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ENGINEERING EVALUATION AND INTERIM REMOVAL REMEDIAL WORK PLAN/INTERIM MEASURE WORK PLAN REVISION 1 FOR SITE 45 DRY CLEANERS FACILITY BUILDING 193 MCRD PARRIS ISLAND SC

12/22/1997

BECHTEL

ENGINEERING EVALUATION AND INTERIM REMOVAL REMEDIAL WORK PLAN/INTERIM MEASURE WORK PLAN

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SITE 45/SWMU 45
DRY CLEANERS FACILITY
BUILDING 193

MARINE CORPS RECRUITING DEPOT

PARRIS ISLAND, SOUTH CAROLINA

EPA I.D. No. SC6 170 022 762

Prepared for

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

Under Contract No. N62467-93-D-0936

Prepared by

BECHTEL ENVIRONMENTAL, INC.
OAK RIDGE, TENNESSEE

December 1997
REVISION 1
BECHTEL JOB NO. 22567

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Prepared: _____ 12/22/97
Project Engineer — Date

Approved: _____ 12/22/97
Project Manager — Date

Approved: _____ _____
Navy Contracting Officer — Date

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ACRONYMS AND ABBREVIATIONS

1,2-DCE	1,2 Dichloroethene
Bechtel	Bechtel Environmental, Inc.
EE/WP	Engineering Evaluation and Interim Remedial Work Plan/Interim Measure Work Plan
EPA	U.S. Environmental Protection Agency
FOTW	federally owned treatment works
IRA	interim removal action
MCRD	Marine Corps Recruit Depot
PCE	tetrachloroethene
PPs	project procedures
QC	quality control
RAC	Response Action Contractor
RCRA	Resource Conservation and Recovery Act
ROICC	Resident Officer in Charge of Construction
SCDHEC	South Carolina Department of Health and Environmental Control
SOUTHDIV	Naval Facilities Engineering Command, Southern Division
TCE	trichloroethene
VOC	volatile organic compounds

UNITS OF MEASURE

cm/sec	centimeter per second
ft	foot (feet)
gal	gallon/gallons
in.	inch (inches)
mg/L	milligrams per liter
mil	1/1,000 of an inch
mm	millimeters
MSL	mean sea level
ppb	parts per billion
psi	pounds per square inch
scfm	standard cubic feet per minute

1.0 INTRODUCTION

Bechtel Environmental, Inc. (Bechtel) has been contracted by the Department of the Navy, Naval Facilities Engineering Command, Southern Division (SOUTHDIV), to provide remedial services as the Navy's Environmental Response Action Contractor (RAC). Under Delivery Order 0048 of Prime Contract N62467-93-D-0936, Bechtel has been contracted to prepare an Engineering Evaluation and Interim Removal Work Plan/Interim Measures Work Plan (EE/WP) to implement an interim removal action (IRA) at Site 45/SWMU 45, the Dry Cleaners Facility, Building 193, Marines Corps Recruit Depot (MCRD), Parris Island, South Carolina. This is an active recruit basic training facility located in southeast South Carolina (Fig. 1.1).

A spill of tetrachloroethlene (PCE) occurred at the dry cleaning facility on March 11, 1994. This spill occurred due to inadvertent overfilling of the aboveground storage located adjacent to the north side of the Dry Cleaners Facility. See Attachment 1 for a copy of the spill report. A contamination assessment was performed in the summer of 1994 to evaluate the impact of the reported spill. This initial assessment concluded that soil and groundwater in the vicinity of the dry cleaning facility had been adversely affected due to the spill (Ref. 3).

During the summer of 1996, groundwater samples were collected to determine the extent of the contamination at the site. This sampling effort was performed using direct push technology. Analytical results of these samples indicated that a plume of groundwater contaminated with PCE; trichloroethene (TCE); 1,2-Dichloroethene (1,2-DCE); and vinyl chloride exists at concentrations exceeding the regulatory levels at the site (Attachment 2.). Based on this information, a decision was made to conduct an IRA to remove the source of contamination to minimize further degradation of the groundwater.

This EE/WP identifies the proposed IRA alternative as part of the remediation at the dry cleaner facility. It addresses the implementability, effectiveness, and cost of the IRA.

1.1 SITE CHARACTERIZATION

The MCRD is located within the Parris Island Quadrangle, S. C., USGS 7.5 min topographic map. The subject dry cleaning facility is bounded between Panama Street to the north, Kyushu Street to the south, and Samoa Street to the east. Immediately to the west of the existing facility is the new Dry Cleaners Facility which also includes a laundry and tailor and cobbler shops.

1.1.1 Regional Hydrogeology

The area is characterized by flat terrain dissected by rivers and streams which flow into the Atlantic Ocean. Drainage is provided by the Broad and Beaufort Rivers. The area averages 47 to 50 in. of rainfall per year. Average well yields are reported to be from less than 50 to 1,500 gal per minute from wells in Beaufort County. Soil types in this area are typically clayey and sandy. These are underlain by unconsolidated to poorly consolidated interbedded clays and sands and marls which range in age from Late Cretaceous to Holocene (Ref. 2).

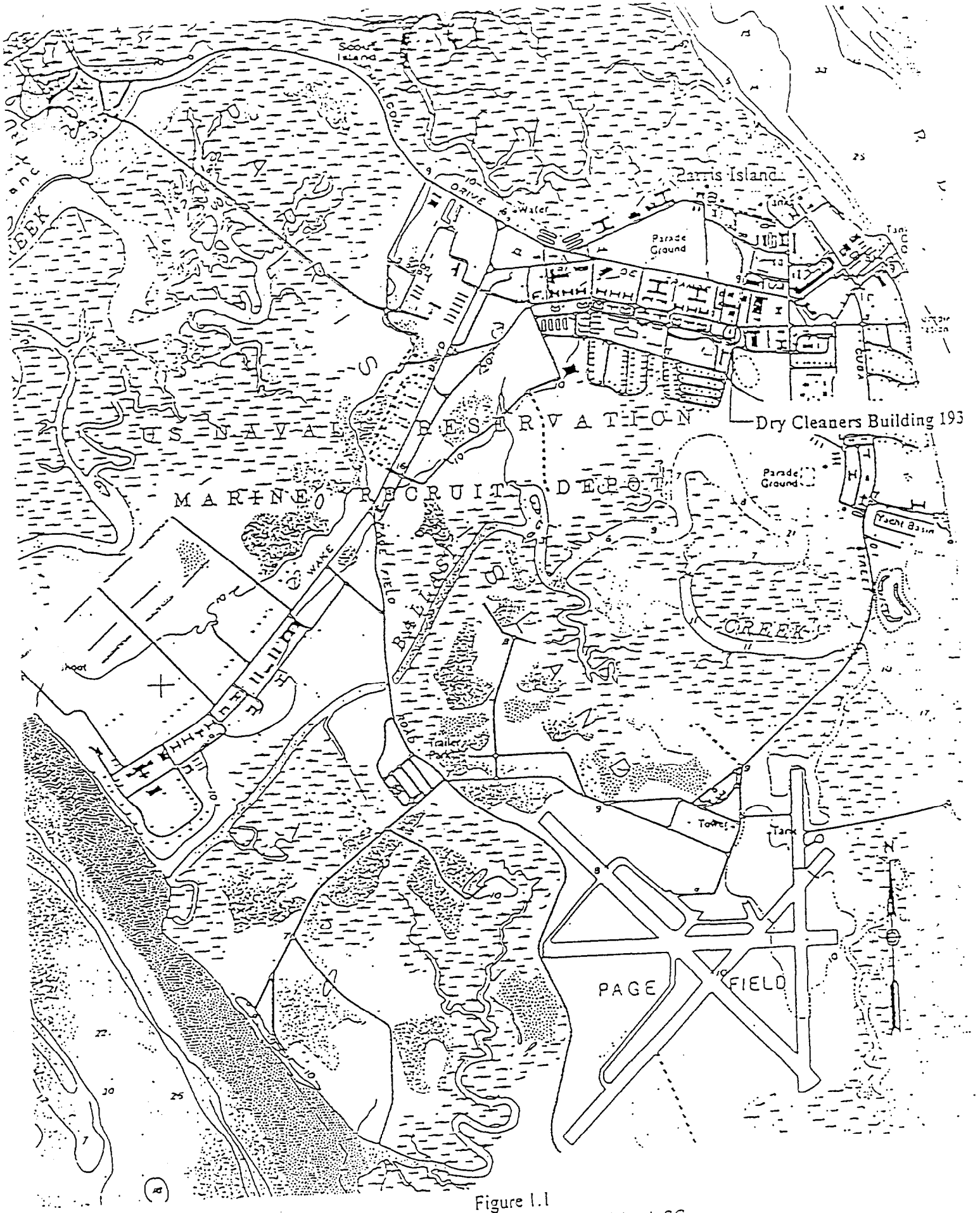

Figure 1.1
Marine Corps Recuit Depot, Parris Island, SC

1.1.1.1 Floridan Aquifer

The principal source of groundwater in the Beaufort County area is the Floridan Aquifer. This aquifer system has a total depth of approximately 900 ft and divided into the Upper Unit and the Lower Unit. The Upper Floridan Aquifer is contained within the late Eocene Age Ocala Limestone. Most wells which tap this aquifer system are from 50 to 250 ft deep (Ref. 5).

The lithology of the upper portion of the Ocala Limestone consists of bioclastic limestone and is highly permeable. The lower portion of the Ocala Limestone consists of sandy to clayey limestone and marl and hydraulically separates the Upper Floridan Aquifer from the Lower Floridan. In the Parris Island vicinity, the top of the Ocala Limestone has a reported transmissivity of about 20,000 ft^2/day (Ref. 5).

The Lower Floridan Aquifer is contained within the middle Eocene age Santee Limestone. In the study area, the Santee is reported to be a massive, calcarenitic limestone. Permeability within the Santee Limestone is reported to be low (Ref. 5).

1.1.1.2 Surficial Aquifer

The surficial or water table aquifer in the study area is restricted to the shallow Pliocene to Holocene age sedimentary deposits of the Pamplico and Waccamaw Formations. The hydraulic characteristics of these formations are not particularly well known. A few shallow monitoring wells in St. Helena and Ladies Islands have been hydraulically tested. An estimated transmissivity of 1,300 ft^2/day was reported for coarse sands within the shallow deposits. A storage coefficient of 0.20 has also been reported for these deposits (Ref. 5).

1.1.1.3 Confining Units

The shallow deposits are underlain by the Miocene Hawthorn Formation. Some researchers have defined another Miocene formation (Duplin Marl). These formations are significant because they hydraulically separate the unconfined surficial aquifer from the underlying artesian Floridan aquifer. The elevation at the top of the Hawthorn is reported be approximately 30 ft below mean sea level (MSL) at Parris Island. Thickness of the Hawthorn Formati[illegible] this area is reported to range from about 25 ft to as much as 40 ft near the confluence of the Beaufort and [illegible]oad Rivers. Previous regional studies have indicated a wide range of vertical hydraulic conductivity values for samples obtained from the Hawthorn Formation. Using an average formation thickness of 30 ft and vertical hydraulic conductivity of 0.006 ft/day, it was calculated that the leakance through the Hawthorn Formation is 0.0002 ft^3/day for every 1 ft of head difference (Ref. 5).

The Hawthorn Formation is breached in numerous locations throughout Beaufort County. Immediately adjacent to Parris Island, tidal scour and stream erosion (during lowered sea level stands) have probably breached the Hawthorn Formation beneath the Beaufort and Broad Rivers. A small area of recharge to the Upper Floridan is reported at the southeastern end of Parris Island. Sampling has confirmed that the Hawthorn layer exists at the Dry Cleaner Facility Site (Ref. 1).

1.1.2 Site Hydrogeology

The upper 30 ft of sediment underlying MCRD Parris Island consists predominantly of very fine yellow-brown sand containing traces of clay and silt. Occasional thin (approximately 6-in. thick) layers of greenish-gray silty clay occur within the sands. These are the only distinct beds found in the superficial

layers appear to have prevented the migration of the bulk of the contamination from reaching 22 ft below grade. The IRA will only focus on the groundwater above the aquitard shown on Figures 1.2, 1.3, and 1.4. Onsite borehole data collected during well installation in December of 1996 confirm these findings as seen in Figures 1.2, 1.3, and 1.4. Water table elevations recorded during the same time range from a high of 5.02 ft (above MSL) at the northwest to a low of 4.04 ft (above MSL) in the southeast. Similar water table levels have been reported at other sites at Parris Island (Ref. 2). The general groundwater flow is to the southeast with a gradient of 0.003 ft/ft. (Attachment 3.)

The regional hydrogeology and the data collected during the direct push sampling in the summer of 1996 indicates that the bottom of the surfical aquifer at the site is the top of the Hawthorn Formation which is approximately 30 ft below MSL.

1.2 SITE HISTORY

At one time, the Dry Cleaning Facility maintained four above ground storage tanks in a concrete containment basin. These tanks have been in place since 1988 and stored PCE solvent used for dry-cleaning. These above ground tanks were constructed to replace an underground storage tank system containing petroleum-based solvent used prior to the use of PCE at the facility. On March 11, 1994, a reportable spill of PCE occurred at the dry cleaners when one of the tanks was inadvertently overfilled, spilling PCE into the concrete containment basin. It is also reported that the PCE was subsequently released onto the ground when the containment basin was drained following heavy rains. See Figure 1.6 for the location of the spill. The spill was reported to South Carolina Department of Health and Environmental Control (SCDHEC). The use of the tanks for storing PCE was discontinued in the 1994-1996 time frame.

On March 14, 1994, Parris Island personnel collected soil and water samples along Panama Street. The analytical results of these samples indicated elevated levels of PCE in the samples, requiring excavation of the contaminated soils. Parris Island personnel excavated and disposed of PCE-contaminated soils outside the containment basin. These PCE contaminated soils were incinerated by a licensed facility. Following this removal action, S&ME conducted a PCE-contamination assessment in June, 1994 to determine the extent of contaminated groundwater and to develop a conceptual remediation plan. As part of this effort, S&ME installed temporary piezometers to measure water levels and drilled boreholes to collect soil and groundwater samples (Ref. 3).

In the summer of 1996, Bechtel conducted a site investigation of the groundwater to define the current extent of contamination at the site. Groundwater samples were collected with direct push technology and analyzed with a field gas chromatograph. Results of these tests indicated that a plume of PCE, TCE, 1,2 DCE, and vinyl chloride contaminated groundwater exists with concentrations exceeding the regulatory limits. The results of this screening effort are presented in the report "Phase Two Sampling Effort" (Attachment 2).

Based on this information, monitoring wells were installed and an air sparging pilot test was conducted as presented in the "Technical Memorandum For Well Installation and Air Sparging Pilot Test" (Ref. 1). The objectives of this investigation conducted in December 1996 were as follows:

- Installing a well monitoring network
- Soil sampling to determine lithology and geological stratigraphy

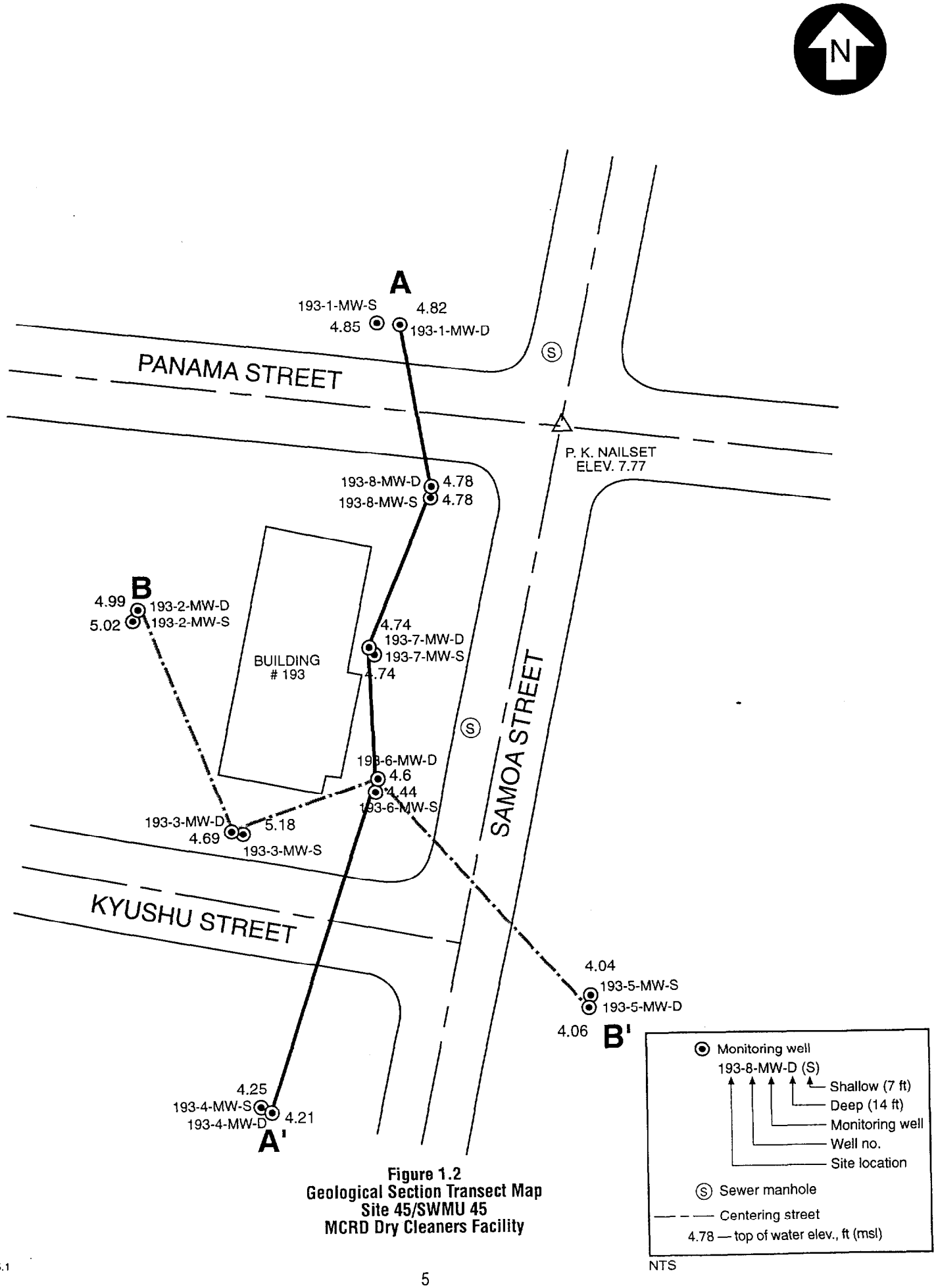

Figure 1.2
Geological Section Transect Map
Site 45/SWMU 45
MCRD Dry Cleaners Facility

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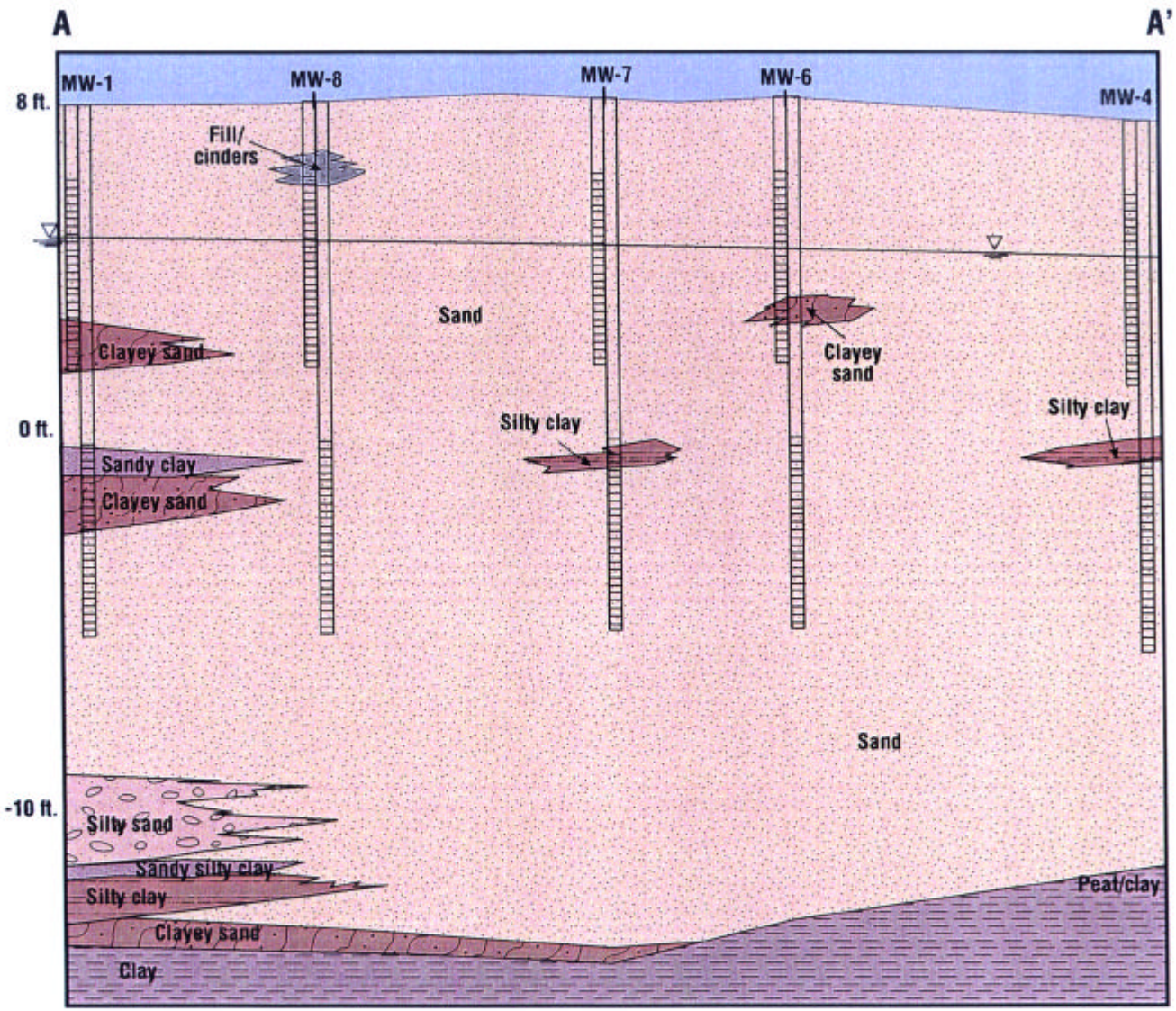

Vertical scale: 1" = 4'
Horizontal scale: 1" = 75'

Figure 1.3
Generalized Geological Section of Site 45/SWMU 45 MCRD Dry Cleaners Facility; A - A'

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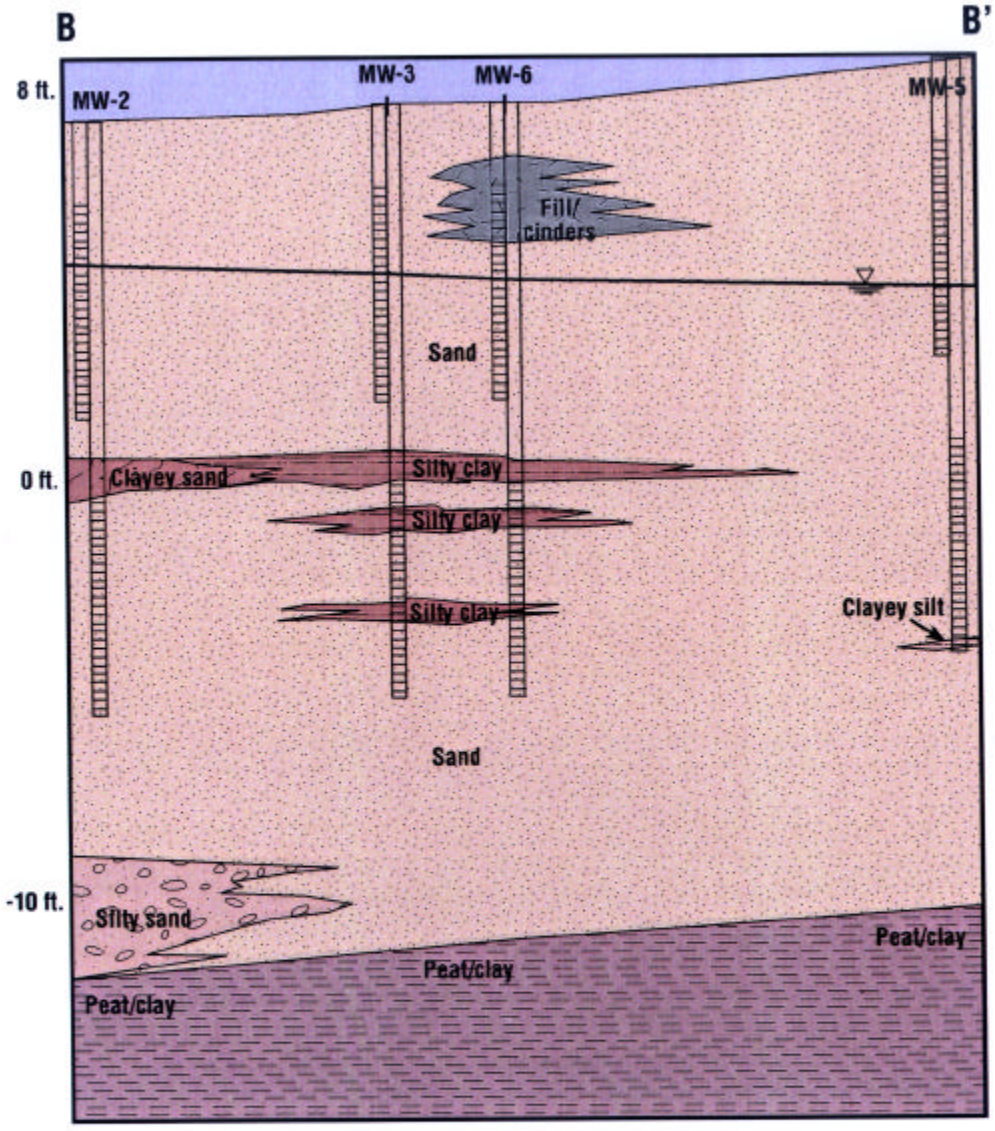

Vertical scale: 1" = 4'
Horizontal scale: 1" = 75'

Figure 1.4
Generalized Geological Section of Site 45/SWMU 45 MCRD Dry Cleaners Facility; B - B'

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- Sampling and analysis to establish baseline soil and groundwater contamination levels
- Conducting an air sparging pilot study

The well monitoring network was comprised of sixteen wells placed at eight locations around the Dry Cleaners Facility. At each location, a shallow well was installed to a depth of 7 ft and a deep well was installed to a depth of 14 ft. Figure 1.5 shows the locations of these monitoring wells. Details of this investigation and the findings are presented in the "Technical Memorandum For Groundwater Evaluation and Air Sparging Pilot Study, Building 193, Parris Island, SC" (Attachment 3).

1.3 NATURE AND EXTENT OF CONTAMINATION

1.3.1 Soil Sampling Results

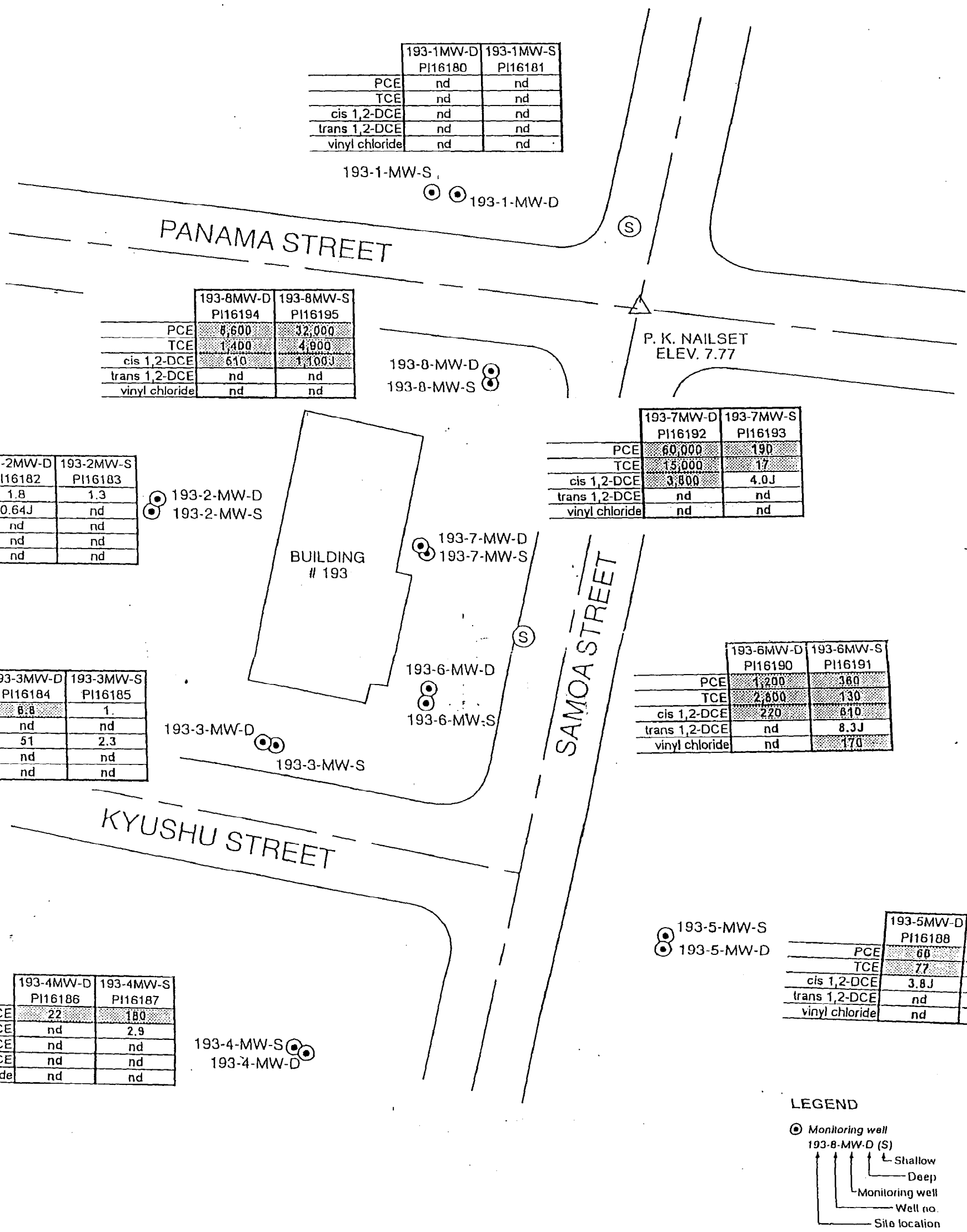
Soil samples were collected from 1-3 ft and 5-7 ft intervals during drilling for monitoring wells 193-6MW-D, 193-7MW-D, and 193-8MW-D and were analyzed for volatile organic compounds (VOCs). These three wells were placed within the highest concentration of the contaminated groundwater based on the direct-push technology results. The analytical results of the soil samples (except for one) indicate that no significant concentrations of the contaminants of concern are present in the soil matrix. However, a soil sample collected from 5-7 ft interval at monitoring well 193-8MW-D was found contaminated with PCE at 1,100 ppb. This location is to the north of the dry cleaner in the area of the reported spill.

1.3.2 Groundwater Sample Results

The direct push sampling indicated that low levels of groundwater contamination had spread down to the Hawthorn, but the groundwater contamination levels at the 22-ft. level were several orders of magnitude lower than those at 14-ft. level. See direct push sampling results in Attachment 2. The focus of the IRA is the groundwater above the aquitard. Monitoring wells were not installed through the aquitard to avoid creating a pathway for possible migration of contamination deeper into the surficial aquifer.

Groundwater samples were collected from each monitoring well and analyzed for VOCs, chloride, sulfate, and nitrate. Figure 1.5 shows the sampling results and the extent of the solvent contamination at the site. The results from this phase of the investigation correlated closely with the results from the direct push sampling. Figure 1.6 combines the results from the direct push sampling and the monitoring wells. The analytical results are presented in the technical memorandum (Attachment 3).

During the direct-push sampling, water samples were collected and analyzed for total iron at a South Carolina-certified offsite laboratory . The total iron concentrations of these samples were high (at times as high as 100 mg/L). It was thought that the samples exhibited elevated iron levels because the direct push samples were very turbid. Ferric iron normally precipitates; therefore, representative groundwater samples were collected from all the monitoring wells and analyzed onsite for ferrous iron using a Hach test kit. The highest ferrous iron detected was only 2.2 mg/L and should not be a concern for iron fouling of the remediation system.



	193-1MW-D PI16180	193-1MW-S PI16181
PCE	nd	nd
TCE	nd	nd
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-8MW-D PI16194	193-8MW-S PI16195
PCE	6,600	32,000
TCE	1,400	4,900
cis 1,2-DCE	610	1,100J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-7MW-D PI16192	193-7MW-S PI16193
PCE	60,000	190
TCE	15,000	17
cis 1,2-DCE	3,800	4.0J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-2MW-D PI16182	193-2MW-S PI16183
PCE	1.8	1.3
TCE	0.64J	nd
cis 1,2-DCE	nd	nd
ans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-6MW-D PI16190	193-6MW-S PI16191
PCE	1,200	360
TCE	2,800	130
cis 1,2-DCE	220	810
trans 1,2-DCE	nd	8.3J
vinyl chloride	nd	170

	193-3MW-D PI16184	193-3MW-S PI16185
PCE	8.8	1.
TCE	nd	nd
cis 1,2-DCE	51	2.3
ans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-5MW-D PI16188	193-5MW-S PI16189
PCE	60	52
TCE	77	84
cis 1,2-DCE	3.8J	2.6J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-4MW-D PI16186	193-4MW-S PI16187
PCE	22	180
TCE	nd	2.9
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

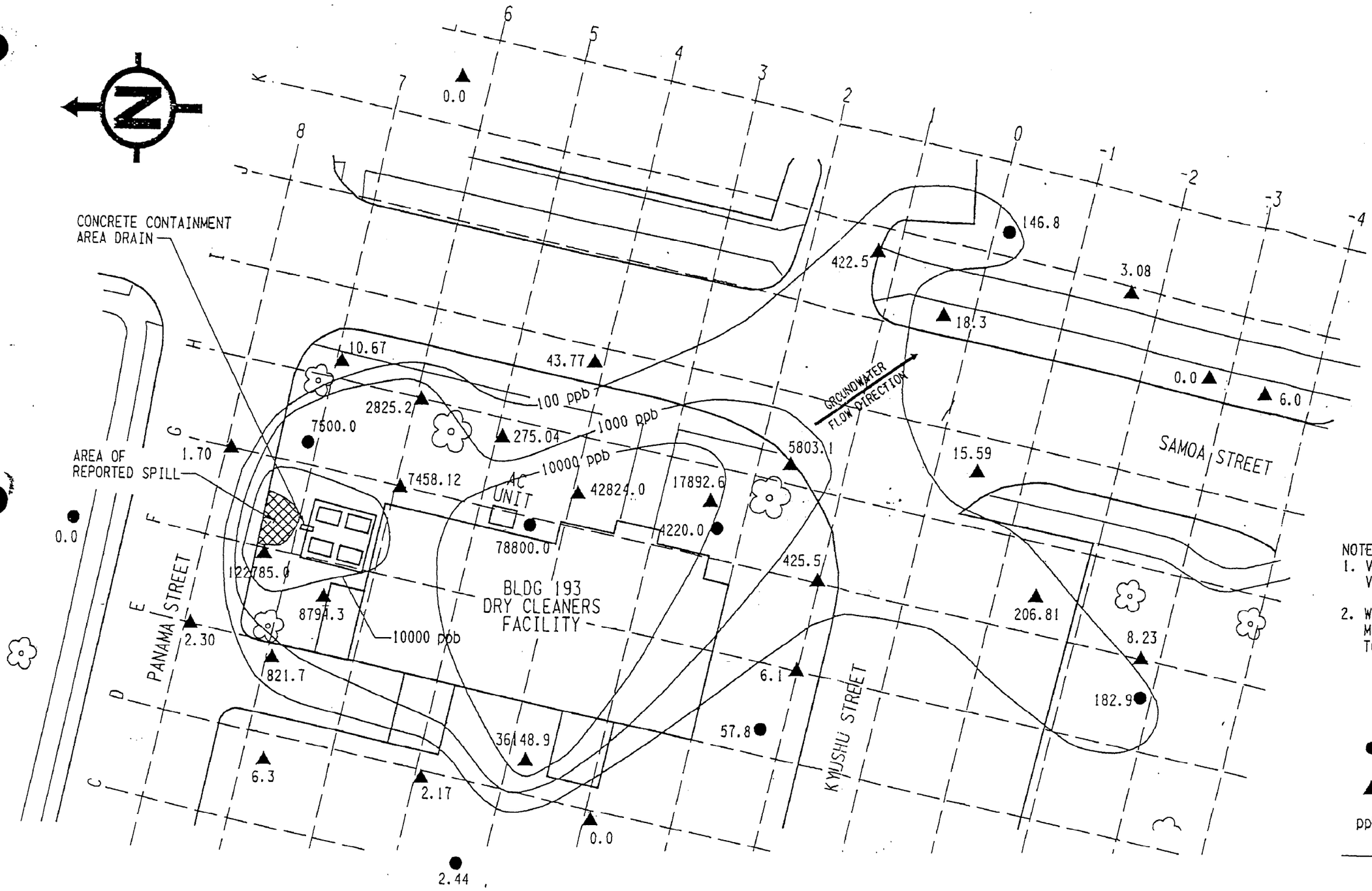
LEGEND

Monitoring well
193-8-MW-D (S)
Shallow
Deep
Monitoring well
Well no.
Site location

MCLs	Well ID Sample ID
PCE	5
TCE	5
cis 1,2-DCE	70
trans 1,2-DCE	100
vinyl chloride	2

All detections above MCLs are shaded.

Figure 1.5
Groundwater Analytical Results (ppb)
Site 45/SWMU 45
MCRD Dry Cleaners Facility



NOTES:
1. VALUES POSTED ARE MAXIMUM TOTAL VOC'S FROM MONITORING WELL CLUSTER.
2. WHERE SAMPLES WERE COLLECTED AT MORE THAN ONE DEPTH, THE MAXIMUM TOTAL VOC'S VALUE IS REPORTED.

LEGEND

- ● MONITORING WELL LOCATION (SEE NOTE 1)
- ▲ DIRECT PUSH SAMPLE LOCATION (SEE NOTE 2)
- ppb PARTS PER BILLION
- —— CONTAMINATION CONTOURS
- - — GRID LINES (25'x25')

0 30 60 90

1"=30'

22567/145/FIG1.6.DGN

Figure 1.6
Groundwater VOC Isopleths (ppb)
Site 45/SWMU 45
MCRD Dry Cleaners Facility

1.4 IDENTIFICATION OF INTERIM REMOVAL ACTION OBJECTIVES

1.4.1 Determination Of Scope

Chlorinated aliphatic compounds, including PCE; TCE; 1,2-DCE; and vinyl chloride pose a risk to human and ecological receptors at their elevated concentrations in the groundwater in the vicinity of the dry cleaning facility at the Parris Island MCRD. The scope of the IRA at the Dry Cleaners is to minimize further degradation to the groundwater and treat the source of contamination at the center of the plume. The proposed IRA will gain control over the groundwater contaminant source loading and reduce the concentrations of contaminants in the groundwater.

1.4.2 Interim Removal Action Objectives

The objectives of the proposed interim removal action are to:

- Minimize further migration of groundwater containing solvents by providing hydraulic control of the site.
- Reduce elevated concentrations of the contaminants in groundwater in the area of concern.
- Operate the remedial system until the equilibrium is reached. Equilibrium is defined as 3 month's recovery well groundwater samples without a significant (10%) decrease in groundwater concentrations. The estimated operation time of the system is two years.
- Allow an orderly transition to any required final remedy at the site.

1.5 COMPARATIVE ANALYSIS OF INTERIM REMOVAL ACTION ALTERNATIVES

Based on the objectives of the proposed interim removal action presented in the previous section, several alternatives were considered at the Dry Cleaners Facility as presented in Table 1.1. These alternatives are described briefly in the table and are evaluated based on effectiveness, implementability, and qualitative cost. To evaluate the effectiveness, consideration was given to the overall protection of human health and environment and both long term and short term effectiveness of the alternative. Evaluation of the implementability of each alternative included consideration of the technical feasibility, commercial availability, administrative feasibility, and public acceptance. The cost comparison estimate is qualitative in that costs are based on orders of magnitude estimates for capital costs, annual operation, and maintenance costs.

1.6 EVALUATION OF SELECTED REMEDIAL ALTERNATIVES

Three different technologies were considered as viable alternatives for the IRA at the Dry Cleaner Facility:

- air sparging and soil vapor extraction
- in well vapor stripping
- pump and treat

TABLE 1.1 COMPARATIVE ANALYSIS OF ALTERNATIVES

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
No Action	None	None	No further response actions of any type.	Does not remove site-related contamination or control contaminant migration; therefore, *does not meet remedial action objectives.*	Does not entail any action.	No direct costs.	Not retained as a Interim Removal Action Alternative
Institutional Controls	Land Use Restrictions	Deed Restrictions	Deed restriction issued for property within potentially contaminated areas to restrict future uses that may result in exposures to contaminated groundwater.	Effective for prevention of human contact with contaminated water; reliability is dependent upon long-term enforcement. Does not remove site-related contamination or control contaminant migration.	Easily implemented; however, may impact future land uses.	Negligible capital and O&M costs.	Not retained as a Interim Removal Action Alternative
	Monitoring	Groundwater Sampling and Analysis	Periodic sampling and analysis of groundwater to monitor contaminant extent and migration.	Effective means to monitor contaminant movement, intrinsic bioremediation processes, and/or progress of remedial action. Does not remove site-related contamination or control contaminant migration.	Readily implementable. Some groundwater monitoring wells would be in place when remediation starts.	Low capital and moderate O&M costs.	Retain as support technology.
Natural Attenuation	None	Oxic/ Anoxic Redox Conditions	Naturally-occurring attenuation mechanisms (biodegradation, adsorption, dispersion, volatilization, diffusion & dilution) reduce contaminant concentrations.	Contaminants ultimately transformed to innocuous byproducts; requires extended duration.	Readily implementable. Some groundwater monitoring wells would be in place when remediation starts.	Low capital and moderate O&M costs.	Retained as a Interim Removal Action Alternative
Containment	Vertical Barriers	Slurry Wall	Trench backfilled with a soil-bentonite or cement-bentonite mix to restrict or divert groundwater flow.	Widely used and generally effective for containing groundwater plumes; *site-specific conditions may not lend themselves suitable for construction of slurry walls?*	Readily implementable at the site, given that contamination plume is shallow and fairly small.	High capital costs and low O&M costs.	Not retained as a Interim Removal Action Alternative
		Sheet Piling	Drive interlocking sheet piles to construct a vertical low permeability barrier; restricts groundwater flow.	Effectively restricts flow of groundwater. Piling may be negatively impacted by high TDS concentrations in groundwater. Also, vertical barriers would not provide for long-term containment.	Readily implementable in sites with unconsolidated soils such as occur at the Parris Island site	High capital costs and low O&M costs.	Eliminate from further consideration on the basis of effectiveness.
		Grout Curtains	A cement grout is pressure-injected along contamination boundaries using an overlapping pattern of drilled holes to form barrier to restrict groundwater flow.	Potentially effective in creating low-permeability barrier to inhibit groundwater flow; however not likely to provide for long-term containment (*might require modeling*)	Uses standard construction/ drilling and grouting equipment. Limited data showing successful implementation at contaminated sites.	High capital and low O&M costs.	Eliminate based on effectiveness, implementability, and costs.
	Capping	RCRA-Type Cap/ Non-RCRA Cap	Low-permeability multimedia cap with vegetative cover (RCRA-cap); or single or multilayered soil, clay, and/or pavement cap (non-RCRA) designed to prevent infiltration of precipitation.	Capping can effectively reduce infiltration, thereby decreasing the loading of contaminants to groundwater *if vadose zone is contaminated.* Presence of several structures at the site may not allow construction of caps.	Non-RCRA caps are readily constructed with common construction equipment/ methods. Capping may limit/ restrict future land uses.	Moderate to high capital and O&M costs.	Eliminate based on effectiveness, implementability, and costs.
	Hydraulic Controls	Extraction/ Injection	Control of groundwater flow/contaminant transport via the use of extraction and/or injection wells to modify hydraulic gradient.	Effectively controls groundwater flow by creating mounds or depressions through groundwater injection or extraction.	Readily implementable. Potential for biofouling and scaling in injection wells.	Low capital and moderate O&M costs.	Not retained as a Interim Removal Action Alternative

TABLE 1.1 COMPARATIVE ANALYSIS OF ALTERNATIVES

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
In Situ Treatment	Biological Treatment	Anaerobic Bioremediation	Delivering precultured dechlorinating anaerobic granules to the subsurface to effectively remediate the chlorinated aliphatics. These granules are self-immobilized microbial consortium.	Given the permeable nature of both saturated and vadose zones, MCRD is a good candidate site for insitu bioremediation.	Pilot Study needs to be conducted to determine if this technology is applicable at this site. Implementability decreases as the area of contamination increases	Moderate capital and O&M costs.	Retain for further consideration.
		Aerobic Bioremediation	A mixture of methane (substrate), air, and nutrients injected into the subsurface through new / existing wells placed beneath contaminated zone and harnessing the indigenous microbes to remediate the plume.	Given the permeable nature of both saturated and vadose zones, MCRD is a good candidate site for insitu bioremediation.	Remediation of chlorinated aliphatic plumes using insitu bioremediation are being successfully implemented at several sites. Pilot study required	Moderate capital and O&M costs	Retain for further consideration
		Insitu microbial filter	Placing insitu microbial filter consisting of permeable wall of TCE degrading microorganisms in the subsurface.	Given the permeable nature of both saturated and vadose zones and that the preliminary data indicate ongoing biodegradation of PCE/ TCE, MCRD is a good candidate site for insitu microbial filters.	Has been successfully demonstrated at two other similar sites. Problems associated with nutrient addition is minimal. Flat water table at the site may make passive hydraulic control difficult.	Moderate capital and O&M costs.	Retain for further consideration
	Physical Treatment	Air Sparging	Compressed air injected into lower portion of contaminated aquifer percolates up through saturated zone causing transfer of VOCs from aqueous to vapor phases, which migrate upward to vadose zone and are collected with SVE system.	Require air injection, contaminated vapor stream extraction, the vapor stream might need treatment. (Data to support the technology need to be collected)	Pilot Study needs to be conducted to determine if this technology is applicable at this site. Implementability decreases as the area of contamination increases.	Moderate capital and O&M costs. Interference with existing utilities could increase costs	Retain for further consideration
		Hydrofracturing	Pressurized water is injected into the subsurface to increase the permeability of subsurface materials and enhance the recovery of contaminants from vadose or saturated zone.	Current permeability of the subsurface should be adequate	Requires specialized drilling/injection equipment; limited full-scale demonstrations for contaminated sites.	Moderate capital and no O&M costs (*one-time action*).	Eliminate based on implementability
		In-Well Vapor Stripping	Involves preferentially extracting VOCs dissolved in groundwater by converting them to vapor phase and treating the vapor. The system involves the combination of air lift pumping and aeration within the borehole to strip volatiles from the groundwater.	Effectively removes the contaminants at the vapor phase without pumping the water to the surface		Moderate capital and O&M costs.	Eliminated based on insufficient case studies
	Chemical Treatment	Permeable Reaction Walls (Iron Filings Wall with funnel and gate system)	Permeable reaction wall installed across flowpath of contaminant plume; treatment occurs as groundwater flows through wall under natural or enhanced gradient. Potentially effective for removal of inorganics from groundwater.	Limited applications to date; reported to be successful in degrading greater than 90% of TCE in groundwater. Limited data concerning effectiveness in attaining final cleanup goals, but technology is generally viewed as promising.	Limited full-scale applications. Would require treatability testing (bench and potentially pilot-scale) to support design and optimize performance. Flat watertable at the site may make passive hydraulic control difficult.	Moderate capital and O&M costs. Interference with existing utilities could increase costs.	Retain for further consideration.
Removal/ Treatment/ Discharge	Groundwater Extraction	Wells	Extraction wells and pumps installed to collect contaminated groundwater for subsequent conveyance to treatment facilities.	Potentially effective for removal of VOC contamination. May not achieve complete aquifer remediation.	Readily implementable. Will require treatment/disposal of extracted groundwater.	Low capital and O&M costs.	Retain for further consideration.
		Drains	Underground gravel-filled trenches generally constructed with tile or perforated pipe to collect groundwater.	Expected to be effective for shallow groundwater collection or hydraulic gradient control.	Implementable. Will require treatment/disposal of extracted groundwater.	Moderate capital and low O&M costs.	Not selected as representative technology; may be re-evaluated during design phase.

TABLE 1.1 COMPARATIVE ANALYSIS OF ALTERNATIVES

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Removal/ Treatment/ Discharge	Biological Treatment	Biological Processes	Ex situ sequential anaerobic aerobic treatment would be used to degrade TCE and other site contaminants. Need provision for nutrient addition, mixing, etc.	Chlorinated organics may be degraded in an anaerobic system. Treatability studies would be needed to develop design for ex situ system	Complicated process that requires control and monitoring of large number of variables; has been successfully implemented.	High capital and O&M costs.	Eliminate from further consideration; other technologies offer more cost-effective means for ex situ treatment.
	Physical Treatment	Air Stripping / Steam Stripping	TCE and other VOCs are stripped from water by coming in contact with air or stream usually in a packed column. Normally used ahead of activated carbon units	Effective for removal of VOCs from water; off-gas would be collected and require further treatment. Removal efficiencies > 99.9% could be achieved for VOCs.	Well-proven, reliable technology. SDHEC permit may be required for off-gas treatment; tower height and location may be restricted.	Moderate capital and O&M costs.	Retain for further consideration
		Carbon Adsorption (GAC)	Contaminants transfer to the activated carbon adsorbent due to the imbalance of forces in the pore walls of the adsorbent. Normally used as a secondary unit to air stripping	Widely demonstrated effectiveness for removal of low concentrations of VOCs.	Available and proven technology. Spent carbon must be regenerated or disposed. Mobile units available.	Low capital costs and moderate O&M costs.	Retain for further consideration
		Filtration	Isolates solid particles by running a fluid stream through a porous medium. Driving force is either gravity or a pressure differential across the filtration medium.	Effectively removes particulate-borne contaminants from water; effectiveness dependent on pore size and particulate size.	Technically feasible and widely available through commercial vendors. Residuals may require treatment or disposal.	Low capital and O&M costs.	. Eliminate based on cost; VOCs can be removed more cost-effectively by other means.
	Chemical Treatment	Chemical Oxidation	Ultraviolet (UV) radiation in conjunction with ozone and/or hydrogen peroxide oxidizes TCE and related compounds to render them nonhazardous or to make them more amenable to subsequent removal or destruction processes.	Effective for oxidation and destruction of chlorinated hydrocarbons. May result in the formation of partially oxidized and undesirable byproducts. The high TDS and TSS at this site makes this treatment technology not applicable.	Use of UV radiation may require pretreatment to prevent fouling or scaling of UV lights.	High capital costs and O&M costs.	Eliminate based on cost; VOCs can be removed more cost-effectively by other means.
	Groundwater Discharge - *Treated*	Surface Outfall	Treated groundwater discharged to near-by surface water	Effective means of disposal for treated groundwater; discharge limits in NPDES permit would dictate treatment goals.	Technically feasible;. Potential administrative issues if permit to be prepared	Low capital and O&M costs.	Retain for further consideration. as support technology
		Publicly-Owned Treatment Works (POTW)	Treated groundwater discharged to POTW or subsequent treatment/discharge	Effective means to dispose of treated groundwater; discharge would have to meet POTW limits for industrial discharges.	Significant administrative problems with POTW acceptance of treated (or untreated) groundwater.	Low capital costs and O&M costs.	Retain for further consideration. as support technology
		Injection/ Infiltration	Treated groundwater discharged to the ground via an injection well or infiltration gallery.	Effective means of disposal of treated groundwater; additional treatment may be required to meet permit conditions for injection. Can be used to enhance hydraulic containment or contaminant removal.	Technically feasible; permit from SDHEC may be required	Low capital and moderate O&M costs.	Retain for further consideration.
		RCRA TSD Facility	Untreated groundwater would be collected and transported to a RCRA-permitted facility for treatment/disposal; the receiving facility would determine treatment requirements.	Effective method for disposal of contaminated water.	Implementability dependent on the volume of water requiring off-site transport and geographic location of RCRA facility.	Low capital and high O&M costs.	Eliminate based on cost.
		Beneficial Uses	Treated groundwater would be used for landscape irrigation, pond or fountain replenishment, habitat maintenance or other non-consumptive uses.	Reuse of water maximizes overall benefit of remediation and is consistent with SDHEC policy of efficient utilization of water reuse	Technical feasibility depends on type of redevelopment in surrounding areas and ability to tie into infrastructure for distribution of water.	Low capital costs and low O&M costs.	Not selected as representative technology; may be re-evaluated during design or implementation as redevelopment occurs.

1.6.1 Air Sparging and Soil Vapor Extraction

Air Sparging was evaluated and the pilot study indicated that it might be a viable option. The design air flow rate from the pilot study was 2 scfm. Higher flow rates were used during the pilot study, but they caused water to bubble from one of the observation wells and groundwater mounding in the other observation wells. If the higher flow rates were used for the remediation system, groundwater mounding and breaching the ground surface could become a concern.

The second concern for the system is the uncertainty associated with the capture of the emissions from the air sparging. A soil vapor extraction system (SVE) would need to be installed over the area of air sparging to collect emissions from the air sparging. Because of the fine layered silts, high water table, and site conditions, all of the generated emissions might not be captured. This could be a safety and health concern to MCRD personnel, and the general public as well. The installation costs for this system are estimated to be $420,000.

Air Flow Dynamics

Recent research has demonstrated that at several sites, air flow through saturated soil is in the form of channels, not bubbles. Only sites with an average grain size of 2.0 mm or larger will form bubbles. The channel flow will not create the convection currents and the groundwater will not likely recirculate around the sparging wells thus limiting the effect of the sparging wells. The average grain size for soil sample from the site at Parris Island was 0.125 mm. Thus the flow regime is most likely to be channels (Ref. 5).

Diffusion and Rate Limitations

Since channels are the most likely path for airflow, the groundwater and the contaminants are not all equally exposed to the airflow. The channels are likely to be several inches to several feet apart. The contaminants then must migrate this distance using molecular diffusion processes to reach the air channel to volatilize. This would mean that the remediation time at Parris Island could be long and the system effectiveness could be limited (Ref. 5).

Minimum Permeability

The minimum permeability of 1×10^{-3} cm/sec is generally necessary to achieve an effective rate of air injection for air sparging. Slug tests have been conducted at several sites at Parris Island, but not in the area of the Dry Cleaners Facility. The permeability values from these tests range from 1.57×10^{-3} cm/sec to 4.71×10^{-3} cm/sec. (Ref. 4). These values are very close to the minimum recommended values (Ref. 5).

Minimum Air Flow Recommendations

The Wisconsin Department of Natural Resources "Guidance for the Installation of Air Sparging Systems" recommends the air flow for an air sparging well to be at least 5 scfm per well. This rate has been revised from a recommended rate of 0.5 scfm in their 1993 guidance document. The selected design rate for an air sparging system was 2 scfm per well based on the pilot study results. This rate is below the guideline's recommended minimum and could result in unsatisfactory results (Ref. 5).

1.6.2 In-Well Vapor Stripping

In-well vapor stripping is a process that removes the volatiles by aerating the groundwater circulating through a recovery well. The flow of air results in an airlift pump effect that creates a circulation cell. The contaminated groundwater is treated as it passes through the well. This technology is currently being demonstrated at a number of sites.

Some of the advantages that this technology has over air sparging at this site are:

- The radius of influence of this method is reportedly larger and more uniform than air sparging.
- The treatment zone is more predictable than air sparging.
- The treatment zone is lower in the aquifer
- The capture of emissions is from the well and a separate vapor extraction system is not required. This technology has a higher likelihood that the vapors are captured and discharge is controlled.

Some of the disadvantages of this method include:

- The well can clog or scale from biological or mineral sources. This can be cleaned by high pressure cleaning or chemical treatment.
- The depth of a recovery well at the dry cleaner facility would be shallow. This could affect the system's radius of influence and the ability to remove the contaminants in one cycle through the circulation cell. More cycles of the groundwater may be necessary because of the limited depth of the wells.
- The recharge of the groundwater at this site could be a problem (especially during the rainy season), because of the depth to groundwater across the site is only 2 to 3 ft.

The installation costs for this system are estimated to be $300,000.

This system was not acceptable to SCDHEC, because the discharge water would not meet Maximum Contaminant Levels (MCLs) until it had been cycled through the recovery wells several times. The injection permit would require the treated water to meet MCLs prior discharge to the recharge gallery. This technology will not be considered further.

1.6.3 Pump and Treat

For this site, pump and treat offers some advantages over some of the more innovative technologies. The following lists some of the advantages of this technology:

- It will provide hydraulic control of the site and prevent further migration of the solvent plume.
- The recovery wells will be located slightly downgradient from the center of the most contaminated area of the plume.
- The Depot's federally-owned treatment works (FOTW) will accept the pumped water after it is treated to reduce solvent concentrations to MCLs.

- Groundwater modeling for the three-well system indicates that complete hydraulic control can be achieved with a modest total flow rate of only 6 gal per minute (see Attachment 4).

The main disadvantage that pump and treat has is it's inability to reduce groundwater concentrations to below MCLs. At this site, the objectives of the IRA are hydraulic control and source removal. The pump and treat system will meet these goals. The installation costs for this system are estimated to be $300,000.

1.7 RECOMMENDED INTERIM REMOVAL ACTION ALTERNATIVE

Detailed analysis of the technical evaluation and comparison of the costs leads to pump and treat as the selected alternative for the IRA at the dry cleaning facility

1.7.1 Pump and Treat

The treatment system will consist of the following:

- The groundwater extraction system will include three electric recovery pumps, groundwater discharge piping, fittings, flow counters, limit switches and accessories.
- A low profile air stripper to remove the volatile contaminants from the groundwater.
- A pumping system to pump the treated groundwater to an adjacent sewer manhole for discharge to the FOTW.

1.7.2 Off-Gas Discharge

Off-gases generated for the operation of the air stripper will be vented out the stack from the top of the treatment building. Treatment of the off-gases will not be required. The maximum estimated emissions from the system are approximately 90 pounds per month. SCDHEC Bureau of Air Quality has determinated that an air permit will not be required for this level of emissions (Attachment 5). During startup and optimization of the treatment system, operating data will be evaluated to ensure that the estimated emissions are correct. If the actual emissions are higher, the Bureau of Air Quality will be contacted for further guidance.

2.0 REMOVAL ACTION ACTIVITIES

This section of the document provides guidance and direction to the Bechtel construction crew during the implementation of the EE/WP and serves to meet the contractual requirements between Bechtel and the Navy. This section also provides a more detailed description of the physical processes to be employed at the dry cleaning facility.

2.1 CONSTRUCTION DRAWINGS

After incorporating public comments into the EE/WP and SOUTHDIV approval, Bechtel will prepare the final construction drawings. These drawings will serve as the basis for the Record Drawings and will be used in the procurement of treatment system equipment and materials. The preliminary construction drawings are included in Attachment 6. Additional details necessary for the field crew to implement the design will be included on the final construction drawings. Final construction drawings will be maintained at the site by the Bechtel Construction Site Superintendent. Red line construction drawings detailing the

actual installation shall be provided to the Bechtel Project Engineer for incorporation into the Record Drawings.

2.2 EQUIPMENT PROCUREMENT

After approval of the EE/WP, Bechtel will complete the procurement of the treatment system equipment and materials. This will include the air stripper, pumps, valves, system control, treatment building, and miscellaneous piping.

2.3 SUBCONTRACTING

After approval of the EE/WP, Bechtel will complete the subcontracting to support the work at the dry cleaning facility. These will include:

- Well Drilling
- Survey
- Transportation, Treatment, and Disposal Services
- Miscellaneous Site Services
- Analytical Services
- Operation and Maintenance (O&M)

2.4 PERMITS

Necessary permits identified for the work at the site include a facility excavation permit and well installation permits. The well permits will be obtained prior to mobilization.

2.5 MOBILIZATION

Once notice to proceed has been given to Bechtel by SOUTHDIV, Bechtel will mobilize a work force, support equipment, material, and subcontractors necessary to complete the work.

2.5.1 Pre-Construction Meeting

Before the physical work begins, a preconstruction meeting will be held with the Resident Officer in Charge of Construction (ROICC). This meeting will discuss execution of the work, site access, staging areas, transportation haul routes, and contact personnel for utilities, fire, environmental, safety and health, security, waste management, and public and troop interface.

2.5.2 Temporary Facilities

A hookup for minor use of potable water for decontamination, safety and health, and miscellaneous usage will be coordinated with the ROICC. A storage container for tools, small supplies, safety and health equipment, and other supplies will be staged to the site.

2.5.3 Utility and Excavation Interference Identification

Before the start of any excavation activities, the Bechtel Site Superintendent will perform all the necessary utility clearances and contacts. This will include contacting the MCRD Public Work Department, the

ROICC, and facility personnel. Bechtel will also use utility locating equipment before any intrusive work in an area. The drilling subcontractor will be required to post-hole the first 4 ft of depth before drilling the borehole. Hand digging shall be used to excavate around all existing utilities.

2.6 GROUNDWATER TREATMENT SYSTEM INSTALLATION

The pump and treat system installation consists of recovery well installation, equipment installation, and piping installation. The project drawings are included in Attachment 6.

2.6.1 Recovery Well Installation

Recovery wells will be installed for the groundwater treatment system. Wells will be installed at the locations shown on project drawings. Well completion details are also included on the project drawings. Well screens will be installed above the top of the aquitard at approximately 16 to 18 ft below grade.

2.6.2 Equipment Installation

An air stripper and controls will be installed in the equipment building. The system controls will allow the system to operate all the wells continuously. The normal groundwater pumping rate will be 2 gal per minute per well. The system will be sized to allow flow rates as high as 5 gal per minute per well.

2.6.3 Piping Installation

Buried piping will be installed below ground from the equipment building to each recovery well and from the equipment building to the sewer manhole. Trenching will be of sufficient size to allow for the inspection of the work, but comply with the requirements of Occupational Safety and Health Administration Safety Standards, 29 CFR 1926.651, Subpart P. All existing utilities or other obstructions will be located before the start of excavation. Backfill shall be compacted to 85 percent of the maximum dry density in accordance with ASTM D1557. Spoils generated from excavation activities which are not used as backfill will be tested and dispositioned as described in Section 3.0, Waste Management.

Concrete pavement installation and repairs will require a sub-base consisting of a 6-in. layer of CR14 crushed stone compacted to 95 percent of the maximum dry density in accordance with ASTM D1557. Concrete shall be 4,000 psi, low water content to reduce shrinkage with fiber reinforcement. The minimum flexural strength shall be 650 psi at 28 days.

2.7 EQUIPMENT BUILDING

The air stripper, the electrical power distribution center, and control instrumentation will be centrally located within a pre-fabricated building. The location of the building is indicated in the project drawings. Vents and a temperature controlled forced air ventilation system will be provided. Color and style of the building shall be coordinated with the Navy. The final building drawings will be provided by the vendor.

2.8 ELECTRICAL SERVICE

Electrical service will be 208 volt 3-phase supplied by overhead line from an existing power pole to the equipment building. All electrical services shall be performed by a South Carolina-licensed electrician. All

systems and services shall conform to the National Electrical Code and the authority having jurisdiction. The main service location shall be coordinated with the MCRD personnel.

2.9 INSTRUMENTATION

The system installed as part of this IRA is designed to operate unattended. To accomplish this, sensors will be installed that send signals to the controller and/or local actuators to control system processes. In the event that the system operates outside of established parameters, the system will discontinue operation.

2.10 SURVEY

After the installation of the equipment, wells, and other utilities, a survey to document the final as-built locations will be performed. Reference points and elevations will be obtained as required to be consistent with data available for the other site monitoring wells. One existing monitoring well elevation will be verified during this survey.

2.11 INITIAL STARTUP TESTING

After installation of the physical system has been completed, startup testing of the equipment and the process can begin. All testing records and initial readings will be recorded in logbooks created by the Field Engineer. These logbooks will become the basic site visit guidelines. Included will be time, temperature, weather conditions, pressure readings at each gauge, flow readings at each well head, position of each solenoid valve, and water chemistry field measurements. Also included will be a list of sampling requirements and activities to be accomplished during each visit.

2.11.1 Equipment Testing

After the installation of the equipment and hookup of the electrical service, the equipment vendor will be brought to the site for a system inspection. The vendor will inspect wiring connections, motor anchorage, and any other primary items of concern. Once the vendor has approved installation and authorized power of the systems, motors will be initially bumped to ensure proper rotation. Sensors will be activated and deactivated to ensure signals to the controller are being received. The wiring of gauges and sensors to the panels will be validated.

Other equipment will be checked and inspected for orientation and working valves. Piping will be inspected to ensure it is secure and in place. Electrical conduits will be inspected to ensure they are properly installed.

Final inspection check lists and quality assurance requirements are discussed in Section 6.0, Quality Assurance.

2.12 OPERATIONS MONITORING AND OPTIMIZATION

After completion of the initial startup testing and evaluation, the initial operations monitoring and optimization will commence. The initial operations monitoring and optimization will occur during the first month of operations. Daily monitoring will be performed for the first week and weekly monitoring will be performed for the first month. After the first month of operation, the normal monthly O&M visits will begin.

2.12.1 Record Keeping

A check list form will be generated to record pertinent information that will be used to evaluate system performance. This form will include information on pressures, flow rates, and field measurements and identify samples collected for laboratory analysis.

2.12.2 System Optimization

Using the data gathered during the first month of operations, the initial settings of flow rates and pressures at each recovery well will be established. Every quarter these parameters will be reviewed and evaluated.

3.0 WASTE MANAGEMENT

General waste management practices used by Bechtel on this project will be as defined in the *Environmental Response Action Contract Waste Management Plan*. There are several waste management activities that are anticipated during this remedial action, including disposal of:

- Construction debris
- Excavated Soils
- Decontamination water
- Well purge and development water
- Personal protective equipment and other incidentally contaminated materials
- Other non-hazardous solid wastes.

3.1 WASTE MINIMIZATION

Construction activities at this site will be controlled to minimize the amount of materials that must be disposed of. Waste minimization is an important goal and will be implemented during all site operations.

These practices will include:

- Limiting extraneous materials taken into contaminated areas
- Decontamination of equipment used to support onsite activities
- Use of consumable items that can be compacted or otherwise volume reduced.

3.2 HAZARDOUS WASTE

On March 11, 1994, a spill of PCE occurred at the dry cleaning facility at Building 193. The spill was noted by the MCRD Environmental Office and reported to SCDHEC and the National Response Center. Information regarding the spill was obtained from a *Fact Sheet* dated March 31, 1994 (Attachment 1). The groundwater contamination at this site is most probably a result of the March 11, 1994 spill and other past practices at the dry cleaning facility. Based on this process knowledge, contaminated media containing PCE, TCE, or vinyl chloride will be classified as Resource Conservation and Recovery Act (RCRA) listed wastes. Wastes generated as a result of the installation of the IRA system at this site will be sampled for these hazardous constituents.

Hazardous waste could be generated during the remedial actions at this site. When any hazardous wastes are identified, they will be managed in accordance with South Carolina State Regulations, RCRA, 40 CFR Part 260, and related federal regulations. Bechtel will facilitate transport and disposal using waste profiles and manifests signed by the MCRD as the waste generator.

3.3 WASTE DISPOSAL

The following sections provide guidance for the decision process for disposal of the wastes generated at the site. The Bechtel Site Superintendent is responsible for filling in the Bechtel Navy RAC waste tracking logs and ensuring they are kept up to date. Manifests or shipping papers, as required, will be signed by the MCRD.

3.3.1 Construction Debris

Non hazardous construction debris will be checked for contamination and cleaned by brushing off visible soils. The material will then be disposed of at a South Carolina-licensed landfill or recycled.

3.3.2 Excavated Soils

Excavated soils will be sampled for disposition. All excavated material will be placed on 10-mil plastic liners and covered, until sampling results are known. If the excavated material is determined to be a RCRA hazardous waste, it will be containerized and disposed of as such. Excavated material determined to be non-hazardous will be used as backfill. Surplus backfill material will be deposited at the AS-18 site.

Drill cuttings generated during well installation will be containerized and sampled. If these drill cuttings are determined to be a RCRA hazardous waste, they will be disposed of as such.

3.3.3 Decontamination, Well Purge, Development, and Miscellaneous Water

Decontamination, well purge, and development water will be containerized in 55-gal drums approved by the Department of Transportation or in poly tanks. The water will be stored onsite and treated using the groundwater treatment system.

3.3.4 Personal Protective Equipment

Personal protective equipment (gloves, boot covers, etc.) will be cleaned of loose soil, double bagged, and disposed of at a South Carolina Subtitle D landfill. These will be collected and bagged daily and disposed of at the end of each week.

3.4 SPILL PREVENTION PLAN

Activities associated with the refueling of equipment will be conducted in a manner to ensure that product or fuel is not released into the environment. When conducting operations which may result in possible fuel release, Bechtel's work will provide best management practices to preclude a spill. Provisions for spill prevention and control that will be used during transfer of fuel will include:

- Performing manual level checks in the portable fuel tank prior to refilling
- Performing manual level checks in the equipment tank prior to refueling

- Manual transfer of fuel
- Surveillance monitoring: All tanks will be checked during refueling operations to ensure overflow conditions do not occur
- Use of process controls where feasible
- Immediate availability of spill mitigation equipment (e.g., absorbent materials)
- Notification to the MCRD fire department and then to MCRD Environmental personnel if a spill occurs

Other provisions and procedures will be discussed with MCRD before implementation of the refueling operations. Daily inspections of the refueling operations will be performed by the Safety and Health representative to ensure availability of prevention controls.

4.0 SAMPLING AND ANALYSIS

Project procedures (PPs) based on the EPA and SCDHEC sample collection guidelines will be utilized throughout the data collection phase of this project. This section outlines the specific field methods and techniques that will be used to collect soil and water samples during the course of the activities outlined in this work plan. This section also provides an overview of the groundwater monitoring plan.

4.1 SAMPLING PROTOCOL

The following Bechtel Navy RAC Project Procedures will be utilized for this work:

- PP 6003 Sample Identification and Data Encoding
- PP 6004 Field Logbook Management
- PP 6005 Chain-of-Custody Record Procedures
- PP 6006 Sample Tracking
- PP 6010 Sample Containers, Preservation and Aliquot Requirements
- PP 6011 Sample Packaging and Shipment
- PP 6021 Water Sampling
- PP 6024 Decontamination of Field Sampling Equipment
- PP 6025 Soil Sampling.

4.2 FIELD SAMPLING AND ANALYSIS

Samples identified in this section will be collected in accordance with the previously identified project procedures. Analysis of these samples will be in accordance with EPA criteria for the defined method or by the procedure identified as appropriate. Sampling efforts can be segregated on the basis of data objectives:

- Soil Disposal Sampling
- System Startup Sampling
- Groundwater Monitoring
- System Performance Monitoring - Field Measurements

4.2.1 Soil Disposal Sampling

Excavated soils and drill cuttings will be sampled before disposal. Soils samples will be collected and analyzed as required by the transportation/disposal facility.

4.2.2 Groundwater Monitoring

One complete round of groundwater samples will be collected within one month before system startup. All 16 monitoring wells at the site will be sampled and the samples will be analyzed for VOCs and other parameters listed in the Monitoring Well Sampling Section.

During the implementation of the remedial action for groundwater treatment, groundwater samples will be collected from the monitoring wells on a quarterly basis. The following provides a description of the activities to be performed.

Well Inspections

During each groundwater sampling event, the wells will be inspected to ensure that the well covers remain water tight, that the concrete pad is not cracked or unstable and that the well seal is in place. Deficiencies or damage to the wells will be recorded on the Groundwater Sampling Record included as Attachment 7. Damaged wells will be repaired as necessary.

Water Levels

Water level measurements will be taken from 16 monitoring wells located around Building 193. The well cap will be removed for a period of not less than 10 minutes, after which the water level can be taken and recorded. All 16 monitoring well water levels will be taken within a 4-hour period.

Well Purge

After completion of the water level measurements, one technician will begin the purging activities. The purging regime will start with the uncontaminated or least contaminated wells and move toward the most contaminated. A low flow pump will be used to purge the monitoring wells. During the purging activities, the parameters of pH, temperature, and conductivity will be recorded at appropriate intervals based on estimated volume of purge water. Purging will be considered complete when a minimum of five well volumes have been removed and pH, conductivity, and temperature have stabilized. Final readings of pH, Eh, conductivity, temperature, and dissolved oxygen will be taken and recorded.

The purge volume will be calculated by taking the depth to water from the top of the well casing and subtracting it from the listed total well depth, then multiplying this number by the calculated volume of water per foot of well depth to provide the number of gallons. Purging will be completed following the Bechtel Navy RAC PP 6021, "Groundwater Sampling."

Monitoring Well Sampling

At the completion of monitoring well purging, sampling activities will begin. Sampling activities will start with the uncontaminated wells or least contaminated wells and move toward the most contaminated wells. Sample activities for the monitoring wells to be sampled will be completed within 24 hours of purging. Groundwater sampling will be conducted in accordance with the Bechtel Navy RAC PP 6021,

"Groundwater Sampling." Samples will be analyzed for VOCs and the following natural attenuation parameters:

- Iron (filtered sample to remove sediment)
- Sulfate
- Alkalinity
- pH
- Temperature
- Conductity
- Oxidation/reduction Potential
- Chloride
- Nitrate
- Total Organic Carbon

Discharge Water Sampling

Water samples will be collected from the sampling port for each recovery well and analyzed for VOCs. They will be collected twice during the first week of operation and monthly thereafter. The samples collected monthly will also be analyzed for the natural attenuation parameters listed in the above Monitoring Well Sampling Section.

After the first round of quarterly sampling, the monitoring wells sampling results will be compared with the startup sampling. The need to continue quarterly sampling of the outlying wells will be evaluated.

5.0 SYSTEM STARTUP, OPERATIONS AND MAINTENANCE

An operations and maintenance manual will be completed during the initial operations. At the end of the four week initial operations, normal O&M activities will begin, with monthly visits to the site. Bechtel will continue the system O&M for the first 6 months of operations, after which time the system effectiveness will be evaluated. The following sections outline the general requirements of the operations, evaluation, sampling, reporting, and maintenance of the system.

5.1 STARTUP, OPERATIONS, AND MAINTENANCE MANUAL

A startup, operations, and maintenance manual will be created before system startup. This manual will include startup procedures, shutdown procedures, normal activities, monthly activities, quarterly activities, reporting requirements, maintenance requirements, and logs for data and maintenance activities.

5.2 SYSTEM MONITORING

The following is a description of system monitoring on a per visit basis:

- Upon arrival at the site, record the readings on the pressure indicators and flow meters.
- Monitor flow rates from each recovery wells.
- Collect water samples from discharge from each recovery well.
- Collect water level readings and field chemistry data from monitoring wells.

- Perform preventative maintenance.
- If appropriate, collect quarterly groundwater field chemistry data and samples from the monitoring wells.

5.3 SYSTEM EVALUATION

During the course of the normal operations and maintenance, the system will be periodically evaluated for effectiveness in reducing contaminant concentrations. Groundwater analytical data will be compared to the original baseline data. Parameters will be plotted to demonstrate changes in the system. Emission data will be evaluated to demonstrate compliance with emissions standards. Quarterly reports will be forwarded to SOUTHDIV.

6.0 QUALITY CONTROL

Appropriate quality control (QC) criteria are developed and included in the site-specific addendum to the Quality Control Plan. This site-specific plan, called the Quality Control Plan Addendum, is based on the Navy-approved QC Plan for the basic contract. Bechtel will implement, maintain, and comply with the Navy-approved basic contract Quality Control Plan and the site-specific Quality Control Plan Addendum.

The intent of this section is to provide general guidance to the field construction crew as to the items that require inspection during installation. In addition, this section identifies some of the items that require spot inspection. The following sections discuss the construction field inspection, testing requirements, and submittals. These sections will be revised as appropriate during actual field implementation based on equipment.

6.1 EXCAVATION

During excavation operations to install system piping, the QC Representative will ensure that the proper soil disposal sampling protocol is followed and the results are reported before the soil is transported from the site. Final disposition and final clean soil sampling shall also be noted on the tracking log for the soil, as will the notation of the proper number of post-treatment samples, based on permit and regulatory requirements.

6.2 SITE RESTORATION

During site restoration activities, the QC Representative will ensure grading and seeding. Additionally, erosion controls will be inspected for proper placement and usage to prevent sediment runoff.

6.3 PIPING

All pressure piping will be leak tested by pressuring the line to 100 psi with air and checking joints with soap for leaks. The QC Representative will fill in field inspection reports noting the testing and the results.

6.4 ELECTRICAL SERVICE

The QC Representative will verify that all electrical components and utilities are installed in accordance with the design drawings and specifications. This will include verification that wiring was pulled correctly,

grounding is present, and conduit has been properly sealed. The QC Representative will verify before start-up or placement in service that all appropriate testing has been completed.

6.5 EQUIPMENT INSTALLATION

Equipment will be checked before installation for certificate of testing. After installation, the QC Representative will verify that equipment tests are conducted in accordance with the manufacturer's instruction. The oil level in the air compressor shall be verified before startup.

6.6 WELL INSTALLATION

The QC Representative will verify the drilling permit record keeping and materials used in well construction. Each recovery well will be logged as to depth, observations (including material retrieved by augers), and depth to groundwater. The wells where split-spoons were taken will be noted on the well log forms. The Bechtel representative will be responsible for logging the well. The QC Representative will ensure that the well was developed to verify proper seating of the sand pack to prevent siltation of the well during use.

6.7 SYSTEM STARTUP AND OPERATIONS

The QC Representative will verify the well installation permit is in place and that the proper records are maintained to document startup and operation.

6.8 RECORD DRAWINGS

Record Drawings documenting system installation will be prepared and submitted to SOUTHDIV.

7.0 SAFETY AND HEALTH

A Program Safety and Health Plan defines the policies for the Navy RAC project. A Site Safety and Health Plan has been prepared for each of the Navy RAC bases. An addendum to the site specific plan which will be provided to the Navy under separate cover defines task-specific requirements for the activities at the dry cleaning facility.

A process hazards review of the safety hazards associated with the operation of the groundwater treatment system will be conducted prior to completion of the Remedial Design. The purpose of the process hazards review is to ensure that the procedures, instruments, equipment, and administrative controls required to prevent, mitigate, or control process hazards are in place.

8.0 PROJECT MANAGEMENT

8.1 PROJECT ORGANIZATION

As the Environmental RAC for the Navy, Bechtel provides management of the dry cleaning facility field activities, which include all activities necessary to implement field work delineated in work plans. Typically, these activities include the development and procurement of subcontract services; the development, implementation, and overview of plans; the collection and review of data, including sampling

results, quality control submittals, and sample tracking and custody; technical guidance to onsite personnel; report preparation; cost management; and schedule control.

9.0 REFERENCES

1. Bechtel, 1996b. "Technical Memorandum For Well Installation and Air Sparging Pilot Test," December. (CCN000060)

2. RUST Environment, 1993. "Remedial Action Plan - MCRD Parris Island South Carolina," August. (CCN000025)

3. S&ME, 1994. "Tetrachloroethylene Contamination Assessment and Conceptual Corrective Action Plan, US Marine Corps Recruit Depot Dry Cleaning Facility," June. (CCN000079)

4. Sirrine Environmental Consultants, 1991, "Final Contamination Assessment Report, Marine Corps Recruit Depot, Parris Island, South Carolina," April.

5. Wisconsin Department of Natural Resources "Guidance for Design, Installation and Operation of In Situ Air Sparging Systems," Publ-SW186-93 September 1993 and Errata Sheet dated August 11, 1995.

ATTACHMENT 1

SPILL FACT SHEET

6280
NREAO
31 Mar 94

FACT SHEET

Subject: SPILL 11 MARCH 1994 DRY CLEANING PLANT

On 11 March 1994, a reportable spill of Tetrachloroethylene at the MWR Dry Cleaners was noted by the Environmental Office and reported to SCDHEC.

On 14 March 1994, samples were taken from the water in the containment basin and soil by the discharge line and sent off for analysis. The results were positive. The allowable limits under RCRA is 0.7 ppm (parts per million). Sample 1 (containment basin) indicated 2000 ppm. Sample 2 (berm/road) indicated 3000 ppm, (Encl 1).

On 15 March 1994, the National Response Center was notifed. As required by regulation one pound of contaminants discharged into the environment is reportable.

On 18 March 1994, the Environmental Officer, Mr. Clark, surveyed the ground to identify the extent of contamination.

On 19 March 1994, seventeen samples were taken from the ground along the side of the road some of which were taken through holes bored in the road surface to quantify the contamination. Results indicated contamination has leached through the cracks in the road to the subsurface in excess of RCRA limits (Encl 2).

Mr. Russell Berry of the South Carolina Department of Health and Environmental Control Office inspected the site on March 14, 1994. He expressed concerns of clean up to meet the RCRA limits of 0.7 ppm.

Mr. Clark has been advised by the DRMO who administers the HW contract that a roll-off container can be obtained for $2000. The containerized material would go out at fifty cents per pound.

Johnsie A. Nabors
NREAO Ext. 2779

ATTACHMENT 2

Results from the June 1996 Phase 2 Sampling Effort

GROUNDWATER RESULTS
18 JUNE TO 30 JUNE 1996

1.0 INTRODUCTION

An assessment of groundwater at the MCRD Parris Island, S.C., Dry Cleaner Facility was conducted by Bechtel Environmental, Inc. (BEI) between June 12 and June 30, 1996. The purpose was to confirm and further define the vertical and horizontal extent of groundwater contamination and to collect groundwater physical properties needed to aid in the selection and design of a treatment system. The assessment was based on a contamination assessment May 1994 report written under the direction of Morale, Welfare and Recreation, MCRD Parris Island, S.C.

2.0 RESULTS

The basis for the proposed borehole locations, Figure 1 which was submitted with the 17 June 1996 Monitoring Well Request, was the May 1994 TCE Contamination Assessment Report. Prior to actual sampling, three cone penetrometer boreholes were drilled outside the limits of the contaminant plume, both up- and down- gradient, to locate intermediate clay lenses as well as the Hawthorn formation. After these locations were determined, water samples were collected using direct push technology at various depths in between the clay lenses and analyzed for PCE, TCE, DCE (cis- and trans-) and VC with a field GC. Table 1 gives a summary of all field GC data. Other physical properties were collected on the groundwater which are shown in Table 2. Approximately ten percent of the samples were sent to an offsite laboratory for confirmation whose results are also shown in Table 1. These results, including chain of custody forms, are in Appendix A. Appendix A also contains the information from the three samples for metals, ion analysis, total dissolved solids, total suspended solids, TKN, sulfites, BOD, ammonia, total phosphorus, total organic carbon, filtered total carbon, carbonate, hardness, and turbidity.

Figure 2a depicts the as-built groundwater sampling locations. The borehole locations varied horizontally as the GC sample results indicated the direction of the contaminant plume. Vertical groundwater samples were collected and analyzed until two clean samples were noted. Boreholes with no contamination are exhibited around the entire perimeter of the plume.

Figure 2b has 5 clear overlays which depict the total solvent plumes which exceeded the maximum contaminant limit (MCL) at the various depths. The 7' and the 14' depths have internal plumes which indicates areas >1ppm total solvents. The total solvent number was simply derived by adding the value of each contaminant collectively. No weighted measures were used.

Appendix B includes the information from the samples collected and analyzed for methane by USGS in Columbia S.C. Appendix C includes the geologic information obtained from the direct push technology. A summary table of conductivity measurements is presented before the hydrocone test information for easy reference, and Appendix D includes copies of the GC log data along with a written narrative explaining the GC/sample preparation, calibration and peak identification.

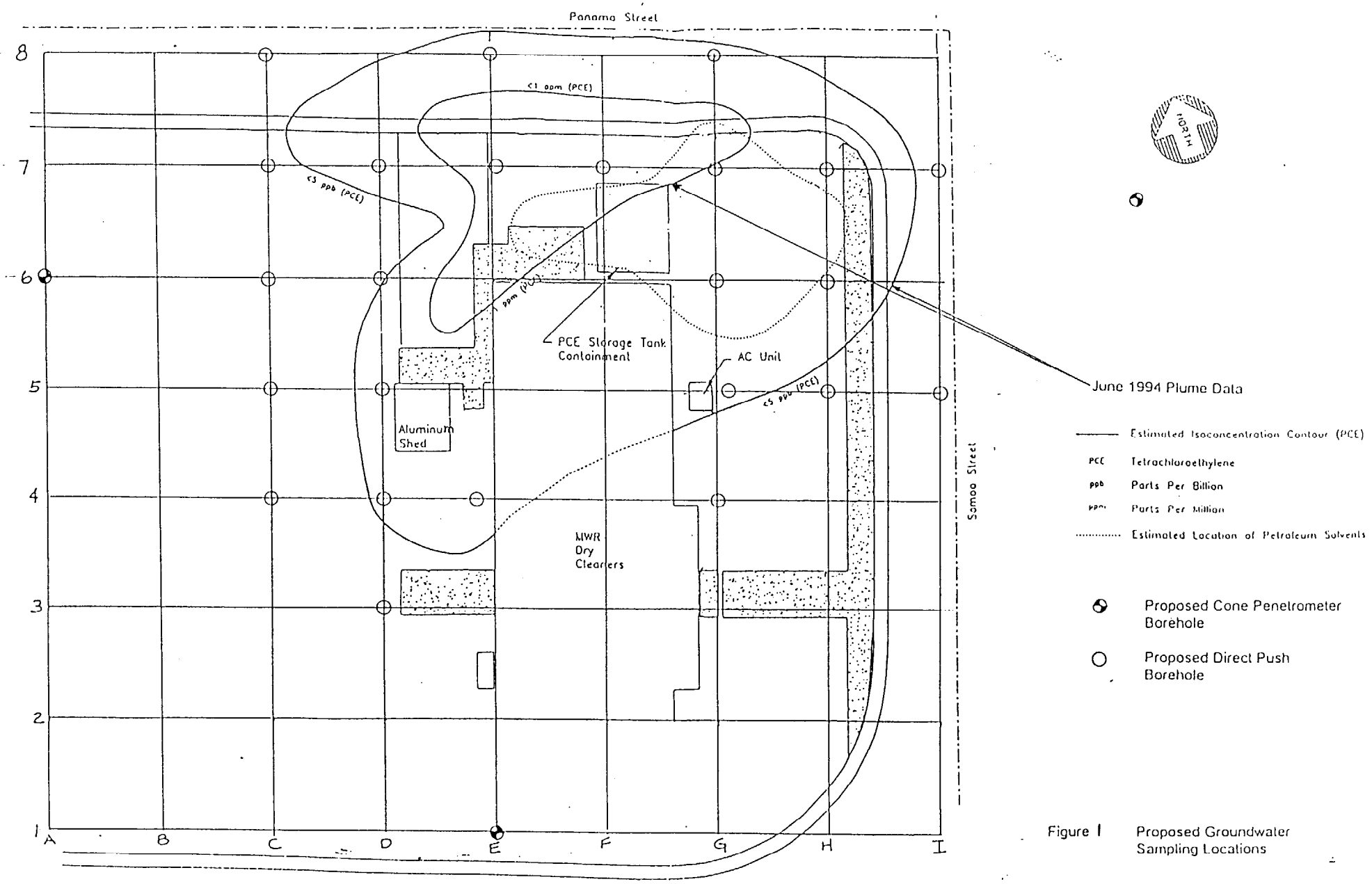


Figure 1 Proposed Groundwater Sampling Locations

TABLE 1
FIELD GC SUMMARY DATA
18 JUNE TO 30 JUNE 1996
MCRD PARRIS ISLAND DRY CLEANER FACILITY

Gas Chromotograph used was HNU Model 311
-: no peek found at retention time
< : peek found less than calibration
>: actual concentration may exceed reported value
T: tentatively identified; peek not resolved

SAMPLE NUMBER	DATE COLLECTED	DATE ANALYZED	SAMPLE RUN	VINYL CHLORIDE MCL - 2 ppb	1,2-TRANS DCE MCL - 100 ppb	1,2-CIS DCE MCL - 70 ppb	TCE MCL - 5 ppb	PCE MCL- 5 ppb
615E15-22-21	6/19/96	6/19/96	13	T	1.1	-	-	-
615E15-30	6/19/96	6/19/96	14	-	-	-	-	-
615E15-37	6/19/96	6/19/96	16	T	<0.5	-	-	-
610K13-15	6/19/96	6/19/96	9	T	-	-	-	-
615E15-6	6/19/96	6/19/96	10/12	T	164	8,617	13.3	-
615E15-13	6/19/96	6/20/96	17	-	-	38.5	21.7	-
615E15-13REP	6/19/96	6/20/96	18	-	-	56.5	32.8	18.1
615E15-13; Duplicate sent to lab					-	***57.8***	***25.9***	***7.2***
322D09-7.5	6/20/96	6/20/96	9/10	T	61.9	2,569	21,686	11,832
322D09-13	6/20/96	6/20/96	11	T	-	-	1.6	-
322D09-13; Duplicate sent to lab					-	-	***0.57J***	-
322D09-22	6/20/96	6/20/96	13	T	-	-	1.4	<5
322D09-28	6/20/96	6/20/96	14	-	-	-	0.6	<5
322D09-36	6/20/96	6/20/96	15	T	-	-	-	<5
621C18-14	6/20/96	6/20/96	19	T	-	-	-	-
621C18-7	6/20/96	6/20/96	21	-	-	2	3.2	1.1
621C18-21	6/20/96	6/21/96	7	T	-	-	-	-
300C22-7	6/20/96	6/21/96	9	T	-	-	-	-
300C22-22	6/21/96	6/21/96	13	T	-	-	-	-
300C22-14	6/21/96	6/21/96	14	T	-	-	-	-
500C24-14	6/21/96	6/21/96	17	T	-	-	-	-
500C24-7	6/21/96	6/21/96	19	T	2.17	-	-	-
500C24-22	6/21/96	6/21/96	18	T	-	-	-	-
700D21-7	6/21/96	6/21/96	26	-	29.7	528	208	56
700D21-14	6/21/96	6/21/96	28	T	-	-	-	-
700D21-22	6/21/96	6/21/96	32	-	-	-	-	-
700D21-28	6/21/96	6/21/96	33	T	-	-	-	-
800E00-7	6/24/96	6/24/96	13	-	< 0.5	< 0.5	-	-

SAMPLE NUMBER	DATE COLLECTED	DATE ANALYZED	SAMPLE RUN	VINYL CHLORIDE MCL - 2 ppb	1,2-TRANS DCE MCL - 100 ppb	1,2-CIS DCE MCL - 70 ppb	TCE MCL - 5 ppb	PCE MCL- 5 ppb
800E00-14	6/24/96	6/24/96	14	-	2.35	-	-	-
800G00-7	6/24/96	6/24/96	18	-	1.7	-	-	-
800G00-7; Duplicate sent to lab					-	-	-	-
800G00-14	6/24/96	6/24/96	19	T	0.5	-	-	-
700H05-7	6/24/96	6/24/96	20	-	-	9.2	1.47	-
700H05-14	6/24/96	6/24/96	23	-	-	-	-	-
500G20-7	6/24/96	6/24/96	31	T	2.56	45	-	-
500G20-14	6/24/96	6/24/96	30	T	4.84	>161	>89.6	>19.6
710E24-14	6/24/96	6/24/96	38	T	-	-	-	14.4
710E24-21	6/25/96	6/25/96	12	-	-	3.87	-	1.2
710E24-28	6/25/96	6/25/96	15	-	-	6.58	< 0.5	36.6
710E24-7	6/24/96	6/24/96	40	-	290	2,454	4,711	>115,330
600G00-14	6/25/96	6/25/96	26/27	-	-	9.12	4,553	2,896
600G00-21	6/25/96	6/25/96	28	-	-	-	-	0.8
600G00-34	6/25/96	6/25/96	30	-	-	-	-	-
710E24-38	6/25/96	6/25/96	32	-	-	-	-	<5
600G00-28	6/25/96	6/25/96	31	-	-	-	-	-
404H21-7	6/26/96	6/26/96	8	-	<5	19	< 0.5	<5
404H21-14	6/26/96	6/26/96	9	-	-	42.6	1.17	-
400G09-7	6/26/96	6/26/96	16	-	-	-	-	-
400G09-14	6/26/96	6/26/96	17/19	-	126	1,865	7,702	33,131
600H00-14	6/26/96	6/26/96	23	-	-	30.2	1,049	1,746
500G20-28	6/26/96	6/26/96	25	-	-	-	2.55	14
600H00-7	6/26/96	6/26/96	24	-	-	26.7	23.4	74.8
500G20-34	6/26/96	6/26/96	28	-	-	-	-	-
212G15-14	6/26/96	6/26/96	29/31	-	54.6	700	4,349	12,789
212G15-28	6/26/96	6/27/96	7	-	-	-	4.8	6.5
500G20-37	6/26/96	6/27/96	8	-	-	-	1	1.94
600H00-28	6/27/96	6/27/96	17	-	-	-	1.64	4.59
600H00-23	6/27/96	6/27/96	18	-	-	-	<0.5	<5.0
102G00-14	6/27/96	6/27/96	19	-	-	1.3	62.2	362
600H00-36	6/27/96	6/27/96	20	-	-	-	0.8	<5
-110G10-14	6/27/96	6/27/96	22	-	0.9	199	1.91	<5
118H05-14	6/27/96	6/27/96	25/26	T	19.1	307	4,279	1,198
102F00-14	6/27/96	6/27/96	27	T	-	0.6	<5	<0.5
400G09-23	6/27/96	6/27/96	9	-	1.96	-	< 0.5	<5
400G09-28	6/27/96	6/28/96	8	-	2.18	2.14	<5	1.98
400G09-36	6/27/96	6/28/96	7	-	-	-	5.2	14.1

SAMPLE NUMBER	DATE COLLECTED	DATE ANALYZED	SAMPLE RUN	VINYL CHLORIDE MCL - 2 ppb	1,2-TRANS DCE MCL - 100 ppb	1,2-CIS DCE MCL - 70 ppb	TCE MCL - 5 ppb	PCE MCL- 5 ppb
-218G00-14	6/28/96	6/28/96	12	-	3.23	-	-	<5
010J05-14	6/28/96	6/28/96	13	-	4.73	-	8.13	<5
010J05-14; Duplicate sent to lab					-	***1.9J***	***9.9***	***2.2***
102F00-23	6/28/96	6/28/96	15	-	-	-	-	-
102F00-28	6/28/96	6/28/96	16	T	8.48	-	-	0.9
-011H14-7	6/28/96	6/28/96	17	-	5.39	1.91	<5	0.7
-011H14-14	6/28/96	6/28/96	18	T	8.65	<	1.66	5.28
-011H14-14; Duplicate sent to lab					-	***0.89J***	***2.9***	***6.2***
-011H14-36	6/28/96	6/28/96	19	-	0.5	-	<5	2.32
-011H14-36; Duplicate sent to lab					-	-	***0.93J***	***3.6***
-011H14-28	6/28/96	6/28/96	21	-	12.1	-	-	-
-011H14-28; Duplicate sent to lab					-	-	-	-
-218J05-36	6/28/96	6/28/96	22	-	9.84	-	-	-
-218J05-28	6/28/96	6/28/96	23	-	5.91	-	1.96	9.37
-218J05-14	6/28/96	6/28/96	24	-	-	-	-	-
-218G00-28	6/28/96	6/28/96	26	-	8.16	-	-	-
118H05-7	6/29/96	6/29/96	14	-	5.8	54	454	794
118H05-36	6/29/96	6/29/96	17	-	4.6	< 0.5	1.06	1.06
118H05-28	6/29/96	6/29/96	18	-	-	-	-	-
108J18-14	6/29/96	6/29/96	27	-	<5	-	-	-
-115J23-14	6/29/96	6/29/96	24	-	-	-	-	-
-218G00-36	6/28/96	6/29/96	30	T	3.9	-	-	-
-115J23-28	6/29/96	6/29/96	26	-	0.6	-	-	-
108J18-7	6/29/96	6/29/96	32	-	15.7	303	61.7	42.1
108J18-28	6/29/96	6/29/96	33	-	12.7	-	-	-
108J18-36	6/29/96	6/29/96	34	-	9.55	-	-	-
102F00-7	6/29/96	6/29/96	38	-	-	-	-	-
-310J05-14	6/29/96	6/29/96	39	T	<5	-	-	<1
-310J05-28	6/29/96	6/29/96	40	T	<5	-	-	<2
-310J05-36	6/29/96	6/29/96	41	T	2.13	-	-	-
-115J23-7	6/29/96	6/29/96	43	T	2.08	-	-	<1
200L13-9	6/30/96	6/30/96	8	-	-	-	-	4.98
200L13-16	6/30/96	6/30/96	11	-	4.97	<	-	-
200L13-30	6/30/96	6/30/96	12	-	13.6	<	-	<
010J05-28	6/30/96	6/30/96	16	-	3.5	-	-	-
-110G10-28	6/30/96	6/30/96	18	-	2.1	-	-	-
200M15-9	6/30/96	6/30/96	21	-	-	-	-	-

TABLE 2
FIELD CHEMISTRY RESULTS
19 JUNE TO 30 JUNE 1996
MCRD PARRIS ISLAND DRY CLEANER FACILITY

LOCATION	DATE	TIME	DEPTH	pH	TEMP	TURBIDITY	CONDUCTIVITY	ORP	SALINITY	D.O. (mg/l)	D.O. (mg/l)	TOTAL ALKALINITY
			(ft)		(°C)	(NTU)	(mS/cm)	(mV)	%	INSTRUMENT	WINKLER	(mg/l) AS CaCO3
601K13	19-Jun	8:35	15	6.19	26.3	999	0.804	-79.1	0.03	0.61	0	60
601K13	19-Jun	9:00	15	6.08	26.2	562	0.792	-92.2	0.03	0.13	0	60
615E15	19-Jun	14:45	13	6.74	26.4	999	0.399	-14.6	0.01	0.57	TOO TURBID	TOO TURBID
615E15	19-Jun	15:06	13	6.2	25	434	0.392	-80.9	0.01	1.16	0	110
615E15	19-Jun	17:17	21	6.41	28.1	38	0.904	-115.9	0.05	1.06	2.4	110
615E15	19-Jun	17:45	30	7.35	28.5	200	1.29	-45.8	0.07	1.39	*3.2	270
615E15	19-Jun	18:42	37	7.73	28	999	1.36	46.7	0.07	3.77	4.5	320
322D09	20-Jun		7.5	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
322D09	20-Jun	10:41	13	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
322D09	20-Jun	11:54	22	6.3	27.4	999	1.92	-7.9	0.11	0.02	0[1]	120
322D09	20-Jun	13:32	28	6.82	29.8	259	1.91	-60.8	0.11	1.44	1.6	200
322D09	20-Jun	14:17	36	7.25	30.7	290	1.75	-75.8	0.08	1.58	*3	320
621C18	20-Jun		7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
621C18	20-Jun	15:58	14	6.54	27.4	971	0.536	-26.1	0.02	1.25	1.2[2]	0
621C18	20-Jun	17:08	21	7.21	26.3	399	1.22	-91.6	0.05	0.36	1.6	300
300C22	20-Jun	16:09	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
300C22	21-Jun	8:15	14	6.24	24.8	999	0.439	35.6	0.02	1.16	1.4[3]	120
300C22	21-Jun	9:27	22	6.19	25	999	1.99	-9.6	0.09	0.07	< 0.2	110
500C24	21-Jun	10:26	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
500C24	21-Jun	11:16	14	6.43	27.2	999	0.526	-4.2	0.03	1.57	1.2	150
500C24	21-Jun	11:55	22	7.1	27.9	775	1.3	-64.1	0.07	0.04	< 0.2	320
700D21	21-Jun	14:20	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
700D21	21-Jun	15:12	14	6.77	29.2	826	0.595	-17.8	0.03	1.87	2.4	160
700D21	21-Jun		22	SLOW FILL, WET CHEM SAMPLE NOT TAKEN								
800E00	24-Jun	8:30	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
800E00	24-Jun	9:16	14	6.64	29.5	999	0.59	-15.7	0.03	1.1	1.2	150
800G00	24-Jun	10:19	7	6.3	32	999	0.412	-36.9	0.02	0.57	TOO TURBID[4]	TOO TURBID
800G00	24-Jun	10:55	14	6.51	30.3	999	0.415	11.5	0.02	0.64	<0.2[1]	140
700H05	24-Jun	11:41	7	NO SAMPLE FOR WET CHEMISTRY								
700H05	24-Jun	12:26	14	6.64	29	999	0.468	-19.2	0.02	0.11	(NO COLOR)	N/A
500G20	24-Jun	13:35	14	6.46	31.7	999	0.491	2.6	0.02	0.12	-	110

LOCATION	DATE	TIME	DEPTH	pH	TEMP	TURBIDITY	CONDUCTIVITY	ORP	SALINITY	D.O. (mg/l)	D.O. (mg/l)	TOTAL ALKALINITY
			(ft)		(^{0}C)	(NTU)	(mS/cm)	(mV)	%	INSTRUMENT	WINKLER	(mg/l) AS CaCO3
500G20	24-Jun		7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
710E24	24-Jun	16:15	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
710E24	24-Jun	16:53	14	6.48	29.8	999	0.481	-4.7	0.01	0.04	O FLOC SETTLE	160
710E24	25-Jun	8:49	22	6.53	28	161	0.729	-49.0	0.03	1.28	1.8	85
710E24	25-Jun	9:53	28	6.79	28.2	557	1.12	-47.5	0.05	1.26	1.8	180
600G00	25-Jun	11:02	7	6.59	28.5	999	0.568	124.4	0.02	0.8	TOO TURBID	TOO TURBID
600G00	25-Jun	13:49	14	6.36	29	999	0.444	22.6	0.01	2.89	1.4	95
600G00	25-Jun		22	ONLY COLLECTED APPROX. 100ml, NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
600G00	25-Jun	15:26	28	6.87	29.9	999	0.93	-44.9	0.05	0.68	0.4	160
600G00	25-Jun	16:06	34	7.54	29	401	1.17	-36.9	0.06	2.48	2.6	280
710E24	25-Jun	17:04	38	7.83	29.9	541	1.34	34.8	0.07	1.04	1.8	320
404H21	26-Jun	8:00	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
404H21	26-Jun	8:58	14	6.13	27.5	851	0.586	13.2	0.03	1.74	2	110
400G09	26-Jun	10:26	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
400G09	26-Jun	11:04	14	6.32	26.6	999	0.492	17.9	0.02	0.38	0.6	110
600H00	26-Jun	11:56	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
600H00	26-Jun	13:44	14	6.35	27.7	661	0.468	39.2	0.02	1.76	2.4	120
500G20	26-Jun	14:32	28	7.18	25.1	999	0.901	-2.7	0.03	1.68	1.8	210
500G20	26-Jun	15:23	34	7.63	26.6	674	1.23	44.3	0.07	1.65	2.2	400
212G15	26-Jun	15:56	14	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
212G15	26-Jun	16:32	28	7.31	26.8	562	1.48	-16.7	0.08	1.75	*2.6	240
500G20	26-Jun	17:16	37	7.4	25.3	843	1.17	-44.5	0.05	1.79	*2.4	300
600H00	27-Jun	8:33	23	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
600H00	27-Jun	9:15	28	6.89	24.1	891	1.01	-36.0	0.05	1.14	*1.0	180
600H00	27-Jun	10:14	36	7.39	24.2	999	1.18	-125.8	0.06	0.33	0.2	350
102G00	27-Jun	11:28	14	6.05	26.5	999	0.92	55.8	0.04	1.46	0.8	80
-110G10	27-Jun	12:29	14	6.64	27.9	999	1.12	118.9	0.05	3.96	4.2[6]	150
118H05	27-Jun	14:15	14	6.34	27.1	600	0.67	30.8	0.03	1.92	1	160
102F00	27-Jun	15:04	14	6.17	27.4	959	0.95	66.1	0.04	1.97	1.8	100
400G09	27-Jun	16:15	23	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
400G09	27-Jun	16:41	28	7	26.3	999	1.07	-29.3	0.04	1.17	*1.6	200
400G09	27-Jun	15:10	36	7.74	27.5	223	1.27	93.8	0.05	2.97	4.2	280
-218G00	28-Jun	8:09	14	5.65	23.7	484	2.74	105.8	0.13	1.37	1.4	45
010J05	28-Jun	9:15	14	6.14	25.5	664	1.06	-1.3	0.04	1.73	1.8	90
102F00	28-Jun	10:36	21	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
102F00	28-Jun	11:18	28	6.84	26.9	324	3.79	-51.9	0.19	1.99	2.4	140
-011H14	28-Jun	13:15	7	6.15	31.5	999	0.609	-49.6	0.02	0.43	TOO TURBID[1]	80

LOCATION	DATE	TIME	DEPTH	pH	TEMP	TURBIDITY	CONDUCTIVITY	ORP	SALINITY	D.O. (mg/l)	D.O. (mg/l)	TOTAL ALKALINITY
			(ft)		(^{0}C)	(NTU)	(mS/cm)	(mV)	%	INSTRUMENT	WINKLER	(mg/l) AS CaCO3
-011H14	28-Jun	14:12	14	6	29.4	314	1.52	10.1	0.07	1.63	1.8	80
-011H14	28-Jun	14:53	28	7.14	27.9	358	1.59	-62.7	0.09	1.5	2	220
-011H14	28-Jun	15:40	36	7.75	28	213	1.97	**	0.09	3.88	4.2	340
-218J05	28-Jun	17:00	14	6.36	27.7	462	1.54	**	0.07	1.04	1.2	130
-218J05	28-Jun	17:34	28	7.08	26.6	303	1.04	**	0.04	2.05	2.4	140
-218J05	28-Jun	18:11	36	7.42	25.4	612	1.42	**	0.06	0.77	1.6	360
-218G00	28-Jun	19:13	28	6.96	24.3	662	5.35	**	0.28	1.02	1.6	230
-218G00	28-Jun	19:50	36	6.86	23.8	109	15.9	**	0.93	1.51	2.2	320
118H05	29-Jun	7:55	7	NO SAMPLE FOR WET CHEMISTRY								
118H05	29-Jun	9:03	28	7.07	25.3	457	1.46	**	0.06	0.6	1.2	260
118H05	29-Jun	9:41	36	7.45	25.4	999	1.57	**	0.07	2.44	3.6	460
-115J23	29-Jun	10:42	14	6.15	27	305	1.16	**	0.05	1.42	1.4[6]	60
-115J23	29-Jun	11:20	28	7.11	26.6	999	0.734	**	0.03	0.35	0.8	180
108J18	29-Jun	12:28	14	6.15	29.4	587	3.4	**	0.17	1.51	0.8	70
108J18	29-Jun	13:52	7	5.67	32.5	999	0.516	**	0.02	2.52	0.4	40
108J18	29-Jun	14:30	28	7.17	28.6	879	0.76	**	0.03	1.75	2	180
108J18	29-Jun	15:03	36	7.56	29	497	1.26	**	0.05	1.43	1.2	420
102F00	29-Jun	16:17	7	NO SAMPLE FOR WET CHEMISTRY								
-310J05	29-Jun	17:11	14	NOT RUN- LOCATING ADDITIONAL SAMPLE POINTS								
-310J05	29-Jun	17:50	28	6.99	27.9	999	1.03	**	0.04	1.39	2.2	140
-310J05	29-Jun	18:23	36	7.52	27	990	1.39	**	0.06	0.86	1	520
-115J23	29-Jun	18:54	7	NOT ENOUGH SAMPLE FOR WET CHEMISTRY								
200L13	30-Jun	8:07	9	6	28.4	999	0.235	**	0	3.04	3	60
200L13	30-Jun	8:45	16	6.03	25.6	999	0.372	**	0.01	1.08	0.4	80
200L13	30-Jun	9:28	30	7.01	25.6	999	0.654	**	0.02	1.27	1.4	180
010J05	30-Jun	10:10	28	6.75	26.7	930	0.98	**	0.04	0	<0.2	160
-110G10	30-Jun	11:38	28	6.69	27.6	188	3.24	**	0.16	0.37	0.6	180
200M15	30-Jun	13:49	9	NO SAMPLE FOR WET CHEMISTRY								

D.O. : Dissolved Oxygen

ORP : Oxidation Reduction Potential

* D.O. Floc Floating

** Meter Quit Responding

[1]Very turbid; gray

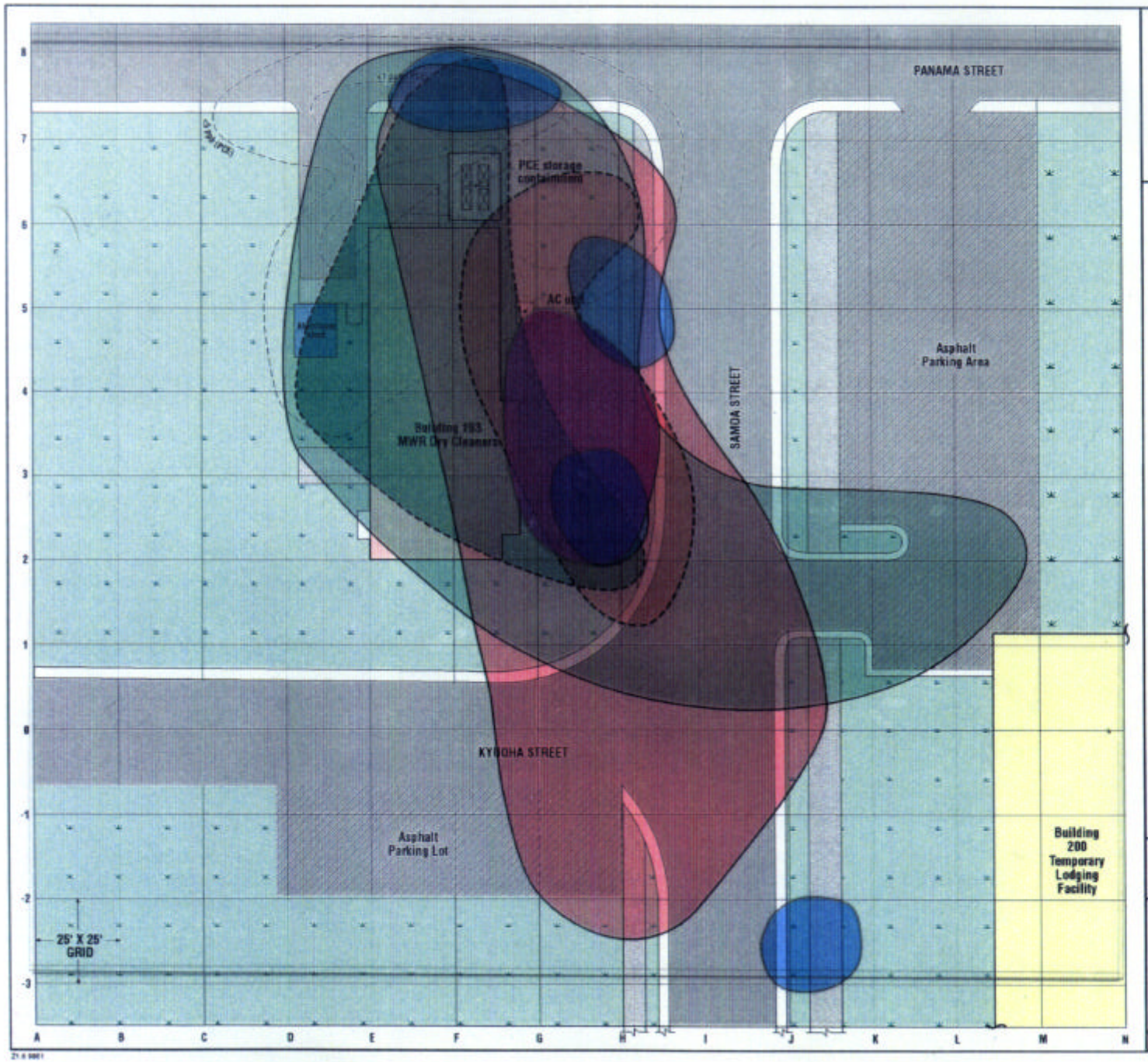
[2]Alk turned pink on addition of BCG

[3]Floc resuspended on last step

[4]Too turbid to titrate; very muddy brown

[5]Floc did not settle

[6]Very silty



Sample Location Numbering Scheme

Grid intersection point

616 H21

Distance in feet North & East from grid intersection point. (max. value would be 25 ft). (e.g. 16 ft North of grid line 6, and 21 ft East of grid line H.

Figure 2B

LEGEND

- Estimated Isoconcentration Contour (PCE) from June 1994 S & ME Report
- Estimated Location of Petroleum Solvents from June 1994 S & ME Report
- **PCE** Tetrachloroethylene
- **ppb** parts per billion
- **ppm** parts per million

- >1 ppm total solvents
- Maximum Contamination Limit (MCL) Line
- >1 ppm total solvents
- Maximum Contamination Limit (MCL) Line
- Maximum Contamination Limit (MCL) Line
- Maximum Contamination Limit (MCL) Line

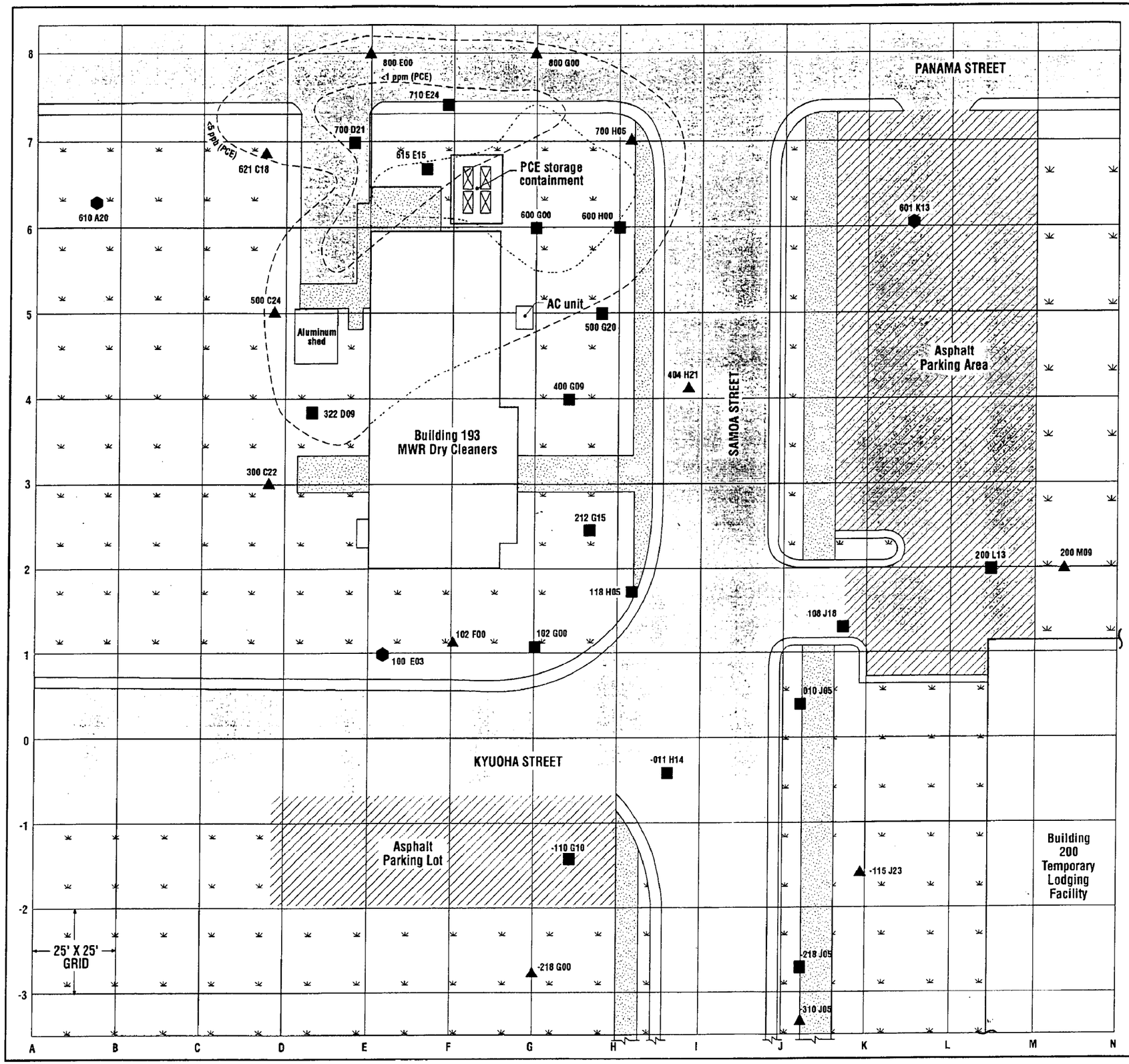
Bechtel

Navy Rac Project

Contract No. N62467-95-D-0936

MCRD Parris Island, SC
As-Built Groundwater Sampling Locations
contamination at 7 ft depth
contamination at 14 ft depth
contamination at 22 ft depth
contamination at 28 ft depth
contamination at 36 ft depth

Date: 7/1/96 D.O. #48



Z1.6 9851

Sample Location Numbering Scheme

Grid intersection point

616 H21

Distance in feet North & East from grid intersection point. (max. value would be 25 ft). (e.g. 16 ft North of grid line 6, and 21 ft East of grid line H.

Figure 2A

LEGEND

- - - - - - Estimated Isoconcentration Contour (PCE) from June 1994 S & ME Report

- · - · - · - Estimated Location of Petroleum Solvents from June 1994 S & ME Report

PCE Tetrachloroethylene

ppb parts per billion

ppm parts per million

⬢ Cone Penetrometer Borehole

▲ Borehole with no Contamination

■ Borehole with Contamination

Bechtel

Navy Rac Project

Contract No. N62467-93-D-0936

MCRD Parris Island, SC
As-Built Groundwater Sampling Locations

Date: 7/1/96 D.O. #48

APPENDIX A
RESULTS FROM LAB CONFIRMATION SAMPLES

Laboratory Analysis copies are available upon request.

APPENDIX B
RESULTS OF METHANE SAMPLES ANALYZED BY USGS COLUMBIA, S.C.

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Water Resources Division
720 Gracern Road - Suite 129
Columbia, SC 29210-7651

Karen Atchley
Bechtel Environmental, Inc.
151 Lafayette Dr.
Oak Ridge, TN 37831-0350

August 20, 1996

Dear Ms. Atchley:

Please find enclosed results for dissolved inorganic carbon (DIC) and methane (CH_4) for the wells you sampled at the Parris Island dry cleaners site.

There is quite a range in DIC concentrations; I gather that sample PI-161711 is the background well, and the others are contaminated (> 200 mg/L DIC is a large number). These elevated DIC numbers can indicate significant mineralization of hydrocarbons if most of the DIC is from CO_2 generated by such a process. For methane, 0.1 to 1.2 mg/L is not high, but does indicate some methanogenesis has occurred in those wells.

Thanks for your patience while these samples were being analyzed.

Sincerely,

James E. Landmeyer, Ph.D.

DIC and METHANE concentrations at Parris Island Site.

June 19-20, 1996

NA = NOT ANALYZED; ND = BELOW DETECTION LIMIT OF 0.01 mg/L OR 1 µM.

SAMPLE		UNCORRECTED DIC			CORRECTED DIC		METHANE		
		HEAD	SAMPLE		SAMPLE		HEAD	SAMPLE	
		µM	mg/L	µM	mg/L	µM	µM	mg/L	µM
BLANK		18.7	5.6	127.1			ND	----------	----------
Bechtel	PI161711	294.3	88.0	2001.1	82.5	1874.0	11	1.2	72.1
	PI1617214	804.5	240.7	5470.4	235.1	5343.4	1	0.1	8.6
	PI1617304	797.8	238.7	5424.8	233.1	5297.7	ND	----------	----------
	PI1617305	655.5	196.1	4457.4	190.5	4330.3	ND	----------	----------

Calibration Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\001F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 1
Sample Name	: 5% STD	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 11:17 AM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:36 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 09 JUL 96 03:37 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Calibration Table

Pk#	RT	Lvl	umol/L	Amt/Area	Ref Istd I#	Name
1	2.374	1	1631.0	1.2739e-003	1	CH4
2	4.671	1	2036.0	8.9395e-004	2	CO2

Calibration Settings

Title:

Reference window:	5.000 %
Non-reference window:	5.000 %
Units of amount:	umol/L
Multiplier:	1.0
RF uncal peaks:	0.0
Sample Amount:	0.0

Sample ISTD Information

No Sample ISTD Amounts

Multilevel Information

Fit: Linear
Origin: Force

==========

Calibration Report

==========

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\002F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 2
Sample Name	: 5% STD	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 11:56 AM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:36 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Calibration Table

Pk#	RT	Lvl	umol/L	Amt/Area	Ref Istd I#	Name
1	2.377	1	1631.0	1.3014e-003	1	CH4
2	4.679	1	2036.0	9.2406e-004	2	CO2

Calibration Settings

Title:

Reference window:	5.000 %
Non-reference window:	5.000 %
Units of amount:	umol/L
Multiplier:	1.0
RF uncal peaks:	0.0
Sample Amount:	0.0

Sample ISTD Information

No Sample ISTD Amounts

Multilevel Information

Fit: Linear
Origin: Force

External Standard Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\003F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 3
Sample Name	: BLANK	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 12:34 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:41 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\003F0101.D

Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.377	* not found *			1		CH4
4.809	22032	PV	0.164	2	20.359	CO2

Not all calibrated peaks were found

External Standard Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\004F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 4
Sample Name	: BLANK	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 12:40 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:46 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\004F0101.D

Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.377	* not found *			1		CH4
4.805	20222	PV	0.161	2	18.686	CO2

Not all calibrated peaks were found

External Standard Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\005F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 5
Sample Name	: BECHTELPI161711	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 12:46 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:59 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\005F0101.D

Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.423	8158	MM	0.087	1	10.617	CH4
4.799	318462	FV	0.169	2	294.279	CO2

User Modified

==========

External Standard Report

==========

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\006F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 6
Sample Name	: BECHTELPI1617214	Injection Number	: 1
Run Time Bar Code:		Sequence Line	: 1
Acquired on	: 20 Aug 96 12:52 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 12:59 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\006F0101.D

Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.413	967	MM	0.088	1	1.259	CH4
4.768	870582	PV	0.171	2	804.473	CO2

User Modified

External Standard Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\008F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 8
Sample Name	: BECHTELPI1617305	Injection Number	: 1
Run Time Bar Code	:	Sequence Line	: 1
Acquired on	: 20 Aug 96 01:05 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 01:11 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\008F0101.D

Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.423	87	MM	0.055	1	0.113	CH4
4.782	709362	MM	0.182	2	655.496	CO2

User Modified

External Standard Report

Data File Name	: C:\HPCHEM\1\DATA\BECH0696\007F0101.D		
Operator	: PAUL M BRADLEY	Page Number	: 1
Instrument	: MSG TCD	Vial Number	: 7
Sample Name	: BECHTELPI1617304	Injection Number	: 1
Run Time Bar Code:		Sequence Line	: 1
Acquired on	: 20 Aug 96 12:58 PM	Instrument Method	: CO2&CH4.MTH
Report Created on	: 20 Aug 96 01:05 PM	Analysis Method	: CO2&CH4.MTH
Last Recalib on	: 20 Aug 96 12:36 PM	Sample Amount	: 0
Multiplier	: 1	ISTD Amount	:

Sig. 1 in C:\HPCHEM\1\DATA\BECH0696\007F0101.D

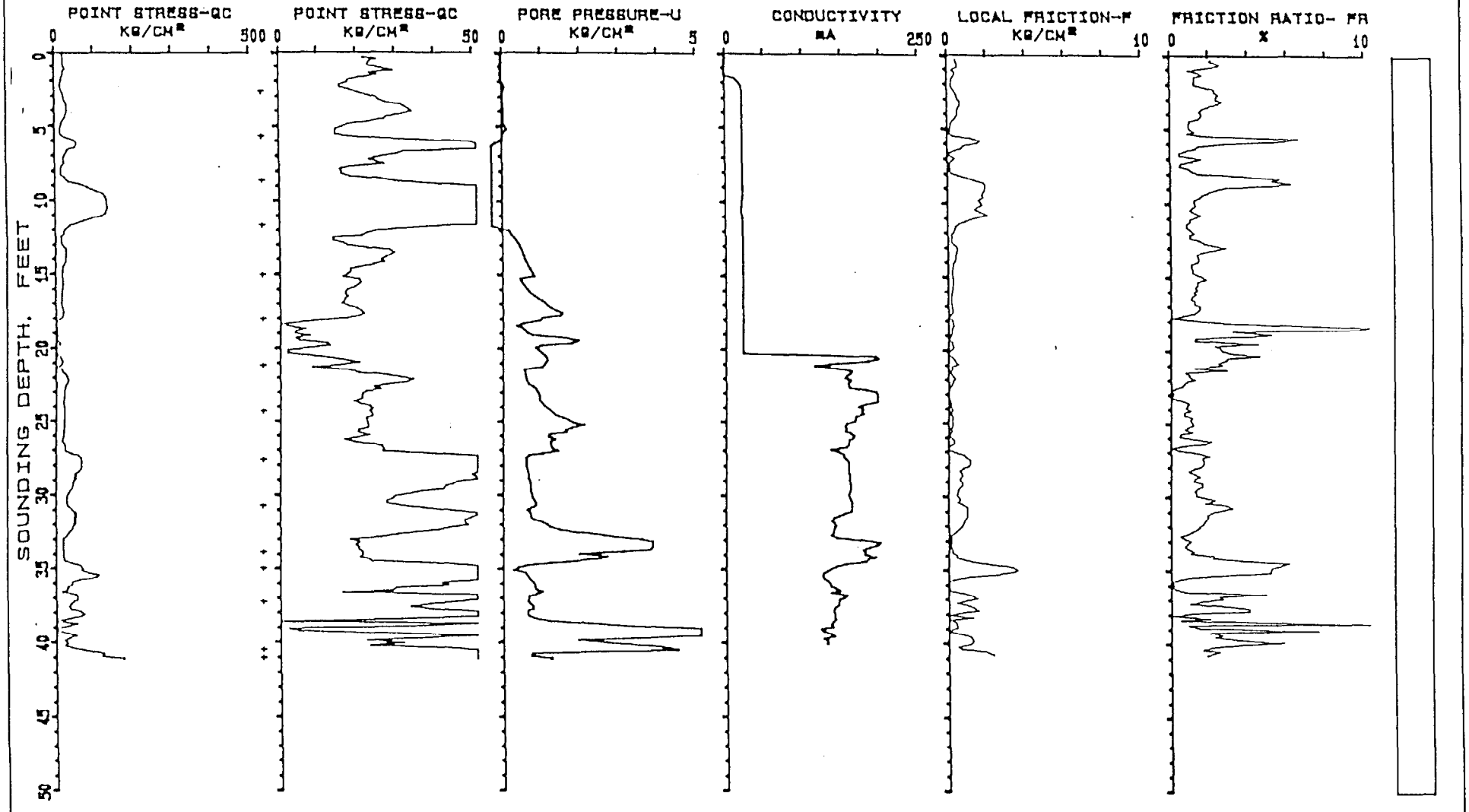
Ret Time	Area	Type	Width	Ref#	umol/L	Name
2.423	144	MM	0.073	1	0.188	CH4
4.770	863320	MM	0.183	2	797.762	CO2

User Modified

APPENDIX C
GEOLOGIC INFORMATION FROM DIRECT PUSH

CONDUCTIVITY/PIEZOCONE SOUNDING TEST

CONDUCTIVITY / PIEZOCONE SOUNDING TEST



\+ PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
SOUNDING # 100E03
TEST DATE 08-20-1998 00:28:44

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
FILE NAME..... 100E03

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
1	DENSE OR CEMENTED S.	6084.4	.49	1014	1014	.058	>90%	>48	13385	--	--	--	--
2	CLAYEY FINE SAND	24	.31	9	9	.107	40%-50%	44-46	52	--	--	--	--
3	SANDY CLAY	19.5	.46	9	9	.151	--	--	--	1.21	4.1	.01	>6
4	CLAYEY FINE SAND	30.2	.59	12	12	.2	50%-60%	42-44	66	--	--	--	--
5	SILTY TO CLAYEY F.S.	25.7	.28	8	8	.23	40%-50%	40-42	56	--	--	--	--
6	SILTY CLAY TO CLAY	22.6	.85	15	15	.258	--	--	--	1.39	2.6	UD	>6
7	SILTY TO CLAYEY F.S.	43.4	.42	14	14	.289	60%-70%	42-44	95	--	--	--	--
8	CLAYEY FINE SAND	21.9	.24	8	8	.319	40%-50%	38-40	48	--	--	--	--
9	CLAY	30.6	1.54	30	30	.344	--	--	--	1.88	1.9	UD	>6
[illegible]	SILTY TO CLAYEY F.S.	106.9	1.81	35	35	.375	70%-80%	44-46	235	--	--	--	--
[illegible]	SILTY FINE SAND	134.3	1.64	33	33	.406	80%-90%	46-48	295	--	--	--	--
[illegible]	SILTY FINE SAND	76.2	.59	19	19	.437	70%-80%	42-44	167	--	--	--	--
13	CLAYEY FINE SAND	18.8	.32	7	7	.467	<40%	36-38	41	--	--	--	--
14	CLAYEY FINE SAND	26	.41	10	10	.498	<40%	36-38	57	--	--	--	--
15	CLAYEY FINE SAND	21.9	.26	8	8	.529	<40%	36-38	48	--	--	--	--
16	CLAYEY FINE SAND	19.1	.26	7	7	.56	<40%	34-36	42	--	--	--	--
17	CLAYEY FINE SAND	17.1	.22	6	6	.59	<40%	34-36	37	--	--	--	--
18	SILTY TO CLAYEY F.S.	19.4	.05	6	6	.621	<40%	34-36	42	--	--	--	--
19	CLAY	6.5	.22	6	6	.646	--	--	--	.33	2.9	.03	3
20	SILTY CLAY TO CLAY	7.9	.18	5	5	.673	--	--	--	.42	4.2	.03	3
21	SANDY CLAY	10.1	.26	5	5	.701	--	--	--	.55	3.9	.02	3
22	CLAYEY FINE SAND	20.3	.25	8	8	.732	<40%	34-36	44	--	--	--	--
23	SILTY TO CLAYEY F.S.	28.4	.11	9	9	.762	<40%	36-38	62	--	--	--	--
24	SILTY TO CLAYEY F.S.	21.4	.13	7	7	.793	<40%	32-34	47	--	--	--	--
25	SILTY TO CLAYEY F.S.	23.4	.23	7	7	.824	<40%	34-36	51	--	--	--	--
26	SILTY TO CLAYEY F.S.	22.2	.19	7	7	.855	<40%	32-34	48	--	--	--	--
27	SILTY TO CLAYEY F.S.	22.5	.2	7	7	.885	<40%	32-34	49	--	--	--	--
28	SILTY TO CLAYEY F.S.	51.1	.9	17	17	.916	<40%	38-40	112	--	--	--	--
29	SILTY TO CLAYEY F.S.	58.2	.69	19	19	.947	40%-50%	38-40	128	--	--	--	--

DE03 CONTINUED BECHTEL ENVIRONMENTAL

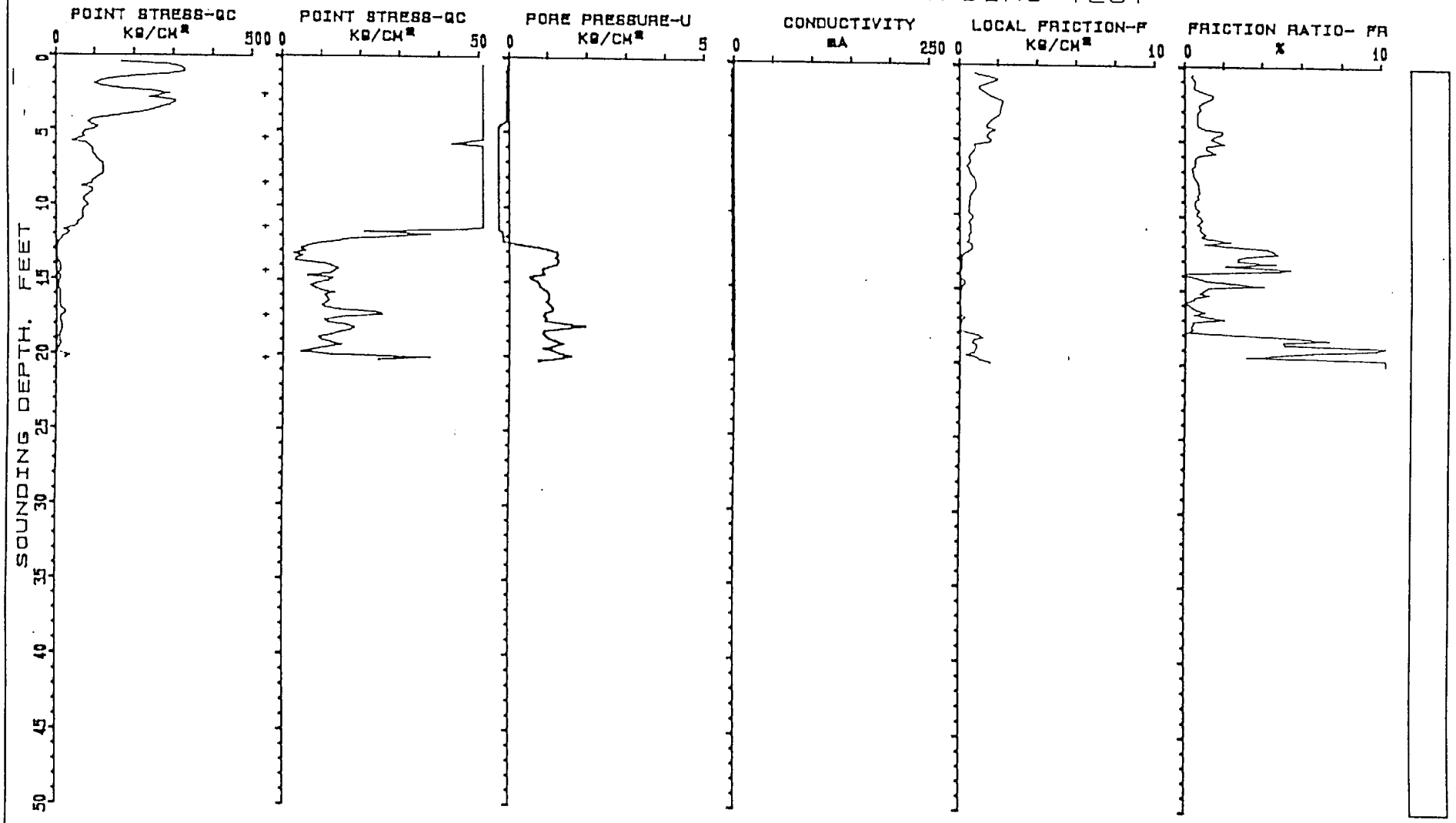
DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL STRESS	RELATIVE DENSITY	FRICTION ANGLE	YOUNGS MODULUS	UNDRAINED SHEAR ST	SENSITIVITY	COMP.	OCR
30	SILTY TO CLAYEY F.S.	42.3	.59	14	14	.978	<40%	36-38	93	--	--	--	--
31	CLAYEY FINE SAND	31.9	.79	12	12	1.008	<40%	34-36	70	--	--	--	--
32	SILTY TO CLAYEY F.S.	48.8	.83	16	16	1.039	<40%	36-38	107	--	--	--	--
33	SILTY TO CLAYEY F.S.	34.8	.29	11	11	1.07	<40%	34-36	76	--	--	--	--
34	CLAYEY FINE SAND	20.4	.27	8	8	1.101	<40%	30-32	44	--	--	--	--
35	CLAY	37.8	2.2	37	37	1.126	--	--	--	2.23	1.7	UD	6
36	SILTY TO CLAYEY F.S.	77.5	1.08	25	25	1.156	40%-50%	38-40	170	--	--	--	--
37	SILTY TO CLAYEY F.S.	38.7	.66	12	12	1.187	<40%	34-36	85	--	--	--	--
38	SILTY TO CLAYEY F.S.	47.9	.86	15	15	1.218	<40%	36-38	105	--	--	--	--
39	SILTY FINE SAND	46.4	.28	11	11	1.249	<40%	36-38	102	--	--	--	--
40	SANDY CLAY	26.3	.86	13	13	1.276	--	--	--	1.49	3	.02	6

\# N'=POINT STRESS*(.2+.04*FRICTION RATIO)
* NORMALLY CONSOLIDATED SANDS
** FOR OVERCONSOLIDATED SANDS,SLIGHTLY REDUCE ABOVE FRICTION ANGLES
*** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER
**** NK OF 16 USED. FOR OVERCONSOLIDATED CLAYS, AN NK OF 17 IS SUGGESTED

THE ABOVE DATA WAS COMPUTED FOLLOWING 'BASIC' GUIDELINES BY P. K. ROBERTSON AND R. G. CAMPANELLA IN THE HANDBOOK 'GUIDELINES FOR USE AND INTERPERTATION OF THE ELECTRONIC CONE PENETRATION TEST'

ADDITIONAL LOCAL CORRELATIONS DEVELOPED BY IN-SITU TECHNOLOGY HAVE ALSO BEEN USED IN COMPUTING THE ABOVE DATA. IT IS THE POLICY OF IN-SITU TECHNOLOGY TO CONTINUALLY UPGRADE AND MODIFY C.P.T CORRELATIONS AS PUBLISHED RESEARCH AND LOCAL EXPERIENCE GROWS.

CONDUCTIVITY / PIEZOCONE SOUNDING TEST



\+ PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
SOUNDING # 200L13
TEST DATE 08-29-1998 20:31:21

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
FILE NAME..... 200L13

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N' ‡	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
1	DENSE OR CEMENTED S.	314.3	1.83	52	52	.058	>90%	>48	691	--	--	--	--
2	FINE SAND	213	1.42	42	42	.112	>90%	>48	468	--	--	--	--
3	FINE SAND	191.8	2.07	38	38	.166	>90%	>48	421	--	--	--	--
4	FINE SAND	267	1.83	53	53	.219	>90%	>48	587	--	--	--	--
5	SILTY FINE SAND	129.9	1.58	32	32	.25	>90%	46-48	285	--	--	--	--
6	SILTY TO CLAYEY F.S.	78.7	1.04	26	26	.281	70%-80%	44-46	173	--	--	--	--
7	SILTY FINE SAND	89.7	.54	22	22	.312	70%-80%	44-46	197	--	--	--	--
8	FINE SAND	118.6	.78	23	23	.345	80%-90%	46-48	260	--	--	--	--
9	FINE SAND	97.4	.66	19	19	.378	70%-80%	44-46	214	--	--	--	--
	SILTY FINE SAND	83.7	.54	20	20	.409	70%-80%	44-46	184	--	--	--	--
	SILTY FINE SAND	75	.6	18	18	.44	60%-70%	42-44	165	--	--	--	--
12	SILTY TO CLAYEY F.S.	50.8	.54	16	16	.47	50%-60%	40-42	111	--	--	--	--
13	SANDY CLAY	16.7	.41	8	8	.498	--	--	--	.99	4	.01	6
14	SILTY CLAY TO CLAY	5.1	.1	3	3	.525	--	--	--	.26	4.7	.04	1-1.5
15	CLAYEY FINE SAND	11.7	.15	4	4	.556	<40%	32-34	25	--	--	--	--
16	CLAYEY FINE SAND	10.2	.04	4	4	.587	<40%	30-32	22	--	--	--	--
17	CLAYEY FINE SAND	11.8	.03	4	4	.617	<40%	30-32	25	--	--	--	--
18	SILTY TO CLAYEY F.S.	17.1	.05	5	5	.648	<40%	32-34	37	--	--	--	--
19	CLAY	13.6	.84	13	13	.673	--	--	--	.78	1.6	.01	6

‡ N'=POINT STRESS*(.2+.04*FRICTION RATIO)
* NORMALLY CONSOLIDATED SANDS
** FOR OVERCONSOLIDATED SANDS,SLIGHTLY REDUCE ABOVE FRICTION ANGLES
*** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER
**** NK OF 16 USED. FOR OVERCONSOLIDATED CLAYS, AN NK OF 17 IS SUGGESTED

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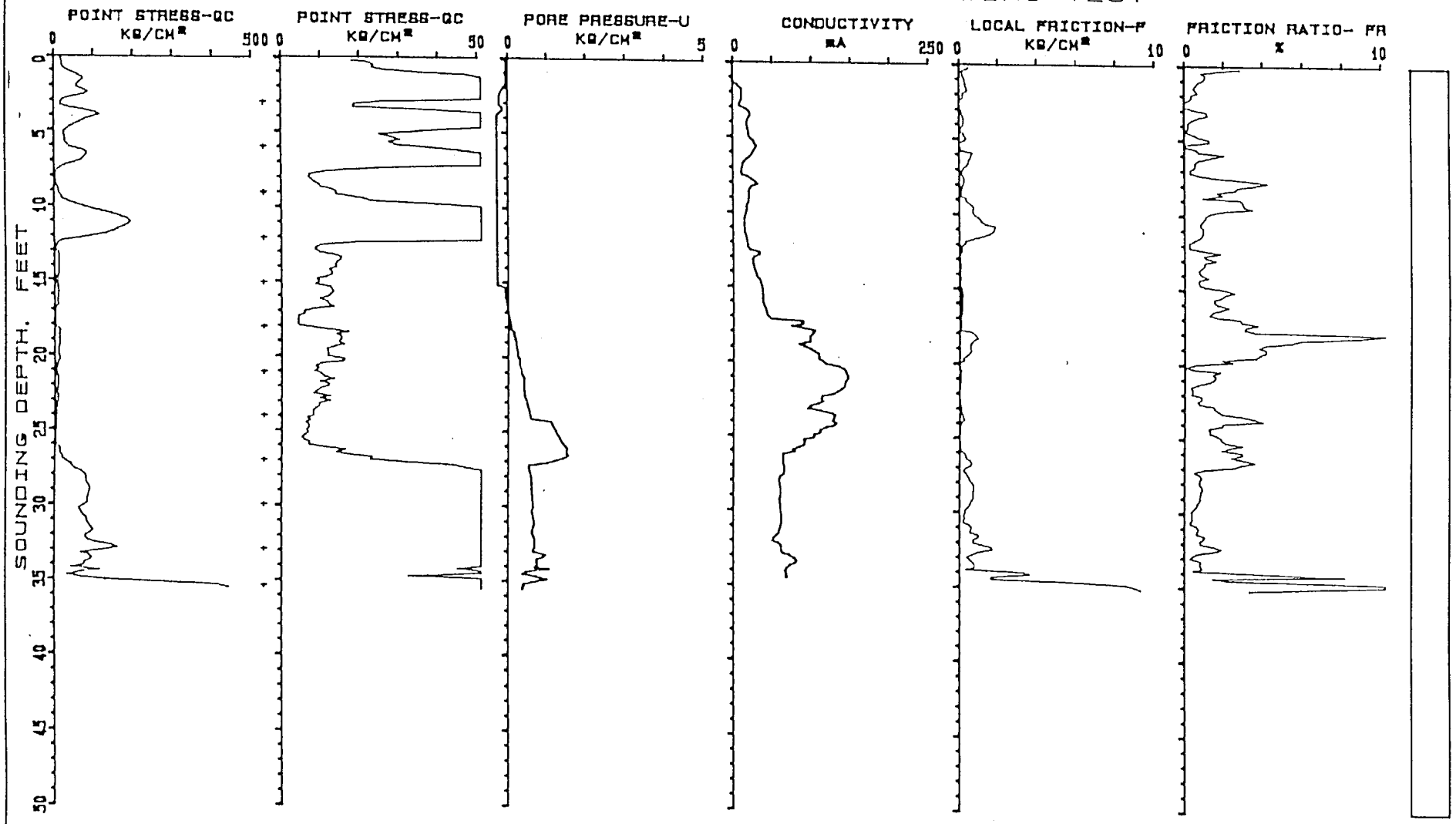
CONDUCTIVITY / PIEZOCONE SOUNDING TEST



* PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-8C-0594
SOUNDING # 322D09
TEST DATE 06-20-1996 08:52:04

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594

FILE NAME..... 322D09

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N' VALUES	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
1	SILTY TO CLAYEY F.S.	26.4	.29	8	8	.048	50%-60%	>48	58	--	--	--	--
2	SILTY FINE SAND	60.3	.37	15	15	.097	70%-80%	>48	132	--	--	--	--
3	SILTY FINE SAND	63.7	.14	15	15	.146	70%-80%	46-48	140	--	--	--	--
4	SILTY FINE SAND	48.2	.27	12	12	.195	60%-70%	44-46	106	--	--	--	--
5	SILTY FINE SAND	74	.27	18	18	.226	70%-80%	46-48	162	--	--	--	--
6	SILTY TO CLAYEY F.S.	29.9	.32	9	9	.256	40%-50%	40-42	65	--	--	--	--
7	SILTY FINE SAND	67.7	.43	16	16	.287	70%-80%	44-46	148	--	--	--	--
8	SILTY TO CLAYEY F.S.	27.7	.26	9	9	.318	40%-50%	40-42	60	--	--	--	--
9	SANDY CLAY	10.3	.26	5	5	.345	--	--	--	.61	3.9	.02	6
	CLAYEY FINE SAND	28.7	.71	11	11	.376	40%-50%	38-40	63	--	--	--	--
	SILTY FINE SAND	123.5	1.37	30	30	.407	80%-90%	44-46	271	--	--	--	--
	FINE SAND	170.1	1.14	34	34	.44	>90%	46-48	374	--	--	--	--
13	SILTY FINE SAND	49.2	.18	12	12	.471	50%-60%	40-42	108	--	--	--	--
14	CLAYEY FINE SAND	13.1	.13	5	5	.502	<40%	32-34	28	--	--	--	--
15	CLAYEY FINE SAND	12.6	.12	5	5	.532	<40%	32-34	27	--	--	--	--
16	SANDY CLAY	11.5	.22	5	5	.56	--	--	--	.66	5.1	.02	6
17	SANDY CLAY	11.7	.19	5	5	.587	--	--	--	.67	6	.02	6
18	CLAY	5.4	.23	5	5	.612	--	--	--	.27	2.2	.04	1-1.5
19	CLAY	11.8	.76	11	11	.637	--	--	--	.67	1.5	.02	6
20	SANDY CLAY	13.9	.41	6	6	.664	--	--	--	.79	3.3	.02	6
21	CLAYEY FINE SAND	11.8	.11	4	4	.695	<40%	30-32	25	--	--	--	--
22	CLAYEY FINE SAND	11.2	.07	4	4	.726	<40%	30-32	24	--	--	--	--
23	CLAYEY FINE SAND	11	.11	4	4	.756	<40%	30-32	24	--	--	--	--
24	SANDY CLAY	9.4	.22	4	4	.784	--	--	--	.5	4.2	.03	3
25	SANDY CLAY	7	.11	3	3	.811	--	--	--	.34	6.3	.04	1-1.5
26	SILTY CLAY TO CLAY	6.4	.17	4	4	.838	--	--	--	.3	3.6	.03	1-1.5
27	SANDY CLAY	16	.48	8	8	.866	--	--	--	.9	3.2	.01	6
28	SILTY TO CLAYEY F.S.	49.5	.47	16	16	.897	<40%	38-40	108	--	--	--	--
29	SILTY FINE SAND	85.1	.75	21	21	.927	50%-60%	40-42	187	--	--	--	--
30	SILTY FINE SAND	87.9	.52	21	21	.958	50%-60%	40-42	193	--	--	--	--

2D09 CONTINUED BECHTEL ENVIRONMENTAL

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL STRESS	RELATIVE DENSITY	FRICTION ANGLE	YOUNGS MODULUS	UNDRAINED SHEAR ST	SENSITIVITY	COMP.	OCR
31	SILTY FINE SAND	75.7	.39	18	18	.989	50%-60%	38-40	166	--	--	--	--
32	SILTY FINE SAND	91.5	.77	22	22	1.02	50%-60%	40-42	201	--	--	--	--
33	SILTY FINE SAND	107.8	1.06	26	26	1.05	60%-70%	40-42	237	--	--	--	--
34	SILTY FINE SAND	103.2	1.03	25	25	1.081	50%-60%	40-42	227	--	--	--	--
35	CLAY	70.3	4.86	70	70	1.106	--	--	--	4.26	1.4	UD	6

\# N'=POINT STRESS*(.2+.04*FRICTION RATIO)
* NORMALLY CONSOLIDATED SANDS
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*** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER
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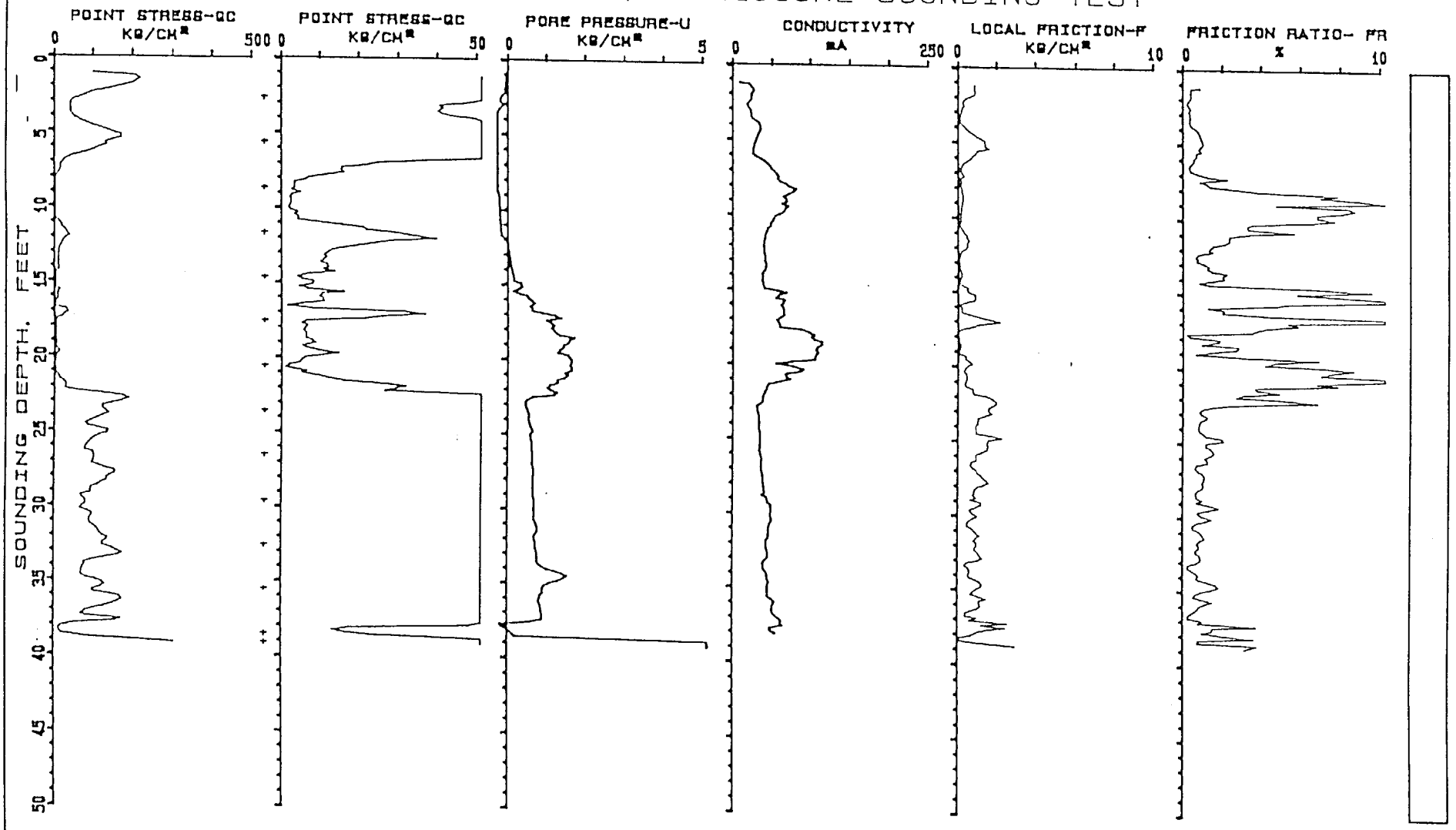
CONDUCTIVITY / PIEZOCONE SOUNDING TEST



+ PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
SOUNDING # 601K13
TEST DATE 06-18-1996 19:33:15

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
FILE NAME..... 601K13

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N' VALUES	N' VALUES #	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
2	DENSE OR CEMENTED S.	203.6	.75	33	33	.058	>90%	>48	447	--	--	--	--
3	FINE SAND	105.9	.27	21	21	.112	80%-90%	>48	232	--	--	--	--
4	SILTY FINE SAND	43.1	.23	10	10	.161	60%-70%	44-46	94	--	--	--	--
5	SILTY FINE SAND	86.9	.98	21	21	.191	70%-80%	46-48	191	--	--	--	--
6	FINE SAND	150	1.11	30	30	.225	>90%	>48	330	--	--	--	--
7	SILTY FINE SAND	79	.32	19	19	.255	70%-80%	44-46	173	--	--	--	--
8	CLAYEY FINE SAND	15.9	.22	6	6	.286	<40%	38-40	34	--	--	--	--
9	CLAY	4.5	.26	4	4	.311	--	--	--	.25	1.7	.05	3
10	SOFT CLAY	2.8	.18	2	2	.327	--	--	--	.14	1.5	UD	1-1.5
[illegible]	CLAY	4.3	.21	4	4	.352	--	--	--	.23	2	.05	3
[illegible]	LAYEY FINE SAND	24.3	.49	9	9	.383	<40%	38-40	53	--	--	--	--
13	SILTY TO CLAYEY F.S.	21.8	.17	7	7	.414	<40%	36-38	47	--	--	--	--
14	SANDY CLAY	11.5	.19	5	5	.441	--	--	--	.67	5.9	.02	6
15	CLAY	8.9	.33	8	8	.466	--	--	--	.5	2.6	.02	6
16	CLAY	9.2	.59	9	9	.491	--	--	--	.52	1.5	.02	6
17	CLAY	11.2	.91	11	11	.516	--	--	--	.64	1.2	.02	6
18	SANDY CLAY	19.2	.59	9	9	.543	--	--	--	1.14	3.2	.01	6
19	SENSITIVE FINE GRAIN	6.6	.05	3	3	.565	--	--	--	.34	12.4	.03	3
20	CLAY	9.1	.43	9	9	.59	--	--	--	.5	2.1	.02	3
21	SOFT CLAY	5.1	.43	5	5	.606	--	--	--	.24	1.1	UD	1-1.5
22	CLAY	15.6	.75	15	15	.631	--	--	--	.9	2	.01	6
23	SILTY TO CLAYEY F.S.	103.2	1.76	34	34	.662	60%-70%	42-44	227	--	--	--	--
24	FINE SAND	138.5	1.23	27	27	.695	70%-80%	42-44	304	--	--	--	--
25	SILTY FINE SAND	110.7	1.38	27	27	.726	60%-70%	42-44	243	--	--	--	--
26	SILTY FINE SAND	107.3	1.32	26	26	.756	60%-70%	42-44	236	--	--	--	--
27	SILTY FINE SAND	93.1	.88	23	23	.787	60%-70%	40-42	204	--	--	--	--
28	FINE SAND	127	1.3	25	25	.82	70%-80%	42-44	279	--	--	--	--
29	FINE SAND	117.6	.89	23	23	.854	60%-70%	42-44	258	--	--	--	--
30	SILTY FINE SAND	82.4	.99	20	20	.884	50%-60%	40-42	181	--	--	--	--
31	SILTY FINE SAND	84.5	.71	21	21	.915	50%-60%	40-42	185	--	--	--	--

J1K13 CONTINUED BECHTEL ENVIRONMENTAL

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL STRESS	RELATIVE DENSITY	FRICTION ANGLE	YOUNGS MODULUS	UNDRAINED SHEAR ST	SENSITIVITY	COMP.	OCR
32	SILTY FINE SAND	103.2	.97	25	25	.946	60%-70%	40-42	227	--	--	--	--
33	FINE SAND	130.3	1.06	26	26	.979	60%-70%	42-44	286	--	--	--	--
34	FINE SAND	134.7	.61	26	26	1.012	70%-80%	42-44	296	--	--	--	--
35	SILTY FINE SAND	79.3	.93	19	19	1.043	50%-60%	38-40	174	--	--	--	--
36	FINE SAND	118.5	1.08	23	23	1.076	60%-70%	40-42	260	--	--	--	--
37	FINE SAND	147.2	.75	29	29	1.11	70%-80%	42-44	323	--	--	--	--
38	SILTY FINE SAND	101.4	1.42	25	25	1.14	50%-60%	40-42	223	--	--	--	--

\# N'=POINT STRESS*(.2+.04*FRICTION RATIO)
* NORMALLY CONSOLIDATED SANDS
** FOR OVERCONSOLIDATED SANDS,SLIGHTLY REDUCE ABOVE FRICTION ANGLES
*** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER
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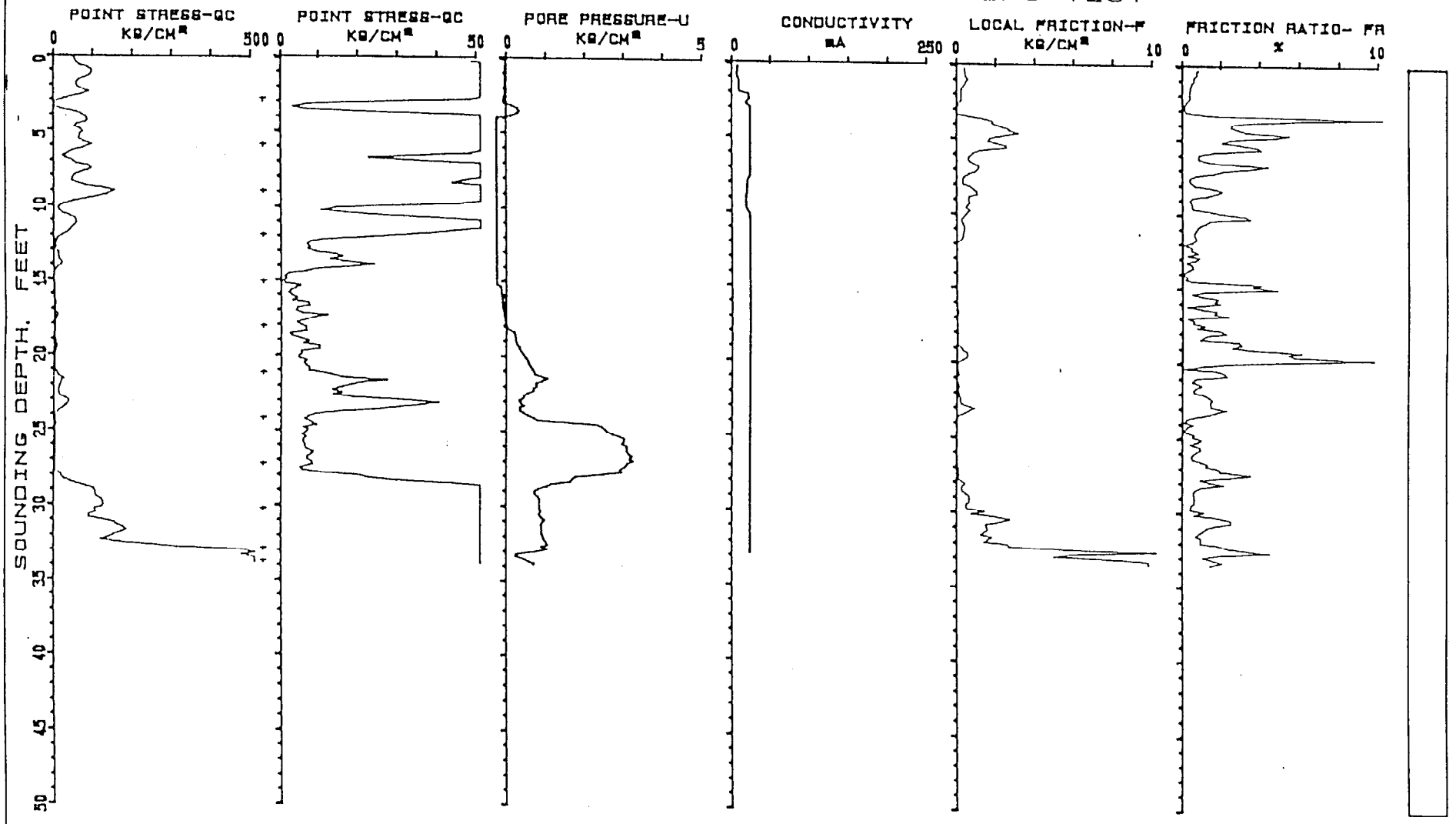
CONDUCTIVITY / PIEZOCONE SOUNDING TEST



* PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
SOUNDING # 610A20
TEST DATE 06-18-1998 16:33:02

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
FILE NAME..... 610A20

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
1	SILTY FINE SAND	74.1	.52	18	18	.048	70%-80%	>48	163	--	--	--	--
2	SILTY FINE SAND	79.1	.32	19	19	.097	70%-80%	>48	174	--	--	--	--
3	SILTY FINE SAND	63.3	.14	15	15	.146	70%-80%	46-48	139	--	--	--	--
4	SILTY CLAY TO CLAY	28.2	1.13	18	18	.19	--	--	--	1.75	2.4	UD	>6
5	CLAYEY FINE SAND	72.4	2.35	28	28	.221	70%-80%	46-48	159	--	--	--	--
6	SILTY TO CLAYEY F.S.	73.9	1.63	24	24	.251	70%-80%	44-46	162	--	--	--	--
7	SILTY TO CLAYEY F.S.	52.1	.86	17	17	.282	60%-70%	42-44	114	--	--	--	--
8	SILTY FINE SAND	68.9	.57	17	17	.313	70%-80%	44-46	151	--	--	--	--
9	SILTY FINE SAND	78.8	.76	19	19	.344	70%-80%	44-46	173	--	--	--	--
	ILTY FINE SAND	92.1	.58	23	23	.375	70%-80%	44-46	202	--	--	--	--
	'LAYEY FINE SAND	27.3	.37	10	10	.405	40%-50%	38-40	60	--	--	--	--
12	SILTY FINE SAND	48.5	.27	12	12	.436	50%-60%	40-42	106	--	--	--	--
13	CLAYEY FINE SAND	13.4	.03	5	5	.467	<40%	34-36	29	--	--	--	--
14	CLAYEY FINE SAND	14.3	.05	5	5	.498	<40%	34-36	31	--	--	--	--
15	SENSITIVE FINE GRAIN	9.1	.01	4	4	.52	--	--	--	.51	67.5	.02	3
16	SENSITIVE FINE GRAIN	2.5	.02	1	1	.542	--	--	--	.1	9	.08	1
17	SENSITIVE FINE GRAIN	4.5	.06	2	2	.564	--	--	--	.22	7	.04	1-1.5
18	SANDY CLAY	6.7	.07	3	3	.591	--	--	--	.35	8.4	.02	3
19	CLAY	5	.12	5	5	.616	--	--	--	.24	4.1	.05	1-1.5
20	CLAY	7.2	.39	7	7	.641	--	--	--	.38	1.8	.03	3
21	SANDY CLAY	6.2	.07	3	3	.668	--	--	--	.31	8	.02	1-1.5
22	CLAYEY FINE SAND	17	.14	6	6	.699	<40%	32-34	37	--	--	--	--
23	CLAYEY FINE SAND	18	.35	7	7	.73	<40%	32-34	39	--	--	--	--
24	SILTY TO CLAYEY F.S.	26.3	.3	8	8	.76	<40%	34-36	57	--	--	--	--
25	SENSITIVE FINE GRAIN	7.6	.02	3	3	.782	--	--	--	.38	26.8	.02	1-1.5
26	SENSITIVE FINE GRAIN	6.3	.04	3	3	.804	--	--	--	.3	13.3	.03	1-1.5
27	SANDY CLAY	7.1	.07	3	3	.832	--	--	--	.34	9.4	.04	1-1.5
28	SANDY CLAY	9.5	.22	4	4	.859	--	--	--	.49	4.2	.03	3
29	SILTY FINE SAND	52.2	.47	13	13	.89	40%-50%	38-40	114	--	--	--	--
30	FINE SAND	115.9	.75	23	23	.923	60%-70%	40-42	254	--	--	--	--

10A20 CONTINUED BECHTEL ENVIRONMENTAL

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL STRESS	RELATIVE DENSITY	FRICTION ANGLE	YOUNGS MODULUS	UNDRAINED SHEAR ST	SENSITIVITY	COMP.	OCR
31	SILTY TO CLAYEY F.S.	110	1.75	36	36	.954	60%-70%	40-42	242	--	--	--	--
32	FINE SAND	161.2	1.68	32	32	.987	70%-80%	42-44	354	--	--	--	--
33	SILTY TO CLAYEY F.S.	231.2	5.9	77	77	1.018	>90%	44-46	508	--	--	--	--
34	SILTY FINE SAND	494.6	9.44	123									
					123	1.048	>90%	46-48	1088	--	--	--	--

‡ N'=POINT STRESS*(.2+.04*FRICTION RATIO)
* NORMALLY CONSOLIDATED SANDS
** FOR OVERCONSOLIDATED SANDS,SLIGHTLY REDUCE ABOVE FRICTION ANGLES
*** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER
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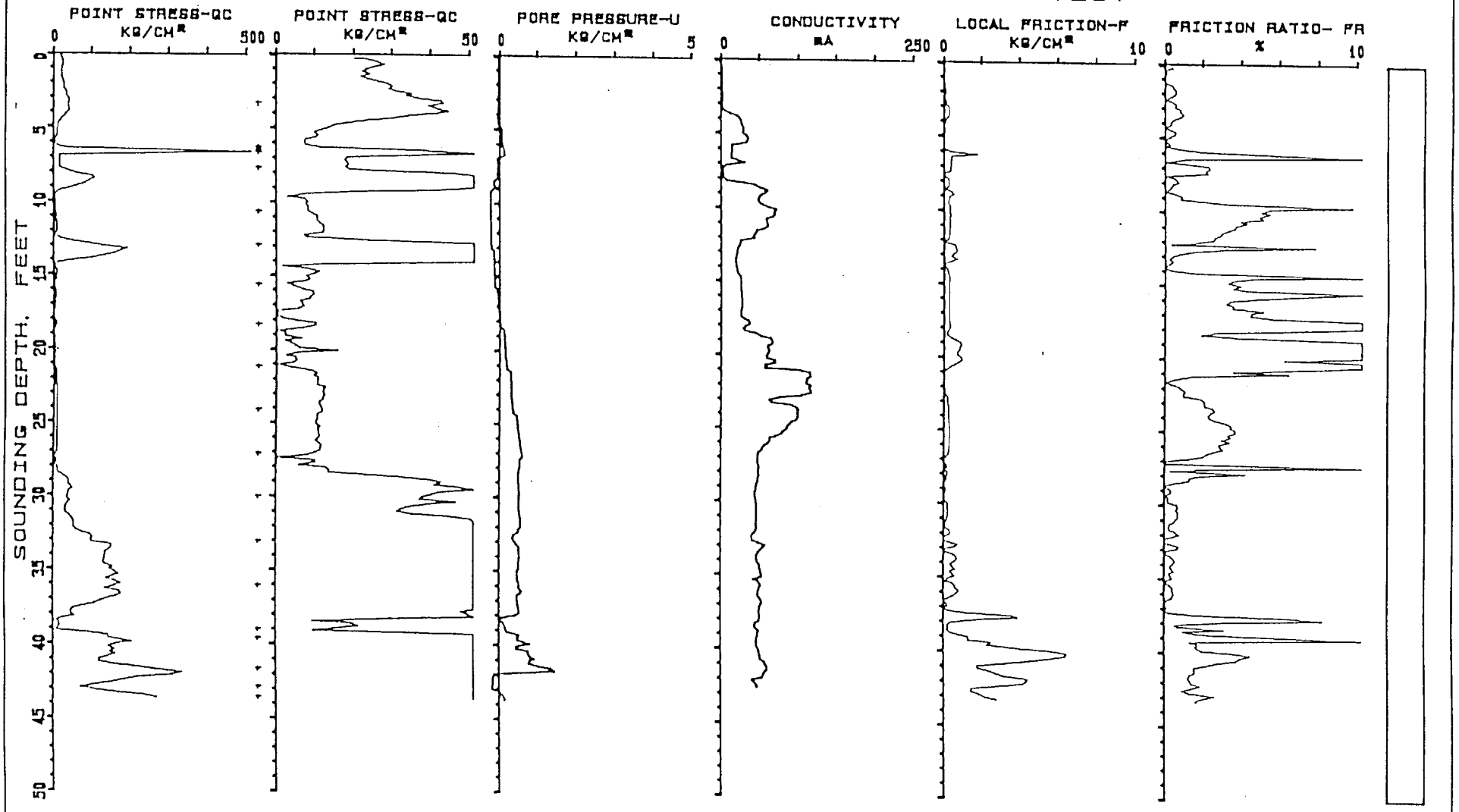
CONDUCTIVITY / PIEZOCONE SOUNDING TEST



* PUSH INTERRUPTED TO ADD ROD
PORE PRESSURE DECAY DATA MAY BE AVAILABLE

FILE #..... BECHTEL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594
SOUNDING # 615E15
TEST DATE 06-19-1998 12:28:56

IN-SITU TECHNOLOGY SOIL BEHAVIOR TABLE
FOR SOUTHEASTERN UNITED STATES SOILS

JOB NAME ..... BECHTEL ENVIRONMENTAL
PARRIS ISLAND CLEANERS
PROJECT# 22567-145-SC-0594

FILE NAME..... 615E15

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N' VALUES	VERTICAL EFFECTIVE STRESS (KG/CM2)	RELATIVE DENSITY (%) *	FRICTION ANGLE (DEGREES) **	YOUNGS MODULUS (KG/CM2) ***	UNDRAINED SHEAR STRENGTH (KG/CM2) ****	SENSITIVITY	COMP.	OCR
				#									
1	SILTY TO CLAYEY F.S.	25.3	0	8	8	.048	50%-60%	46-48	55	--	--	--	--
2	SILTY TO CLAYEY F.S.	24.4	.09	8	8	.097	50%-60%	44-46	53	--	--	--	--
3	SILTY TO CLAYEY F.S.	32.2	.17	10	10	.146	50%-60%	44-46	70	--	--	--	--
4	SILTY TO CLAYEY F.S.	41.4	.27	13	13	.195	60%-70%	44-46	91	--	--	--	--
5	SILTY TO CLAYEY F.S.	25.2	.01	8	8	.226	40%-50%	40-42	55	--	--	--	--
6	CLAYEY FINE SAND	10	.08	4	4	.256	<40%	36-38	22	--	--	--	--
7	FINE SAND	119.6	.09	23	23	.29	80%-90%	46-48	263	--	--	--	--
8	CLAYEY FINE SAND	9	.07	3	3	.32	<40%	34-36	19	--	--	--	--
9	FINE SAND	80	.06	16	16	.354	70%-80%	44-46	176	--	--	--	--
	SANDY CLAY	16.5	.35	8	8	.381	--	--	--	.99	4.6	.01	6
	CLAY	8.7	.39	8	8	.406	--	--	--	.5	2.2	.02	6
12	SANDY CLAY	11.5	.32	5	5	.433	--	--	--	.67	3.5	.02	6
13	CLAYEY FINE SAND	21.2	.44	8	8	.464	<40%	36-38	46	--	--	--	--
14	FINE SAND	140.5	.27	28	28	.497	80%-90%	44-46	309	--	--	--	--
15	CLAYEY FINE SAND	19.5	.3	7	7	.528	<40%	36-38	42	--	--	--	--
16	CLAY	7	.33	7	7	.553	--	--	--	.38	2	.03	3
17	CLAY	8.1	.31	8	8	.578	--	--	--	.44	2.5	.03	3
18	SOFT CLAY	3	.36	3	3	.594	--	--	--	.12	.8	UD	1
19	CLAY	4.7	.36	4	4	.619	--	--	--	.22	1.2	.05	1-1.5
20	SOFT CLAY	1.5	.89	1	1	.635	--	--	--	.02	.1	UD	<1
21	SOFT CLAY	1.4	.57	1	1	.651	--	--	--	.01	.2	UD	<1
22	SENSITIVE FINE GRAIN	7	.01	3	3	.673	--	--	--	.36	51.4	.02	3
23	SANDY CLAY	11.5	.17	5	5	.7	--	--	--	.63	6.7	.02	3
24	SANDY CLAY	11.8	.27	5	5	.728	--	--	--	.65	4.2	.02	3
25	SILTY CLAY TO CLAY	11.2	.34	7	7	.755	--	--	--	.61	3.2	.02	3
26	SILTY CLAY TO CLAY	10.9	.35	7	7	.782	--	--	--	.59	3.1	.02	3
27	SANDY CLAY	11.2	.21	5	5	.81	--	--	--	.6	5.1	.02	3
28	SOFT CLAY	.5	.13	0	0	.826	--	--	--	-.07	.3	UD	<1
29	SILTY TO CLAYEY F.S.	20.5	.06	6	6	.857	<40%	32-34	45	--	--	--	--
30	SILTY FINE SAND	44	.04	11	11	.887	<40%	36-38	96	--	--	--	--

5E15 CONTINUED BECHTEL ENVIRONMENTAL

DEPTH FEET	SOIL BEHAVIOR TYPE	PT (KG/CM2)	LF (KG/CM2)	N VALUES	N'	VERTICAL STRESS	RELATIVE DENSITY	FRICTION ANGLE	YOUNGS MODULUS	UNDRAINED SHEAR ST	SENSITIVITY	COMP.	OCR
31	SILTY TO CLAYEY F.S.	37.5	.24	12	12	.918	<40%	36-38	82	--	--	--	--
32	SILTY FINE SAND	47.3	.23	11	11	.949	<40%	36-38	104	--	--	--	--
33	FINE SAND	79.2	.21	15	15	.982	50%-60%	40-42	174	--	--	--	--
34	FINE SAND	132.4	.48	26	26	1.015	60%-70%	42-44	291	--	--	--	--
35	FINE SAND	138.7	.49	27	27	1.048	70%-80%	42-44	305	--	--	--	--
36	FINE SAND	159.9	.56	31	31	1.082	70%-80%	42-44	351	--	--	--	--
37	FINE SAND	162.6	.29	32	32	1.115	70%-80%	42-44	357	--	--	--	--
38	SILTY TO CLAYEY F.S.	87	1.49	29	29	1.146	50%-60%	38-40	191	--	--	--	--
39	SILTY TO CLAYEY F.S.	28.9	.35	9	9	1.176	<40%	32-34	63	--	--	--	--
40	SILTY TO CLAYEY F.S.	104.9	2.93	34	34	1.207	50%-60%	40-42	230	--	--	--	--
41	SILTY TO CLAYEY F.S.	161	4.8	53	53	1.238	70%-80%	42-44	354	--	--	--	--
42	SILTY FINE SAND	192.8	2.97	48	48	1.269	70%-80%	42-44	424	--	--	--	--
43	SILTY FINE SAND	198.7	2.57	49	49	1.3	70%-80%	42-44	437	--	--	--	--

\# N'=POINT STRESS*(.2+.04*FRICTION RATIO)

* NORMALLY CONSOLIDATED SANDS

** FOR OVERCONSOLIDATED SANDS,SLIGHTLY REDUCE ABOVE FRICTION ANGLES

** FOR OVERCONSOLIDATED SANDS, YOUNG'S MODULUS MAY BE AS MUCH AS 3 TO 6 TIMES HIGHER

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HYDROCONE TEST

SUMMARY OF CONDUCTIVITY MEASUREMENTS (cm/sec)
18 JUNE TO 30 JUNE 1996
MCRD PARRIS ISLAND DRY CLEANER FACILITY

							Borehole Depth							
Borehole Location	7ft	9ft	13ft	14ft	16ft	21ft	22ft	23ft	28ft	30ft	34ft	36ft	37ft	38ft
300C22	3.22*10-4			2.23*10-3			N.A.							
500C24	3.14*10-5			1.15*10-4			9.69*10-5							
322D09	2.08*10-4		5.11*10-3				1.59*10-5		5.81*10-4			5.76*10-4		
700D21	2.48*10-4			7.15*10-5		3.34*10-5			4.33*10-4					
615E15	N.A.		N.A.			1.75*10-4				7.51*10-4			6.46*10-4	
710E24	7.71*10-5			3.28*10-4			1.17*10-4		8.74*10-4					1.37*10-4
102F00	2.45*10-4			N.A.				8.75*10-5	2.37*10-4					
800E00	4.29*10-4			1.49*10-4										
621C18	7.31*10-4			7.66*10-5		2.07*10-5								
102G00				8.77*10-4										
-110G10				N.A.					1.02*10-5					
212G15				3.32*10-4					N.A.					
-218G00				2.58*10-4					2.3*10-5			2.95*10-4		
400G09	5.7*10-5			8.12*10-5				3.26*10-5	1.43*10-3			2.62*10-4		
500G20	1.62*10-3			2.06*10-3					5.45*10-4		5.17*10-4		3.07*10-4	
600G00	N.A.			1.51*10-3		N.A.			6.97*10-4		4.5*10-4			
800G00	8.27*10-4			4.16*10-4										
118H05	2.02*10-3			3.37*10-4					3.81*10-5			5.73*10-4		
-011H14	1.09*10-3			1.07*10-4					3.22*10-4			2.72*10-4		
404H21	1.17*10-4			4.22*10-4										
600H00	2.62*10-4			6.28*10-4				1.43*10-5	2.82*10-4			2.23*10-4		
700H05	4.94*10-3			2.49*10-4										
010J05				1.39*10-4					1.41*10-3					
108J18	2.25*10-3			1.08*10-4					2.8*10-4			5.4*10-4		
-115J23	4.82*10-4			8.99*10-5					1.15*10-3					
-218J05				5.24*10-5					3.04*10-4			2.65*10-4		
-310J05				1.36*10-4					2.17*10-4			6.33*10-4		
200L13		2.12*10-3			1.08*10-4					1.31*10-3				
200M09		3.75*10-5												

N A - DATA NOT AVAILABLE

ATTACHMENT 3

Technical Memorandum for Groundwater Evaluation and Air Sparging Pilot Study

DEPARTMENT OF THE NAVY

SOUTHERN DIVISION

TECHNICAL MEMORANDUM

FOR

GROUNDWATER EVALUATION AND AIR SPARGING PILOT STUDY

AT

BUILDING 193, PARRIS ISLAND, SOUTH CAROLINA

REV	DATE	REASON FOR REVISION	BY	EGS	PE	PM
0	02/13/97	Issued for Use	RS	–	Peh	VSA

Groundwater Evaluation And Air Sparging Pilot Study - Bldg. 193 - Parris Island, SC	JOB NO. 22567 Memorandum TM-145-001	REV. 0

1.0 INTRODUCTION

The Marine Corps Recruit Depot (MCRD), Parris Island, South Carolina is an active recruit basic training facility. The Morale, Welfare and Recreation (MWR) Dry Cleaning Facility is one of the many support activities that operates at the MCRD. Past practices and spills of the dry cleaning solvent tetrachloroethylene (PCE) at the dry cleaning facility have resulted in the contamination of the groundwater underlying the facility. Bechtel Environmental Inc. (BEI) conducted a site investigation of the groundwater during June 1996 to determine the extent of the contaminants at the site. Direct push technology and a field GC were used for this effort to provide screening information about the extent of the plume. The results of this screening effort are contained in the report "June 1996 Phase Two Sampling Effort" Chron 000041.

The results of the screening effort were used to plan a full scale field investigation that included the following elements:

- Installation of a well monitoring network.
- Analytical sampling to establish baseline soil and groundwater contamination.
- Operation of an air sparging pilot study.
- Split spoon sampling during well installation to determine geological stratigraphy.

The entire scope of work for this effort is detailed in "Technical Memorandum for Well Installation and Air Sparging Pilot Test" (Chron 00060). This field effort was conducted during December 1996.

2.0 AIR SPARGING PILOT STUDY

The Air Sparging Pilot Study was conducted on the north side of the site, upgradient of the plume of contaminated groundwater. The main purpose for the study was to determine:

- If air sparging could be effective through the layer of fine sands and silts located about seven feet below grade.
- If air sparging would be an applicable technology for this site.
- Design parameters for a full scale system.

The study was a success. Attachment 1 contains the Air Sparging Pilot Test Results with a complete description of procedures, data collected, conclusions and recommendations.

3.0 WELL INSTALLATION

Sixteen wells were installed at the site at eight locations. At each location, a shallow well was installed to a depth of seven feet and a deep well was installed to a depth of 14 feet. Attachment 2 contains the following data:

- Borehole logs,
- Well construction logs

- Geotechnical testing results.

Figure 1 shows the locations of the wells installed for the monitoring well network.

3.1 Site Geology

The deep wells at each location were continuously split spoon sampled during borehole drilling to provide information on the subsurface geology at the site. A geological section transect map was developed from this data and is attached as Figure 2. Figures 3 and 4 are of the Generalized Geological Sections 'A-A' and 'B-B'.

3.2 Site Hydrogeology

Water levels were collected from the installed monitoring wells. Two groundwater flow direction maps were prepared using the water level data. One was prepared using the deep well water levels (Figure 5) and one was prepared using the shallow well water levels (Figure 6). The general flow direction on both maps is toward the southeast with a gradient of 0.003 ft/ft. This flow direction is consistent with the extent of contamination at the site.

4.0 ANALYTICAL RESULTS

4.1 Groundwater Sample Results

Groundwater samples were collected from each monitoring well and sent to an offsite laboratory for analysis. These samples were analyzed for VOCs, chloride, sulfate and nitrate. Figure 7 shows the sampling results and the extent of the solvent contamination at the site. The results from this phase of the investigation correlated closely with the results from the direct push sampling. The complete analysis results are included in Attachment 3.

Groundwater samples were collected from each monitoring well and analyzed on site for ferrous iron using a Hach test kit. The levels of iron detected were much lower than those previously detected during the direct push effort. The direct push method samples were very turbid and this may have contributed to the elevated iron results. The iron results from the onsite testing are included in Attachment 3.

4.2 Soil Sampling Results

Soil samples were collected from the 1'-3' interval and the 5'-7' during borehole drilling of monitoring wells 193-6MW-D, 193-7MW-D and 193-8MW-D. These three wells are in the center of the plume of contaminated groundwater. The results are included in Table 1. The soil results indicate that the soil is not greatly impacted by the dry cleaning solvents.

5.0 SITE SURVEY

A site survey was performed to determine the elevations and locations of the monitoring wells. A copy of the site survey is included as Attachment 4.

TABLE 1
SOIL SAMPLING RESULTS

Well and Sample ID Number	Contaminant (ppb)					Sample interval
	PCE	TCE	cis 1,2-DCE	trans 1,2-DCE	vinyl chloride	
193-7MW-D PI16196	2J	0.8J	0.9J	nd	nd	5'-7'
193-7MW-D PI16197	32	6	3J	nd	nd	1'-3'
193-8MW-D PI16199	30	5J	3J	nd	nd	1'-3'
193-8MW-D PI16200	1100E	80	22J	nd	nd	5'-7'
193-6MW-D PI16202	1J	1J	nd	nd	nd	1'-3'
193-6MW-D PI16203	nd	nd	nd	nd	nd	5'-7'
Composite PI16204	69	21	3J	nd	nd	composite 3 drums

J Indicates presence of analyte between DL (Detect Limit) and RL (Report Limit)

E Indicates concentrations exceed the calibration range of the GC/MS instrument for that specific analysis

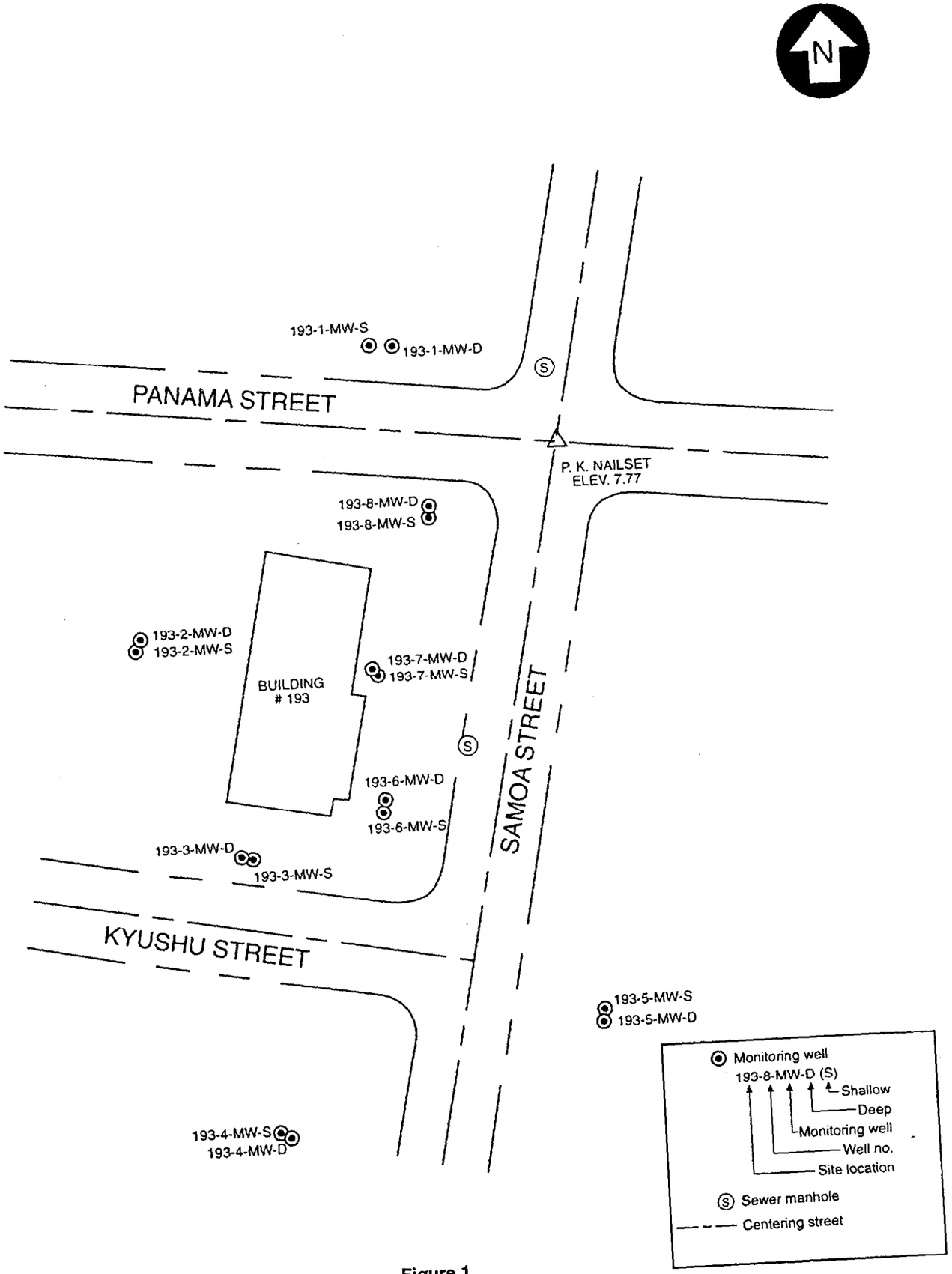

Figure 1
Monitoring Well Location Map

Z1.9 0545.1

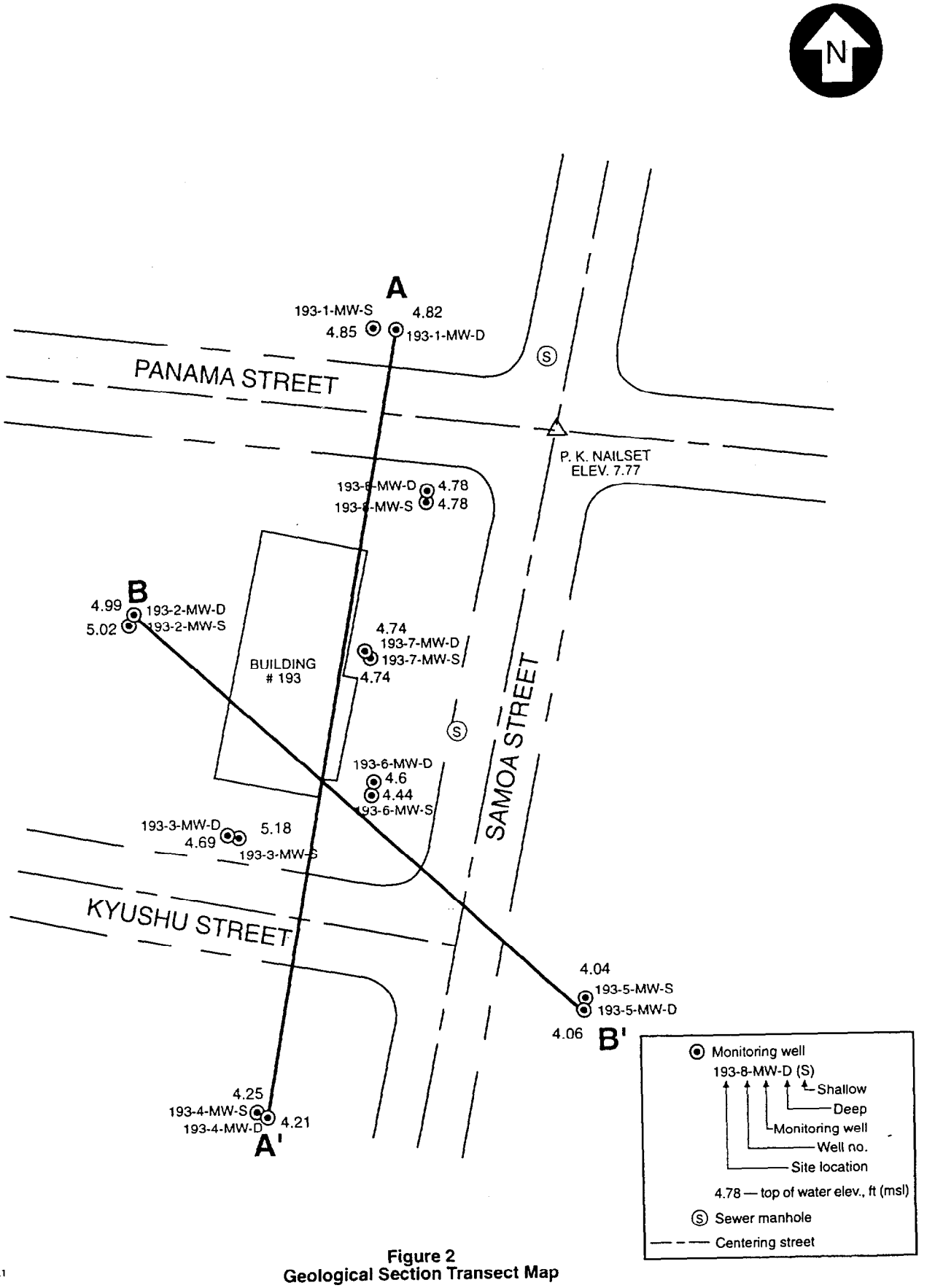

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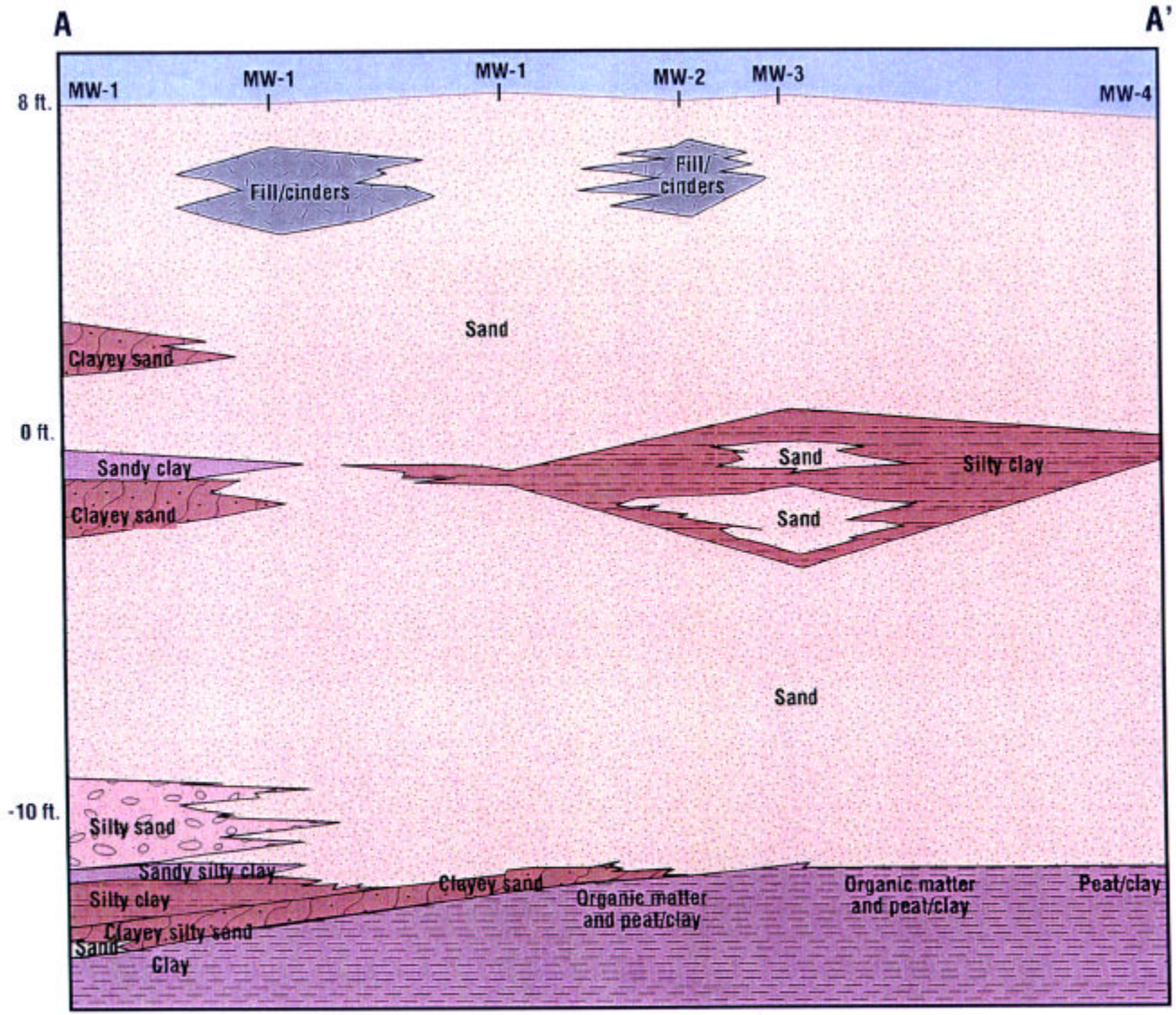
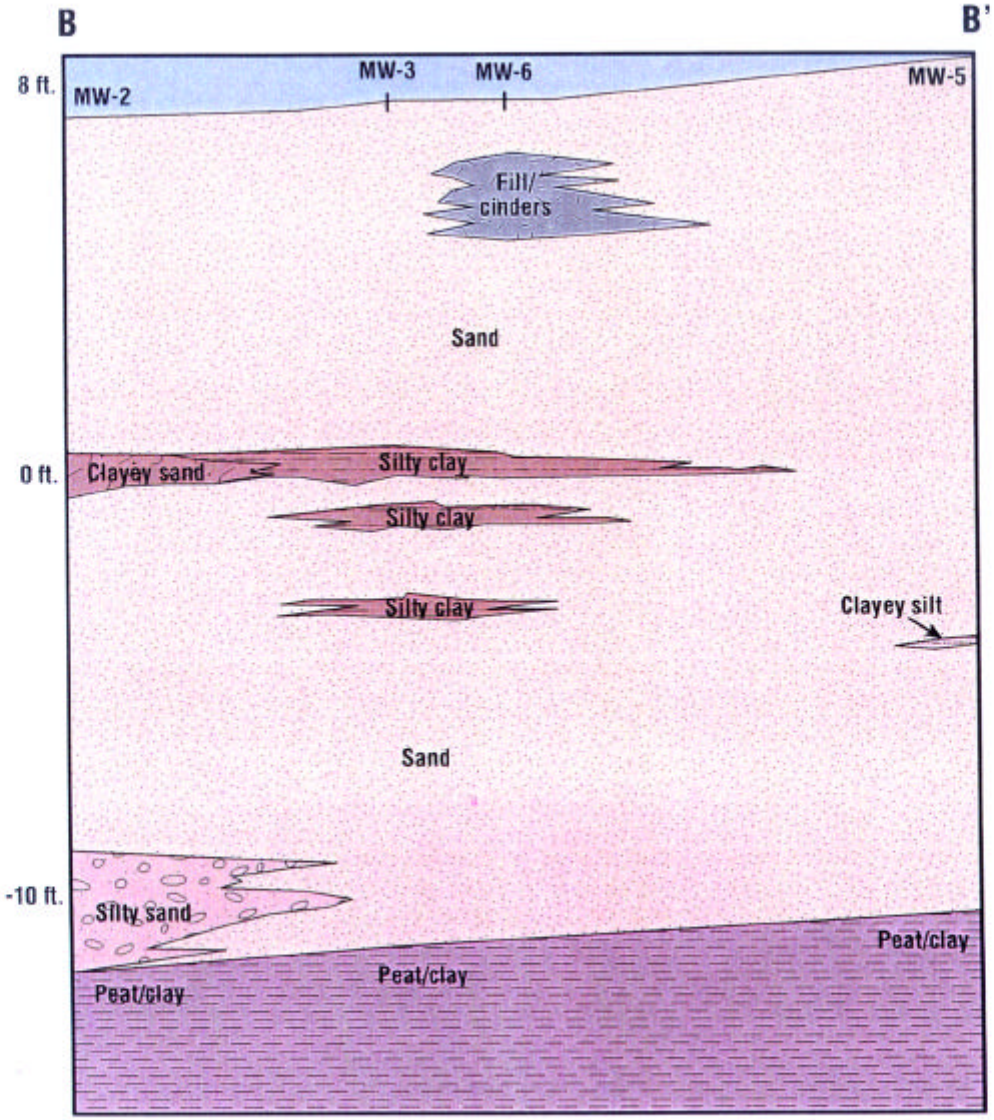
Figure 2
Geological Section Transect Map



Vertical scale: 1" = 4'
Horizontal scale: 1" = 75'

Figure 3
Generalized Geological Section of Site 193 "Dry Cleaners"; A - A'

Z1.9 0545



Vertical scale: 1" = 4'
Horizontal scale: 1" = 75'

Figure 4
Generalized Geological Section of Site 193 "Dry Cleaners"; B - B'

Z1.9 0545.2

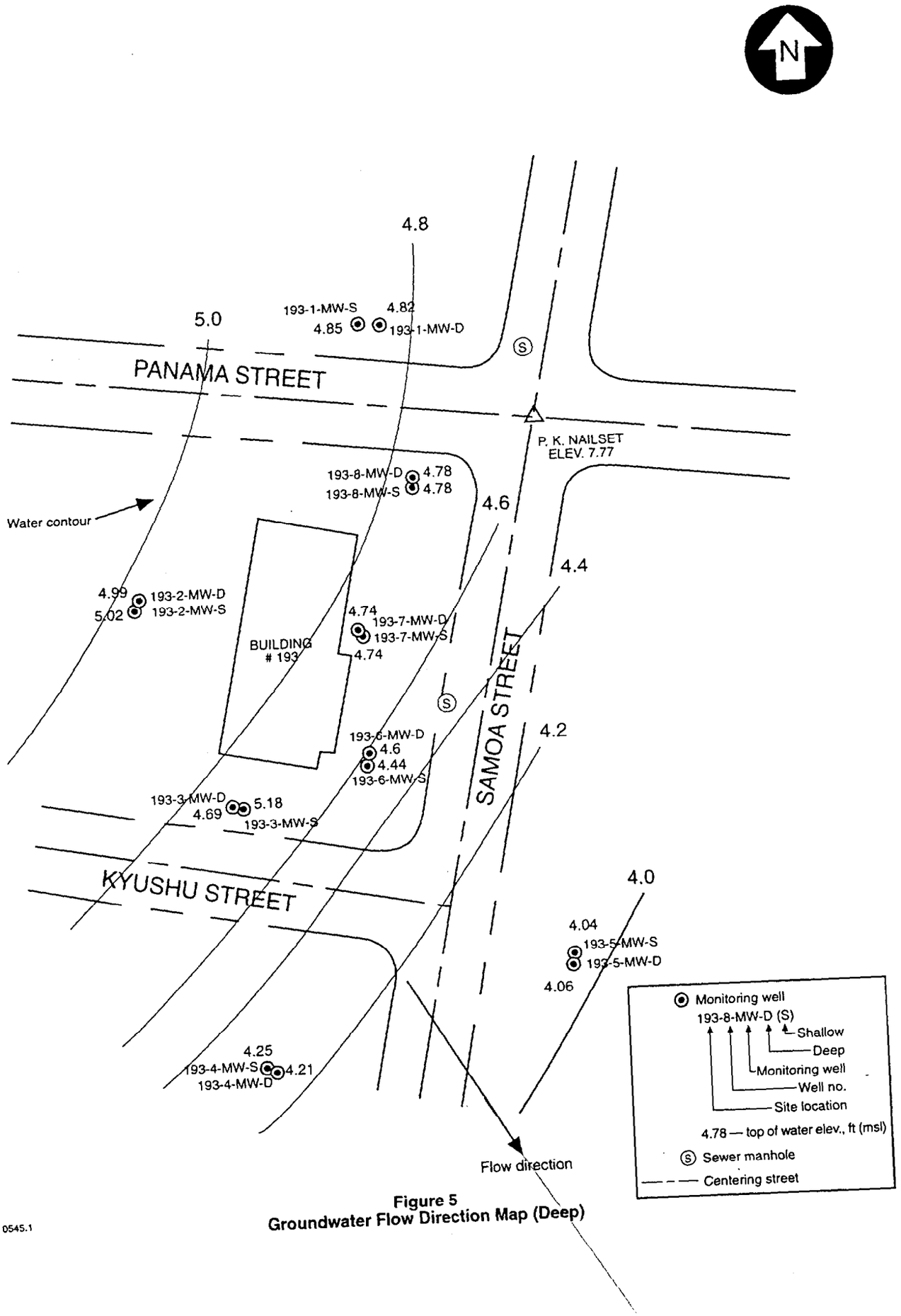


Figure 5
Groundwater Flow Direction Map (Deep)

Z1.9 0545.1

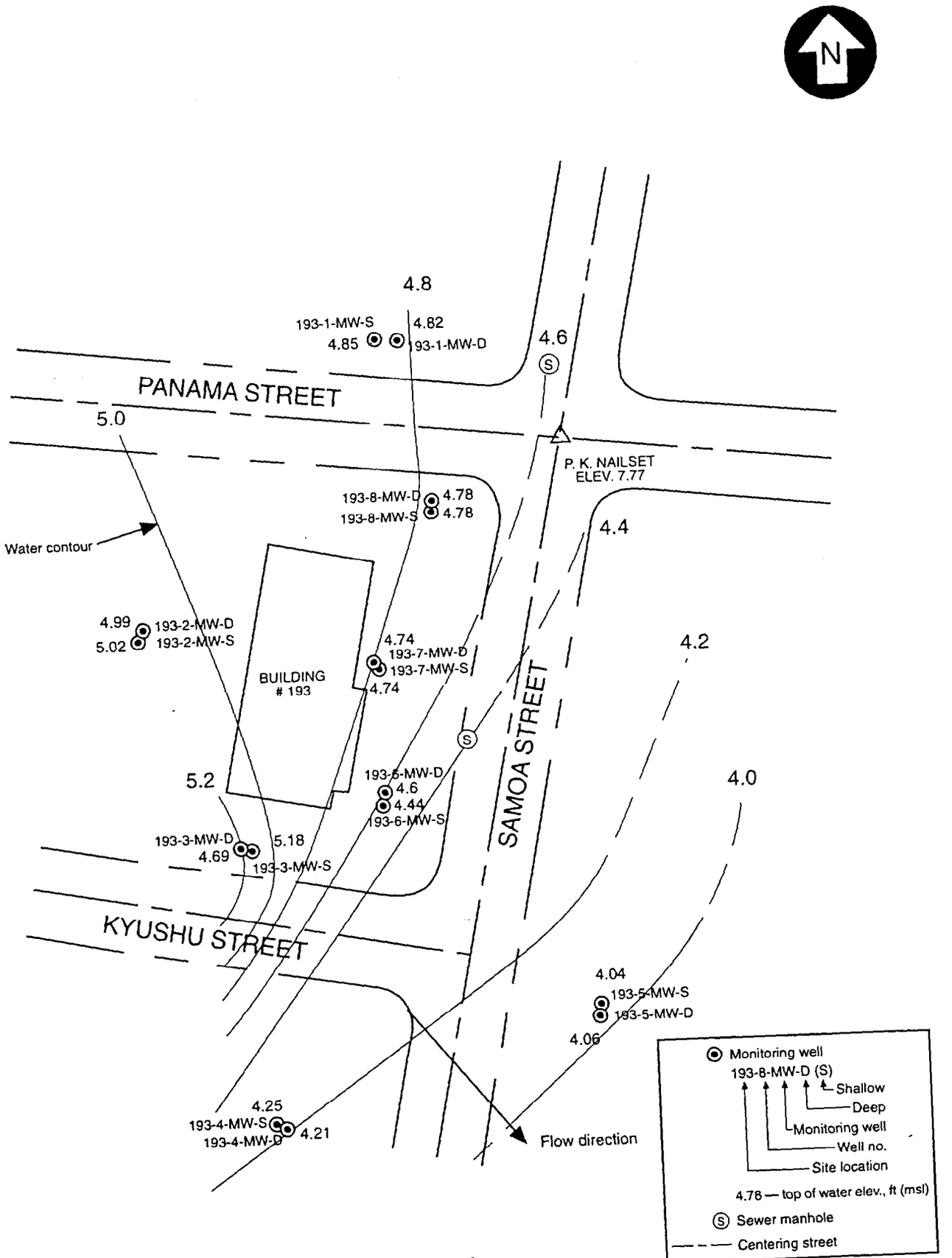


Figure 6
Groundwater Flow Direction Map (Shallow)

Z1.9 0545.1

	193-1MW-D PI16180	193-1MW-S PI16181
PCE	nd	nd
TCE	nd	nd
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-8MW-D PI16194	193-8MW-S PI16195
PCE	5,600	32,000
TCE	1,400	4,900
cis 1,2-DCE	510	1,100J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-2MW-D PI16182	193-2MW-S PI16183
PCE	1.8	1.3
TCE	0.64J	nd
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

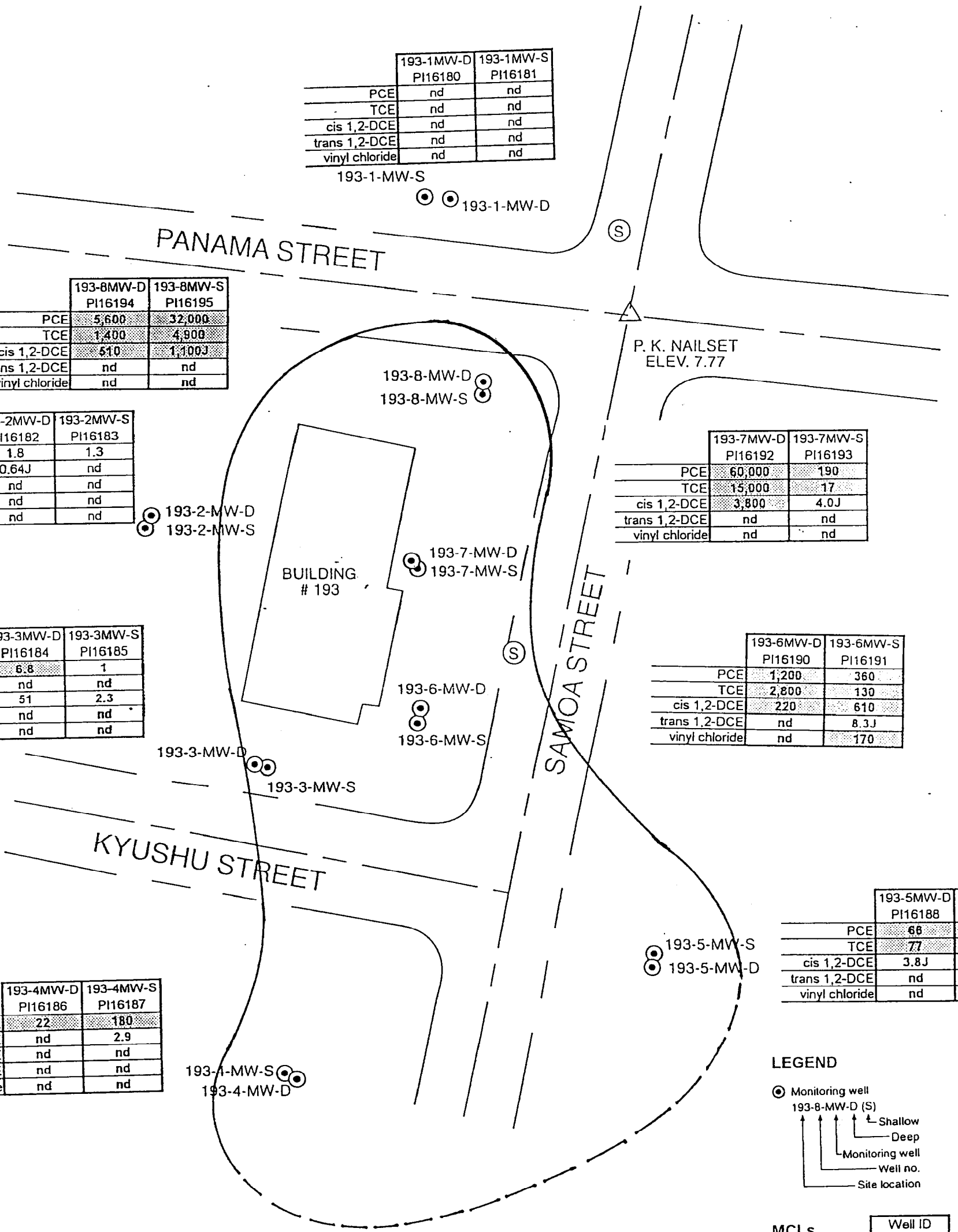
	193-7MW-D PI16192	193-7MW-S PI16193
PCE	60,000	190
TCE	15,000	17
cis 1,2-DCE	3,800	4.0J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-3MW-D PI16184	193-3MW-S PI16185
PCE	6.8	1
TCE	nd	nd
cis 1,2-DCE	51	2.3
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-6MW-D PI16190	193-6MW-S PI16191
PCE	1,200	360
TCE	2,800	130
cis 1,2-DCE	220	610
trans 1,2-DCE	nd	8.3J
vinyl chloride	nd	170

	193-5MW-D PI16188	193-5MW-S PI16189
PCE	68	52
TCE	77	84
cis 1,2-DCE	3.8J	2.6J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-4MW-D PI16186	193-4MW-S PI16187
PCE	22	180
TCE	nd	2.9
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd



LEGEND

Monitoring well
193-8-MW-D (S)
Shallow
Deep
Monitoring well
Well no.
Site location

MCLs	Well ID Sample ID
PCE	5
TCE	5
cis 1,2-DCE	70
trans 1,2-DCE	100
vinyl chloride	2

All detections above MCLs are shaded.

—— > MCLs

Figure 7.
Groundwater Analytical Results (ppb)

Summary Report For
Air Sparging Pilot Test

Dry Cleaner Site
MCRD
Parris Island

Navy RAC Southern Division
Contract No. N62467-93-D-0936

Bechtel Environmental, Inc.
Oak Ridge, Tennessee

Job No. 22567

February 1997

1.0 INTRODUCTION

The Marine Corps Recruit Depot (MCRD), Parris Island, South Carolina, is an active recruit basic training facility. During the summer of 1996, groundwater samples were collected at the Dry Cleaner Facility at Parris Island with direct push technology and analyzed with a field GC. Results of these tests indicated that a plume of PCE, trichloroethene (TCE), and 1,2 dichloroethene (1,2 DCE) contaminated groundwater exists with concentrations exceeding the regulatory limits. Based on this information, Southern Division, Naval Facilities Engineering Command made a decision to conduct an interim removal action to contain the contaminated plume of groundwater.

The objectives of the interim action at this facility are:

- containment of the plume
- treatment of the excessively contaminated groundwater at the center of the plume
- establishment of parameters to monitor natural attenuation at the edges of the plume, if natural attenuation is selected as a final remedy.

Field activities were conducted in June and December of 1996 to determine the extent of the contamination at the site and to establish a well network to monitor plume migration. In addition, an air sparging pilot study was conducted in December 1996 to determine the viability of this technology and to develop operating parameters. This report provides a summary of the air sparging pilot study results, conclusions and recommendations.

2.0 AIR SPARGING PILOT STUDY

The purpose of the this pilot study is to establish the following to be used in the system design / installation:

- Determine if air sparging is a viable option
- Radius of influence of the air sparging well and
- Optimum air injection rate and pressure at the sparging well.

2.1 SYSTEM DESCRIPTION

The air sparging pilot system operated at the Parris Island site consisted of the following components:

- One sparging well and five observation wells (including one monitoring well)
- An air compressor and air filter
- Valves, gages, and flow meters for controlling and monitoring the system
- Pressure transducers, datalogger, and air sampling equipment
- Peristaltic pump for collecting groundwater samples
- Helium tracer gas cylinder and controls

See Figure 1 for details of the air sparging pilot system.

2.1.1 Description of Air Sparging and Observation Wells

The air sparging well used for the pilot study was monitoring well MW-1D. This well was located north of the dry cleaning building, upgradient of the plume of contaminated groundwater in a clean area. This well

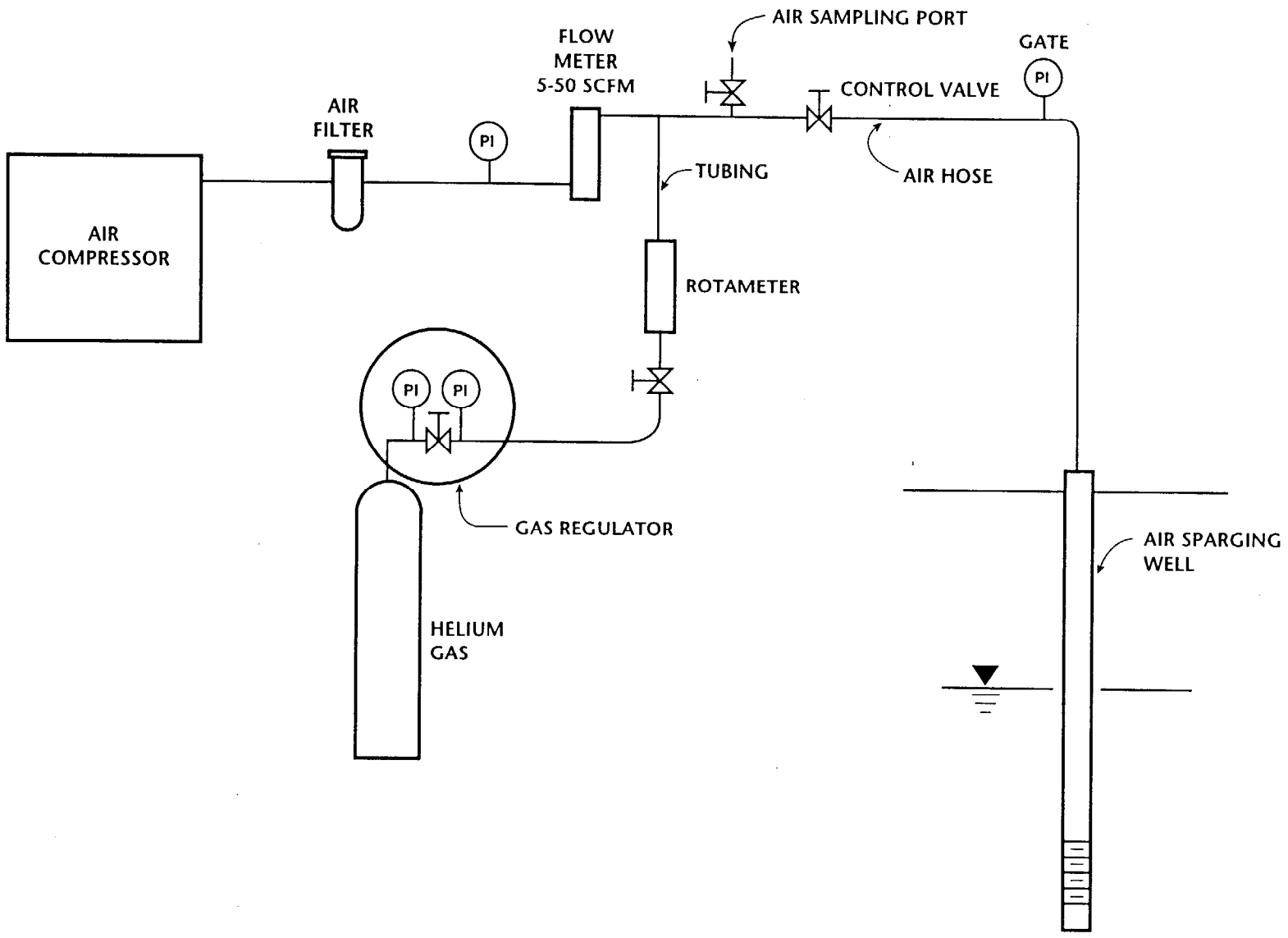


FIGURE 1. AIR SPARGING SYSTEM

Z1.9 0381.1

was installed 14 feet deep with a two feet long well screen. Five observation wells were installed to monitor the pilot study. See Figure 2 for the location of the wells. MW-1S was a seven foot deep well installed two feet south of MW-1D. Two well clusters of two wells each were installed at 10 and 20 feet distances from the sparging well. Each well cluster had a shallow deep and well of 7 feet and 14 feet. These wells were constructed as shown on Figure 3.

2.1.2 Air Compressor and Associated Equipment

The air compressor providing the air for the pilot study was capable of generating air flows in the ranges of 5 to 30 scfm with accompanying pressures of 5 to 10 psi. The air flow was monitored by a pressure indicator and a flow meter. The total flow was controlled by a gate valve. The compressed air was filtered to remove particulates and oil prior to injection of air into the sparging well.

2.1.3 Tracer Gas

Helium was used as a tracer gas for this pilot study. Helium was added to the air stream at a 5% concentration. A helium detector was used to monitor for the presence the helium in the monitoring wells.

2.1.4 System Operation

The pilot system was operated three consecutive days at varying air flow rates and pressures. The system was operated about 4 hours each day. Flow rates, pressures, and operation times were adjusted in the field as appropriate.

Three sets of data were collected during the pilot test. The first test was conducted at an air flow rate of 3.0 scfm and the second test was conducted at 1.8 scfm. During the third day a stepped test was performed. The initial air flow rate was set at 2.0 scfm and was run for approximately one hour. Then the air flow rate was stepped up to 3 scfm and operated for one hour. Finally, the air flow rate was increased to 4 scfm and run for an additional one hour. Helium was injected during the first two tests. The following data were collected during the operation.

- Water level changes in the wells were measured and recorded before, during and after system operation. Data was collected using a data-logger and transducers in each well.
- Groundwater samples were collected and analyzed for dissolved oxygen levels. These levels were measured before startup and at regular intervals until after the system was shutdown.
- Helium detections in the wells.

The field monitoring data are presented in Appendix C.

2.1.5 Planned vs Actual Implementation

Some of the planned activities for the pilot study had to be modified to match field conditions. The pilot study was designed with redundant data collection activities, so that the inability to collect some of the planned data would not jeopardize the results. Air pressure changes, oxygen concentration changes and carbon dioxide concentrations changes of the vadose zone were not measured in the observation wells. This data could not be collected because the water table was much higher than anticipated and the top of the well screens had to be set below the water table.

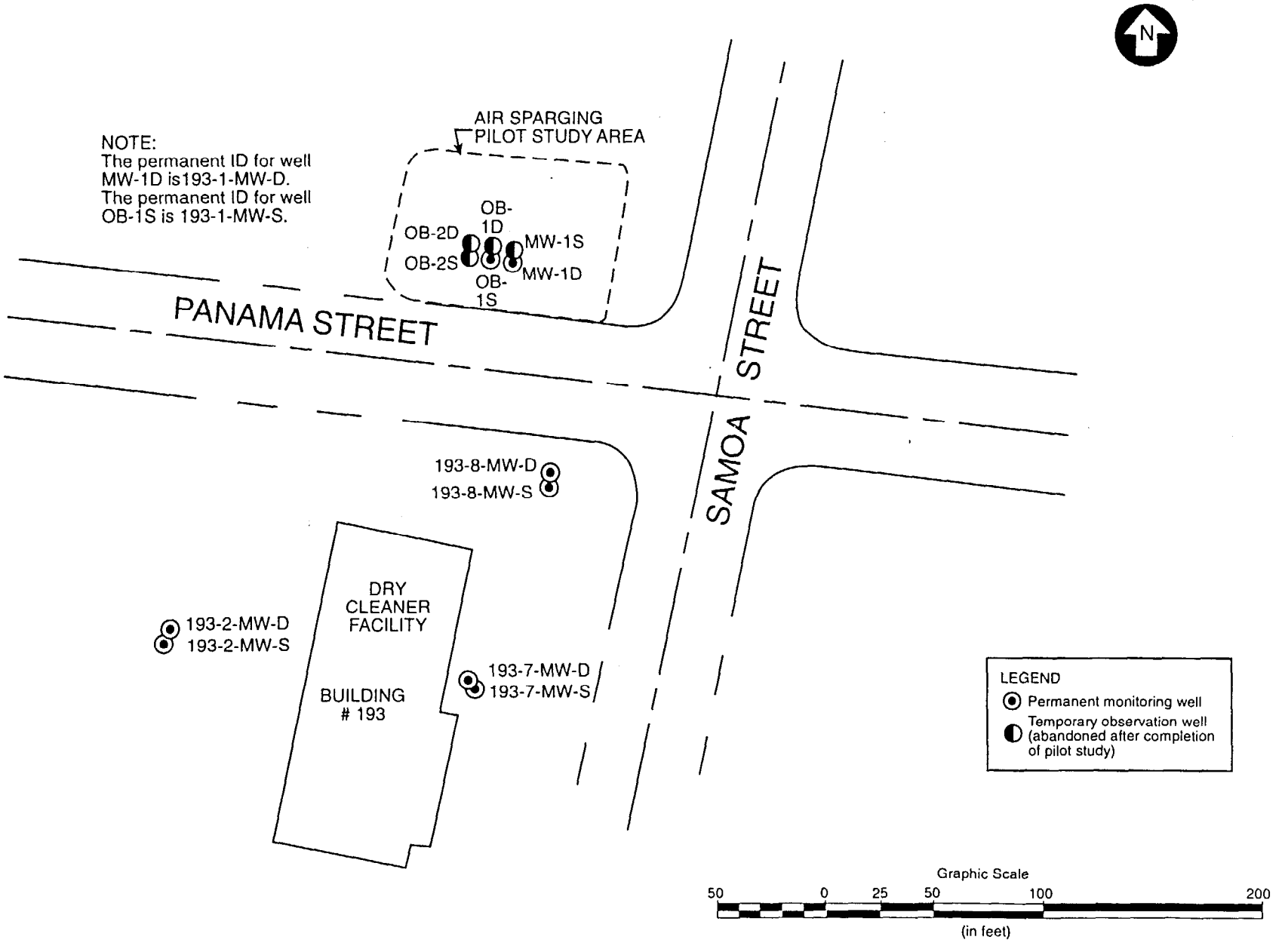


FIGURE 2. AIR SPARGING PILOT STUDY LOCATION MAP

Z1.9 0545.3

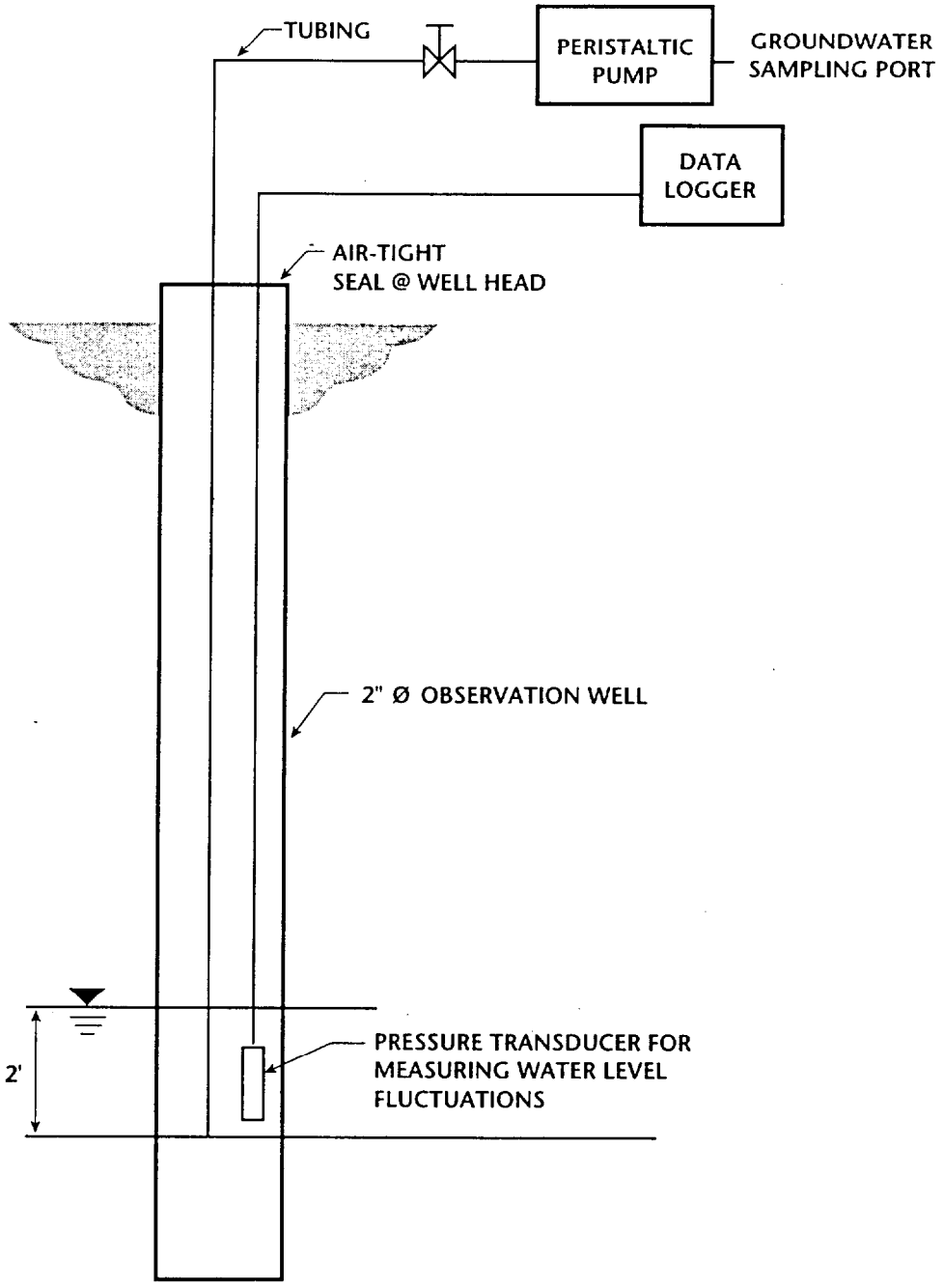


FIGURE 3. AIR SPARGING OBSERVATION WELL MONITORING DETAILS

Z1.9 0381.3

The injection rates of air into the sparging well were less than anticipated. Test #1 was run at an initial flow rate of 5 scfm. This injection rate forced groundwater out of observation well OB-1D. Therefore, the rate was reduced to 3 scfm shortly after Test #1 was started.

Water levels were to be monitored in all five observation wells. The data transducer that was in monitoring well OB-1 deep malfunctioned during the pilot study. Therefore, no data was collected in the data logger in this well.

3.0 DATA EVALUATION AND CONCLUSIONS

3.1 WATER LEVEL DATA

Water levels data collected during the pilot test are presented in Appendix A as Tables A1, A2, and A3 and the corresponding Figures A1 through A5 as follows.

Test #	Air Flow Rate scfm	Table #	Figure #
1	3	A1	A1 & A2
2	1.8	A2	A3
3	2, 3, & 4	A3	A4 & A5

Water levels registered in the data logger and the calculated (actual) water levels are presented in the same tables. As seen from the figures, the water levels increased immediately after turning the sparger on, increasing slowly for few more minutes, dropping off slowly after that, and then leveled off until shut down. The water level dropped off immediately as soon as the sparger was shut down and leveling off to reach the normal level. These trends were observed for all flow rates in all wells. Such a trend of immediate raise, leveling off at steady state, and immediate drop was also observed during the third test when the air flow rates were stepped (Figure A5).

Aeration of the water column was observed in OB-1S and OB-1D. Air bubbles were observed in these two wells during air sparging. Bubbles were not observed in OB-2S or OB-2D. However, care should be taken so that air flow rate does not exceed 3 or 4 scfm during full-scale remediation since at high air flow rates, there is the potential of raising the water level above the ground surface.

In general, the increase in water levels ranged from 1 ft to 5 ft depending upon the air flow rate, distance of the observation well, and the depth of the well. The only deep well (for which data logger records were available) registered the highest increase in water level indicating that air sparging was effective even at a distance of 20 ft. This increase in water level in the deep well rather than in shallow well in response to air injection in deep well demonstrates the soil permeability is higher in the lateral direction than in the vertical direction.

3.2 DISSOLVED OXYGEN LEVEL DATA

Dissolved oxygen data were manually collected for air flow rates 3 scfm and 1.8 scfm. Dissolved oxygen data are presented in Appendix B as Tables B1 and B2 and the corresponding charts are presented as Figures B1 and B2.

The air sparging technology does not require increase in dissolved oxygen concentrations during remediation for it to be effective. However, dissolved oxygen levels measured during the pilot test serve as a good indicator of how well the groundwater is being sparged. The oxygen level data in combination with the change in water levels due to sparging will be used to determine design parameters (such as radius of influence) for the sparge wells.

Prior to operation of the pilot system for Test #1, the dissolved oxygen in OB1-S was 3.2 mg/ L. As seen in Figure B2, after air sparging was started, there was a drop in dissolved oxygen in OB1-S followed by a steady increase in the dissolved oxygen level. For OB1-D, the dissolved oxygen was as low as 0.75 mg/L and steadily increased to a high of 3.9 mg/L. The data also indicates that the ***rate of increase in dissolved oxygen*** at OB1-D is higher than that at OB1-S for the obvious reason that air sparging is done at 14 ft in the deep well. Similar higher ***rate of increase in dissolved oxygen*** was observed for the flow rate at 1.8 scfm in Test #2.

Both the farthest observation wells (OB2-S and OB2-D) registered low dissolved oxygen levels prior to system operation. While there was a slight increase in dissolved oxygen in OB2-S, there was a drop in dissolved oxygen levels in OB2-D. The highest ***increase in water level*** as registered in OB2-D, is not reflected in dissolved oxygen. During air sparging, the injected air tends to travel at approximately 45° to the horizontal as documented by several researchers. For this reason, the air sparging might not have sufficiently oxygenated the groundwater in the farthest wells, especially Well OB-2D.

3.3 HELIUM DETECTIONS

Helium was detected in all the wells. These detections were only used as an indicator of where the sparged air was going. The detections were much higher at OB-1S and OB-1D than they were at OB-2S and OB-2D.

3.4 CONCLUSIONS AND RECOMMENDATIONS

- The pilot test conducted at the site provided adequate information to support the design of an air sparging system.
- The air sparging was effective through the layer of finer material at the 7 foot depth.
- Air flow rates of 2 to 3 scfm should be adequate. The system should be designed for a capacity of 5 scfm per well. Air flow rate can be adjusted as required during system startup.
- It is observed that air sparging affected the water table levels even at a distance of 20 ft. However, dissolved oxygen levels in wells at 20 ft distance from the sparge well indicate that sufficient oxygenation does not occur in those wells.
- Considering the increase in water levels and dissolved oxygen data, a radius of influence of 15 ft is recommended.

APPENDIX A

Table A1

AIR SPARGING PILOT TEST, WATER LEVELS

DRY CLEANER SITE, PARRIS ISLAND, SC

TEST #1/ Air Flow Rate = 3 scfm

Observed Water Levels in the wells

Time	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
0	-4.092	6.475	10.91	6.993	5.591
10	-4.092	6.477	10.905	6.996	5.587
20	-4.104	6.488	10.905	6.989	5.589
30	-4.111	6.501	10.91	6.993	5.591
40	-4.117	6.512	10.907	6.805	5.587
50	-4.063	6.341	10.901	6.875	5.578
60	-4.117	6.215	10.77	6.893	5.58
70	-3.303	6.398	10.892	6.891	5.571
80	-3.237	6.263	10.875	6.858	5.484
90	-3.278	6.414	10.901	6.727	5.573
100	-3.373	6.444	10.901	6.847	5.576
110	-3.486	6.457	10.91	6.882	5.589
120	-3.578	6.466	10.916	6.897	5.598
130	-3.666	6.471	10.923	6.906	5.606
140	-3.726	6.475	10.92	6.91	5.606
150	-3.786	6.479	10.925	6.915	5.606
160	-3.824	6.481	10.925	6.915	5.608
170	-3.855	6.484	10.927	6.917	5.606
180	-6.945	6.915	13.808	7.162	6.65
190	-7.121	7.606	13.716	7.532	7.21
200	-7.371	7.56	13.804	7.656	7.369
210	-7.491	7.799	13.506	7.672	7.365
220	-7.431	7.998	13.465	8.063	7.472
230	-7.434	7.947	13.303	8.149	7.407
240	-7.402	7.932	13.246	8.044	7.35
250	-7.399	7.759	13.235	8.192	7.354
260	-7.402	7.785	13.165	8.162	7.332
270	-7.061	7.831	13.406	8.105	7.31
280	-7.099	7.785	13.229	8.07	7.267
290	-6.506	7.488	12.321	7.965	6.742
300	-6.468	7.459	12.203	7.663	6.431
310	-6.345	7.389	11.979	7.735	6.459
320	-6.383	7.247	12.052	7.735	6.453
330	-6.405	7.258	12.043	7.733	6.451
340	-6.427	7.26	12.043	7.722	6.44
350	-6.427	7.271	12.012	7.715	6.418
360	-6.417	7.28	11.99	7.624	6.398
370	-6.402	7.114	11.798	7.604	6.328
380	-6.405	7.133	11.894	7.643	6.333
390	-6.411	7.129	11.881	7.648	6.319
400	-6.417	7.147	11.868	7.641	6.308
410	-6.424	7.131	11.868	7.195	6.225
420	-6.433	7.022	11.859	7.553	6.278
430	-4.423	6.304	8.779	7.219	5.103
440	-4.032	6.005	7.674	6.821	4.012
450	-3.972	6.035	8.243	6.783	4.128

Actual Water Levels in the Wells

Time	MW-1S	OB-1S	OB-2S	OB-2D
0	0	0	0	0
10	0	0.002	0.003	-0.004
20	0.012	0.013	-0.004	-0.002
30	0.019	0.026	0	0
40	0.025	0.037	-0.188	-0.004
50	-0.029	-0.134	-0.118	-0.013
60	0.025	-0.26	-0.1	-0.011
70	-0.789	-0.077	-0.102	-0.02
80	-0.855	-0.212	-0.135	-0.107
90	-0.814	-0.061	-0.266	-0.018
100	-0.719	-0.031	-0.146	-0.015
110	-0.606	-0.018	-0.111	-0.002
120	-0.514	-0.009	-0.096	0.007
130	-0.426	-0.004	-0.087	0.015
140	-0.366	0	-0.083	0.015
150	-0.306	0.004	-0.078	0.015
160	-0.268	0.006	-0.078	0.017
170	-0.237	0.009	-0.076	0.015
180	2.853	0.44	0.169	1.059
190	3.029	1.131	0.539	1.619
200	3.279	1.085	0.663	1.778
210	3.399	1.324	0.679	1.774
220	3.339	1.523	1.07	1.881
230	3.342	1.472	1.156	1.816
240	3.31	1.457	1.051	1.759
250	3.307	1.284	1.199	1.763
260	3.31	1.31	1.169	1.741
270	2.969	1.356	1.112	1.719
280	3.007	1.31	1.077	1.676
290	2.414	1.013	0.972	1.151
300	2.376	0.984	0.67	0.84
310	2.253	0.914	0.742	0.868
320	2.291	0.772	0.742	0.862
330	2.313	0.783	0.74	0.86
340	2.335	0.785	0.729	0.849
350	2.335	0.796	0.722	0.827
360	2.325	0.805	0.631	0.807
370	2.31	0.639	0.611	0.737
380	2.313	0.658	0.65	0.742
390	2.319	0.654	0.655	0.728
400	2.325	0.672	0.648	0.717
410	2.332	0.656	0.202	0.634
420	2.341	0.547	0.56	0.687
430	0.331	-0.171	0.226	-0.488
440	-0.06	-0.47	-0.172	-1.579
450	-0.12	-0.44	-0.21	-1.463

Due to mechanical/ electrical problems associated with the transducer data log, OB-1D data is not presented in this table.

Figure A1
Air Sparging Pilot Test Well Data, Parris, Island, SC
Test #1 / Air Flow Rate = 3 scfm

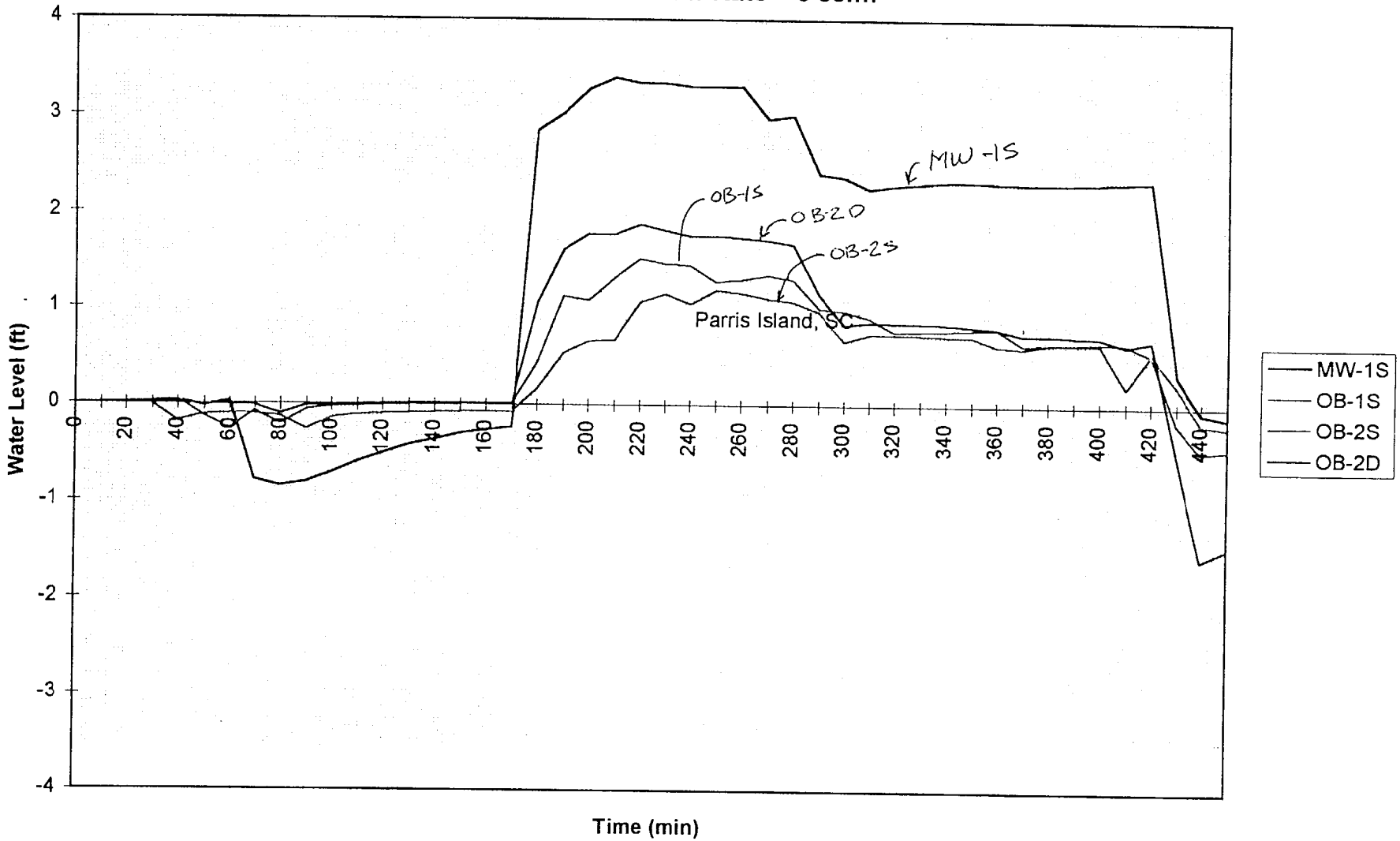


Figure A2
Air Sparging Pilot Test Well Data, Parris, Island, SC
Test #1 - Air Flow Rate = 3 scfm

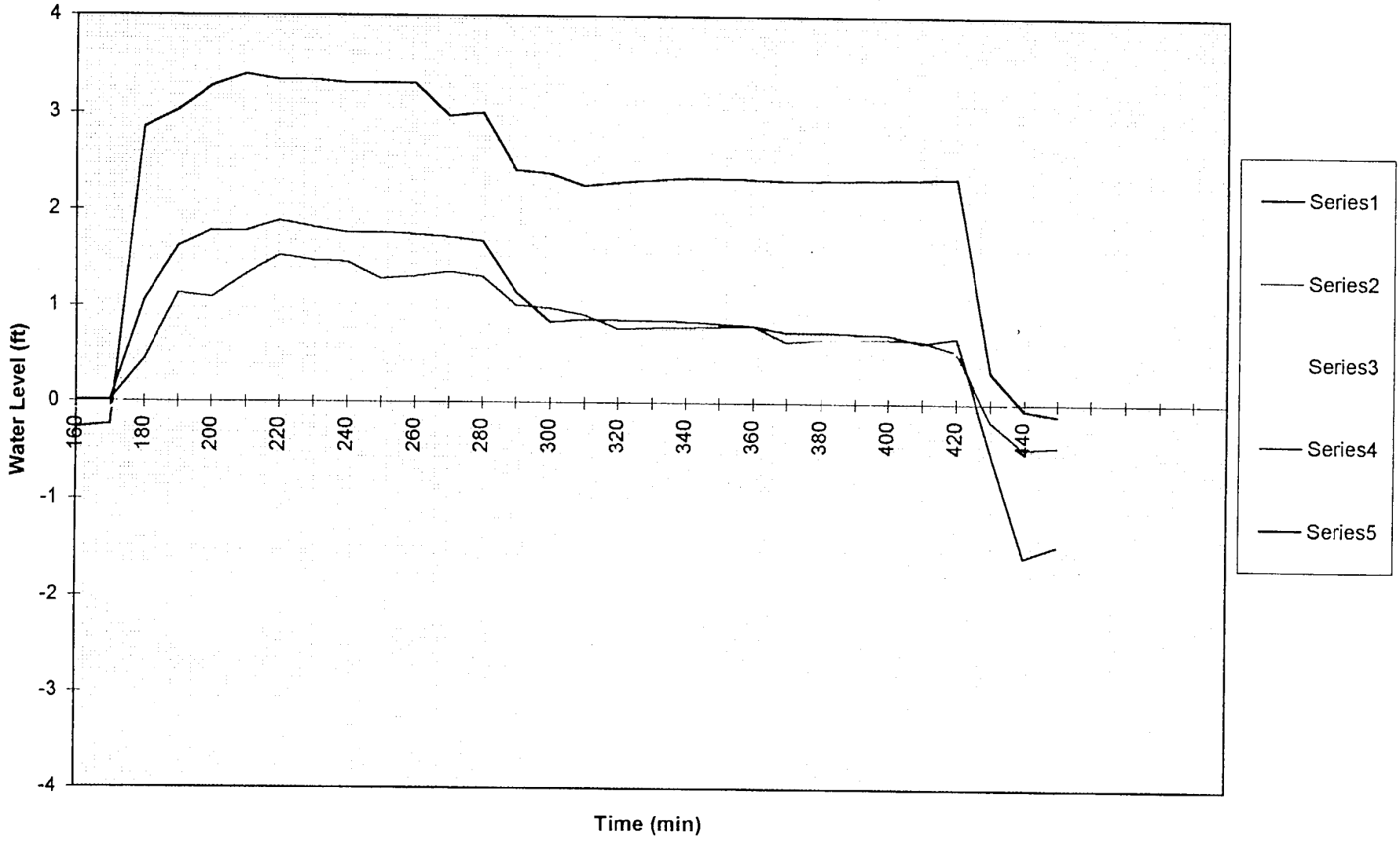


Table A2
Air Spaging Pilot Test Data
Parris Island, SC
Test #2 / Air Flow Rate = 1.8 scfm

Observed Water Levels in the Wells

Time min	unit 1	unit 2	unit 3	unit 4	unit 5
0	-6.143	-5.674	-15.671	-6.658	-3.686
5	-6.744	-5.553	-15.691	-6.653	-3.681
10	-6.749	-5.674	-15.616	-6.275	-3.625
15	-5.856	-5.709	-15.646	-6.421	-3.353
20	-6.007	-5.735	-15.686	-6.477	-3.61
25	-7.96	-6.885	-21	-6.714	-5.124
30	-8.51	-7.678	-22.106	-7.249	-6.37
35	-8.677	-7.673	-21.868	-7.698	-6.769
40	-8.778	-8.233	-21.727	-7.985	-6.88
45	-8.818	-7.799	-21.47	-8.223	-6.89
50	-8.828	-8.359	-21.238	-8.389	-6.869
55	-8.843	-8.187	-20.874	-8.551	-6.809
60	-8.843	-8.202	-20.708	-7.879	-6.713
65	-8.838	-8.152	-20.46	-8.021	-6.536
70	-8.833	-8.117	-20.309	-8.096	-6.587
75	-8.833	-8.091	-20.132	-8.107	-6.536
80	-8.828	-7.496	-19.941	-8.152	-6.446
85	-8.833	-7.9	-19.754	-7.461	-6.33
90	-8.828	-7.905	-19.628	-7.622	-6.123
95	-8.838	-7.874	-19.522	-7.673	-6.183
100	-8.838	-7.819	-19.396	-7.718	-6.138
105	-8.838	-7.789	-19.29	-7.758	-6.082
110	-8.858	-7.647	-18.957	-7.819	-6.022
115	-8.869	-7.642	-19.062	-7.304	-5.936
120	-8.874	-7.662	-18.967	-7.96	-5.336
125	-8.869	-7.678	-18.876	-8.036	-5.785
130	-8.858	-7.627	-18.719	-8.026	-5.759
135	-8.858	-7.587	-18.618	-8.021	-5.699
140	-8.848	-7.128	-18.482	-8.086	-5.613
145	-8.848	-7.324	-18.427	-7.309	-4.599
150	-8.848	-7.345	-18.346	-7.334	-5.346
155	-8.848	-7.35	-18.275	-7.38	-5.457
160	-8.848	-7.329	-18.215	-7.451	-5.426
165	-8.843	-7.299	-18.154	-7.491	-5.391
170	-8.838	-7.294	-18.089	-7.551	-5.346
175	-8.838	-7.128	-17.882	-7.587	-5.295
180	-8.838	-7.198	-17.952	-7.395	-4.503
185	-8.843	-7.203	-17.917	-7.466	-5.169
190	-8.838	-7.254	-17.877	-7.496	-5.189
195	-8.838	-7.188	-17.841	-7.562	-5.174
200	-8.843	-7.218	-17.776	-7.597	-5.144
205	-8.843	-6.724	-17.725	-7.632	-5.149
210	-8.843	-7.027	-17.639	-7.657	-5.068
215	-8.843	-7.062	-17.614	-7.38	-4.564
220	-8.838	-7.128	-17.604	-7.43	-4.972
225	-8.828	-7.148	-17.569	-7.481	-4.998
230	-8.848	-6.26	-17.543	-7.526	-5.023
235	-8.858	-6.87	-17.463	-7.122	-4.427
240	-8.869	-6.996	-17.443	-7.203	-4.811
245	-8.864	-7.017	-17.422	-7.319	-4.902
250	-8.864	-7.037	-17.407	-7.365	-4.892
255	-8.874	-7.052	-17.382	-7.425	-4.887
260	-8.879	-6.603	-17.367	-7.486	-4.866
265	-8.889	-6.774	-17.276	-6.905	-3.761
270	-8.081	-5.851	-13.865	-6.991	-3.56
275	-7.264	-4.589	-8.944	-6.936	-1.561
280	-7.032	-4.115	-7.43	-6.583	-0.012
285	-6.875	-4.029	-7.264	-6.532	-0.007
290	-6.784	-4.039	-7.289	-5.715	-0.038
295	-6.714	-4.085	-7.385	-5.538	-0.033
300	-6.668	-4.155	-8.107	-5.533	-0.038
305	-6.648	-4.216	-8.773	-5.533	-0.038
310	-6.633	-4.276	-9.383	-4.907	-0.038
315	-6.623	-4.342	-9.959	-4.927	-0.108
320	-6.613	-4.418	-10.494	-4.927	-0.361
325	-6.608	-4.488	-11.003	-4.937	-0.613

Actual Water Levels in the Wells

Time min	MW-1S	OB-1S	OB-2S	OB-2D
0	0	0	0	0
5	0.601	-0.121	-0.005	-0.005
10	0.606	0	-0.383	-0.061
15	-0.287	0.035	-0.237	-0.333
20	-0.136	0.061	-0.181	-0.076
25	1.817	1.211	0.056	1.438
30	2.367	2.004	0.591	2.684
35	2.534	1.999	1.04	3.083
40	2.635	2.559	1.327	3.194
45	2.675	2.125	1.565	3.204
50	2.685	2.685	1.731	3.183
55	2.7	2.513	1.893	3.123
60	2.7	2.528	1.221	3.027
65	2.695	2.478	1.363	2.85
70	2.69	2.443	1.438	2.901
75	2.69	2.417	1.449	2.85
80	2.685	1.822	1.494	2.76
85	2.69	2.226	0.803	2.644
90	2.685	2.231	0.964	2.437
95	2.695	2.2	1.015	2.497
100	2.695	2.145	1.06	2.452
105	2.695	2.115	1.1	2.396
110	2.715	1.973	1.161	2.336
115	2.726	1.968	0.646	2.25
120	2.731	1.988	1.302	1.65
125	2.726	2.004	1.378	2.099
130	2.715	1.953	1.368	2.073
135	2.715	1.913	1.363	2.013
140	2.705	1.454	1.428	1.927
145	2.705	1.65	0.651	0.913
150	2.705	1.671	0.676	1.66
155	2.705	1.676	0.722	1.771
160	2.705	1.655	0.793	1.74
165	2.7	1.625	0.833	1.705
170	2.695	1.62	0.893	1.66
175	2.695	1.454	0.929	1.609
180	2.695	1.524	0.737	0.817
185	2.7	1.529	0.808	1.483
190	2.695	1.58	0.838	1.503
195	2.695	1.514	0.904	1.488
200	2.7	1.544	0.939	1.458
205	2.7	1.05	0.974	1.463
210	2.7	1.353	0.999	1.382
215	2.7	1.388	0.722	0.878
220	2.695	1.454	0.772	1.286
225	2.685	1.474	0.823	1.312
230	2.705	0.586	0.868	1.337
235	2.715	1.196	0.464	0.741
240	2.726	1.322	0.545	1.125
245	2.721	1.343	0.661	1.216
250	2.721	1.363	0.707	1.206
255	2.731	1.378	0.767	1.201
260	2.736	0.929	0.828	1.18
265	2.746	1.1	0.247	0.075
270	1.938	0.177	0.333	-0.126
275	1.121	-1.085	0.278	-2.125
280	0.889	-1.559	-0.075	-3.674
285	0.732	-1.645	-0.126	-3.679
290	0.641	-1.635	-0.943	-3.648
295	0.571	-1.589	-1.12	-3.653
300	0.525	-1.519	-1.125	-3.648
305	0.505	-1.458	-1.125	-3.648
310	0.49	-1.398	-1.751	-3.648
315	0.48	-1.332	-1.731	-3.578
320	0.47	-1.256	-1.731	-3.325
325	0.465	-1.186	-1.721	-3.073

Due to mechanical/ electronic problem associated with the transducer data log, OB1-D is not presented in this table and the chart.

Figure A3
Air Sparging Pilot Test Well Data, Parris, Island, SC
Test #2 - Air Flow Rate = 1.8 scfm

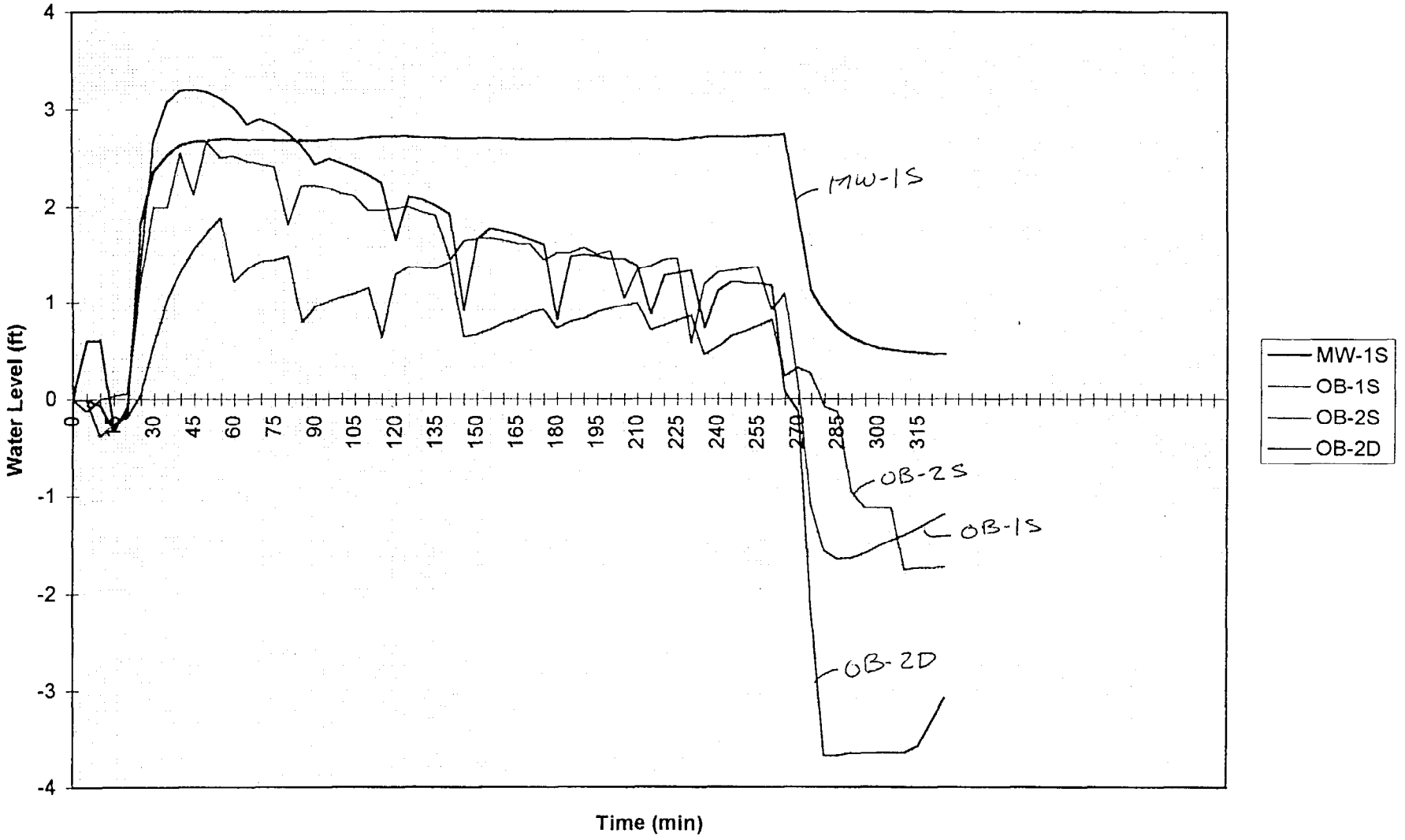


Table A3

AIR SPARGING PILOT TEST, WATER LEVELS

DRY CLEANER SITE, PARRIS ISLAND, SC

TEST #3/ Air Flow Rate = 2, 3, &4 scfms (As Noted)

	Observed Water Levels in the Wells								Actual Water Levels in the Wells			
Time min	Input 1	Input 2	Input 3	Input 4	Input 5		Air Flow scfm	Time min	MW-1S	OB-1S	OB-2S	OB-2D
0	-5.553	-6.154	*-15.641*	-6.497	-3.61		2	0	0	0	0	0
5	-5.568	-6.159	*-15.646*	-6.497	-3.63		2	5	0.015	0.005	0	0.02
10	-5.583	-6.159	*-15.646*	-6.497	-3.63		2	10	0.03	0.005	0	0.02
15	-6.022	-6.477	*-18.598*	-6.532	-4.089		2	15	0.469	0.323	0.035	0.479
20	-6.633	-7.92	*-21.899*	-6.749	-5.971		2	20	1.08	1.766	0.252	2.361
25	-6.951	-8.213	*0.053*	-6.956	-6.723		2	25	1.398	2.059	0.459	3.113
30	-6.991	-8.52	*0.179*	-7.067	-6.996		2	30	1.438	2.366	0.57	3.386
35	-6.996	-8.641	*0.189*	-7.223	-7.056		2	35	1.443	2.487	0.726	3.446
40	-7.006	-8.626	*0.113*	-7.385	-7.036		2	40	1.453	2.472	0.888	3.426
45	-7.022	-8.702	*0.088*	-7.562	-6.991		2	45	1.469	2.548	1.065	3.381
50	-7.032	-8.727	*0.083*	-7.869	-6.945		2	50	1.479	2.573	1.372	3.335
55	-7.042	-8.687	*0.078*	-8.061	-6.895		3	55	1.489	2.533	1.564	3.285
60	-7.052	-8.742	*0.078*	-8.157	-6.824		3	60	1.499	2.588	1.66	3.214
65	-7.057	-8.707	*0.078*	-8.223	-6.753		3	65	1.504	2.553	1.726	3.143
70	-7.067	-8.571	*0.068*	-8.228	-6.567		3	70	1.514	2.417	1.731	2.957
75	-7.072	-8.48	*0.068*	-8.218	-6.39		3	75	1.519	2.326	1.721	2.78
80	-7.087	-8.52	*0.063*	-8.243	-6.365		3	80	1.534	2.366	1.746	2.755
85	-7.339	-8.853	*0.037*	-8.308	-7.132		3	85	1.786	2.699	1.811	3.522
90	-7.44	-8.919	*0.012*	-8.566	-7.359		3	90	1.887	2.765	2.069	3.749
95	-7.496	-8.985	*-0.042*	-8.788	-7.47		3	95	1.943	2.831	2.291	3.86
100	-7.521	-8.647	*-0.204*	-8.904	-7.47		3	100	1.968	2.493	2.407	3.86
105	-7.541	-8.662	*-0.38*	-9.035	-7.399		3	105	1.988	2.508	2.538	3.789
110	-7.556	-8.692	*-0.481*	-9.171	-7.339		3	110	2.003	2.538	2.674	3.729
115	-7.562	-8.647	*-0.537*	-9.368	-7.273		3	115	2.009	2.493	2.871	3.663
120	-7.567	-8.641	*-0.567*	-9.504	-7.223		3	120	2.014	2.487	3.007	3.613
125	-7.577	-8.611	*-0.491*	-9.479	-7.203		3	125	2.024	2.457	2.982	3.593
130	-7.592	-8.53	*-0.507*	-9.424	-6.991		4	130	2.039	2.376	2.927	3.381
135	-7.607	-8.53	*-0.507*	-9.398	-6.986		4	135	2.054	2.376	2.901	3.376
140	-7.819	-9.02	*-0.517*	-9.575	-7.778		4	140	2.266	2.866	3.078	4.168
145	-7.925	-9.212	*-0.426*	-9.923	-8.297		4	145	2.372	3.058	3.426	4.687
150	-7.99	-9.287	*-0.436*	-10.166	-8.454		4	150	2.437	3.133	3.669	4.844
155	-7.996	-9.192	*-0.446*	-10.115	-8.197		4	155	2.443	3.038	3.618	4.587
160	-8.006	-9.065	*-0.466*	-10.176	-8.186		4	160	2.453	2.911	3.679	4.576
165	-8.021	-9.086	*-0.486*	-10.065	-7.929		4	165	2.468	2.932	3.568	4.319
170	-8.026	-9.081	*-0.507*	-10.085	-8.202		4	170	2.473	2.927	3.588	4.592
175	-8.046	-9.086	*-0.491*	-10.166	-8.252		4	175	2.493	2.932	3.669	4.642
180	-8.061	-9.055	*-0.496*	-10.166	-8.222		4	180	2.508	2.901	3.669	4.612
185	-8.081	-9.04	*-0.456*	-10.155	-8.171		4	185	2.528	2.886	3.658	4.561
190	-8.096	-9.045	*-0.542*	-10.135	-8.171		System Shut-	190	2.543	2.891	3.638	4.561
195	-8.102	-9.01	*-0.512*	-10.191	-8.232		down	195	2.549	2.856	3.694	4.622
200	-7.657	-6.89	*-0.446*	-9.06	-5.346			200	2.104	0.736	2.563	1.736
205	-6.704	-5.588	*-0.219*	-7.143	-2.071			205	1.151	-0.566	0.646	-1.539
210	-6.663	-5.038	*0.123*	-6.688	-0.285			210	1.11	-1.116	0.191	-3.325
215	-6.658	-4.741	*0.477*	-6.694	-0.063			215	1.105	-1.413	0.197	-3.547
220	-6.663	-4.544	*0.048*	-6.694	-0.063			220	1.11	-1.61	0.197	-3.547
225	-6.678	-4.392	*0.048*	-6.032	-0.058			225	1.125	-1.762	-0.465	-3.552
230	-6.688	-4.296	*0.048*	-5.442	-0.058			230	1.135	-1.858	-1.055	-3.552
235	-6.709	-4.271	*0.053*	-5.432	-0.058			235	1.156	-1.883	-1.065	-3.552
240	-6.724	-4.276	*0.058*	-4.746	-0.058			240	1.171	-1.878	-1.751	-3.552
245	-6.734	-4.296	*0.053*	-4.488	-0.058			245	1.181	-1.858	-2.009	-3.552
250	-6.744	-4.307	*0.058*	-4.508	-0.058			250	1.191	-1.847	-1.989	-3.552
255	-6.759	-4.322	*0.063*	-4.534	-0.053			255	1.206	-1.832	-1.963	-3.557
260	-6.774	-4.367	*0.058*	-4.559	-0.058			260	1.221	-1.787	-1.938	-3.552
265	-6.779	-4.418	*0.063*	-4.579	-0.053			265	1.226	-1.736	-1.918	-3.557
270	-6.789	-4.473	*0.058*	-3.953	-0.27			270	1.236	-1.681	-2.544	-3.34
275	-6.794	-4.539	*0.058*	-3.984	-0.477			275	1.241	-1.615	-2.513	-3.133

Due to mechanical/ electronic problem associated with the transducer data log, OB1-D is not presented in this table and the chart

Figure A4
Air Sparging Pilot Test Well Data, Parris, Island, SC
Test #3- Air Flow Rate = As indicated

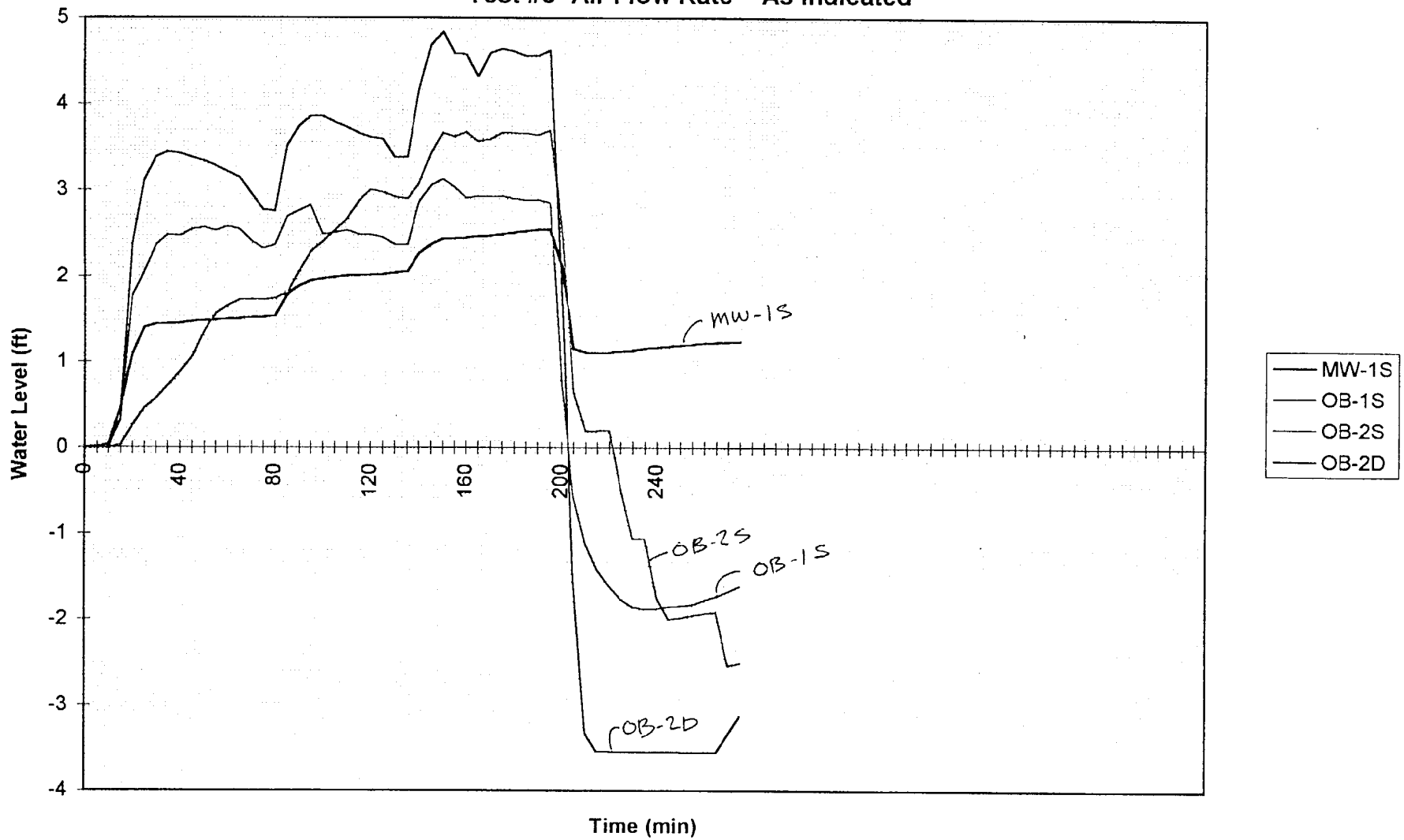
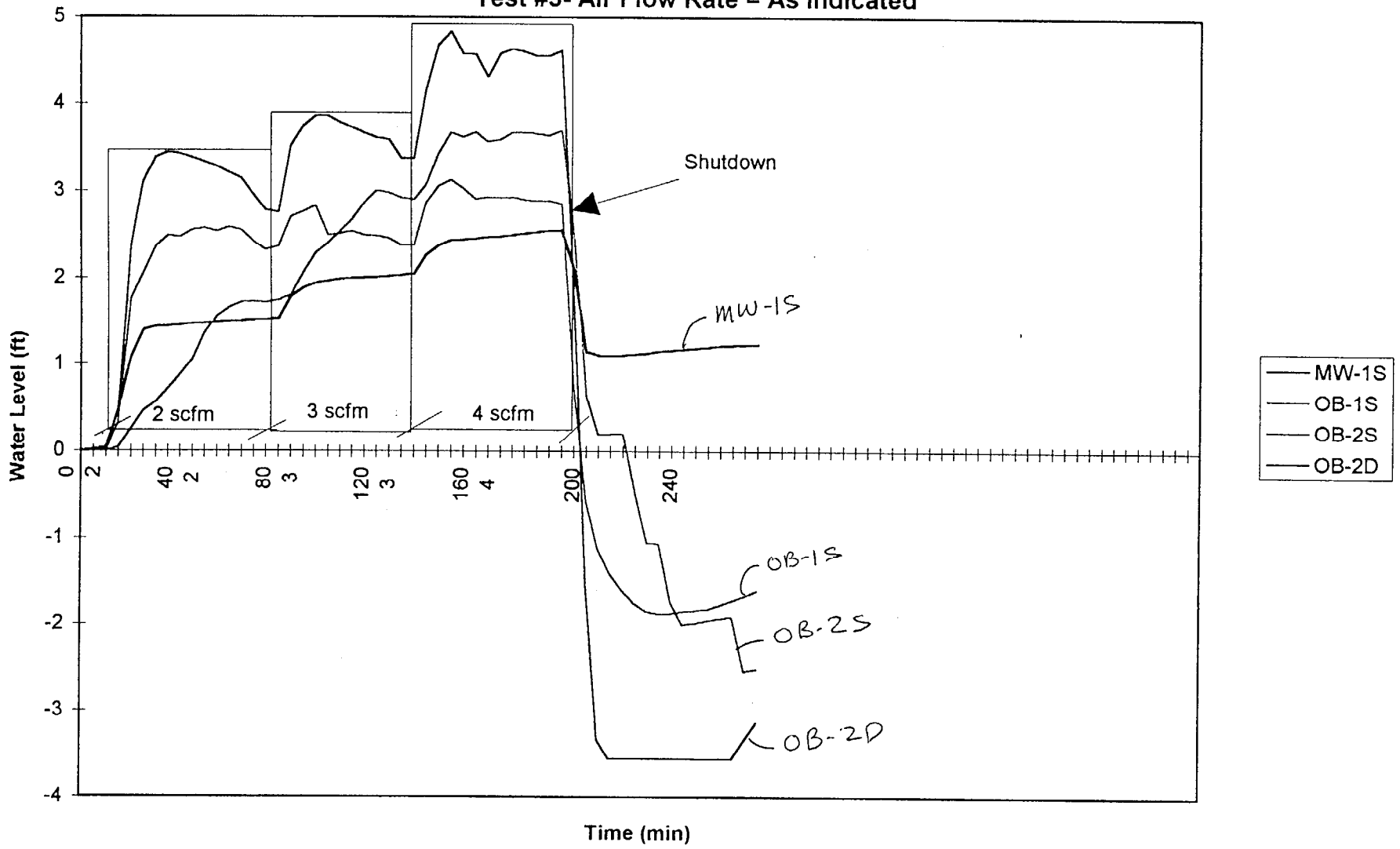


Figure A5
Air Sparging Pilot Test Well Data, Parris, Island, SC
Test #3- Air Flow Rate = As indicated



APPENDIX B

Table B1

Air Sparging Pilot Test

Parris Island, SC

Dissolved Oxygen Levels mg/L

Date: December 13,1996 | Test #1 | Airflow Rate 3 scfm

Time hrs	Time min	OB1-S	OB1-D	OB2-S	OB1-D
11:00	0				
11:05	5		0.75		
11:10	10				0.95
11:15	15	3.20			
11:20	20				
11:25	25			1.09	
11:30	30				
11:35	35				
11:40	40				
11:45	45				
11:50	50				
11:55	55				
12:00	60				
12:05	65				
12:10	70				
12:15	75				
12:20	80				
12:25	85				
12:30	90				
12:35	95				
12:40	100				
12:45	105				
12:50	110				
12:55	115				
13:00	120				
13:05	125				
13:10	130		1.00		
13:15	135				
13:20	140	2.45		0.66	
13:25	145				1.15
13:30	150				
13:35	155				
13:40	160				
13:45	165				
13:50	170				
13:55	175				1.50
14:00	180			0.22	
14:05	185				
14:10	190				
14:15	195		1.32		
14:20	200				
14:25	205				
14:30	210				
14:35	215				
14:40	220				
14:45	225				
14:50	230				
14:55	235			0.3	
15:00	240				
15:05	245	2.35			0.88
15:10	250				
15:15	255				
15:20	260				
15:25	265				
15:30	270				
15:35	275				
15:40	280				
15:45	285				
15:50	290				
15:55	295			0.75	
16:00	300				0.8
16:05	305	3.50			
16:10	310				
16:15	315		1.58		
16:20	320				
16:25	325				
16:30	330				
16:35	335				
16:40	340				
16:45	345				
16:50	350			1.00	
16:55	355	4.15			1.10
17:00	360		3.90		

Figure B1
Air Sparging Pilot Test, Parris Island, SC
Test #1; Air Flow Rate 3 scfm

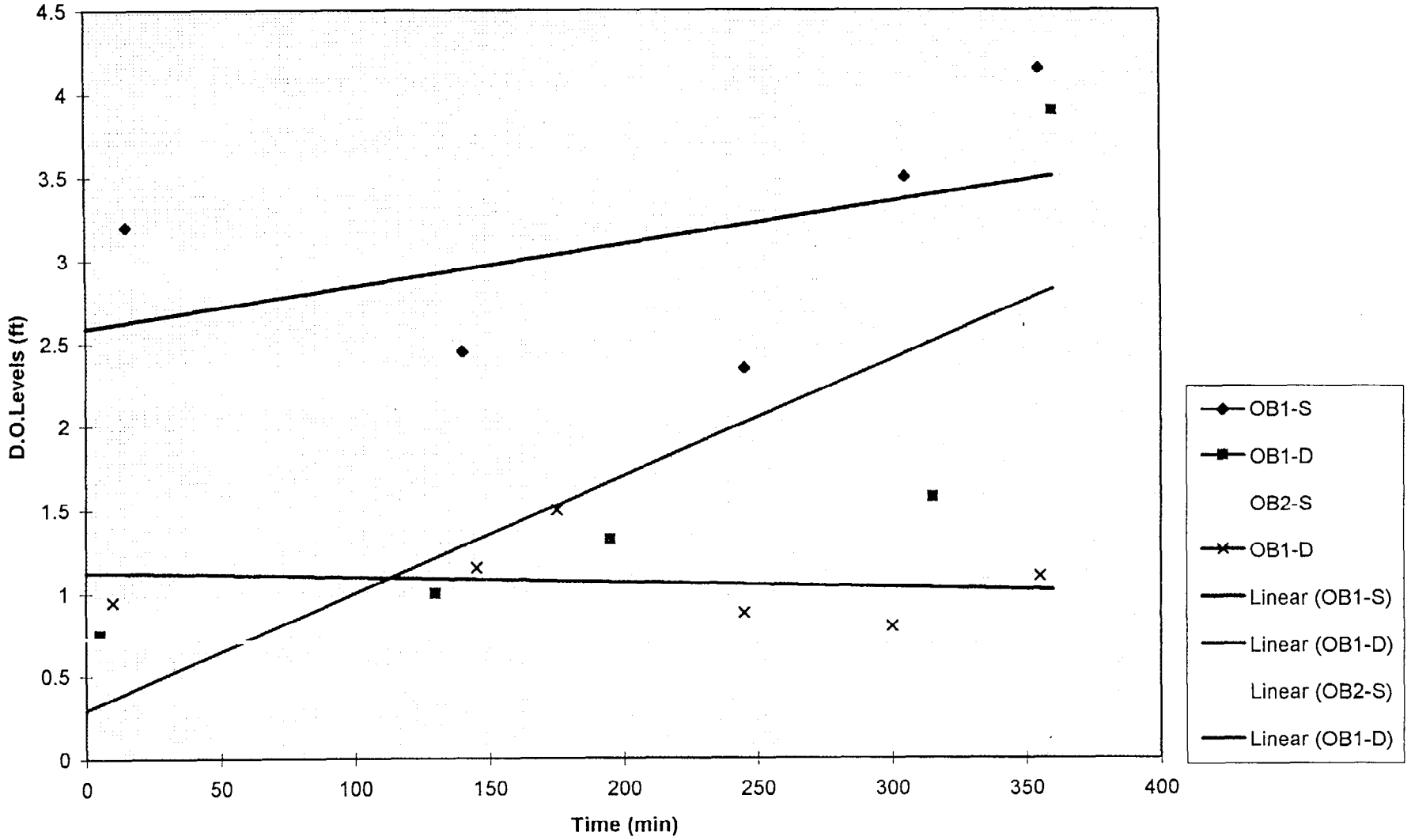


Table B2

Air Sparging Pilot Test

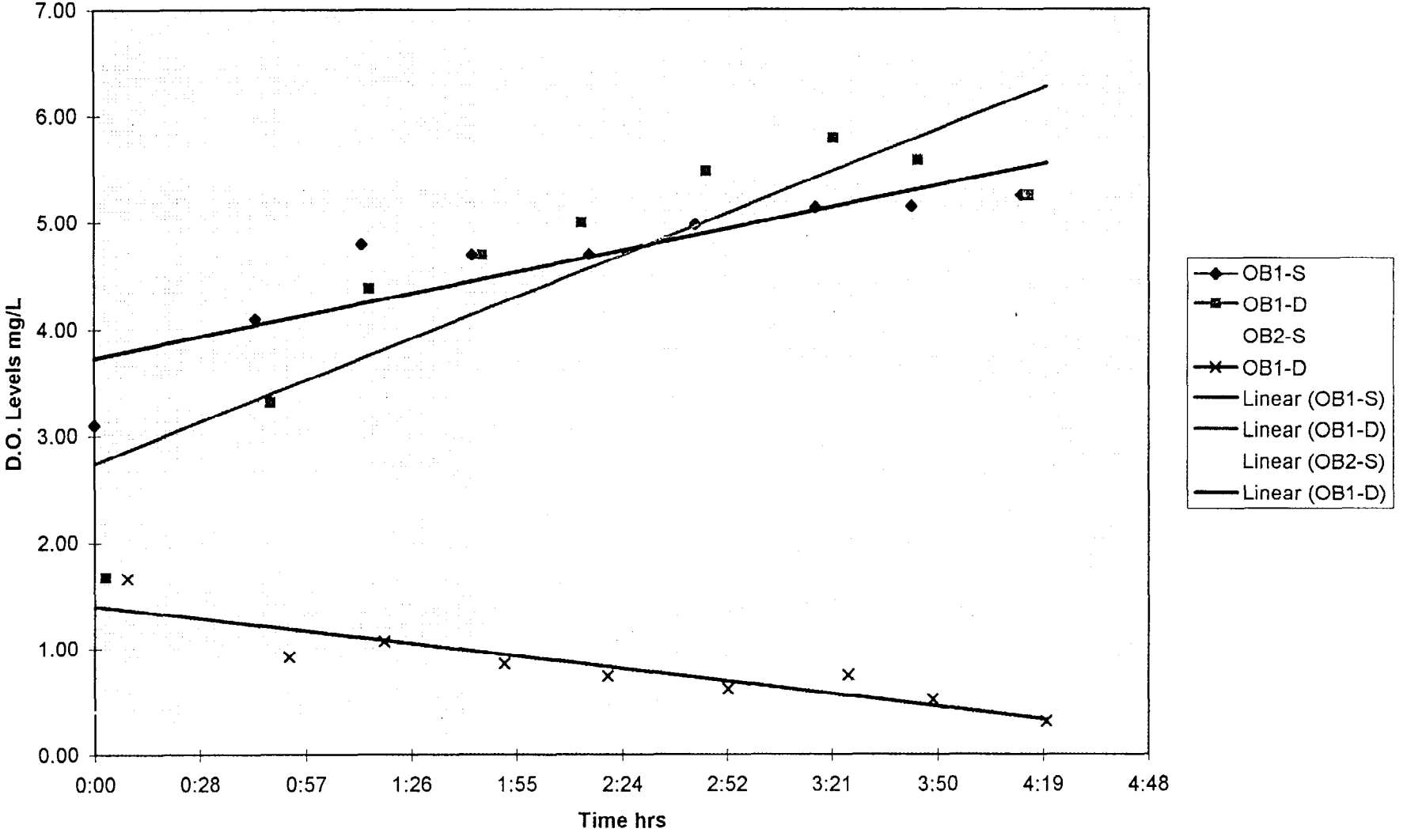
Parris Island, SC

Dissolved Oxygen Levels mg/L

Date: December 14, 1996 | Test #2 | Airflow Rate 1.8 scf

Time hrs	Time hrs	OB1-S	OB1-D	OB2-S	OB1-D
9:47	0:00	3.10			
9:50	0:03		1.68		
9:53	0:06			0.73	
9:56	0:09				1.67
10:31	0:44	4.10			
10:35	0:48		3.32		
10:37	0:50			0.52	
10:40	0:53				0.93
11:00	1:13	4.80			
11:02	1:15		4.39		
11:05	1:18			0.92	
11:06	1:19				1.08
11:30	1:43	4.70			
11:33	1:46		4.70		
11:36	1:49			1.11	
11:39	1:52				0.87
12:00	2:13		5.00		
12:02	2:15	4.70			
12:05	2:18			1.11	
12:07	2:20				0.75
12:31	2:44	4.98			
12:34	2:47		5.48		
12:36	2:49			1.43	
12:40	2:53				0.63
13:04	3:17	5.14			
13:09	3:22		5.79		
13:10	3:23			1.90	
13:13	3:26				0.76
13:30	3:43	5.15			
13:32	3:45		5.58		
13:34	3:47			1.94	
13:36	3:49				0.53
14:00	4:13	5.25			
14:02	4:15		5.25		
14:05	4:18			2.14	
14:07	4:20				0.33

Figure B2
Air Sparging Pilot Test, Parris Island, SC
Test # 2; Air Flow Rate 1.8 scfm



bhlg

BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		Borehole No.: 193-1-MW
Project Number: 22567-145	Elevation: 7.81 ft msl	
Location: Bld 193, Dry Cleaners	Date Started: 12/11/96	Date Completed: 12/11/96
Driller: Brian Cornell	Total Depth (ft): 20.0	
Equipment: Mobile B-57	Depth to Bedrock (ft): None	
Drilling Method: Hollow Stem Auger	Hole Diameter (in): 10	
Drilling Fluid: None	Depth to Water (ft): 3.0	
Completion: Completed as Monitoring Well See Well Construction Logs for details	Logged By: P. Linley	Posthole to 4ft BGL

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-5ft: SAND: *(SP)*, gry blk (N2) to lt brn gry (5YR6/1) to gry org (10YR7/4) to dk yel org (10YR6/6), fine, unconsld, mod well sort, subang to subrd, moist to v moist w/depth.	1	SS	80		2/3/3/5
		2	SS	70		5/6/5/4
5	5-6ft: CLAYEY SAND: *(SC)*, med lt gry (N6) v fine to fine, mod sort, unconsld, subang to subrd, v moist.	3	SS	90		3/2/2/4
	6-8ft: SAND: *(SP)*, lt gry (N7) to gry org (10YR7/4) to dk yel org (10YR6/6) to lt brn (5YR5/6) to med lt gry (N6), fine, mod well sort, unconsld, subang to subrd, wet at 7.5ft.	4	SS	100		5/6/3/2
		5	SS	100		2/2/1/2
10	8ft: SANDY CLAY: *(CL)*, med gry (N5), v fine to fine, unconsld, mod well sort, subang to subrd, v moist to wet.	6	SS	100		6/11/5/3
	8-10ft: CLAYEY SAND: *(SC)*, dk yel org (10YR6/6) to pale yel brn (10YR6/2) to med lt gry (N6), v fine to fine, unconsld, mod poor sort, subang to subrd, v moist to wet, @ 8.5-9ft fine sand lense.	7	SS	100		2/1/2/1
15		8	SS	100		2/2/1/1
	10-15.5ft: SAND: *(SP)*, dk yel org (10YR6/6) to gry org (10YR 7/4) to lt gry (N7) to v lt gry (N8), fine, unconsld, mod well sort, subang to subrd, wet @ 11.5ft, minor silt frac 10%.	9	SS	100		2/1/1/2
	15.5-17.7ft: SILTY SAND: *(SM)*, med dk gry (N4) to v pale org (10YR8/2) to gry org (10YR7/4) to med dk gry (N4), v fine to fine, unconsld, mod sort, subang to subrd, v moist.	10	SS	100		3/2/4/2
20	17.7-18ft: SANDY SILTY CLAY: *(CL)*					
	18-19ft: SILTY CLAY: *(CL)*, pale yel org (10YR6/2), v fine to fine, mod sort, unconsld, subang to subrd, v moist.					
25	19-19.3ft: CLAYEY SILTY SAND: *(SM/SC)*					
	19.3-19.7ft: SAND: *(SP)*, pink gry (5 YR8/1) to v lt gry (N8)					
	19.7-20ft: SANDY SILTY CLAY: *(CL)*, med dk gry (N4)					
	20ft: PEAT: *(Pt)*, dusky yel brn (10YR2/2) to brn blk (5YR2/1)					
30						

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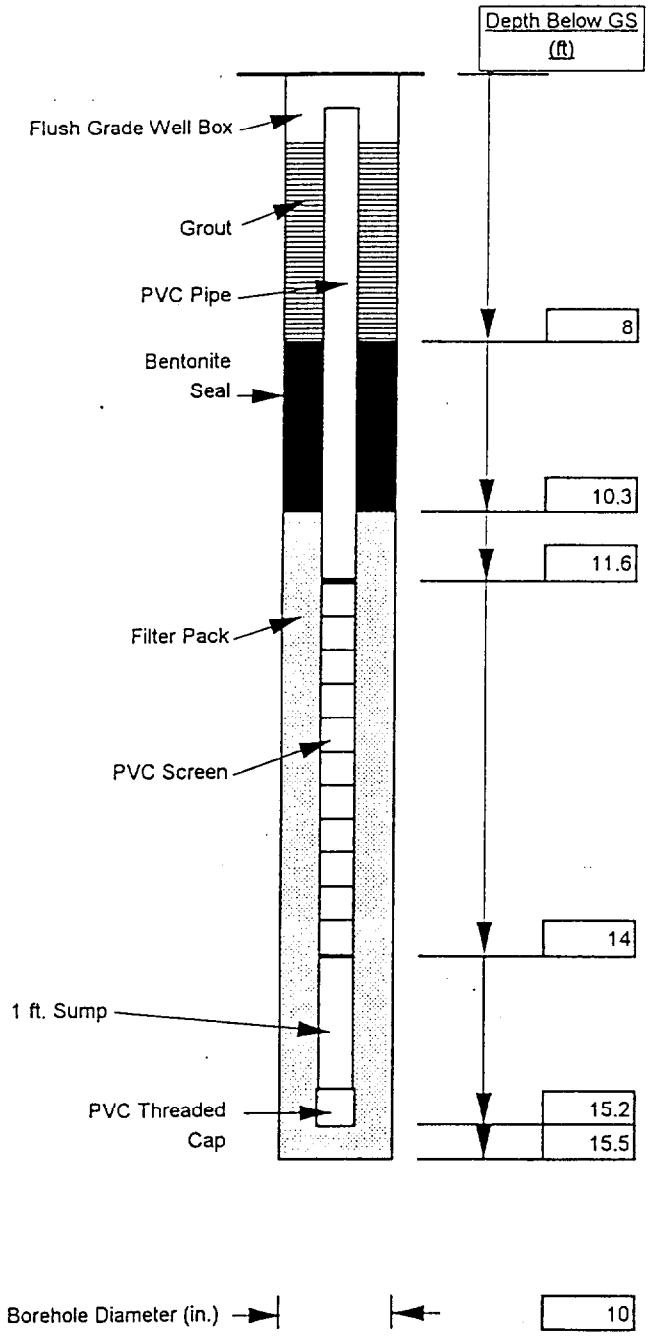
WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N 187454.710
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96		E 2099308.355
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	12.3

Backfill

Type	Grout Seal
Length (ft)	8
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2.3
Placement	Pour

Filter Pack

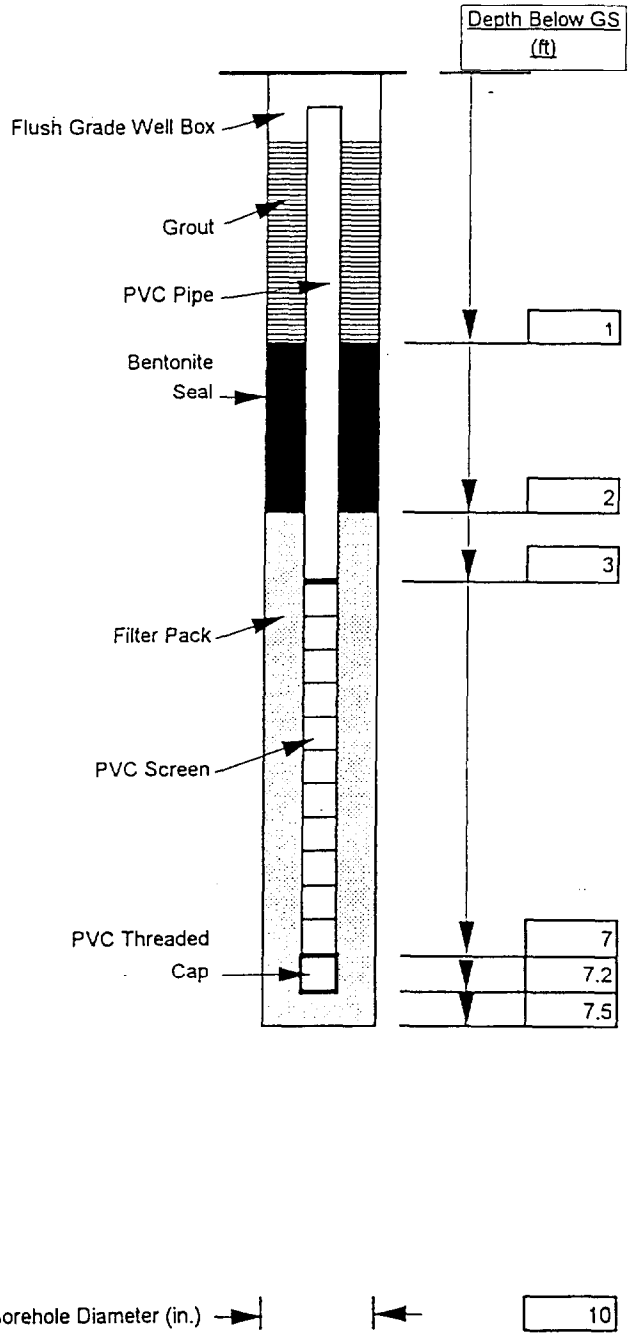
Type	20/30
Length (ft)	5.2
Placement	Pour
Amount Placed	162.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	2.4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N 187455.597
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96		E 2099298.879
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	325 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

bhlg

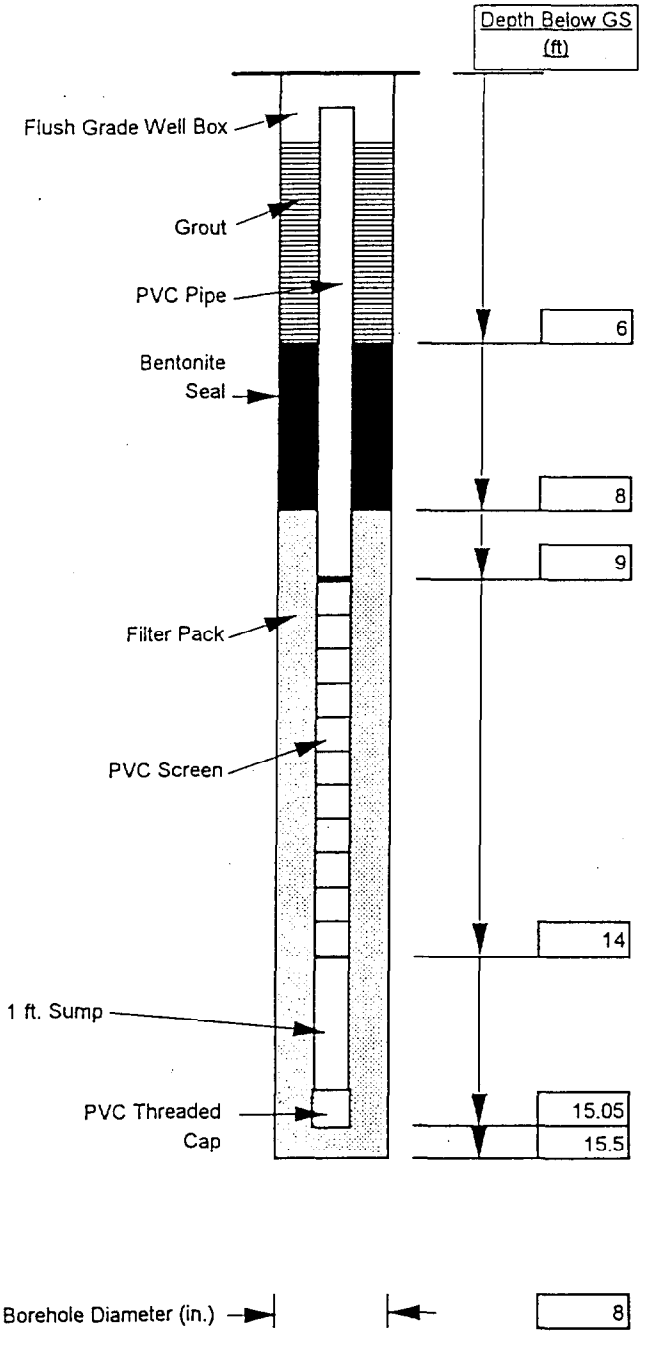
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		Borehole No.: 193-2-MW
Project Number: 22567-145	Elevation: 7.45 ft msl	
Location: Bldg 193, Dry Cleaners	Date Started: 12/12/96	Date Completed: 12/12/96
Driller: Brian Cornell	Total Depth (ft): 18.0	
Equipment: Mobile B-57	Depth to Bedrock (ft): None	
Drilling Method: Hollow Stem Auger	Hole Diameter (in): 8	
Drilling Fluid: None	Depth to Water (ft): 3.0	
Completion: Completed as Monitoring Well See Well Construction Logs for details	Logged By: P. Linley	Posthole to 4ft BGL

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-7ft: SAND: *(SP)*, pale yel brn (10YR6/2) to dk gry (N3) to brn gry (5YR4/1) to lt brn gry (5YR6/1) to dk yel org (10YR6/6) fine, unconsld, mod well sort, subang to subrd, moist to v moist, wet at 6ft.	1	SS	40		3/4
5		2	SS	90		9/8/6/7
	7-7.8ft: CLAYEY SAND: *(SC)*, lt gry (N7), v fine to fine, mod sort, subang to subrd, unconsld, wet.	3	SS	100		4/3/3/3
	7.8-15.3ft: SAND: *(SP)*, dk yel org (10YR6/6) to med lt gry (N6) to v lt gry (N8) to pale brn (5YR5/2) to med dk gry (N4) to dk gry (N3), fine, mod sort, subang to subrd, unconsld, wet to saturated, minor silt frac	4	SS	100		2/3/6/4
10		5	SS	100		4/3/3/2
		6	SS	100		3/3/3/2
15		7	SS	100		2/2/2/1
	15.3-18ft: SILTY SAND: *(SM)*, med dk gry (N4) to dk gry (N3) to pale brn (5YR5/2) to pale yel brn (10YR6/2) @ 17ft lt gry (N7) at 17.6ft med dk gry (N4) to dk gry (N3) - clay frac increased to 20%, saturated, note organic matter (wood & roots) at	8	SS	100		1/2/3/3
20	17.8ft: PEAT: *(Pt)*, dusky yel brn (10YR2/2) to brn blk (5YR2/1)					
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/14/96	Coordinates:	N 187341.197
Drilling Equipment:	Mobile B-57	Date Completed:	12/14/96		E 2099201.966
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.23 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

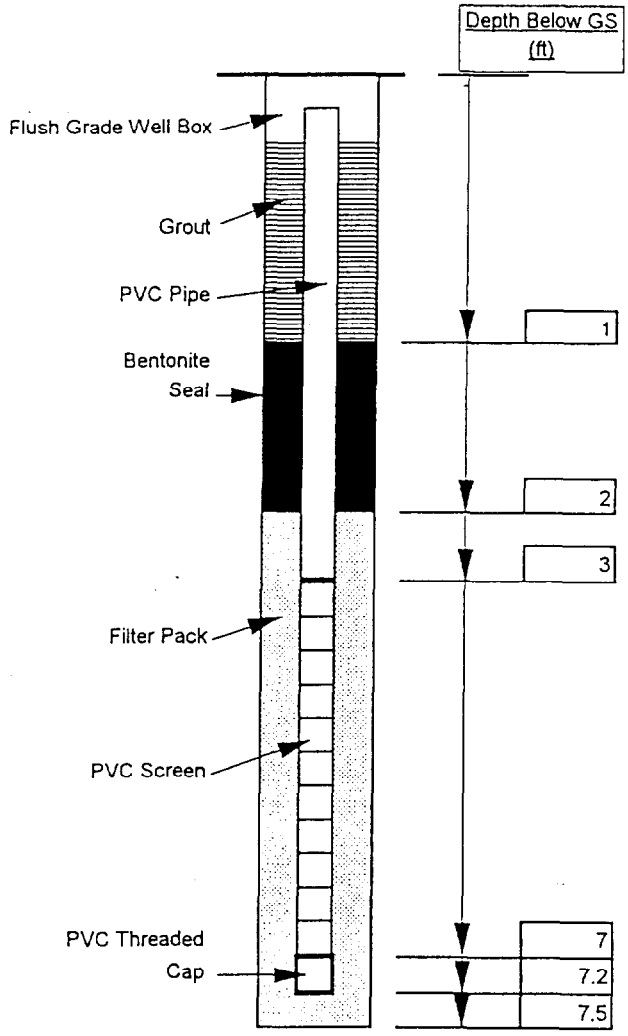
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/14/96	Coordinates:	N 187345.032
Drilling Equipment:	Mobile B-57	Date Completed:	12/14/96		E 2099203.731
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.11 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	5

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

Borehole Diameter (in.) 8

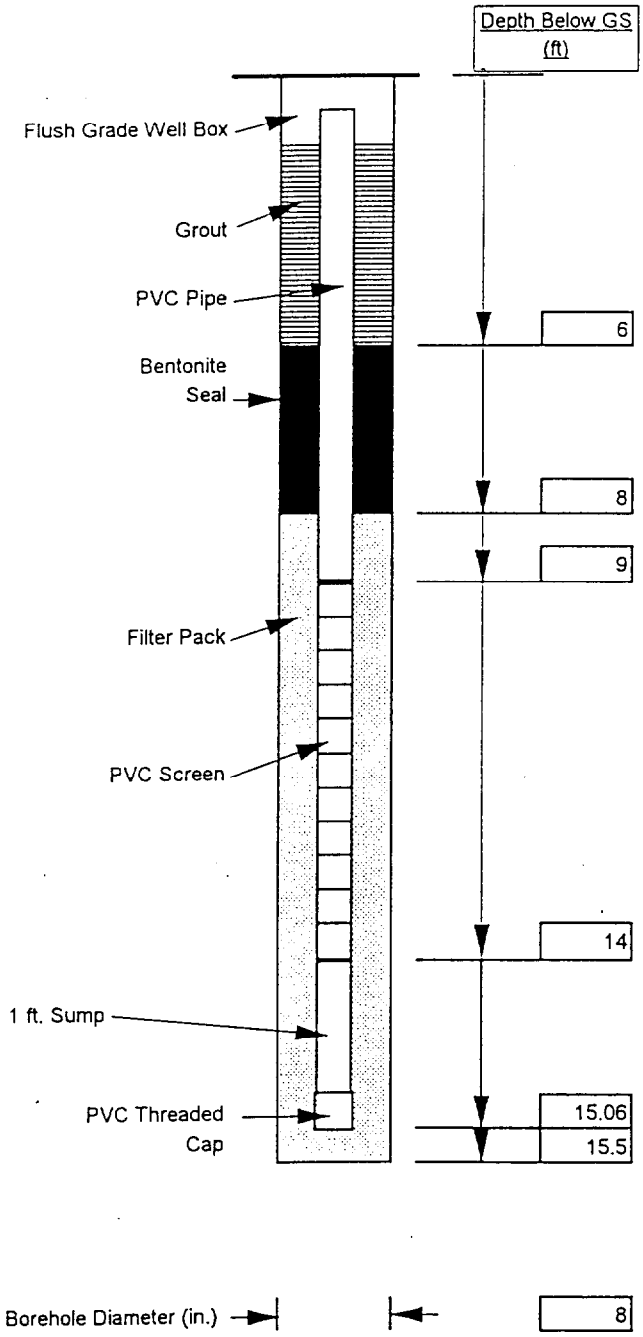
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-3-MW*
Project Number: 22567-145	*Elevation:* 7.78 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/12/96*	*Date Completed: 12/12/96*
Driller: Brian Cornell	*Total Depth (ft): 18.0*	
Equipment: Moblie B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 8*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	*Posthole to 4ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-7.3ft: SAND: *(SP)*, gry blk (N2) to brn gry (5YR4/1) to med lt gry (N6) to med dk gry (N4), fine, unconsld, mod well sort, subang to subrd, v lt gry (N8), wet at 3ft, minor silt frac 10%	1	SS	25		1/5
		2	SS	75		4/4/4/5
5		3	SS	100		2/1/0/1
	7.3-8ft: SILTY CLAY: *(CL)*, med gry (N5), v fine, unconsld, mod well sort, subang to subrd, wet.	4	SS	100		1/0/2/7
	8-10ft: SILTY CLAY/SAND: *(SM)*, lt gry (N6), v fine, unconsld, mod sort, subang to subrd, wet.	5	SS	100		5/14/23/25
10	10-17.8ft: SAND: *(SP)*, pale yel brn (10YR6/2) to mod yel brn (10YR5/4) to pale brn (5YR5/2) to lt gry (N7) to v lt gry (N8) to lt olive gry (5Y5/2) to dk yel org (10YR6/6) to lt brn (5YR5/6) to white (N9) to med dk gry (N4) to dk gry (N3), fine, unconsld, mod well sort, subang to subrd, wet, silt frac 10%.	6	SS	100		10/4/5/5
		7	SS	100		3/3/2/2
15	10.6-10.7ft SILTY CLAY: lt gry (N7) lense.	8	SS	100		2/1/3/7
	17.8-18ft: SILTY CLAY: *(CL)*:, dk gry (N3).note ogranic matter (peat) w/in sample, v fine, semiconsld, mod sort, wet.					
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-3-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187258.713
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099239.820
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

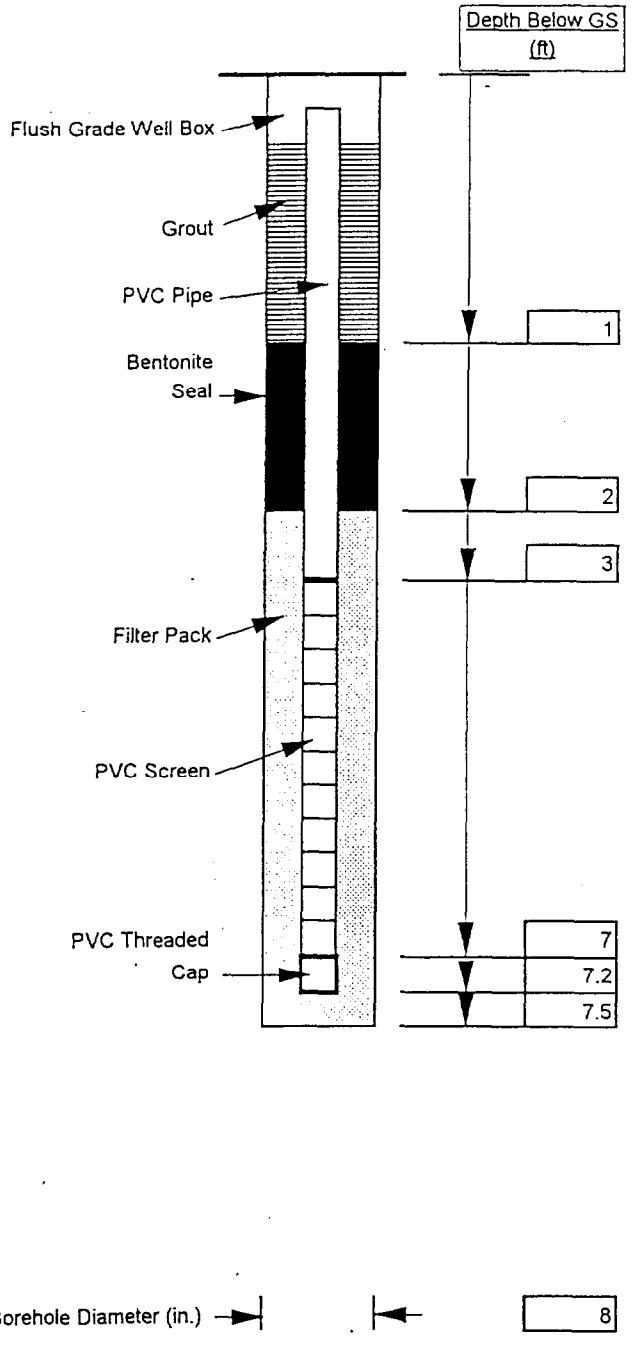
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-3-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187257.657
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099244.001
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4.7

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

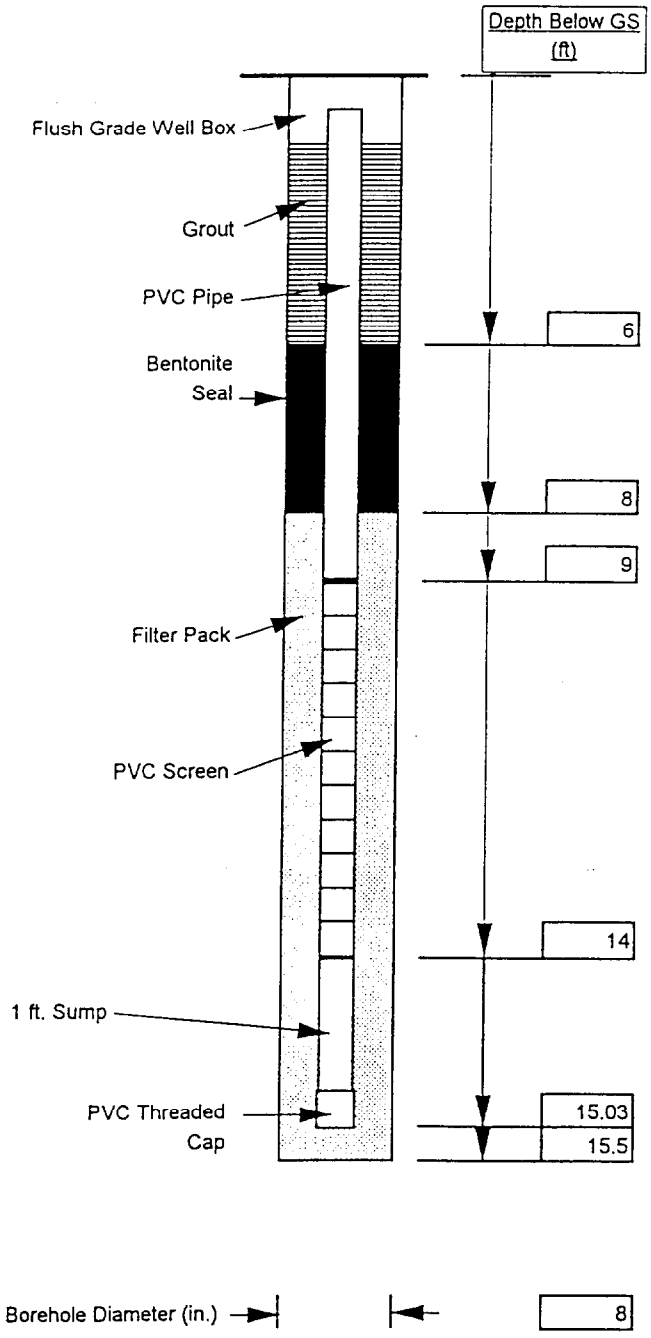
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-4-MW*
Project Number: 22567-145	*Elevation:* 7.14 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/12/96*	*Date Completed: 12/12/96*
Driller: Brian Cornell	*Total Depth (ft): 18.0*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 8*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	*Posthole to 4ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-7.2ft: SAND: *(SP)*, gry blk (N2) to med lt gry (N6) to dk yel org (10YR6/6) to brn gry (5YR4/1) to lt brn (5YR5/6), fine, mod well sort, unconsld, subang to subrd, wet at 3ft, silt frac 15%.					
		1	SS	50		2/5
5		2	SS	70		2/2/3/6
	7.2-7.9ft: SILTY CLAY: *(CL)*, lt gry (N7), v fine to fine, mod sort, unconsld, subang to subrd, wet.	3	SS	70		5/1/1/2
	7.9-17.2ft: SAND: *(SP)*, lt gry (N7) to v lt gry (N8) to white (N9) to med gry (N5) to gry org (10YR7/4) to pale yel brn (10YR6/2) to med dk gry (N4) to dk gry (N3), fine, unconsld, mod well sort, subang to subrd, silt frac 10-15%, wet to saturated	4	SS	60		5/7/11/15
10		5	SS	75		5/8/7/6
		6	SS	100		1/2/2/3
15		7	SS	100		1/2/1/2
	17.2-18ft: CLAY: *(CL)*, med dk gry (N4) to dk gry (N3), v fine semiconsld, mod well sort, v moist to wet.	8	SS	100		1/3/4/6
	17.4ft: PEAT: *(Pt)*, dusky yel brn (10YR2/2) to brn blk (5YR2/1)					
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-MW-4D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/12/96	Coordinates:	N 187149.280
Drilling Equipment:	Mobile B-57	Date Completed:	12/12/96		E 2099253.080
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	6.93 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

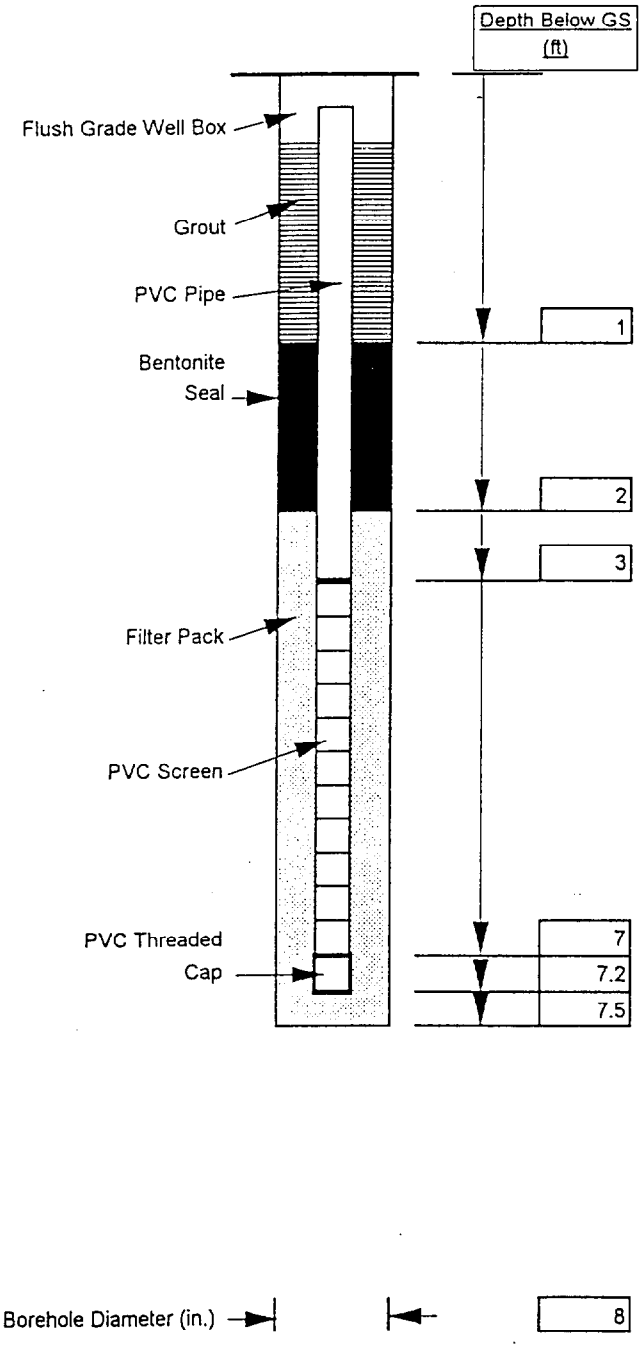
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-4-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/12/96	Coordinates:	N 187150.910
Drilling Equipment:	Mobile B-57	Date Completed:	12/12/96		E 2099249.096
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	6.98 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4.7

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	162.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

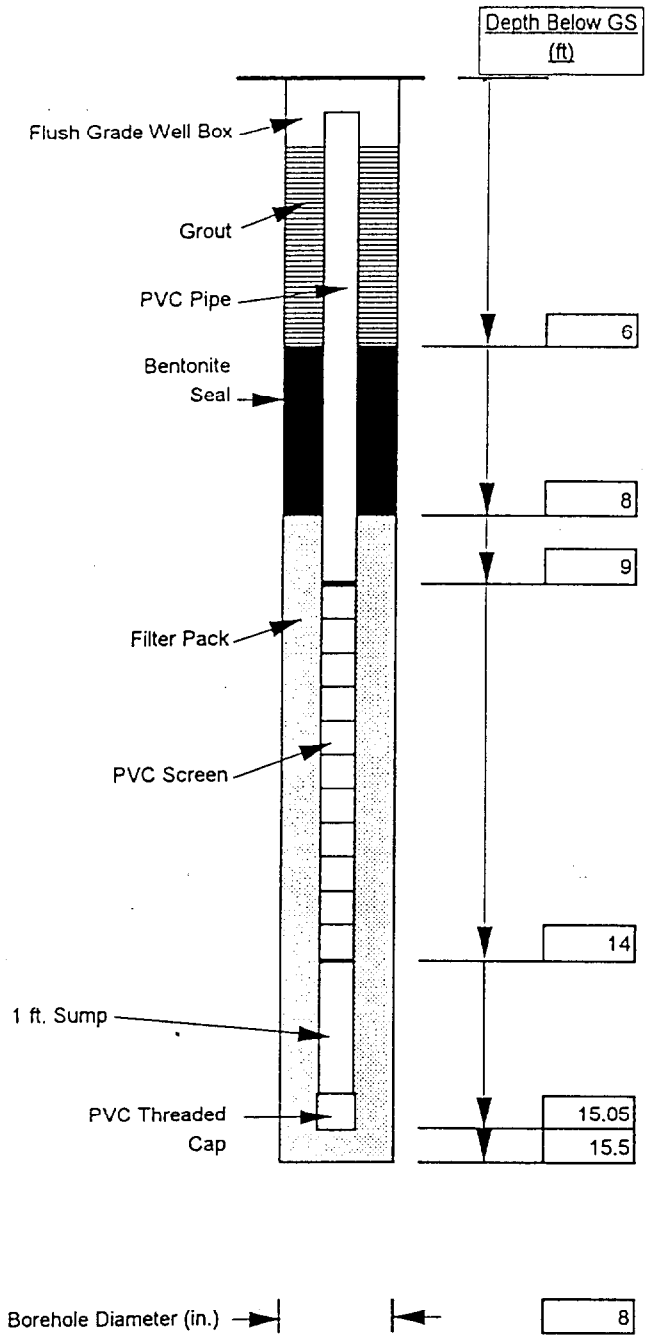
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-5-MW*
Project Number: 22567-145	*Elevation:* 8.64 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/13/96*	*Date Completed: 12/13/96*
Driller: Brian Cornell	*Total Depth (ft): 18.0*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 8*	
Drilling Fluid: None	*Depth to Water (ft): 4.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	*Posthole to 4ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-12ft: SAND: *(SP)*, pale brn (5YR5/2) to gry blk (N2) to lt brn gry (5YR6/1) to v lt gry (N8) to lt gry (N7) to med lt gry (N6), fine, unconsld, mod well sort, subang to subrd, wet at 3ft, silt frac 10-15%.	1	SS	60		2/1/4/5
5		2	SS	80		5/5/7/9
		3	SS	95		8/8/4/3
10		4	SS	100		1/2/1/1
	12ft: CLAYEY SILT: *(ML)*, dk gry (N3), v fine, unconsld, mod sort, subang to subrd, wet.	5	SS	100		2/2/4/4
	12-17.8ft: SAND: *(SP)*, lt brn gry (5YR6/1) to v lt gry (N8), fine unconsld, mod sort, subang to subrd, wet, silt and clay frac	6	SS	100		2/2/2/2
15	increasing w/depth, 13.5-14ft dk gry (N3).	7	SS	100		2/2/2/4
	17.8-18ft: PEAT: *(Pt)*, dusky brn (5YR2/2)					
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-5-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187187.346
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099376.763
Drilling Method:	HSA	Depth to Water:	4ft bgl		
Drilling Fluid:	None	Elevation:	8.26 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

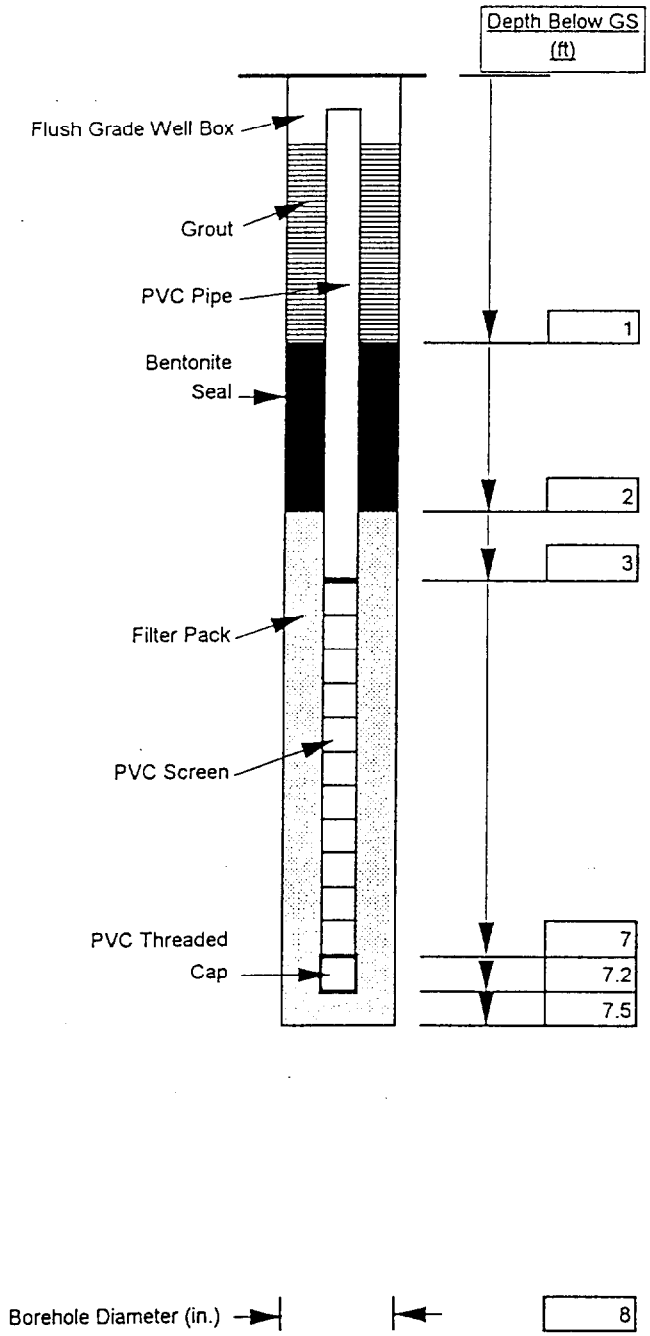
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	200 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-5-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187192.220
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099377.309
Drilling Method:	HSA	Depth to Water:	4ft bgl		
Drilling Fluid:	None	Elevation:	8.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4.7

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

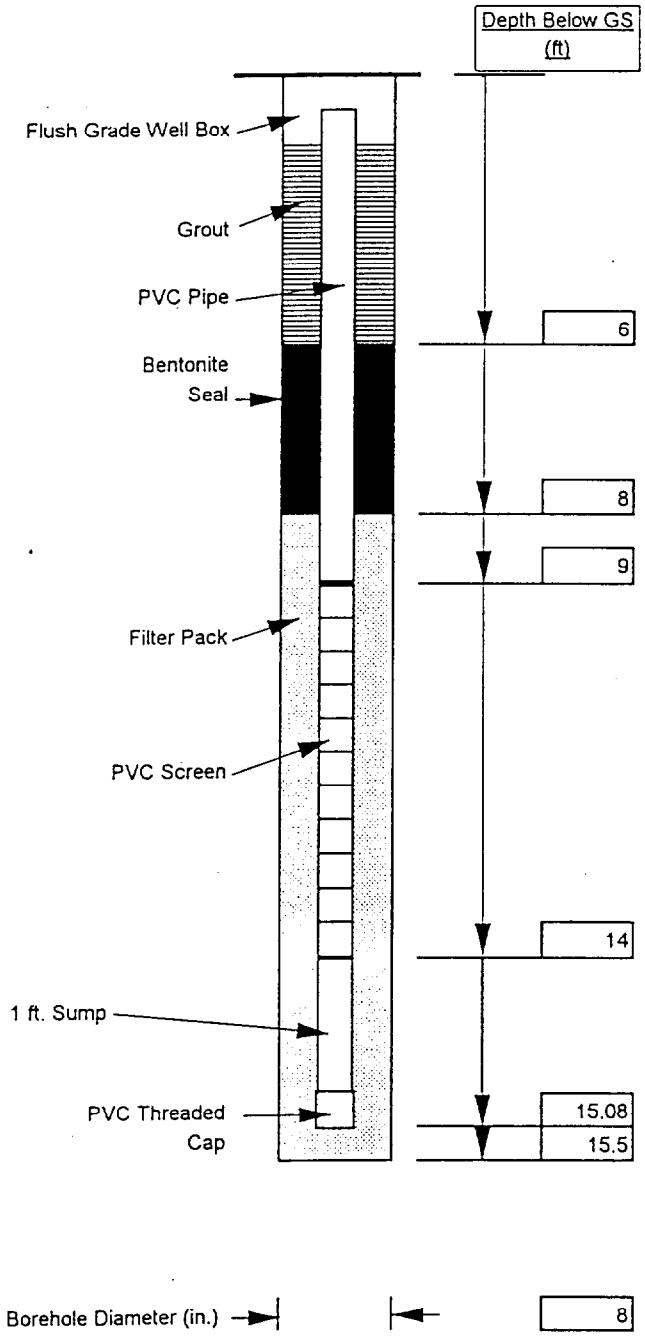
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-6-MW*
Project Number: 22567-145	*Elevation:* 7.76 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/16/96*	*Date Completed: 12/16/96*
Driller: Brian Cornell	*Total Depth (ft): 15.5*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 8*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	*Posthole 1ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-4.2ft SAND: *(SP)*, Fill/slag/cinders; dusky yel brn (10YR2/2) to pale yel brn (10YR6/2) to olive gry (5Y4/1), fine, unconsld, mod well sort, subang to subrd, wet at 3ft.	1	SS	75		Split spoon from 1-7ft analytical sample (1-3ft bgl)
	4.2-5ft: CLAYEY SAND: *(SC)*, med gry (N5), v fine to fine, mod sort, unconsld, subang to subrd, saturated, silt frac 15%.	2	SS	100		N/A
5	5-15.5ft: SAND: *(SP)*, grn gry (5G6/1) to dk yel brn (10YR6/6) to med lt gry (N6), to lt gry (N7), fine, unconsld, mod sort, sub-ang to subrd, saturated, silt frac 10-15%; 8ft lt olive gry (5Y5/2) 12ft cuttings soupy; 15ft lt olive gry (5Y6/1) to med gry (N5).	3	SS	65		8/8/8/6 analytical sample (5-7ft bgl)
10						
15						
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-6-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187277.268
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099296.248
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.52 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

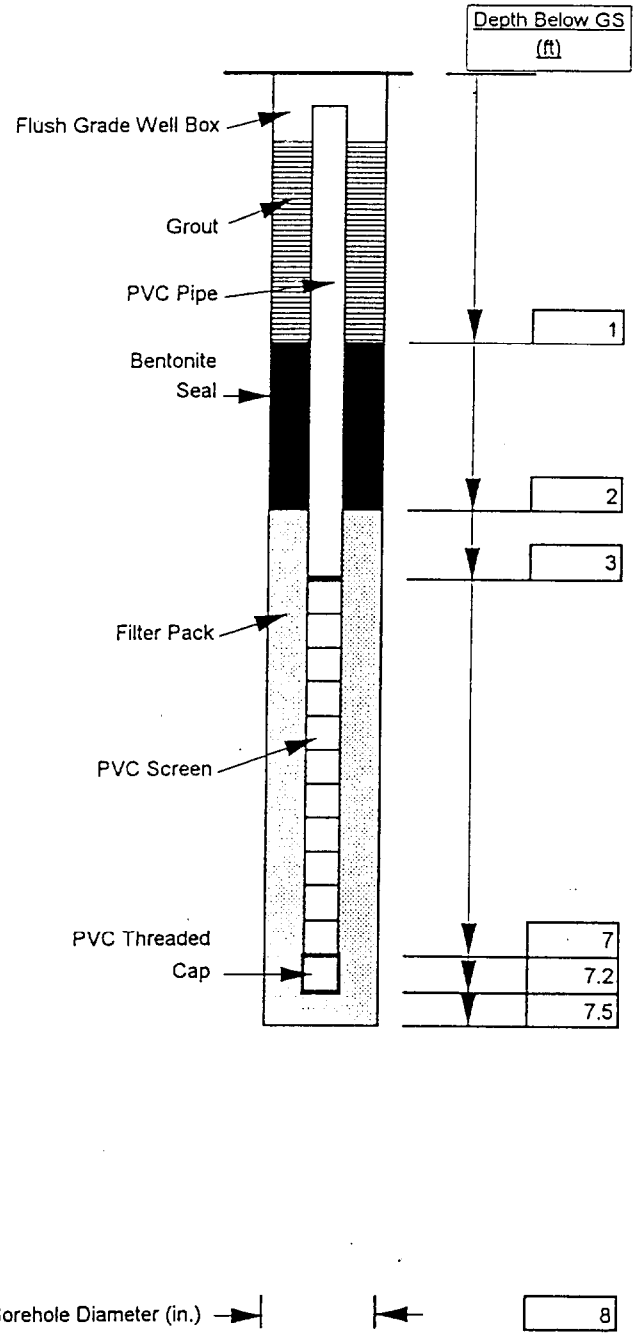
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	125 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-6-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187273.011
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099295.097
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.61 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	5

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

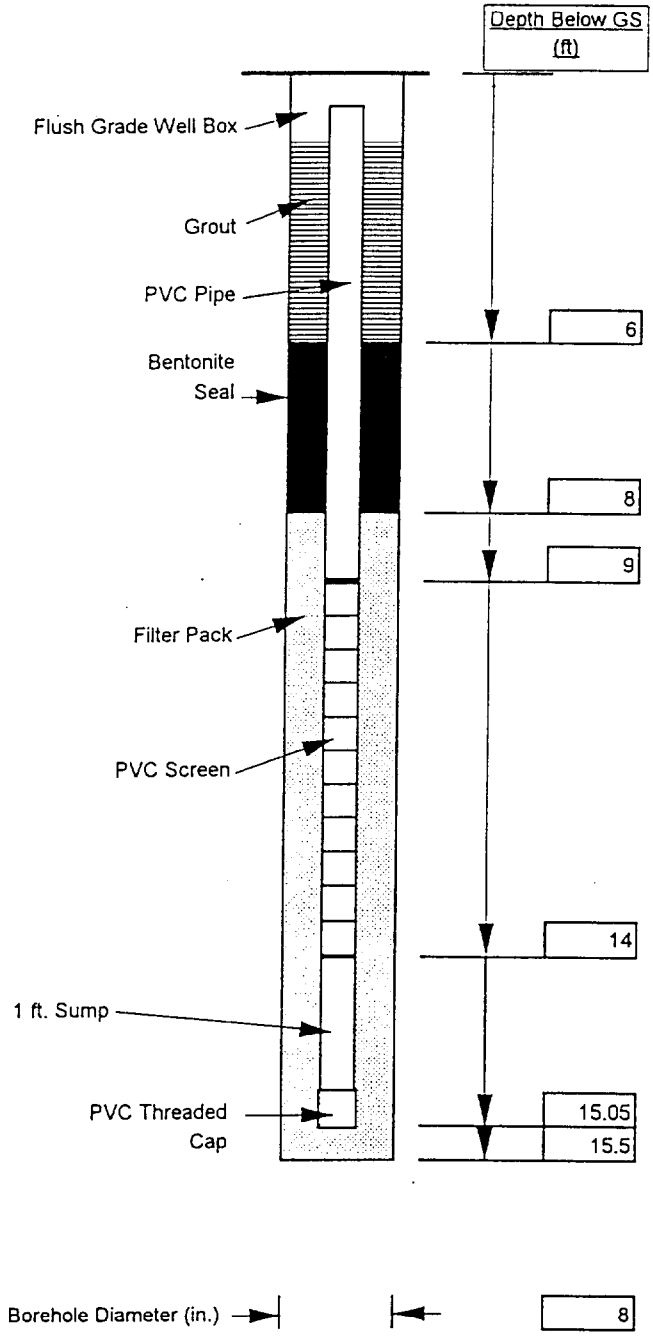
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-7-MW*
Project Number: 22567-145	*Elevation:* 7.95 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/16/96*	*Date Completed:12/16/96*
Driller: Brian Cornell	*Total Depth (ft): 19.0*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 8*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	*Posthole to 1ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-8.8ft: <u>SAND</u>: *(SP)*, gry brn (5YR3/2) to dusky brn (5YR2/2) to lt olive brn (5Y5/6) to lt gry (N7) to brn blk (5YR2/1) to dk yel org (10YR6/6) to pale yel org (10YR8/6), fine, unconsld, mod well sort, subang to subrd, wet at 3ft, silt frac to 15%.	1	SS	75		N/A analytical sample
		2	SS	60		2/4/2/2
5		3	SS	70		6/7/8/7 analytical sample
		4	SS	80		7/2/2/1
	8.8-9ft: <u>SILTY CLAY</u>: *(CL)*, med lt gry (N6) v fine, unconsld, mod sort, subang to subrd, wet.	5	SS	100		10/20/20/20
10	9-18.5ft: <u>SAND</u>: *(SP)*, brn gry (5YR4/1) to dk yel org (10YR6/6) to v lt gry (N8) to pale yel org (10YR8/6) to gry org (10YR7/4) to pink gry (5YR8/1) to med gry (N5) to white (N9) to med lt gry (N6), fine, mod well sort, unconsld, subang to subrd, wet to saturated, silt frac 10-15%.	6	SS	100		10/3/3/4
		7	SS	100		2/2/1/2
15		8	SS	100		2/2/3/4
		9	SS	100		2/2/1/4 analytical sample (TOC)
	18.5-19ft: <u>CLAYEY SAND</u>: *(SC)*, med gry (N5) wet, organic layer at 18.8ft brn blk (5YR2/1) to dusky brn (5YR2/2), moist.					
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-7-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187328.810
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099293.569
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.72 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

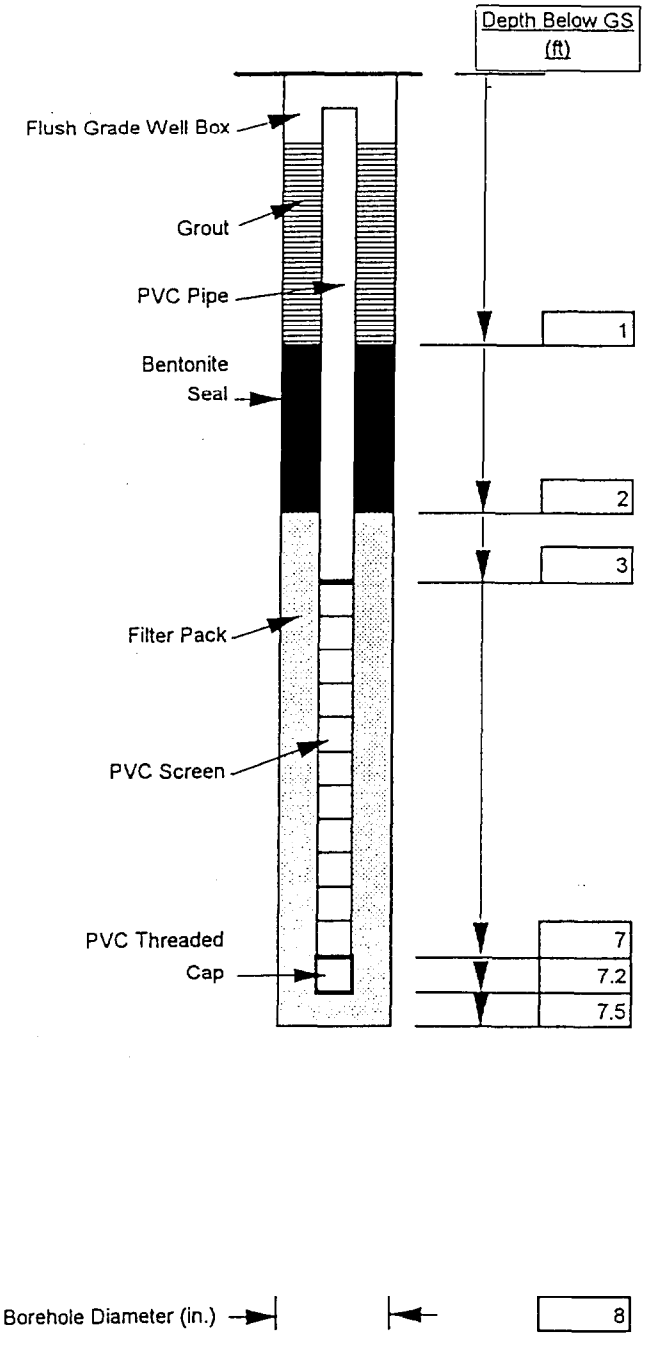
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-7-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187326.652
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099295.775
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.68 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	5

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

bhlg

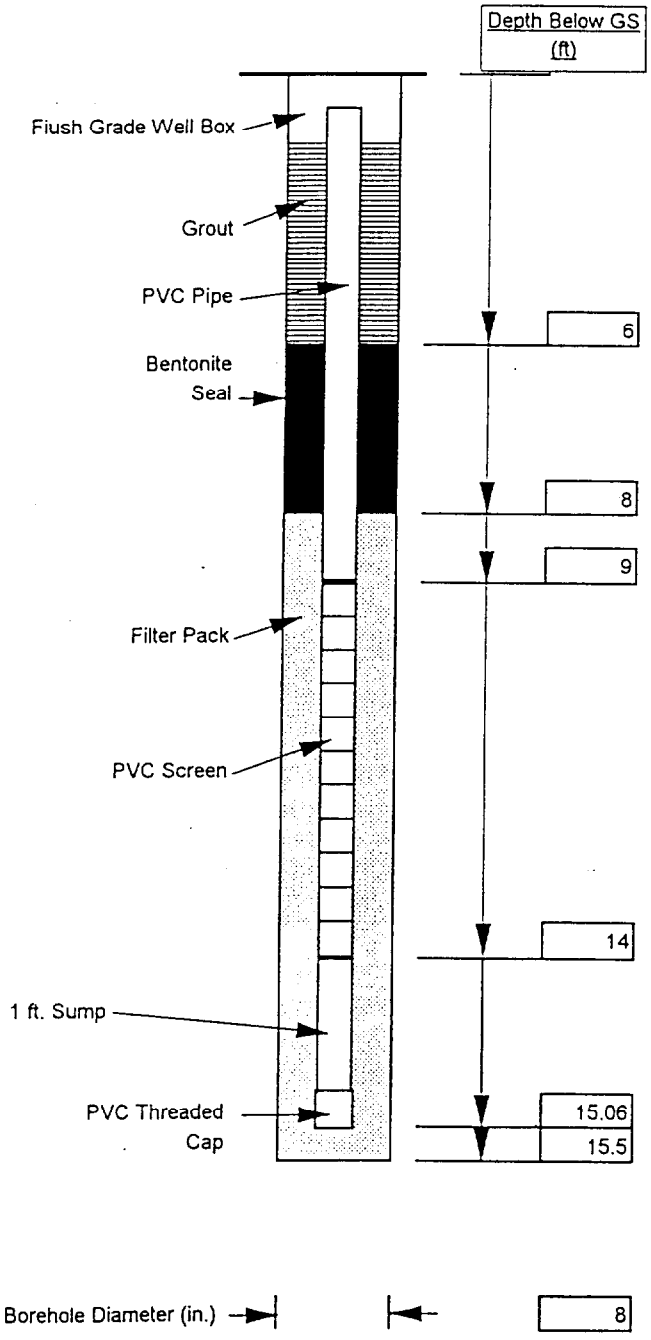
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.: 193-MW-8*
Project Number: 22567-145	*Elevation:* 7.77 ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started:* 12/16/96	*Date Completed:* 12/16/96
Driller: Brian Cornell	*Total Depth (ft):* 15.5	
Equipment: Mobile B-57	*Depth to Bedrock (ft):* None	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in):* 8	
Drilling Fluid: None	*Depth to Water (ft):* 3.0	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By:* P. Linley	*Posthole to 1ft BGL*

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-15.5ft: <u>SAND</u>: *(SP)*, dusky yel brn (10YR2/2) to blk (N1) to brn gry (5YR4/1) to dk yel org (10YR6/6) to mod yel brn (10YR 5/4) to pink gry (5YR8/1) to med dk gry (N4) to yel gry (5Y7/2) fine, unconsld, mod sort, subang to subrd, upper 1.5ft gvl frac 25% to 2.5" dia., 1-3ft poorly sorted - fine to coarse grained (slag/cinders layer), 3ft wet to saturated, 15ft silt & clay frac increasing w/depth to 10-15% each.					Spilt spoon from 1-7ft
		1	SS	80		N/A analytical sample
		2	SS	70		N/A
5		3	SS	90		2/5/7/7 analytical sample
10						
15						
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-MW-8D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187391.271
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099319.322
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.53 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

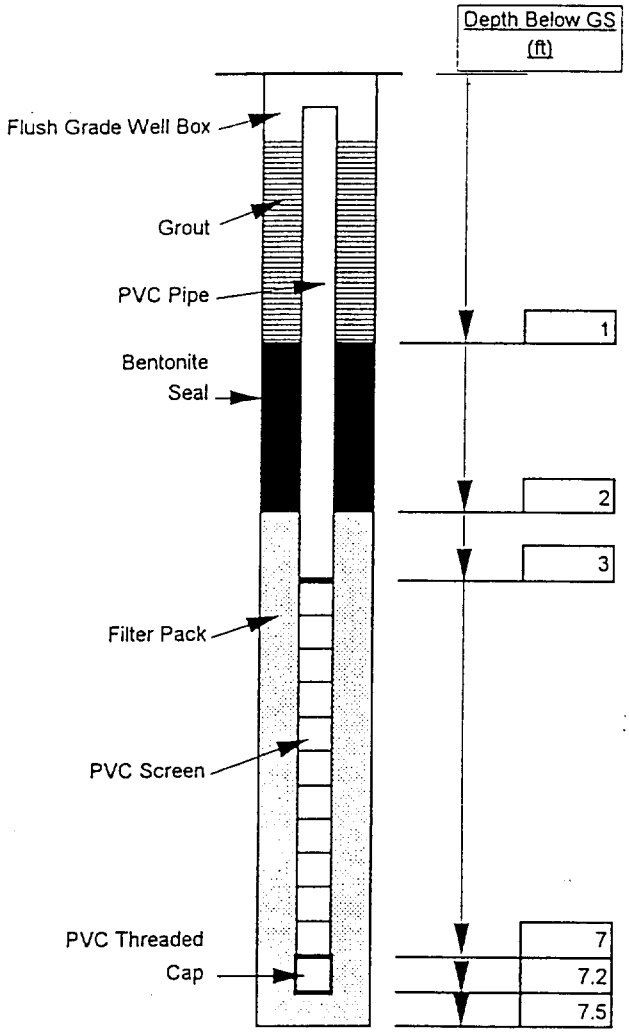
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	137.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-8-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187387.149
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099318.846
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.60 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	5

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

Borehole Diameter (in.) 8

bhlg

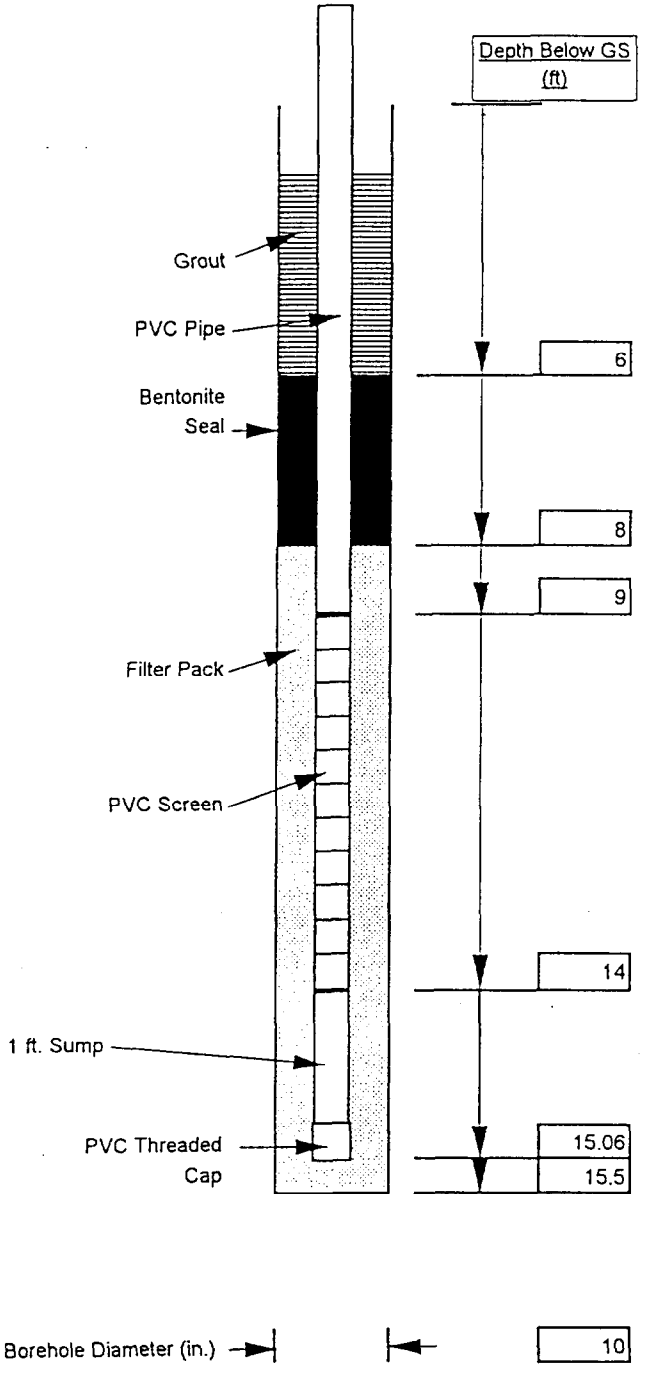
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.:193-1-TMW*
Project Number: 22567-145	*Elevation:* 7.81ft msl	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/11/96*	*Date Completed: 12/11/96*
Driller: Brian Cornell	*Total Depth (ft): 15.5*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 10*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	Temporary well; removed & plugged immediately after permeability test.

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-8ft: <u>SAND</u>: *(SP)*, dusky brn (5YR2/2), fine, unconsld, mod well sort, subang to subrd, gvl frac 3% to 3/8" dia. 3ft: lt brn gry (5YR6/1) to gry org (10YR7/4).					No samples collected during drilling operations, borehole logged based on cuttings.
5	5-8ft: <u>CLAYEY SAND</u>: *(SC)*, dk yel org (10YR6/6), v fine to fine, unconsld, mod sort, subang to subrd, wet.					
	8-15.5ft: <u>SILTY SAND</u>: *(SM)*, gry org (10YR7/4), v fine to fine unconsld, mod sort, subang to subrd, wet.					
10	10ft: dk yel org (10YR6/6) to lt brn (5YR5/6).					
	12ft: lt gry (N7) to med dk gry (N4), saturated.					
15						
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-TMW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N187456.710E2099300.355
Drilling Equipment:	B-57	Date Completed:	12/11/96	Temporary well; removed and plugged immediately after permeability test was completed.	
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	10

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

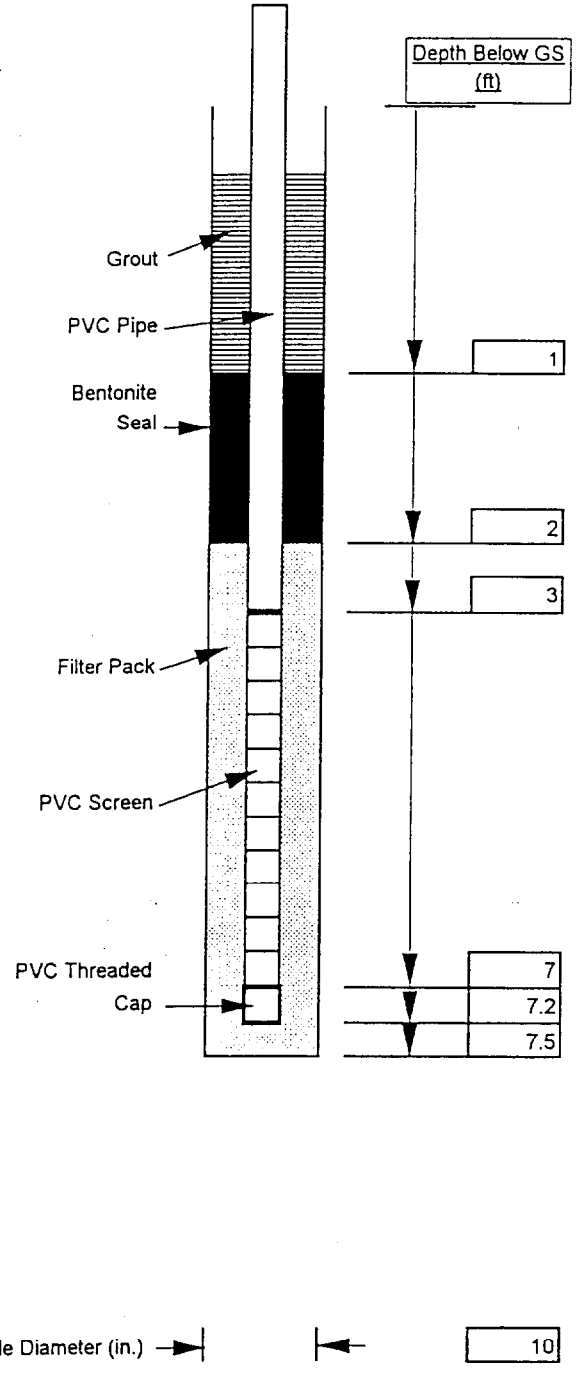
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	275 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-TMW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N187454.710E2099300.355
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96	Temporary well; removed and plugged immediately after permeability test was completed.	
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4.9

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	325 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

bhlg

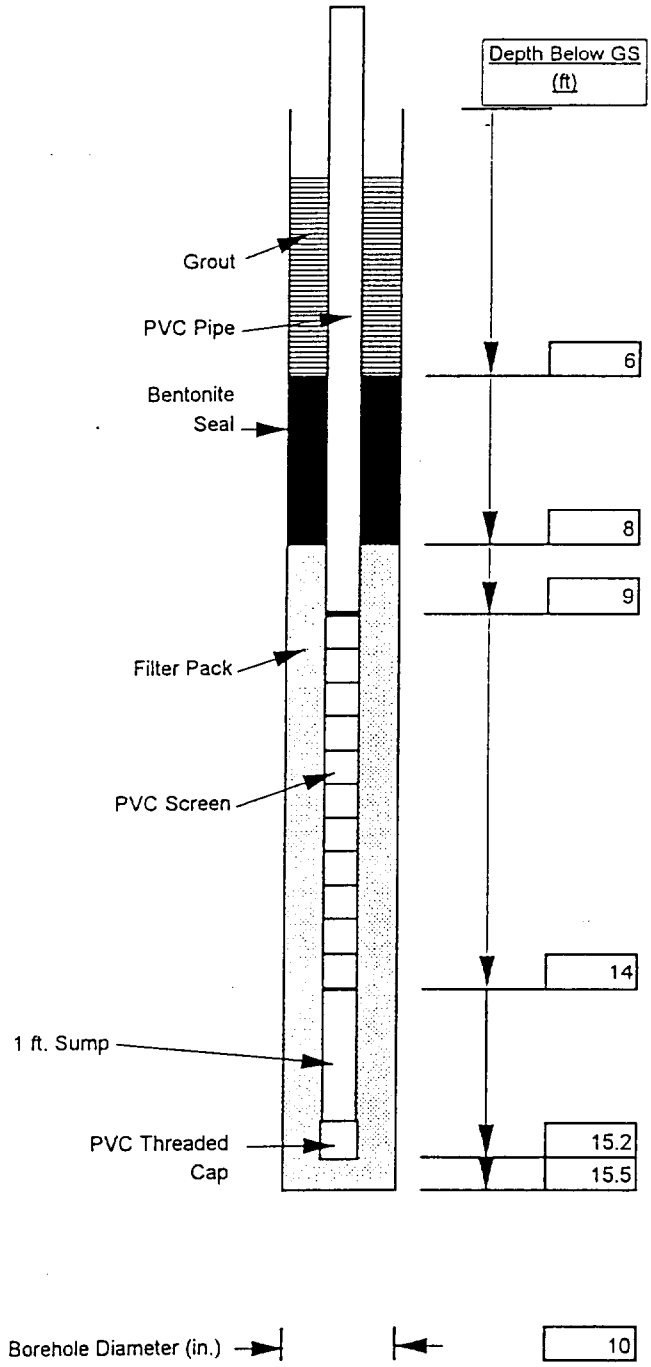
BOREHOLE LOG

Project Name: Parris Island, SC, MCRD		*Borehole No.:193-2-TMW*
Project Number: 22567-145	*Elevation: 7.57ft msl*	
Location: Bldg 193, Dry Cleaners	*Date Started: 12/11/96*	*Date Completed: 12/11/96*
Driller: Brian Cornell	*Total Depth (ft): 14.0*	
Equipment: Mobile B-57	*Depth to Bedrock (ft): None*	
Drilling Method: Hollow Stem Auger	*Hole Diameter (in): 10*	
Drilling Fluid: None	*Depth to Water (ft): 3.0*	
Completion: Completed as Monitoring Well See Well Construction Logs for details	*Logged By: P. Linley*	Temporary well; removed & plugged immediately after permeability test.

Depth (ft)	Description	Sample Number	Sample Type	% Recovery	Blow Count	Comments
	0-2ft: SAND: *(SP)*, med dk gry (N4) to dk gry (N3), fine, unconsld, mod well sort, subang to subrd.	1	SS	25		2/3/4/4
	2-4ft: SAND: *(SP)*, as above, @ 3ft wet, dk yel org (10YR6/6) to pale yel brn (10YR6/2) to pink gry (5YR8/1)	2	SS	100		4/3/3/3
5	4-6ft: SAND: *(SP)*, as above, pale yel brn (10YR6/2) to lt gry (N7), wet	3	SS	100		2/3/4/5
	6-8ft: SAND: *(SP)*, as above, lt gry (N7) w/ lt brn (5YR5/6) banding throughout, wet.	4	SS	100		3/1/1/2
	8-10ft: SAND: *(SP)*, as above, wet, minor clay frac 15%.	5	SS	100		2/2/5/12
10	10-12ft: SAND: *(SP)*, as above, bottom 4-inches med dk gry (N4), saturated.	6	SS	100		2/1/0/1
	12-14ft: SAND: *(SP)*, as above, v lt gry (N8) to med gry (N5), silt frac 10%.	7	SS	100		2/1/2/1
15						
20						
25						
30						

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-TMW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N187457.710E2099288.355
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96	Temporary well; removed and plugged immediately after permeability test was completed.	
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	9.75

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

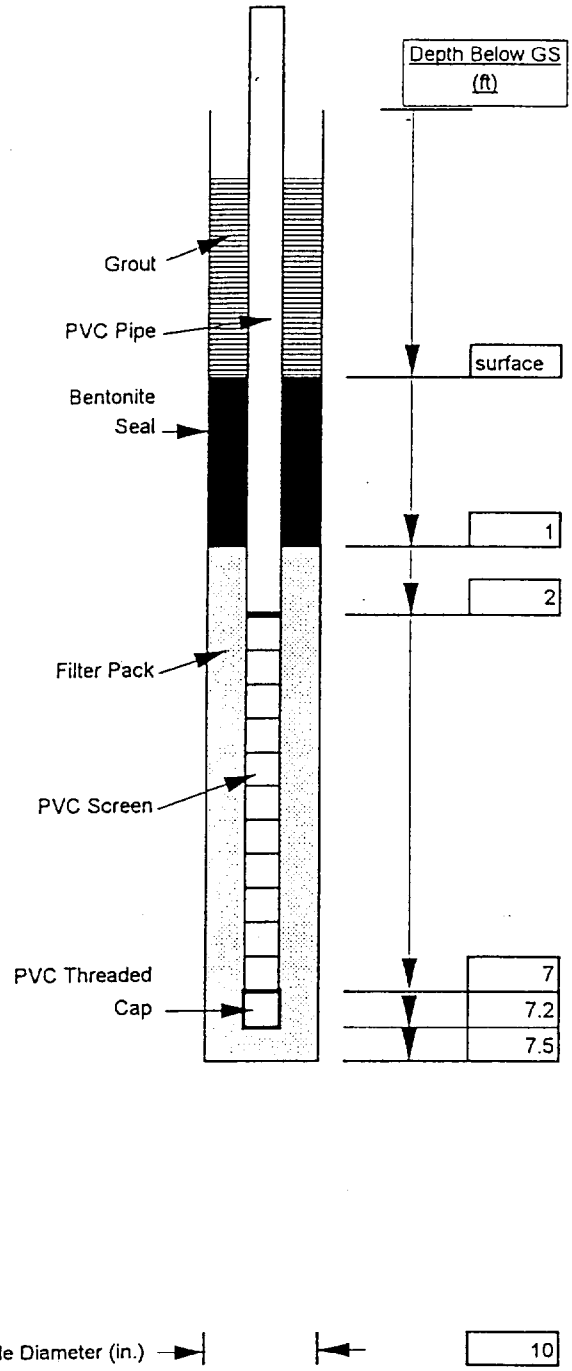
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	250 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-TMW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N187454.710 E2099288.355
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96	Temporary well; removed and plugged immediately after permeability test was completed.	
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	4.8

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	6.5
Placement	Pour
Amount Placed	300 lbs

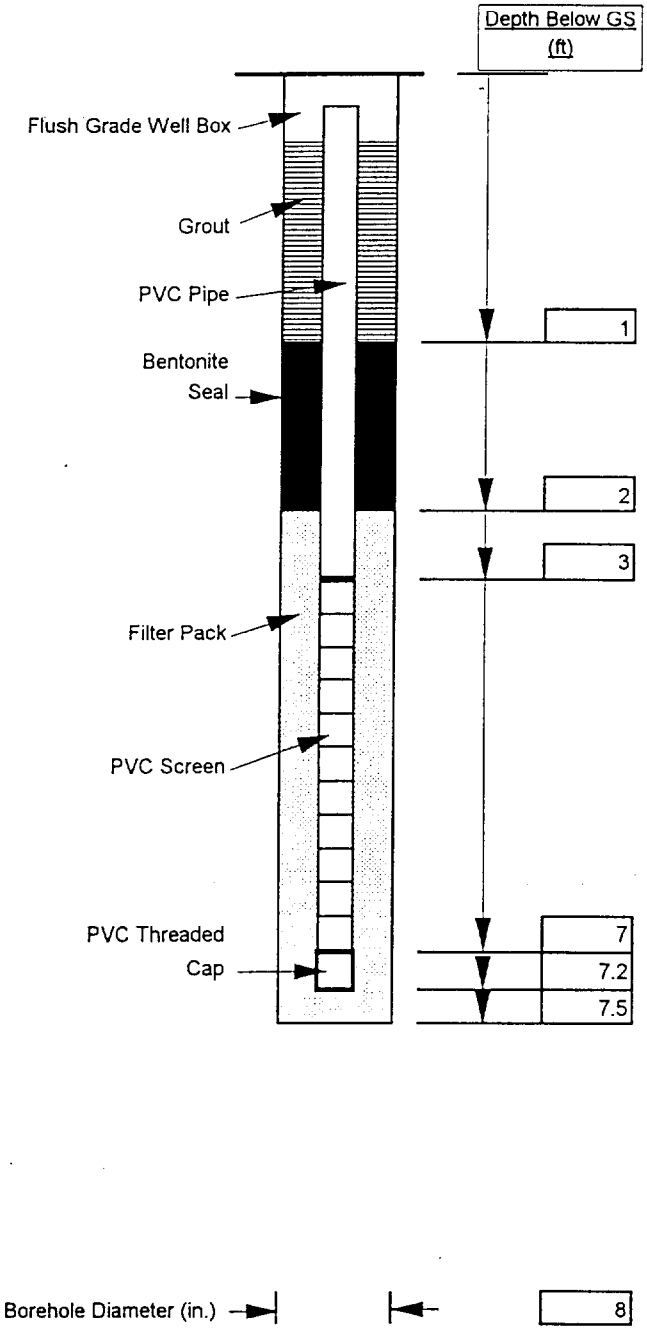
Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

000075

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-8-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187387.149
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099318.846
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.60 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.83

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

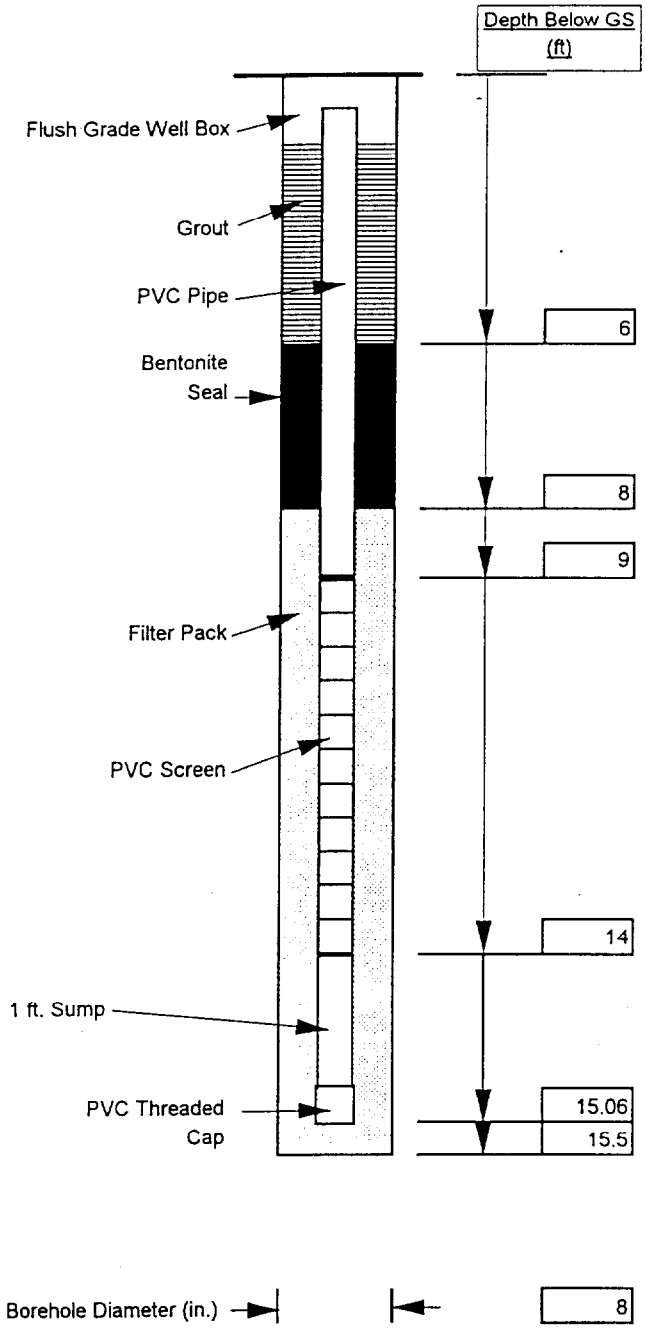
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-MW-8D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187391.271
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099319.322
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.53 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.76

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

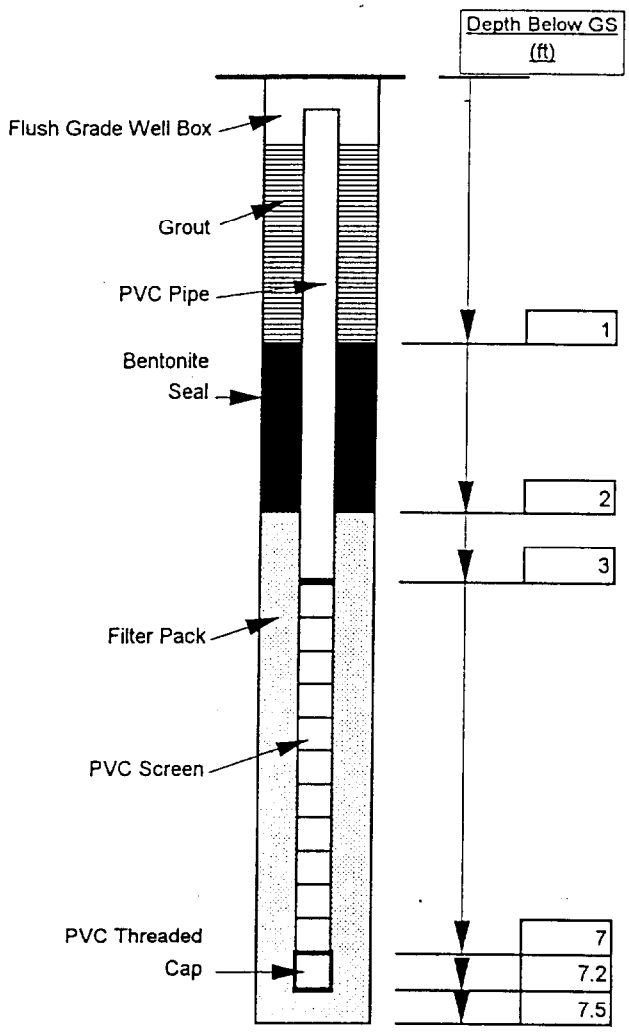
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	137.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-7-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187326.652
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099295.775
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.68 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.73

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

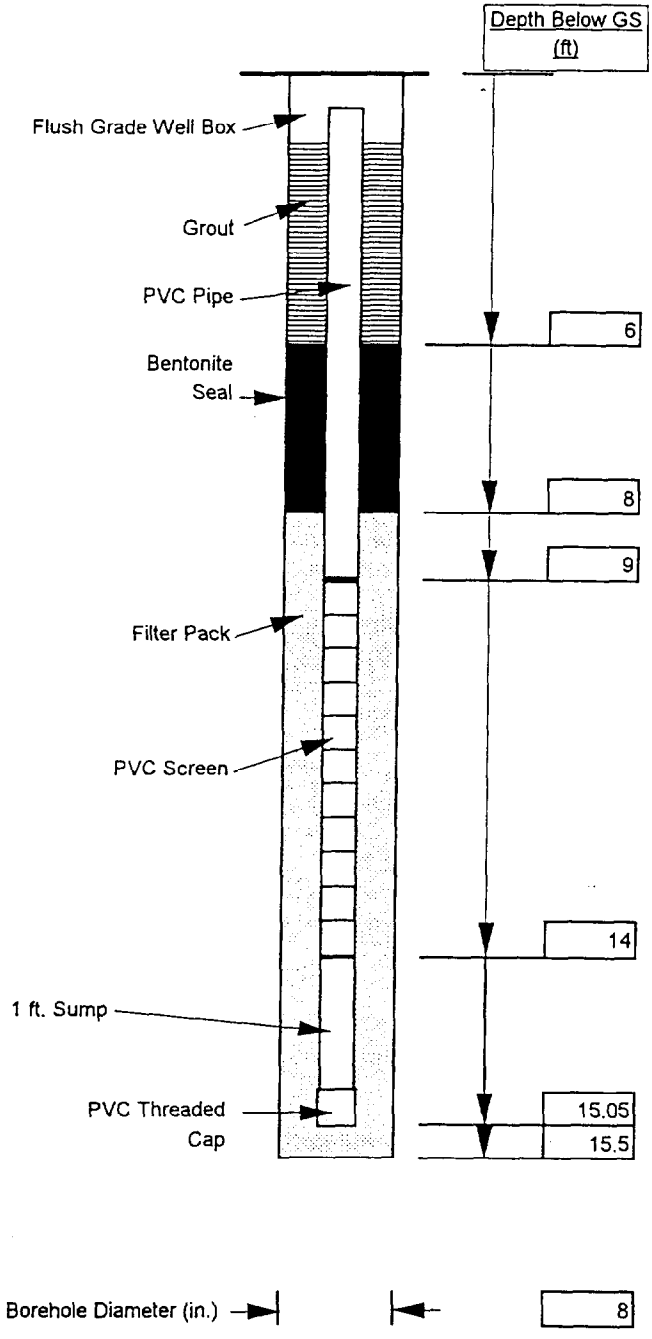
Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

Borehole Diameter (in.) 8

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-7-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187328.810
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099293.569
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.72 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.77

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

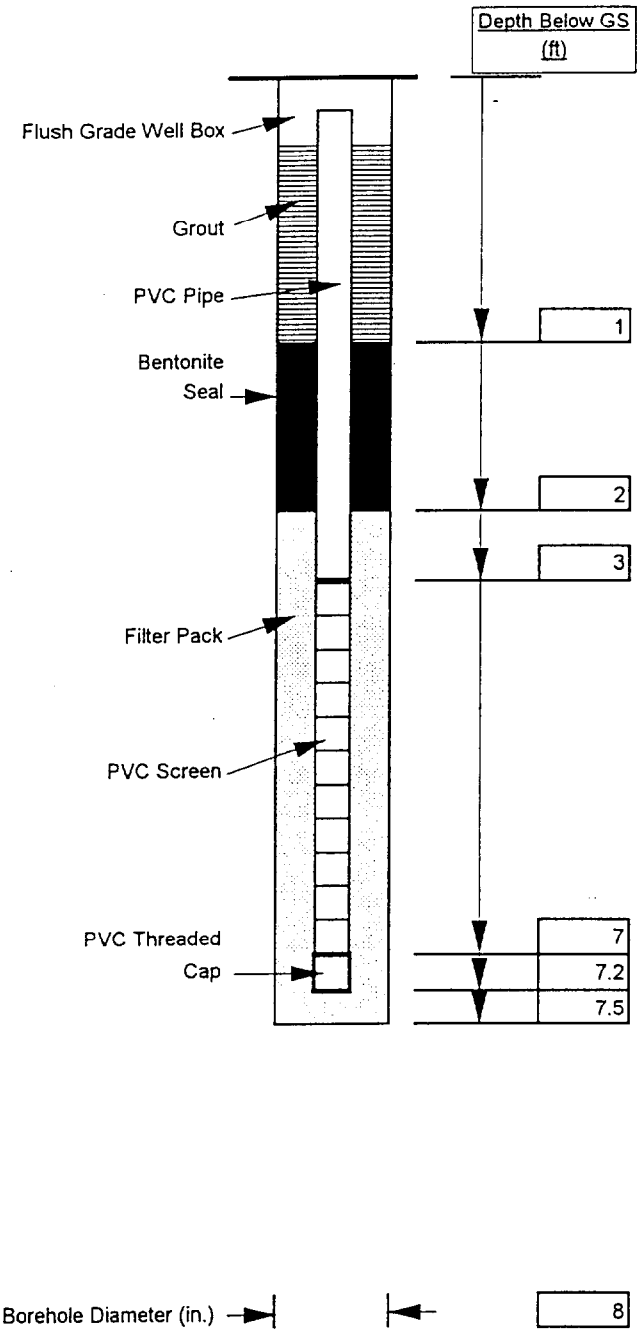
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-6-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187273.011
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099295.097
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.61 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.85

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

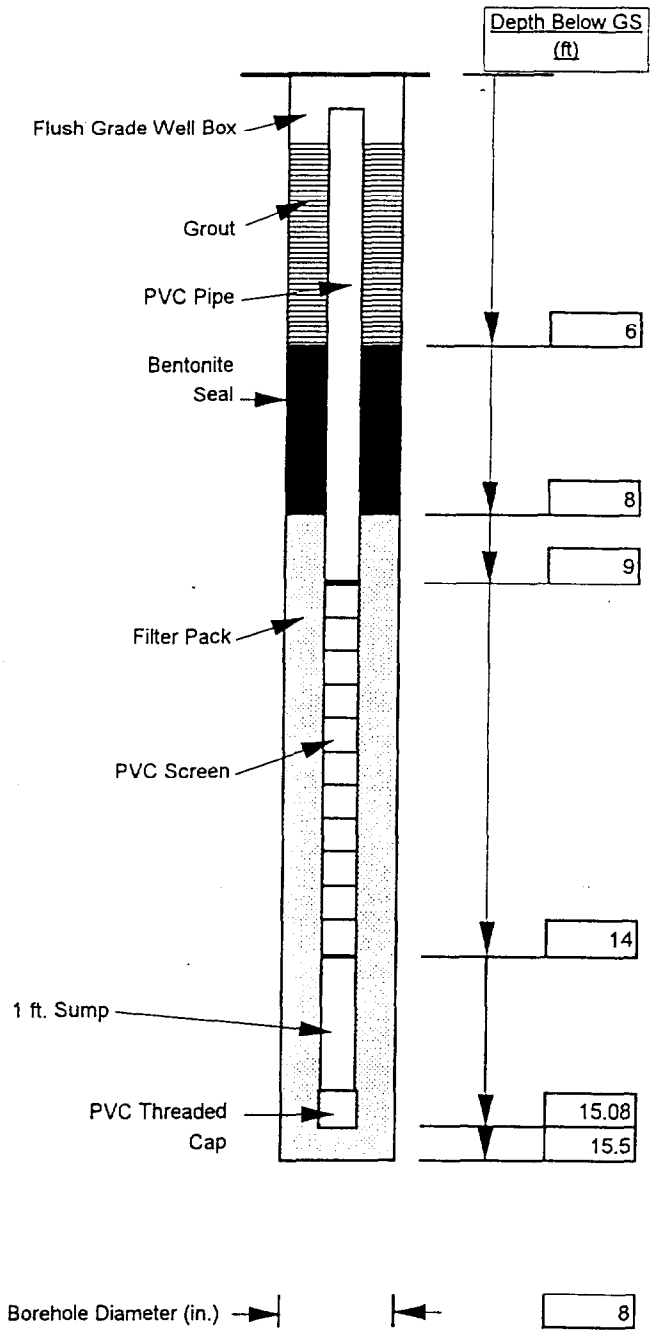
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-6-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/16/96	Coordinates:	N 187277.268
Drilling Equipment:	Mobile B-57	Date Completed:	12/16/96		E 2099296.248
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.52 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.76

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

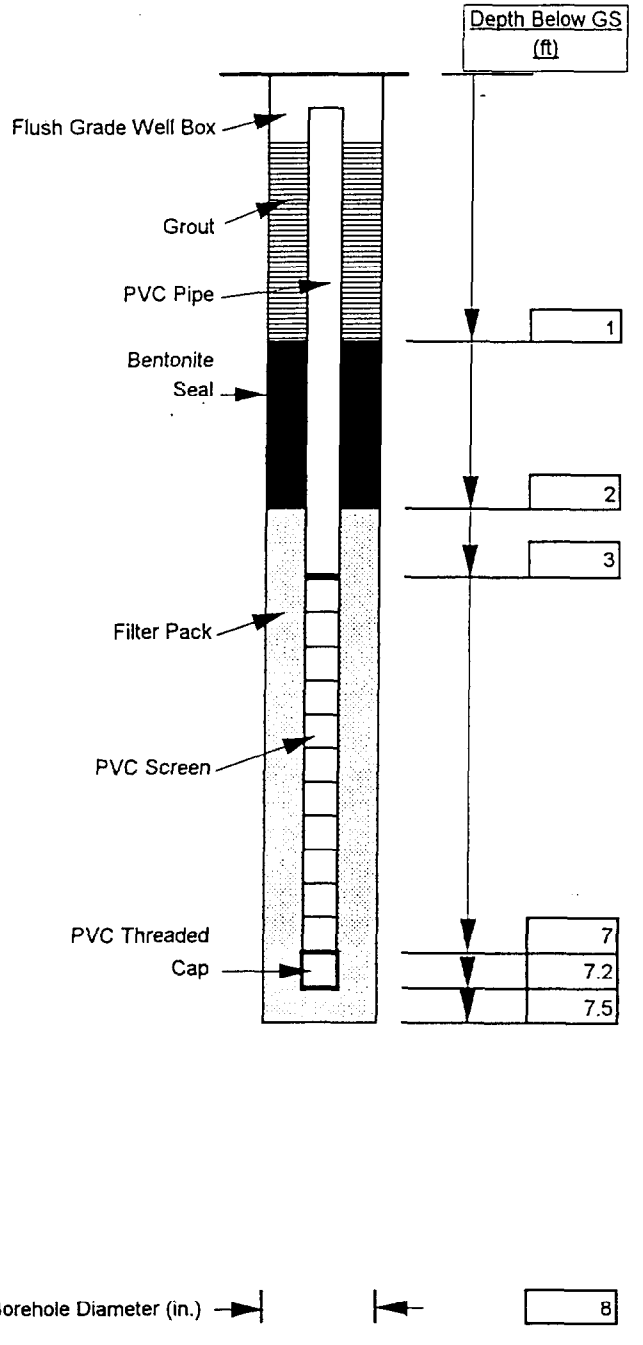
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	125 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-5-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187192.220
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099377.309
Drilling Method:	HSA	Depth to Water:	4ft bgl		
Drilling Fluid:	None	Elevation:	8.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.96

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

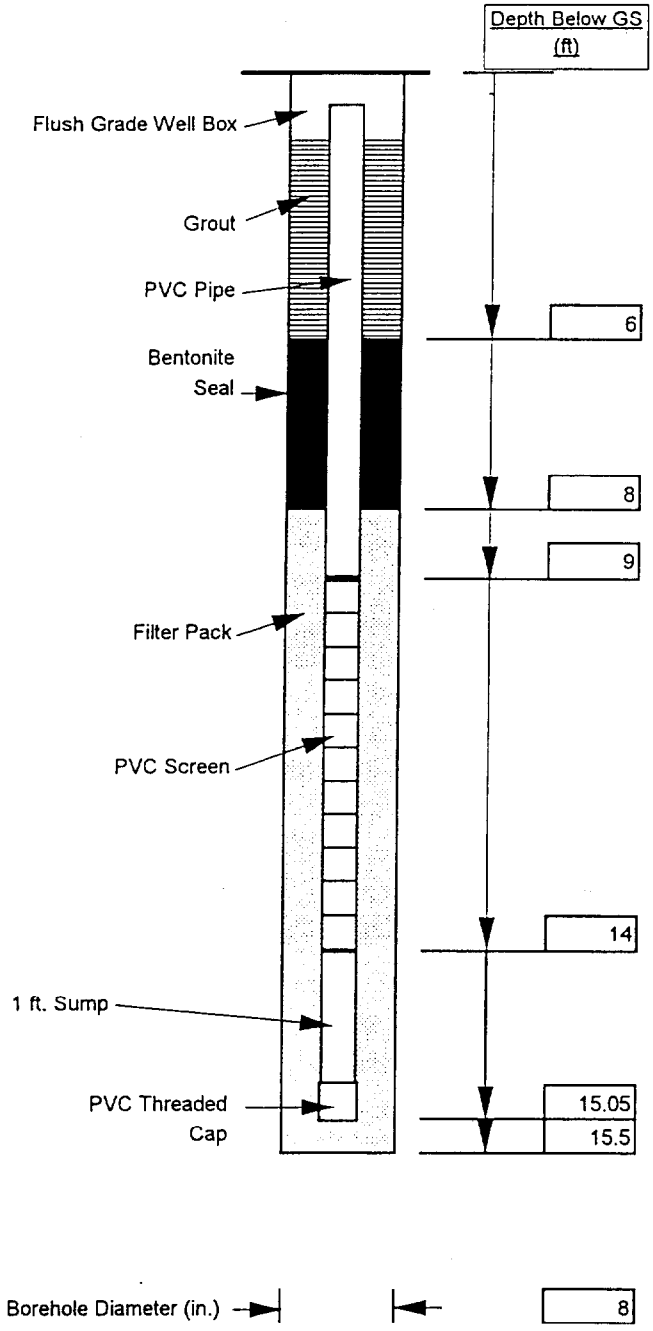
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-5-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187187.346
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099376.763
Drilling Method:	HSA	Depth to Water:	4ft bgl		
Drilling Fluid:	None	Elevation:	8.26 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.62

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

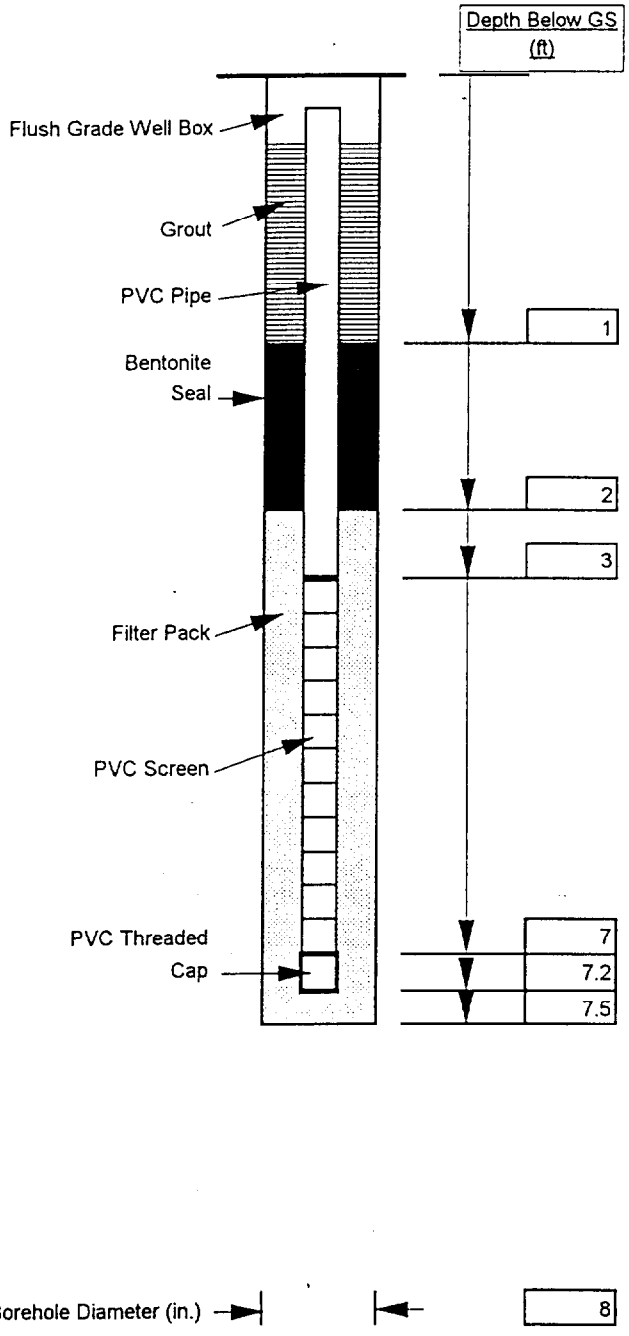
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	200 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-4-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/12/96	Coordinates:	N 187150.910
Drilling Equipment:	Mobile B-57	Date Completed:	12/12/96		E 2099249.096
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	6.98 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.84

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

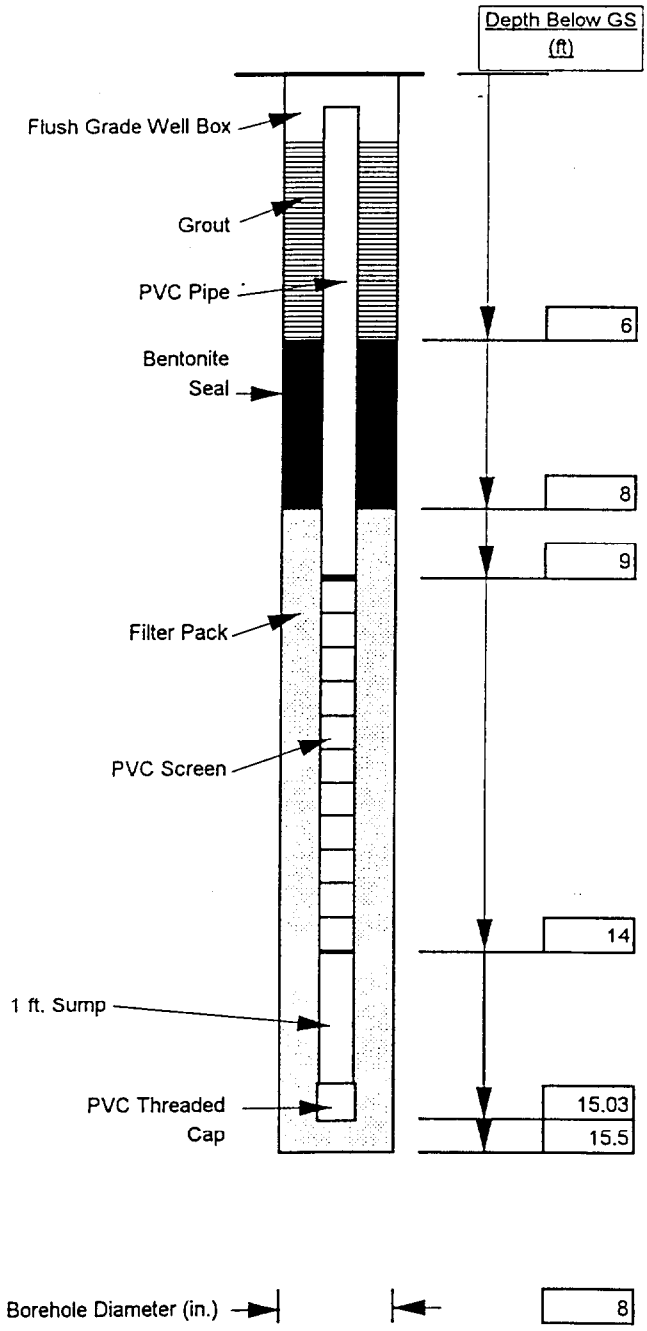
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	162.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-MW-4D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/12/96	Coordinates:	N 187149.280
Drilling Equipment:	Mobile B-57	Date Completed:	12/12/96		E 2099253.080
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	6.93 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.79

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

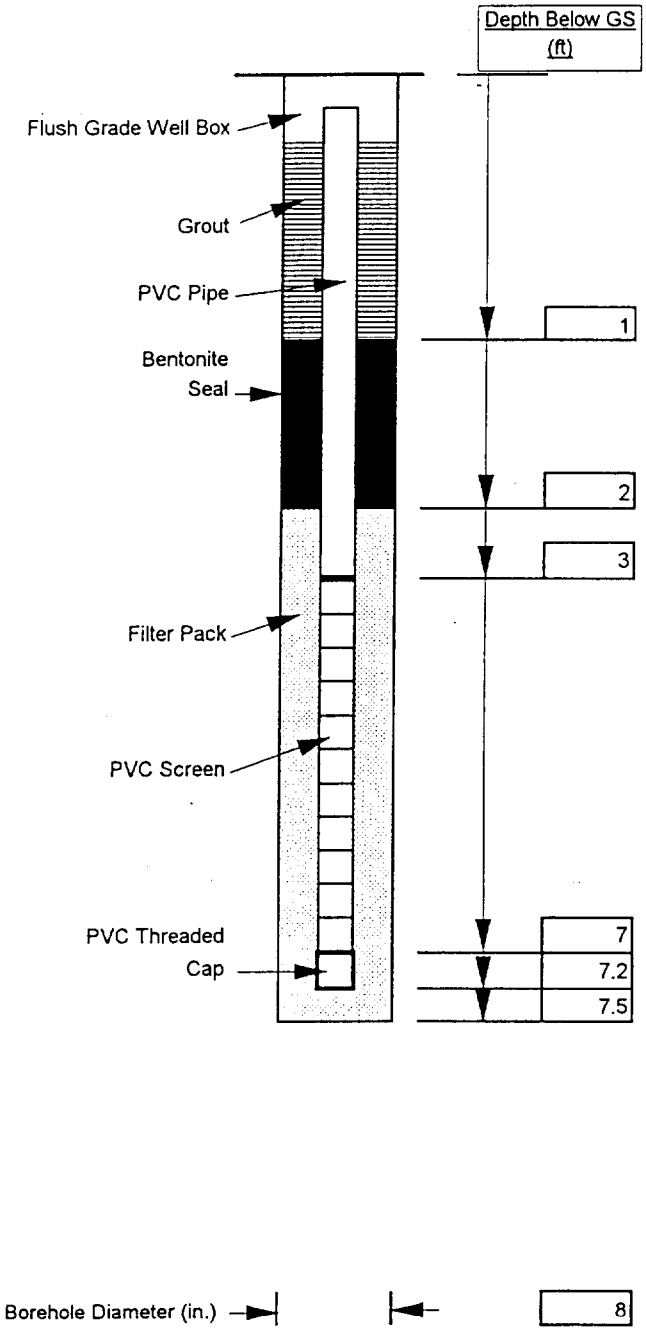
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-3-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187257.657
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099244.001
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.82

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

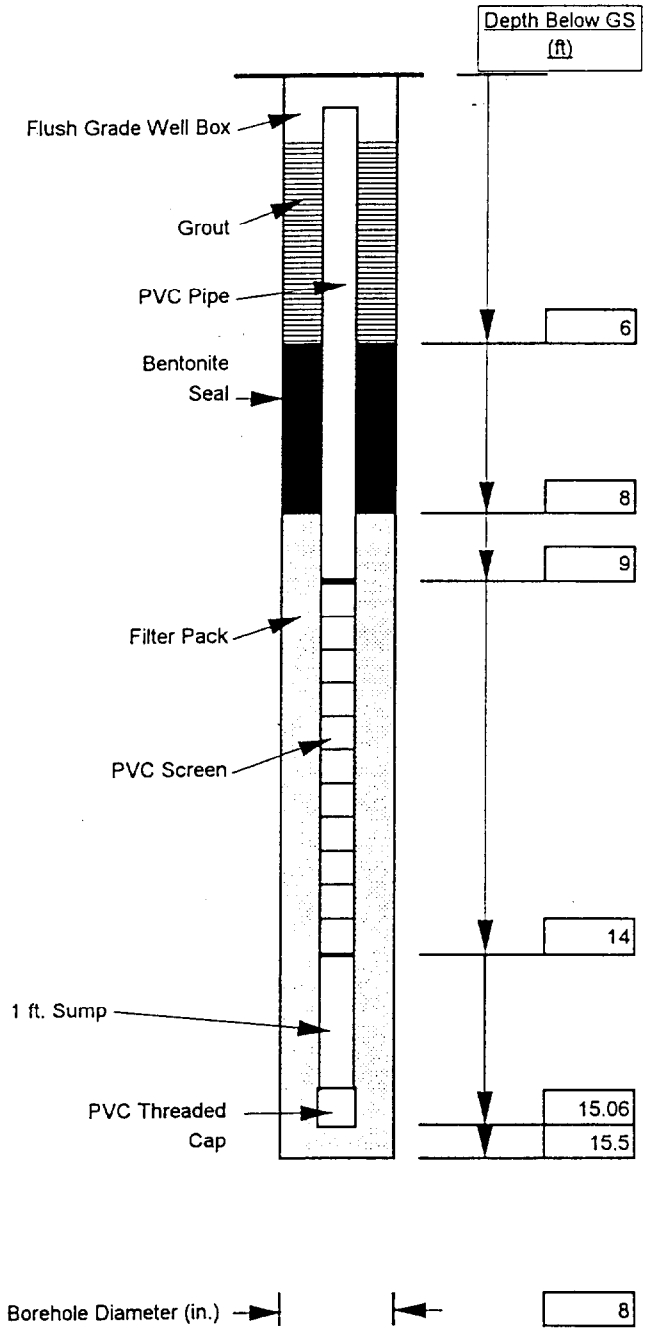
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-3-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/13/96	Coordinates:	N 187258.713
Drilling Equipment:	Mobile B-57	Date Completed:	12/13/96		E 2099239.820
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.79

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

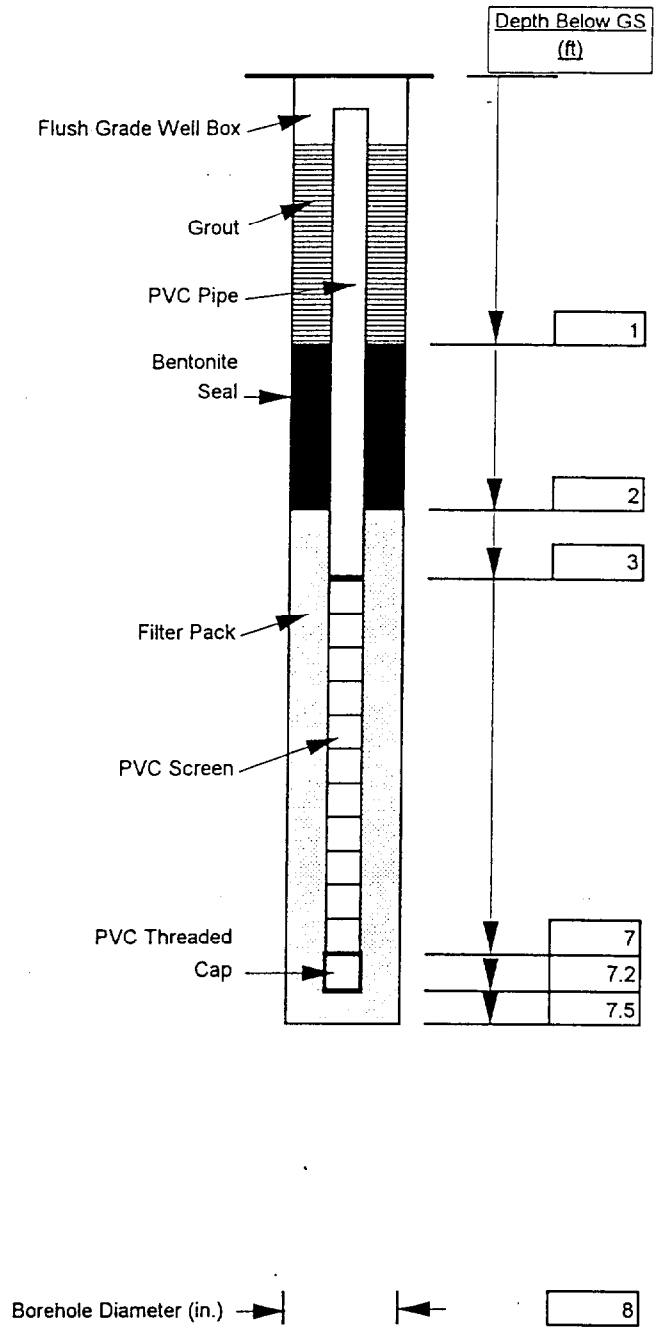
Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/14/96	Coordinates:	N 187345.032
Drilling Equipment:	Mobile B-57	Date Completed:	12/14/96		E 2099203.731
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.11 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.66

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

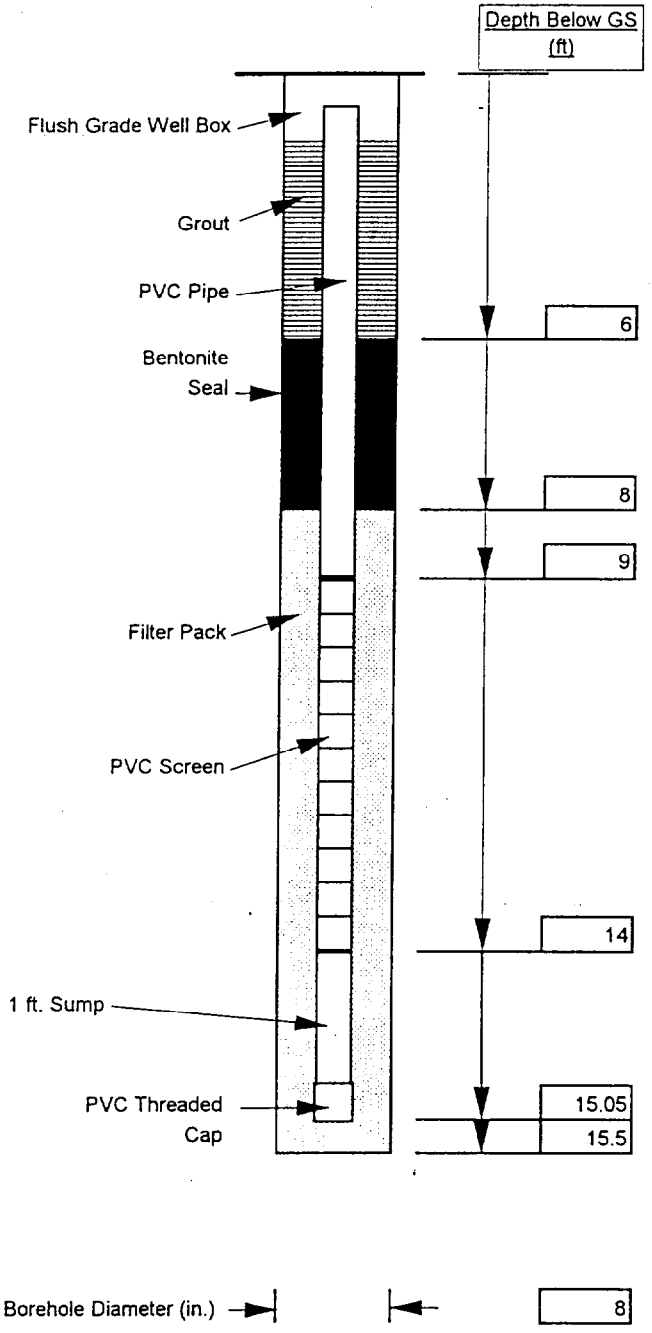
Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	150 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-2-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/14/96	Coordinates:	N 187341.197
Drilling Equipment:	Mobile B-57	Date Completed:	12/14/96		E 2099201.966
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.23 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	8.78

Backfill

Type	Grout Seal
Length (ft)	6
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	7.5
Placement	Pour
Amount Placed	150 lbs

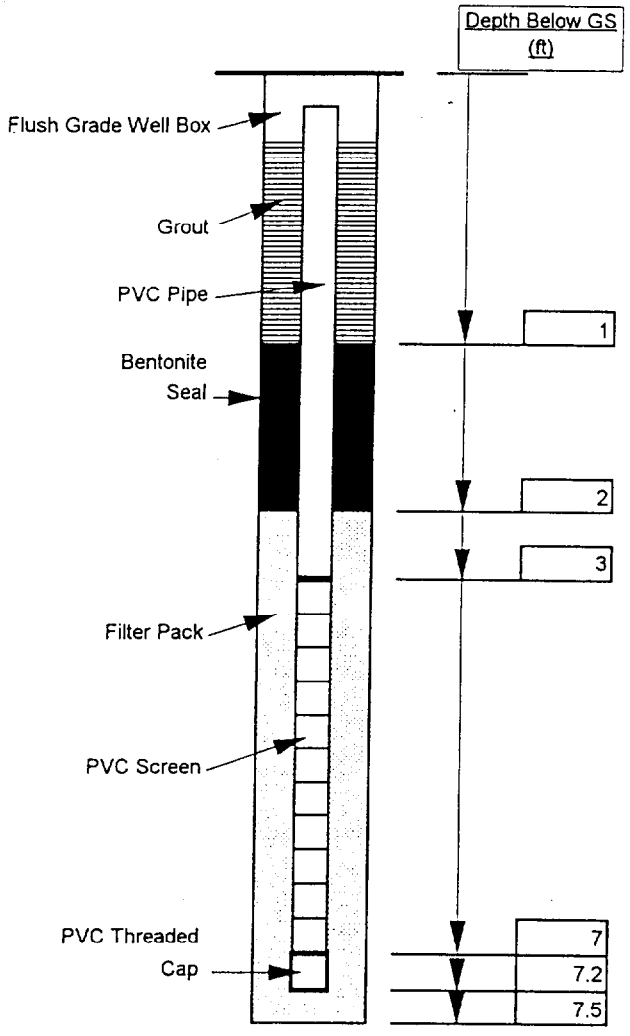
Screen

Type	Schedule 40 PVC
Length (ft)	5
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

000075

WELL CONSTRUCTION LOG

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-MW-S
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N 187455.597
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96		E 2099298.879
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.6 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	2.79

Backfill

Type	Grout Seal
Length (ft)	N/A
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	1
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.5
Placement	Pour
Amount Placed	325 lbs

Screen

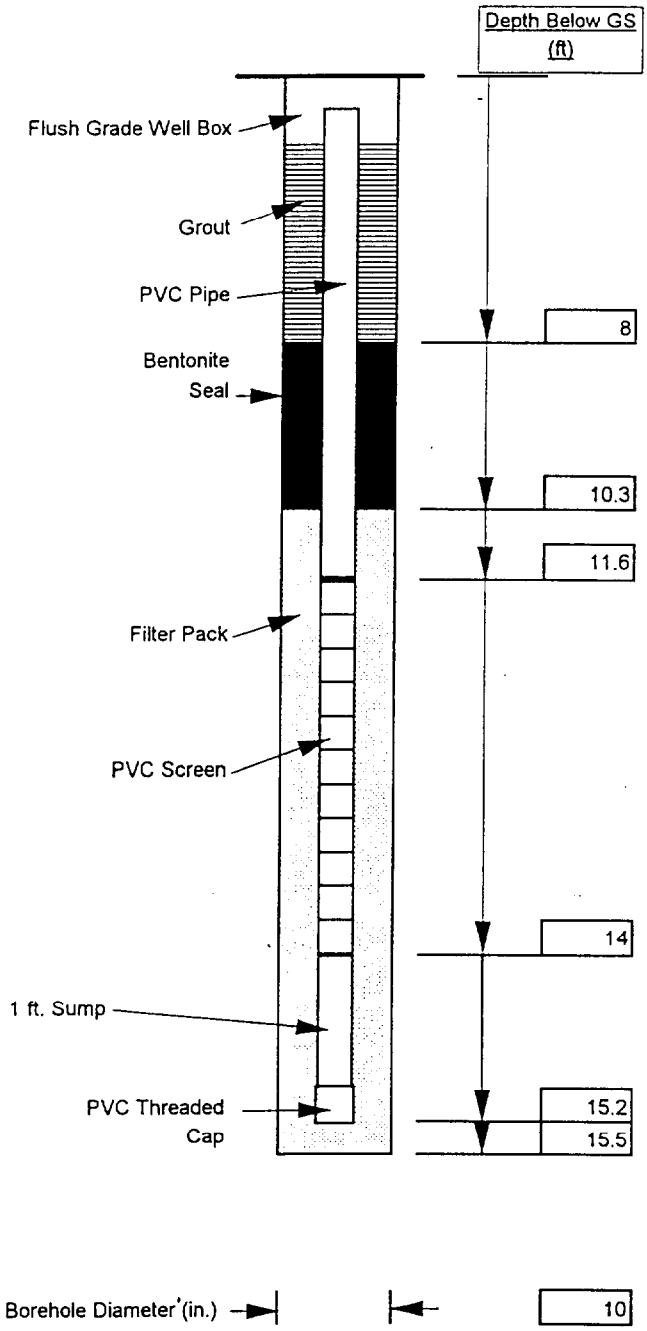
Type	Schedule 40 PVC
Length (ft)	4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

Borehole Diameter (in.) 10

WELL CONSTRUCTION LOG

000075

MCRD Parris Island	Site: Dry Cleaners Bld 193			Well No.:	193-1-MW-D
Drilling Company:	Environmental Drilling Inc.	Project No.:	22567-145	Logged By:	P. Linley
Driller:	Brian Cornell	Date Started:	12/11/96	Coordinates:	N 187454.710
Drilling Equipment:	Mobile B-57	Date Completed:	12/11/96		E 2099308.355
Drilling Method:	HSA	Depth to Water:	3ft bgl		
Drilling Fluid:	None	Elevation:	7.57 ft msl		



MATERIALS

Riser Pipe

Type	Schedule 40 PVC
Diameter (in.)	2
Length (ft)	11.36

Backfill

Type	Grout Seal
Length (ft)	8
Placement	Tremie

Seal

Type	Bentonite Pellets
Length (ft)	2.3
Placement	Pour

Filter Pack

Type	20/30
Length (ft)	5.2
Placement	Pour
Amount Placed	162.5 lbs

Screen

Type	Schedule 40 PVC
Length (ft)	2.4
Diameter (in.)	2
Slot Size (in.)	0.01
Slot Type	Machine Slotted

000067

SOIL ANALYSIS TEST PROGRAM

FINAL REPORT

CORE LABORATORIES

CORE LABORATORIES

SOIL ANALYSIS TEST PROGRAM

FINAL REPORT

Performed for:

BECHTEL ENVIRONMENTAL, INC.
151 LAFAYETTE DRIVE, P.O. BOX 350
OAKRIDGE, TENNESSEE 37831-0350

January 7, 1997

Performed by:

CORE LABORATORIES, INC.
Rock Properties Laboratory
Dallas Advanced Technology Center
1875 Monetary Drive
Carrollton, Texas 75006

File: DAL-96497

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CORELAB

PETROLEUM SERVICES

January 7, 1996

Bechtel Environmental, Inc.
151 Lafayette Drive, P.O. Box 350
Oakridge, Tennessee 37831-0350

Attention: Ms. Karen Atchley

Subject: Final Report
Soil Analysis Test Program
File: DAL-96497

Dear Ms. Atchley:

A testing program to determine intrinsic permeability, air permeability, bulk density, water content, and particle size distribution has been completed for Bechtel. This study was authorized by Ms. Atchley by delivery of the sample on December 13, 1996. Final results of all testing are presented herein.

One sample of soil identified as " 193-MW-4 5'-7' " was received on December 13, 1996. Two companion 1-inch diameter horizontal core plugs were punched from the supplied soil sample and labeled as Sample 1 and Sample 2. In addition, remnant core material from the same interval was removed and labeled as Sample 3. Subsequent sample preparation is described on Page ii.

Permeability to liquid was determined on Sample 1 as outlined on Page iii. The liquid permeability value for the sample was 5.87E-13 cm^2. The permeability to air, measured using a steady-state permeameter, was 3.47E+02 millidarcys. Bulk density (2.01 g/cm^3) and moisture content (0.437 cm^3/cm^3) were determined on Sample 2 as described on Page iv. Particle size distribution was determined on the section labeled Sample 3 as described on Page v. A summary of test results is presented on Page 1 and 2. Permeability to liquid and hydraulic conductivity calculations follow on Pages 3 and 4. ASTM procedures and testing methods are listed on page 5.

Thank you for this opportunity to be of service to Bechtel. Please contact us if you have any questions concerning the enclosed information, or if we may be of any additional service.

Very truly yours,

Wade Williams

Wade Williams
Rock Properties Laboratory
Dallas Advanced Technical Center

3 copies: Addressee

Bechtel
File: DAL-96497

PROJECT PARTICIPANTS

Particle Size Distribution	Robert Lee Robert Lee
Limited Site Assessment Analyses Final Report Preparation	Wade Williams Wade Williams
Final Review	Melanie F. Dunn Melanie F. Dunn

EXPERIMENTAL PROCEDURES

Sample Preparation

1. Upon receipt, the suite of samples was assigned job number DAL-96497 for laboratory tracking.

2. Samples 1 and 2 were trimmed to right cylinders approximately 1-inch in length. Each sample was then placed in a 1-inch diameter metal sleeve with 120 mesh and 60 mesh stainless steel screens installed on the top and bottom. The samples were then weighed to the nearest 0.001 gm. Corrected weights were obtained by subtracting the weights of the mounting materials.

3. Samples 1 and 2 were designated for testing as follows:

   - Sample 1: permeability tests
   - Sample 2: moisture content and bulk density tests

4. Sample 3 was submitted for Particle Size determinations, see page v.

5. A chain of custody (COC) form was prepared for each sample. All pertinent data relating to the sample was recorded on this form which accompanied the sample throughout testing.

6. The length and diameter of Sample 1 and 2 were measured to the nearest 0.001 cm using digital calipers and recorded on the COC form. Cross-sectional area were calculated as follows:

$$L = (l - C_1)$$
$$A = ((D - C_2)/2)^2 * pi$$

where:
- l = Gross sample length, cm
- L = Corrected sample length, cm
- A = Cross-sectional area, cm^2
- D = Gross sample diameter, cm
- pi = 3.14159
- C_1 = Metal sleeve and screen length correction, cm
- C_2 = Metal sleeve diameter correction, cm

Permeability to Liquid Measurement

1. Sample 1 was briefly evacuated of air, saturated with tap water, and weighed. The weight was recorded on the COC sheet. The plug was installed in a hydrostatic coreholder and 100 psi net confining stress was applied.

2. Tap water, which had been previously evacuated of air, was injected at a constant upstream pressure. Differential pressure was monitored using a Validyne transducer calibrated, prior to use, using a dead weight tester. Pressure readings are accurate to plus or minus 0.5 percent of the full scale value. Tap water viscosity was measured with a calibrated Canon-Fenske glass capillary viscometer. Tap water density was determined using a pycnometer.

3. The produced rate was monitored as a function of time using a class A pipette until the relative percent difference in incremental produced rate (measured over a two hour period) was less than 10 percent over a 24 hour period.

4a. Permeability to liquid in millidarcys was calculated from the observed data using the following equation (Darcy's law):

$$K = (C_1 * C_2 * \mu * V L) / (P * A * T)$$

where:
- K = permeability to liquid, millidarcys
- C_1 = constant, psi/atm
- C_2 = constant, millidarcys/darcy
- μ = viscosity of liquid, centipoise
- V = incremental produced volume, ml
- L = length, cm
- P = differential pressure, psi
- A = cross-sectional area, cm^2
- T = incremental time, sec

4b. Permeability in cm^2 was calculated from this value using the conversion factor:

$$cm^2 = \text{millidarcys} \times 9.869E\text{-}12$$

5a. Hydraulic conductivity in meters per second was calculated from the observed data using the following equation:

$$k = (V * L) / (A * T * P)$$

where:
- k = Hydraulic conductivity, m/sec
- V = Incremental produced volume, m^3
- L = Length, m
- P = Differential pressure, m H_2O
- A = Cross-sectional area, m^2
- T = Incremental time, sec

5b. Hydraulic conductivity in meters per year was calculated from this value using the conversion factor:

$$\text{meters per year} = \text{meters per sec} * 31{,}536{,}600$$

6. The sample was then submitted for air permeability determination.

Bulk Density and Moisture Content Determination

1. Bulk density and moisture content were determined on Sample 2.

2. Bulk density is defined to be the sample weight divided by the sample bulk volume and is presented in grams per cubic centimeter.

3. Bulk volume was calculated from the corrected length and area of the samples determined in the sample preparation step as follows:

$$BV = L * A$$

where:
BV = Bulk volume, cc
L = Length, cm
A = Area, cm^2

4. Bulk density was calculated from the bulk volume and the corrected weight of the sample (see sample preparation) as follows:

$$BD = W_{sample} / BV$$

where:
BD = Bulk density, grams/cc
BV = Bulk volume, cc
W_{sample} = Sample weight, grams

5. The sample was dried to a constant weight in a vacuum oven at 220°F. The weight difference was used to calculate the fluid saturated pore volume as follows:

$$SV = (W_{saturated} - W_{dry}) / \rho_{fluid}$$

where:
SV = Fluid saturated volume, cc
$W_{saturated}$ = Saturated weight, grams
W_{dry} = Dry weight, grams
ρ_{fluid} = Saturant fluid density, grams/cc

6. Moisture content was calculated by the following equation:

$$MC = SV / BV$$

where:
MC = Moisture content, cc/cc
SV = Fluid saturated volume, cc
BV = Bulk volume, cc

Particle Size Analysis

The selected samples were cleaned, dried, and separated in two portions. A dry sieve analysis was conducted on one portion of each sample to define the larger grain sizes (> 20 microns) while laser particles sieve analysis was performed on the remaining portion of each sample to categorize the particles below 20 microns.

Laser particle size analysis was performed using the Coulter LS 130 laser particle size analyzer. The LS series measures particle size by measuring the amount of light scattered by the particle in different directions by means of a Fourier lens. The diffraction detector system consists of 126 photodiode detectors in three sets. These are low angle (mainly for large particles), mid-angle (average particles), and high-angle (small particles).

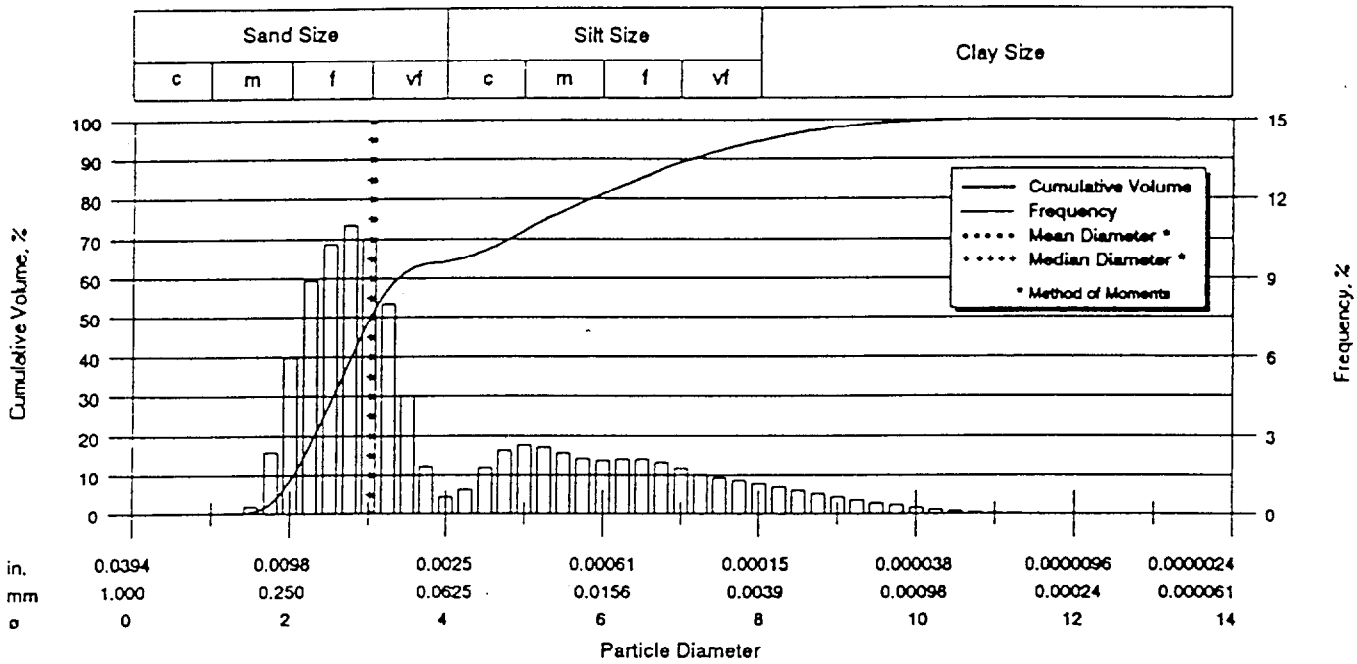
Additionally, the LS 130's Polarization Intensity Differential Scattering Assembly utilizes polarized light to provide the primary sized information for particles in the 0.1 to 0.4 micron range and enhances the resolution of the particle sized distributions of up to 1 micron. Measured particle range is 0.1 to 800 microns with a repeatability of <1% about mean size (repeat runs of same sample).

The dry sieve and laser particle size measurements then were combined to obtain the overall sample distribution.

LASER PARTICLE SIZE ANALYSIS

Bechtel

File: DAL-96497



Particle Size Distribution

	[U.S. Sieve]	Diameter [in]	[mm]	[phi]	Volume, % [Inc.]	[Cum.]
Coarse Sand	20	0.0331	0.84	0.25	0.00	0.00
	25	0.0280	0.71	0.50	0.00	0.00
	30	0.0232	0.59	0.75	0.00	0.00
	35	0.0197	0.50	1.00	0.00	0.00
Medium Sand	40	0.0165	0.42	1.25	0.00	0.00
	45	0.0138	0.35	1.50	0.28	0.28
	50	0.0118	0.30	1.75	2.36	2.64
	60	0.0098	0.25	2.00	5.98	8.62
Fine Sand	70	0.0083	0.210	2.25	8.90	17.52
	80	0.0070	0.177	2.50	10.31	27.83
	100	0.0059	0.149	2.75	11.01	38.84
	120	0.0049	0.125	3.00	10.52	49.36
Very Fine Sand	140	0.0041	0.105	3.25	8.01	57.37
	170	0.0035	0.088	3.50	4.52	61.89
	200	0.0029	0.074	3.75	1.81	63.70
	230	0.0025	0.063	4.00	0.69	64.39
Silt	270	0.0021	0.053	4.25	0.93	65.32
	325	0.0017	0.044	4.50	1.80	67.12
	400	0.0015	0.037	4.75	2.42	69.54
	450	0.0012	0.031	5.00	2.66	72.20
	500	0.0010	0.025	5.32	3.25	75.45
	635	0.0008	0.020	5.64	2.87	78.32
		0.00061	0.0156	6.00	2.97	81.29
		0.00031	0.0078	7.00	7.92	89.21
		0.00015	0.0039	8.00	5.36	94.57
Clay		0.000079	0.0020	9.00	3.41	97.98
		0.000039	0.00098	10.0	1.57	99.55
		0.000019	0.00049	11.0	0.41	99.96
		0.0000094	0.00024	12.0	0.04	100.00
		0.0000047	0.00012	13.0	0.00	100.00
		0.0000039	0.00010	13.3	0.00	100.00

Sorting Statistics

Parameter	[Moment]	[Trask]	[Inman]	[Folk]
Mean, in	0.0047	0.0027	0.0020	0.0027
Mean, mm	0.1195	0.0692	0.0520	0.0694
Mean, phi	3.0649	3.8529	4.2657	3.8493
Median, in	0.0048	0.0048	0.0048	0.0048
Median, mm	0.1236	0.1236	0.1236	0.1236
Median, phi	3.0162	3.0166	3.0166	3.0166
Std Deviation, in	0.0035	0.0141	0.0094	0.0099
Std Deviation, mm	0.0900	0.3603	0.2403	0.2548
Std Deviation, phi	3.4736	1.4725	2.0573	1.9727
Skewness	0.3030	1.4095	0.9567	0.6195
Kurtosis	-0.8960	0.2794	0.5143	0.8986
Mode, mm	0.1525			
95% Confidence	0.1018			
Limits, mm	0.1371			
Variance, mm2	0.0081			
Coef. of Variance, %	75.35			

Percentiles [volume, %]	Particle Diameter [in]	[mm]	[phi]
5	0.0107	0.2737	1.8695
10	0.0095	0.2431	2.0402
16	0.0084	0.2164	2.2084
25	0.0072	0.1853	2.4321
50	0.0048	0.1236	3.0166
75	0.0010	0.0258	5.2737
84	0.0005	0.0125	6.3230
90	0.0003	0.0072	7.1252
95	0.0001	0.0036	8.1003

Core Laboratories

SUMMARY OF SOILS TEST PROGRAM RESULTS

Bechtel

File: DAL-96497

Sample I.D.	Permeability to Liquid,		Hydraulic Conductivity,		Permeability to Air,	Moisture Content,	Bulk Density,
	millidarcys	cm^2	m/sec	m/year	millidarcys	cc/cc	g/cc
193-MW-4 5'-7'	5.94E-02	5.87E-13	5.93E-10	1.87E-02	3.47E+02	0.437	2.01

Core Laboratories

SUMMARY OF PERMEABILITY TO LIQUID TEST RESULTS

Fluid: Tap Water

Bechtel

File: DAL-96497

Sample I.D.	Length, cm	Area, cm²	Viscosity, cp	Differential Pressure, psi	Incremental Volume, ml	Incremental Time, sec	Permeability to Liquid,	
							millidarcys	cm²
193-MW-4 5'-7'	2.98	4.99	0.97	50.0	4.29	12300.	5.94E-02	5.87E-13

Core Laboratories

SUMMARY OF HYDRAULIC CONDUCTIVITY CALCULATIONS

Fluid: Tap Water

Bechtel

File: DAL-96497

Sample I.D.	Length, m	Area, m^2	Viscosity, cp	Differential Pressure, m H2O	Quantity of Flow, m^3	Incremental Time, sec	Hydraulic Conductivity, m/sec	Hydraulic Conductivity, m/year
193-MW-4 5'-7'	2.98E-02	4.99E-04	9.70E-01	3.52E+01	4.29E-06	1.23E+04	5.93E-10	1.87E-02

Core Laboratories

SITE ASSESSMENT TESTING METHODS

Bechtel

File: DAL-96497

Test Description	Procedure
Moisture Content	ASTM D2216
Particle Size Analysis	ASTM D422
Intrinsic Permeability	ASTM D5084
Bulk Density	Gravimetric and Volumetric Determination
Air Permeability	Steady-State Air Pemeameter

Sample ID/Location
Cross Reference Index

Sample ID	Station ID	Sample Matrix	Parameters
PI1618001	193-1MW-D	WATER	VOCs
PI1618101	193-1MW-S	WATER	VOCs
PI1618201	193-2MW-D	WATER	VOCs
PI1618303	193-2MW-S	WATER	VOCs
PI1618403	193-3MW-D	WATER	VOCs
PI1618503	193-3MW-S	WATER	VOCs
PI1618601	193-4MW-D	WATER	VOCs
PI1618701	193-4MW-S	WATER	VOCs
PI1618803	193-5MW-D	WATER	VOCs
PI1618902	193-5MW-S	WATER	VOCs
PI1618004	193-1MW-D	WATER	Chloride, Sulfate, Nitrate
PI1618104	193-1MW-S	WATER	Chloride, Sulfate, Nitrate
PI1618204	193-2MW-D	WATER	Chloride, Sulfate, Nitrate
PI1618304	193-2MW-S	WATER	Chloride, Sulfate, Nitrate
PI1618404	193-3MW-D	WATER	Chloride, Sulfate, Nitrate
PI1618504	193-3MW-S	WATER	Chloride, Sulfate, Nitrate
PI1618604	193-4MW-D	WATER	Chloride, Sulfate, Nitrate
PI1618704	193-4MW-S	WATER	Chloride, Sulfate, Nitrate
PI1618804	193-5MW-D	WATER	Chloride, Sulfate, Nitrate
PI1618904	193-5MW-S	WATER	Chloride, Sulfate, Nitrate
PI1619601	193-7MW-D 5'-7'	SOIL	TOCs
PI1619701	193-7MW-D 1'-3'	SOIL	TOCs
PI1619801	193-7MW-D 17'-19'	SOIL	TOCs
PI1619901	193-8MW-D 1'-3'	SOIL	TOCs
PI1620001	193-8MW-D 5'-7'	SOIL	TOCs
PI1619004	193-6MW-D	WATER	Chloride, Sulfate, Nitrate
PI1619104	193-6MW-S	WATER	Chloride, Sulfate, Nitrate
PI1619204	193-7MW-D	WATER	Chloride, Sulfate, Nitrate
PI1619304	193-7MW-S	WATER	Chloride, Sulfate, Nitrate
PI1619404	193-8MW-D	WATER	Chloride, Sulfate, Nitrate
PI1619504	193-8MW-S	WATER	Chloride, Sulfate, Nitrate
PI1620201	193-6MW-D 1'-3'	SOIL	TOCs
PI1620301	193-6MW-D 5'-7'	SOIL	TOCs
PI1619602	193-7MW-D 5'-7'	SOIL	VOCs
PI1619702	193-7MW-D 1'-3'	SOIL	VOCs
PI1619902	193-8MW-D 1'-3'	SOIL	VOCs
PI1620002	193-8MW-D 5'-7'	SOIL	VOCs
PI1620101	Trip Blank	WATER	VOCs
PI1619001	193-6MW-D	WATER	VOCs
PI1619101	193-6MW-S	WATER	VOCs
PI1619201	193-7MW-D	WATER	VOCs
PI1619301	193-7MW-S	WATER	VOCs
PI1619401	193-8MW-D	WATER	VOCs
PI1619501	193-8MW-S	WATER	VOCs
PI1620202	193-6MW-D	SOIL	VOCs
PI1620302	193-6MW-D	SOIL	VOCs
PI1620402	Composite drill spoils	SOIL	VOCs
PI1620501	Trip Blank	WATER	VOCs

Hard copies of the analytical data and the Survey
are available upon request.

ATTACHMENT 4

GROUNDWATER MODELING

GROUNDWATER MODELING FOR PARRIS ISLAND DRY CLEANERS IN WELL STRIPPING

The model Visual Modflow Version 2.5 from Waterloo Hydrogeologic was used for this model. The runs is provided for a three well model.

Grid Properties

A 400 ft. by 400 ft area was modeled. The overall grid was a 10 ft. by 10 ft. The grid spacing was reduced to 5 ft. by 5 ft. in the area of the wells. The model used four layers. The total depth of the model was 18 feet.

Constant Head Boundaries

Constant head boundaries were used on all sides. The heads were sloped to match the gradient at the site of 0.003 ft/ft. This gave a water table drop of 1.7 feet across the model.

Aquifer Properties

Sirrine Environmental performed slug test on several wells across the Depot. These were used for an approximate Kx and Ky values. The Sirrine data is attached. The properties used in the model were:
Kx - 0.003 cm/sec
Ky - 0.003 cm/sec
Kz - 0.0003 cm/sec
Ss - 0.001 1/ft
Sy - 0.2
Eff. porosity - 0.2
Total porosity - 0.35

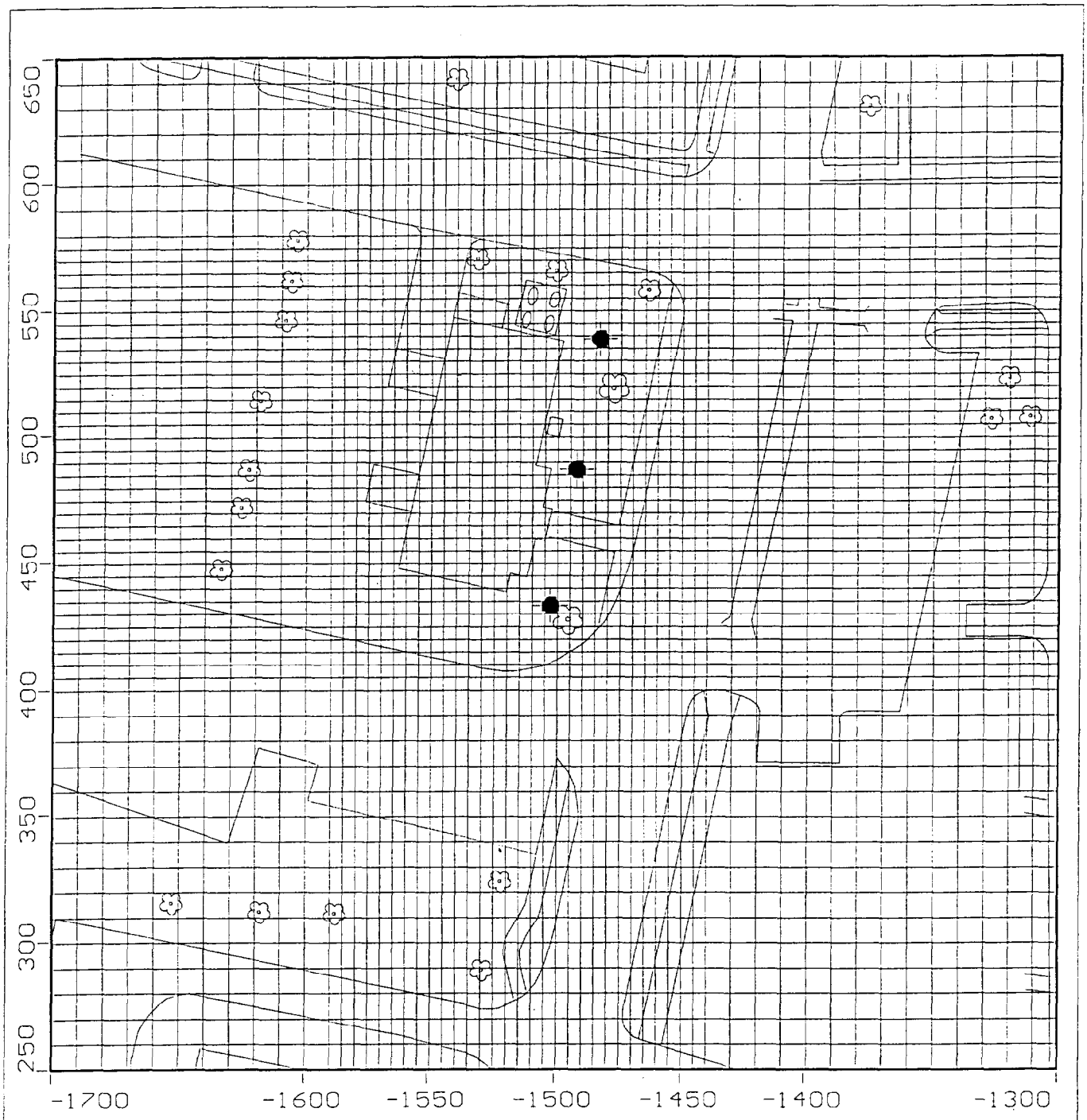
The rest of the properties are assumptions made for the model.

Wells

Wells were input into the model as 4" diameter with a ten foot screen. The flow rates used for the wells were 2 gpm.

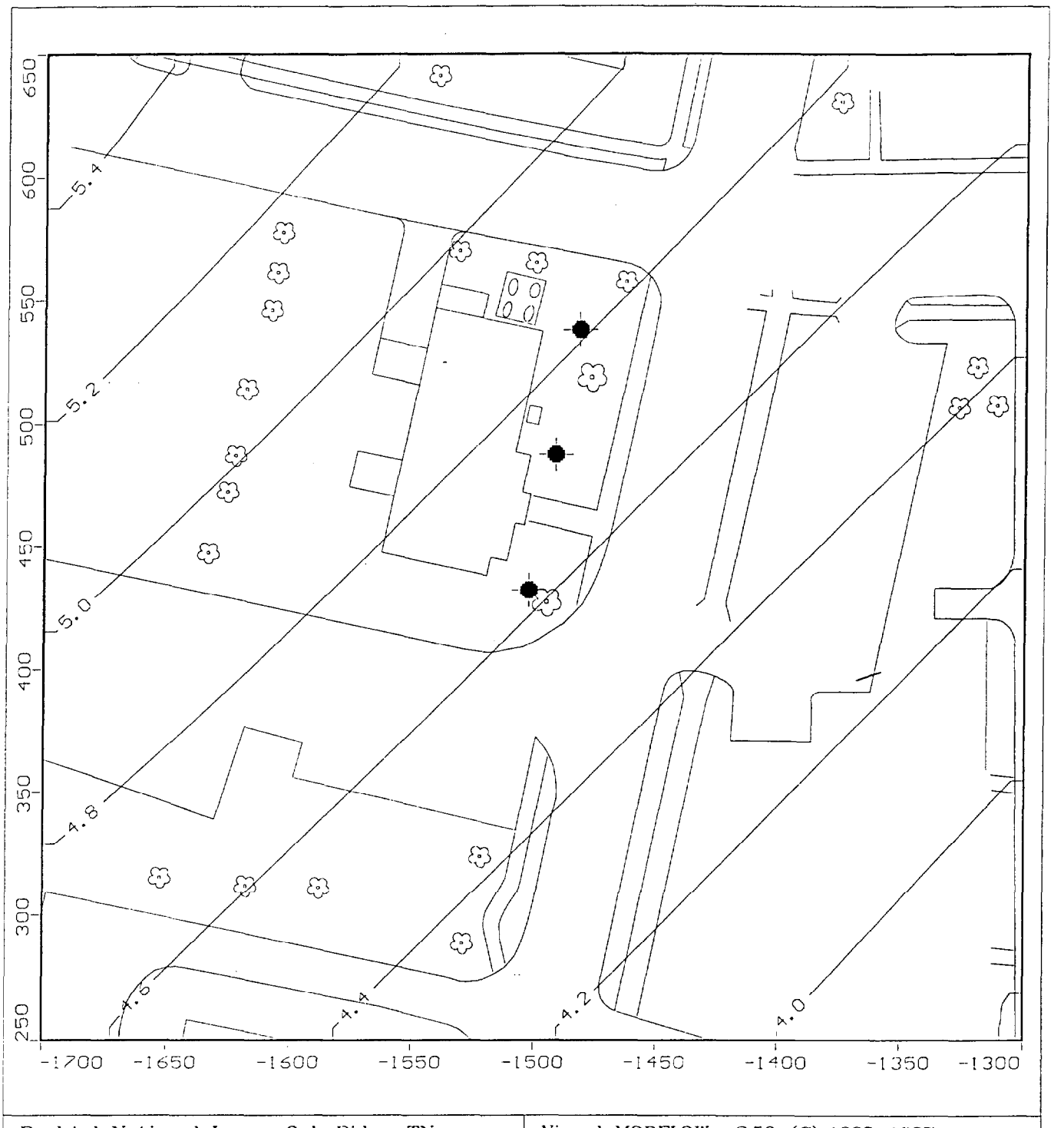
Results

The system will hydraulically control the site with a small pumping rate of 6 gpm total flow. Since the aquifer properties are not well know for the site, the remediation system will be sized for extra capacity.



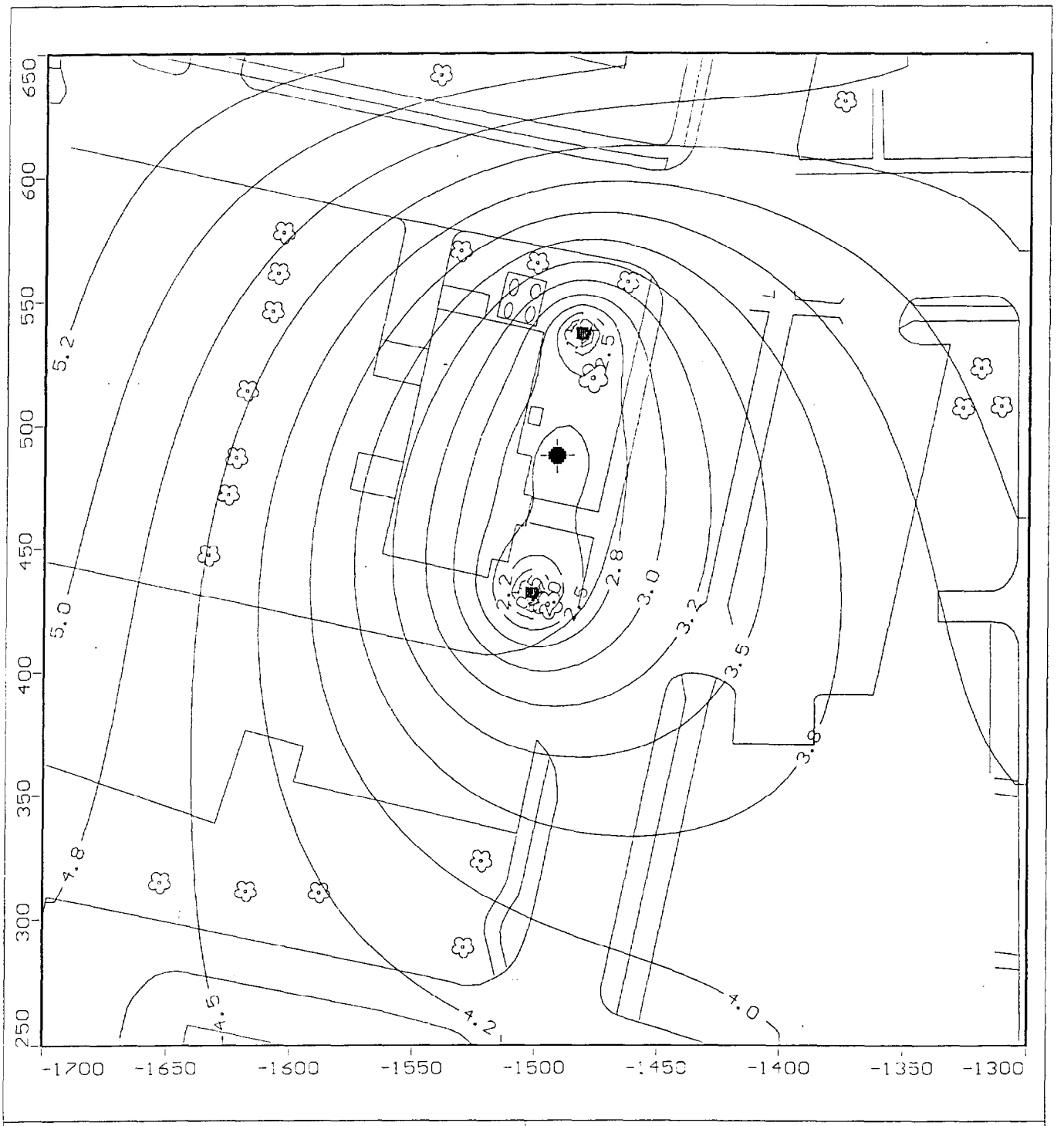
Bechtel National Inc. – Oak Ridge, TN
Project: PI Dry Cleaners
Description: 3 wells–2 gpm each
Modeller: Roy Hoekstra
15 Sep 97

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 55 NR: 58 NL: 4
Current Layer: 1



Bechtel National Inc. – Oak Ridge, TN
Project: PI Dry Cleaners
Description: Boundary Conditions
Modeller: Roy Hoekstra
15 Sep 97

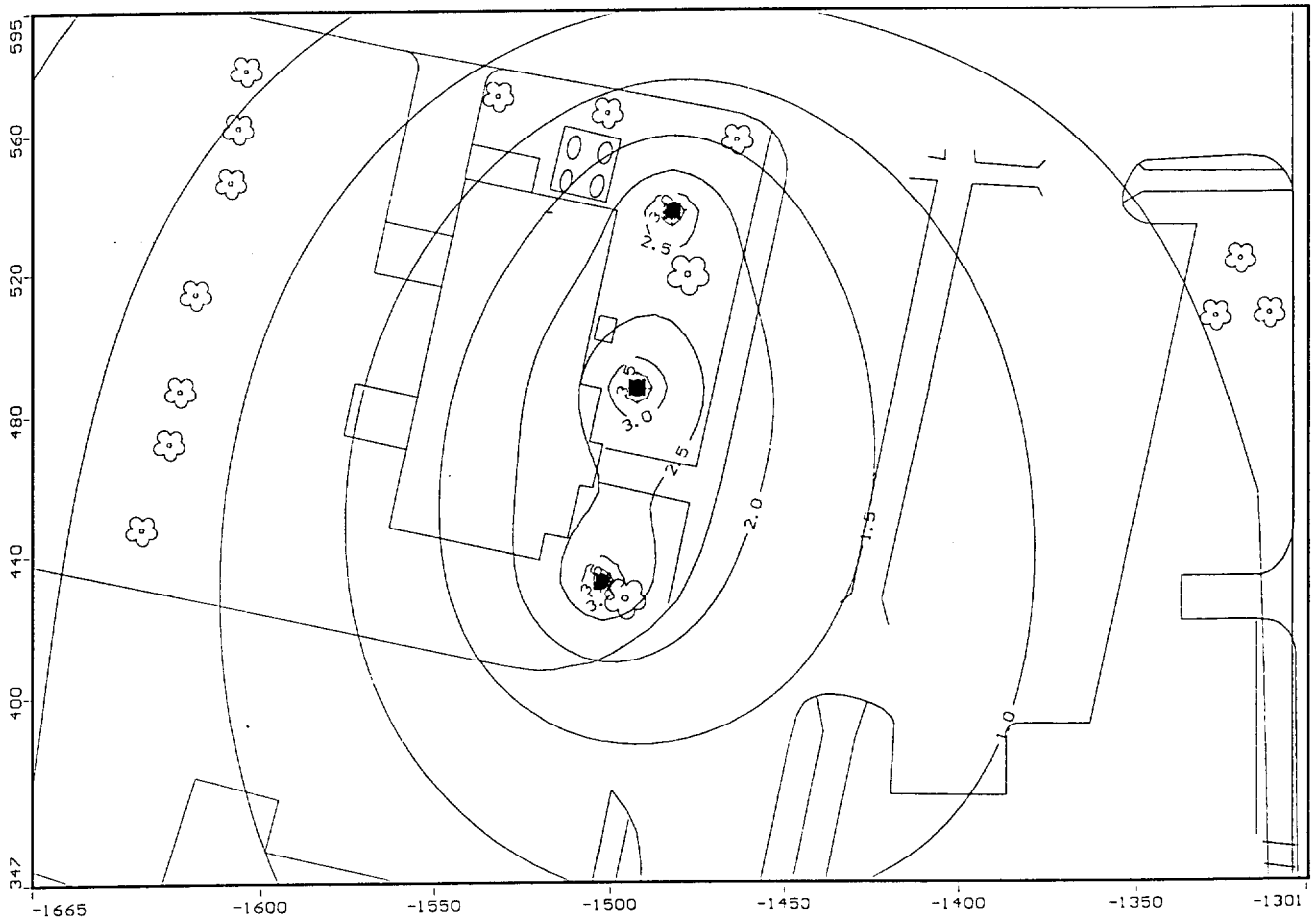
Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 55 NR: 58 NL: 4
Current Layer: 1



Bechtel National Inc. – Oak Ridge, TN
Project: PI Dry Cleaners
Description: 3 Wells – 2 GPM Each
Modeller: Roy Hoekstra
15 Sep 97

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 55 NR: 58 NL: 4
Current Layer: 1

ELEVATIONS - TOP OF WATER



Bechtel National Inc. – Oak Ridge, TN
Project: PI Dry Cleaners
Description: 3 wells–2 gpm each
Modeller: Roy Hoekstra
11 Sep 97

Visual MODFLOW v.2.50, (C) 1995–1997
Waterloo Hydrogeologic Software
NC: 55 NR: 58 NL: 4
Current Layer: 1

DRAW DOWNS –

FINAL

Contamination Assessment Report
Marine Corps Recruit Depot
Parris Island, South Carolina

April, 1991

Contract N62467-88-D-0655
Amendment 4

Prepared By
Sirrine Environmental Consultants, Inc.
2694A Lake Park Drive
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Project C9295

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4/15/91

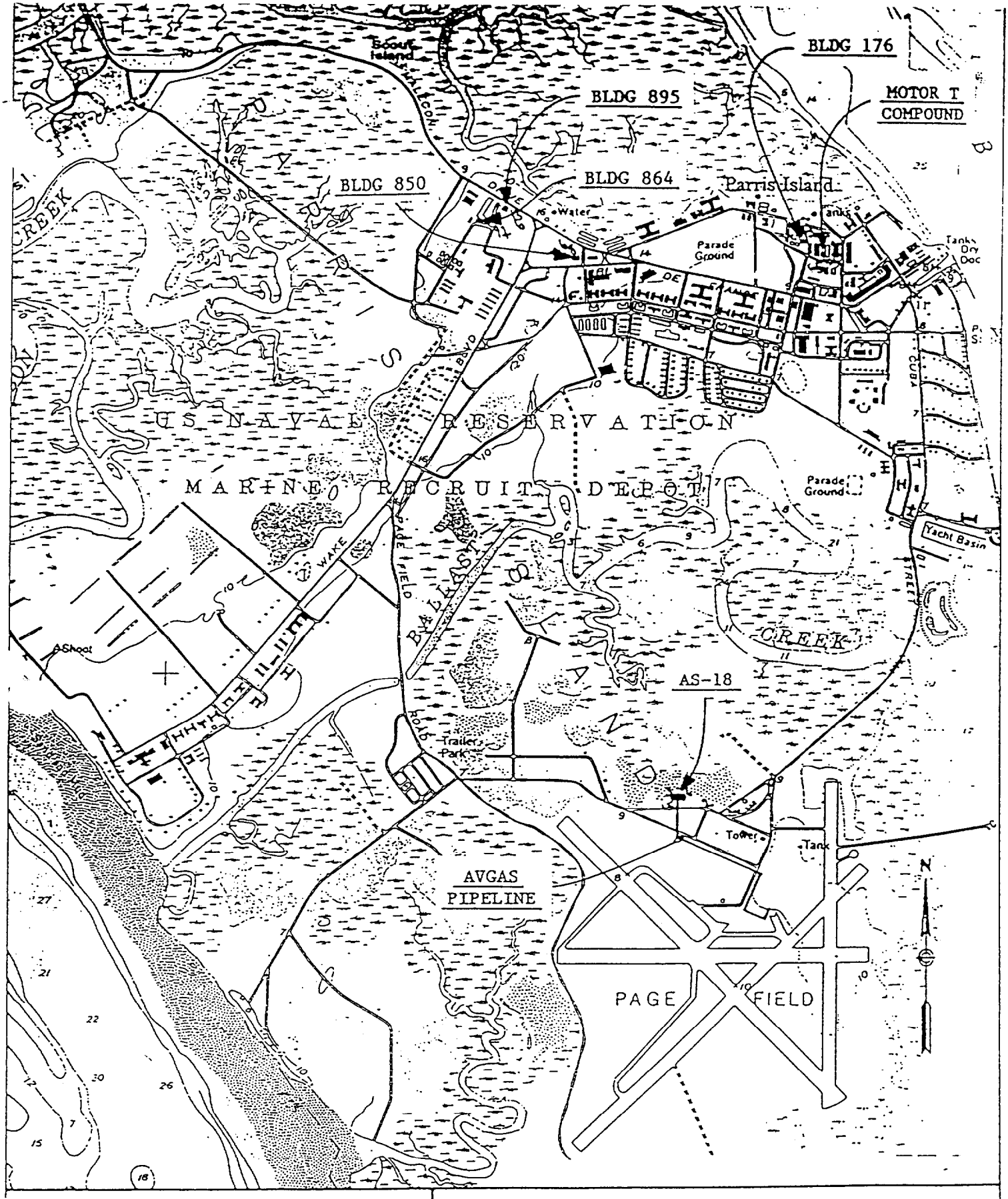

FIGURE 1-2

FACILITY LOCATIONS

CONTAMINATION ASSESSMENT

M C R D PARRIS ISLAND

4.5 Hydraulic Conductivity Tests

In-situ aquifer tests (slug tests) were performed for each well to determine site-specific hydraulic conductivity. These tests were conducted on 31 October, 1 November and 7 November, 1990. Hydraulic conductivities were calculated using a version of the method described by Bouwer and Rice (1979) and modified by Bouwer (1989). Plots of rising head data for each monitoring well are provided in Appendix C, the raw data are provided in Appendix D, and hydraulic conductivities are summarized in Table 4-4.

The equation used to calculate hydraulic conductivities from the slug test results was:

$$K = \frac{rc2\ln(Re/rw)}{2Le} \; 1/t \; \ln y_o/y_t$$

where: $$\ln Re/rw = \left[\frac{1.1}{[\ln(Lw/rw)} + \frac{A+B\ln[(H-Lw)/rw]}{Le/rw}\right]^{-1}$$

where:

K	=	hydraulic conductivity (ft/sec)
rc	=	radius of casing (ft)
Re	=	effective radial distance of drawdown (ft)
rw	=	radial distance of undisturbed aquifer (ft)
Le	=	length of screen (ft)
t	=	time (sec)
y_o	=	drawdown at time 0 (ft)
y_t	=	drawdown at time t (ft)
Lw	=	height of water column in well (ft)
A	=	function of Le/rw (dimensionless)
B	=	function of Le/rw (dimensionless)
H	=	head (ft)

For example, the hydraulic conductivity for well PAI-157-1 was calculated as follows:

Lw = 3.95 ft	Y_o = 0.51 ft
rw = 0.33 ft	t = 60 sec
Le = 3.95 ft	y_t = 0.34 ft
H = 14.46 ft	ln(re/rw) = 1.58
A = 1.2	rc = 0.19 ft
B = 0.3	K = 5.16 x 10^{-5} ft/sec

TABLE 4-4

FIELD HYDRAULIC CONDUCTIVITIES[1]
MCRD Parris Island

Well ID	Yo[1]	Yt[1]	t[1]	K ft/sec	K ft/day	K cm/sec	T ft²/day[2]
PAI-157-1	0.51	0.34	60	5.16E-5	4.46	1.57E-3	156
PAI-157-2	1.10	0.64	60	6.64E-5	5.74	2.02E-3	201
PAI-157-3	1.10	0.55	60	8.41E-5	7.26	2.56E-3	254
PAI-176-1	0.50	0.33	60	5.29E-5	4.57	1.61E-3	160
PAI-850-4	0.42	0.21	60	6.37E-5	5.50	1.94E-3	193
PAI-850-5	0.30	0.11	60	9.23E-5	7.97	2.81E-3	279
PAI-850-6	0.33	0.18	60	5.63E-5	4.86	1.72E-3	170
PAI-864-1	0.81	0.30	60	9.18E-5	7.93	2.80E-3	278
PAI-895-1	0.20	0.03	60	1.55E-4	13.36	4.71E-3	468
PAI-895-2	0.20	0.05	60	1.02E-4	8.83	3.11E-3	309
PAI-895-3	0.21	0.07	60	7.87E-5	6.80	2.40E-3	238
PAI-AS18-4	0.32	0.20	60	3.21E-5	2.77	9.77E-4	97
PAI-AS18-5	0.36	0.20	60	6.27E-5	5.42	1.91E-3	190
PAI-AS18-6	0.53	0.23	60	5.28E-5	4.56	1.61E-3	160
PAI-AS18-7	0.55	0.30	60	7.17E-5	6.19	2.18E-3	217
PAI-AS18-8	0.47	0.19	60	7.73E-5	6.68	2.36E-3	234
PAI-AS18-9	0.32	0.20	60	5.53E-5	4.78	1.69E-3	167
PAI-AS18-10	0.28	0.17	60	4.44E-5	3.84	1.35E-3	135
PAI-AS18-11	1.15	0.45	60	8.71E-5	7.52	2.65E-3	263
PAI-AS18-12	0.30	0.18	60	3.18E-5	2.75	9.70E-4	96

(1) Yo and Yt measured in feet, time (t) measured in seconds

(2) Saturated thickness assumed to be 35 feet

AN APPROXIMATE VALUE OF 3×10^{-3} WAS USED FOR THE MODELING

ATTACHMENT 5

AIR EMISSIONS

DEC 3 1997

Sub Job 048 Rec Type LT Comm Date 14-NOV-97 Admin Rec N CCN-Item No. 000098-1

Subject DO#0048 PERMIT DETERMINATION FOR AIR STRIPPER AT MCRD PARRIS ISLAND DRY CLEANING FACILITY

From DANTZLER, K. Org DHEC To HOEKSTRA, R. Org BEI File Loc M Closes CCN

Comm Reference Published N

Cross Reference (Affected Doc) DO#0048 Field CCN

Site Codes 145

Subject Codes 1020 7550 Film Reel

Owed By Org Due Date Closing CCN

Owed To Org Forecast Date Compl Date

Comment/Action

000098-1-860000

DISTRIBUTION		WA	WO	DISTRIBUTION	WA	WO	DISTRIBUTION		WA	WO
PROGRAM MGR	P. W. TOMICZEK						NAVY SouthDiv:	E. G. BALL		
PROG MGR SCTY	D. MOORE							S. BERRY		
PROJ MGRS	M McNEIL							B. HILL		
	T. CONRAD							M. HERRON		
	K. ATCHLEY	/						K. LOTT		
	V. H. BAUER							R. MEDDICK		
	R. J. COHOSE							B. GATES		
	L. M. SIMS							D. GASKINS		
PROJECT ENGINEERS	J. R. MANNING							B. GLOVER		
P.E.	D. OBENAUER							B. KIZER		
P.E.	R. HOEKSTRA	/						D. PATRICK		
SITE SUPERINTENDENTS	E. NAJMOLA							G. TURNER		
	W. HEVRDEYS	/								
	G. RHODES									
	S. MOORE									
{FIELD PDCC}	A. MASSEY									
DATA MGMT	L. DAVENPORT						ABB-ES			
S&H MANAGER	R. W. THOMPSON						ENSAFE			
ENVIR COMPLIANCE	R. ATWOOD						BROWN & ROOT			
CONTRACT ADM MGR	TIM STONE						RUST ENVIR			
FIELD PROCUREMENT	S. WEINMAN									
PROJ CTRLS MGR	C. J. PERRY			REFERENCE LIBRARY			SUBCONTRACTORS:			
	F. McGhee	/								
				75-YEAR RECORD FILE			GEL			
ACCTNG	E. FARMER/K. COURTNEY			SENSITIVE FILE			GTI			
FIELD QC MGR	J. A. GRISSETT			SUBMITTAL FILE			INCHCAPE			
PROJECT ADMINISTRATOR	L. LANDERS									
RECORDS MGMT	B. STOUT			PDCC FILE	1		MEI			

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA

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11/24/97

D H E C

PROMOTE PROTECT PROSPER

145- 0002

2600 Bull Street
Columbia, SC 29201-1708

COMMISSIONER:
Douglas E. Bryant

BOARD:
John H. Burriss
Chairman

William M. Hull, Jr., MD
Vice Chairman

Roger Leaks, Jr.
Secretary

Mark B. Kent

Cyndi C. Mosteller

Brian K. Smith

Rodney L. Grandy

November 14, 1997

Mr. Roy Hoekstra
Bechtel Environmental, Inc.
P.O. Box 350
Oak Ridge, Tennessee 37831-0350

Re: Permit determination for air stripper at the MCRD, Parris Island Dry Cleaning Facility: File 0360-0002

Dear Mr. Hoekstra

The Department has received your letter dated November 10, 1997, requesting a permit determination be made for a pump and treat system at the Marine Corps Recruiting Depot, Parris Island Dry Cleaning facility. At this time the Department has determined that a construction permit will not be needed. This determination has been made based upon the information submitted in the above request. All air toxic emissions fall well below modeling and permitting de minimus levels. If there are any changes in the process which might increase the potential release of any regulated air pollutant, the Department must be notified in advance of such change.

If you have any further questions, feel free to contact me at (803) 734-9339.

Sincerely,

Ken Dantzler

Ken Dantzler
Engineering Services Division
Bureau of Air Quality

cc: Commanding General, U.S. Marine Recruit Depot
Jennifer Minor, Low Country EQC District

DEC 1 1997

NAVRAC PROJECT, JOB# 22567 CCN: 145- 0
DO# 0048 SITE CODE 145 DATE RCV'D: NOV 10

Sub Job 048 **Rec Type** LT **Comm Date** 10-NOV-97 **Admin Rec** N **CCN-Item No.** 00009

Subject DO#0048 AIR PERMITTING REQUIREMENTS FOR MCRD PARRIS ISLAND, SC SITE 45 SWMU 45 DR CLEANER'S FACILITY, IRA

From HOEKSTRA, R. **Org** BEI **To** DANTZLER, K. **Org** DHEC **File Loc** M **Closes CCN**

Comm Reference **Published** N

Cross Reference (Affected Doc) DO#0048 **Field CCN**

Site Codes 145

Subject Codes 7510 **Film Reel**

Owed By **Org** **Due Date** **Closing CCN**

Owed To **Org** **Forecast Date** **Compl Date**

Comment/Action

000097-1

DISTRIBUTION		WA	WO	DISTRIBUTION		WA	WO	DISTRIBUTION		WA	WO
PROGRAM MGR	P. W. TOMICZEK		1	K. DANTZLER (SCDHEC)		ORIG*		NAVY SouthDiv:	E. G. BALL		
PROG MGR SCTY	D. MOORE								S. BERRY		
PROJ MGRS {CHS/PEN}	K. ATCHLEY	1		A. SANFORD (SDIV)		1 (SDIV POUCH 11/10/97)			M. E. HERRON		
{CF/JAX/MAY/KB}	V. H. BAUER			T. HARRINGTON (MCRD)		1 (REGMAIL)			K. LOTT		
{ALB/ATH} KW/ORL}	R. J. COHOSE								R. MEDDICK		
									M. DAVIDSON		
{MAY/NELP}	L. M. SIMS								D. GASKINS		
PROJECT ENGINEER	J. R. MANNING								B. GLOVER		
P.E. {CF/JAX/MAY}	D. OBENAUER								B. KIZER		
P.E. {KW/PI}	R. HOEKSTRA	1							D. PATRICK		
SITE SUPERINTENDENTS	E. NAIMOLA								G. TURNER		
{JAX}	G. RHODES								N. UGOLINI		
{MAY}	S. MOORE										
{CF/JAX/MAY/KB}	J.STONE										
{CF}								ROICCs			
{NELP REP}	V. McCAIN										
{FIELD PDCC}	T. JENKINS										
DATA MGMT	L. DAVENPORT							ABB-ES			
S&H MANAGER	R. W. THOMPSON							ENSAFE			
ENVIR COMPLIANCE	R. ATWOOD							BROWN & ROOT			
CONTRACT ADM MGR	TIM STONE							RUST ENVIR			
FIELD PROCUREMENT	S. WEINMAN										
PROJ CTRLS MGR	C. J. PERRY			REFERENCE LIBRARY				SUBCONTRACTORS:			
FLD PROJ CTRLS SUPVSR	G.S. OSTROSKY			75-YEAR RECORD FILE				GEL			
ACCTNG	E. FARMER/K. COURTNEY			SENSITIVE FILE				GTI			
FIELD QC MGR	J. A. GRISSETT			SUBMITTAL FILE				INCHCAPE			
RECORDS MGMT	McKISSACK/STOUT			PDCC FILE	1			MEI			

*FED EX 11/10/97

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA

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8/18/97

145 - 00 - 78

Bechtel

Oak Ridge Corporate Center
151 Lafayette Drive
P.O. Box 350
Oak Ridge, Tennessee 37831-0350
Telephone: (423) 220-2000

NOV 10 1997

Ken Dantzler
Bureau of Air Quality
SCDHEC
2600 Bull St.
Colombia, SC 29201

SUBJECT: Bechtel Job No. 22567
Department of the Navy Contract No. N62467-93-D-0936
DO 0048: SITE 45/SWMU45, DRY CLEANERS FACILITY, INTERIM REMOVAL ACTION AIR PERMITTING REQUIREMENTS, MARINE CORPS RECRUITING DEPOT, PARRIS ISLAND, SOUTH CAROLINA
Subject Code: 7510

Dear Mr. Dantzler:

I spoke to you briefly a couple weeks ago to discuss the air permitting requirements for a pump and treat system that is being planned for the dry cleaner's facility at MCRD, Parris Island. You suggested that I gather the pertinent information and submit it to you for a determination if an air permit would be required.

A spill of tetrachloroethlene (PCE) occurred at this site in March 1994, when the storage tanks were overfilled. The Depot removed the contaminated soils, but the groundwater is contaminated at the site. An Interim Removal Action has been proposed to install a pump and treat groundwater remediation system to remove the central portion of the plume. The groundwater will be pumped from three wells and treated by air stripping prior to discharge to the Depot's wastewater treatment plant.

Enclosed, please find some very conservative calculations on the amount of air emissions that this system could generate (2.91 lbs/day or 87.3 lbs/month). These calculations are based on the latest groundwater sampling data. Normally, when systems like this start operation, the emissions will be the highest at the start and drop quickly with time. Also enclosed is Figure 1.5 detailing the latest groundwater data and the drawing showing the proposed recovery well locations.

If you have any questions, please feel free to call me at (423) 220-2271 or Karen Atchley at (423) 220-2167.

Sincerely,

Roy Hoekstra
Project Engineer

REH:dcm:LR1437
Enclosure: As stated

cc: A. Sanford (SouthDiv) w/enc.
T. Harrington (MCRD) w/enc.

Bechtel Environmental, Inc.

Estimate of Air Emissions from Pump and Treat Air Stripper - Dry Cleaners Facility - Parris Island

Levels of Contaminants in the monitoring wells in the center of the plume (ppb)

Contaminant	Well 8-MW	Well 7-MW	Well 6-MW
PCE	32,000	60,000	1,200
TCE	4,800	15,000	2,800
cis 1,2 DCE	1,100	3,800	220
trans 1,2 DCE	nd	nd	8.3
vinyl chloride	nd	nd	170
Total Solvents	37,900	78,800	4,398

avg = 40,400ppb or 40.4 ppm

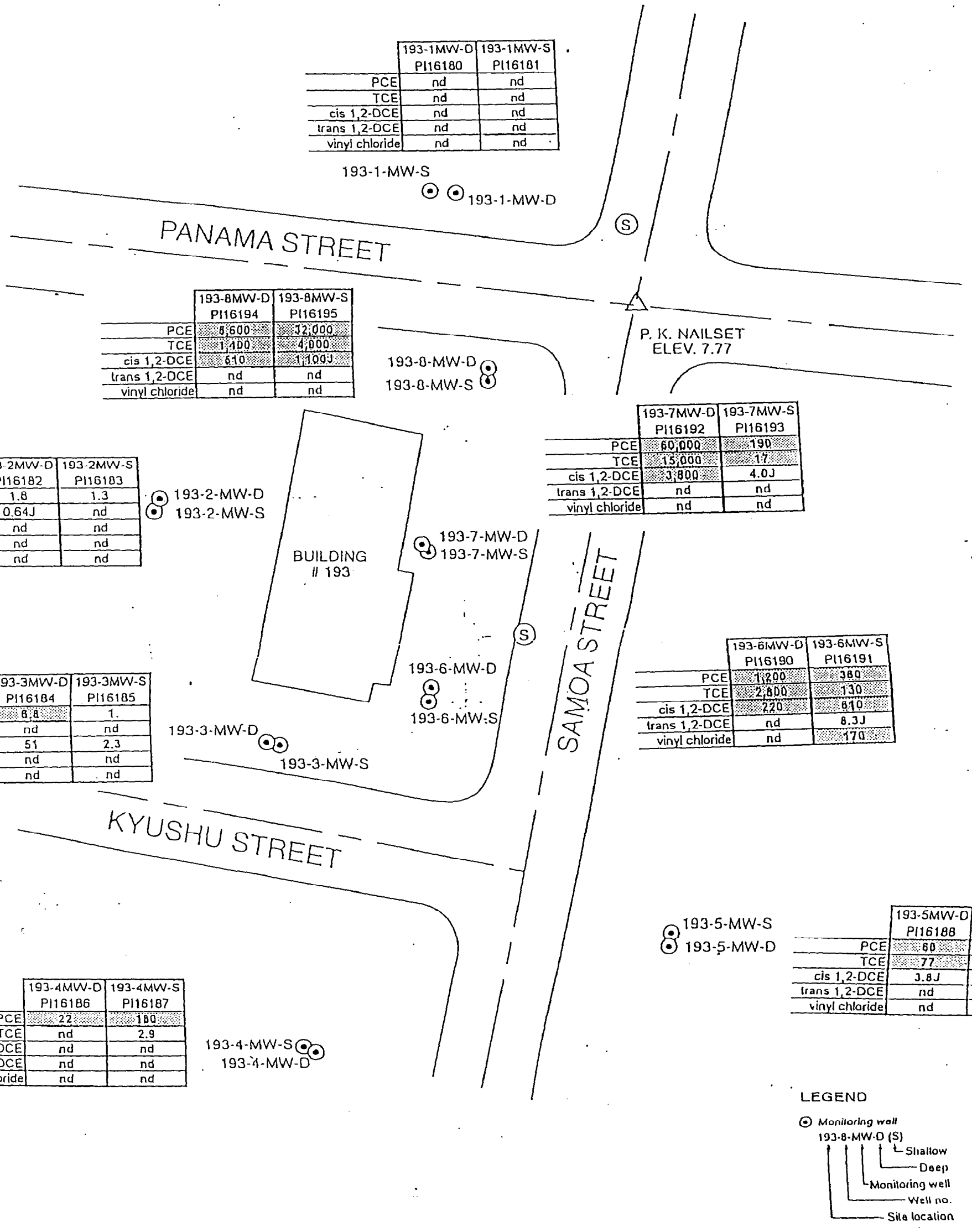
Assume pump and treat contamination levels to be the same as the monitoring wells.

Assume pumping rate of 2 gpm per well

Weight of water pumped in 24 hours at 6 gpm

6gpm x 8.34 lbs/gal x 60 minutes x 24 hours/day = 72,060 lbs/day

Air emissions per day = 72060 x 40.4/1,000,000 = 2.91 lbs/day or 87.3 lbs/month



	193-1MW-D PI16180	193-1MW-S PI16181
PCE	nd	nd
TCE	nd	nd
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-8MW-D PI16194	193-8MW-S PI16195
PCE	8,600	12,000
TCE	1,400	4,000
cis 1,2-DCE	610	1,100J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-7MW-D PI16192	193-7MW-S PI16193
PCE	60,000	190
TCE	15,000	17
cis 1,2-DCE	3,800	4.0J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-2MW-D PI16182	193-2MW-S PI16183
PCE	1.8	1.3
TCE	0.64J	nd
is 1,2-DCE	nd	nd
is 1,2-DCE	nd	nd
nyl chloride	nd	nd

	193-6MW-D PI16190	193-6MW-S PI16191
PCE	1,200	380
TCE	2,800	130
cis 1,2-DCE	220	610
trans 1,2-DCE	nd	8.3J
vinyl chloride	nd	170

	193-3MW-D PI16184	193-3MW-S PI16185
PCE	6.8	1.
TCE	nd	nd
cis 1,2-DCE	51	2.3
ns 1,2-DCE	nd	nd
nyl chloride	nd	nd

	193-5MW-D PI16188	193-5MW-S PI16189
PCE	60	52
TCE	77	84
cis 1,2-DCE	3.8J	2.6J
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

	193-4MW-D PI16186	193-4MW-S PI16187
PCE	22	180
TCE	nd	2.9
cis 1,2-DCE	nd	nd
trans 1,2-DCE	nd	nd
vinyl chloride	nd	nd

LEGEND

Monitoring well

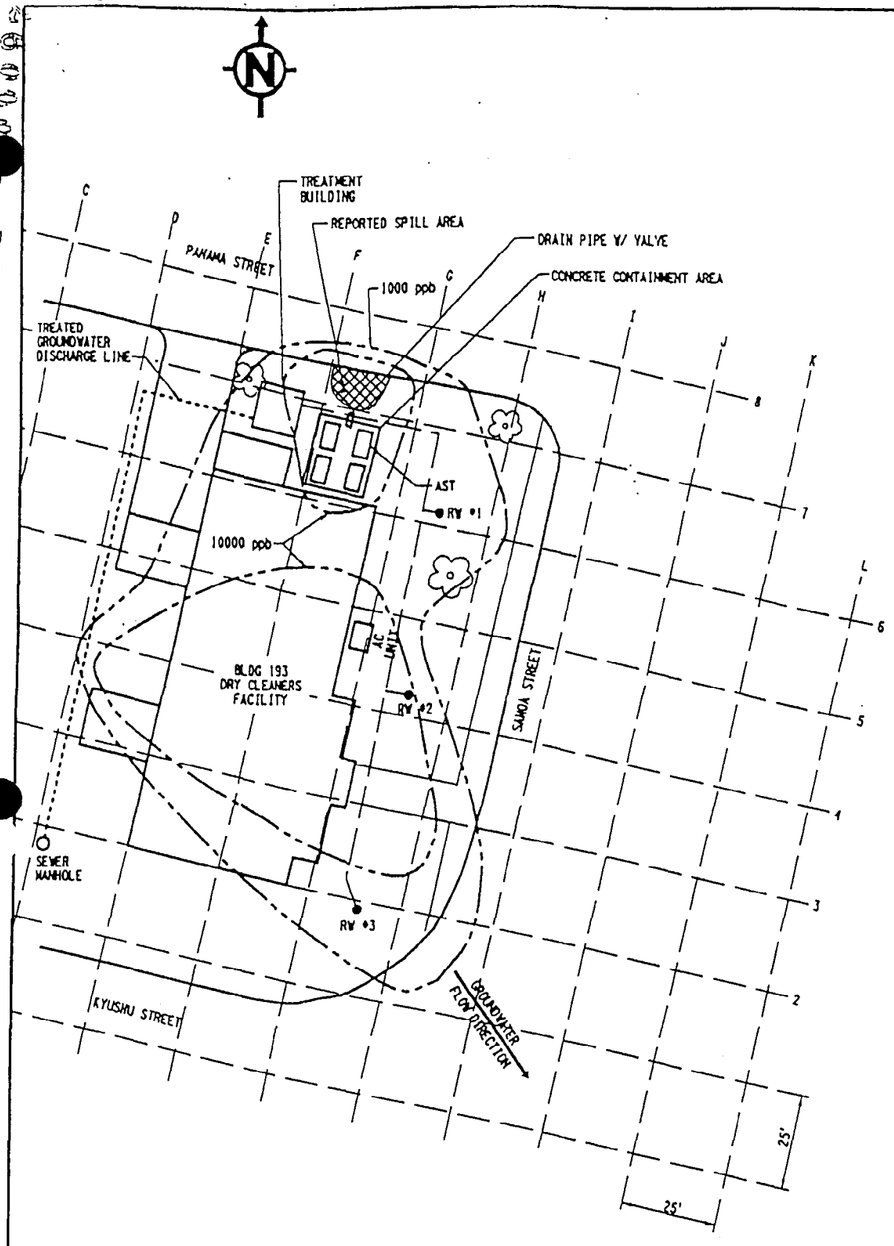
193-8-MW-D (S)

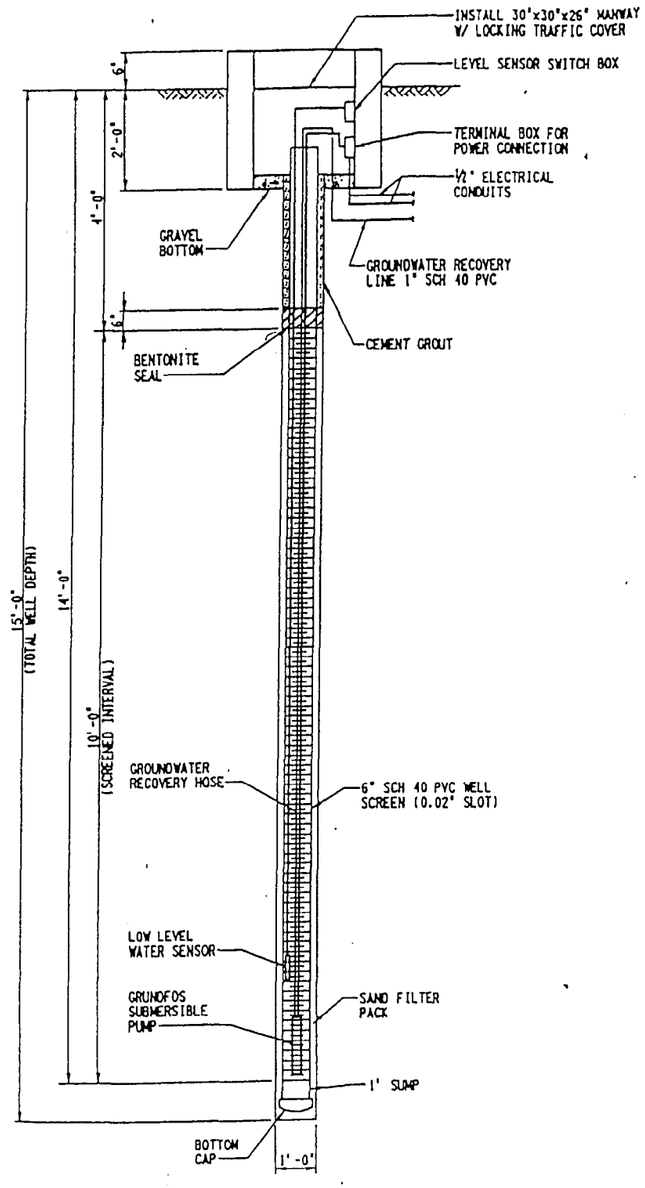
- Shallow
- Deep
- Monitoring well
- Well no.
- Site location

MCLs	Well ID Sample ID
PCE	5
TCE	5
cis 1,2-DCE	70
trans 1,2-DCE	100
vinyl chloride	2

All detections above MCLs are shaded.

Figure 1.5
Groundwater Analytical Results (ppb)
Site 45/SWMU 45
MCRD Dry Cleaners Facility





RECOVERY WELL PROFILE

NTS (3 REQUIRED)

NOTES

1. DEPTH OF SCREEN WILL BE ADJUSTED TO SET SCREEN ABOVE EXISTING CLAY LAYER.
2. PRIOR TO ADVANCING DRILL AUGERS THE DRILL HOLE SHALL BE ADVANCED 4' BELOW LAND SURFACE USING HAND TOOLS TO VERIFY THE ABSENCE OF UNDERGROUND INDUSTRIAL OR UTITLIY LINES.
3. LOCATIONS SHOWN FOR RECOVERY WELLS ARE APPROXIMATE. THEIR LOCATION WILL BE ADJUSTED TO AVOID CONFLICT WITH UNDERGROUND UTILITIES.
4. SCALE SHOWN ON THIS DRAWING IS BASED ON A DRAWING SIZE OF 22" X 34"; ANY REDUCTION IN DRAWING SIZE WILL REQUIRE AN APPROPRIATE ADJUSTMENT IN THE SCALE.

LEGEND

—— -	GRID LINE
●	RECOVERY WELL RW #
— —	UNDERGROUND AIR LINE
- ——	GROUNDWATER CONTAMINATION CONTOUR
ppb	PARTS PER BILLION

0 20 40 60

1"=20'

NO.	DATE	REVISIONS	BY	CHKD	REVIEW MGR	CHKD	PROJ ENGR	W/CRD FLND
C		ISSUED FOR REVIEW						
B	6/19/97	ISSUED FOR REVIEW IN WELL VAPOR STRIPPING						
A	3/12/97	ISSUED FOR REVIEW	RGB	WEH	FWB	FWB	JRH	

SCALE 1"=20' 22567 145 1450002.DGN

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
GROUNDWATER TREATMENT SYSTEM

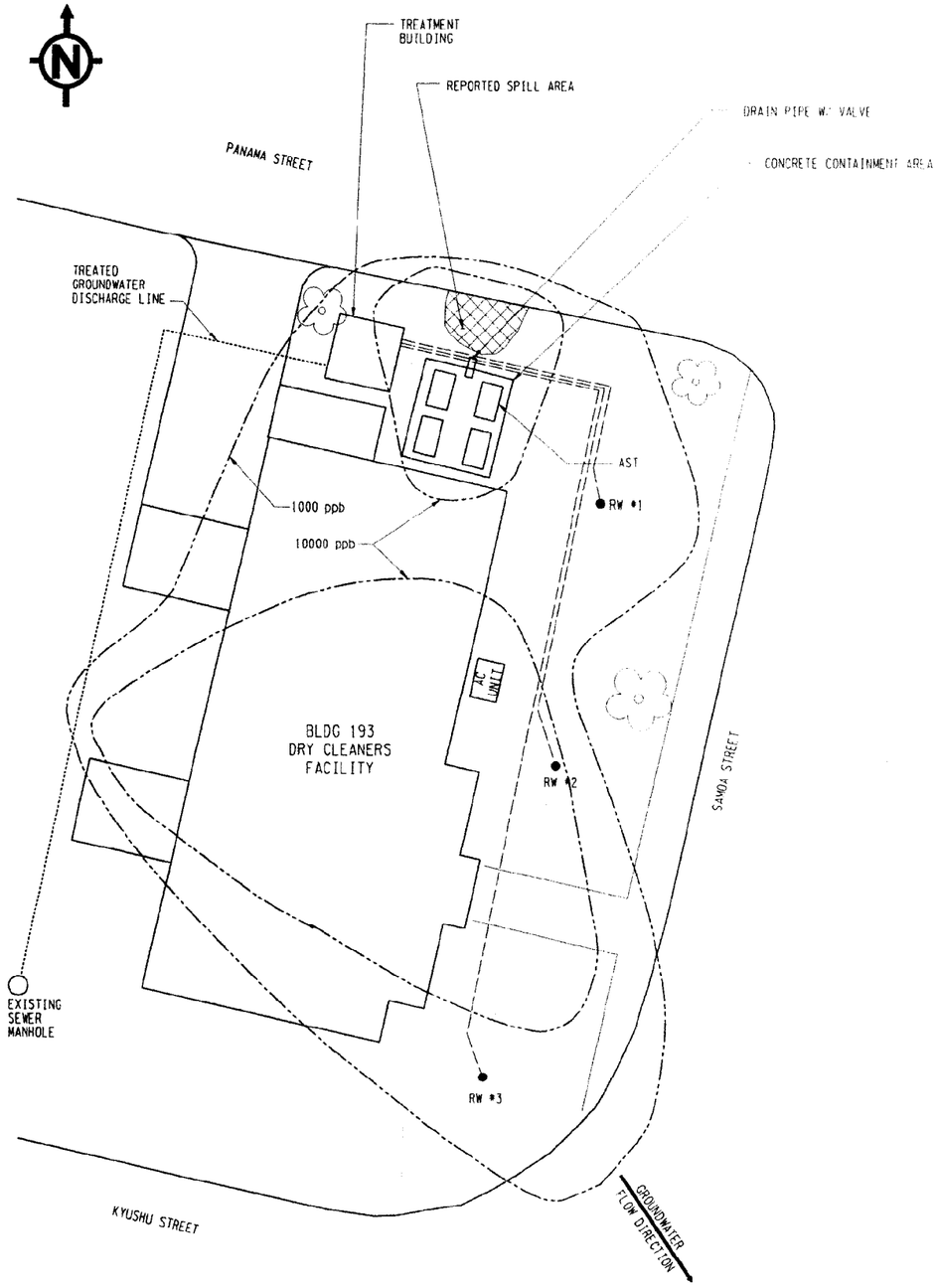
JOB NO.	DRAWING NO.	REV
22567	145-D000-002	C

22567/145/1450002.RGA

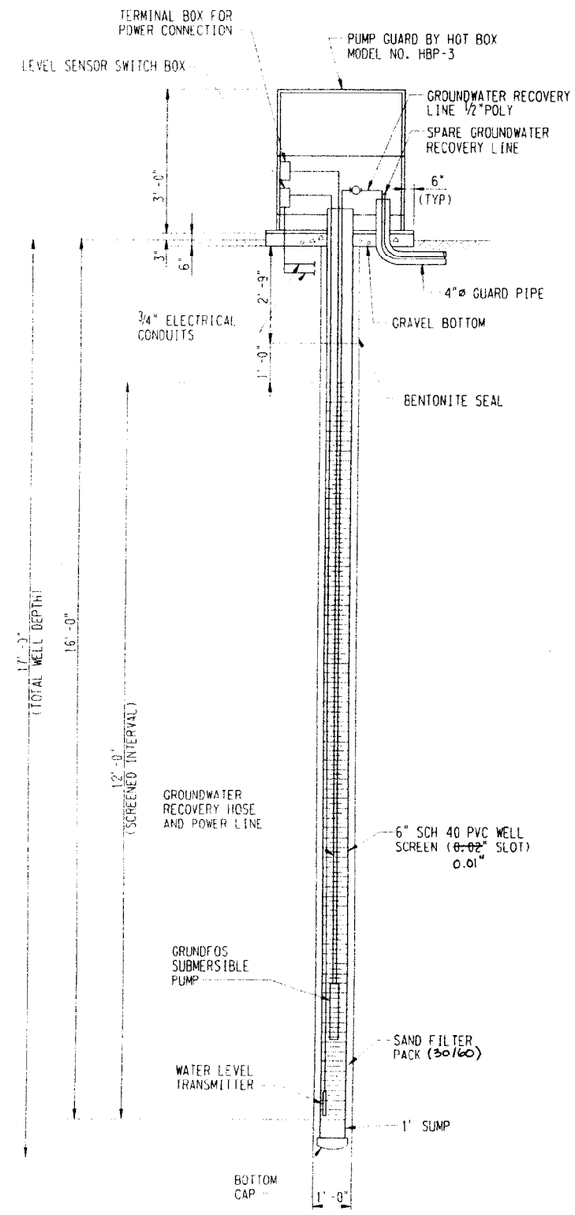
22 X 34

ATTACHMENT 6

CONSTRUCTION DRAWINGS



FACILITY PLAN
1"=15'-0"



RECOVERY WELL PROFILE
NTS (3 REQUIRED)

NOTES

1. DEPTH OF SCREEN WILL BE ADJUSTED TO SET SCREEN ABOVE EXISTING AQUITARD.
2. PRIOR TO ADVANCING DRILL AUGERS THE DRILL HOLE SHALL BE ADVANCED 4' BELOW LAND SURFACE USING HAND TOOLS TO VERIFY THE ABSENCE OF UNDERGROUND INDUSTRIAL OR UTITLIY LINES.
3. LOCATIONS SHOWN FOR RECOVERY WELLS ARE APPROXIMATE. THEIR LOCATION WILL BE ADJUSTED TO AVOID CONFLICT WITH UNDERGROUND UTILITIES.
4. SCALE SHOWN ON THIS DRAWING IS BASED ON A DRAWING SIZE OF 22" X 34"; ANY REDUCTION IN DRAWING SIZE WILL REQUIRE AN APPROPRIATE ADJUSTMENT IN THE SCALE.
5. LOCATION SHOWN FOR UNDERGROUND RECOVERY LINES ARE APPROXIMATE. THEIR LOCATIONS WILL BE ADJUSTED TO AVOID CONFLICT WITH UTILITIES AND TREES.
6. DEPTH OF UNDERGROUND RECOVERY LINES SHALL BE 12" MINIMUM.

REFERENCE DRAWINGS

GROUNDWATER TREATMENT SYSTEM P&ID	145-D000-007
GROUNDWATER EQUIPMENT BUILDING	145-D000-008
ELECTRICAL SYSTEM	145-D000-009
CONTROL SYSTEM	145-D000-010

LEGEND

- ● RECOVERY WELL RW #
- ---- UNDERGROUND GROUNDWATER RECOVERY LINE
- —·—·— GROUNDWATER CONTAMINATION CONTOUR
- ppb PARTS PER BILLION

NO.	DATE	REVISIONS	BY	CHKR	MISSION SUPV	ENGR	PROJ ENGR	MICRO FLMD
B		ISSUED FOR REVIEW FOR PUMP & TREAT SYSTEM						
A	3/12/97	ISSUED FOR REVIEW	RGB	WEH	FMB	FMB	JRM	

SCALE NOTED 22567 145 1450002.DGN

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

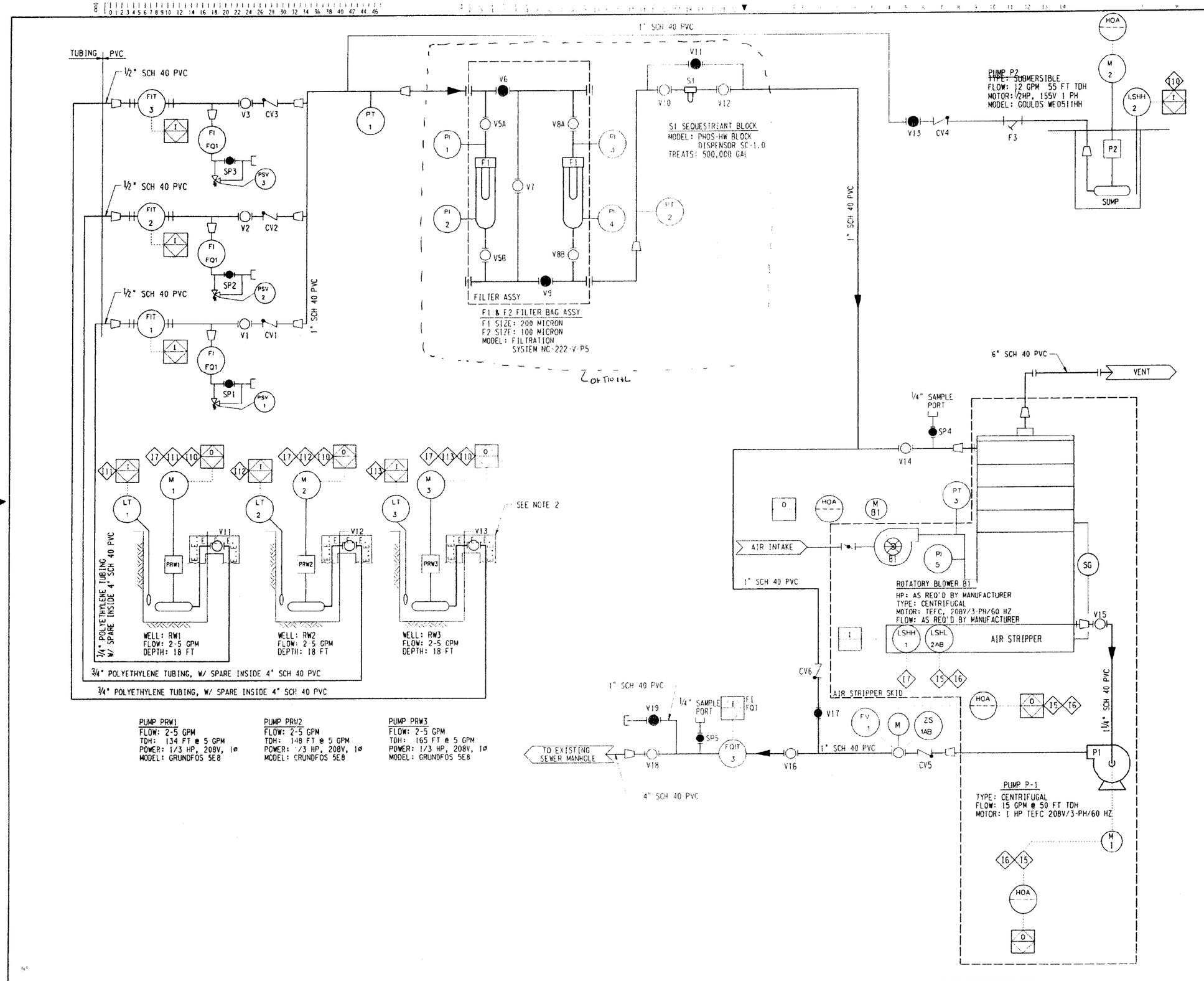
DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
GROUNDWATER TREATMENT SYSTEM

JOB NO.	DRAWING NO.	REV
22567	145-D000-002	B

22567/145/1450002.DGN

22 X 34



NOTES

1. FIT 1 THROUGH FIT 3 MUST BE INSTALLED IN VERTICAL RUN OF PIPE.
2. POWER FEED WILL BE INSTALLED TO EACH WELL FOR FUTURE HEAT TRACE INSTALLATION (IF NEEDED).

LEGEND

INTERLOCKS

I5 - AIR STRIPPER SUMP LOW
I6 - AIR STRIPPER SUMP HIGH
I7 - AIR STRIPPER SUMP HIGH HIGH
I10 - SUMP HIGH HIGH LEVEL
I11 - WATER LEVEL AT P1
I12 - WATER LEVEL AT P2
I13 - WATER LEVEL AT P3

NO.	DATE	REVISIONS	BY	CHKR	DESIGN SUPV	ENGR	PROJ ENGR	MICRO FLMD
A		ISSUED FOR REVIEW						

SCALE NOTED

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

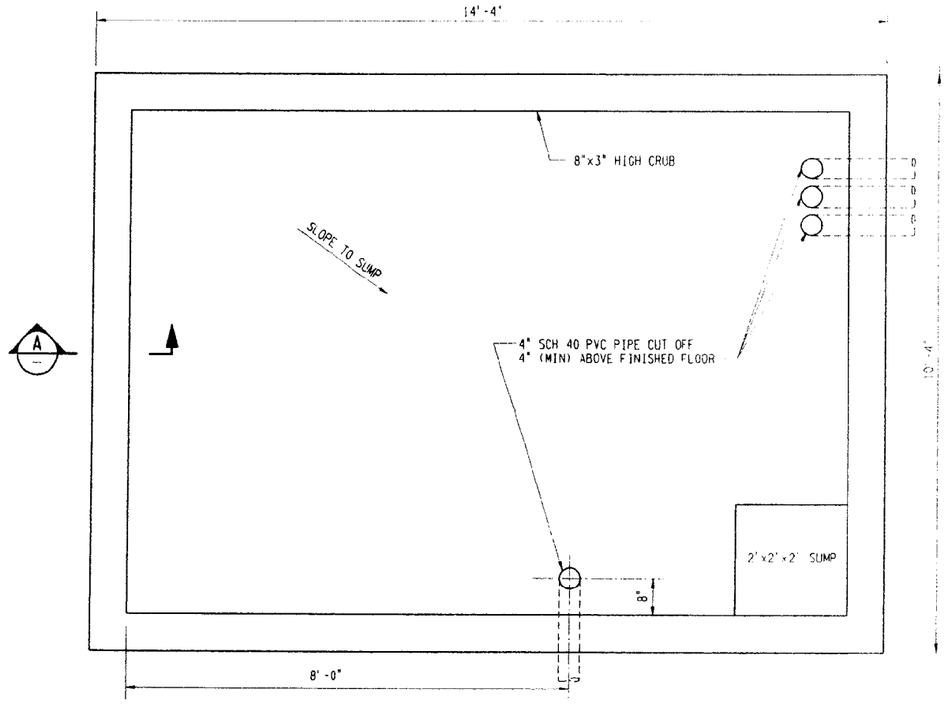
DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
GROUNDWATER TREATMENT SYSTEM P & ID

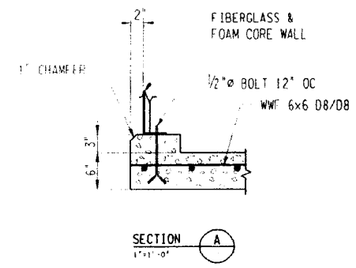
JOB NO.	DRAWING NO.	REV
22567	145-D000-007	A

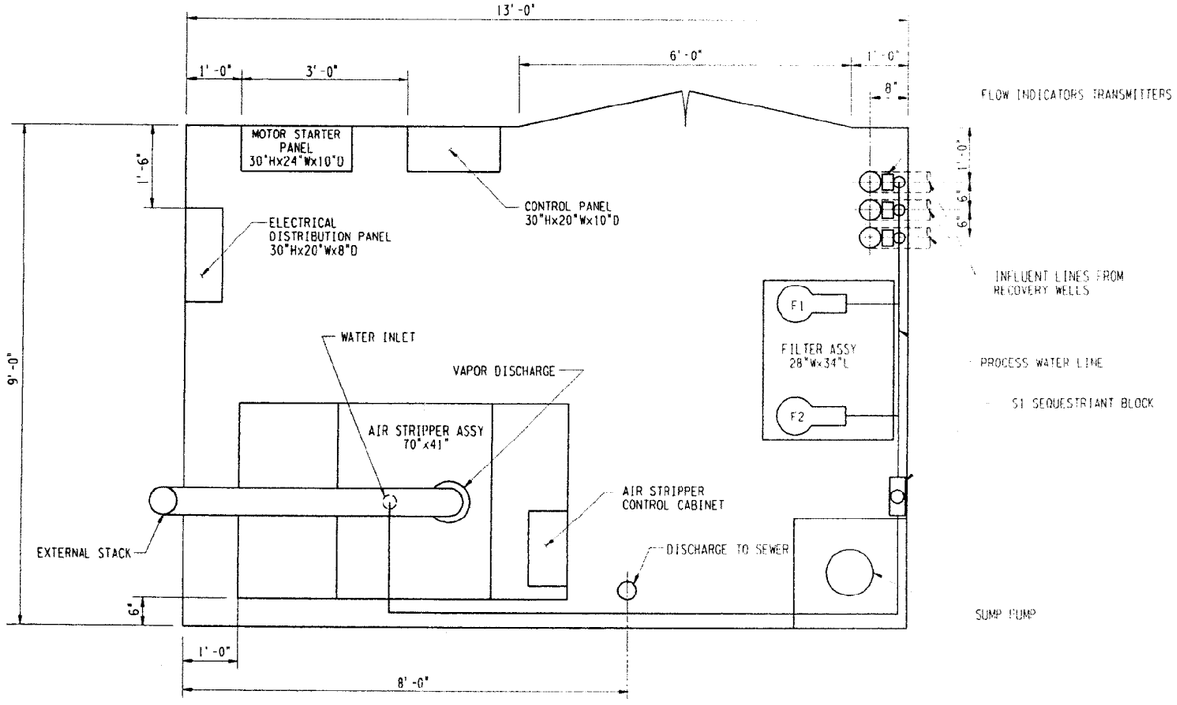
22567 145 145D007.DGN

22 X 34



SHED SLAB





EQUIPMENT BUILDING, PLAN VIEW

NOTES

LEGEND

NO.	DATE	REVISIONS	BY	CHKR	DESIGN SUPV	ENGR	PROJ ENGR	MICRO FILMD
A		ISSUED FOR REVIEW						

SCALE NOTED

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

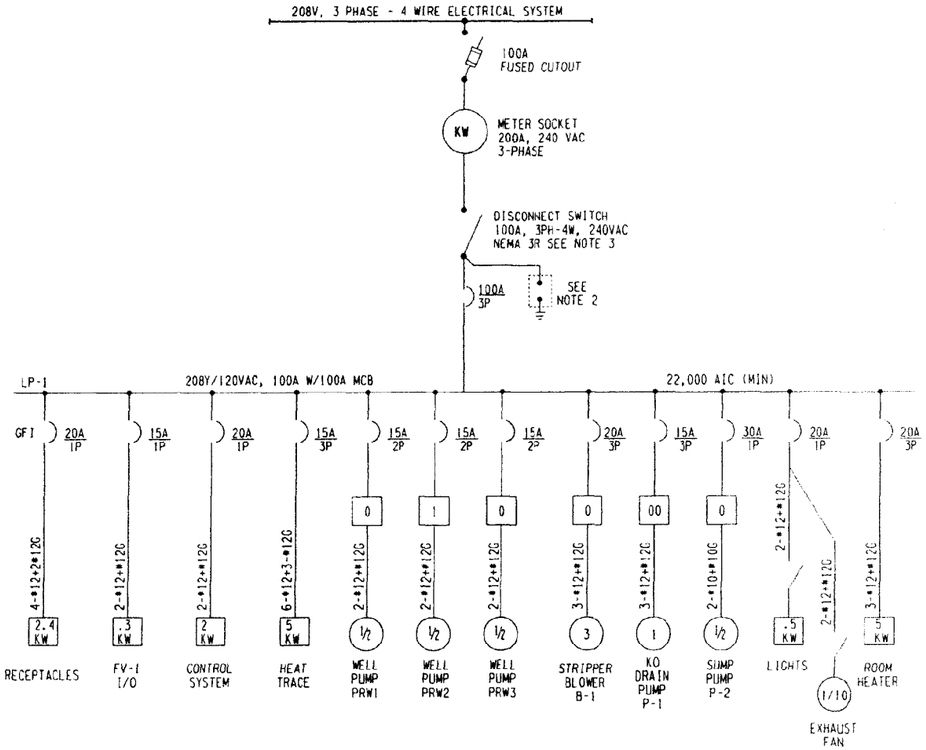
DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
GROUNDWATER EQUIPMENT BUILDING

JOB NO.	DRAWING NO.	REV
22567	145-D000-008	A

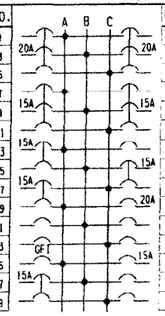
22567 145 145D008.DGN

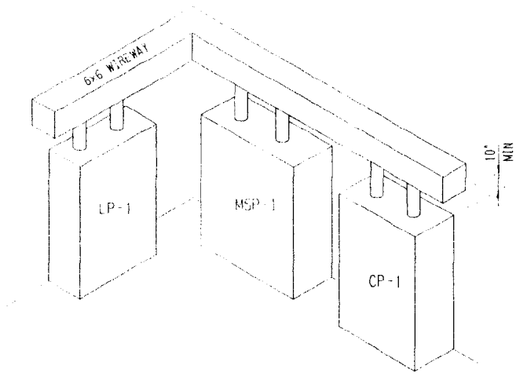
22 X 34



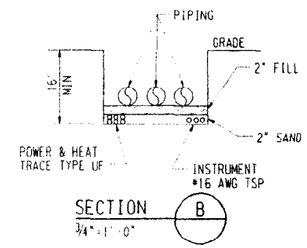
PANEL NO. LP-1	VOLTAGE: ☒ 120/208V, 3 PHASE	GROUND: ☒ LUG ☐ BUS
MOUNTING: ☐ FLUSH ☒ SURFACE	MAINS: ☐ LUGS ONLY AMP. ☒ MAIN BREAKER 100 AMP. ☒ TOP ☐ BOTTOM	NEUTRAL: ☐ 50 % ☒ 100 %
COVER: ☒ WITH DOOR ☐ WITHOUT DOOR ☒ WITH LOCK ☐ WITHOUT LOCK	ALL BRANCH BKRS. 20A., 1 POLE UNLESS NOTED OTHERWISE U/L LISTED BKR. INTERRUPTING RATING 22000 RMS SYM. AMPS.	
CONNECTED LOAD: PHASE A 7.28 KW.....PHASE B 7.77 KW.....PHASE C 7.87 KW.....TOTAL 22.92		

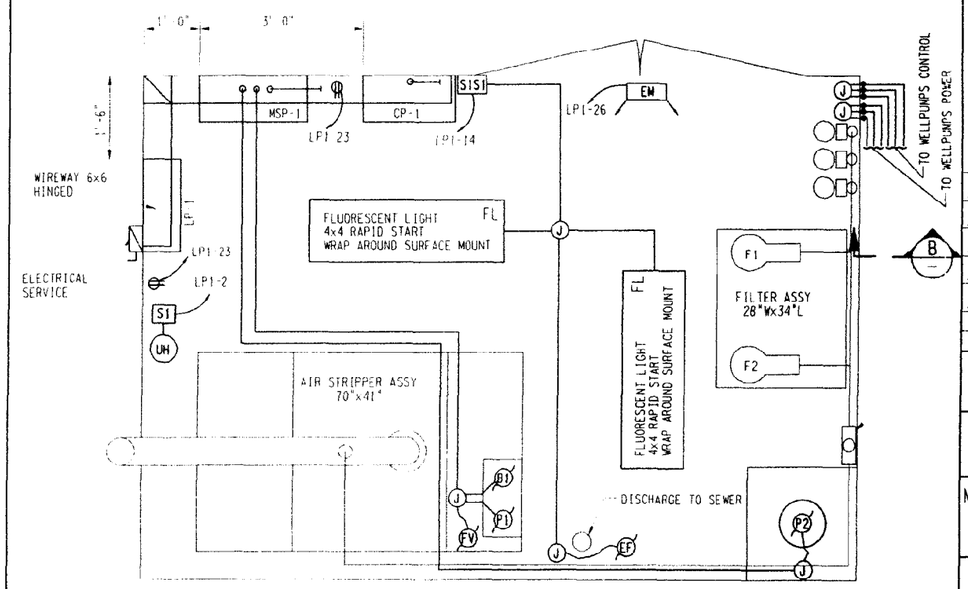
LOCATION	LOAD	NO.	NO.	LOAD	LOCATION
STRIPPER BLOWER B-1	1.19	1	2	1.67	ROOM HEATER
	1.19	3	4	1.67	
	1.19	5	6	1.67	
KO DRAIN PUMP P-1	0.44	7	8	1.67	HEAT TRACE
	0.44	9	10	1.67	
	0.44	11	12	1.67	
WELL PUMP PRW1	0.25	13	14	0.50	LIGHTS & EXHAUST FAN
	0.25	15	16	0.25	WELL PUMP PRW2
WELL PUMP PRW3	0.25	17	18	0.25	
	0.25	19	20	1.01	SUMP PUMP P-2
CONTROL SYSTEM	2.00	21	22	0.30	FV-1 MOTOR VALVE
RECEPTACLES	2.40	23	24		SPARE
I/O AC POWER	0.50	25	26	0.03	EMERGENCY LIGHT
SPARE		27	28		SPACE
		29	30		SPACE





PANEL ARRANGEMENT
NTS





EQUIPMENT BUILDING, PLAN VIEW
3/4"=1'-0"

NOTES

1. ELECTRICAL WORK SHALL BE DONE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (NFPA 70).
2. SURGE ARRESTER, WIREWORLD SENTRON HB-120Y.
3. MOUNT DISCONNECT SWITCH ON SERVICE DROP POLE OR ON OUTSIDE OF TREATMENT BUILDING TO PROVIDE EASY ISOLATION POINT.
4. CONDUIT INSIDE BUILDING TO BE E.M.T.
5. CABLING TO WELLS TO BE DIRECT BURIED.
6. FLEXIBLE CONDUIT TO BE USED FOR MOTOR CONNECTION. FLEX LENGTH TO BE APPROXIMATELY 5 FEET.

LEGEND

	DUPLEX RECEPTACLE
UH	ELECTRIC HEATER
EF	EXHAUST FAN MOTOR
FL	FLUORESCENT LIGHT FIXTURE
J	JUNCTION/PULL BOX
EM	EMERGENCY LIGHT DUAL-LITE DL-2, 120V
	DISCONNECT SWITCH

NO.	DATE	REVISIONS	BY	CHKR	DESIGN SUPV	ENGR	PROJ ENGR	MICRO FLMD
A		ISSUED FOR REVIEW	RB					

SCALE NONE

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

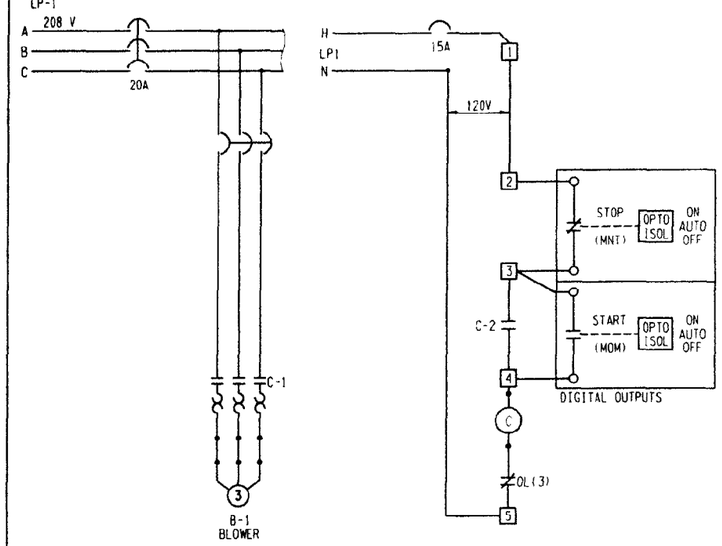
MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
ELECTRICAL SYSTEM

JOB NO.	DRAWING NO.	REV
22567	145-D000-009	A

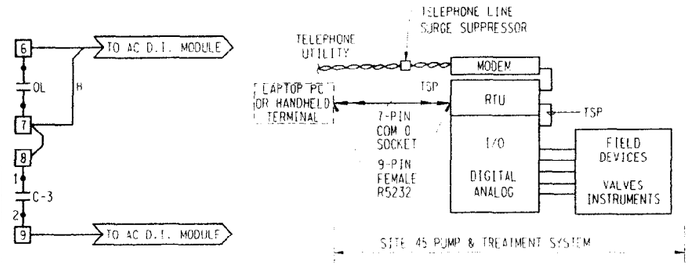
22567 145 1450009.DGN

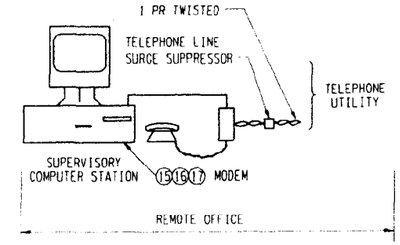
22 X 34

X 11 8020



208V, 3 PHASE MOTOR CONTROL SCHEMATIC, SINGLE SPEED



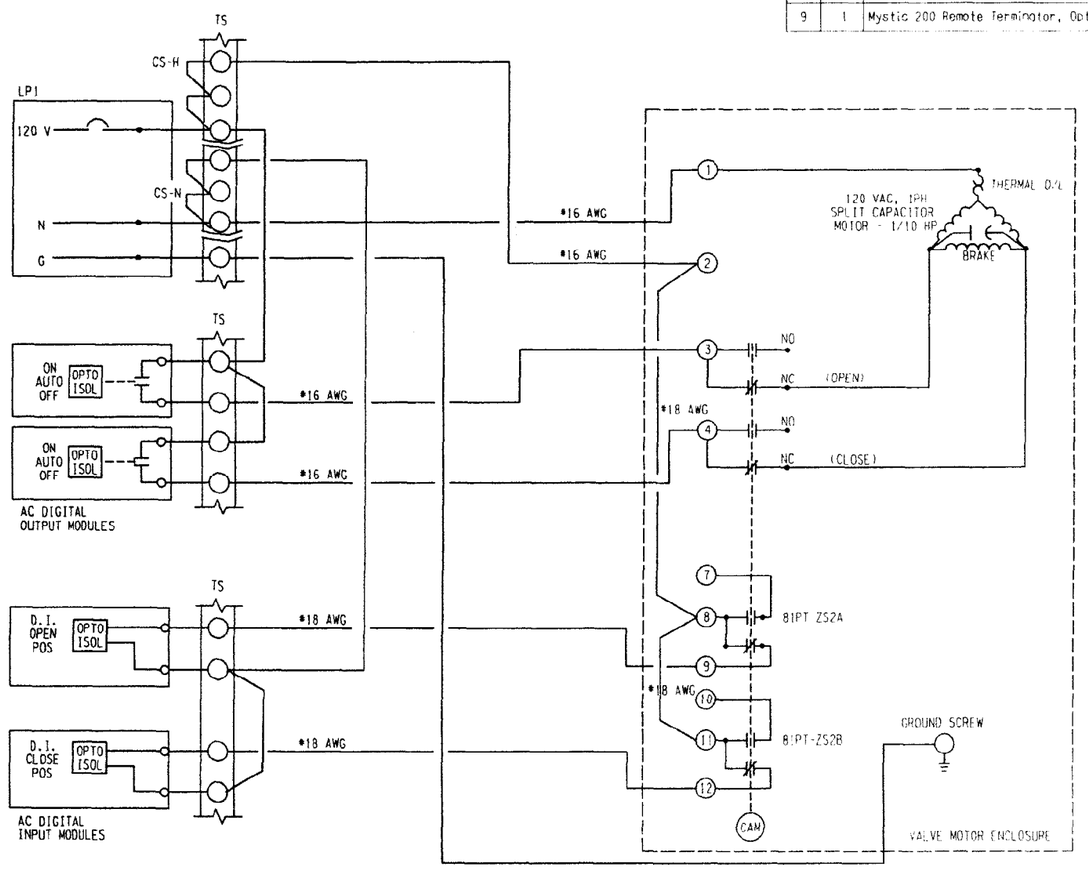


CONTROL SYSTEM BLOCK DIAGRAM

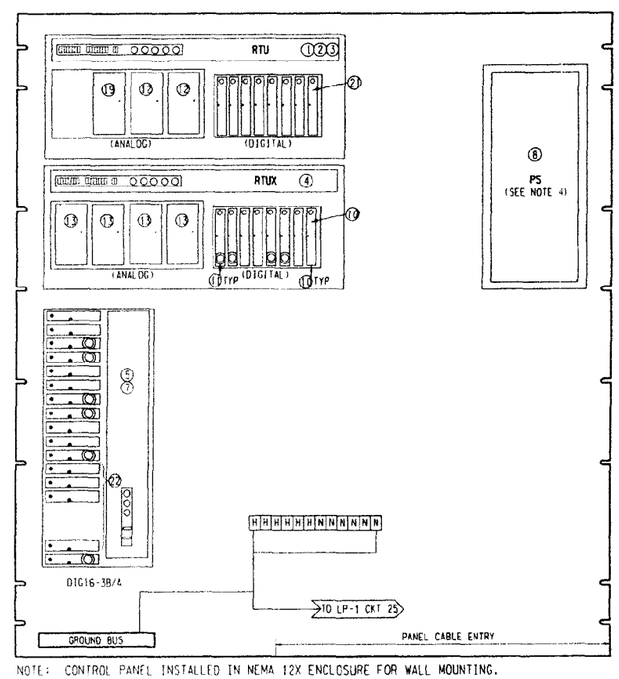
NTS

ITEM	QTY	DESCRIPTION
1	1	Remote Telemetry Unit, Opto 22 P/N M4RTU
2	1	RTU AC Power Supply 90 130V, Opto 22 P/N M4PS120A
3	1	RTU Serial Adapter Card, Opto 22 P/N M4SSER
4	1	Remote Telemetry Unit Extender, Opto 22 P/N M4RTUX
5	1	Mystic 200 Remote Digital Brick 16 I/O Points, Opto 22 P/N G4D16R
7	1	Single Brick Terminal Adapter, Opto 22 P/N SBTA
8	1	Mystic Brick Power Supply, 120V FM Opto 22 P/N G4PS24XAFM
9	1	Mystic 200 Remote Terminator, Opto 22 P/N G4TERMR

ITEM	QTY	DESCRIPTION
10	15	Digital AC Input Module, Opto 22 P/N G4IAC5
11	12	Digital AC Output Relays, with mode control toggle switch, Opto 22 P/N G4OAC5MA
12	10	Analog Input Module, 4-20 mADC, Opto 22 P/N G4AD3
14	1	Software, Mystic 200 Processor, lot Opto 22 P/N 'Cyrano 200'
15	1	Software, Mystic 200 Windows MMI, lot Opto 22 P/N 'Mystic MMI'
16	2	4 MEG RAM Expansion, Opto 22 P/N G4RAM4M
18	1	OPTO 22 P/N G4REG



FV MOTOR CONTROL SCHEMATIC



NOTE: CONTROL PANEL INSTALLED IN NEMA 12X ENCLOSURE FOR WALL MOUNTING.

CONTROL SYSTEM PANEL LAYOUTS

NTS

NOTES

1. FV MOTOR LOCKED-ROTOR CURRENT ESTIMATED TO BE 0.8 AMPERES. TYPICAL CONTROLLER RELAY OUTPUT HAS RATING OF 1 AMPERE. USE OF MOTOR STARTER IS NOT REQUIRED.

LEGEND

GROUNDWATER PUMP AND TREATMENT SYSTEM P&ID	145-D000-010

LEGEND

C	CONTACTOR
DO	DIGITAL OUTPUT
DI	DIGITAL INPUT
NO	NORMALLY OPEN
NC	NORMALLY CLOSED

NO.	DATE	REVISIONS	BY	CHKR	DESIGN SUPV	ENGR	PROJ ENGR	MECHC FLMD
A		ISSUED FOR REVIEW						

SCALE NONE

BECHTEL ENVIRONMENTAL INC.
OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

MARINE CORPS RECRUIT DEPOT, PARRIS ISLAND, S.C.
SITE 45/SWMU 45, DRY CLEANERS FACILITY
CONTROL SYSTEM

JOB NO.	DRAWING NO.	REV
22567	145-D000-010	A

22567 145 145D010.DGN

22 X 34

0208 101

ATTACHMENT 7

GROUNDWATER SAMPLING RECORD

NAVY RAC GROUNDWATER SAMPLING RECORD

Sampling Event:	Logbook ID:	Sheet 1 of 2

SAMPLING STATION

Station ID	Station Type

SAMPLE

Sample ID	Sample Matrix	Sample Type	Collection Method	Date	Time	By

Weather Conditions:

Field Logbook(s) Pages	ES&H Jrnl(s) Pgs	SEIR No.:

Flush Mount Well Inspection

Is the concrete pad cracked or unstable? ☐ Yes ☐ No	Is the water-tight cover damaged? ☐ Yes ☐ No	Is water in the interior of the casing? ☐ Yes ☐ No	Is the bentonite seal cracked or damaged? ☐ Yes ☐ No

Remarks:

Instruments	**Manufacturer/Mode**	**Serial No.**	**Func. Ck.**	**Calib. Due**	**Reference**
pH/Eh					
Conductivity/Temp					
Dissolved Oxygen					
Turbidity					

GROUND LEVEL DATA (before purging)

Well Variables	**Casing Volume Calculations**
Depth of water = (TD - H) = h (ft) [H = depth to top of water] Inside diam. of casing = d(in.); 1/2(d) = r(in.) $\frac{r(in.)}{12(in.)} = R(ft)$; [7.48 gal/ft^3 constant]	$V = \pi(R)^2 h \times (7.48\ gal/ft^3)$ V = _____ 3x _____ V = _____ gal

WELL PURGE INFORMATION

Purge equipment:	S/N:	Purge method:	Pump type:

Prog Cyc	Date	Time	Temp (°C)	pH	Eh	Units	Cond.	Units	Turb ( )		D.O. ( )	VolPrdg (gal)	Purge rate (gpm)

Well purged to dryness: ☐ Yes ☐ No

NAVY RAC GROUNDWATER SAMPLING RECORD

Sampling Event:	Logbook ID:	Sheet 2 of 2

Container Information				
Analytes	**Container ID**	**Preservative**	**Container ID**	**Comment**

Parameters during sampling (Record immediately before sampling and every 2 hours if sampling time exceeds 2 hours):

Date	Time	Temp	pH	Eh	Conductivity	Turb.	D.O.

Remarks:

Recorded by:	Date	Reviewed by	Date