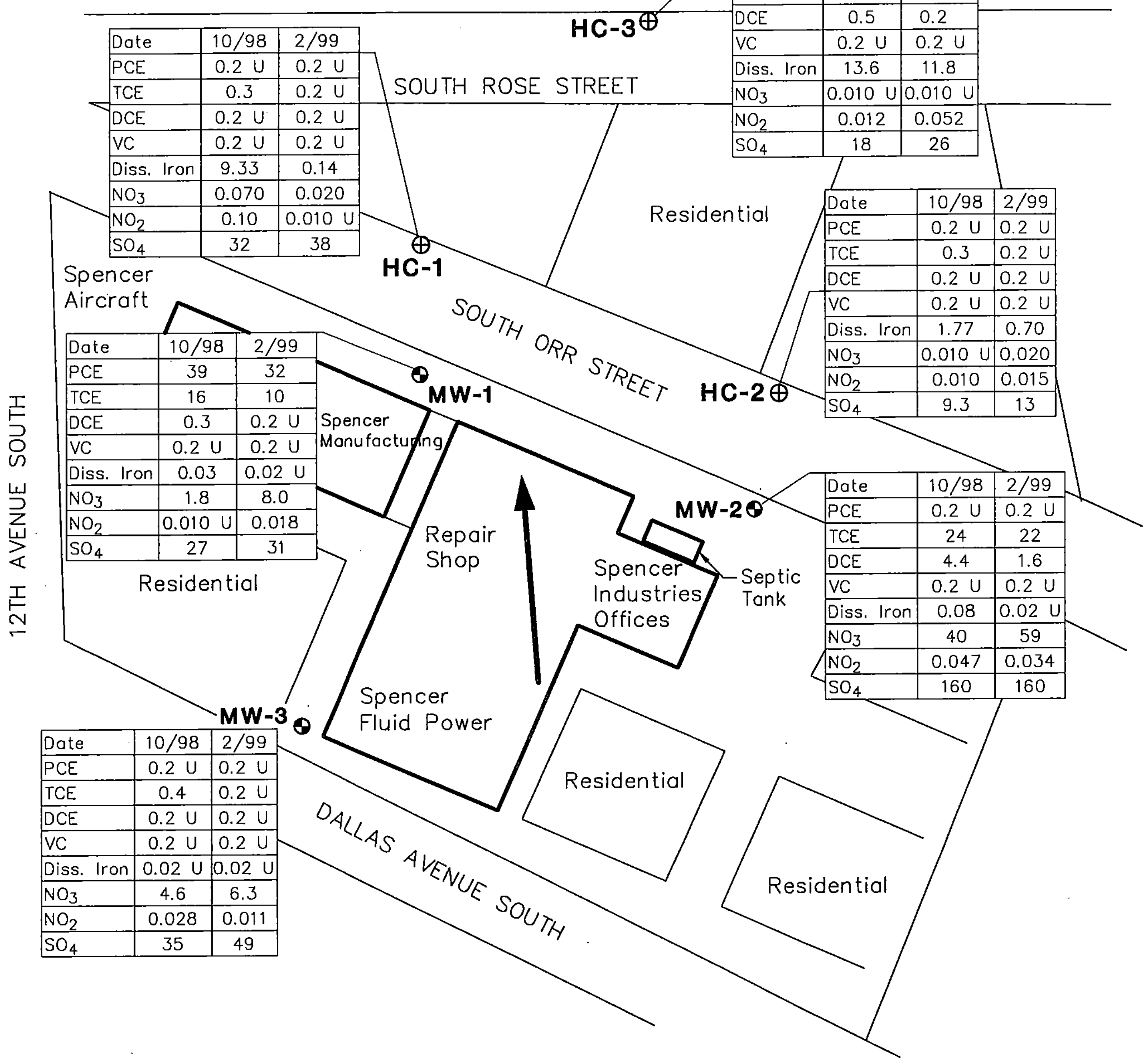
HARTCROWSER

J-4686-02 3/99

Figure 8

manual figure

Groundwater Analytical Data-
Natural Attenuation Study



Date	10/98	2/99
PCE	0.3	0.4
TCE	0.7	0.4
DCE	0.5	0.2
VC	0.2 U	0.2 U
Diss. Iron	13.6	11.8
NO_3	0.010 U	0.010 U
NO_2	0.012	0.052
SO_4	18	26

Date	10/98	2/99
PCE	0.2 U	0.2 U
TCE	0.3	0.2 U
DCE	0.2 U	0.2 U
VC	0.2 U	0.2 U
Diss. Iron	9.33	0.14
NO_3	0.070	0.020
NO_2	0.10	0.010 U
SO_4	32	38

Date	10/98	2/99
PCE	0.2 U	0.2 U
TCE	0.3	0.2 U
DCE	0.2 U	0.2 U
VC	0.2 U	0.2 U
Diss. Iron	1.77	0.70
NO_3	0.010 U	0.020
NO_2	0.010	0.015
SO_4	9.3	13

Date	10/98	2/99
PCE	39	32
TCE	16	10
DCE	0.3	0.2 U
VC	0.2 U	0.2 U
Diss. Iron	0.03	0.02 U
NO_3	1.8	8.0
NO_2	0.010 U	0.018
SO_4	27	31

Date	10/98	2/99
PCE	0.2 U	0.2 U
TCE	24	22
DCE	4.4	1.6
VC	0.2 U	0.2 U
Diss. Iron	0.08	0.02 U
NO_3	40	59
NO_2	0.047	0.034
SO_4	160	160

Date	10/98	2/99
PCE	0.2 U	0.2 U
TCE	0.4	0.2 U
DCE	0.2 U	0.2 U
VC	0.2 U	0.2 U
Diss. Iron	0.02 U	0.02 U
NO_3	4.6	6.3
NO_2	0.028	0.011
SO_4	35	49

MW-3	Monitoring Well Location and Number (CRA, November 1996)
⊕ HC-1	Monitoring Well Location and Number (Hart Crowser, October 1998)
←	Average Groundwater Flow Direction
PCE, TCE, DCE, and VC	Concentration in µg/L
Iron, NO_3, NO_2, and SO_4	Concentration in mg/L
U	Not Detected at detection limit indicated

January 1999 anomolous sampling round data not shown.

N

0 80 160
Scale in Feet

HARTCROWSER

J-4686-02 3/99

Figure 9

CVD 3/31/99 1=80 woodstk.pc2
4686201

APPENDIX A
FIELD PROCEDURES AND EXPLORATION LOGS

APPENDIX A
FIELD PROCEDURES AND EXPLORATION LOGS

This appendix summarizes the subsurface explorations, monitoring well installation procedures, and soil and groundwater sampling activities conducted by Hart Crowser at the Spencer Industries property located at 8410 Dallas Avenue South, in Seattle, Washington. Figures presenting the various explorations conducted at this site are presented at the end of this appendix. The following field activities are discussed in this appendix:

- Soil Sampling;
- Cone Penetrometer Explorations;
- Monitoring Well Installation and Development; and
- Groundwater Sampling.

Explorations and Their Location

Subsurface explorations performed for Hart Crowser for this project include borings SP-1 through SP-14, borings B-1 through B-16, borings D-1 and D-2, monitoring wells HC-1 through HC-3, and cone penetrometer probes CPT-1 and CPT-2. The exploration logs within this appendix show our interpretation of the drilling data. They indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Figures 2 and 7 show the location of explorations, located by hand taping or pacing from existing physical features. Top of casing elevations of the monitoring wells were surveyed by Hart Crowser on October 30, 1998, using an assumed elevation datum of 100 feet at MW-3.

Soil Sampling

The soil sampling completed in November 1996 included fourteen Strataprobe borings (SP-1 through SP-14) at the locations shown on Figure 2. Borings were completed at depths of 12 to 14 feet. Based on field screening results, ten soil samples (plus two field duplicates) were selected from nine of the borings (SP-1, SP-3, SP-4, SP-5, SP-6, SP-10, SP-12, SP-13, and SP-14) for analysis of VOCs.

The soil sampling completed in April 1997 as part of the potential source area assessment included sixteen borings (B-1 through B-16), from which 24 soil samples were selected for analysis of VOCs. Six borings (B-1 through B-6) were performed using a Strataprobe and were completed at depths of approximately 9 feet. The remaining ten (B-7 through B-16) were performed using a rotohammer.

Soil samples were field screened using a HNU photoionization detector. Headspace measurements were taken by half filling a 16-oz jar with soil, covering the opening with aluminum foil and allowing to sit for at least 15 minutes. Vapor concentration was measured by piercing the foil with the tip of the PID and recording the relative HNU concentration. These values were used to help select soil samples for chemical analysis.

Samples were collected in 4-oz glass jars with teflon lined lids, which were placed in a cooler with blue ice. Sample jars were filled completely and compacted using a stainless steel spoon to minimize head space.

Selected samples were transported to Hart Crowser Chemistry Laboratory under standard chain of custody protocol and submitted for analysis of volatile organic compounds by EPA method 8010.

Cone Penetrometer Explorations

We used a cone penetrometer to probe the subgrade soils for this study. Completed by Northwest Cone Exploration (NCE) on April 17, 1997, the probes, designated CPT-1 and CPT-2, were advanced to depths of 91 and 67 feet, respectively, below the ground surface. They used a Hogentogler type cone system (See Figure A-30).

The cone and its sleeve provide information by which we can interpret the density and consistency of the soils. A direct correlation exists between the point resistance of the cone and the bearing capacity in the soil. Another direct correlation exists between the friction registered on the sleeve and the friction characteristics of the soil. We use the penetrometer results in conjunction with the soil classification chart developed by Robertson et al. (1990). See Figure A-30.

Logs of cone penetrometer probes are presented on Figures A-31 and A-32.

Monitoring Well Installation and Development

Three monitoring wells (HC-1, HC-2, and HC-3) were installed on October 21, 1998 by McDonald Drilling. Well borings were advanced using a truck mounted hollow-stem auger drill rig. A Hart Crowser geologist observed the drilling and recorded changes in soil lithology. The wells were completed at depths of approximately 20 feet. The wells consist of 2-inch-diameter schedule 40 PVC riser with 10 feet of 2-inch 20-slot screen and a 10/20 Colorado Silica sand pack. The wells were installed with flush-mount monuments, and fitted with locking caps. All drilling equipment was steam cleaned prior to starting each new well.

Following monitoring well installation, the wells were developed to reduce turbidity and increase hydraulic connection with the surrounding aquifer. The wells were developed using a Grundfoss submersible pump. Turbidity in the discharge water was monitored. When the discharge water became clear, the pump head was moved up and down within the well casing to create a surging action and complete development.

Groundwater Sampling

Monitoring Wells and Borings. Groundwater samples were collected from monitoring wells using either a Grundfoss submersible pump or a Whale submersible pump with disposable tubing. Groundwater samples from strataprobe and hollow-stem auger borings were collected using a peristaltic pump with disposable tubing. Depth to groundwater was measured in each monitoring well or boring and recorded prior to the start of purging. Using the recorded depth-to-water measurement, the volume of water within the boring or well casing (casing volume) was calculated. A minimum of three casing volumes of water were purged prior to sample collection.

For the April 1997 and November 1997 sampling rounds, discharge water was collected in a plastic sample cup to measure temperature, pH, and electrical conductivity (EC) after each casing volume. For the November 1998, and January and February 1999 sampling rounds a YSI Model 3560 water quality meter with flow through cell was used to continuously monitor temperature, pH, eH, EC, and dissolved oxygen. If the measurements were stable between the second and third casing volumes a sample was collected. If the parameters were not stable, purging continued until they were stable between successive half casing volumes.

Groundwater samples were collected for laboratory testing by directly filling a labeled sample bottle from the pump discharge line. Dissolved iron samples were field filtered using an inline 0.45 μm filter. Immediately following sample collection, sample containers will be placed in an ice chest containing blue ice or ice for transport to the analytical laboratory under chain of custody control.

Cone Penetrometer Probes. The BAT system was used to collect groundwater samples from the cone penetrometer probes. This system consists of a sealed glass vial which is connected to a wireline to collect the water samples at any specified depth. Rods were pushed to the specified sampling depth and groundwater was drawn into the BAT vial through a syringe needle via a vacuum in the vial. This ensured that the sample was not exposed to the atmosphere, minimizing the losses of VOCs through volatilization. Prior to collecting the sample in the BAT vial, one BAT vial was collected to purge the sample area.

Groundwater samples were transported to the analytical laboratory under chain of custody control.

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 perceptable moisture
Damp	Some perceptable moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptable moisture, probably above optimum

Minor Constituents

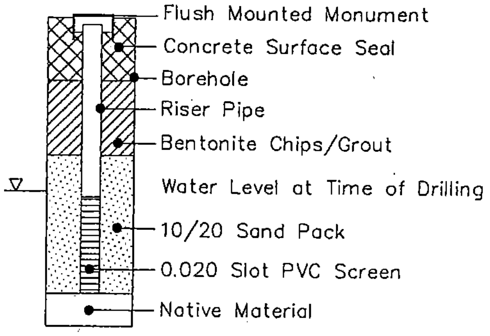
	Estimated Percentage
Not identified in description	0 – 5
Slightly (clayey, silty, etc.)	5 – 12
Clayey, silty, sandy, gravelly	12 – 30
Very (clayey, silty, etc.)	30 – 50

Legends

Sampling Test Symbols

BORING SAMPLES		TEST PIT SAMPLES	
☒	Split Spoon	☒	Grab (Jar)
⧅	Shelby Tube	⧅	Shelby Tube
▥	Cuttings	⧄	Bag
◫	Core Run		
*	No Sample Recovery		
P	Tube Pushed, Not Driven		

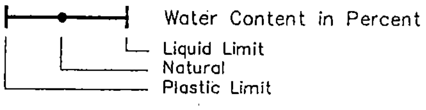
Groundwater Observations



1=1 FLUSH

Test Symbols

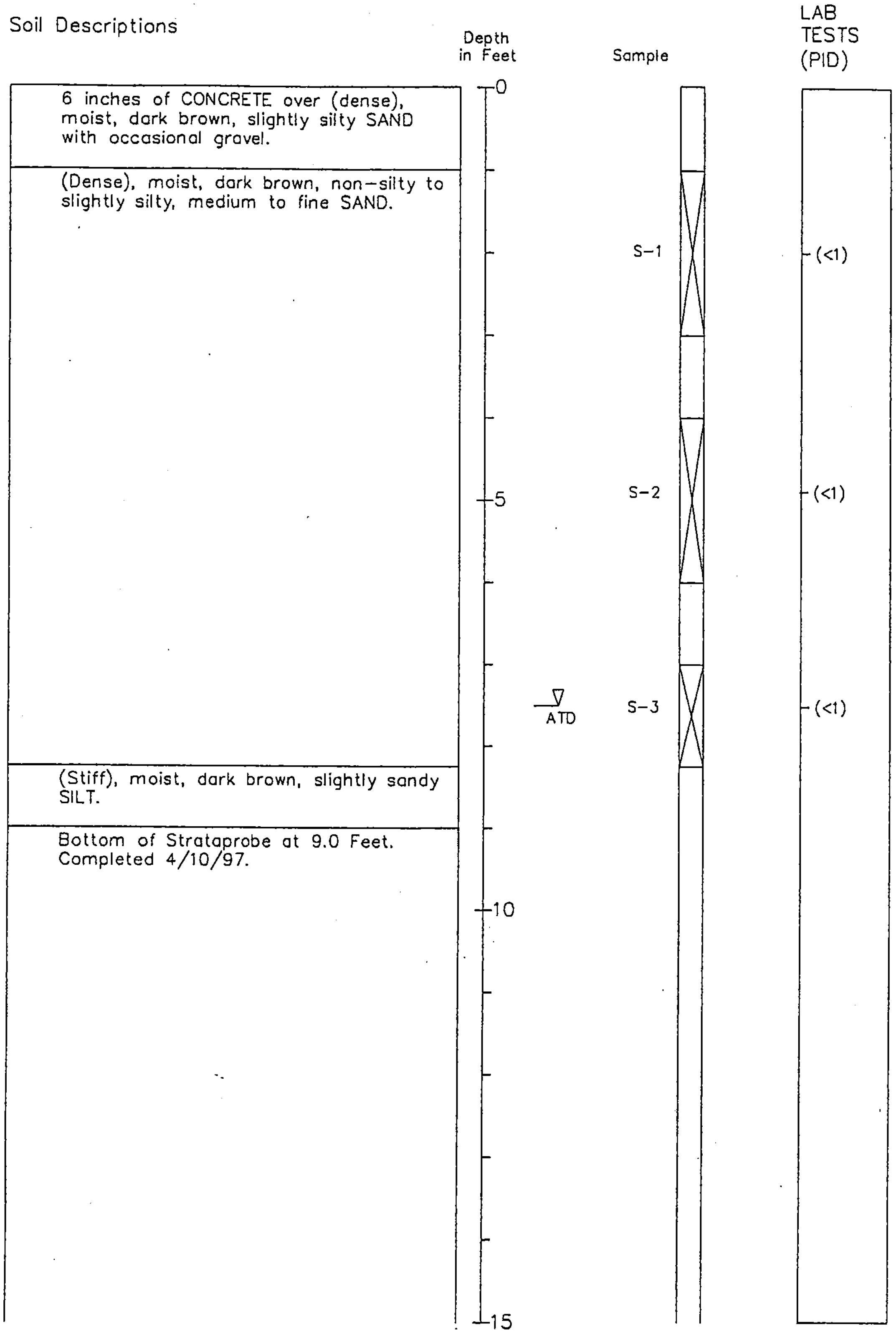
GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeabilty
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear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



HARTCROWSER

J-4686-02 2/99
Figure A-1

Strataprobe Boring Log B-1



6 inches of CONCRETE over (dense), moist, dark brown, slightly silty SAND with occasional gravel.

(Dense), moist, dark brown, non-silty to slightly silty, medium to fine SAND.

(Stiff), moist, dark brown, slightly sandy SILT.

Bottom of Strataprobe at 9.0 Feet. Completed 4/10/97.

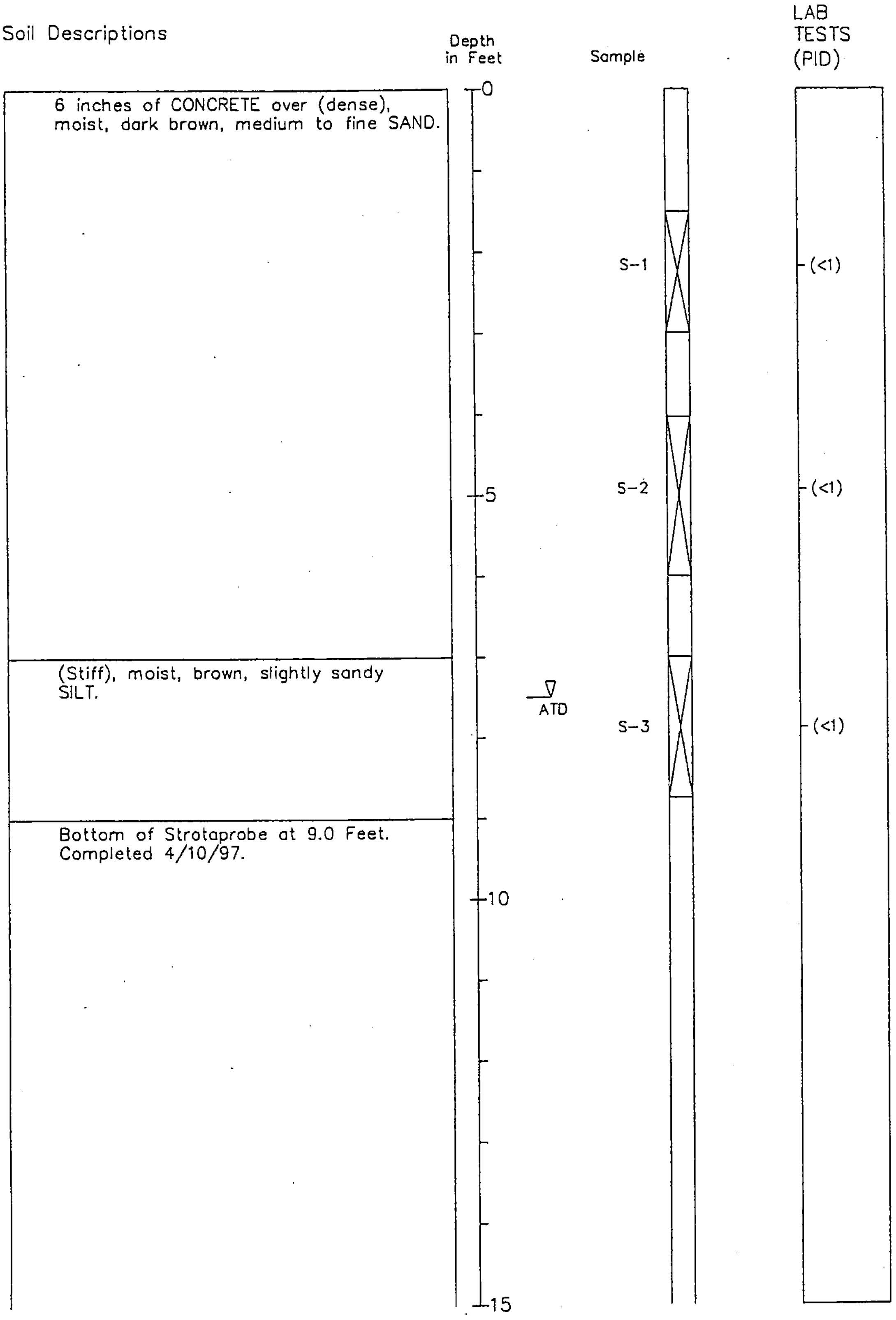
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-01 4/97

Figure A-2

Strataprobe Boring Log B-2



6 inches of CONCRETE over (dense), moist, dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

Bottom of Strataprobe at 9.0 Feet. Completed 4/10/97.

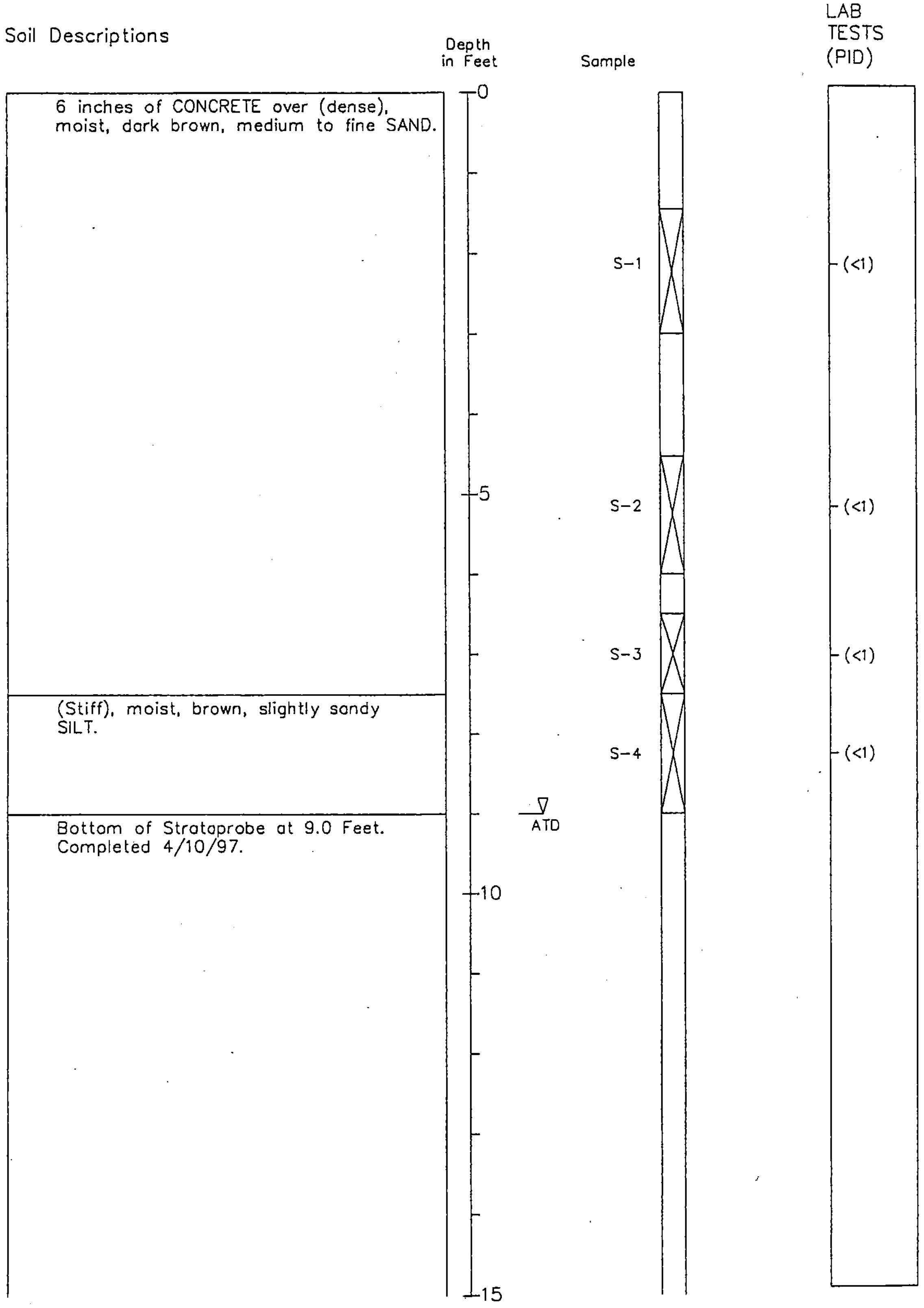
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-01 **4/97**

Figure A-3

Strataprobe Boring Log B-3



6 inches of CONCRETE over (dense), moist, dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

Bottom of Strataprobe at 9.0 Feet. Completed 4/10/97.

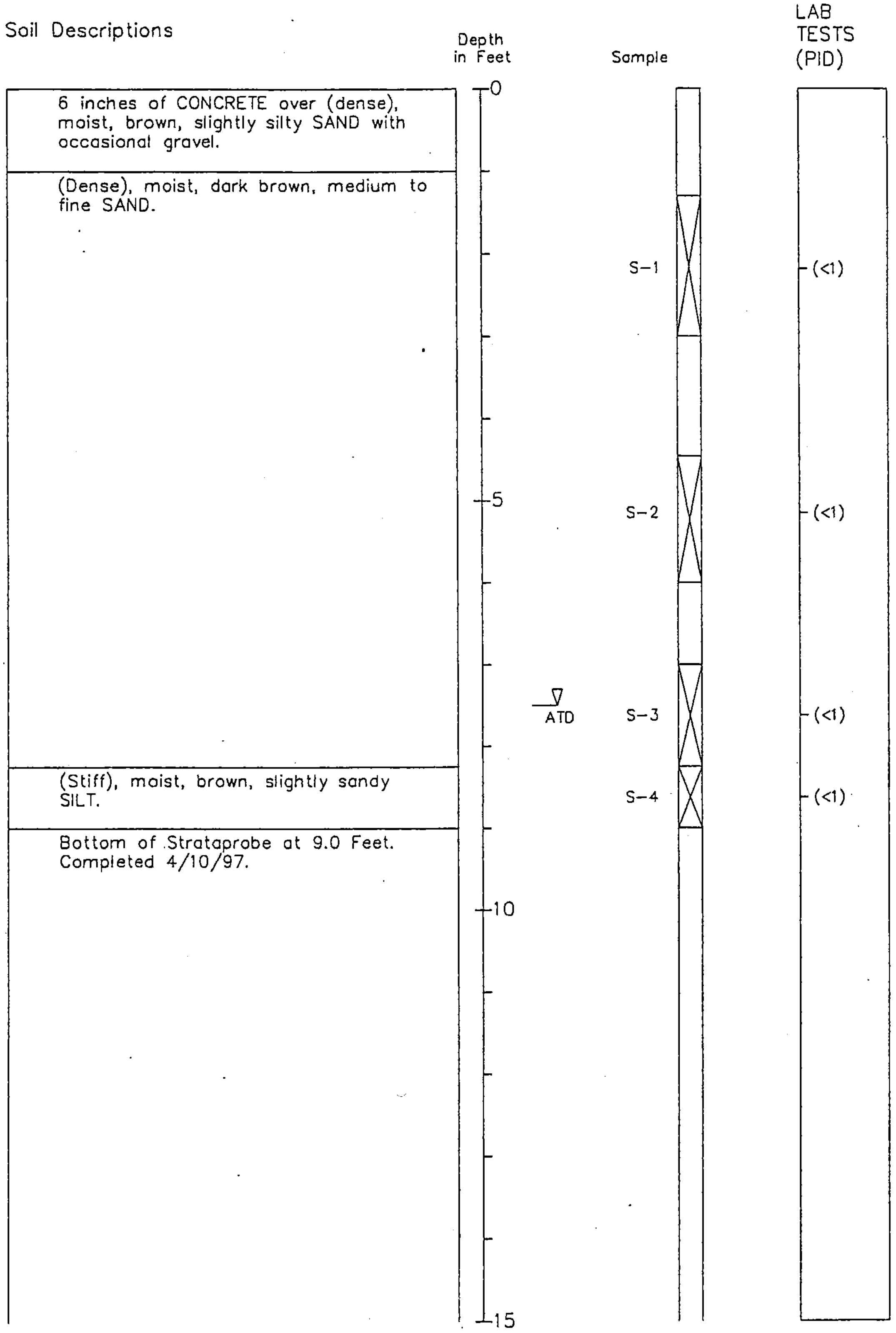
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-01 4/97

Figure A-4

Strataprobe Boring Log B-4



6 inches of CONCRETE over (dense), moist, brown, slightly silty SAND with occasional gravel.

(Dense), moist, dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

Bottom of Strataprobe at 9.0 Feet. Completed 4/10/97.

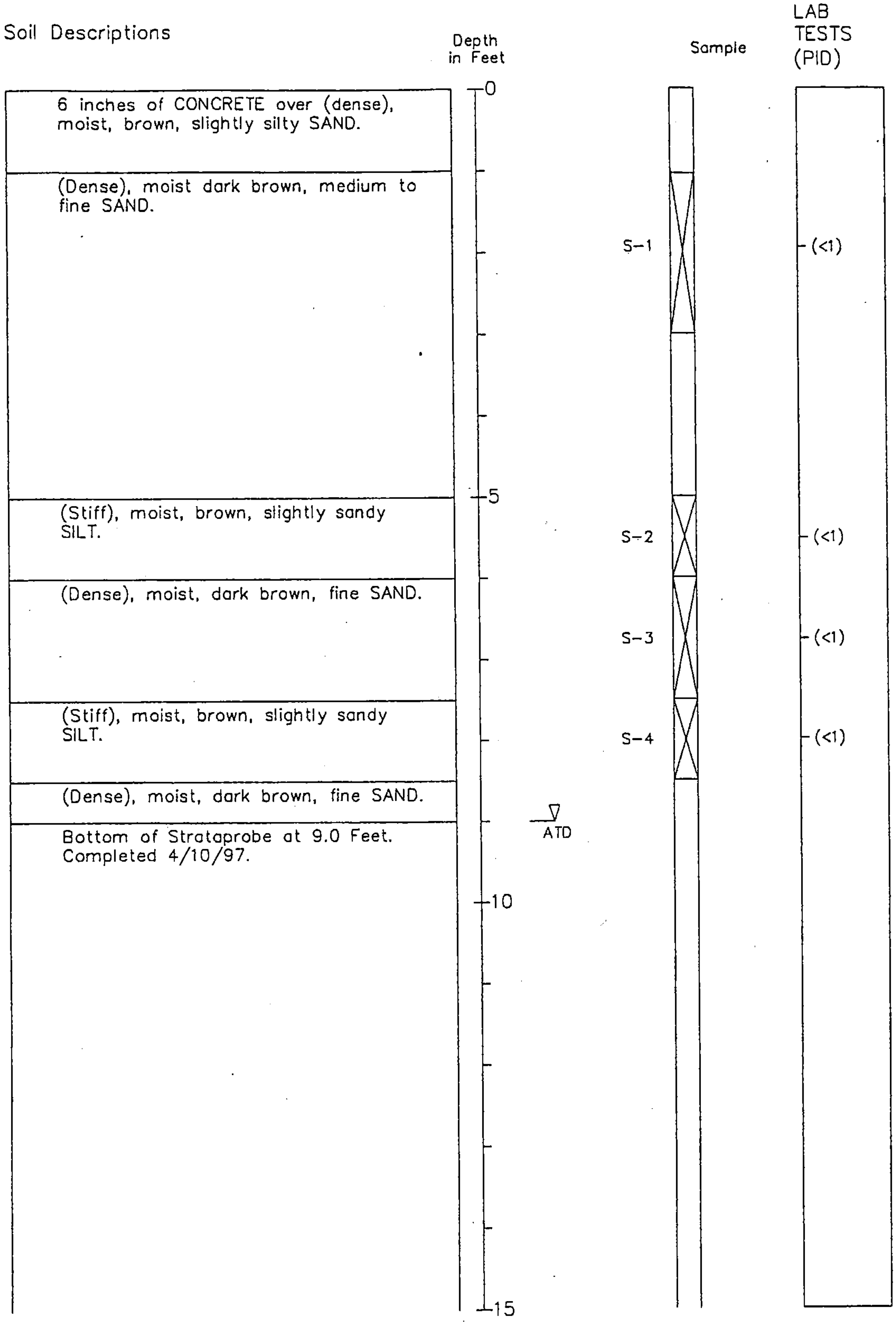
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-01 4/97

Figure A-5

Strataprobe Boring Log B-5



6 inches of CONCRETE over (dense), moist, brown, slightly silty SAND.

(Dense), moist dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

(Dense), moist, dark brown, fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

(Dense), moist, dark brown, fine SAND.

Bottom of Strataprobe at 9.0 Feet.
Completed 4/10/97.

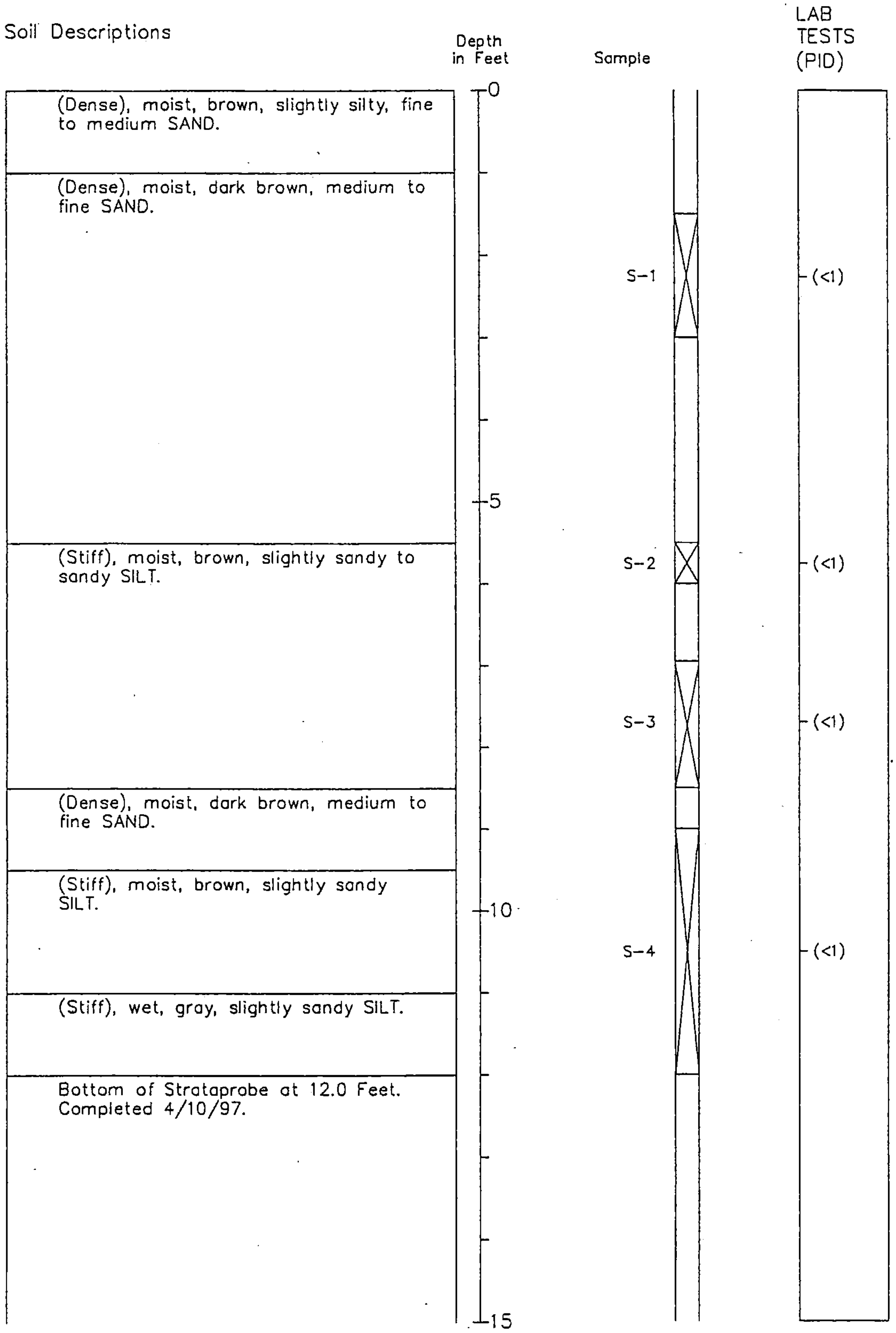
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-01 **4/97**

Figure A-6

Strataprobe Boring Log B-6



(Dense), moist, brown, slightly silty, fine to medium SAND.

(Dense), moist, dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy to sandy SILT.

(Dense), moist, dark brown, medium to fine SAND.

(Stiff), moist, brown, slightly sandy SILT.

(Stiff), wet, gray, slightly sandy SILT.

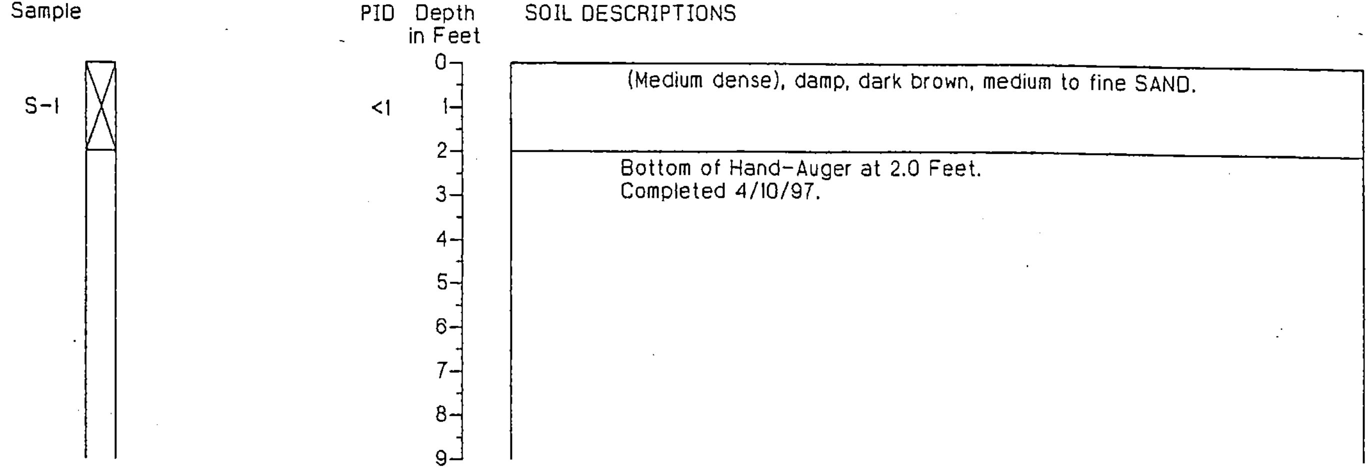
Bottom of Strataprobe at 12.0 Feet.
Completed 4/10/97.

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.

HARTCROWSER

J-4684-01 4/97
Figure A-7

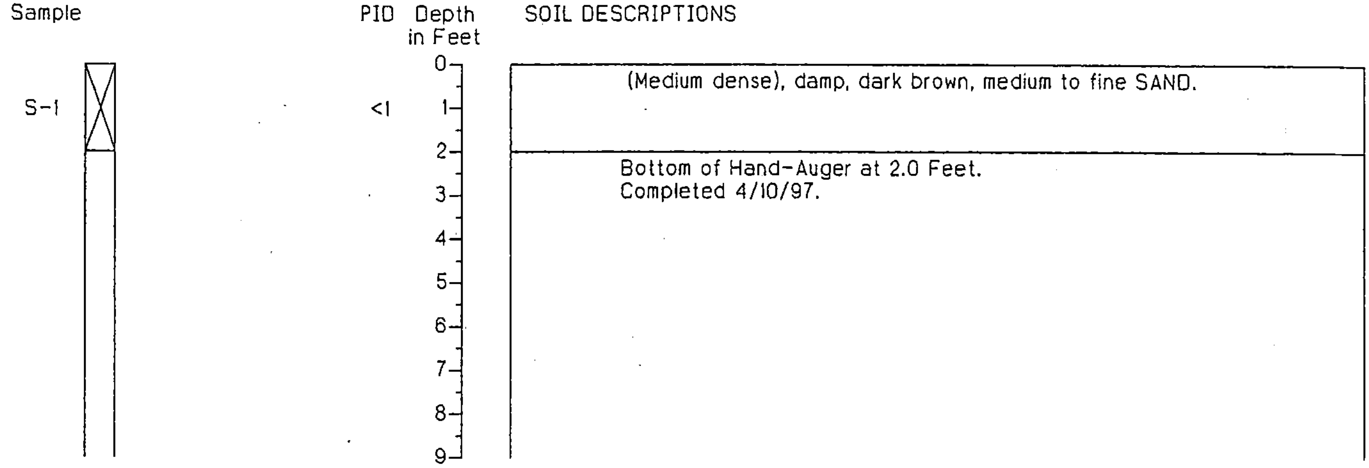
Hand-Auger Boring Log B-7



(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

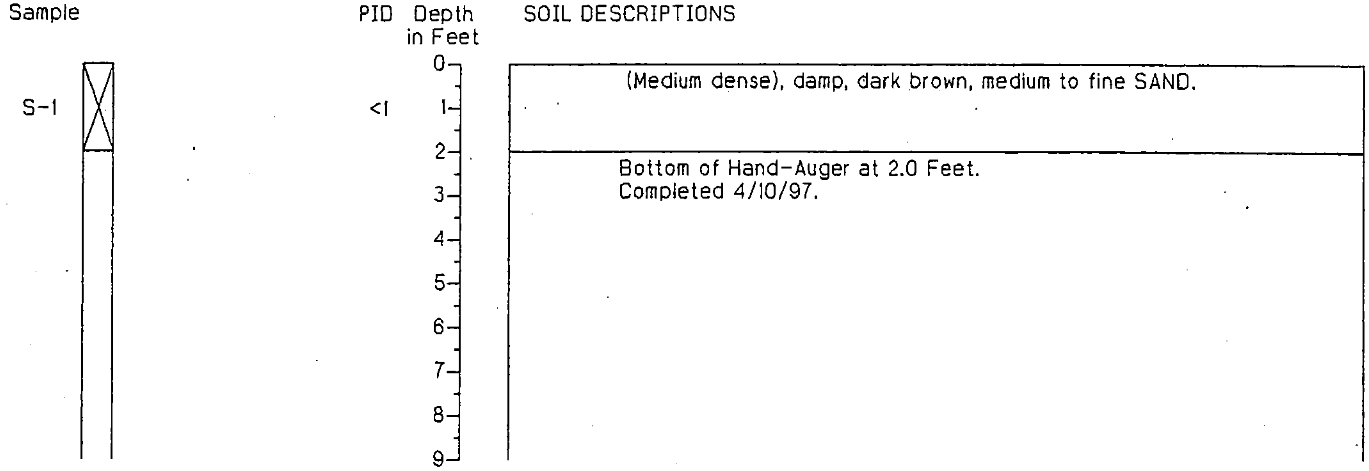
Hand-Auger Boring Log B-8



(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

Hand-Auger Boring Log B-9



(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

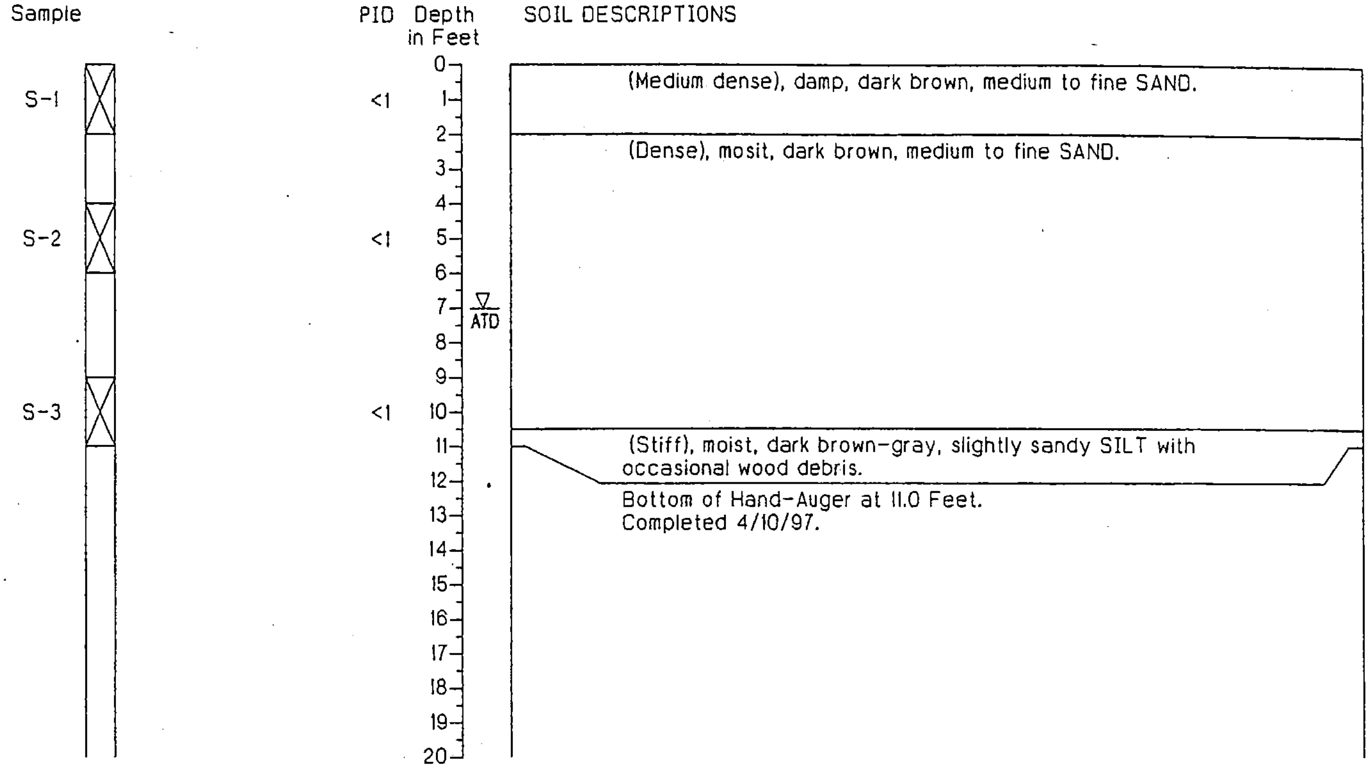
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER

J-4686-01 **4/97**

Figure A-8

Hand-Auger Boring Log B-10



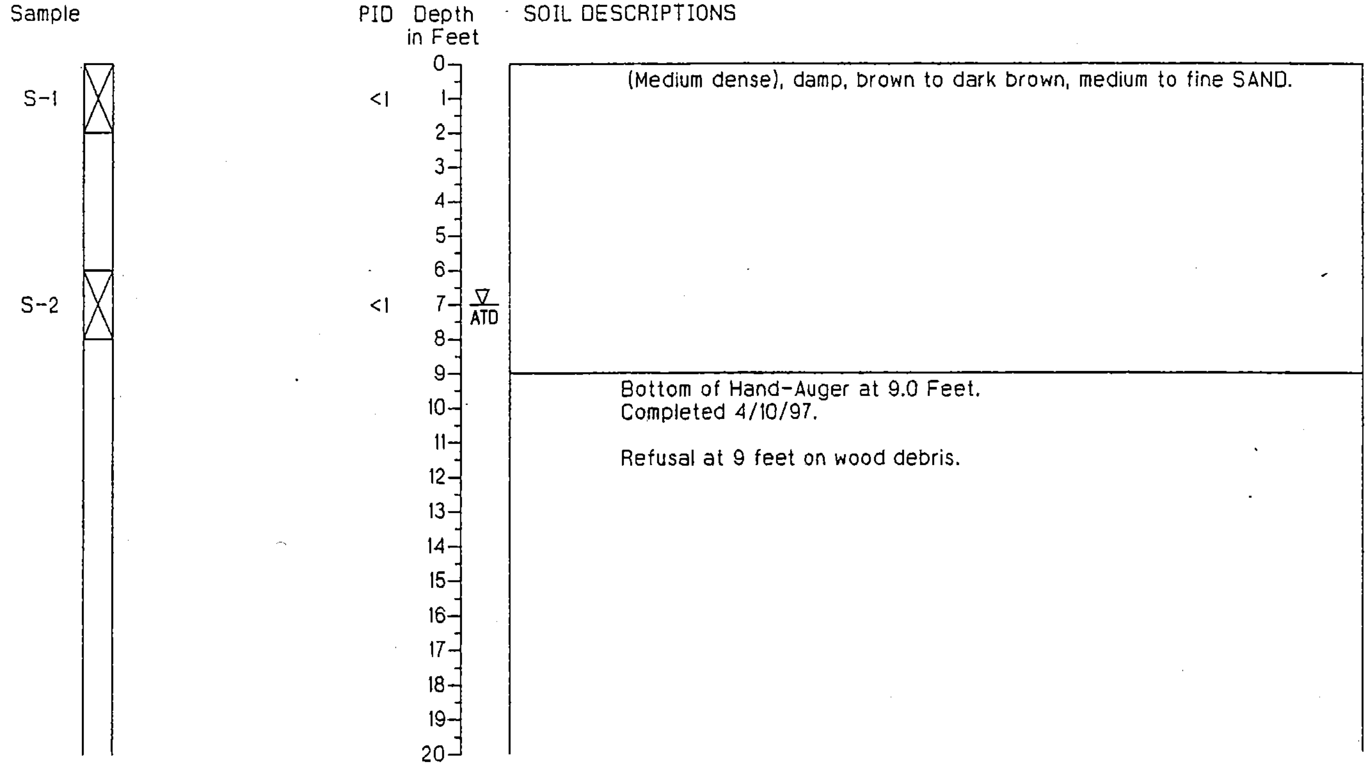
(Medium dense), damp, dark brown, medium to fine SAND.

(Dense), mosit, dark brown, medium to fine SAND.

(Stiff), moist, dark brown-gray, slightly sandy SILT with occasional wood debris.

Bottom of Hand-Auger at 11.0 Feet.
Completed 4/10/97.

Hand-Auger Boring Log B-11



(Medium dense), damp, brown to dark brown, medium to fine SAND.

Bottom of Hand-Auger at 9.0 Feet.
Completed 4/10/97.

Refusal at 9 feet on wood debris.

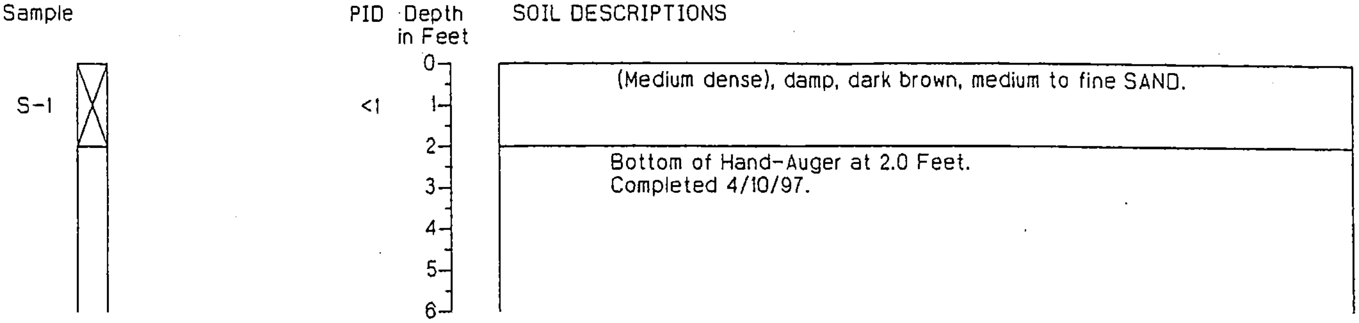
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER

J-4686-01 **4/97**

Figure A-9

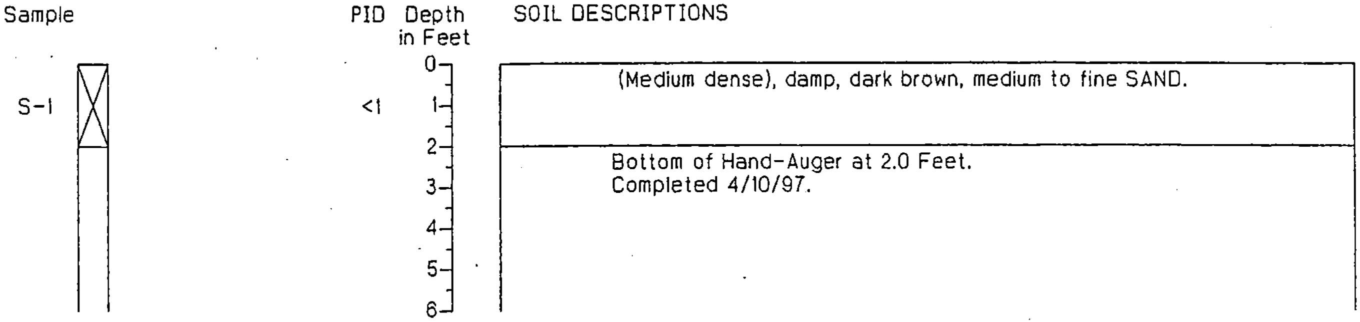
Hand-Auger Boring Log B-12



(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

Hand-Auger Boring Log B-13



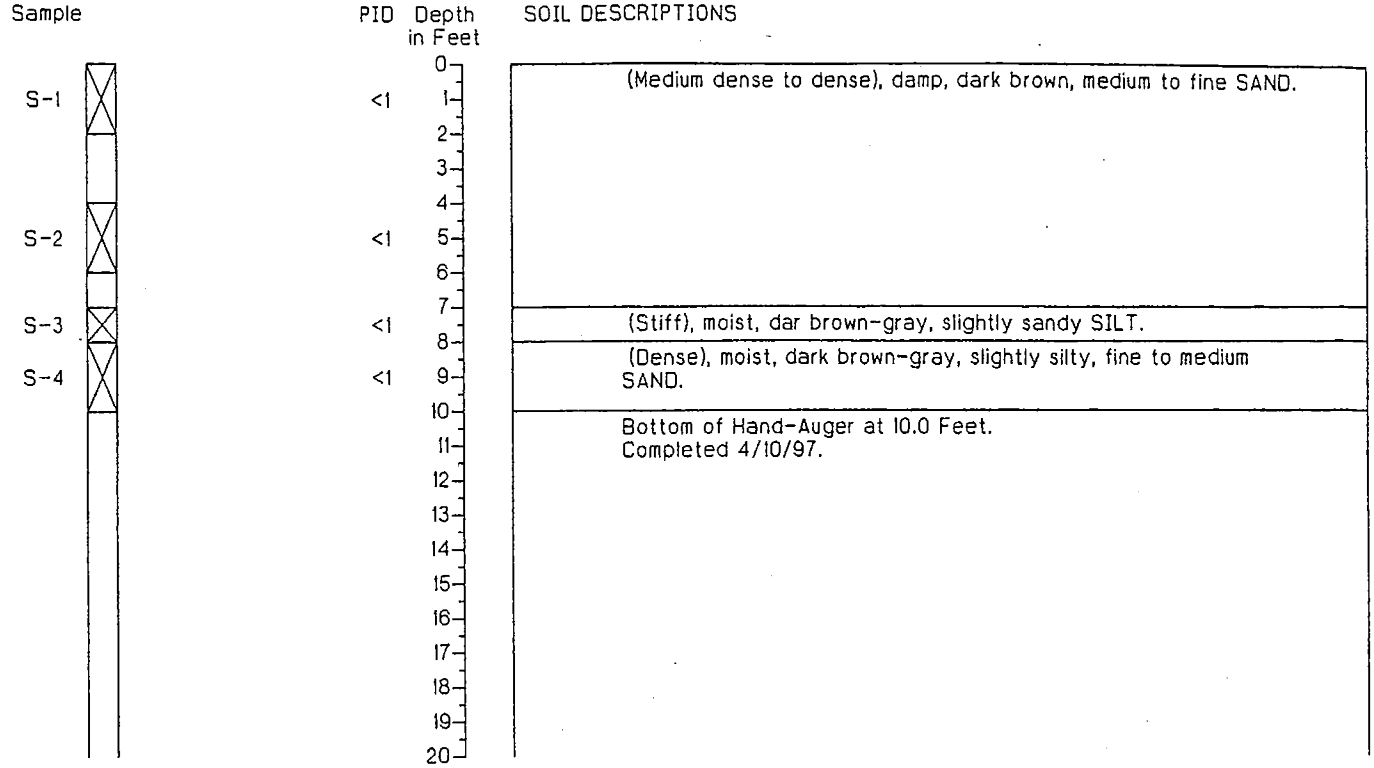
(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

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.

HARTCROWSER
J-4686-01 *4/97*
Figure A-10

Hand-Auger Boring Log B-14



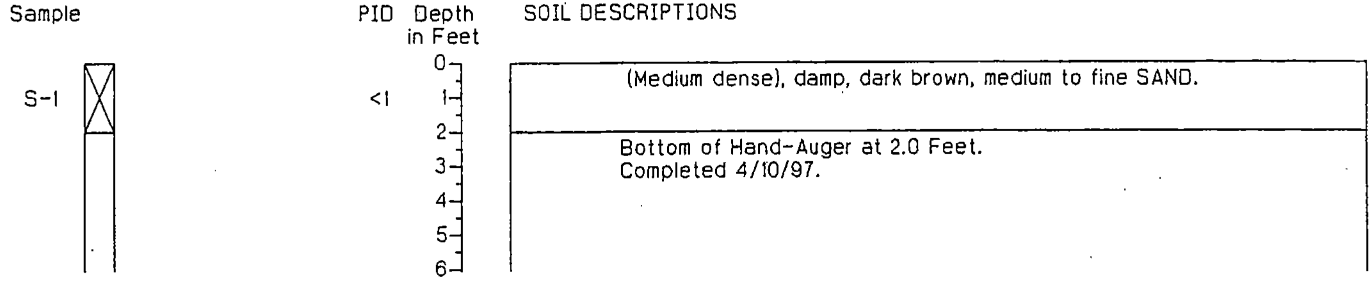
(Medium dense to dense), damp, dark brown, medium to fine SAND.

(Stiff), moist, dar brown-gray, slightly sandy SILT.

(Dense), moist, dark brown-gray, slightly silty, fine to medium SAND.

Bottom of Hand-Auger at 10.0 Feet.
Completed 4/10/97.

Hand-Auger Boring Log B-15



(Medium dense), damp, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 2.0 Feet.
Completed 4/10/97.

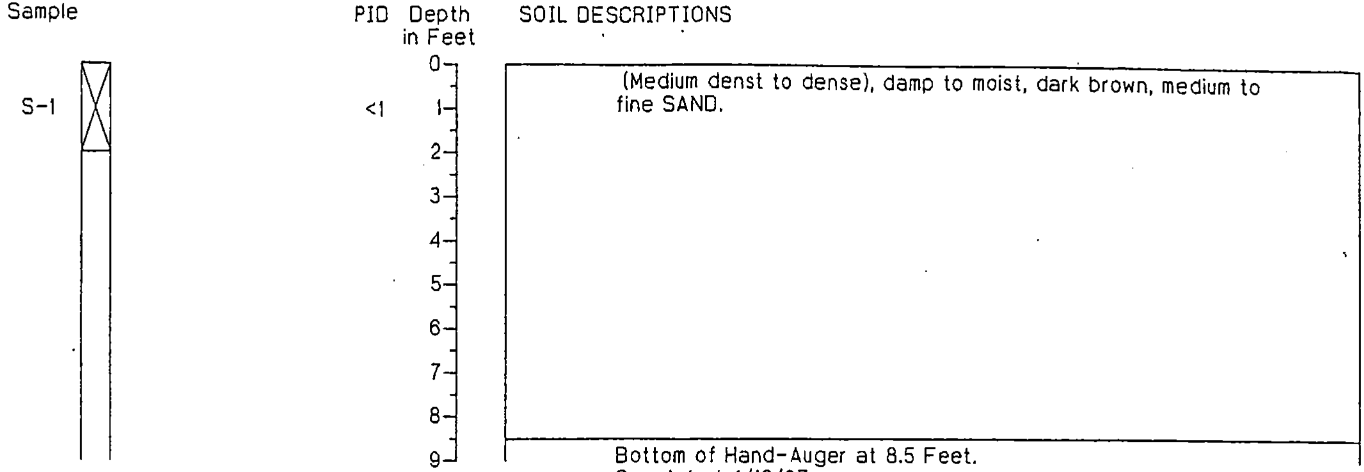
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER

J-4686-01 4/97

Figure A-11

Hand-Auger Boring Log B-16



(Medium denst to dense), damp to moist, dark brown, medium to fine SAND.

Bottom of Hand-Auger at 8.5 Feet.
Completed 4/10/97.

Refusal at 8.5 feet on wood debris.

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.

HARTCROWSER

J-4686-01 4/97

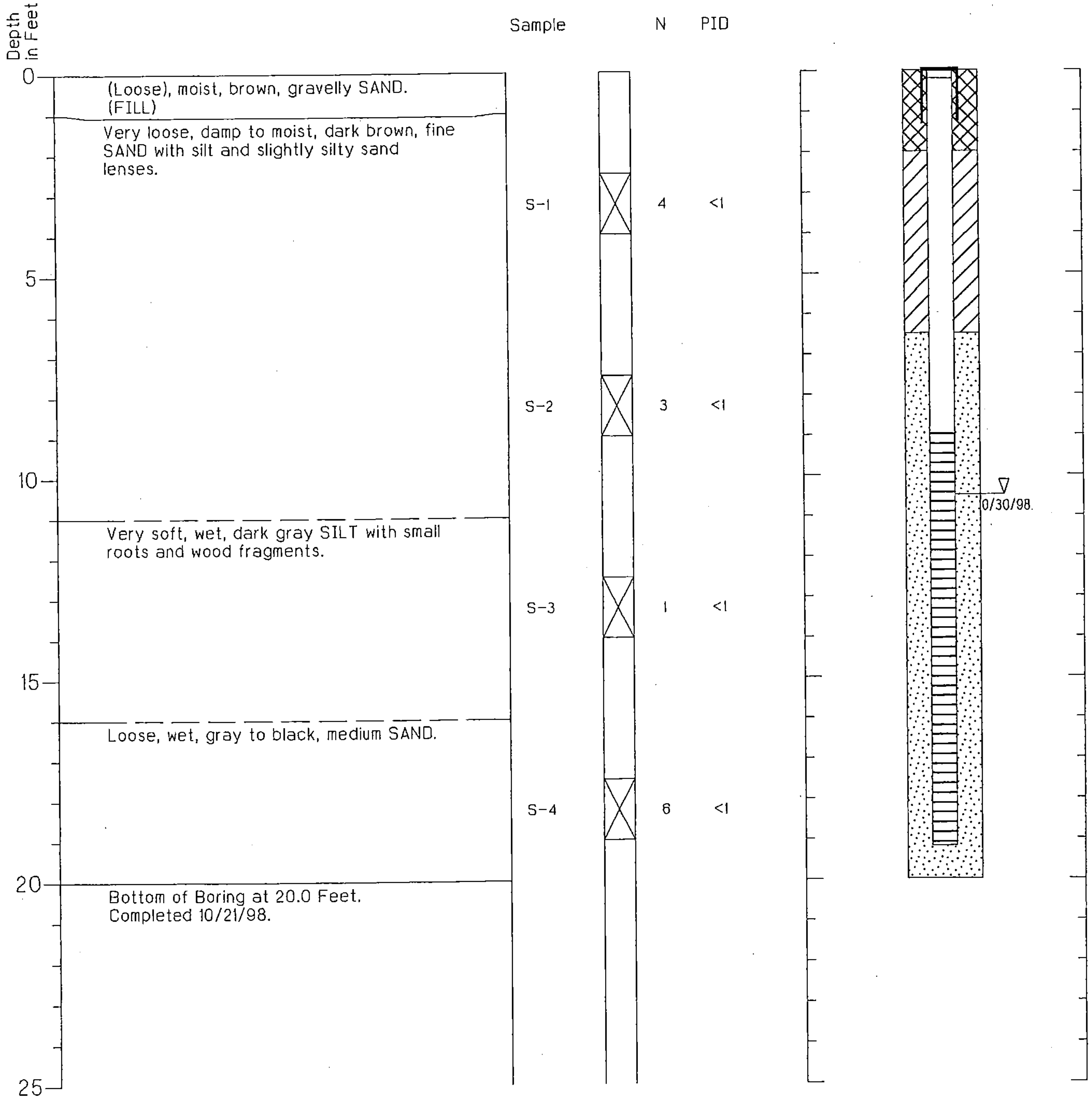
Figure A-12

Boring Log and Construction Data for Monitoring Well HC-1

Geologic Log

Monitoring
Well Design

Casing Stickup in Feet: -0.2
Top of Casing in Feet: 99.78



(Loose), moist, brown, gravelly SAND. (FILL)

Very loose, damp to moist, dark brown, fine SAND with silt and slightly silty sand lenses.

Very soft, wet, dark gray SILT with small roots and wood fragments.

Loose, wet, gray to black, medium SAND.

Bottom of Boring at 20.0 Feet.
Completed 10/21/98.

Sample	N	PID
S-1	4	<1
S-2	3	<1
S-3	1	<1
S-4	6	<1

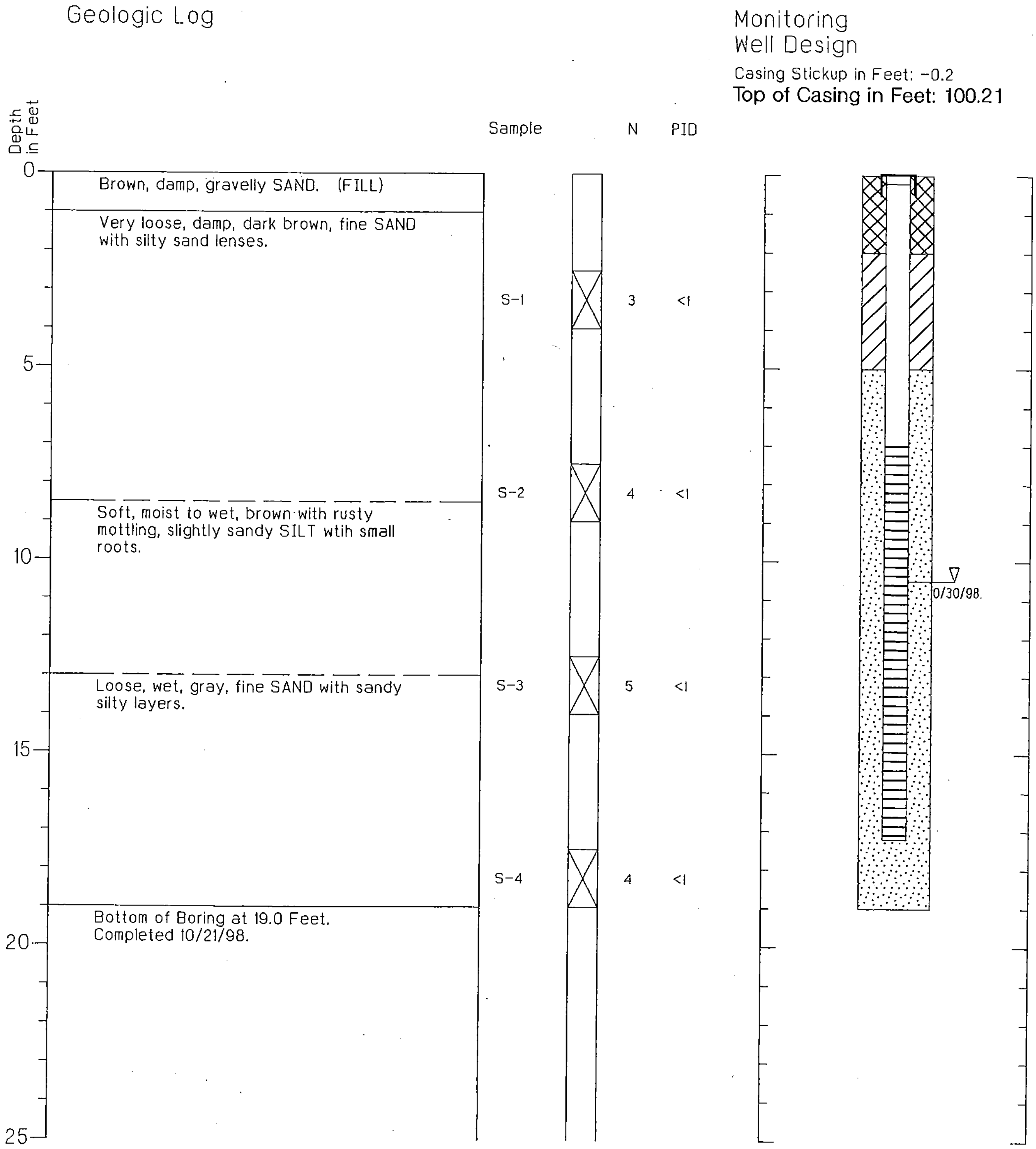
1. Refer to Figure 1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-02 10/98

Figure A-13

Boring Log and Construction Data for Monitoring Well HC-2



Geologic Log

Monitoring Well Design

Casing Stickup in Feet: -0.2

Top of Casing in Feet: 100.21

Brown, damp, gravelly SAND. (FILL)

Very loose, damp, dark brown, fine SAND with silty sand lenses.

Soft, moist to wet, brown with rusty mottling, slightly sandy SILT wtih small roots.

Loose, wet, gray, fine SAND with sandy silty layers.

Bottom of Boring at 19.0 Feet. Completed 10/21/98.

Sample	N	PID
S-1	3	<1
S-2	4	<1
S-3	5	<1
S-4	4	<1

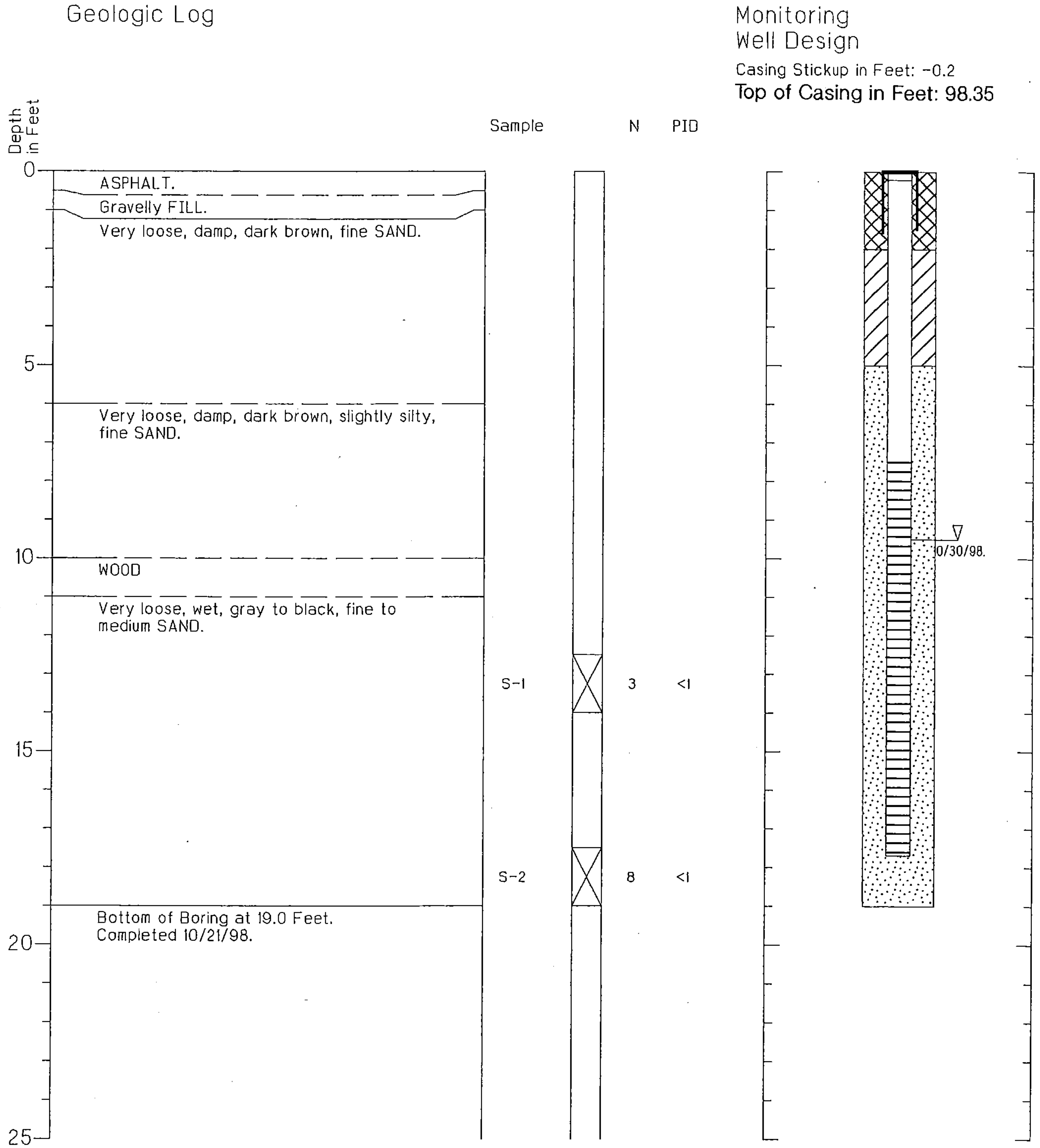
1. Refer to Figure 1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4686-02 **10/98**

Figure A-14

Boring Log and Construction Data for Monitoring Well HC-3



ASPHALT.

Gravelly FILL.

Very loose, damp, dark brown, fine SAND.

Very loose, damp, dark brown, slightly silty, fine SAND.

WOOD

Very loose, wet, gray to black, fine to medium SAND.

Bottom of Boring at 19.0 Feet.
Completed 10/21/98.

1. Refer to Figure 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.

HARTCROWSER

J-4686-02 **10/98**

Figure A-15

Boring Location:

Elevation: Datum:

bs. Well Install. Yes No

HARTCROWSER

Boring SP-1 Date 11/25/96 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather
Drilled By HOLT
Drill Type/Method 2" STRATAPROBE - LTD ACCESS RIG
Sampling Method 1" SS
Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
								0				
								1				
								2				
	90-95	5-10	NA	2	4			3		Med dense, damp, red brown slightly silty SAND (med-fine grained). Not enough volume for a sample. No odor		
								4				
								5				
								6		Dense, damp/moist, brown, med silty SAND. No odor.		
	70	30	NA	6	8			7				
								8				
								9				
						12	▼	10				
	70	30	NA * 0	10	12			1		SAME except definitely moist/wet. With occasional wood debris.		
								12				
								3				
								4		* split sample in SS and took reading - nothing registered above background		
								5				
								6				
								7				
								8				
								9				
								0				

HARTCROWSER

J-4686-02 4/99

Figure A-16

Boring Location:

Elevation: Datum:

Obs. Well Install. ☐ Yes ☐ No

HARTCROWSER

Boring SP-2 Date 11/25/9 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather Cloudy 40s
Drilled By HOLT
Drill Type/Method 2" STRATAPROBE - LTD ACCESS RIG
Sampling Method 1" SS
Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
			0	2	4					Med dense, damp, dark brown med SAND No odor Dense, moist, brown, silty SAND No odor.	SP2-S-2-4	
			0	4	6						SP2-S-4-6	
			0	6	8					Gray, dense, moist, silty SAND	SP2-S-6-8	
			0	10	12					Dense, damp/moist, brown-red slightly silty SAND. No odor.	SP2-S-10-12	
			0	12	14					Dense, moist, grey brown, med SAND. No odor.	SP2-S-12-14	

HARTCROWSER

J-4686-02 4/99

Figure A-17

Boring Location:

Elevation: Datum:

Obs. Well Install. ☐ Yes ☐ No

HARTCROWSER

Boring SP-3 Date 11/25/96 Sheet 1 of 1

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL/FEIDER Weather Cloudy 40s

Drilled By HOLT

Drill Type/Method 2" STRATAPROBE - LTD ACCESS RIG

Sampling Method SPLIT SPOON 1"

Bottom of Boring 12' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
								0				
								1				
	>95	<2	PID 1.4	2	4			2		Med Dense, damp, dark brown SAND. No odor.	Coarse grain	
								3				
								4				
								5				
	95	5	PID 1.4	6	8			6		Med dense, damp, dark brown slightly silty SAND. No odor	Finer grained	
	>95	<2				▨		7		Med dense, damp, dark brown SAND (as @ 2-4' interval). No odor.	Coarse grain	
								8				
								9				
	>95	<2	PID 1.4	10	12		▼	10		Loose, ~~wet~~ moist, greybrown SAND No odor.		
								11				
								12		BOTTOM OF HOLE		
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				

NB: PID background reading was 1.4 units

HARTCROWSER

J-4686-02 4/99

Figure A-18

Boring Location:

Elevation: Datum:

Obs. Well Install. ☐ Yes ☐ No

HARTCROWSER

Boring SP-4 Date 11/25/96 Sheet 1 of

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather Cloudy 40s

Drilled By HOLT

Drill Type/Method 2" STRATAPROBE - LID ACCESS RIG

Sampling Method 1" SS

Bottom of Boring 12' ATD Water Level Depth No

SIZE (%) G	S	F	PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
Max.	Range	Att. Limits		From	To	Type	Number					
								0				
								1				
	>95	<2	PID NA 0	2	4			2		Med dense, damp, dark brown med. SAND (coarse grain). No odor.	SP4-S-2-4	
								3				
								4				
								5				
	>95	<2	PID NA 0	6	8			6			SP4-S-6-8	
								7				
								8				
								9				
	>95	<2	PID . 0	10	12		▼	10		Dense, moist/wet, dark brown SAND (med-coarse grain). No odor	SP4-S-10-12	
								1				
								2		Driller noted ≈ 8-10" of heave when placing casing		
								3				
								4			NA- Not enough sample to collect PID sample.	
								5				
								6				
								7				
								8				
								9				
								0				

HARTCROWSER

J-4686-02 4/99

Figure A-19

Boring Location:

Elevation: Datum:

Obs. Well Install. Yes No

HARTCROWSER

Boring SP-5 Date 11/25/96 Sheet 1 of 1

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather

Drilled By HOLT -

Drill Type/Method 2" PROBE - LTD ACCESS RIG

Sampling Method 1" SS

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%)			PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
	S	F										
Max.	Range	Att. Limits		From	To	Type	Number					
	>95	<2	NA	2	4			2–4		Dense, damp, dark brown, med grained SAND. No odor. SP5-S-2-4		
	70 >95	30 <2	Ø	6	8			6–8		Med dense, moist, brown grey, silty SAND. No odor Med dense, moist, dark brown, med SAND. No odor.	SP5-S-6-8	
	>95	<2	Ø	10	12			10–12		Med dense, moist/wet, dark brown med SAND. No odor.	SP5-S-10-12	

HARTCROWSER

J-4686-02 4/99

Figure A-20

Boring Location:

Elevation: Datum:

Obs. Well Install. ☐ Yes ☐ No

HARTCROWSER

Boring SP-6 Date 11/25/96 Sheet 1 of

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather Cloudy 40s

Drilled By HOLT -

Drill Type/Method 2" STRATAPROBE - LTD ACCESS RIG

Sampling Method 1" SS.

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%)			PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
G	S	F		From	To	Type	Number					
Max.	Range	Att. Limits										
								0				
								1				
								2				
			NA	2	4			3		No sample recovered.		
								4				
								5				
								6		Med dense/dense, damp, dark brown SAND. No odor		
			NA	6	8			7		Med dense, damp, brown red silty SAND. No odor	SP6-S-6-8	
								8		Loose, damp, brown med SAND. No odor.		
								9				
								10				
	90	5	NA					1		Dense, damp, brown, slightly silty SAND (med grain). No odor.	SP6-S-10-12	
								12				
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				

HARTCROWSER

J-4686-02 **4/99**

Figure A-21

Boring Location:

Elevation: Datum:

bs. Well Install. Yes No

HARTCROWSER

Boring SP-7 Date 11/25/96 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather Cloudy 40s
Drilled By HOLT -
Drill Type/Method 2" STRATAPROBE - LTD ACCESS RIG
Sampling Method 1" SS
Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
	95	5	NA	2	4					Loose, dry-damp, med v slightly silty SAND. No odor Brown SP7-S-2-4		
	-	-	NA	6	8					No sample recovered Med dense, dry-damp, slighty silty-silty SAND. Brown.		
	70	30	0	10	12					Dense, moist, brown silty SAND (med-fine grained) No odor.	SP7-S-10-12	
	>95	<2	0	12	14					Dense, moist, dark brown med grained SAND No odor	SP7-S-12-14	
	75	25								← Layer of dense, moist, brown silty SAND. No odor.		
										◦ 1' heave noted by driller when installing casing.		

HARTCROWSER

J-4686-02 4/99

Figure A-22

HARTCROWSER

oring Location:

levation: Datum:

bs. Well Install. Yes No

Boring SP-8 Date 11/25/96 Sheet 1 of 1

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather Cloudy rain 40s

Drilled By HOLT

Drill Type/Method 2" PROBE - LTD ACCESS RIG

Sampling Method 1" SS

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
	>95	<2	0	2	4			2–4		Med dense, damp, dark brown, Med SAND. No odor SP8-S-2-4		
	90 65	10 35	0	6	8			6–8		Dense, moist, dark brown gray, slightly silty SAND. Dense moist, brown red, silty SAND SP8-S-6-8		
								10–12		Dense, moist, dark gray, silty SAND. No odor. Thin lens of red brown silty SAND Dense, moist, dark gray, slightly silty SAND. No odor.		

HARTCROWSER

J-4686-02 **4/99**

Figure A-23

Boring Location:

Elevation: Datum:

Obs. Well Install. Yes [✓ No]

HARTCROWSER

Boring SP-9 Date 11/26/96 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather Cloudy 40s
Drilled By HOLT
Drill Type/Method LTD ACCESS RIG / 2" PROBE
Sampling Method 1" SPLITSPOON
Bottom of Boring 4' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
										START 10:55		
			0	2	4					Refer to prior log. Assume same.		
			0	4	6					Med-dense, damp, dark brown med SAND. No odor.	SP9-S-4-6	
										SAME		
			0	6	8					Dense, moist, gray, slightly sandy SILT. No odor.	SP9-S-6-8	
			0	10	12					Dense, moist, greg, ~~s~~ silty SAND. No odor	SP9-S-10-12	
										FINISH 11:15		

HARTCROWSER

J-4686-02 4/99

Figure A-24

Boring Location:

evation: Datum:

bs. Well Install. Yes No

HARTCROWSER

Boring SP-10 Date 11/26/96 Sheet 1 of 1

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather

Drilled By HOLT

Drill Type/Method LTD ACCESS RIG / 2" PROBE

Sampling Method 1" SS

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G	S	F	PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
Max.	Range	Att. Limits		From	To	Type	Number					
								0				
								1				
								2		Med dense-stiff, moist, silty SAND, red brown No odor	SP10-S-2-4	
	70	30	0	2	4			3				
	>95	<2						4		Med dense, damp, dark brown med SAND No odor		
								5				
								6				
	95	5	0	6	8			7		Med dense, moist, dark brown med SAND, maybe v. slightly silty. No odor.	SP10-S-6-8	
								8				
								9				
								10				
	>95	<2	0	10	12			1		Dense, moist, dark brown, med SAND. No odor.	SP10-S-10-12	
								12		Dense, moist, graybrown, stiff vslightly sandy, SILT. No odor.		
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				

HARTCROWSER

J-4686-02 4/99

Figure A-25

Boring Location:

Elevation: Datum:

Obs. Well Install. Yes No

HARTCROWSER

Boring SP-11 Date 11/26/96 Sheet 1 of 1

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather Cloudy 40s

Drilled By HOLT

Drill Type/Method LTD ACCESS RIG/2" PROBE

Sampling Method 1" SS

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%)			PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
G	S	F										
Max.	Range	Att. Limits		From	To	Type	Number					
								0		START 11:25		
								1				
								2				
	>95	<2	0	2	4			3		Med dense, damp, dark brown med SAND w/occasional gravel. No odor.	SP11-S-2-4	
								4				
								5				
								6				
	>95	<2	0	6	8			7			SP11-S-6-8	
								8				
								9				
								10				
	>95	<2	0	10	12			1		except wet.	SP11-S-10-12	
								12				
								3		FINISH 12:05		
								4				
								5				
								6				
								7				
								8				
								9				
								0				

HARTCROWSER

J-4686-02 4/99

Figure A-26

Boring Location:

evation: Datum:

Obs. Well Install. Yes No

HARTCROWSER

Boring SP-12 Date 11/26/96 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather Cloudy 40s
Drilled By HOLT
Drill Type/Method LTD ACCESS RIG W/ 2" PROBE
Sampling Method 1" SS
Bottom of Boring 14' ATD Water Level Depth No

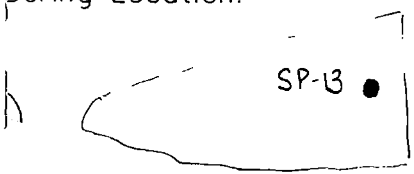
SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	To	SAMPLE Type	Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
			NA	2	4					Loose, dry-damp, brown v slightly silty SAND. No odor	SP12-S-2-4	
										No recovery		
			NA	6	8					Loose-med dense, damp, brown, med SAND. Note - driller was able to push casing by hand!!	SP12-S-6-8	
			0	8	10					Same as 6-8' interval Dense, moist, grey slightly sandy SILT. No odor	SP12-S-8-10	
				10	12					No recovery		
				12	14					Loose, wet, gray sandy SILT to silty SAND.	SP12-S-12-14	
										NB - NO RECOVERY ON FIRST ATTEMPT AT BORING SO RELOCATED ≈ 3' AWAY.		

HARTCROWSER

J-4686-02 4/99

Figure A-27

Boring Location:



Elevation: Datum:

Obs. Well Install. ☐ Yes ☐ No

HARTCROWSER

Boring SP-13 Date 11/26/96 Sheet 1 of 1
Job SPENCER INDUSTRIES Job No. 4686
Logged By JAISWAL Weather Sunny 40s
Drilled By HOLT
Drill Type/Method 2" PROBE - LTD ACCESS RIG
Sampling Method 1" SS
Bottom of Boring 14' ATD Water Level Depth No

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	DEPTH To	SAMPLE Type	SAMPLE Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
	>95	<2	0	2	4					Med dense, damp, brown, med SAND. No odor.		
	>95	<2	0	6	8					Med - - ↓ - - -		
	65	35	0	10	12					Dense, moist, brown grey, silty SAND. No odor.		

HARTCROWSER

J-4686-02 4/99

Figure A-28

oring Location:

.evation: Datum:

bs. Well Install. Yes No

HARTCROWSER

Boring SP-14 Date 11/26/96 Sheet 1 of (

Job SPENCER INDUSTRIES Job No. 4686

Logged By JAISWAL Weather Drizzle, 50s

Drilled By HOLT

Drill Type/Method LTD ACCESS RIG - 2" PROBE

Sampling Method 1" SS

Bottom of Boring 14' ATD Water Level Depth No

SIZE (%)			PID or other	DEPTH		SAMPLE		SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
	S	F										
Max.	Range	Att. Limits		From	To	Type	Number					
								0				
								1				
			NA	2	4			2		V poor recovery <4" of stiff dense, damp, dark brown slightly sandy SILT.		
								3				
								4				
								5				
	10	90	NA	6	8			6		Stiff Dense, moist, greybrown slightly sandy SILT	SP14-S-6-8	
								7				
			NA	8	10			8		SAME	SP14-S-8-10	
								9				
	>95	<2		10	12			10		Med dense, damp, dark brown med SAND. No odor.	SP14-S-10-12	
								12				
								3		No evidence of GW ∴ go deeper.		
			-	14	16			14				
								5				
								16				
								7				
								8				
								9				
								0				

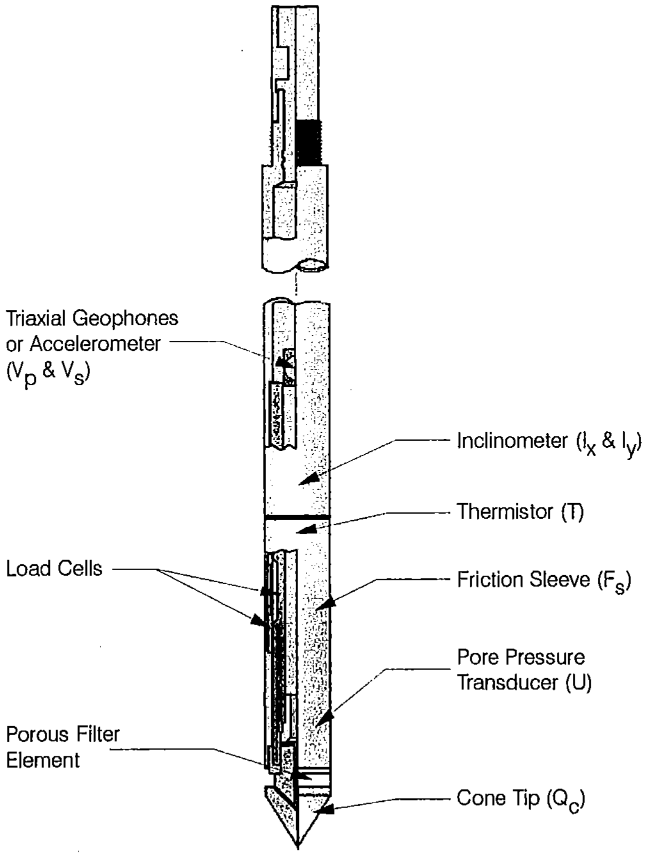
HARTCROWSER

J-4686-02 **4/99**

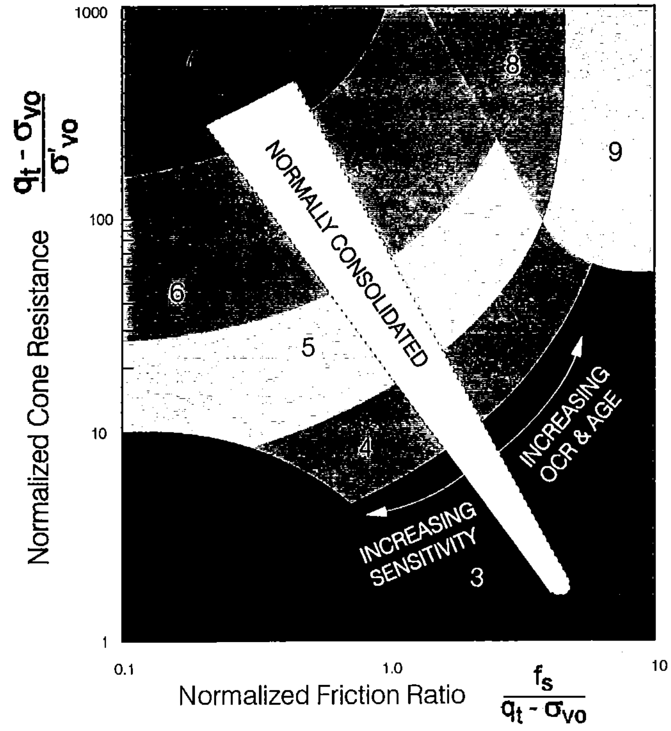
Figure A-29

Electric (Piezocone) Cone Penetrometer

Schematic of Electric Piezocone (Typical)



Simplified Classification Chart (Robertson et al., 1990)



Zone		Soil Behaviour Type
1	■	sensitive fine grained
2	■	organic soils - peats
3	■	clays - clay to silty clay
4	▨	silt mixtures - clayey silt to silty clay
5	☐	sand mixtures - silty sand to sandy silt
6	▨	sands - clean sand to silty sand
7	■	gravelly sand to sand
8	▨	very stiff sand to clayey sand *
9	☐	very stiff fined grained *

* overconsolidated or cemented

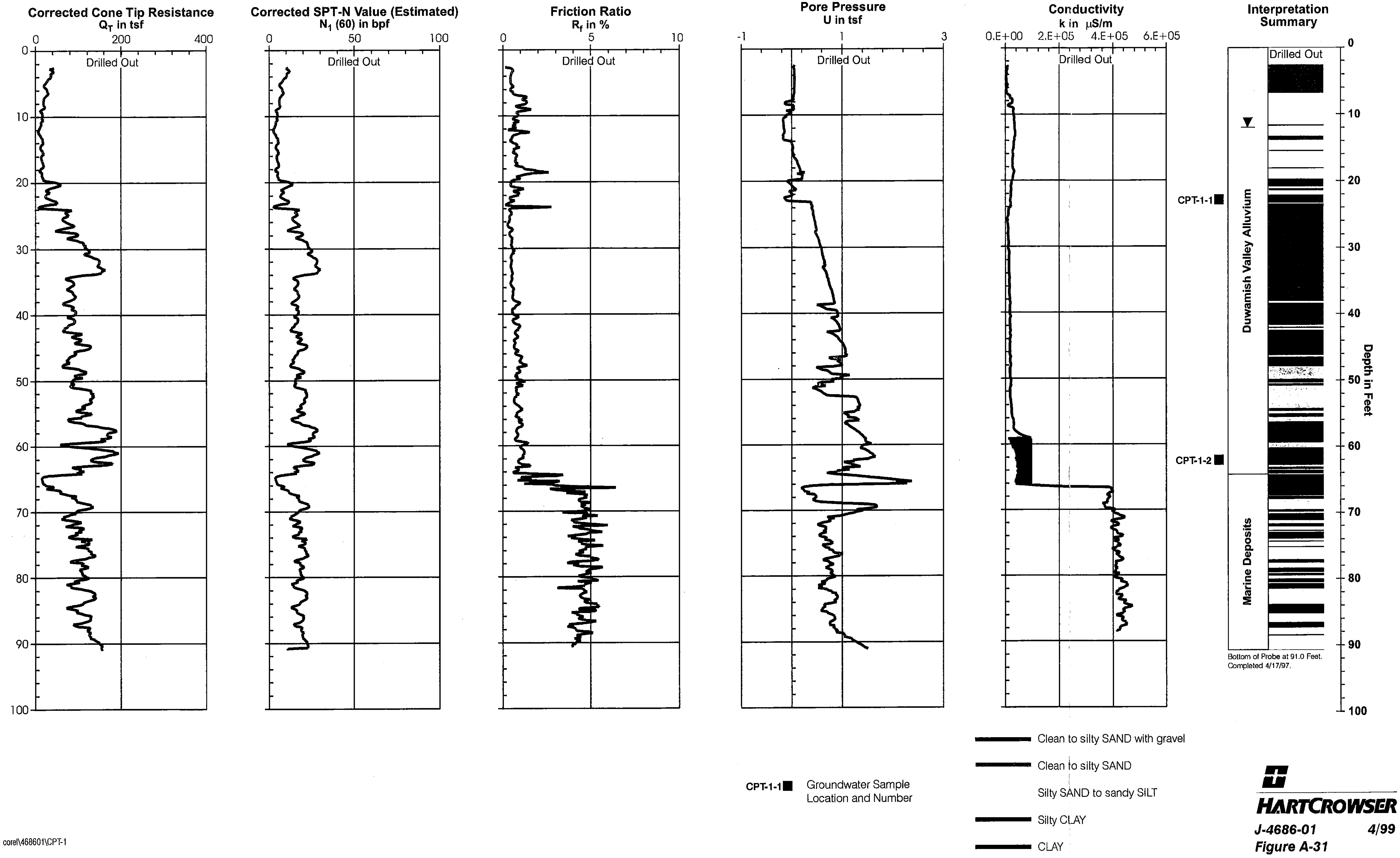
Corel\jobs\468601\fig_1

HARTCROWSER

J-4686-01 **4/99**

Figure A-30

Log of Piezocone Probe CPT-1



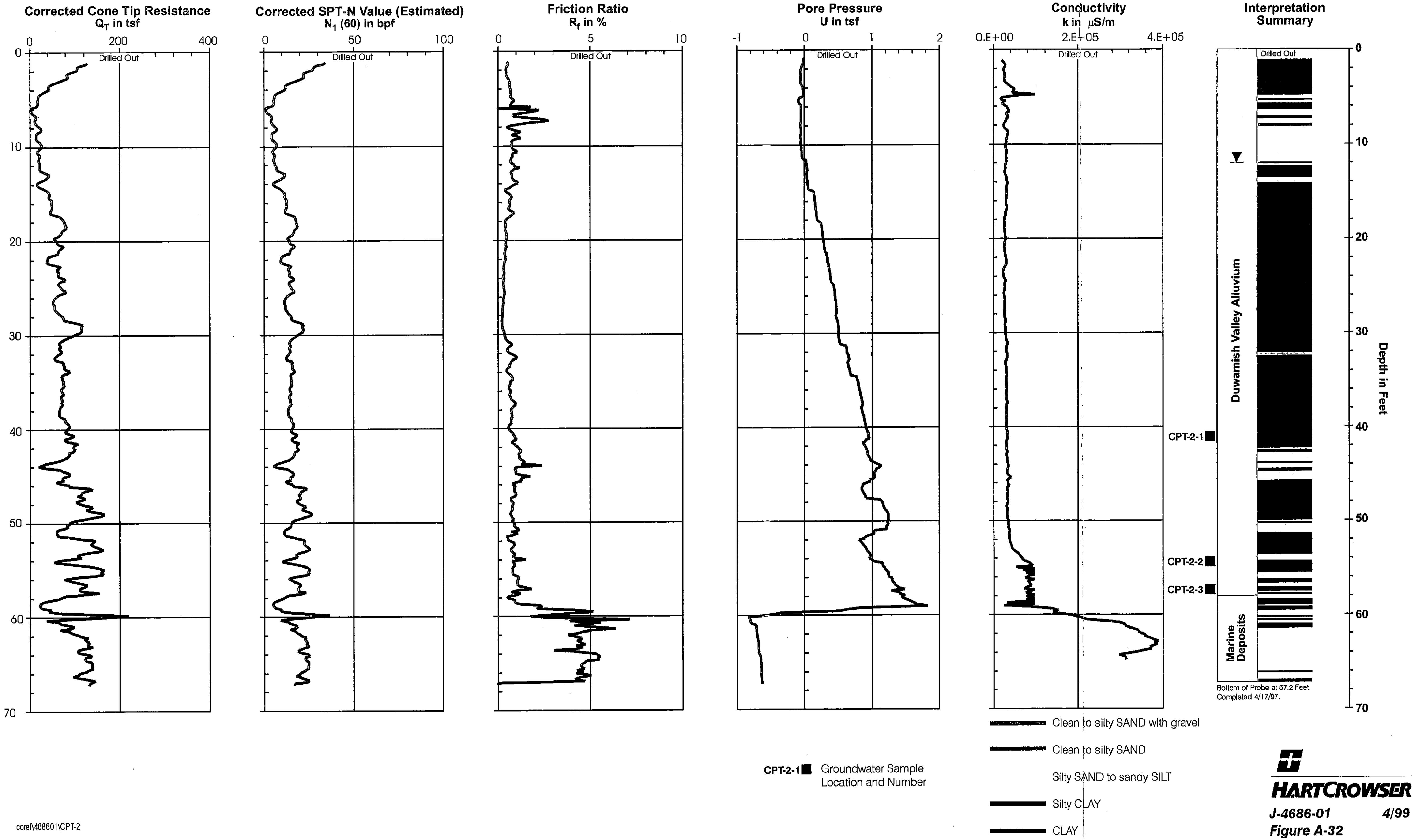
corel\468601\CPT-1

HARTCROWSER

J-4686-01 *4/99*

Figure A-31

Log of Piezocone Probe CPT-2



HARTCROWSER

J-4686-01 *4/99*

Figure A-32

corel\468601\CPT-2