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Line Shack
Site Inspection

Naval Air Station, Oceana
Final Report

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CH2M HILL
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INTRODUCTION

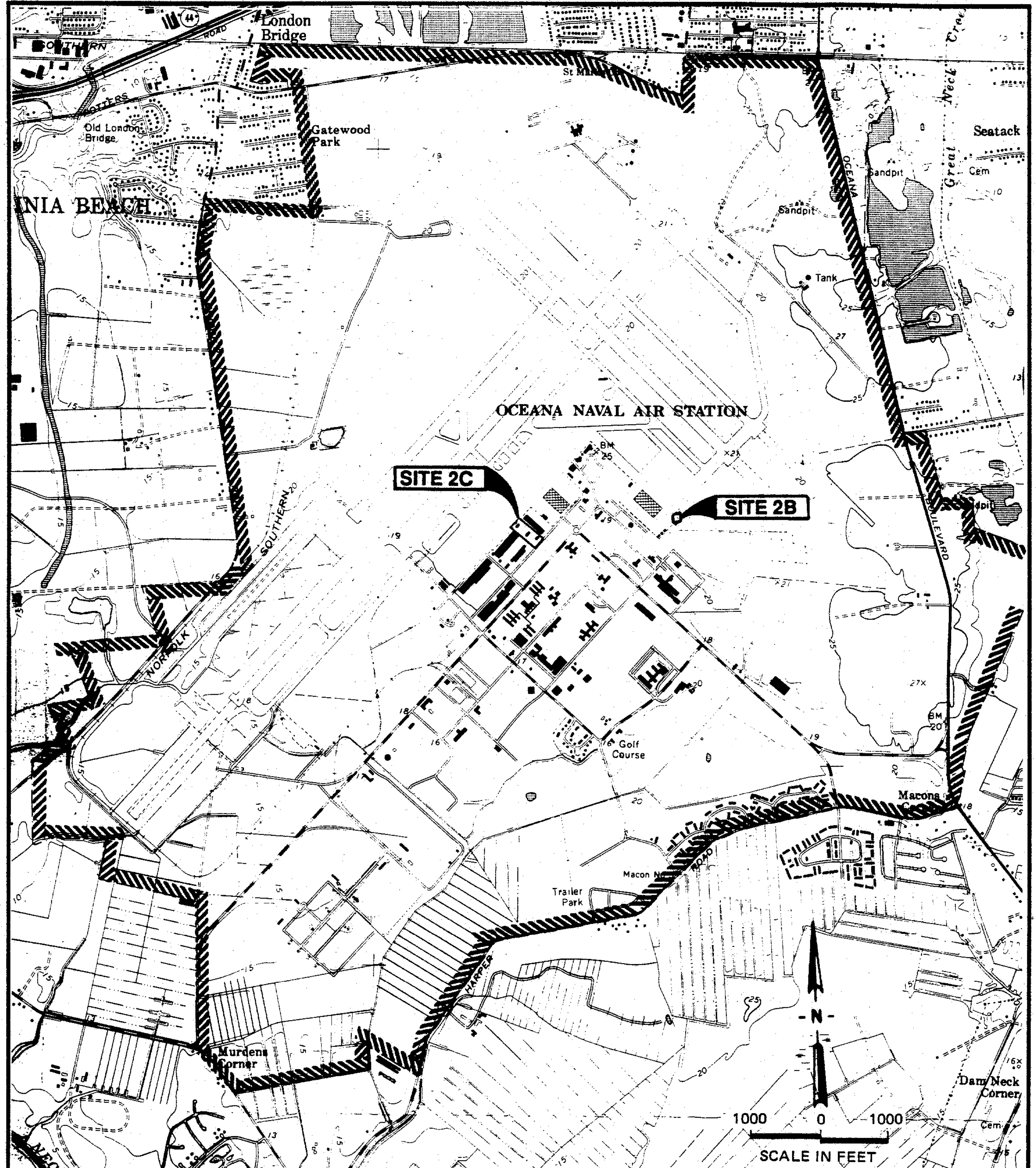
This Site Inspection (SI) represents a continuation of the Navy's Installation Restoration (IR) program at Naval Air Station (NAS), Oceana. The IR program is designed to identify and correct problems of environmental contamination caused by past operating procedures at Naval facilities. In 1984, an Initial Assessment Study (IAS) of NAS Oceana identified sites where past practices of hazardous material handling may have resulted in a current or potential threat to human health or the environment (Rogers, Golden and Halpern, 1984).

This SI involves two of the sites that were identified in the IAS: Site 2B--Line Shacks 130-131, and Site 2C--Line Shack 400. The location of these sites is shown in Figure 1. Site 2B was investigated previously during the initial phase of the Confirmation Study (CH2M HILL, 1986). In the current investigation, Site 2B has been expanded beyond the area described in the IAS to include the area south of building 122, and the vicinity of buildings 132 and 133. Site 2C, however, is investigated for the first time in this study. A description of each site, including past waste disposal practices, is presented in the IAS.

The principal objective of the SI is to determine if the chemicals that were analyzed in soil and groundwater as specified in the Scope of Work were released into the environment at either site. Based on this determination, recommendations are made with respect to future activities such as implementing the Navy's Remedial Investigation/Feasibility Study (RI/FS) process, or removal actions. The Navy's RI/FS process is independent of the Superfund program administered by the U.S. Environmental Protection Agency (EPA). Accordingly, a recommendation for Navy RI/FS action does not imply that the site has Superfund designation.

This report presents the results of chemical analyses on soil and groundwater samples collected at each site. Applicable, Relevant, and Appropriate Requirements (ARARs) of Superfund (U.S. EPA, 1987) and Health Advisories published by the EPA and the State of Virginia are presented only as a basis of comparison. The Navy is not bound to address ARARs because the sites are not Superfund sites. In addition, the soil samples were analyzed using the Extraction Procedure (EP) toxicity test, which is a procedure used under the Resource Conservation and Recovery Act to determine whether a waste is hazardous. General health and safety issues related to potential worker exposure to detected contaminants are also discussed.

This report does not discuss whether the sites pose potential threats to human health or the environment. For



LEGEND

Base Boundary

Site Boundary

SITE 2B - Line Shack (130-131) Disposal Area

SITE 2C - Line Shack 400 Disposal Area

Figure 1
SITE LOCATIONS
Naval Air Station, Oceana

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such determinations, a qualitative or quantitative risk assessment and an environmental assessment would be required. There are four parts in a risk assessment, as follows:

- The hazard identification is a qualitative assessment of each contaminant's toxicity to humans.

- The dose-response estimate is a quantitative determination of the potency of each toxic chemical. The estimate may depend on the route of exposure.

- The exposure assessment is a determination of how and to what extent the chemicals present in various environmental media at a site could reach a human population and be taken into the body. To properly conduct an exposure assessment, it is important to collect enough samples from the various media at the site and analyze the samples for any potential toxic chemicals, as well as to validate the data.

- During risk characterization, site-specific concentration levels determined from the exposure assessment are combined with the dose-response information to identify and possibly quantity potential health threats posed by the site.

All of the conclusions presented in this report are based on analytical data for the chemical parameters specified in the Scope of Work. The sample medium, number of samples, and sampling locations were stated in the Scope of Work developed by the Navy. The conclusions and recommendations contained in this report are solely for the use of the Navy to assist in evaluating the need for future study, as well as the health and safety procedures of contractors that may work at these sites.

SITE INVESTIGATIONS

FIELD INVESTIGATION AND LABORATORY METHODOLOGY

Field work was conducted at both sites from August 23 to September 23, 1988. The work centered on the collection of soil and groundwater samples for subsequent chemical analysis. The associated activities and procedures were described in detail in the Work Plan and Sampling Plan submitted previously.

Law Engineering, Inc., of Chesapeake, Virginia, was employed to drill soil borings and install monitoring wells according to the methodology presented in the Work Plan. Boring logs for all soil borings and monitoring wells are presented in Appendix A. Following installation, all monitoring wells were surveyed for vertical control to the nearest 0.01 foot by Baldwin and Gregg, LTD., of Norfolk, Virginia.

Soil samples were collected for chemical analysis from all soil borings and selected monitoring well boreholes. Surface soil samples were collected independently of the drilling activities using a stainless-steel hand auger. All soil sampling equipment was cleaned between samples with detergent, methanol, and clean water solutions.

Groundwater samples were collected from each well after the parameters pH, Eh, conductivity, and temperature remained stable over a volume of purged water equal to three well volumes. A submersible, positive-displacement bladder pump was used both to purge the wells and to collect the samples. All groundwater samples that were analyzed for metals were filtered in the field with a 0.45 micron filter. The sampling equipment was cleaned with a detergent solution, followed by a water-methanol solution after each sample was collected.

The CH2M HILL laboratory in Montgomery, Alabama did all of the chemical analyses with the exception of ignitability, which was done by Pioneer Labs in Gainesville, Florida. All chemical analyses were performed in accordance with the NEESA guidance manual and the CH2M HILL Draft Quality Assurance Manual submitted previously. The type and number of samples collected at each site is summarized in Tables 1 and 2. Tables 3, 4, and 5 list the specific chemical analysis with respect to volatile organic compounds (VOC), acid and base-neutral extractable organic compounds, and metals, respectively. In addition, Tables 3 and 4 include the laboratory method detection limit associated with each parameter.

Organic compounds were analyzed using a gas chromatograph/mass spectrometer in accordance with procedures described in

Table 1
SUMMARY OF CHEMICAL ANALYSES PERFORMED AT
SITE 2B
LINE SHACK 130-131

Sample Medium	VOC	Metals	E.P. Tox Metals	Ignitability	B.N.	Acids
Groundwater	6	6	-	-	-	-
Groundwater (duplicate)	1	1	-	-	-	-
Soil	59	-	59	2	2	2
Soil (duplicate)	6	-	2	-	-	-
Equipment Blank (water)	1	1	-	-	-	-
Field Blank (water)	1	1	-	-	-	-
Matrix Spike/Matrix Spike Duplicate	6	1	-	-	1	1
Total Number of Samples	80	10	61	2	3	3

VOC = Priority Pollutant Volatile Organic Compounds, Xylene, MEK, MIBK (Table 3)
Metals = Priority Pollutant Metals (Table 5)
B.N. = Base-Neutral Extractable Organic Compounds (Table 4)
Acids = Acid-Extractable Organic Compounds (Table 4)

Table 2
SUMMARY OF CHEMICAL ANALYSES PERFORMED AT
SITE 2C
LINE SHACK 400

Sample Medium	VOC	Metals	E.P. Tox Metals	Ignitability	B.N.	Acids
Groundwater	5	5	-	-	-	-
Soil	25	-	25	2	2	2
Soil (duplicate)	3	-	2	-	-	-
Equipment Blank (water)	1	1	-	-	-	-
Matrix Spike/Matrix Spike Duplicate	4	-	-	-	1	1
Total Number of Samples	38	6	27	2	3	3

VOC = Priority Pollutant Volatile Organic Compounds, Xylene, MEK, MIBK (Table 3)
Metals = Priority Pollutant Metals (Table 5)
B.N. = Base-Neutral Extractable Organic Compounds (Table 4)
Acids = Acid-Extractable Organic Compounds (Table 4)

Table 3
VOLATILE ORGANIC COMPOUNDS (VOC)
AND DETECTION LIMITS

	Soil Detection Limit (µg/kg)	Water Detection Limit (µg/l)
EPA Method 624 Compounds		
Benzene	5	5
Carbon tetrachloride	5	5
Chlorobenzene	5	5
1,1-Dichloroethane	5	5
1,2-Dichloroethane	5	5
1,1,1-Trichloroethane	5	5
1,1,2-Trichloroethane	5	5
1,1,2,2-Tetrachloroethane	10	10
Chloroethane	10	10
2-Chloroethyl vinyl ether	10	10
Chloroform	5	5
1,1-Dichloroethene	5	5
trans-1,2-Dichloroethene	5	5
1,2-Dichloropropane	5	5
1,3-Dichloropropane	5	5
Ethylbenzene	5	5
Methylene chloride	10	10
Chloromethane	10	10
Bromomethane	10	10
Bromoform	5	5
Bromodichloromethane	5	5
Chlorodibromomethane	5	5
Tetrachloroethene	5	5
Toluene	5	5
Trichloroethene	5	5
Vinyl chloride	10	10
Additional VOC		
Acetone	10	10
Carbon disulfide	5	5
cis-1,3-Dichloropropene	5	5
4-Methyl-2-Pentanone	10	10
Vinyl acetate	10	10
2-Butanone	10	10
trans-1,3-Dichloropropene	5	5
2-Hexanone	10	10
Styrene	5	5
Total xylenes	5	5

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Table 4
ACID AND BASE-NEUTRAL EXTRACTABLE ORGANIC COMPOUNDS, AND DETECTION LIMITS

Base-Neutral Extractable Organic Compounds (EPA Method 625)	Soil Detection Limit (µg/kg)	Water Detection Limit (µg/l)
1,2,4-Trichlorobenzene	3,900	10
Hexachlorobenzene	3,900	10
Hexachloroethane	3,900	10
bix (2-Chloroethyl) ether	3,900	10
2-Chloronephthalene	3,900	10
1,2-Dichlorobenzene	3,900	10
1,3-Dichlorobenzene	3,900	10
1,4-Dichlorobenzene	3,900	10
3,3'-Dichlorobenzidine	7,800	40
2,4-Dinitrotoluene	3,900	10
2,6-Dinitrotoluene	3,900	10
Fluoranthene	3,900	10
4-Chlorophynyl phenyl ether	3,900	10
4-Chlorophenyl phenyl ether	3,900	10
4-Bromophenyl phenyl ether	3,900	10
bis (2-Chloroisopropyl) ether	3,900	10
bis (2-Chloroethosy) methane	3,900	10
Hexachlorobutadiene	3,900	10
Isophorone	3,900	10
Naphthalene	3,900	10
Nitrobenzene	3,900	10
bis (2-Ethylhexyl) phthalate	3,900	10
Acenaphthene	3,900	10
N-Nitrosodi-n-propylamine	3,900	10
Butyl benzyl phthalate	3,900	10
Di-n-butyl phthalate	3,900	10
Di-n-octyl phthalate	3,900	10
Diethyl phthalate	3,900	10
Dimethyl phthalate	3,900	10
Benzo (a) anthracene	3,900	10
Benzo (a) pyrene	3,900	10
Benzo (b) fluoranthene	3,900	10
Benzo (Ik) fluoranthene	3,900	10
Chrysene	3,900	10
Acenaphthylene	3,900	10
Acenaphthylene	3,900	10
Anthracene	3,900	10
Benzo (g,h,i) perylene	3,900	10
Fluorene	3,900	10
Phenanthrene	3,900	10
Dibenzo (a,h) anthracene	3,900	10
Indeno (1,2,3,-cd) pyrene	3,900	10
Pyrene	3,900	10

Table 4
(continued)

	Soil Detection Limit (µg/kg)	Water Detection Limit (µg/l)
Acid Extractable Organic Compounds (EPA Method 625)		
2,4,6-Trichlorophenol	3,900	10
4-Chloro-m-cresol	3,900	10
2-Chlorophenol	3,900	10
2-Nitrophenol	3,900	10
Pentachlorophenol	3,900	10
2,4-Dimethylphenol	3,900	10
4-Nitrophenol	3,900	10
2,4-Dinitrophenol	19,000	50
4,6-Dinitro-o-cresol	3,900	10
2,4-Dichlorophenol	3,900	10
Phenol	3,900	10
Additional Extractable Organic Compounds		
Hexachlorocyclopentadiene	3,900	10
N-Nitrosodiphenylamine	3,900	10
Benzyl alcohol	3,900	10
2-Methylphenol	3,900	10
4-Methylphenol	3,900	10
Benzoic Acid	19,000	50
2-Methylnaphthalene	3,900	10
2,4,5-Trichlorophenol	19,000	50
2-Nitroaniline	19,000	50
3-Nitroaniline	19,000	50
Dibenzofuran	3,900	10
4-Nitroaniline	19,000	50
4-Chloroaniline	3,900	10

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Table 5
METAL ANALYSES IN SOIL AND GROUNDWATER

SOIL (EP TOXICITY)

Arsenic	Lead
Barium	Mercury
Cadmium	Selenium
Chromium	Silver

GROUNDWATER

PRIORITY POLLUTANT METALS

Antimony	Mercury
Arsenic	Nickel
Beryllium	Selenium
Cadmium	Silver
Total Chromium	Thallium
Copper	Zinc
Lead	

Additional Metals

Aluminum	Magnesium
Barium	Manganese
Calcium	Potassium
Cobalt	Sodium
Iron	Vanadium

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EPA-600/4-82-057 Methods 624 and 625 (1982). The soil samples were analyzed in accordance with procedures described in Test Methods of Evaluating Solid Waste, SW846, Methods 8080, 8240, and 8270 (1982).

Metal analyses were performed by either an atomic absorption spectrophotometer or an induced coupled argon plasma spectrometer. EP toxicity metals were analyzed following Method 13-10, Extraction Procedure, Toxicity Test Method and Structural Integrity Test (1986).

SITE 2B

Groundwater samples were collected from the three existing wells (2B-MW1, 2B-MW2, and 2B-MW3) as well as the three new monitoring wells (2B-MW4, 2B-MW5, and 2B-MW6). Soil samples were collected from the three new monitoring well boreholes and 15 soil borings at depths of zero to 2 feet (S1), 3 to 5 feet (S2), and 8 to 10 feet (S3); soil samples were also collected from five surface locations (less than 1 foot in depth). The locations of all of these sampling points are shown in Figure 2.

The two sampling points at which additional soil was collected for acid and base-neutral extractable compounds, and ignitability analyses, were B4-S1 and B12-S3. The criteria for selecting these sample locations are described in the Work Plan.

Results

The physical and chemical groundwater parameters measured in the field are presented in Table 6. The reported values represent measurements after the parameters had stabilized following the purging of each well. The results of the VOC chemical analyses for soil and groundwater are shown in Tables 7 and 8, respectively. Only those compounds that were reported above detection limits are included in these tables. The results of the acid and base-neutral extractable organics are not summarized in table form because all of the data were below detection limits (shown in Table 5). The results of the ignitability tests are not tabulated. In both of the samples analyzed, the soil did not ignite at the maximum applied temperature (100°C). The results of metals analyses in groundwater are presented in Table 9. The results of the EP toxicity metals analyses are not presented because they are below the values that would classify the soil as a hazardous waste (40 CFR 261, Table 1). Appendix B contains a complete listing of all laboratory data from both sites.

In addition to chemical data, water-level information was obtained from all six monitoring wells. The water-level

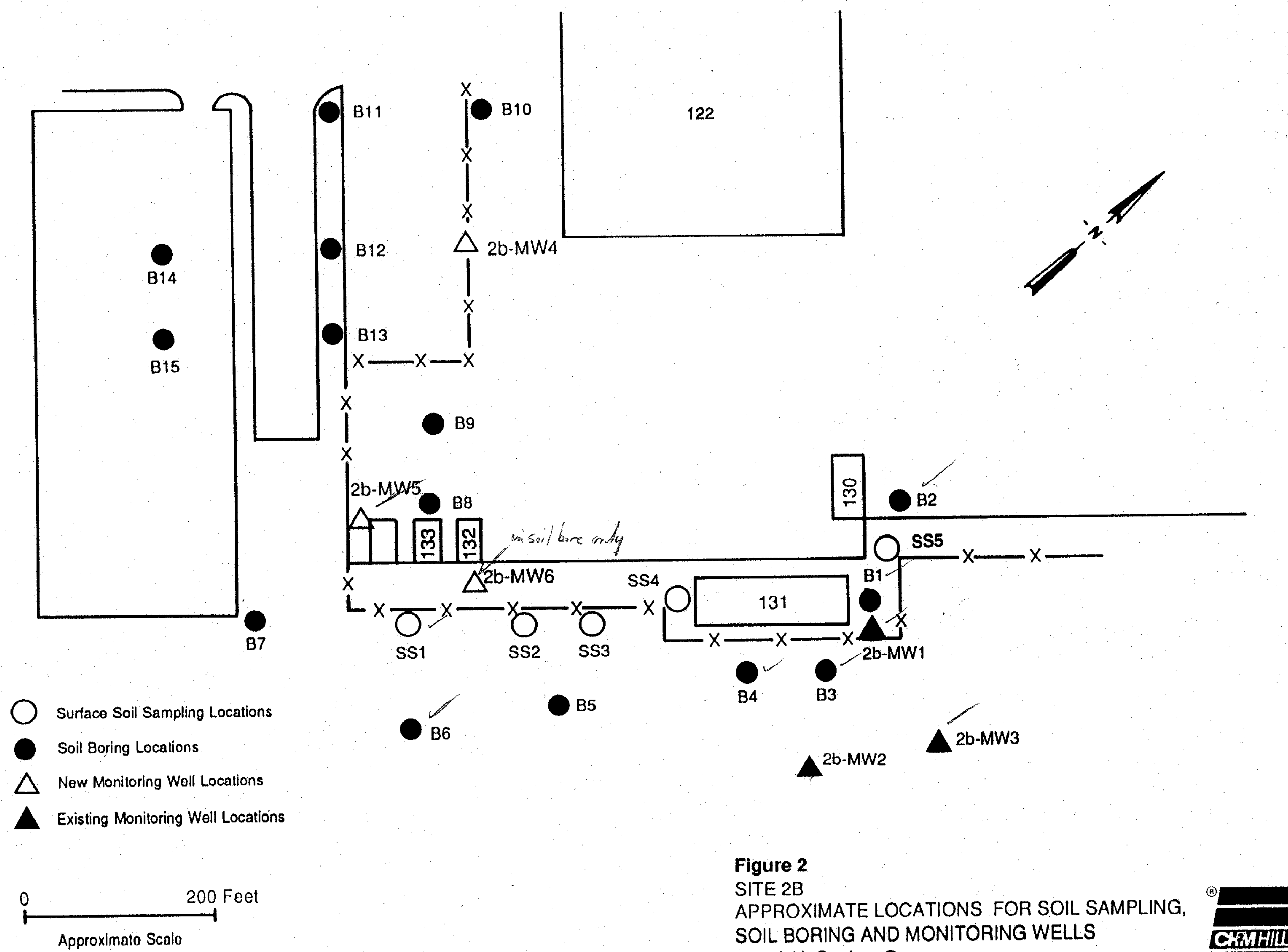

Figure 2
SITE 2B
APPROXIMATE LOCATIONS FOR SOIL SAMPLING, SOIL BORING AND MONITORING WELLS
Naval Air Station, Oceana

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Table 6
FIELD PARAMETER MEASUREMENTS
SITE 2B

Well No.	Date	Time	pH	Eh[a] (mV)	Conductivity (μmho/cm)	Temperature (°C)
2B-MW1	9/22/88	13:43	5.7	-14	360	22
2B-MW2	9/22/88	15:09	7.6	-124	295	18
2B-MW3	9/22/88	16:07	6.9	-55	870	20
2B-MW4	9/23/88	7:54	5.8	17	463	22
2B-MW5	9/23/88	8:52	6.1	3	462	22
2B-MW6	9/22/88	11:55	6.1	-7	277	22

[a]Eh values are uncorrected field measurements.

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Table 7
VOLATILE ORGANIC COMPOUNDS IN SOIL SAMPLES AT SITE 2B NAS, OCEANA
September 1988
(Concentrations in µg/kg)

Soil Borings No.	Acetone	Methylene Chloride	Benzene	Ethylbenzene	Toluene	Xylenes (Total)	MEK[a]	MIBK[b]	Carbon Disulfide	TCE[c]
B1-S1	-	64	-	-	-	-	-	-	-	-
S2	-	580	-	-	-	-	-	-	-	-
S3	-	15	-	-	-	-	-	-	-	-
B2-S1	-	-	-	-	-	-	-	-	-	-
S2	-	-	-	-	-	-	-	-	-	-
S3	140	840	-	-	-	-	-	-	-	-
B3-S1	-	130	-	85	-	480	-	-	-	-
S2	-	-	-	-	-	-	-	-	10	-
S3	180	660	-	-	-	-	-	-	-	32
B4-S1	65	390	-	11	10	18	-	-	-	-
S2	26	30	-	-	-	-	-	-	13	-
S3	-	78	-	-	-	-	-	-	-	54
B5-S1	-	-	-	-	-	-	-	-	-	-
S2	-	-	-	-	-	-	-	-	-	-
S3	-	-	-	-	-	-	-	-	-	-
B6-S1	-	220	-	-	6	-	-	-	-	-
S2	-	300	-	-	-	-	-	-	-	-
S3	-	260	-	-	-	-	-	-	-	-
B7-S1	-	160	-	-	-	-	-	-	-	-
S2	-	180	-	-	-	-	-	-	-	-
S3	-	26	-	-	-	-	-	30	-	-
B8-S1	38	12[d]	-	7	-	7	-	-	-	-
S2	63	17[d]	12	32	110	7	-	-	10	-
S3	-	160	-	-	-	-	-	-	-	-
B9-S1	82	12[d]	-	-	-	-	-	-	-	-
S2	-	13[d]	-	-	-	-	-	-	-	-
S3	57	31[d]	-	-	-	-	-	-	-	-
B10-S1	92	41[d]	-	-	-	-	-	-	-	-
S2	240	-	-	-	-	-	27	-	-	-
S3	-	-	-	-	-	-	-	-	-	-
B11-S1	-	14[d]	-	-	-	-	-	-	-	-
S2	-	460[e]/140[e]	-	-	17[e]/6[d]	-	-	-	-	-
S3	-	150[e]	-	-	-	-	-	-	-	-
B12-S1	-	17[d]	-	-	-	-	-	-	-	-
S2	47[d]	16[d]	-	-	-	-	17	-	18	-
S3	28[d]		-	-	-	-	-	-	-	-
B13-S1	-	24	-	-	-	-	-	-	-	-
S2	-	69	-	-	-	-	-	-	-	-
S3	-	-	-	-	-	-	-	-	-	-
B14-S1	-	55[d]	-	-	-	-	-	-	-	-
S2	57	-	-	-	-	-	-	-	-	-
S3	-	15[d]	-	-	-	-	-	-	-	-
B15-S1	14	17[d]	-	-	-	-	-	-	-	-
S2	-	17[d]	-	-	-	-	-	-	-	-
S3	-	12[d]/21[d]	-	-	-	-	-	-	-	-

Table 7
(Continued)

	Acetone	Methylene Chloride	Benzene	Ethylbenzene	Toluene	Xylenes (Total)	MEK[a]	MIBK[b]	Carbon Disulfide	TCE[c]
Soil Borings No.										
MW4-S1	34[d]	36[e]	-	-	-	-	-	-	-	-
S2	49[d]	19[e]	-	-	-	-	-	-	-	-
S3	39[d]	32[e]	-	-	-	-	-	-	-	-
MW5-S1	47[d]	-	-	-	-	-	-	-	-	-
S2	120[e]	120[e]	-	-	-	-	-	-	-	-
S3	-	-	-	-	-	-	-	-	-	-
MW6-S1	-	-/20[d]	-	-	-	-	-	-	-	-
S2	41[d]	-	-	-	-	-	-	-	-	-
S3	-	490[e]	-	-	-	-	-	-	-	-
Surface Soil No.										
SS1	-	430	-	-	-	-	-	-	-	-
SS2	-	-	-	-	-	-	-	-	-	-
SS3	-	-	-	-	-	-	-	-	-	-
SS4	57	42[d]	-	-	-	-	-	-	-	-
SS5	-	21[d]	-	-	-	-	-	-	-	-

[a]MEK--2-Butanone

[b]MIBK--4-Methyl-2-Pentanone

[c]TCE--Trichloroethene

[d]Compound found in blank as well as sample. Sample concentration less than 10 times blank concentration.

[e]Compound found in blank as well as sample. Sample concentration greater than 10 times blank concentration.

12/12 Indicates sample result and duplicate sample result.
All values not reported were below detection limits.

Sample Depths:
S1--0 to 2 feet
S2--3 to 5 Feet
S3--8 to 10 feet

Table 8
VOLATILE ORGANIC COMPOUNDS DETECTED IN
GROUNDWATER AT SITE 2B NAS, OCEANA
September 1988
(Concentrations in µg/l)

Well No.	Vinyl Chloride	Trichloroethene	1,1-Dichloroethene	1,1-Dichloroethane	1,2-Dichloroethene (total)
2B-MW1	31/27	330/340	13/6	82/52	340/290
2B-MW2	-	5	-	-	-
2B-MW3	-	820	420	44	-
2B-MW4	-	-	-	-	-
2B-MW5	55	22	49	7	-
2B-MW6	-	-	-	-	-

31/27 Indicates sample result and duplicate sample result.

All values not reported were below detection limits.

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Table 9
RESULTS OF METALS ANALYSIS OF GROUNDWATER SITE 2B NAS, OCEANA
September 1988

Parameter	2b-MW1	2b-MW2	2b-MW3	2b-MW4	2b-MW5	2b-MW6
Silver (µg/L)	<3/<3	<3	<3	<3	<3	<3
Aluminum (µg/L)	<200/<200	<200	<200	<200	<200	<200
Arsenic (µg/L)	<5/<5	<5	<5	<5	13	17
Barium (µg/L)	<200/<200	<200	<200	<200	<200	<200
Beryllium (µg/L)	<5/<5	<5	<5	<5	<5	<5
Calcium (mg/L)	14.5/13.5	42.2	104	47.5	37.6	16.8
Cadmium (µg/L)	17/<3	<3	<3	<3	<3	<3
Cobalt (µg/L)	<50/<50	<50	<50	<50	<50	<50
Chromium (µg/L)	<10/<10	<10	<10	<10	<10	<10
Copper (µg/L)	<25/<25	<25	<25	<25	70	<25
Iron (µg/L)	5840/5670	1340	7470	12.1*	23.4*	13.7*
Mercury (µg/L)	0.4/<0.2	<0.2	1.0	<0.2	<0.2	0.5
Potassium (mg/L)	<5.0/<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Magnesium (mg/L)	15.7/14.8	5.6	10.0	16.3	26.3	8.2
Manganese (µg/L)	190/190	310	640	420	1000	390
Sodium (mg/L)	42.8/40.3	24.0	62.9	25.6	23.3	14.0
Nickle (µg/L)	<40/<40	<40	<40	<40	<40	<40
Lead (µg/L)	<5/<5	<5	<5	<5	<5	<5
Antimony (µg/L)	<5/<5	<5	<5	<5	<5	<5
Selenium (µg/L)	<5/<5	<5	<5	<5	<5	<5
Thallium (µg/L)	<5/<5	<5	<5	<5	<5	<5
Vanadium (µg/L)	<50/<50	<50	<50	<50	<50	<50
Zinc (µg/L)	170/160	50	160	220	170	130

<3/<3 Indicates a sample result and a duplicate sample result.
* Value reported in mg/l.

WDR05/063

data are summarized in Table 10, and graphically presented as water-level contours in Figure 3.

Discussion

Methylene chloride and acetone were the two most frequently detected volatile compounds in the soil samples from Site 2B. Both of these compounds were also frequently detected in the laboratory blanks. The higher soil concentrations of methylene chloride and acetone were generally from soil borings in the vicinity of line shacks 130 and 131 (B1-B4) and Building 133 (B8). Some of these samples also indicated the presence of fuel hydrocarbon constituents ethylbenzene, toluene, and xylene. These results are consistent with observations of what appeared to be oil contaminated soils adjacent to B3 and B4. Additional volatile compounds found in soil samples across the site include benzene, MEK, MIBK, carbon disulfide, and TCE.

Volatile organics detected in groundwater at Site 2B are ethene and ethane compounds. TCE was found in groundwater and in soil samples that were collected below the water table (B3-S3, B4-S3). All three of the existing wells (2B-MW1, 2B-MW2, and 2B-MW3) show the presence of VOCs, which is consistent with the chemical data from the previous round of sampling (CH2M HILL, 1986). Of the three new wells installed as part of the current study, only 2B-MW5 indicates the presence of these VOCs.

A review of Figure 3 indicates that the flow of groundwater is generally in a southerly direction at Site 2B. The hydraulic gradient, however, appears to differ by an order of magnitude at different locations across the site. In the vicinity of the original monitoring wells (2B-MW1, 2B-MW2, and 2B-MW3), the gradient is higher (approximately 0.005) than between the three new wells (2B-MW4, 2B-MW5, and 2B-MW6), where the gradient is approximately 0.0004.

The higher gradient most likely reflects the topographic relief in the area behind Line Shack 131. The ground surface slopes away from the line shack on the southeast side of the fence line. The difference is only on the order of a few feet, but it is more than enough to account for the 0.5 foot of difference in water level. In contrast, there is essentially no topographic relief between 2B-MW4 and 2B-MW5. Consequently, the groundwater gradient is correspondingly low over this portion of the site. The conclusions drawn from Figure 3 must be qualified by the fact that the data are for a single point in time (September 22, 1988), and that the well locations are not exactly to scale on the map.

Table 10
WATER LEVELS IN MONITORING WELLS
SITE 2B NAS, OCEANA
September 22, 1988

Well Number	Water Level (feet above MSL)	Top of Protective Casing Elevation (feet above MSL)
MW1	13.87	21.59
MW2	13.17	20.34
MW3	13.23	19.23
MW4	13.75	20.93
MW5	13.64	21.49
MW6	13.62	21.01

Water level measurements are accurate to ±0.02 feet, which include ±0.01 feet for top of protective casing measurements.

Elevations are referenced to the National Geodetic Survey Datum of 1929.

WDR387/041/1

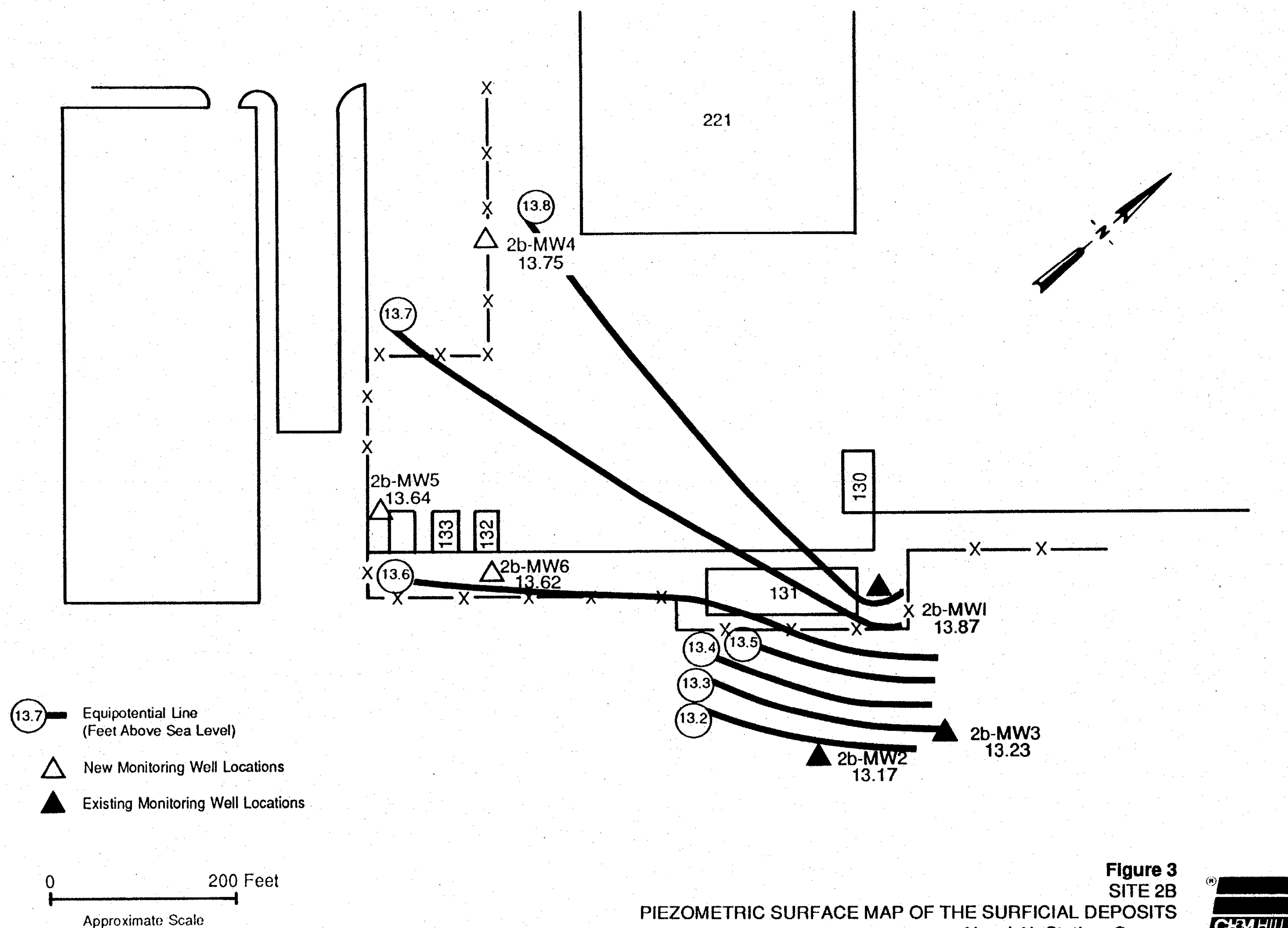

Figure 3
SITE 2B
PIEZOMETRIC SURFACE MAP OF THE SURFICIAL DEPOSITS
Naval Air Station, Oceana

CH2M HILL

SITE 2C

The locations of all soil and groundwater sampling points are shown on Figure 4. Groundwater samples were collected from the four monitoring wells installed as part of the SI, and from an existing production well. The production well was sampled from inside the building located adjacent to 2C-MW2. The exact location and depth of the well are not known.

Soil samples were collected from the boreholes of 2C-MW2 and 2C-MW3 at depths of 3 to 5 feet (S1); 8 to 10 feet (S2), and 14 to 16 feet (S3); six soil borings at depths of 3 to 5 feet (S1) and 8 to 10 feet (S2); and six surface locations (less than 1 foot in depth).

The two sampling points in which additional soil was collected for acid and base-neutral extractable compounds, and ignitability analyses were B3-S1 and B4-S2. The criteria used in the selection of these locations is described in the Work Plan.

Results

The physical and chemical groundwater parameters measured in the field are presented in Table 11. The reported values represent measurements after the parameters had stabilized following the purging of each well. The results of the VOC chemical analyses for soil and groundwater are shown in Tables 12 and 13, respectively. Only those compounds that were reported above detection limits are included in these tables. The results of the acid and base-neutral extractable organics are not summarized in table form because all of the data were below detection limits shown in Table 5. The results of the ignitability testing are not tabulated. In both of the samples analyzed the soil did not ignite at the maximum applied temperature (100°C). The results of metals analysis in groundwater are presented in Table 14. The results of the EP toxicity metals analyses are not presented because the data are all well below the values that would classify the soil as a hazardous waste. A complete listing of all laboratory data is presented in Appendix B.

Water-level data obtained from the four monitoring wells are summarized in Table 15. It was not possible to obtain a water-level measurement from the production well. The data are graphically presented as water-level contours in Figure 5.

Discussion

A review of Figure 5 indicates that the principal direction of groundwater flow is generally to the south-southeast. The gradient is roughly 0.001, and appears fairly uniform

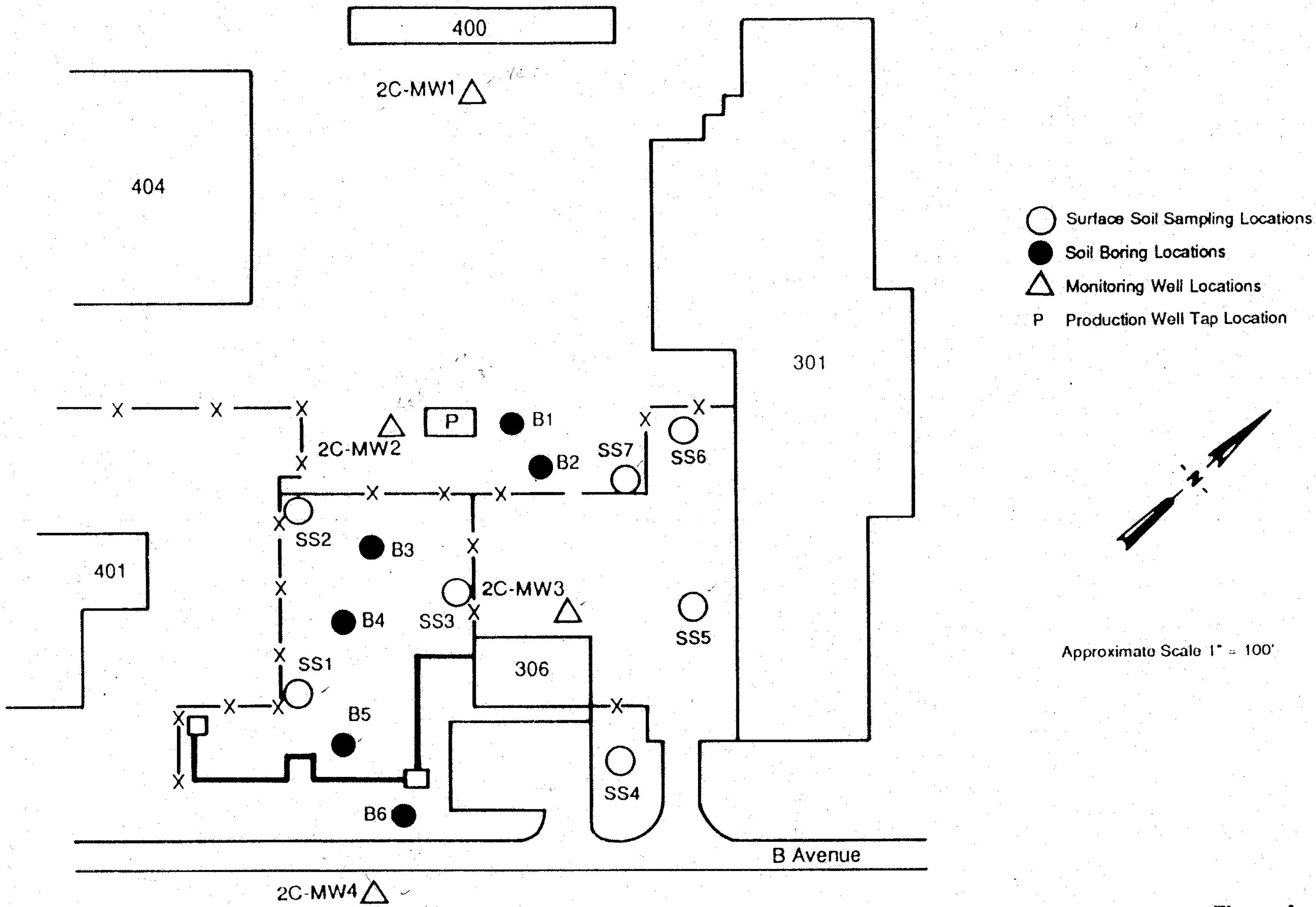

Figure 4
SITE 2C
APPROXIMATE LOCATIONS FOR SOIL SAMPLING,
SOIL BORING AND MONITORING WELLS
Naval Air Station, Oceana

Table 11
SITE 2C
FIELD PARAMETER MEASUREMENTS

Well No.	Date	Time	pH	Eh[a] (mV)	Conductivity (µmho/cm)	Temperature (°C)
2C-MW1	9/23/88	11:03	6.3	-40	700	24
2C-MW2	9/23/88	10:04	6.4	-27	610	21
2C-MW3	9/23/88	12:00	6.1	-39	590	22
2C-MW4	9/22/88	17:12	6.2	6	478	22

[a]Eh values are uncorrected field measurements.

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Table 12
VOLATILE ORGANIC COMPOUNDS IN SOIL AT SITE 2C, NAS, OCEANA
September 1988
(Concentrations in µg/kg) ppb

Soil Boring No.	Acetone	Methylene Chloride	Toluene	Xylenes (Total)	Carbon Disulfide	Vinyl Chloride	1,1-Dichloroethane	Chloroform
B1-S1	-	170[a]	-	-	-	-	-	6[a]
S2	17[a]	-	-	-	-	-	-	7[a]
B2-S1	-	130[a]	-	-	-	-	-	-
S2	-	-	-	-	-	-	-	-
B3-S1	-	-	-	-	-	-	-	8[a]
S2	-	-	-	-	-	-	-	-
B4-S1	16[a]	29[a]	-	-	-	-	-	8[a]
S2	-	-	-	-	-	-	-	-
B5-S1	-	-	-	-	-	-	-	8[a]
S2	110[a]/62	160[a]/10[a]	-	-	--/45	-	-	-
B6-S1	-	-	-	-	-	-	-	-
S2	-	110[a]	-	-	17	-	-	-
Monitoring Well No.								
MW2-S1	-	36[a]	-	-	-	-	-	-
S2	-	140[b]	-	-	-	-	-	-
S3	-	-	-	-	-	-	-	-
MW3-S1	-	22[a]	-	-	-	-	-	6[a]
S2	-	19[a]	12	-	-	30	-	-
S3	-	83[a]	-	-	-	-	9	-
Surface Soil No.								
SS1	-	52	-	-	-	-	-	-
SS2	-	-	-	-	-	-	-	-
SS3	-	89[a]	-	-	-	-	-	-
SS4	-	-	-	-	-	-	-	-
SS5	58[a]	160[a]	6	16	-	-	-	-
SS6	-	18[a]	-	-	-	-	-	-
SS7	-	68[a]	-	-	-	-	-	-

[a]Compound found in blank as well as sample. Sample concentration less than 10 times blank concentration.

[b]Compound found in blank as well as sample. Sample concentration greater than 10 times blank concentration.
All Values not reported were below detection limits.

Sample Depths:

S1--3 to 5 feet
S2--8 to 10 feet
S3--14 to 16 feet

WDR405/060

Table 13
VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER AT SITE 2C NAS, OCEANA
September 1988
(Concentrations in μg/l)

Well No.	Acetone	Benzene	Ethylbenzene	Toluene	Xylenes (Total)	Vinyl Chloride	1,1-Dichloroethane	1,2-Dichloroethene (Total)	Chloroethane
2C-MW1	13	7	15	34		2,500		2,400	
2C-MW2	30					37			
2C-MW3		5			5				
2C-MW4						210	25	12	78
Production Well	18								

All values not reported were below detection limits.

WDR405/061/2

Table 14
RESULTS OF METALS ANALYSIS OF GROUNDWATER SITE 2C NAS, OCEANA
September 1988

Parameter	2C-MW1	2C-MW2	2C-MW3	2C-MW4	Production Well
Silver (μg/L)	<3	<3	<3	<3	<3
Aluminum (μg/L)	<200	<200	<200	<200	<200
Arsenic (μg/L)	<5	<5	<5	6	<5
Barium (μg/L)	<200	<200	<200	<200	<200
Beryllium (μg/L)	<5	<5	<5	<5	<5
Calcium (mg/L)	60.8	52.3	39.0	33.0	59.2
Cadmium (μg/L)	<3	5	<3	<3	<3
Cobalt (μg/L)	<50	<50	<50	<50	<50
Chromium (μg/L)	<10	<10	<10	<10	<10
Copper (μg/L)	<25	<25	<25	<25	<25
Iron (μg/L)	13.5*	8300	7100	4500	3680
Mercury (μg/L)	<0.2	<0.2	<0.2	<0.2	<0.2
Potassium (mg/L)	40.0	11.5	<5.0	<5.0	<5.0
Magnesium (mg/L)	6.9	8.2	15.9	10.6	14.4
Manganese (μg/L)	610	430	690	350	370
Sodium (mg/L)	37.7	31.0	50.6	44.2	52.7
Nickle (μg/L)	<40	<40	50	<40	<40
Lead (μg/L)	<5	<5	<5	<5	<5
Antimony (μg/L)	<5	<5	<5	<5	<5
Selenium (μg/L)	<5	<5	<5	<5	<5
Thallium (μg/L)	<5	<5	<5	<5	<5
Vanadium (μg/L)	<50	<50	<50	<50	<50
Zinc (μg/L)	170	120	160	120	50

*Value reported in mg/L.

WDR05/064

Table 15
WATER LEVELS IN MONITORING WELLS
SITE 2C NAS, OCEANA
September 22, 1988

Well Number	Water Level (feet above MSL)	Top of Protective Casing Elevation (feet above MSL)
MW1	12.70	20.14
MW2	12.49	20.23
MW3	12.47	21.29
MW4	12.11	19.56

Water level measurements are accurate to ±0.02 feet, which include ±0.01 feet for top of protective casing measurements.

Elevations are referenced to the National Geodetic Survey Datum of 1929.

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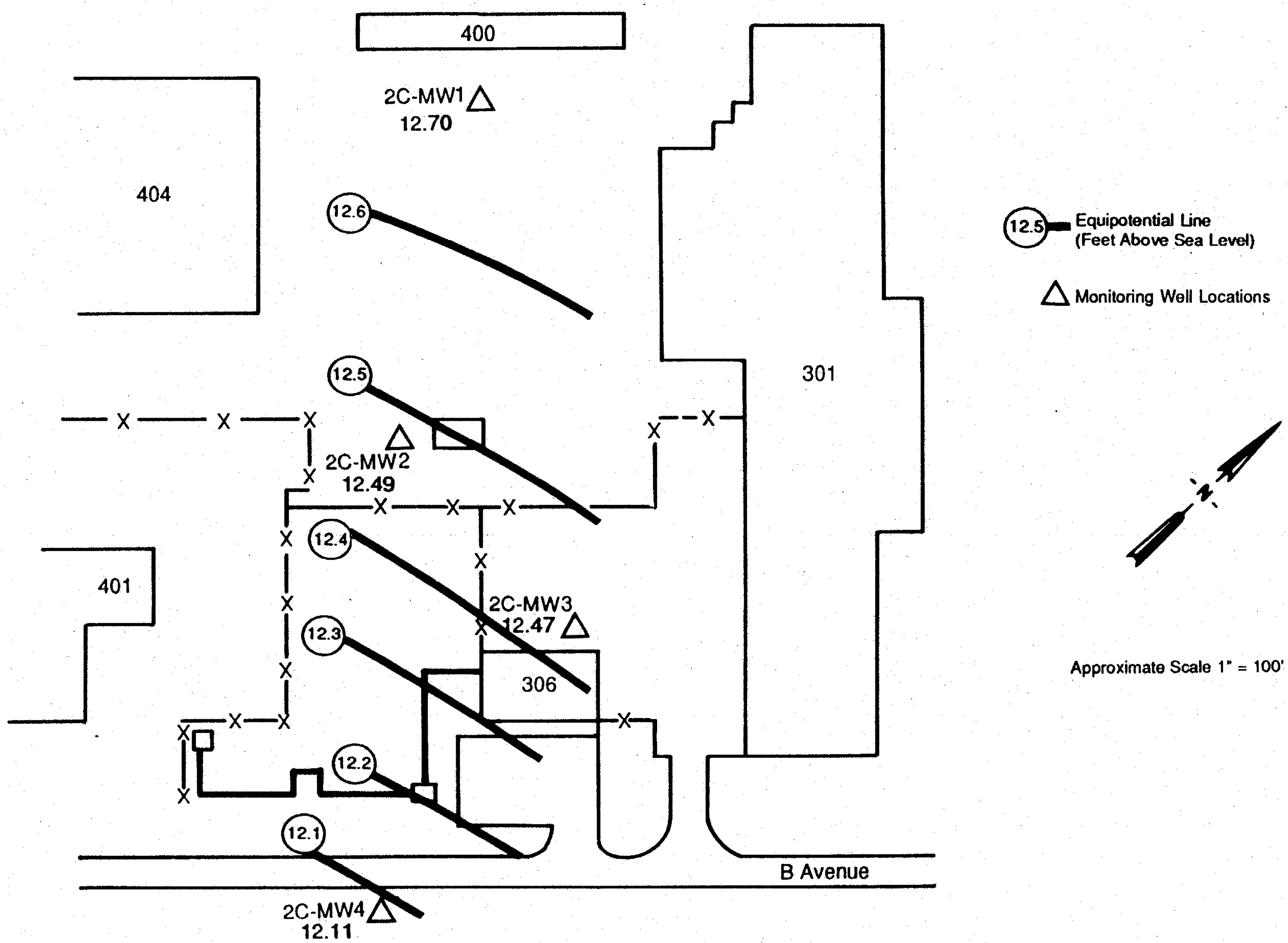

Figure 5
SITE 2C
PIEZOMETRIC SURFACE MAP OF THE SURFICIAL DEPOSITS
Naval Air Station, Oceana

CH2M HILL

across the site. As was the case at Site 2B, the data represent only a single point in time, and all features on the map may not be exactly to scale.

Methylene chloride was frequently detected in soil samples at this site; however, it was also a common constituent of the laboratory blanks along with acetone and chloroform. Other volatile compounds found in soil samples at the site include toluene, xylene, carbon disulfide, vinyl chloride, and 1,1-dichloroethane.

With respect to the groundwater samples, vinyl chloride was detected in three of the four monitoring wells. The one monitoring well in which vinyl chloride was not detected (2C-MW3) yielded the only soil sample to contain the compound. However, soil samples were not analyzed from 2C-MW1 and 2C-MW4. The highest concentration of vinyl chloride in groundwater was detected in 2C-MW1, the well upgradient from the other three. This well also contains a high concentration of 1,2-dichloroethene, and lesser amounts of acetone, benzene, ethylbenzene, and toluene. This suggests that 2C-MW1 is not upgradient of the contaminant source. The furthest downgradient well (2C-MW4) indicated the presence of vinyl chloride, 1,1-dichloroethane, 1,2-dichloroethene, and chloroethane. The only VOC detected in the production well was acetone. Currently, the exact location and depth of this well are unknown. Calcium, iron, potassium, magnesium, manganese, sodium, and zinc--all naturally-occurring in groundwater--were detected as expected. One sample (2C-MW4) contained arsenic at 6 μg/l and one (2C-MW3) contained nickel at 50 μg/l.

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DATA EVALUATION

Tables 16 and 17 compare the maximum concentrations of contaminants detected in groundwater at Sites 2B and 2C with ARARs identified in Superfund and Health Advisories. Methylene chloride was also detected in the groundwater samples, but because it was found in the laboratory blank at a comparable concentration, the reported result is assumed to be false. Similarly, concentrations of copper, lead, mercury, and zinc were found in concentrations close to the detection limits in both the field and quality control samples, which were collected from the base water supply. As a result, these parameters are not reported in these tables.

Federal ARARs for groundwater include maximum contaminant level goals (MCLGs), maximum contaminant levels (MCLs), and water quality criteria (WQC). The following sections provide further information on the ARARs.

Maximum Contaminant Level Goals. MCLGs, established under the Safe Drinking Water Act, are set with a margin of safety at levels at which lifetime exposure is not expected to result in any known or anticipated adverse effects to health. MCLGs for known and probable human carcinogens are set at zero (40 CFR 141.50).

Maximum Contaminant Levels. MCLs are enforceable standards set for public water supply systems promulgated under the Safe Drinking Water Act. They are set at levels that are determined to be protective and are as close as feasible to the MCLGs; but, in addition, the MCL accounts for the use of the best available technology, treatment cost, and other considerations. Secondary MCLs are set at levels affecting the taste or odor of water and are not health-based (40 CFR 141).

Water Quality Criteria. WQC are established under the Clean Water Act for evaluating toxic effects on human health and aquatic organisms. The WQC reported in Tables 16 and 17 are for human exposure from ingestion of contaminated drinking water and were listed in the Superfund Public Health Evaluation Manual (U.S. EPA, 1986b).

The tables present WQC for both carcinogenic and noncarcinogenic chemicals. Values reflecting risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are published for carcinogens. These values represent the increased probability of cancer incidence resulting from lifetime exposure (e.g., a value of 10^{-6} means that the increased probability of cancer is one in one million). Concentration values for cancer risk criteria are strictly health-based and can be below standard detection levels. MCL values, on the other hand, are based on a variety of factors in addition to human health considerations

Table 16
COMPARISION OF CONCENTRATIONS FOUND IN GROUNDWATER
TO SUPERFUND ARARs AND LIFETIME HEALTH ADVISORIES
SITE 2B
(µg/l) PPM

Chemical	Location Detected	Concentrations Reported	MCL (a)	MCLG (b)	Proposed MCLG(c)	Water Quality Criteria for Protection of Human Health (d) Ingestion of Drinking Water Only: Threshold Toxicity Protection	Water Quality Criteria for Protection of Human Health (d) Ingestion of Drinking Water Only: 10^{-6} Cancer Risk	Lifetime Health Advisory(e) 70 kg Adult	Virginia Groundwater Standard (h)
Arsenic, total	2B-MW5	13	50	-	50	-	0.0025	50	50
	2B-MW6	17							
Cadmium, total	2B-MW1	17	10	-	5	10	-	5	0.4
1,1-Dichloroethane	2B-MW1	82	-	-	-	-	-	-	-
	2B-MW3	44							
	2B-MW5	7							
1,1-Dichloroethene	2B-MW1	13	7	7	-	-	0.033	7	-
	2B-MW3	420							
	2B-MW5	49							
1,2-Dichloroethene (total)	2B-MW1	340	-	-	70	-	-	70	-
Iron, total	All	23,400 to 1,340	300*	-	-	-	-	-	-
Manganese, total	All	190 to 1,000	50*	-	-	-	-	-	-
Trichloroethylene	2B-MW1	340	5	0	-	-	2.8	-	-
	2B-MW2	5							
	2B-MW3	820							
	2B-MW5	22							
Vinyl chloride	2B-MW1	31	2	0	-	-	2	-	-
	2B-MW5	55							

* Secondary MCL
a. 40 CFR 141 and 143. Virginia State MCLs, where applicable, are the same as Federaterworks Regulations, February 1, 1982).
b. 40 CFR 141.50.
c. 50 FR 46936; November 13, 1985.
d. 45 FR 79318-79379; November 28, 1980.
e. U.S. EPA, Health Advisories, March 1987.
f. Integrated Risk Information System data base.
g. Assuming drinking water ingestion of 2 liter/day and body weight of 70 kg.
h. Virginia Water Quality Standards Section 62.1-44.15(3) of Virginia Code, June 12,

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Table 17
COMPARISION OF CONCENTRATIONS FOUND IN GROUNDWATER
TO SUPERFUND ARARs AND LIFETIME HEALTH ADVISORIES
SITE 2C
(µg/l)

Chemical	Location Detected	Concentrations Reported	MCL (a)	MCLG (b)	Proposed MCLG(c)	Water Quality Criteria for Protection of Human Health (d) Ingestion of Drinking Water Only: Threshold Toxicity Protection	Water Quality Criteria for Protection of Human Health (d) Ingestion of Drinking Water Only: 10^{-6} Cancer Risk	Lifetime Health Advisories(e) 70 kg Adult	Virginia Groundwater Standard (h)
Acetone	2C-MW1 2C-MW2 Prod. Well	13 30 18	-	-	-	-	-	-	-
Arsenic, total	2C-MW4	6	50	-	50	-	0.0025	50	50
Benzene	2C-MW1 2C-MW3	7 5	5	0	-	-	0.67	-	-
Cadmium, total	2C-MW2	5	10	-	5	10	-	5	0.4
Chloroethane	2C-MW4	78	-	-	-	-	-	-	-
1,1-Dichloroethane	2C-MW4	25	-	-	-	-	-	-	-
1,2-Dichloroethene (total)	2C-MW1 2C-MW4	2,400 12	-	-	70	-	-	70	-
Ethylbenzene	2C-MW1	15	-	-	680	2,400	-	680	-
Iron, total	All	4,500 to 13,500	300*	-	-	-	-	-	-
Manganese, total	All	350 to 690	50*	-	-	-	-	-	-
Nickel, total	2C-MW3	50	-	-	-	15.4	-	150	-
Toluene	2C-MW1	34	-	-	2,000	15,000	-	2,420	-
Vinyl chloride	2C-MW1 2C-MW2 2C-MW4	2,500 87 210	2	0	-	-	2	-	-
Xylenes	2C-MW3	5	-	-	440	-	-	400	-

* Secondary MCL
a. 40 CFR 141 and 143. Virginia State MCLs, where applicable, are the same as Federal MCLs (Commonwealth of Virginia, Waterworks Regulations, February, 1982).
b. 40 CFR 141.50.
c. 50 FR 46936; November 13, 1985.
d. 45 FR 79318-79379; November 28, 1980.
e. U.S. EPA, Health Advisories, March 1987.
f. Integrated Risk Information System data base.
g. Assuming drinking water ingestion of 2 liter/day and body weight of 70 kg.
h. Virginia Water Quality Standards Section 62.1-44.15(3) of Virginia Code, June 12, 1986.

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(i.e., cost of treatment and technological feasibility). WQC are also published for noncarcinogenic effects (U.S. EPA, 1986a). These criteria are referred to as Threshold Toxicity Protection values.

Health Advisories. Health advisories are nonenforceable contaminant limits published by the Office of Drinking Water for 1-day, 10-day, longer term, and lifetime exposures to chemicals. They are generally published for noncarcinogenic endpoints of toxicity. Lifetime health advisories, reported in Tables 16 and 17, are not provided for known or probable human carcinogens because carcinogenic effects are expected to result in health effects at any dose (U.S. EPA, 1987b).

Presented separately from the criteria in Tables 16 and 17 are cancer potency factors and reference doses (RfDs). These criteria have been developed by EPA to establish cleanup levels for a single exposure pathway--at the Navy sites, there may be multiple exposure pathways. They are described further below and are presented in Table 18.

Cancer Potency Factors are developed by the EPA Carcinogen Assessment Group and the EPA Environmental Criteria and Assessment Office. The cancer potency factor can be used to calculate the concentration of a carcinogen associated with a particular cancer risk level by the equation:

$$\text{Concentration} = \frac{\text{Risk x Body Weight}}{\text{Cancer Potency Factor x Ingestion Rate}} \qquad (1)$$

Typical assumptions applied when using this equation are: a body weight of 70 kilograms, and a drinking water ingestion rate of 2 liters per day. For soil, estimates of the ingestion rate range from 100 mg/day to 1 g/day (U.S. EPA, 1986b). Example concentrations (in water) which correspond to a cancer risk level of 10^{-6} are shown in Table 18. It is important to note that 10^{-6} is used only as an example value, and that CH2M HILL does not recognize 10^{-6} to be, necessarily, either an acceptable or an appropriate level of cancer risk. Therefore, it is not appropriate to compare the field data directly with the example concentrations in Table 18.

Reference Doses (RfDs). RfDs are derived from analysis of toxicological data by EPA. The RfD is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of adverse systemic effects during a lifetime. Systemic toxicants are those believed to be toxic only at concentrations above a threshold dose; doses below this threshold are not expected to result in a significant adverse effect. Concentrations calculated from RfDs are determined on the basis of medium-specific lifetime exposure assumptions. At the concentration corresponding to the RfD, toxic effects are not expected to occur. To calculate the concentration

Table 18
CANCER POTENCY FACTORS AND RfDs FOR INGESTION EXPOSURES

Chemical	Cancer Potency Factor (kg day/mg)	Concentration in Water Corresponding to 10^{-6} Risk[a] (μg/l)	RfD mg/kg day	Concentration in Water Corresponding to RfD[b] (μg/l)
Acetone	-	-	0.1	3,500
Benzene	0.05	0.7	-	-
Carbon disulfide	-	-	0.1	3,500
Ethylbenzene	-	-	0.1	3,500
Methyl ethyl ketone (MEK)	-	-	0.05	1,750
Methyl isobutyl-ketone (MIBK)	-	-	0.05	1,750
Methylene chloride	0.0007	50.0	0.06	2,100
Toluene	-	-	0.3	10,500
Trichloroethylene	0.011	3.0	-	-
Vinyl Chloride	2.3	0.015	-	-
Xylene	-	-	0.01	350

[a]Example values assuming: cancer risk factor of 10^{-6}, body weight of 70 kg, and drinking water ingestion rate of 2 l/day.

[b]Example values assuming: body weight of 70 kg, and drinking water ingestion rate of 2 l/day.

of a systemic toxicant associated with the RfD, the following equation is used:

$$\text{Concentration} = \frac{\text{RfD x Body Weight}}{\text{Ingestion Rate}} \quad (2)$$

Typical assumptions applied when using this equation are: a body weight of 70 kilograms, and a drinking water ingestion rate of 2 liters per day. For soil, estimates of the ingestion rate range from 100 mg/day to 1 g/day. Concentrations (in water) assuming these conditions are presented in Table 18.

SITE 2B

Contaminants whose concentrations exceed the MCLs and other ARARs and guidelines at Site 2B include 1,1-dichloroethene, TCE, vinyl chloride, cadmium, iron, and manganese. The MCLs for iron and manganese are secondary MCLs--levels at which the taste or odor of the water is undesirable; health is not affected at these levels. The concentration of 1,2-dichloroethene (total) exceeds the Office of Drinking Water (ODW) health advisory for lifetime exposure to an adult; this level is an unenforceable guideline. The concentrations of arsenic, 1,1-dichloroethene, TCE, and vinyl chloride, exceed the water quality criteria (WQC) for protection of human health at the 10^{-6} excess lifetime cancer risk level; however, with the exception of arsenic, these chemical also exceed their respective MCL. Lastly, the concentration of nickel exceeds the WQC for protection from chronic toxicity (noncarcinogenicity).

SITE 2C

Contaminants whose concentrations exceed the MCLs and other ARARs and guidelines at Site 2C include benzene, vinyl chloride, iron, and manganese. The MCLs for iron and manganese are secondary MCLs--levels at which the taste or odor of the water is undesirable; health is not affected at these levels. The concentration of 1,2-dichloroethene (total) exceeds the Office of Drinking Water (ODW) health advisory for lifetime exposure to an adult; this level is an unenforceable guideline. The concentrations of arsenic, benzene, and vinyl chloride, exceed the water quality criteria (WQC) for protection of human health at the 10^{-6} excess lifetime cancer risk level; however, with the exception of arsenic, these chemical also exceed their respective MCL.

WORKER EXPOSURE GUIDELINES

Table 19 presents toxicity profiles for chemicals that exceed levels reported in Tables 16 and 17.

Volatile organic chemicals and heavy metals were identified in soil and groundwater during site inspection activities. Tables 20 and 21 present the maximum reported concentration in soil and groundwater for VOCs along with their Threshold Limit Value (TLV). The TLV refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

The Occupational Safety and Health Administration (OSHA) adopted the 1968-69 TLVs and called them Permissible Exposure Limits (PELs). The PEL is an enforceable OSHA standard and represents an 8-hour time-weighted average exposure level. In most cases, the TLV is lower than the PEL, but with two notable exceptions. Benzene and vinyl chloride have a PEL of 1 part per million (ppm) while the TLVs are 10 ppm and 5 ppm, respectively. The OSHA PEL is the governing value.

SITE 2B

The VOCs identified in soils were in ppb concentrations with lower concentrations identified in groundwater. 1,2-Dichloroethene and vinyl chloride were not identified in soils but were identified in groundwater at a maximum concentration of 0.34 mg/l and 0.055 mg/l, respectively.

Workers involved in construction activities in the general area of Site 2B would be potentially exposed to ppb concentrations of VOCs present in soil and groundwater.

The maximum reported value for each VOC identified in soil and groundwater is orders of magnitude lower than the TLV. However, the concentrations reported in soil and groundwater can not be directly related to concentrations in air. They can only give an indication of probable concentrations that may be found in air. No actual concentrations were determined in the air at this site.

To fully assess the VOC and vinyl chloride hazards posed to workers during planned construction activities, air, soil, and groundwater monitoring analytical results would need to be obtained in these immediate areas. Without this information, only a preliminary assessment of these hazards can be presented in this report.

Table 19
PROFILES OF SELECTED CHEMICALS

Chemical	Acute Toxicity Summary*	Chronic Toxicity Summary*	Cancer Potential	Other
Benzene	Acute exposures (inhalation) to high levels of benzene may lead to depression of the central nervous system, unconsciousness, and death or may cause fatal cardiac arrhythmias.	Major toxic effect is hematopoietic toxicity (affects formation of blood); chronic exposure of workers to low levels has been associated with blood disorders, such as leukemia and aplastic anemia (depression of all three cell types of the blood in absence of functioning marrow).	Sufficient evidence that human and animal carcinogen; strong correlation between exposure to benzene by inhalation and leukemia.	Chromosomal aberrations in bone marrow and blood have been reported in experimental animals and some workers.
Cadmium	For acute exposures by ingestion, symptoms of cadmium toxicity include nausea, vomiting, diarrhea, muscular cramps, salivation, spasms, drop in blood pressure, vertigo, loss of consciousness, and collapse. Acute renal failure, liver damage, and death may occur. Exposure by inhalation can cause irritation, coughing, labored respiration, vomiting, acute chemical pneumonitis, and pulmonary edema.	Respiratory and renal toxicity are major effects in workers. Chronic oral exposures can produce kidney damage. Cadmium accumulates in kidney, and nephropathy results after critical concentration in kidney is reached, probably about 200 ug/g. Inhalation can cause chronic obstructive pulmonary disease, including bronchitis, progressive fibrosis, and emphysema. Chronic exposure affects calcium metabolism and can cause loss of calcium from bone, bone pain, osteomalacia, and osteoporosis. Chronic exposure may be associated with hypertension. Cadmium can product testicular atrophy, sterility, and teratogenic effects in experimental animals.	Increased risk of prostate cancer and perhaps respiratory tract cancer in workers exposed by inhalation. No evidence of carcinogenicity from chronic oral exposure.	A nonessential element.
cis-1,2-Dichloroethene	Anesthetic at high concentrations; appears half as potent as trans-isomer in depressing CNS; elevated liver enzymes in rats reported after one exposure.	Minimal fatty accumulation in liver of rats chronically exposed to high doses of cis-1,2-DCE in drinking water.		
trans-1,2-Dichloroethene	Inhalation exposure to high levels can cause narcosis and death in rats.	Rats exposed by inhalation exhibited fatty accumulation in liver and infiltration of lungs.		
Iron	Oral exposure can result in severe toxicity, especially in children ingesting medicine; vomiting, sometimes bloody, black stools, shock, metabolic acidosis, liver damage, followed by coagulation defects and renal failure.	Chronic exposure can produce hemosiderosis, disturbances in liver function, diabetes mellitus, endocrine, and cardiovascular effects.		Essential nutrient.

Table 19
(Continued)

Chemical	Acute Toxicity Summary*	Chronic Toxicity Summary*	Cancer Potential	Other
Manganese	Acute inhalation exposures to very high concentrations can cause manganese pneumonitis.	Chronic manganese poisoning results from inhalation of high concentrations of manganese dust. Chronic manganese poisoning is characterized by psychiatric symptoms, such as irritability, difficulty in walking, speech disturbances, and compulsive behavior and by encephalopathy and progressive deterioration of the central nervous system. Chronic effects of manganese poisoning are similar to Parkinson's disease. Liver changes are also frequently seen. Individuals with an iron deficiency may be more susceptible to chronic poisoning.		Manganese is an essential nutrient. Manganese concentrations in water a 50 ug/l may exhibit undesirable taste and discoloration.
Nickel	Signs of acute nickel toxicity may include headaches, nausea, vomiting, chest pain, cough, hyperpnea, cyanosis, gastrointestinal and central nervous system effects, weakness, fever, pneumonia, respiratory failure, cerebral edema, and death. Acute exposures to nickel containing dust may result in chemical pneumonitis.	Rhinitis, nasal sinusitis, and nasal mucosal injury are among the effects reported among workers chronically exposed to various nickel compounds. Allergic contact dermatitis and other dermatological effects are the most frequent effects of dermal exposure to nickel and nickel-containing compounds.	There is extensive epidemological evidence indicating excess cancer of the lung and nasal cavity for workers exposed to certain nickel compounds. Nickel compounds implicated as having carcinogenic potential include insoluble dusts of nickel subsulfide and nickel oxides, vapor of nickel carbonyl and soluble aerosols of nickel sulfate, nickel carbonyl.	May or may not be an essential element.
Vinyl Chloride	Acute occupational exposure to high concentrations of vinyl chloride can produce symptoms of narcosis in humans. Respiratory tract irritation, bronchitis, headache, irritability, memory disturbances, and tingling sensations may also occur.	Human health effects associated with chronic exposure to vinyl chloride include hepatitis-like liver changes, decreased blood platelets, enlarged spleens, decreased preliminary function, acroosteolysis, selerotic syndrome, and thrombocytopenia.	Vinyl chloride is a known human carcinogen, causing liver angiosarcomas and tumors of the brain, lung, and hemolympopoietic system in humans. Vinyl chloride is carcinogen in mice, rats, and hamsters. Adenomas and ademocarcinomas of the lung, angiosarcomas of th eliver, lymphomas and neuroblastomas of the brain have been induced in laboratory animals by inhalation.	Vinyl chloride is mutagenic in several test systems. Chromosome aberrations have been reported in exposed workers. In humans, possible relationships between exposure and birth defects and fatal death. No animal evidence for teratogenic effects.

Table 19
(Continued)

*Health effect or target organ may be based on animal studies and does not imply that the results of exposure to humans will be the same.

Sources:

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40 CFR 141:25720-25734, July 8, 1987, EPA, Drinking Water.
ACGIH, American Conference of Governmental Industrial Hygienists, Inc., Documentation of the Threshold Limit Values, 1980, 1984.

Table 20
COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS WITH THRESHOLD LIMIT VALUE (TLV)
SITE 2B

Volatile Organic Chemical	Maximum Reported Concentrations in Soil (ppm)	Maximum Reported Concentrations in Water (ppm)	Threshold Limit Value in Air (ppm)[a]
Acetone	.240	---	750
Benzene	.012	---	10[b]
Carbon Disulfide	.018	---	10
1,2-Dichloroethenes (Total)	---	.34	200
Ethyl Benzene	.085	---	100
Methyl Ethyl Ketone	.027	---	200
Methyl Isobutyl Ketone	.030	---	50
Toluene	.110		100
Trichloroethene	.054	.82	50
Vinyl Chloride	---	.55	5[b]
Xylene	.480		100

[a]Threshold limit values for 1988-89, American Conference of Governmental Industrial Hygienists.
[b]The OSHA Permissible Exposure Limit (PEL) is 1 ppm for benzene and vinyl chloride.

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Table 21
COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS WITH THRESHOLD LIMIT VALUE (TLV)
SITE 2C

Volatile Organic Chemical	Maximum Reported Concentrations in Soil (ppm)	Maximum Reported Concentrations in Water (ppm)	Threshold Limit[a] Value in Air (ppm)
Acetone	---	.030	750
Benzene	---	.007	10[b]
Carbon Disulfide	.017	---	10
1,2-Dichloroethenes (Total)	---	2.40	200
Ethyl Benzene	---	---	100
Methyl Ethyl Ketone	---	---	200
Methyl Isobutyl Ketone	---	---	50
Toluene	.012	.034	100
Trichloroethene	---	---	50
Vinyl Chloride	.03	2.50	5[b]
Xylene	.016	.005	100

[a]Threshold limit values for 1988-89, American Conference of Governmental Industrial Hygienists.
[b]The OSHA Permissible Exposure Limit (PEL) is 1 ppm for benzene and vinyl chloride.

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While the exposure potentials at the site appear to be low, a site specific health and safety plan should be developed by the contractor. A discussion of some of the items which should be addressed in the plan is provided below. Protecting personnel against VOC overexposures would require an ongoing air monitoring program to be implemented during construction activities to evaluate the magnitude of the inhalation hazard. Direct reading instruments (photoionization detectors) could be used to measure VOCs in personnel's breathing zone during work activities. The instrument should be calibrated to read vinyl chloride (or other ethene compound) equivalents, and should only be used by personnel trained in its proper operation and maintenance.

A sustained instrument reading corresponding to levels established in the site health and safety plan, based on the PELS, would then require personnel to wear respiratory protection. Workers wearing respirators would be required to be medically qualified by a physician as to their ability to wear respiratory protection and perform construction work.

If vinyl chloride is encountered, then other precautions should be observed. Vinyl chloride has inadequate warning properties (e.g., odors are detected at concentrations much greater than its PEL) and air-purifying respirators are inefficient at removing vinyl chloride from contaminated air. As a result, self-contained breathing apparatus (SCBAs) would be required to be worn for respiratory protection. The construction contractor would also be required to implement a comprehensive respiratory protection program in accordance with OSHA 1910.134. The dermal contact hazard for vinyl chloride, as well as any other contaminants, would be controlled by providing personnel with chemical protective apparel (clothing, boots, and gloves) and instituting decontamination procedures and facilities onsite.

SITE 2C

The VOCs identified in soils were in ppb concentrations with lower concentrations identified in groundwater. 1,2-Dichloroethene and vinyl chloride were not identified in soils but were identified in groundwater at a maximum concentration of 2.4 mg/l and 2.5 mg/l, respectively. The maximum reported values for 1,2-dichloroethyene and vinyl chloride were found at the same location (2C-MW1), which is adjacent to Line Shack 400.

Workers involved in construction activities in the general area of Site 2C would be potentially exposed to ppb concentrations of volatile organics present in soil and groundwater. However, the concentrations reported in soil and groundwater cannot be directly related to concentrations in air. They can only give an indication of probable concentrations that may be found in the air. This assessment is based solely on the limited analytical results of soil and groundwater provided in this report. No actual concentrations were determined in the air at this site.

The exposure potential posed by vinyl chloride is greater than the other VOCs identified in soil and groundwater for two reasons. It was identified at concentrations in groundwater 2-1/2 times its PEL and it is a gas at standard ambient conditions. As a result, workers coming into contact with vinyl chloride-contaminated groundwater during construction activities onsite are potentially exposed to vinyl chloride through inhalation and direct dermal contact.

At some locations VOCs and especially vinyl chloride may be of concern with respect to the proper level of personal protection. A site-specific health and safety plan should be developed by the contractor. A discussion of some of the items that should be addressed in the plan is provided below. Protecting personnel against vinyl chloride or other VOC overexposures would require an ongoing air monitoring program to be implemented during construction activities to evaluate the magnitude of this inhalation hazard. Direct reading instruments (photoionization detectors) could be used to measure VOCs in personnel's breathing zone during work activities. The instrument should be calibrated to read vinyl chloride equivalents and should only be used by personnel trained in its proper operation and maintenance.

A sustained instrument reading corresponding to levels established in the site health and safety plan based on the PELs (vinyl chlorides' PEL is 1 ppm) would then require personnel to wear respiratory protection. Workers wearing respirators would be required to be medically qualified by a physician as to their ability to wear respiratory protection and perform construction work.

If vinyl chloride is encountered, then other precautions should be observed. Since vinyl chloride has inadequate warning properties (e.g., odors are detected at concentrations much greater than its PEL) and air-purifying respirators are inefficient at removing vinyl chloride from contaminated air, self-contained breathing apparatus (SCBAs) would be required to be worn for respiratory protection. The construction contractor would also be required to implement a comprehensive respiratory protection program in accordance with OSHA 1910.134. The dermal contact hazard for vinyl chloride, as well as any other contaminants, would be controlled by providing personnel with chemical protective apparel (clothing, boots, and gloves) and instituting decontamination procedures and facilities onsite.

CONCLUSIONS AND RECOMMENDATIONS

The statements presented in this section are based solely on the results of the activities specified in the Scope of Work. At both sites, the evaluation of current conditions is limited by the specific chemical parameters and sampling locations determined in the Scope of Work by the Navy. The conclusions and recommendations are presented separately for each site.

SITE 2B

For reference in this discussion, the approximate location of the proposed construction at this site is shown in Figure 6. The chemical results indicate that contaminants, particularly VOCs, were detected in both soil and groundwater at Site 2B. The soil contamination does not appear to warrant further investigation. The concentrations of contaminants in groundwater, however, will most likely require additional study.

Soil

The samples of soil collected at this site do not exceed EP toxicity levels, for classification as a hazardous waste. Consequently, no specific remediation action (e.g., soil removal) is considered to be necessary for soil in the immediate vicinity of the sampling locations at this site.

Currently, the State of Virginia does not have any specific regulations concerning the presence of VOCs in soil. However, should soil be excavated during construction, guidance should be obtained from the State as to the proper location and method of disposal. This holds even though the soil from boreholes in the approximate vicinity of the proposed construction (B12 through B15) indicate relatively low concentrations of VOCs.

Groundwater

The results of the VOC analyses indicate elevated levels of volatile compounds in the three existing monitoring wells (2B-MW1, 2B-MW2, and 2B-MW3), and one new well (2B-MW5). The State of Virginia can request that remediation be implemented because VOC concentrations exceed background values in groundwater at these locations. The basis for such a request is the State's general antidegradation policy for groundwater (Virginia State Water Control Board, 1986).

The groundwater contamination is primarily found in the vicinity of Line Shacks 130 and 131; the original area of Site 2B as designated in the IAS. Any groundwater remediation actions will most likely focus on this portion of the

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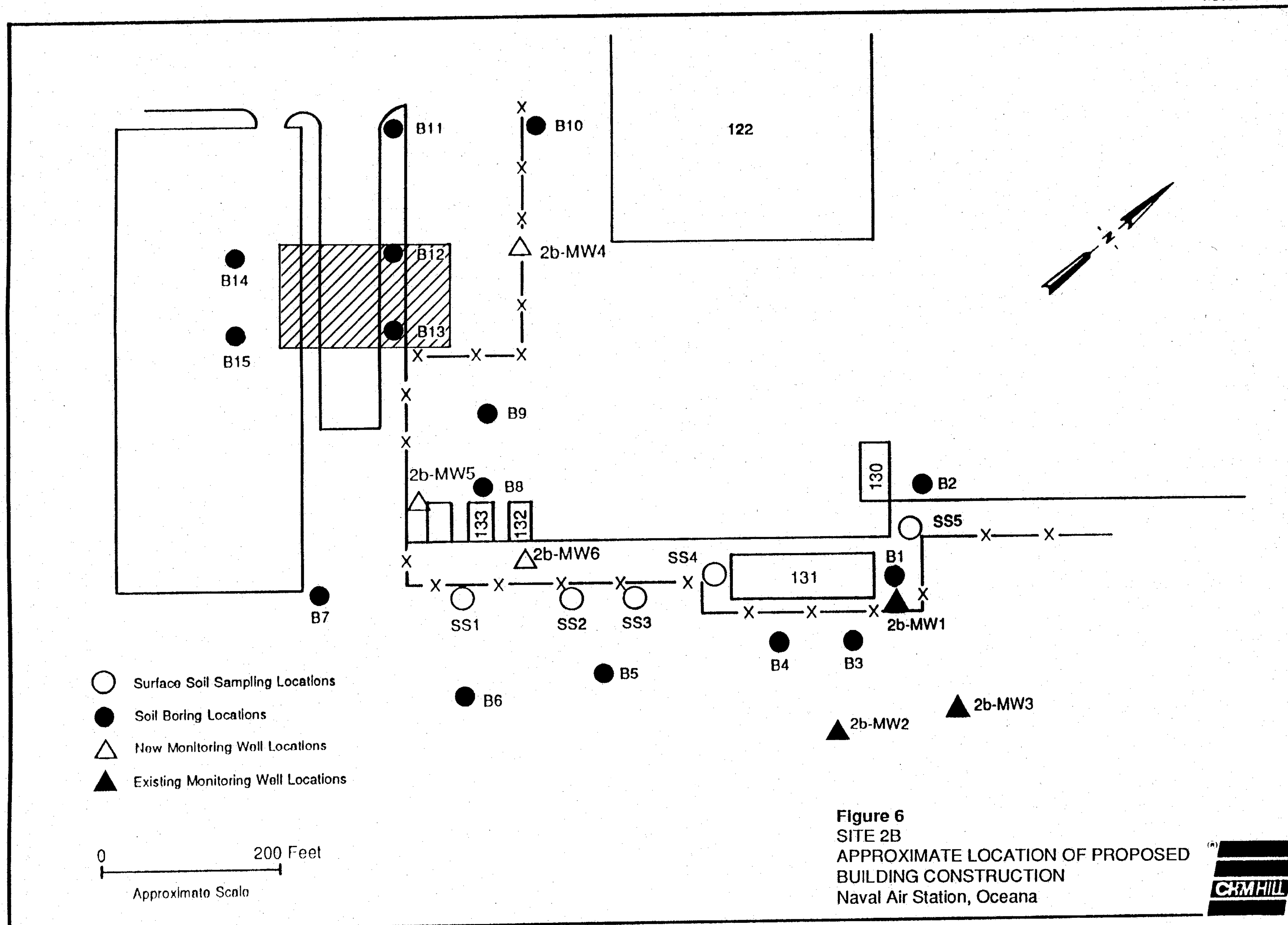

Figure 6
SITE 2B
APPROXIMATE LOCATION OF PROPOSED BUILDING CONSTRUCTION
Naval Air Station, Oceana

site, and the proposed construction activities, as known, are not planned to include this area. The results of the work completed to date suggest that remediation is probably not warranted west of soil boring B9. However, any dewatering activities at this site prior to remedial actions need to consider the effects of the groundwater contamination.

Implementing the proper remedial action will require undergoing further investigation in the Navy's RI/FS process. Satisfactory completion of a RI requires, among other things, a detailed RI work plan and sampling plan. These plans must address the identification of the source(s) and extent of groundwater contamination. This will involve at a minimum, the installation of additional monitoring wells and the implementation of a comprehensive groundwater monitoring program. The extent of the monitoring program can not be defined until a better understanding of the source of the contamination is determined, if possible.

SITE 2C

The chemical results from this site indicates that contaminants, particularly VOCs, were detected in both soil and groundwater. The soil contamination does not appear to warrant further investigation. The concentrations of contaminants in groundwater, however, will most likely require additional study.

Soil

The samples of soil collected at this site do not exceed EP toxicity levels, for classification as a hazardous waste. Consequently, no specific remediation action (e.g., soil removal) is considered to be necessary for soil in the immediate vicinity of the sampling locations at this site.

Currently, the State of Virginia does not have any specific regulations concerning the presence of VOCs in soil; however, should soil be excavated during construction, guidance should be obtained from the State as to the proper location and method of disposal.

Groundwater

The results of the VOC analyses indicated elevated levels of volatile compounds in all four monitoring wells. The State of Virginia can request that remediation be implemented because VOC concentrations exceed background values in groundwater at these locations. The basis of such a request is the State's general antidegradation policy for groundwater (Virginia State Water Control Board, 1986).

Groundwater contamination is in the vicinity of the planned construction. Implementing the actual remediation technologies may not be hindered by construction unless dewatering is necessary. Any dewatering activities prior to remedial actions need to consider the effects of the groundwater contamination. Construction activities could make the additional field investigation more difficult to conduct.

Implementing the proper remedial action will require undergoing further investigation in the Navy's RI/FS process. Satisfactory completion of a RI requires, among other things, a detailed RI work plan and sampling plan. These plans must address the identification of the source(s) and extent of groundwater contamination. This will involve at a minimum, the installation of additional monitoring wells and the implementation of a comprehensive groundwater monitoring program. The extent of the monitoring program cannot be defined until a better understanding of the source of contamination is determined, if possible.

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REFERENCES

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Appendix A

BORING LOGS

CH2M HILL

PROJECT NUMBER: WDC 20368.D0 | BORING NO.: 2B-B1 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGTION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: HOLLOW STEM AUGER, CME
WATER LEVEL AND DATE: START: 8/24/88 FINISH: 8/24/88 LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	6-6-7-9 (13)	Top 7" Clayey silt w/tr. f. sand, dark yel. brown (10YR4/2), dry, crumbly. Bottom 9" F. sand w/ silt, dark yel. orange (10YR6/6), moist.		
	3-5	S2	14	4-7-9-9 (16)	Silty clay, dark brown (5YR2/2), moist, slightly crumbly.		
5							
	8-10	S3	20	2-2-2-14 (4)	Top 17" Clay w/tr. silt, light gray (N7), moist. Bottom 3" F. sand w/ silt, tr. clay, light gray, wet.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B2	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: ~8', 8/24/88   START: 8/24/88   FINISH: 8/24/88   LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	12-13-9-7 (22)	Clay silt, olive gray (5Y3/2), moist.		
	3-5	S2	18	3-3-3-4 (6)	Clay w/ tr. silt, tr. f. sand, light gray (N7), moist.		
5							
	8-10	S3	17	6-15-20-23 (35)	F-m. sand w/ silt, dark yel. orange (10YR6/6), saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B3	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8' START: 8/25/88 FINISH: 8/25/88 LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH INTERVAL	DEPTH TYPE AND NUMBER	REC	STD. PEN. TEST 6"-6"-6 (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	10	4-5-5-4 (10)	M. sand w/ silt, tr. clay, medium gray (N5), moist, slight hydrocarbon odor.		
	3-5	S2	20	1-2-3-4 (5)	Clay, w/ tr. silt, dark gray (N3), dense, moist.		
5							
	8-10	S3	13	5-3-3-4 (6)	F. sand w/ silt, medium gray (N5), saturated.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B4 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8'   START: 8/25/88   FINISH: 8/25/88   LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	18	2-2-3-4 (5)	F. sand w/ silt, distinct bands of clay w/ silt, brownish black (5YR2/1), strong hydrocarbon odor. HNu of sediments ~10 ppm.		
	3-5	S2	17	1-1-2-3 (3)	Clay, tr. silt and f. sand, dark gray (N3), strong hydrocarbon odor, moist.		
5							
	8-10	S3	15	1-1-1-7 (8)	F. v. f. sand w/ small lens of clay/silt, dark gray (N3), saturated. Below the water table no specific odor.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B5 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8' START: 8/25/88 FINISH: 8/25/88 LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	3-4-4-5 (8)	Clay silt, w/ organic material, dark yel. brown (10YR4/2), dry, crumbly.		
	3-5	S2	14	3-10-11-12 (21)	F. sand w/ silt, tr. clay, medium light gray (N6), moist.		
5							
	8-10	S3	10	2-14-5 (19)	V. f. sand w/ silt, tr. clay, dark gray (N3), saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B6 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8', 8/2START: 8/25/88   FINISH: 8/25/88   LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	5	5-7-6-6 (13)	Clay silt, w/ organic material, dark yel. brown (10YR4/2), dry, crumbly.		
	3-5	S2	11	7-6-10-15 (16)	F-v.f. sand w/ silt, tr. clay, medium light gray (N3), moist.		
5							
	8-10	S3	13	5-6-6-10 (12)	V. f. sand w/ silt, medium light gray (N6), saturated.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B7 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: ~4', 8/25/88 START: 8/25/88 FINISH: 8/25/88 LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	10-12-11-19 (23)	Clayey silt, w/ organic material, dark yel. brown (10YR4/2), dry, crumbly.		
	3-5	S2	15	4-5-6-9 (11)	F. sand w/ silt, tr. clay, light gray (N7), wet, water table is w/in sample interval.		
5							
	8-10	S3	15	4-4-7-8 (11)	Vf. sand w/ silt, dark gray (N3), saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B8	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8'   START: 8/30/88   FINISH: 8/30/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	14	3-5-6-2 (11)	Silty f. sand, pale yel. brown (10YR6/2).		
	3-5	S2	20	2-3-6-7 (9)	Silty clay, brownish gray (5YR4/1), moist, medium plasticity.		
5							
	8-10	S3	18	15-17-17-18 (34)	F. sand w/ silt, medium gray (N4) w/ some light brown (5YR5/6), saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B9 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8'   START: 8/30/88   FINISH: 8/30/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	5-8-3-7 (11)	Silty f-m. sand, pale yel. brown (10YR6/2), moist.		
	3-5	S2	17	4-3-4-4 (7)	Clay, brownish gray (5YR4/1), moist, medium plasticity.		
5							
	8-10	S3	20	16-19-16-22 (35)	Vf-f. sand, gray orange (10YR7/4) to medium gray (N5), saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B10	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION — LOCATION: OCEANA
ELEVATION: — DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: ~10', 8/30 — START: 8/30/88 — FINISH: 8/30/88 — LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	18	3-3-3-4 (6)	Silty vf-f. sand, pale yel. brown (10YR6/2), moist.		
	3-5	S2	4	12-7-8-12 (15)	Sandy clay w/ silt, pale yel. brown (10YR6/2), moist, low plasticity, contains gravel fragments (1/4' to 1').		
5							
	8-10	S3	16	6-11-17-20 (28)	Silty sand, tr. clay, light gray (5Y5/2) to brownish gray (5YR4/1), moist.		
10					Silty vf-f. sand, medium gray (N5), wet.		
	10-12	S4	20	4-4-3-2 (7)			
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B11 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8' START: 8/31/88 FINISH: 8/31/88 LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6 (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	16	3-3-7-8 (10)	sSilty f. sand, dark yel. brown (10YR4/2), moist.		
	3-5	S2	24	4-3-3-4 (6)	Silty clay, tr. f. sand, yel. brown (10YR5/4), moist, low plasticity.		
5							
	8-10	S3	20	14-17-21-26 (38)	F. sand, tr. silt medium gray (N5) saturated.		
10					Same as above.		
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B12	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8'   START: 8/31/88   FINISH: 8/31/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	17	2-6-7-10 (13)	Silty sand, tr. gravel brown gray (5YR4/1).		
	3-5	S2	22	4-3-3-4 (6)	Clay, medium light gray (N6), moist, medium plasticity.		
5							
	8-10	S3	15	14-14-10-15 (24)	F. sand, tr. silt light gray (N6) to medium dark (N4), saturated.		
10	10-12	S4	22	3-6-5-6 (11)	Same as above.		
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2B-B13	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 5-8' START: 8/31/88 FINISH: 8/31/88 LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH INTERVAL	TYPE AND NUMBER	REC	STD. PEN. TEST 6"-6"-6 (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	19	2-2-3-2 (5)	Silty vf-v. sand, tr. clay and tr. gravel dark yel. brown (10YR4/2), moist.		
	3-5	S2	13	3-4-3-3 (7)	Clay, tr. silt, medium light gray (N6), moist, medium plasticity.		
5							
	8-10	S3	20	4-5-7-1 (12)	F. sand, tr. silt dark gray (N6), poorly sorted, saturated.		
10							
15							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B14 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: ~6', 8/26/88 START: 8/26/88 FINISH: 8/26/88 LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	14	12-8-8-7 (16)	F. sand w/ tr. silt, pale yel. brown (10YR6/2) and light gray (N7), moist.		
	3-5	S2	18	3-5-5-5 (10)	Clay, w/ silt, tr. v. f. sand, brownish gray (5YR4/1), moist.		
5							
							water table @ ~6 feet
	8-10	S3	20	3-4-4-4 (8)	V. f. sand w/ silt, tr. clay, medium dark gray (N4), saturated.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-B15 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: ~6', 8/26/88   START: 8/26/88   FINISH: 8/26/88   LOGGER: F. LEWIS

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	S1	14	5-6-7-5 (13)	F-v.f. sand w/ tr. silt, pale yel. brown (10YR6/2) to light gray (N7), moist.		
	3-5	S2	20	2-3-4-6 (7)	Clay, w/ silt, tr. v.f. sand, brownish gray (5YR4/1), moist.		
5							
							water table @ ~6 feet
	8-10	S3	17	5-3-3-6 (6)	V. f. sand w/ silt, tr. clay, medium dark gray (N4), saturated.		
10							
15							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-MW4 | SHEET: 1 OF 1

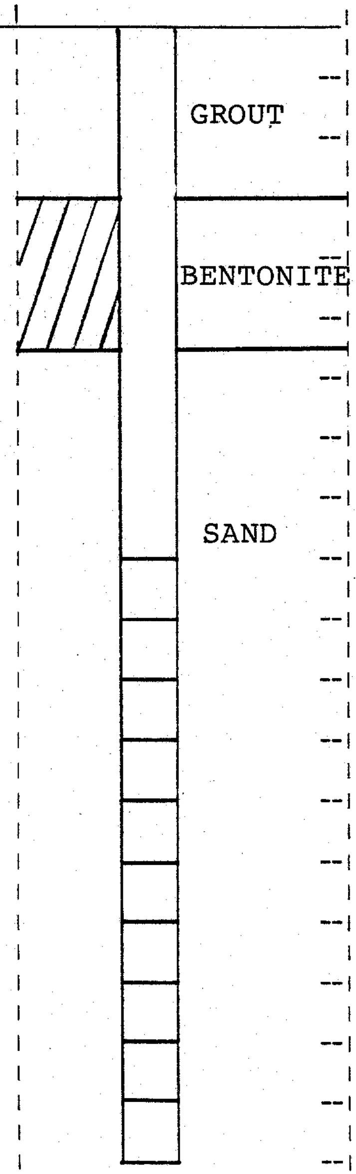
SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION
LOCATION: OCEANA
ELEVATION:
DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 7.5', 9/2/88
START: 9/2/88
FINISH: 9/2/88
LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG
	0-2	S1	14	5-3-8-6 (11)	F. sand, w/ tr. silt, pale yel. brown (10YR6/2), moist.	
	3-5	S2	18	5-4-3-3 (7)	Silty clay, medium gray (N4), moist, low plasticity.	
5						
	8-10	S3	19	4-5-7-6 (12)	F. sand, tr. silt, light gray (N7) saturated.	
10						
	13-15	S4	24	7-5-18-12 (23)	Vf-f. sand, tr. silt, medium gray (N5), saturated.	
15						
	18-20	S5	22	5-7-9-1 (16)	Same as above.	
20						

WELL CONSTRUCTION

2 inch PVC FLUSH MOUNT



SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-MW5 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION

LOCATION: OCEANA

ELEVATION:

DRILLING CONTRACTOR: LAW ENGENEERING

DRILLING METHOD AND EQUIPMENT: CME HSA

WATER LEVEL AND DATE: 7.5', 9/1/88

START: 9/1/88

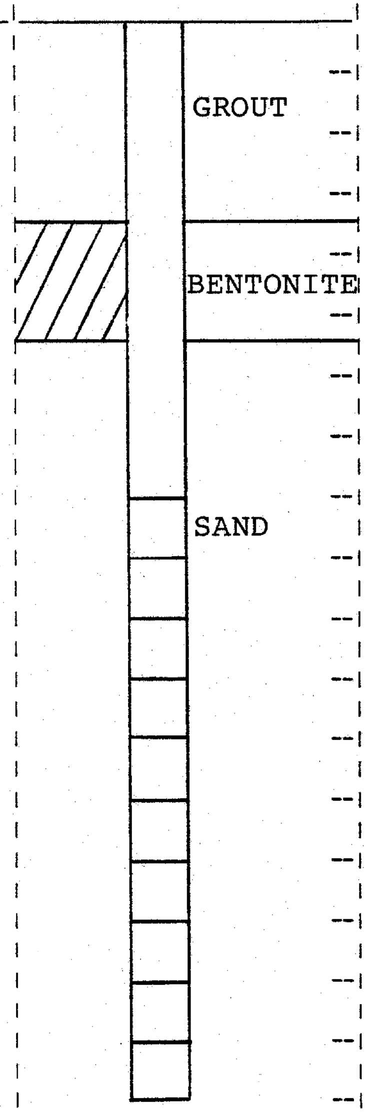
FINISH: 9/1/88

LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL
	0-2	S1	16	4-6-3-6 (9)	Silty f. sand, w/ tr. clay and tr. gravel, medium dark gray (N4), moist.	
	3-5	S2	14	4-3-3-3 (6)	Clay, tr. f. sand, dark gray (N3), moist, low plasticity.	
5						
	8-10	S3	24	5-8-10-11 (18)	F. sand, tr. silt and tr. gravel (< 1/8') light gray (N7) saturated.	
10						
	13-15	S4	24	10-10-12-15 (22)	F. sand, tr. silt, medium gray (N5), saturated.	
15						
	18-20	S5	22	7-9-18-10 (27)	M-c. sand, tr. gravel (<1/4"), medium dark gray (N4), saturated.	
20						

WELL CONSTRUCTION

2 inch PVC FLUSH MOUNT



SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2B-MW6 | SHEET: 1 OF 1

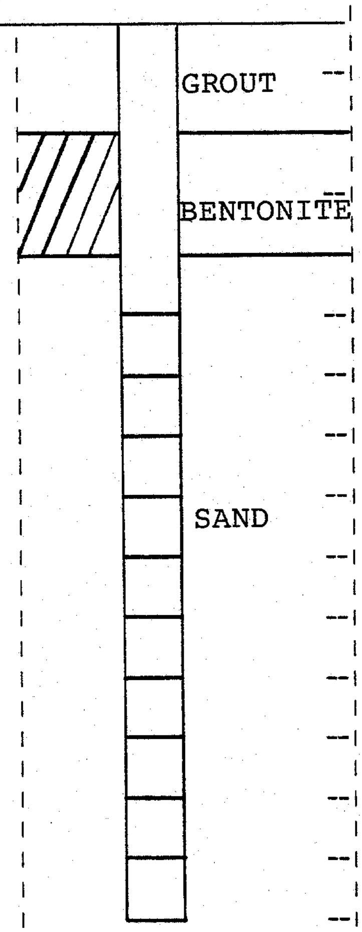
SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION
LOCATION: OCEANA
ELEVATION:
DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 7.5', 9/6/88
START: 9/6/88
FINISH: 9/6/88
LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6 (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG
	0-2	S1	16	8-10-11 6 (21)	Sandy silt, w/ tr. gravel, medium yel. brown (10YR5/4), dry.	
	3-5	S2	20	3-3-2-2 (5)	Clay, medium dark gray (N4), moist, medium plasticity.	
5						
	8-10	S3	19	12-16-21-19 (37)	Vf-m. sand, w/ tr. silt, light gray (N7) saturated.	
10						
	13-15	S4	18	6-6-9-1 (15)	Vf-f. sand, tr. w/ silt, medium gray (N5), saturated.	
15						
	18-20	S5	16	1-1-5-1 (6)	Same ass above.	
20						

WELL CONSTRUCTION

2 inch PVC FLUSH MOUNT



CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-B1 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 7' 2" BLS   START: 9/14/88   FINISH: 9/14/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	3-5	S1	16	12-6-6-6 (12)	Fn to md. sand, moist, w/ trace silt and "chunks" of clay, mod. yellowish brown (10 YR 5/4).		
5							
	8-10	S2	20	6-7-8-10 (15)	Clayey vf. to fn. sand, clay of low plasticity, wet, med. lt. gray (n6).		
10							
15							
20							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-B2 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 6' 9" BLS START: 9/14/88 FINISH: 9/14/88 LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	3-5	S1	16	5-2-2-3 (4)	Clay w/ tr. sand, moist, med. gray (N5), med. plasticity.		
5							
	8-10	S2	18	22-20-23 -17 (43)	Vf. to fn. sand, wet, med. gray (N5).		
10							
15							
20							

CH2M HILL

PROJECT NUMBER: WDC20368.D0	BORING NO.: 2C-B3	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION — LOCATION: OCEANA
ELEVATION: — DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 6' 6" BLS — START: 9/15/88 — FINISH: 9/15/88 — LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	3-5	S1	24	4-5-5-5 (10)	Clay w/ trace silt and sand, moist, org. matter, med. gray (N5), low plasticity.		
5							
	8-10	S2	18	9-9-12-12 (21)	Vf. to fn. sand, poorly sorted, wet, trace clay.		
10							
15							
20							

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-B4 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION
LOCATION: OCEANA
ELEVATION:
DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 6' 3" BLS
START: 9/15/88
FINISH: 9/15/88
LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	3-5	S1	14	3-3-4-5 (7)	Clay w/ trace silt, moist, med. gray (N5), low plasticity.		
5							
	8-10	S2	20	6-8-10-12 (20)	Vf. to fn. sand, poorly sorted, wet, trace clay.		
10							
15							
20							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-B5 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 5' 10" BLS START: 9/15/88 FINISH: 9/15/88 LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	0-2	-	-	-	Silt w/ tr. sand and clay, moist, grayish brown (5 YR 3/2), tr. gravel, org. matter.		
	3-5	S1	24	3-3-5-7 (8)	Clay w/ trace silt and sand, moist, org. matter, med. gray (N5), low plasticity.		
5							
	8-10	S2	22	3-4-5-4 (9)	Vf. to fn. sand, poorly sorted, wet, trace clay.		
10							
15							
20							

SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-B6 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 5' 0" BLS   START: 9/14/88   FINISH: 9/14/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
	3-5	S1	23	5-9-11-10 (20)	Sandy clay, moist, sand is vf. to fn., med. lt. gray (N6).		
5							
	8-10	S2	24	3-4-4-5 (8)	Vf. to fn. sand, wet, med. dk. gray (N4).		
10							
15							
20							

CH2M HILL

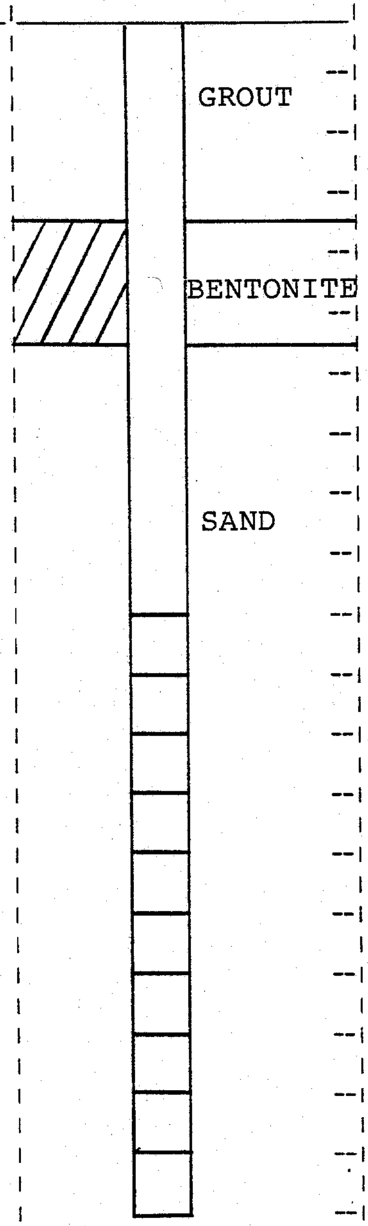
PROJECT NUMBER: WDC20368.D0	BORING NO.: 2C-MW1	SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: -7', 9/13/88 START: 9/13/88 FINISH: 9/13/88 LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG
	0-2	S1	21	4-11-11-8 (22)	F. sand, pale yel. bronw(10YR6/2), moist.	
	3-5	S2	13	4-2-3-3 (5)	Clay w/ tr. organic material, dusky yel. brown (10YR2/2), moist, low plasticity.	
5						
	8-10	S3	11	9-5-4-5 (9)	Vf-f. sand, medium gray (N5), wet.	
10						
	13-15	S4	24	1-1-1-4 (2)	Clayey silty vf-f. sand, dark gray (N3), wet, low plasticity.	
15						
	18-20	S5	20	5-15-31-50 (46)	Vf-f. sand, tr. silt, medium dark gray (N4), wet.	
20						

WELL CONSTRUCTION
2 inch PVC
FLUSH MOUNT



SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.DO	BORING NO.: 2C-MW2	SHEET: 1 OF 1

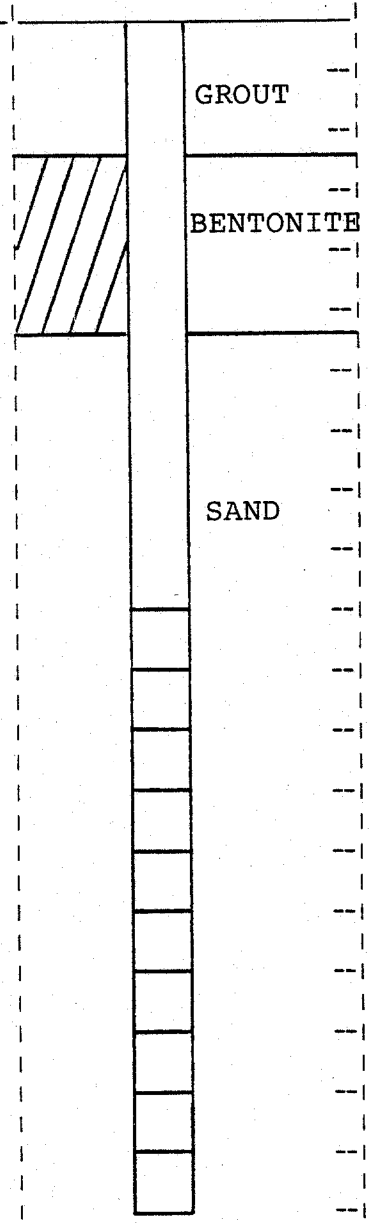
SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGENEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: BETWEEN 10-13'   START: 9/9/88   FINISH: 9/9/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLOG
	0-2	S1	22	9-17-15-14 (32)	Silty f. sand, tr. gravel, dark yel. brown (10YR4/2), moist.	
	3-5	S2	14	6-3-2-2 (5)	F-m. sand, tr. silt and "chunks" of clay, pale yel. brown (10YR6/2), wet. Clay is in the lower 10" of spoon.	
5						
	8-10	S3	24	2-2-7-10 (9)	Clay, light gray (N6), moist, high plasticity.	
10						
	13-15	S4	24	3-4-3-7 (7)	Silty vf. sand, tr. clay, medium dark gray (N4), saturated, low plasticity.	
15						
	18-20	S5	24	6-7-10-12 (17)	Same as above.	
20						

WELL CONSTRUCTION

2 inch PVC FLUSH MOUNT



SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-MW3 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION | LOCATION: OCEANA

ELEVATION: | DRILLING CONTRACTOR: LAW ENGENEERING

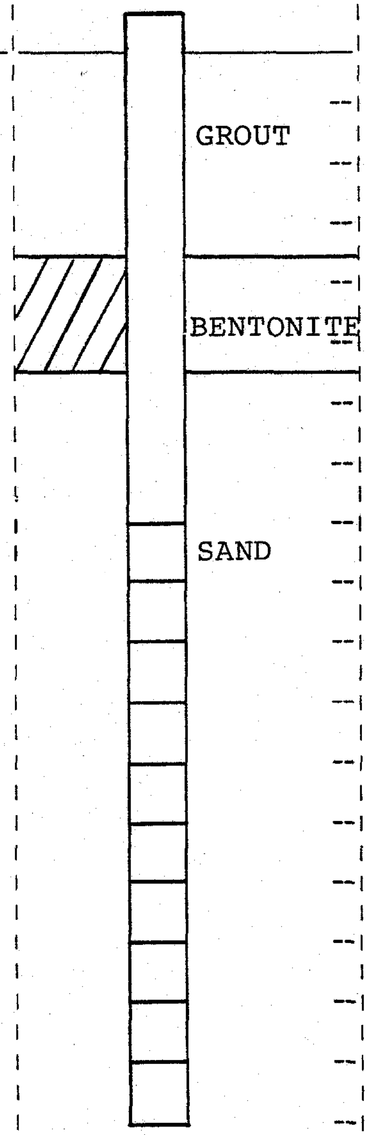
DRILLING METHOD AND EQUIPMENT: CME HSA

WATER LEVEL AND DATE: 7', 9/9/88 | START: 9/9/88 | FINISH: 9/9/88 | LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	DEPTH: REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG
	0-2	S1	15	5-12-11-26 (23)	Silty f. sand, medium gray (N4) to medium brown (5YR5/4), moist, HNu reading of 10 ppm.	
	3-5	S2	10	7-6-5-7 (11)	Clay, tr. silt, dark yel. brown (10YR2/2), moist, low plasticity.	
5						
	8-10	S3	22	7-7-9-10 (16)	Poorly sorted sand, w/ tr. silt, greenish gray (5GY6/1), saturated.	
10						
	13-15	S4	20	1-2-5-8 (7)	F-m. sand, tr. small gravel (<1/16"), medium gray (N5), saturated.	
15						
	18-20	S5	24	1-7-14-21 (21)	Vf-f. sand, medium gray (N5), saturated.	
20						

WELL CONSTRUCTION

2 inch PVC



SBLSYM 06/14/88

CH2M HILL

PROJECT NUMBER: WDC20368.D0 | BORING NO.: 2C-MW4 | SHEET: 1 OF 1

SOIL BORING LOG

PROJECT: LINE SHACK INVESTIGATION   LOCATION: OCEANA
ELEVATION: DRILLING CONTRACTOR: LAW ENGINEERING
DRILLING METHOD AND EQUIPMENT: CME HSA
WATER LEVEL AND DATE: 6.5' to 7.5' BLS   START: 9/14/88   FINISH: 9/14/88   LOGGER: D. McCRACKIN

DEPTH BELOW SURFACE	DEPTH: INTERVAL	DEPTH: TYPE AND NUMBER	REC	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG
	0-2	S1	19	4-4-11-6 (15)	Silty sand, moist, sm. gravel, mod. yellowish brown (10YR 5/4),vf. to fn. sand, top 6" contains dark org. matter	
	3-5	S2	22	5-5-7-7 (12)	Clay w/ tr. silt, moist, mod. plasticity, lt. gray (N7) to med. gray (N8).	
5						
	8-10	S3	17	5-6-7-8 (13)	Vf. to fn sand, wet poorly sorted, med. lt. gray (N6).	
10						
	13-15	S4	12	12-50/6"	Med. sand, wet, lt. gray (n7) to med gray (N6) .	
15						
	18-20	S5	?	?	same as S4.	
20						

WELL CONSTRUCTION