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Work Plan for an Engineering Evaluation/Cost Analysis for

Hill Air Force Base
Ogden, Utah

Prepared For

Air Force Center for Environmental Excellence
Brooks Air Force Base
San Antonio, Texas

and

Hill Air Force Base
Ogden, Utah

August 1993

ENGINEERING-SCIENCE, INC.

1700 Broadway, Suite 900 • Denver, Colorado 80290

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WORK PLAN FOR AN

ENGINEERING EVALUATION/COST ANALYSIS

for

HILL AIR FORCE BASE

OGDEN, UTAH

August 1993

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS

AND

HILL AIR FORCE BASE
OGDEN, UTAH

Prepared by:

Engineering-Science, Inc.
1700 Broadway Suite 900
Denver, Colorado 80290

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 1

INTRODUCTION

This work plan was prepared by Engineering-Science, Inc. (ES) and presents the scope of work required for the collection of data necessary to conduct an engineering evaluation/cost analysis (EE/CA) for remediation of fuel hydrocarbon-contaminated ground water at underground storage tank (UST) Site 870, Hill Air Force Base (AFB), Utah. Several remedial options will be evaluated during the EE/CA, including free product removal; ground water extraction, treatment, and reinjection (i.e., pump and treat); air sparging; and natural contaminant attenuation with long-term monitoring. All hydrogeologic and ground water chemical data necessary to evaluate the various remedial options will be collected under this program; however, this work plan is oriented toward the collection of hydrogeologic data to be used as input into the Bioplume II® ground water model in support of the natural attenuation (intrinsic remediation) with long-term monitoring remedial option for restoration of fuel hydrocarbon-contaminated ground water.

As part of the EE/CA, the Bioplume II® modeling effort has four primary objectives: 1) to determine the fate and transport of fuel hydrocarbon compounds dissolved in ground water at the site; 2) to assess the potential for, and rate of, degradation of these fuel hydrocarbons by indigenous microorganisms; 3) to assess the possible risk to potential downgradient receptors; and 4) to provide technical support for selection of the natural attenuation remedial option as the best remedial alternative at regulatory negotiations, as appropriate.

This work plan was developed based on discussions among representatives from the Air Force Center for Environmental Excellence (AFCEE), Hill AFB, the U.S. Environmental Protection Agency (EPA), and ES at a meeting at Hill AFB on 24 June 1993, on the statement of work (SOW) for this project, and on a review of existing site characterization data. The Bioplume II® modeling effort for this site involves completion of several tasks, which are described in the following sections.

All field work will follow the health and safety procedures presented in the program *Health and Safety Plan for Bioplume II® Modeling Initiative* (ES, 1993) and the site-specific addendum to the program Health and Safety Plan, which has been submitted to EPA for their use. This work plan was prepared for AFCEE, Hill AFB, and the EPA.

1.1 SCOPE OF CURRENT WORK PLAN

The ultimate objective of the work described herein is to provide an EE/CA for remediation of ground water contamination at UST Site 870, Hill AFB, Utah. However, this project is part of a larger, broad-based initiative being conducted by AFCEE in conjunction with EPA and ES to document the biodegradation and resulting attenuation of fuel hydrocarbons dissolved in ground water by indigenous microorganisms, and to model this degradation using the Bioplume II® numerical ground water model. For this reason, the work described in this work plan is directed toward the collection of data in support of this initiative. All data required to design an alternate remediation system, should intrinsic remediation not prove to be a viable remedial option at this facility, also will be collected under this program. This work plan describes the site characterization activities which will be performed in support of the EE/CA and the Bioplume II® modeling effort.

Proposed site characterization activities include drilling and sampling soil borings and ground water monitoring wells, and aquifer testing. Drilling and well installation procedures, aquifer testing procedures, and soil and ground water sampling and analytical protocols both for existing wells and the proposed wells are described herein. Existing site-specific data and data collected during the supplemental site characterization activities described in this work plan will be used as input for the Bioplume II® model. Where site-specific data are not available, conservative values for the types of aquifer materials present at the site will be obtained from widely accepted published literature and used for model input. Sensitivity analyses will be conducted for the parameters which are known to have the greatest influence on the results of the Bioplume II® model, and where possible, the model will be calibrated to historical site data. Upon completion of the Bioplume II® model, ES will provide technical assistance at regulatory negotiations to support the natural attenuation with long-term monitoring remedial option if the results of the modeling indicate that this approach is warranted. If it is shown that natural attenuation is not the most appropriate remedial option, ES will select the most appropriate remedial option based on available data.

This work plan consists of six sections, including this introduction. Section 2 presents the existing site-specific data and a conceptual model for the site. Section 3 describes the proposed sampling strategy and procedures to be used for the collection of additional site characterization data. Section 4 describes the remedial option evaluation procedure and EE/CA report format. Section 5 describes the quality assurance/quality control (QA/QC) measures to be used during this project. Section 6 contains the references used in preparing this document. There are two appendices to this work plan. Appendix A contains a listing of the containers, preservatives, packaging, and shipping requirements for ground water samples. Appendix B contains a summary of ground water analytical data.

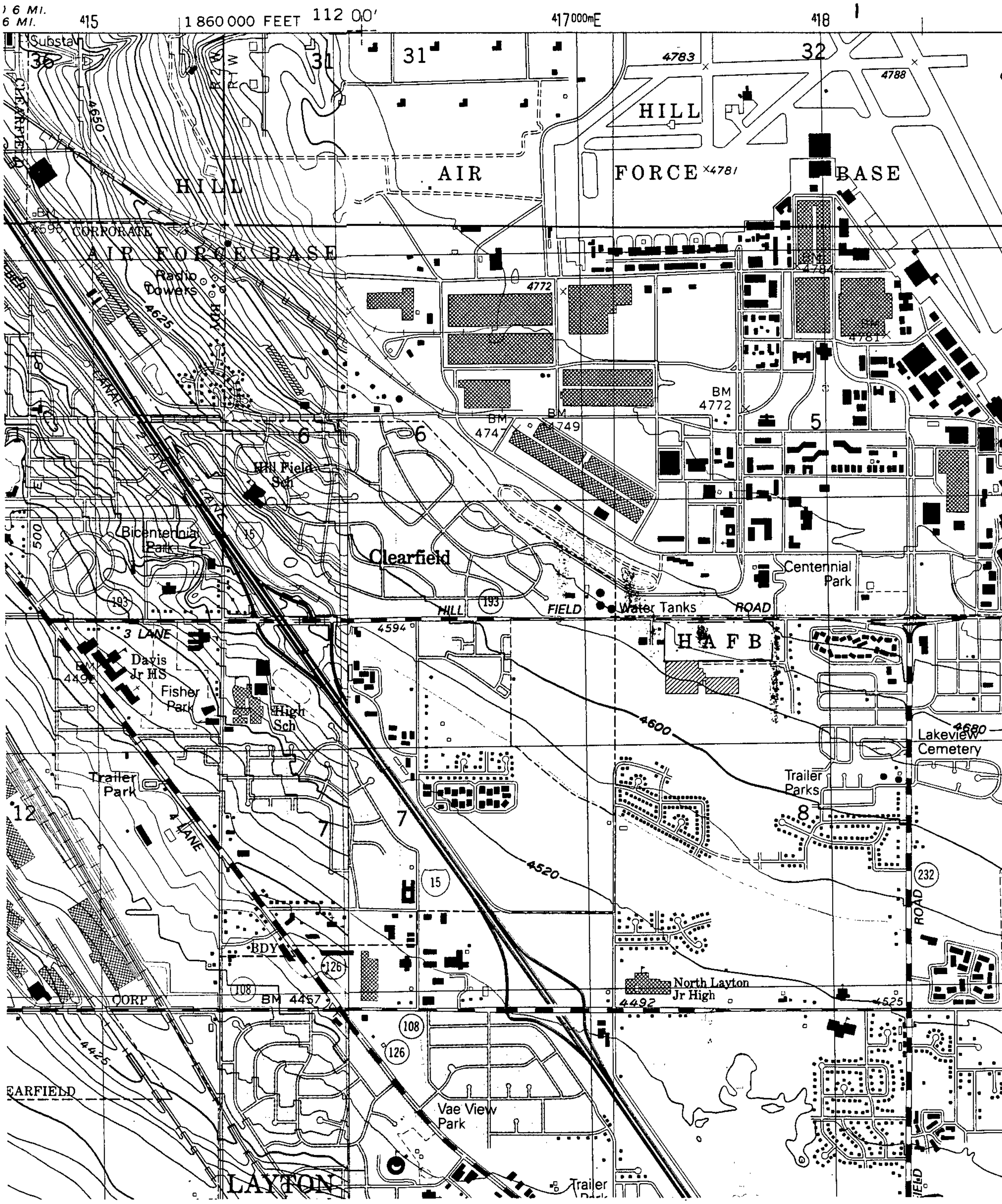
1.2 SITE BACKGROUND

UST Site 870 is located in the southwest corner of Hill AFB, Utah. This site is referred to as Site EGSS by the Utah Division of Environmental Response and Remediation (DERR) and as Site Code ST61 under the Air Force Installation Restoration Program (IRP). Figure 1.1 is a regional location map showing the position of the site relative to Hill AFB and the surrounding area. Figure 1.2 is a site map showing UST Site 870 and the immediately adjacent area in detail. Strictly speaking, UST Site 870 is the area immediately beneath and adjacent to the former location of UST 870.0. For the purposes of this work plan, UST Site 870 refers to the area shown in Figure 1.2. This area includes the base fuel tank farm which consists of nine aboveground storage tanks (ASTs) used to store JP-4 and diesel fuel. A portion of the Patriot Hills Base Housing Area located to the southwest of the AST farm is also included in this area.

Soil and ground water contamination was observed at the site in May 1991 during removal of UST 870.0. Several site investigations have been conducted by James M. Montgomery Consulting Engineers, Inc. (JMM) in response to this contamination. The results of these investigations are covered in several reports, including:

- Site Characterization Report (JMM, 1991)

- Free Product Letter Report (JMM, 1992a)



LEGEND:

SCALE
1:24,000

0 — 1 Mile

Contour Interval = 5 feet for left 1/3; 40 feet for right 2/3

SOURCE: U.S.G.S. 7.5 Minute Quadrangle Maps: Clearfield, Utah (1991) and Kaysville, Utah (1992) Quadrangles

FIGURE 1.1

REGIONAL LOCATION MAP

UST SITE 870, HILL AFB, UTAH

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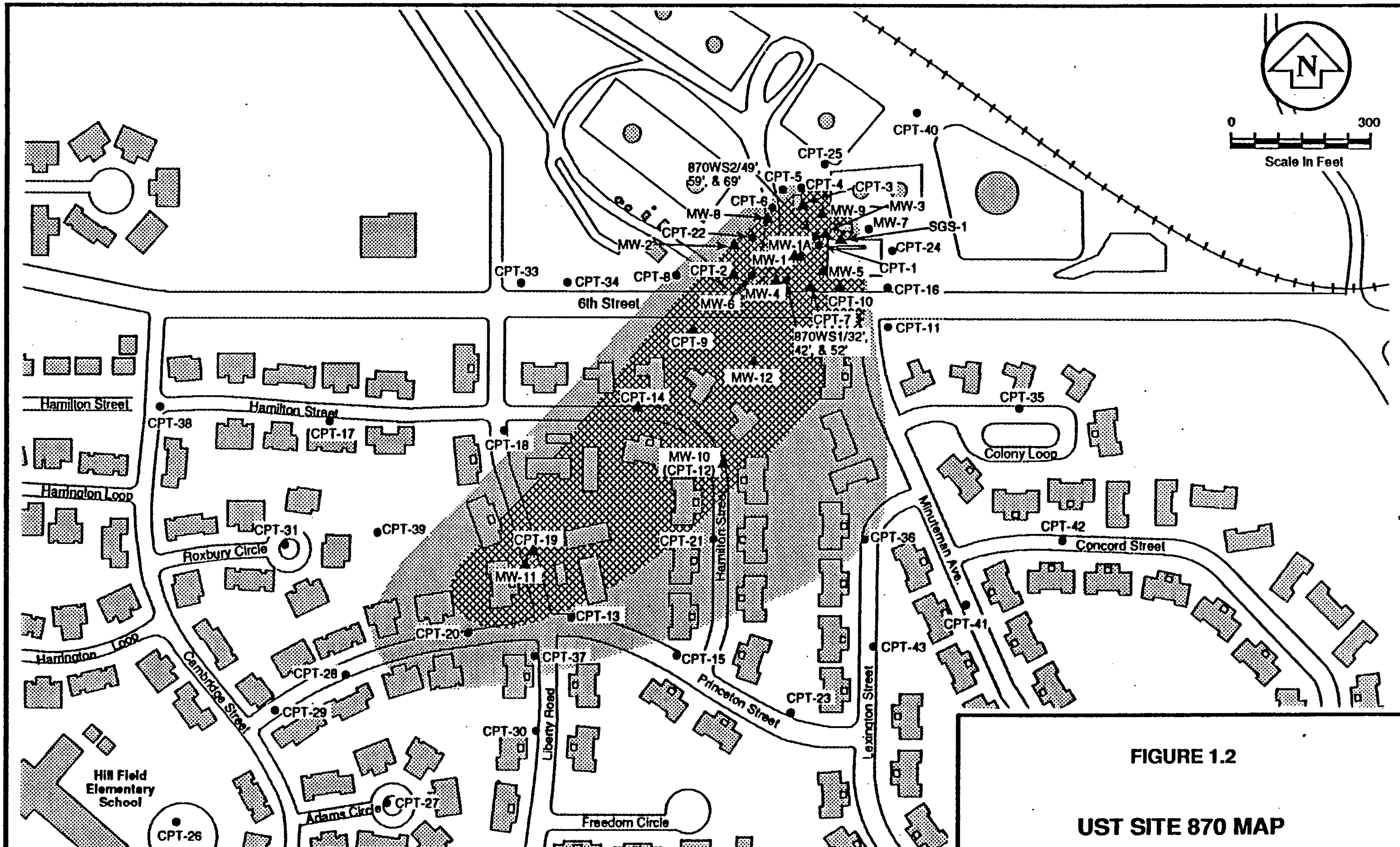
Denver, Colorado



EXPLANATION

- CPT-28 ● Cone penetrometer test point/ piezometer
- MW-12 ● Monitoring well location
- CPT-19 ▲ Free phase JP-4 detected
- Extent of JP-4
- Railroad

Source: JMM, 1993.

FIGURE 1.2

UST SITE 870 MAP

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.
Denver, Colorado

- Pumping Tests and Product Thickness Test Letter Report (JMM, 1992b)
- Remedial Options Letter Report (JMM, 1993a)
- Investigation Summary Report (JMM, 1993b)

The site-specific data and conceptual model presented in Section 2 are based on a review these documents. A synopsis of site characterization activities conducted to date is provided in the 1993 Investigation Summary Report prepared by JMM. As described in Section 2, soil and ground water fuel hydrocarbon contamination at the site is quite extensive.

SECTION 2

DATA REVIEW AND CONCEPTUAL MODEL DEVELOPMENT

Prior to the implementation of field work, existing site-specific data was used to develop a conceptual model for the ground water flow system at UST Site 870. This conceptual model will allow additional data points to be collected in a more efficient manner. The first part of this section (Section 2.1) presents a synopsis of available site data. The second part of this section (Section 2.2) presents the conceptual ground water flow and solute transport model which was developed based on these data.

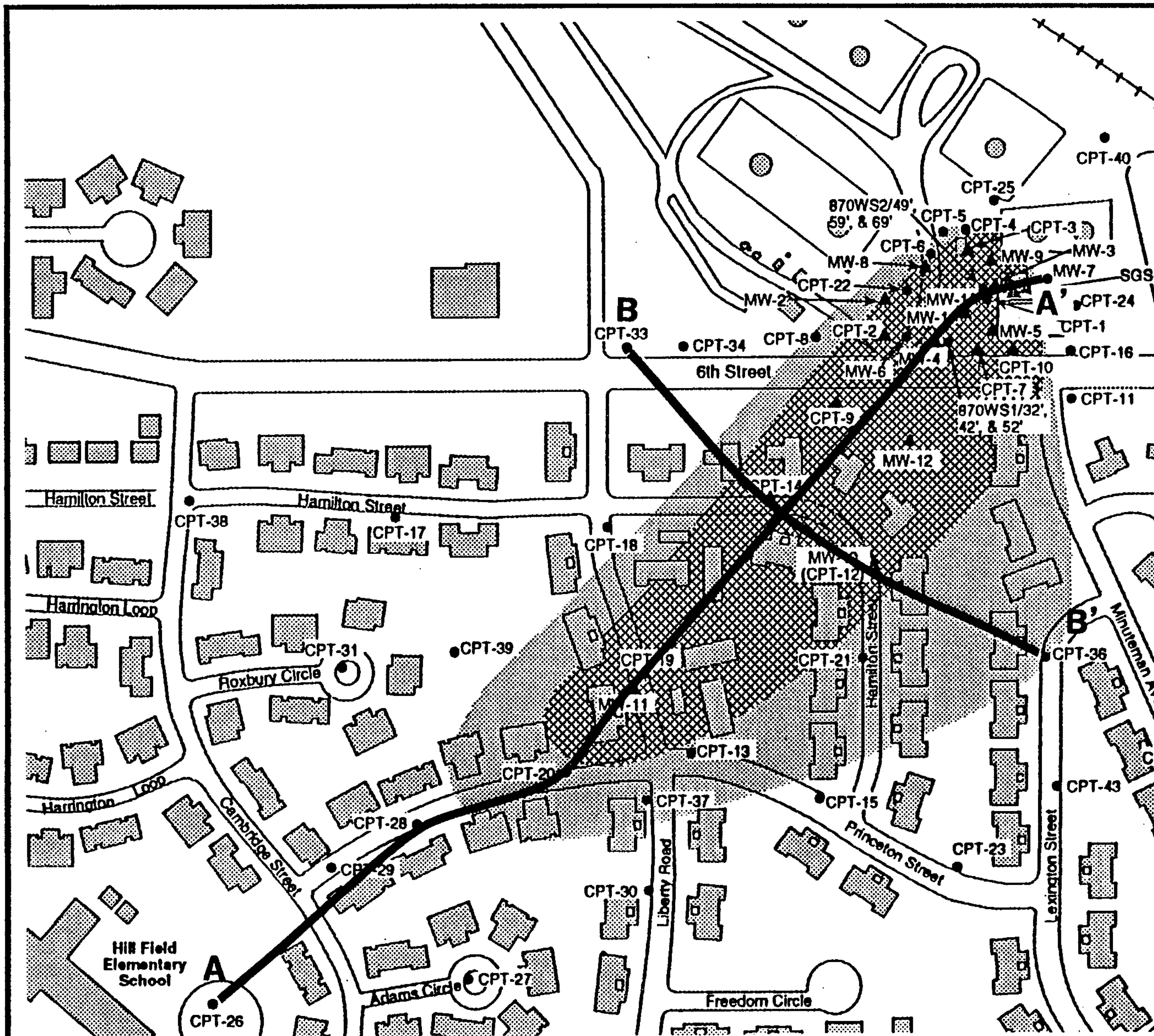
2.1 DATA REVIEW

The reports listed in Section 1.2 and available regional data were reviewed, and relevant portions of these data are summarized in the following sections.

2.1.1 Site Geology and Hydrogeology

Three aquifers are present in the vicinity of UST Site 870. In order of increasing depth, these aquifers are 1) the shallow aquifer, 2) the Sunset aquifer, and 3) the Delta aquifer. Hill AFB is located just west of the Wasatch Front in north-central Utah. Sediment comprising the shallow subsurface at UST Site 870 consists of unconsolidated clay, silt, sand, and gravel which was eroded from the Wasatch Front and deposited as fluvial-deltaic basin-fill deposits where the ancient Weber River entered Lake Bonneville during Quaternary and Recent time (Feth et al., 1966).

Characterization of the vadose zone and shallow aquifer system at UST Site 870 has been the objective of several site investigations. To date, 44 cone penetrometer test (CPT) holes completed (some CPT holes contain piezometers) and 12 ground water monitoring wells have been installed at UST Site 870. Figure 2.1 shows the location of most of these points (with the exception of CPT-44) and the location of hydrogeologic



EXPLANATION

CPT-28 ● Cone penetrometer test point/ piezometer

MW-12 ● Monitoring well location

CPT-19 ▲ Free phase JP-4 detected

Extent of JP-4

Railroad

Source: JMM, 1993.

FIGURE 2.1

HYDROGEOLOGIC SECTION LOCATION MAP

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.

Denver, Colorado

sections A-A' and B-B'. Table 2.1 presents available well and piezometer completion information. Table 2.2 presents currently available ground water elevations and free-product thickness measurements. Figure 2.2 is hydrogeologic section A-A'. Figure 2.3 is hydrogeologic section B-B'. Ground water elevations are shown on Figures 2.2 and 2.3 to show the relationships between the ground water potentiometric surface and the stratigraphy at the site. Figure 2.4 is the potentiometric surface map for the shallow aquifer.

2.1.2 Soil and Ground Water Quality

2.1.2.1 Soil Quality

Soil samples collected during site investigation activities were described and classified using the Unified Soil Classification (USC) system and screened in the field using the "headspace" procedure. Select soil samples were submitted to a laboratory for chemical and geotechnical analyses including benzene, toluene, ethylbenzene, and xylenes (BTEX); total petroleum hydrocarbons (TPH); permeability; Atterberg limits; moisture content; and USC classification. Table 2.3 contains a summary of available soil-quality analytical results. Table 2.4 contains a summary of geotechnical analysis results. Laboratory analytical results for soil samples collected during UST removal and subsequent site investigations at the site indicate that petroleum hydrocarbon contamination is present in the shallow soils near UST Site 870. Headspace soil screening data indicate that soil contamination is greatest near Building 870 and ground water monitoring well MW-3. Free product present on the ground water and in the capillary fringe has resulted in a broad smeared zone of highly contaminated soils at the water table ranging in thickness from 3 to 7 feet. The lateral extent of this smeared zone is coincident with the lateral extent of the free product plume.

2.1.2.2 Ground Water Quality and Chemistry

2.1.2.2.1 Shallow Aquifer

Laboratory analytical results for ground water samples collected during previous site investigations indicate that petroleum hydrocarbon contamination is present in the shallow aquifer in the vicinity of UST Site 870. Table 2.5 summarizes available BTEX ground

TABLE 2.1

WELL COMPLETION INFORMATION
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	EASTING**	NORTHING***	DATUM* ELEVATION (ft msl)	GROUND ELEVATION (ft msl)	TOTAL DEPTH (ft)	WELL DIAMETER (in)	SCREEN LENGTH (ft)	DEPTH TO SCREEN TOP (ft)	DEPTH TO SCREEN BASE (ft)	SCREEN ELEVATION TOP (ft)	SCREEN ELEVATION BASE (ft)
MW-1	2475.32	3841.98	4683.91	4684.24	28.20	4.00	10.00	18.00	28.00	4665.91	4655.91
MW-2	2389.21	3846.24	4684.39	4681.89	27.90	4.00	10.00	15.00	25.00	4669.39	4659.39
MW-3	2533.09	3882.19	4690.67	4688.43	37.24	6.00	20.00	15.00	35.00	4675.67	4655.67
MW-4	2446.70	3798.05	4682.13	4682.56	24.68	6.00	10.00	14.00	24.00	4668.13	4658.13
MW-5	2536.47	3813.49	4686.76	4687.17	27.39	4.00	10.00	17.50	27.50	4669.26	4659.26
MW-6	2389.06	3794.35	4679.03	4679.34	29.34	4.00	10.00	20.00	30.00	4659.03	4649.03
MW-7 (TWP-3)	2621.27	3900.79	4693.80	4691.85	40.20	4.00	10.00	28.00	38.00	4665.80	4655.80
MW-8 (TWP-1)	2449.70	3893.96	4688.02	4686.66	29.72	2.00	10.00	20.00	30.00	4668.02	4658.02
MW-9 (TWP-2)	2529.21	3930.05	4692.09	4689.68	36.65	2.00	20.00	15.00	35.00	4677.09	4657.09
MW-10	2354.84	3397.60	4662.67	4662.95	44.94	6.00	20.50	25.00	45.50	4637.67	4617.17
MW-11	1923.08	3213.91	4637.37	4637.58	45.32	6.00	20.50	25.00	45.50	4612.37	4591.87
MW-12	2457.72	3650.34	4676.87	4677.35	44.80	6.00	20.50	24.50	45.00	4652.37	4631.87
CPT-1	ND	ND	ND	ND							
CPT-2	ND	ND	ND	ND	27.00						
CPT-3	ND	ND	ND	ND	26.00		5.00	21.00	26.00		
CPT-4	ND	ND	ND	ND	27.60						
CPT-5	ND	ND	ND	ND							
CPT-6	ND	ND	ND	ND	24.00		5.00	19.00	24.00		
CPT-7	2547.88	3772.45	4684.21	4684.37	23.85		5.00	18.85	23.85	4665.36	4660.36
CPT-8	ND	ND	ND	ND							
CPT-9	ND	ND	ND	ND	27.85						
CPT-10	2602.28	3772.04	4686.54	4686.80	25.50		5.00	20.50	25.50	4666.04	4661.04
CPT-11	ND	ND	ND	ND	30.25						
CPT-12	2354.84	3397.60	4662.67	4662.95							
CPT-13	2062.91	3060.14	4633.21	4633.43	24.00						
CPT-14	2182.60	3507.60	4655.88	4656.10	28.28		5.00	23.28	28.28	4632.60	4627.60
CPT-15	2262.51	2985.53	4638.74	4638.92	35.40		5.00	30.40	35.40	4608.34	4603.34
CPT-16	ND	ND	ND	ND							
CPT-17	1528.38	3493.12	4635.28	4635.51	14.41		5.00	9.41	14.41	4625.87	4620.87
CPT-18	1885.05	3457.77	4641.46	4641.82	15.09		5.00	10.09	15.09	4631.37	4626.37
CPT-19	1948.46	3215.91	4636.98	4637.31	33.35		5.00	28.35	33.35	4608.63	4603.63
CPT-20	1848.28	3037.59	4625.48	4625.69	28.20		5.00	23.20	28.20	4602.28	4597.28
CPT-21	2349.56	3244.25	4655.91	4656.26	34.15		5.00	29.15	34.15	4626.76	4621.76
CPT-22	ND	ND	ND	ND	25.35		5.00	20.35	25.35		
CPT-23	2526.12	2835.21	4642.49	4642.69	31.00		5.00	26.00	31.00	4616.49	4611.49
CPT-24	ND	ND	ND	ND							
CPT-25	ND	ND	ND	ND	38.00		5.00	33.00	38.00		
CPT-26	1208.02	2573.01	4591.94	4592.20	12.30						
CPT-27	1662.55	2660.73	4604.04	4604.32	10.00		5.00	5.00	10.00	4599.04	4594.04
CPT-28	1538.79	2939.72	4605.62	4605.96	7.77		5.00	2.77	7.77	4602.85	4597.85
CPT-29	1400.23	2863.23	4600.67	4600.89	7.00						
CPT-30	1963.38	2711.28	4610.22	4610.48	15.35		5.00	10.35	15.35	4599.87	4594.87
CPT-31	1418.19	3205.92	4610.88	4611.15	10.35		5.00	5.35	10.35	4605.53	4600.53
CPT-32	ND	ND	ND	ND	9.00						
CPT-33	ND	ND	ND	ND							
CPT-34	ND	ND	ND	ND	21.90						
CPT-35	ND	ND	ND	ND							
CPT-36	2670.91	3231.11	4669.78	4670.01	35.00						
CPT-37	1970.30	2978.15	4625.35	4625.60	27.50		5.00	22.50	27.50	4602.85	4597.85
CPT-38	1177.69	3504.76	4615.66	4615.90	14.55		5.00	9.55	14.55	4606.11	4601.11
CPT-39	ND	ND	ND	ND							
CPT-40	2758.65	4145.21	4715.46	4715.05	55.33		20.00	35.33	55.33	4680.13	4660.13
CPT-41	2857.64	3142.16	4675.19	4675.41	40.05						
CPT-42	3067.32	3238.57	4678.34	4678.49	39.73		5.00	34.73	39.73	4643.61	4638.61
CPT-43	2683.44	3014.06	4659.74	4660.02	37.60		5.00	32.60	37.60	4627.14	4622.14
CPT-44	ND	ND	ND	ND	41.00		5.00	36.00	41.00		

* Datum is top of PVC
** For absolute easting coordinates add 1,860,000 to these numbers
*** For absolute northing coordinates add 280,000 to these numbers
ND = Data not available
Source: JMM, 1993

TABLE 2.2

GROUND WATER ELEVATIONS AND FREE-PRODUCT THICKNESSES
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	EASTING**	NORTHING***	DATUM* ELEVATION (ft msl)	DTW 8/18/92	GWE 8/18/92	DTP 2/12/93	DTW 2/12/93	PT 2/12/93	CDTW 2/12/93	CGWE 2/12/93	DTP 3/4/93	DTW 3/4/93
MW-1	2475.32	3841.98	4683.91									
MW-2	2389.21	3846.24	4684.39				25.20	0.00				
MW-3	2533.09	3882.19	4690.67			28.91	28.93	0.02	28.91	4661.76		
MW-4	2446.70	3798.05	4682.13									
MW-5	2536.47	3813.49	4686.76				25.00	0.00	25.00	4661.76		
MW-6	2389.06	3794.35	4679.03									
MW-7 (TWP-3)	2621.27	3900.79	4693.80				31.61	0.00	31.61	4662.19		
MW-8 (TWP-1)	2449.70	3893.96	4688.02									
MW-9 (TWP-2)	2529.21	3930.05	4692.09									
MW-10	2354.84	3397.60	4662.67			29.18	30.18	1.00	29.43	4633.24		
MW-11	1923.08	3213.91	4637.37				26.73	0.00	26.73	4610.64		
MW-12	2457.72	3650.34	4676.87			25.75	25.84	0.09	25.77	4651.10		
CPT-2	ND	ND	ND	23.22								
CPT-3	ND	ND	ND	23.10								
CPT-4	ND	ND	ND									
CPT-6	ND	ND	ND	17.15								
CPT-7	2547.88	3772.45	4684.21	21.69								
CPT-10	2602.28	3772.04	4686.54	22.10								
CPT-11	ND	ND	ND	29.30								
CPT-13	2062.91	3060.14	4633.21	DRY								
CPT-14	2182.60	3507.60	4655.88	25.38							24.57	27.08
CPT-15	2262.51	2985.53	4638.74	32.97								33.85
CPT-17	1528.38	3493.12	4635.28	11.82								11.48
CPT-18	1885.05	3457.77	4641.46	13.44								12.38
CPT-19	1948.46	3215.91	4636.98	30.73								30.52
CPT-20	1848.28	3037.59	4625.48	25.12								25.19
CPT-21	2349.56	3244.25	4655.91	30.68								32.88
CPT-22	ND	ND	ND	24.07								
CPT-23	2526.12	2835.21	4642.49	28.25								27.08
CPT-25	ND	ND	ND	36.08								
CPT-26	1208.02	2573.01	4591.94	12.35								
CPT-27	1662.55	2660.73	4604.04	8.57								
CPT-28	1538.79	2939.72	4605.62	6.43								6.18
CPT-29	1400.23	2863.23	4600.67	5.15								
CPT-30	1963.38	2711.28	4610.22	12.82								
CPT-31	1418.19	3205.92	4610.88	7.37								5.60
CPT-33	ND	ND	ND	19.79								
CPT-34	ND	ND	ND	DRY								
CPT-36	2670.91	3231.11	4669.78	34.97								
CPT-37	1970.30	2978.15	4625.35	26.40								
CPT-38	1177.69	3504.76	4615.66	13.05								12.08
CPT-40	2758.65	4145.21	4715.46	38.89								
CPT-41	2857.64	3142.16	4675.19									
CPT-42	3067.32	3238.57	4678.34									36.93
CPT-43	2683.44	3014.06	4659.74									29.60
CPT-44	ND	ND	ND									

* Datum is top of PVC
** For absolute easting coordinates add 1,860,000 to these numbers
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ND = Data not available

DTW = Depth To Water
GWE = Ground Water Elevation
DTP = Depth To Product

PT = Product Thickness
CDTW = Corrected Depth To Water
CGWE = Corrected Ground Water Elevation

Source : JMM, 1993

TABLE 2.2 (CONTINUED)
GROUND WATER ELEVATIONS AND FREE-PRODUCT THICKNESSES
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	PT 3/4/93	CDTW 3/4/93	CGWE 3/4/93	DTP 3/18/93	DTW 3/18/93	PT 3/18/93	CDTW 3/18/93	CGWE 3/18/93	DTP 4/2/93	DTW 4/2/93	PT 4/2/93	CDTW 4/2/93	CGWE 4/2/93	DTP 4/21/93
MW-1				22.75	22.80	0.05	22.76	4661.15						20.18
MW-2					25.11	0.00	25.11	4659.28						
MW-3				27.69	28.08	0.39	27.79	4662.88						23.78
MW-4					21.65	0.00	21.65	4660.48						19.80
MW-5					20.95	0.00	20.95	4665.81						18.78
MW-6					22.06	0.00	22.06	4656.97						
MW-7 (TWP-3)					31.52	0.00	31.52	4662.28						
MW-8 (TWP-1)				24.72	24.92	0.20	24.77	4663.25						23.42
MW-9 (TWP-2)				26.90	27.25	0.35	26.99	4665.10						24.44
MW-10				29.02	29.90	0.88	29.24	4633.43	29.12	30.10	0.98	29.37	4633.31	29.11
MW-11					26.20	0.00	26.20	4611.17		26.00	0.00	26.00	4611.37	
MW-12				25.70	25.80	0.10	25.73	4651.14	25.62	25.71	0.09	25.64	4651.23	25.31
CPT-2														
CPT-3														20.45
CPT-4														
CPT-6														
CPT-7														
CPT-10														
CPT-11					28.30	0.00	28.30			28.68		28.68		
CPT-13														
CPT-14	2.51	25.20	4630.68	24.66	27.16	2.50	25.29	4630.60	23.60	27.34	3.74	24.54	4631.35	
CPT-15		33.85	4604.89							33.50		33.50	4605.24	
CPT-17		11.48	4623.80											
CPT-18		12.38	4629.08		11.80		11.80	4629.66		11.65		11.65	4629.81	
CPT-19		30.52	4606.46							29.50		29.50	4607.48	
CPT-20		25.19	4600.29		27.75		27.75	4597.73		24.22		24.22	4601.26	
CPT-21		32.88	4623.03		32.70		32.70	4623.21		32.00		32.00	4623.91	
CPT-22														
CPT-23		27.08	4615.41							26.82		26.82	4615.67	
CPT-25														
CPT-26														
CPT-27														
CPT-28		6.18	4599.44											
CPT-29														
CPT-30														
CPT-31		5.60	4605.28											
CPT-33														
CPT-34														
CPT-36														
CPT-37														
CPT-38		12.08	4603.58											
CPT-40														
CPT-41														
CPT-42		36.93	4641.41							36.80		36.80	4641.54	
CPT-43		29.60	4630.14							29.67		29.67	4630.07	
CPT-44														

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ND = Data not available

DTW = Depth To Water
GWE = Ground Water Elevation
DTP = Depth To Product

PT = Product Thickness
CDTW = Corrected Depth To Water
CGWE = Corrected Ground Water Elevation

Source : JMM, 1993

TABLE 2.2 (CONTINUED)

GROUND WATER ELEVATIONS AND FREE-PRODUCT THICKNESSES
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	DTW 4/21/93	PT 4/21/93	CDTW 4/21/93	CGWE 4/21/93	DTP 4/29/93	DTW 4/29/93	PT 4/29/93	CDTW 4/29/93	CGWE 4/29/93	DTP 5/6/93	DTW 5/6/93	PT 5/6/93	CDTW 5/6/93	CGWE 5/6/93
MW-1	23.10	2.92	20.91	4663.00	19.39	22.77	3.38	20.23	4663.68	19.04	22.00	2.96	19.78	4664.13
MW-2	23.93	0.00	23.93	4660.46		23.69		23.69	4660.70		23.44		23.44	4660.95
MW-3	24.25	0.97	23.52	4667.15	23.57	23.61	0.04	23.58	4667.09	23.21	23.53	0.32	23.29	4667.38
MW-4	20.05	0.25	19.86	4662.27	19.32	19.75	0.43	19.43	4662.70	18.93	19.40	0.47	19.05	4663.08
MW-5	20.03	1.25	19.09	4667.67	18.29	20.01	1.72	18.72	4668.04	18.10	20.03	1.93	18.58	4668.18
MW-6	21.31	0.00	21.31	4657.72		21.10		21.10	4657.93		20.82		20.82	4658.21
MW-7 (TWP-3)	30.56	0.00	30.56	4663.24		30.32		30.32	4663.48		30.06		30.06	4663.74
MW-8 (TWP-1)	23.47	0.05	23.43	4664.59	22.90	23.21	0.31	22.98	4665.04	22.50	22.85	0.35	22.59	4665.43
MW-9 (TWP-2)	24.64	0.20	24.49	4667.60	23.81	24.30	0.49	23.93	4668.16	23.44	23.84	0.40	23.54	4668.55
MW-10	30.12	1.01	29.36	4633.31	29.03	30.07	1.04	29.29	4633.38	28.77	29.85	1.08	29.04	4633.63
MW-11	25.98	0.00	25.98	4611.39		25.98		25.98	4611.39		25.79		25.79	4611.58
MW-12	25.35	0.04	25.32	4651.55	25.27	25.29	0.02	25.27	4651.60		25.16		25.16	4651.71
CPT-2														
CPT-3	21.85	1.40	20.80	-20.80	20.67	21.67	1.00	20.92		23.30	24.35	1.05	23.56	
CPT-4														
CPT-6	18.65		18.65			21.10		21.10			21.15		21.15	
CPT-7	19.74		19.74	4664.47		19.45		19.45	4664.76		19.33		19.33	4664.88
CPT-10	19.50		19.50	4667.04		19.50		19.50	4667.04		19.35		19.35	4667.19
CPT-11						28.28		28.28			28.13		28.13	
CPT-13														
CPT-14					23.32	27.32	4.00	24.32	4631.56	22.98	26.98	4.00	23.98	4631.90
CPT-15						32.67		32.67	4606.07		32.50		32.50	4606.24
CPT-17						11.58		11.58	4623.70		11.72		11.72	4623.56
CPT-18						11.97		11.97	4629.49		12.10		12.10	4629.36
CPT-19						28.95		28.95	4608.03		28.85		28.85	4608.13
CPT-20					22.50	23.50	1.00	22.75	4602.73		23.47		23.47	4602.01
CPT-21											31.59		31.59	4624.32
CPT-22	22.17		22.17			21.59		21.59			20.65		20.65	
CPT-23						26.31		26.31	4616.18		26.18		26.18	4616.31
CPT-25						35.05		35.05			34.85		34.85	
CPT-26														
CPT-27	8.28		8.28	4595.76		8.42		8.42	4595.62		8.35		8.35	4595.69
CPT-28						5.62		5.62	4600.00		5.72		5.72	4599.90
CPT-29														
CPT-30	12.05		12.05	4598.17		12.16		12.16	4598.06		12.15		12.15	4598.07
CPT-31						4.50		4.50	4606.38		4.74		4.74	4606.14
CPT-33														
CPT-34														
CPT-36														
CPT-37	24.00		24.00	4601.35		23.75		23.75	4601.60		23.74		23.74	4601.61
CPT-38						13.33		13.33	4602.33		13.18		13.18	4602.48
CPT-40	52.85		52.85	4662.61		53.33		53.33	4662.13		53.17		53.17	4662.29
CPT-41														
CPT-42						37.00		37.00	4641.34		36.45		36.45	4641.89
CPT-43						29.35		29.35	4630.39		29.42		29.42	4630.32
CPT-44						38.00		38.00			37.80		37.80	

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ND = Data not available

DTW = Depth To Water
GWE = Ground Water Elevation
DTP = Depth To Product

PT = Product Thickness
CDTW = Corrected Depth To Water
CGWE = Corrected Ground Water Elevation

Source : JMM, 1993

TABLE 2.2 (CONTINUED)
GROUND WATER ELEVATIONS AND FREE-PRODUCT THICKNESSES
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	DTP 5/20/93	DTW 5/20/93	PT 5/20/93	CDTW 5/20/93	CGWE 5/20/93	DTP 6/17/93	DTW 6/17/93	PT 6/17/93	CDTW 6/17/93	CGWE 6/17/93	DTP 6/23/93	DTW 6/23/93	PT 6/23/93	CDTW 6/23/93
MW-1	19.07	20.14	1.07	19.34	4664.57	18.69	18.97	0.28	18.76	4665.15	18.66	19.02	0.36	18.75
MW-2		23.01	0.00	23.01	4661.38	22.44	22.57	0.13	22.47	4661.92	22.40	22.61	0.21	22.45
MW-3	22.60	23.00	0.40	22.70	4667.97	22.58	22.91	0.33	22.66	4668.01	22.40	22.68	0.28	22.47
MW-4	18.21	18.54	0.33	18.29	4663.84	18.30	18.55	0.25	18.36	4663.77	18.36	18.79	0.43	18.47
MW-5	17.96	19.43	1.47	18.33	4668.43	18.17	18.95	0.78	18.37	4668.40	18.12	19.36	1.24	18.43
MW-6		20.33	0.00	20.33	4658.70		19.90	0.00	19.90	4659.13		19.84	0.00	19.84
MW-7 (TWP-3)		29.70	0.00	29.70	4664.10		29.23	0.00	29.23	4664.57		29.15	0.00	29.15
MW-8 (TWP-1)	22.08	22.50	0.42	22.18	4665.84	21.71	21.72	0.01	21.71	4666.31	21.81	21.95	0.14	21.84
MW-9 (TWP-2)	22.76	23.24	0.48	22.88	4669.21	22.00	22.36	0.36	22.09	4670.00	21.91	22.59	0.68	22.08
MW-10	28.63	29.73	1.10	28.91	4633.77	28.35	29.43	1.08	28.62	4634.05	28.48	29.68	1.20	28.78
MW-11		25.85	0.00	25.85	4611.52		25.62	0.00	25.62	4611.75		25.75	0.00	25.75
MW-12		24.83	0.00	24.83	4652.04	24.01	24.02	0.01	24.01	4652.86	23.99	24.00	0.01	23.99
CPT-2							26.90	0.00	26.90		19.89	26.89	7.00	21.64
CPT-3	22.05	24.05	2.00	22.55		22.20	24.20	2.00	22.70		19.80	20.60	0.80	20.00
CPT-4							24.05	0.00	24.05			23.93	0.00	23.93
CPT-6		20.07		20.07			20.65	0.00	20.65			19.64	0.00	19.64
CPT-7		18.69		18.69	4665.52		19.96	0.00	19.96	4664.25	17.10	20.00	2.90	17.83
CPT-10	18.16	19.06	0.90	18.38	4668.15		19.10	0.00	19.10	4667.44	17.70	19.00	1.30	18.02
CPT-11		27.77		27.77			27.18	0.00	27.18			26.94	0.00	26.94
CPT-13														
CPT-14	23.22	26.72	3.50	24.09	4631.78	24.03	27.53	3.50	24.91	4630.98	23.00	26.00	3.00	23.75
CPT-15		32.18		32.18	4606.56		31.73	0.00	31.73	4607.01		31.66		31.66
CPT-17		11.67		11.67	4623.61									
CPT-18		12.00		12.00	4629.46		12.20	0.00	12.20	4629.26		12.20	0.00	12.20
CPT-19		28.67		28.67	4608.31		28.32	0.00	28.32	4608.66		28.29	0.00	28.29
CPT-20		23.25		23.25	4602.23		22.89	0.00	22.89	4602.59		22.86	0.00	22.86
CPT-21		31.44		31.44	4624.47							31.27	0.00	31.27
CPT-22		20.52		20.52			20.17	0.00	20.17			20.18	0.00	20.18
CPT-23		25.75		25.75	4616.74		25.14	0.00	25.14	4617.35		25.05	0.00	25.05
CPT-25							34.10	0.00	34.10			33.98	0.00	33.98
CPT-26														
CPT-27		8.20		8.20	4595.84		7.85	0.00	7.85	4596.19		7.56	0.00	7.56
CPT-28		5.97		5.97	4599.65		5.88	0.00	5.88	4599.74		6.96	0.00	6.96
CPT-29														
CPT-30		11.90		11.90	4598.32		11.60	0.00	11.60	4598.62		11.54	0.00	11.54
CPT-31		5.42		5.42	4605.46		5.58	0.00	5.58	4605.30		5.80	0.00	5.80
CPT-33							18.74	0.00	18.74			18.35	0.00	18.35
CPT-34							21.28	0.00	21.28			21.26	0.00	21.26
CPT-36														
CPT-37		23.49		23.49	4601.86		23.15	0.00	23.15	4602.20		23.10	0.00	23.10
CPT-38		13.09		13.09	4602.57		5.60	0.00	5.60	4610.06		11.94	0.00	11.94
CPT-40		53.04		53.04	4662.42		53.20	0.00	53.20	4662.26		53.27	0.00	53.27
CPT-41							39.90	0.00	39.90	4635.29		39.28	0.00	39.28
CPT-42		36.00		36.00	4642.34		35.37	0.00	35.37	4642.97		35.25	0.00	35.25
CPT-43		29.18		29.18	4630.56									
CPT-44		31.48		31.48			36.65	0.00	36.65			35.58	0.00	35.58

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ND = Data not available

DTW = Depth To Water
GWE = Ground Water Elevation
DTP = Depth To Product

PT = Product Thickness
CDTW = Corrected Depth To Water
CGWE = Corrected Ground Water Elevation

Source : JMM, 1993

TABLE 2.2 (CONCLUDED)

GROUND WATER ELEVATIONS AND FREE-PRODUCT THICKNESSES
UST SITE 870-EE/CA
HILL AFB, UTAH

WELL NUMBER	CGWE 6/23/93	DTP 7/1/93	DTW 7/1/93	PT 7/1/93	CDTW 7/1/93	CGWE 7/1/93	DTP 7/8/93	DTW 7/8/93	PT 7/8/93	CDTW 7/8/93	CGWE 7/8/93
MW-1	4665.16		18.60	0.00	18.60	4665.31	18.56	18.85	0.29	18.63	4665.28
MW-2	4661.94	22.27	22.54	0.27	22.34	4662.05	22.26	22.62	0.36	22.35	4662.04
MW-3	4668.20	22.29	22.48	0.19	22.34	4668.33	22.33	23.04	0.71	22.51	4668.16
MW-4	4663.66	18.41	18.54	0.13	18.44	4663.69	18.45	18.57	0.12	18.48	4663.65
MW-5	4668.33	18.56	18.78	0.22	18.61	4668.15	18.41	18.55	0.14	18.45	4668.32
MW-6	4659.19		19.72	0.00	19.72	4659.31		19.69	0.00	19.69	4659.34
MW-7 (TWP-3)	4664.65		28.91	0.00	28.91	4664.89		28.79	0.00	28.79	4665.01
MW-8 (TWP-1)	4666.18	21.60	21.75	0.15	21.64	4666.38	21.72	21.82	0.10	21.74	4666.28
MW-9 (TWP-2)	4670.01	21.66	21.94	0.28	21.73	4670.36	21.61	22.03	0.42	21.71	4670.38
MW-10	4633.89	28.31	29.50	1.19	28.61	4634.06	28.29	29.51	1.22	28.59	4634.07
MW-11	4611.62		25.74	0.00	25.74	4611.63		26.70	0.00	26.70	4610.67
MW-12	4652.88	23.75	23.77	0.02	23.75	4653.11	23.84	23.87	0.03	23.85	4653.02
CPT-2		19.80	26.90	7.10	21.57		19.92	26.92	7.00	21.67	
CPT-3		18.97	20.47	1.50	19.34		19.01	20.51	1.50	19.39	
CPT-4			23.69	0.00	23.69			23.64	0.00	23.64	
CPT-6			19.32	0.00	19.32			19.35	0.00	19.35	
CPT-7	4666.39	17.54	20.44	2.90	18.27	4665.94	16.51	20.51	4.00	17.51	4666.70
CPT-10	4668.52	17.34	18.94	1.60	17.74	4668.80	16.60	19.10	2.50	17.23	4669.31
CPT-11			26.67	0.00	26.67			26.48	0.00	26.48	
CPT-13											
CPT-14	4632.13	23.80	26.80	3.00	24.55	4631.33	22.85	25.35	2.50	23.48	4632.40
CPT-15	4607.08		31.56		31.56	4607.18		31.45		31.45	4607.29
CPT-17											
CPT-18	4629.26		12.55		12.55	4628.91		12.66		12.66	4628.80
CPT-19	4608.69		28.30		28.30	4608.68		28.28		28.28	4608.70
CPT-20	4602.62		22.79		22.79	4602.69		22.76		22.76	4602.72
CPT-21	4624.64		31.16		31.16	4624.75		31.11		31.11	4624.80
CPT-22			20.12		20.12			20.15		20.15	
CPT-23	4617.44		24.87		24.87	4617.62		24.84		24.84	4617.65
CPT-25			33.63		33.63			33.39		33.39	
CPT-26											
CPT-27	4596.48		7.80		7.80	4596.24		7.69		7.69	4596.35
CPT-28	4598.66		5.82		5.82	4599.80		6.19		6.19	4599.43
CPT-29											
CPT-30	4598.68		11.50		11.50	4598.72		11.46		11.46	4598.76
CPT-31	4605.08		7.01		7.01	4603.87		5.78		5.78	4605.10
CPT-33			18.57		18.57			18.46		18.46	
CPT-34			20.80		20.80			19.70		19.70	
CPT-36											
CPT-37	4602.25		22.98		22.98	4602.37		22.94		22.94	4602.41
CPT-38	4603.72		12.19		12.19	4603.47		11.86		11.86	4603.80
CPT-40	4662.19		53.22		53.22	4662.24		53.10		53.10	4662.36
CPT-41	4635.91		39.15		39.15	4636.04		39.30		39.30	4635.89
CPT-42	4643.09		33.05		33.05	4645.29		35.13		35.13	4643.21
CPT-43											
CPT-44			35.14		35.14			34.98		34.98	

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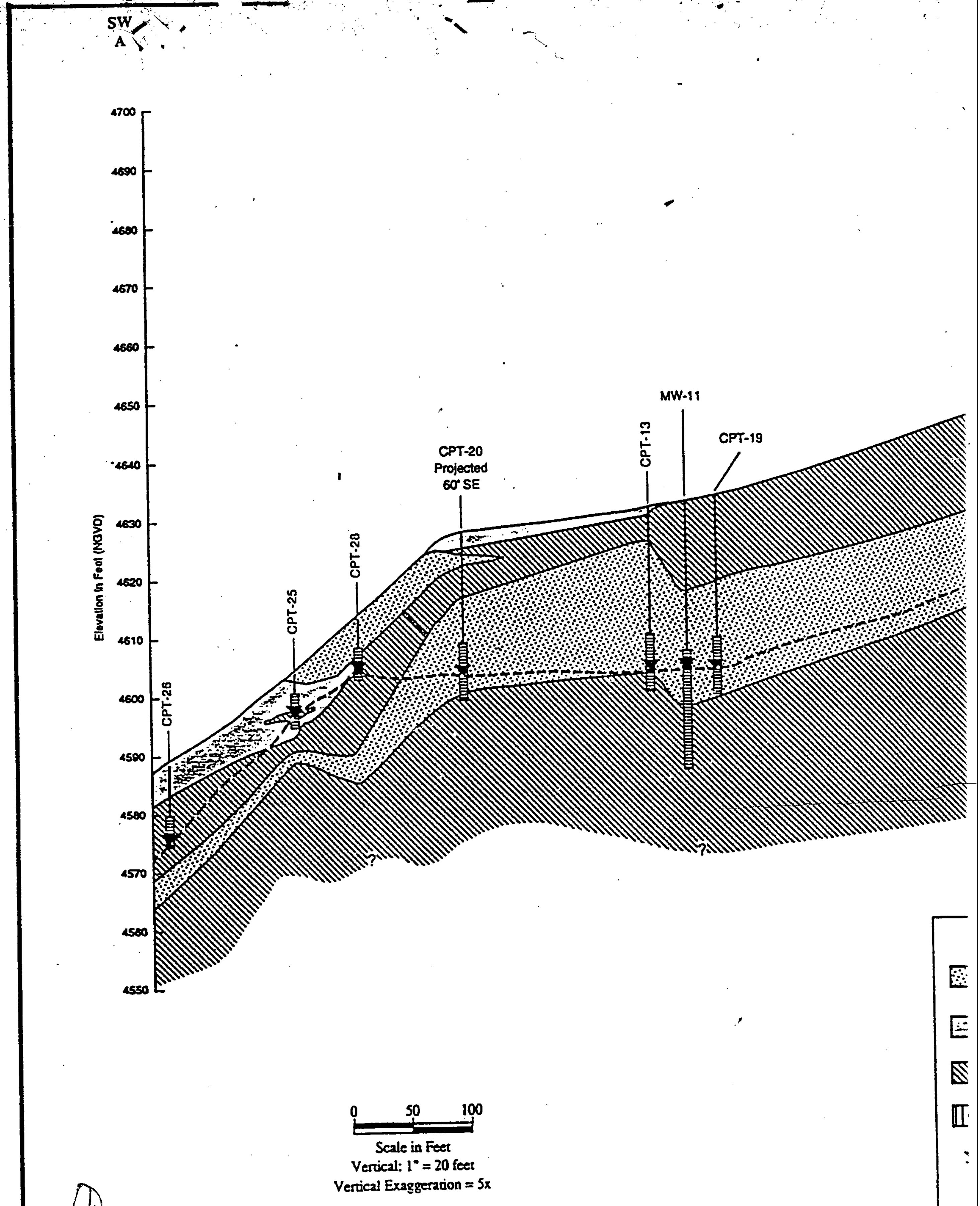
DTP = Depth To Product

PT = Product Thickness
CDTW = Corrected Depth To Water
CGWE = Corrected Ground Water Elevation

Source : JMM, 1993



Source: JMM, 1993.

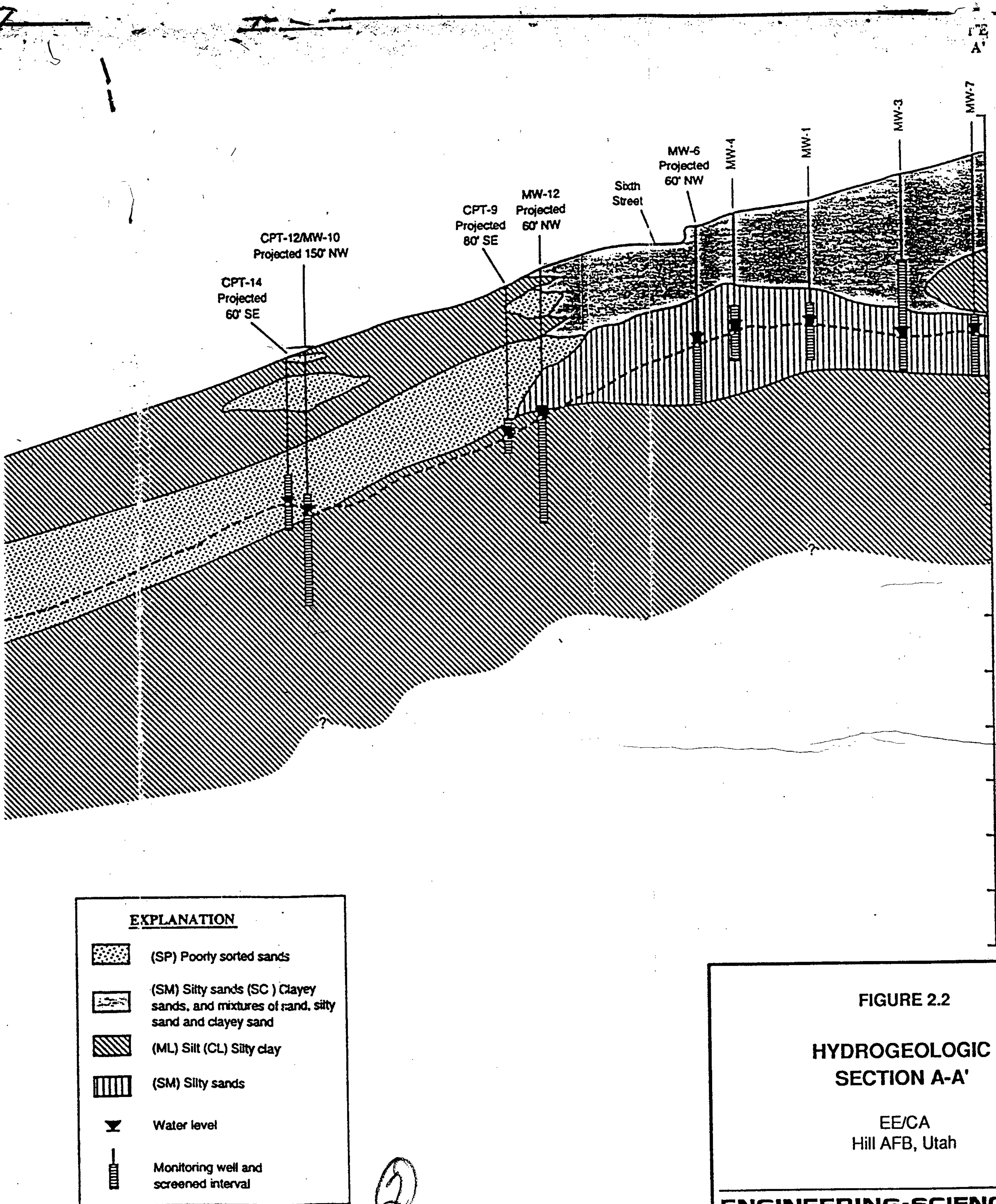


FIGURE 2.2

HYDROGEOLOGIC SECTION A-A'

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENC
Denver, Colorado

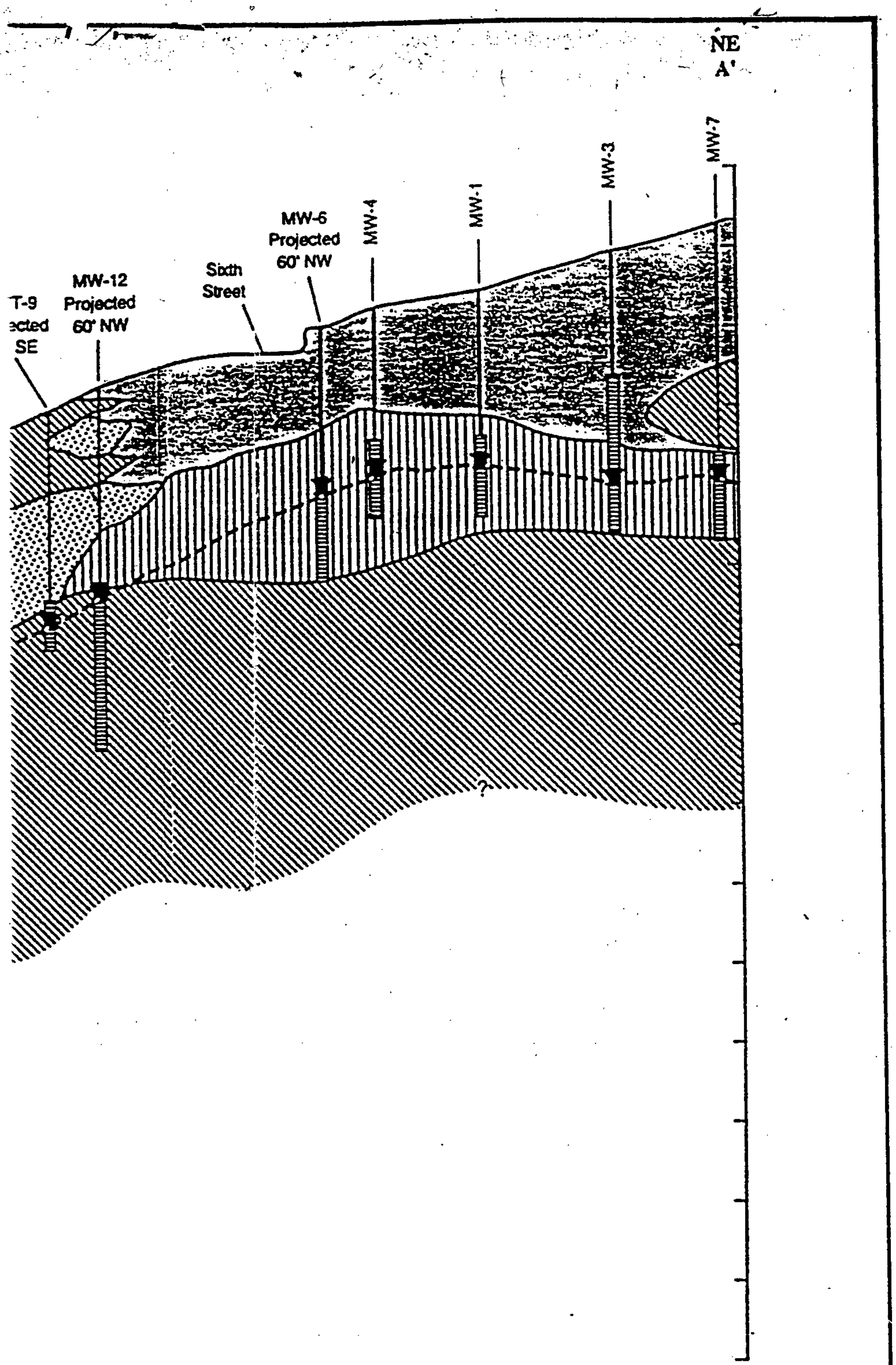
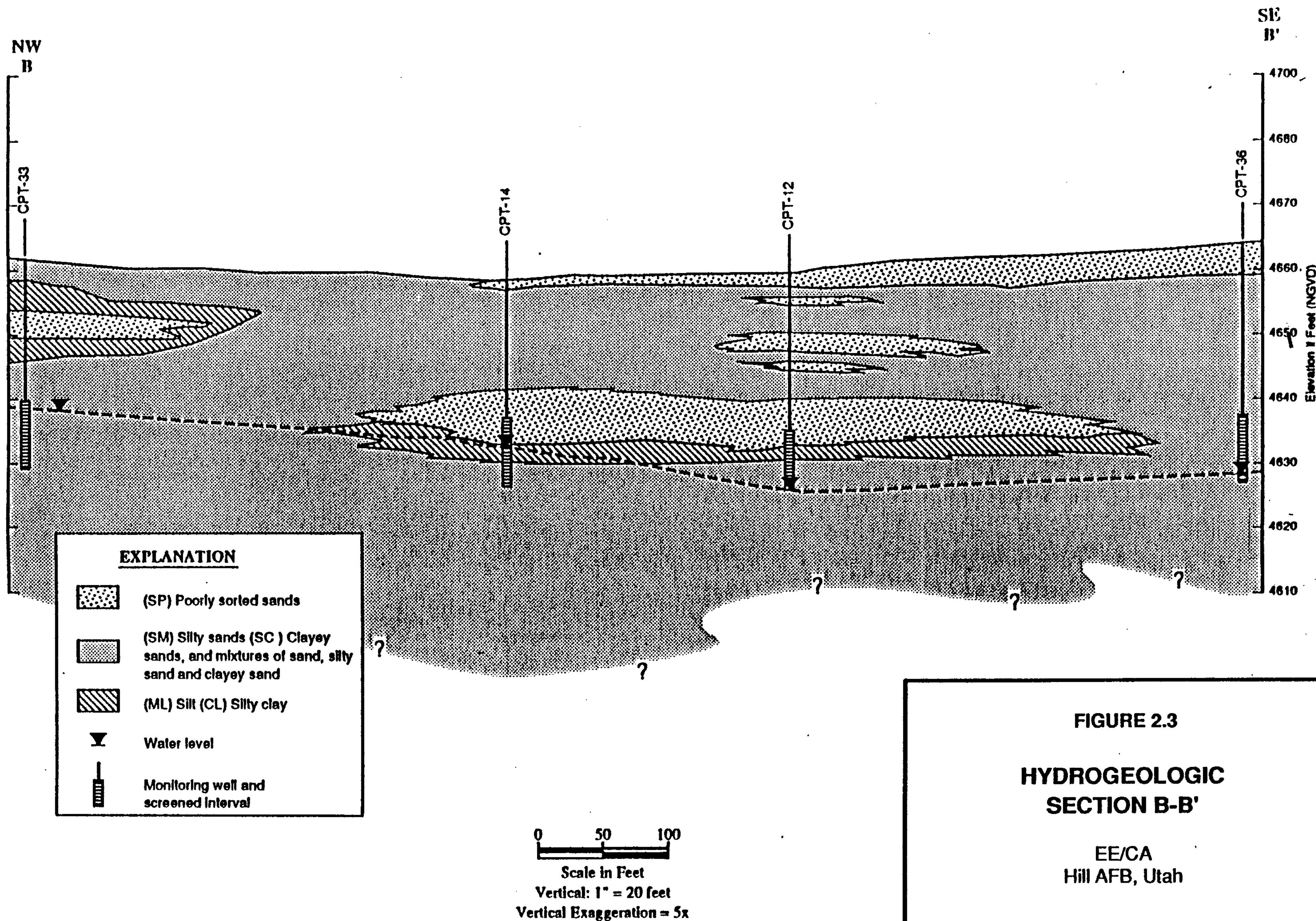


FIGURE 2.2

HYDROGEOLOGIC SECTION A-A'

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.
Denver, Colorado



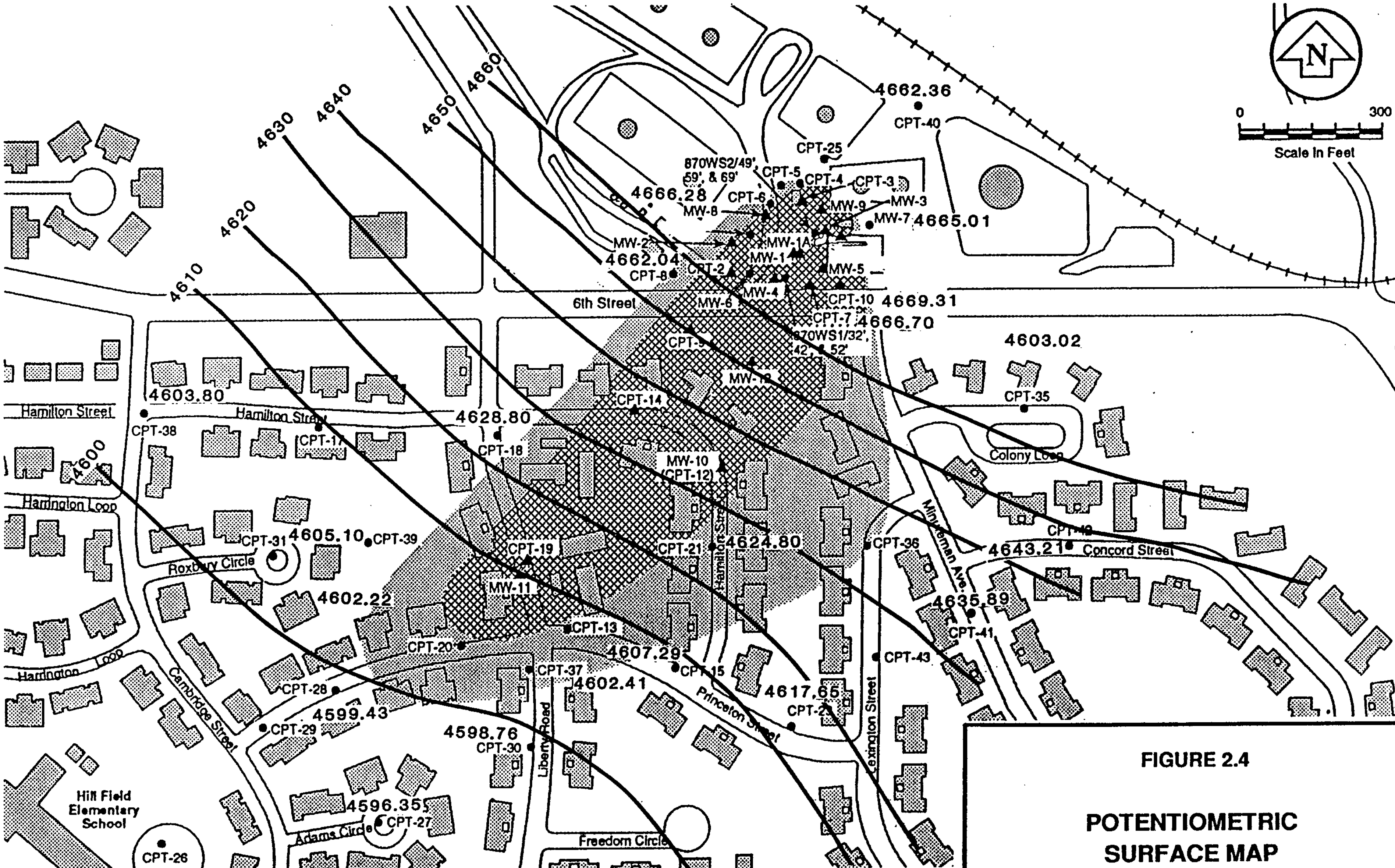
Source: JMM, 1993.

FIGURE 2.3

HYDROGEOLOGIC SECTION B-B'

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.
Denver, Colorado



EXPLANATION

CPT-28 ● Cone penetrometer test point/ piezometer

MW-12 ● Monitoring well location

CPT-19 ▲ Free phase JP-4 detected

Extent of JP-4

Railroad

Source: JMM, 1993.

FIGURE 2.4

POTENTIOMETRIC SURFACE MAP

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.
Denver, Colorado

TABLE 2.3
SOIL ANALYTICAL RESULTS
UST SITE 870-EE/CA
HILL AFB, UTAH

Well Number	Sample Interval (ft bgs)	Benzene (ug/Kg)	Toluene (ug/Kg)	Ethyl Benzene (ug/Kg)	Xylene (ug/Kg)	TPH (mg/kg)
MW-1	16-17	150	129	57	318	<10.0
MW-1	18-19	564	145	341	2249	98.3
SB870A-02	15-16	43.2	51.3	52.2	457.3	23.2
SB870A-02	17-18	13	60.2	57.7	509	37
SB870A-03	11-12	9400	115000	66700	634000	2790
SB870A-03	19-20	338	595	138	1143	<10.0
SB870A-03*	29-30	22200	187000	83100	744000	15100
MW-5	15.5-16	2000	110	260	2800	20
MW-6	21-21.5	9	<5	<5	<5	<10.0
MW-8	11-11.5	<5	31	120	920	110
MW-9	17-17.5	100	100	180	5400	360
MW-1A**	17-17.5	10000	23000	16000	74000	1500
MW-1A**	59.5-60	<5	<5	<5	<10	<10

* Duplicate of 19'-20' (as shown in Table 3, ref. JMM, 1993)
** Well Abandoned
ug/kg - Micrograms/kilogram
mg/kg - Milligrams/kilogram
ft bgs - feet below ground surface

Source: JMM, 1993

TABLE 2.4
GEOTECHNICAL RESULTS
UST SITE 870-EE/CA
HILL AFB, UTAH

Well Number	Sample Interval (ft bgs)	Moisture %	USCS Classification	Atterburg Limits	Permeability (cm/s)
MW-1	25.5-26	23.9	CL	Liquid Limit=28 Plastic Index=7	1.29E-7
SB-3	15.5-16	NA	NA	NA	2.31E-7
MW-5	31-31.5	29.1	CL	Liquid Limit=32 Plastic Index=10	1.78E-7
MW-6	30.5-31	23.9	ML	Non-plastic	2.03E-6

NA - Not analyzed
Source : JMM, 1993

TABLE 2.5

GROUND WATER ANALYTICAL RESULTS
UST SITE 870-EE/CA
HILL AFB, UTAH

Well Number	Benzene (ug/L)	Toluene (ug/L)	Ethyl Benzene (ug/L)	Xylene (ug/L)	Total BTEX (ug/L)	PCE * (ug/L)
MW870A-01	305	690	132	2303	3430	
MW-570 **	222	660	102	2396	3380	
CPT-42	<1.0	<1.0	<1.0	<1.0	0	
CPT-43	<1.0	<1.0	<1.0	<1.0	0	
CPT-7	680	34¦	1400	5700	7780	
MW-5	74	<50	160	900	1134	
MW-27***	76	<50	150	890	1116	
MW-10	<5	17	<5	110	127	
MW-11	26	33	21	180	260	
MW-12	10	<5	29	300	339	
CPT-10	<5	11	16	160	187	
CPT-14	<250,000	<250,000	1,400,000	13,000,000	14,400,000	
870-WS-1/32'	17.4	1.8	<1.0	6.2	25.4	
870-WS-1/42'	30.5	113	56.4	472	671.9	
870-WS-1/92'	27	59.3	21.6	143.4	251.3	
870-WS-2/49'	8.4	13.8	4.5	39.6	66.3	
MW-40****	6.5	7.8	1.7	15.6	31.6	
870-WS-2/59'	24	68	50.7	387.7	530.4	
870-WS-2/69'	43.5	71.7	38.2	321.6	475	
CPT-40	<1.0	<1.0	<1.0	<1.0	0	
CPT-7	<500	<500	1800	6500	8300	
SGS-1	7.7	<5	5.5	27.8	41	18
MW-6	<25	<25	<25	<25	0	
MW-7	<5	<5	<5	<5	0	
MW-27*****	<5	<5	<5	<5	0	
TP-01	0.741	2.273		1.027	4.041	0.425
TP-02	5.203	7.578	0.74	4.177	17.698	3.809
TP-03	2.701	3.112	0.322	1.655	7.79	2.447
TP-07	26.092	21.919	0.753	3.906	52.67	2.204
TP-09	0.992	2.128	0.173	0.301	3.594	1.269
TP-10	1.928	3.214		3.83	8.972	3.618
TP-12	1.163	0.565	0.062	0.265	2.055	0.636
TP-13		0.069		0.062	0.131	
TP-14	1.44	0.392	0.338	1.378	3.548	
TP-17			0.014	0.057	0.071	
TP-19	0.646		0.036	0.149	0.831	0.125
TP-20	0.124	2.699		0.504	3.327	0.303
TP-21				0.057	0.057	
TP-22	0.056	0.09	0.022	0.104	0.272	
TP-35	N/A	N/A	N/A	N/A	0	N/A
TP-36				0.052	0.052	
TP-37	0.789	0.93		4.179	5.898	2.525
TWP-01	0.52	1.271	0.085	0.173	2.049	0.795
SGS-01	0.161	12.645	0.046	0.295	13.147	
GWS-01	0.195	0.946	0.072	0.089	1.302	
MW-03	12.179	6.728		7.669	26.576	2.722

* Tetrachloroethylene
** Duplicate of MW870A-01
*** Blind Duplicate of MW-5
**** Blind Duplicate of 870-WS-2/49'
***** Blind Duplicate of MW-7

¦ - Estimated Value
ug/l - Micrograms/liter
Note: Well numbers with TP prefixes are equivalent to those with CPT prefixes. TP samples were collected during initial cone penetrometer survey.

Source: JMM, 1993

water data. With the exception of the BTEX compounds, the only organic compound observed at the site was tetrachloroethylene (PCE). A summary table of all ground water analytical results to date is presented in the 1993 MW report (JMM, 1993).

The shallow aquifer has total dissolved solids (TDS) concentrations that range between 160 and 1780 milligrams per liter (mg/L). Ground water quality standards of Utah Administrative Code (UAC) R448-6-2 are exceeded in certain areas of the shallow aquifer beneath Hill AFB. UAC R448-6-3 classifies ground water in the shallow aquifer as Class I (Pristine Ground Water), Class II (Drinking Water Quality Ground Water), and Class III (Limited Use Ground Water).

2.1.2.2.2 Deeper Aquifers

Insufficient data are available for ground water in the Sunset aquifer beneath UST Site 870 to allow classification into one of the UAC categories. TDS values for the Delta Aquifer range from 156 to 354 mg/L (JMM, 1993). These TDS values, and the fact that no regulated contaminants have been detected in ground water of the Delta Aquifer, allow the ground water contained in the Delta Aquifer to be classified as Class IA (Pristine Ground Water) under UAC R448-6-3.

2.2 DEVELOPMENT OF CONCEPTUAL MODEL

The conceptual model is a three-dimensional representation of the hydrogeologic system at UST Site 870 based on available geological, hydrological, climatological, and geochemical data. The purpose of the conceptual model is to integrate available data so that a coherent representation of the ground water flow system can be developed. The conceptual model will be used to aid in locating additional data collection points and to help develop the Bioplume II® model.

Successful conceptual model development involves:

- Definition of the problem to be solved;
- Model selection;
- Designing the conceptual model;
- Integrating available data, including;

- Local geologic and topographic data
- Hydraulic data
- Site stratigraphy
- contaminant concentration and distribution data

- Determining additional data requirements.

2.2.1 Conceptual Model Design Components

Site hydrogeologic data were integrated to produce hydrogeologic cross-sections which show the two- and three-dimensional relationships between hydrostratigraphic units (i.e., conductive units and aquitards), surface water bodies, and ground water divides at the site. These cross-sections also integrate ground water potentiometric data to show the position of the potentiometric surface relative to lithostratigraphic units to allow definition of the ground water flow system and identification of preferential contaminant transport pathways. Figure 2.1 depicts the location of two hydrogeologic sections. Figure 2.2 represents hydrogeologic section A-A' which is oriented northeast-southwest and is roughly parallel to the direction of ground water flow. This section shows that the alluvial ground water regime changes from unconfined to confined or semiconfined from northeast to southwest across the site. Figure 2.3 is hydrogeologic section B-B', which is oriented northwest-southeast and is roughly perpendicular to the direction of ground water flow. Figure 2.4 is a potentiometric surface map prepared using July 1992 ground water potentiometric surface data.

Because free product is present at the site, it may be necessary to use the fuel-water partitioning model of Bruce et al. (1991) to provide a conservative source term to model the partitioning of BTEX compounds from the free-product phase into the ground water. In order to use this model, samples of free product must be collected and analyzed for mass fraction of BTEX compounds.

Based on available data, ES will model the site as an unconfined to semi-confined silty and sandy aquifer. This conceptual model will be modified as necessary as additional site hydrogeologic data become available.

Based on the size of the contaminant plume and the potential migration distance, a 20 by 30 model grid will be used. Each grid cell will have dimensions of 75 feet by 100 feet. Figure 2.6 shows the grid overlain onto the site map. The sizes of grid cells can be increased if preliminary runs of the Bioplume II® model indicate that BTEX compounds have the potential to migrate to model boundaries. Conversely, grid size can be reduced if greater resolution is desired and contaminant transport conditions allow.

2.2.2 Potential Pathways and Receptors

Potential preferential contaminant migration pathways such as subsurface utility corridors will be identified during the field work phase of this project. Such information can be obtained from Hill AFB maps which delineate such utility corridors. Pathways to potential receptors may include discharge of contaminated ground water into downgradient surface water bodies, and migration of the contaminant plume into downgradient drinking water wells.

Potential receptors of petroleum hydrocarbon contaminated ground water will be identified. One group of potential receptors is the aquatic wildlife present in a canal located southwest of the site. In addition, a survey of ground water wells located downgradient of the dissolved-phase plume will be conducted. Because of the hydrogeologic setting at the site only the area between UST Site 870 and the canal will be surveyed.

SECTION 3

COLLECTION OF ADDITIONAL DATA

To facilitate implementation of the EE/CA, and to demonstrate that natural attenuation is occurring at UST Site 870, additional site-specific hydrogeologic data will be collected. The physical and chemical hydrogeologic parameters listed below will be determined during the field work phase of the EE/CA.

Physical hydrogeologic characteristics to be determined include:

- Depth from measurement datum to the potentiometric surface.
- Depth from measurement datum to the base of the shallow saturated zone (where feasible).
- Location of potential ground water recharge and discharge areas.
- Hydraulic conductivity through slug tests.
- Estimate of dispersivity.
- Detailed stratigraphic analysis of subsurface media.
- Determination of extent and thickness of free product.

Chemical hydrogeologic characteristics to be determined include:

- Dissolved oxygen concentration.
- Temperature.
- Specific conductance.
- pH.
- Chemical analysis of free product to determine mass fraction BTEX.
- Chemical analysis of ground water and soil for the parameters listed in Table 3.1.

In order to obtain these data, additional drilling, soil and ground water sampling, and aquifer testing will be performed.

TABLE 3.1
LABORATORY ANALYTICAL PROTOCOL FOR GROUND WATER, SOIL, AND SOIL GAS
UST SITE 870-EE/CA
HILL AFB, UTAH

MATRIX	METHOD	FIELD (F) OR ANALYTICAL LABORATORY (L)
WATER		
Total Iron	Colorimetric	F
Ferrous Iron (Fe2+)	Colorimetric	F
Ferric Iron (Fe+3)	Difference between total and ferrous iron	F
Manganese	Colorimetric	F
Sulfate	Colorimetric	F
Nitrate	Colorimetric	F
Nitrite	Colorimetric	F
Oxygen	HACH 16046 DO Meter	F
pH	E150.1/SW9040	L
Conductivity	E120.1/SW9050	L
Carbon Dioxide	Titrimetric, Hach 1436-01	F
Alkalinity (Carbonate [CO3-2] and Bicarbonate [HCO3-1])	E310.2	L
Nitrate	E300 or SW9056	L
Nitrite	E300 or SW9056	L
Chloride	E300 or SW9056	L
Sulfate	E300 or SW9056	L
Methane, Ethane, Ethene	Gas Chromatography	L
Aromatic Hydrocarbons	SW8020	L
Total Hydrocarbons	SW8015	L
SOIL		
Total Organic Carbon	Method 415.1	L
SOIL GAS		
Oxygen	O2 meter/EPA Method 3A	F
Oxygen	Gas chromatography ASTM D-3416	L
Carbon Dioxide (CO2)	ASTM D-3416	L
Carbon Dioxide (CO2)	CO2 meter	F
Methane	ASTM D-3416	L
Aromatic Hydrocarbons	TO-3	L
Total hydrocarbons	TO-3	L
Boiling Point Splits	TO-3	L

The following sections describe the procedures that will be followed when collecting additional site-specific data. Drilling, soil sampling, lithologic logging, and monitoring well development procedures are described in Section 3.1. Ground water sampling procedures are described in Section 3.2. Aquifer testing procedures are described in Section 3.3.

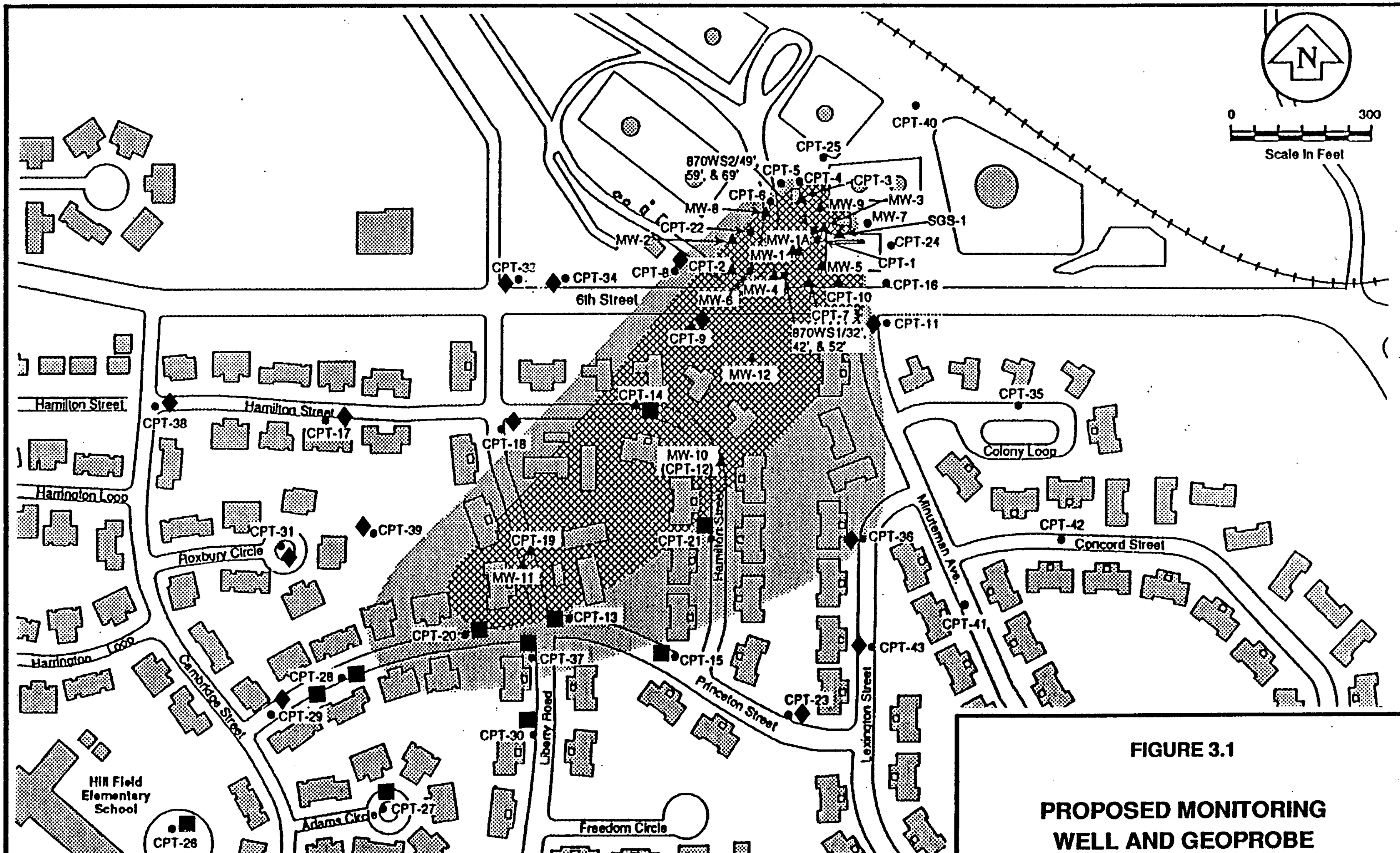
3.1 DRILLING, SOIL SAMPLING, AND MONITORING WELL INSTALLATION

To further characterize the hydrogeologic conditions of the shallow subsurface for Bioplume II® model development, 11 new ground water monitoring wells will be installed at UST Site 870. The following sections describe the proposed well locations and completion intervals, equipment decontamination procedures, drilling and soil sampling, monitoring well installation, well development, and well location and datum surveying.

3.1.1 Well Locations and Completion Intervals

Eleven new wells will be installed to further characterize ground water quality at the site. The locations for 10 of the new wells were determined during the 24 June 1993 meeting at Hill AFB. The necessity for an additional well was determined during a phone conversation between Dr. John Wilson of EPA and Mr. Todd Wiedemeier of ES. The purpose of this additional well is to help determine the hydraulic relationship between the shallow silty clay horizon and the underlying sand horizon.

New monitoring wells will be installed near existing cone penetrometer locations CPT-13, CPT-14, CPT-15, CPT-20, CPT-21, CPT-26, CPT-27, CPT-28 (two wells; one shallow in clay, and one deeper in the sandy interval), CPT-30, and CPT-37. The well locations were selected to provide the hydrogeologic data necessary for successful implementation of the Bioplume II® model. Figure 3.1 shows the proposed background ground water quality well locations, Table 3.2 contains proposed completion details. Wells completed in the sandy interval will be installed so that the entire thickness of the sand is screened. Well completion depths are expected to range between approximately 18 and 35 feet below ground surface (bgs). Screen lengths are expected to range between 5 and 25 feet.



EXPLANATION

■ Proposed monitoring well location

◆ Proposed geoprobe sampling location

CPT-28 ● Cone penetrometer test point/ piezometer

MW-12 ● Monitoring well location

CPT-19 ▲ Free phase JP-4 detected

Extent of JP-4

Railroad

Source: JMM, 1993.

FIGURE 3.1

PROPOSED MONITORING WELL AND GEOPROBE SAMPLING LOCATIONS

EE/CA
Hill AFB, Utah

ENGINEERING-SCIENCE, INC.

Denver, Colorado

TABLE 3.2

PROPOSED MONITORING WELL SPECIFICATIONS
UST SITE 870-EE/CA
HILL AFB, UTAH

PROPOSED WELL LOCATION	PROPOSED WELL NUMBER	DEPTH TO WATER (ft)	TOTAL DEPTH (ft)*	DEPTH TO TOP/BASE OF SAND (ft)	DEPTH TO SCREEN		SCREEN LENGTH (ft)	DEPTH TO BENTONITE SEAL	
					TOP (ft)	BASE (ft)		TOP (ft)	BASE (ft)
Near CPT-13	MW-13	28.38	30	7/27	10	30	20	7	9
Near CPT-14	MW-14	25.43	30	17/29	15	30	15	12	14
Near CPT-15	MW-15	32.97	35	13/35	15	35	20	12	14
Near CPT-20	MW-16	25.1	30	13/25	10	30	20	7	9
Near CPT-21	MW-17	31.83	34	0/37	9	34	25	6	8
Near CPT-26	MW-18	12.14	23	19/24	18	23	5	15	17
Near CPT-27	MW-19	8.7	27	22/27	22	27	5	19	21
Near CPT-28 (deep)	MW-20	8.53	26	22/27	22	27	5	19	21
Near CPT-28 (shallow)	MW-21	8.53	18	22/27	13	18	5	10	12
Near CPT-30	MW-22	18.37	27	7/27	7	27	20	4	6
Near CPT-37	MW-23		30*		20	30	10	17	19

*Estimated

Source: JMM, 1993

c:\de31102\workplan\table3-2.wb1

3.1.2 Well Drilling and Installation Procedures

This subsection addresses the procedures for drilling and installing new monitoring wells. All new monitoring wells will be installed in accordance with general procedures outlined in Section 8.5 of *A Compendium of Superfund Field Methods* (EPA, 1987).

3.1.2.1 Pre-Drilling Activities

All necessary digging, drilling, and ground water monitoring well installation permits will be obtained prior to mobilizing to the field. In addition, all utility lines will be located and proposed drilling locations cleared prior to any drilling activities.

Water to be used in drilling, equipment cleaning, or grouting will be obtained from one of the base's onsite water supplies. Water use approval will be verified by contacting the appropriate facility personnel. Only potable water will be used for the activities listed above. The field hydrogeologist will make the final determination as to the suitability of site water for these activities.

3.1.2.2 Equipment Decontamination Procedures

Prior to arriving at the site, and between each drilling site, the drill rig, augers, drilling rods, bits, casing, samplers, tools and other down-hole equipment will be decontaminated using a high-pressure, steam/hot water wash. Only potable water will be used for decontamination.

During drilling operations, the drill rig, augers, and any down-hole drilling and/or sampling equipment will be decontaminated at the Hill AFB decontamination pad or another location specified by base personnel. Water from the decontamination operations will be allowed to collect in the decontamination pad collection tanks. Precautions will be taken to minimize any impact to the area surrounding the decontamination pad that might result from the decontamination operations.

All sampling tools will be cleaned onsite, prior to use and between each sampling event with a clean water/phosphate-free detergent mix and a clean water rinse. All well completion materials that are not factory sealed will be cleaned onsite prior to use with a high-pressure, steam/hot water wash using approved water. Materials that cannot be cleaned to the satisfaction of the field hydrogeologist will not be used. All decontamination activities must be conducted in a manner so that the excess water will be controlled and not allowed to flow into any open borehole.

If contaminated soils are encountered during drilling [based on visual, olfactory, or photoionization (PID) indications], and the potential for cross-contamination is anticipated, drilling will be stopped and modified drilling procedures will be implemented to prevent the transfer of contaminants to deeper water-bearing strata.

Fuel, lubricants, and other similar substances will be handled in a manner consistent with accepted safety procedures and standard operating practices. Well completion materials will not be stored near or in areas which could be affected by these substances.

Surface runoff such as miscellaneous spills and leaks, precipitation, and spilled drilling fluid will not be allowed to enter any boring or well either during or after drilling/well construction. To prevent this from happening, starter casing, recirculation tanks, berms around the borehole, and surficial bentonite packs, as appropriate, will be used.

3.1.2.3 Drilling and Soil Sampling

Drilling in unconsolidated soils will be accomplished using the hollow-stem auger method. The borings will be drilled and continuously sampled to the proposed total depth of the monitoring well. A final borehole diameter of at least 8 inches will be required for the installation of wells with a 2-inch inside-diameter (ID) casing. The ID of the augers will not be less than 4 inches.

If subsurface conditions are such that the planned drilling technique does not produce acceptable results, e.g. unstable borehole walls or poor soil sample recovery, another technique deemed more appropriate to the type of soils present will be used. Any alternate soil sampling procedure used will be must be approved by the ES field hydrogeologist and will be appropriate for the subsurface lithologies present at the site.

Continuous soil samples will be obtained using a CME® split-barrel continuous sampling device or another similar method judged acceptable by the ES field hydrogeologist. Samples will be collected continuously over the full depth of the soil borehole unless an alternative sampling frequency is requested by the ES field hydrogeologist. Procedures will be modified, if necessary, to ensure good sample recovery. The soil samples collected will be removed from the continuous sampler and placed on clean aluminum foil for logging.

A portion of the soil sample will be placed in a clean glass jar for PID headspace measurements for VOCs. Representative portions of the soil samples collected for the headspace procedure will be quickly transferred to clean glass jars, sealed with aluminum foil, and held for 15 minutes at an ambient temperature of 65 degrees Fahrenheit (°F)or greater. Semi-quantitative measurements will be made by puncturing the aluminum foil seal with the PID probe and reading the concentration of the headspace gases. The PID relates the concentration of total VOCs in the sample to an isobutylene calibration standard. It is anticipated that headspace measurements will be performed on all samples collected during the drilling operations. The PID will also be used to monitor the worker breathing zone.

The ES field hydrogeologist will be responsible for observing all drilling and well installation activities, maintaining a detailed descriptive log of subsurface materials recovered, photographing representative samples, and properly labeling and storing samples. An example of the proposed geologic boring log form is presented in Figure 3.2. The descriptive log will contain:

- Sample interval (top and bottom depth);
- Sample recovery;
- Presence or absence of contamination;
- Soil or rock description, including: relative density, color, major textural constituents, minor constituents, porosity, relative moisture content, plasticity of fines, cohesiveness, grain size, structure or stratification, relative permeability, and any other significant observations; and
- Lithologic contacts: the depth of lithologic contacts and/or significant textural changes will be measured and recorded to the nearest 0.1 foot (1 in.).

Soils exhibiting petroleum hydrocarbon contamination based on PID screening will be drummed and stored onsite during the drilling operations. Upon completion of the drilling activities, two composite samples from the contaminated soil drums will be collected and analyzed by EPA Methods 8020 and 8015 modified. Upon receipt of the soil analytical results, these soils will be transferred to E.T. Technologies, Inc. in Salt Lake City, Utah by Hill AFB personnel. Clean soils will be handled by Hill AFB personnel who will be responsible for the final disposition of these soils.

BOREHOLE LOG

SITE NAME AND LOCATION	DRILLING METHOD:					BORING NO.	
						SHEET OF	
	SAMPLING METHOD:					DRILLING	
						START	FINISH
	WATER LEVEL					TIME	TIME
	TIME						
	DATE					DATE	DATE
DATUM ELEVATION	CASING DEPTH						

DRILL RIG	SURFACE CONDITIONS
ANGLE BEARING	
SAMPLE HAMMER TORQUE FT.-LBS	

DEPTH IN FEET (ELEVATION)	BLOWS/ 6 IN. ON SAMPLER (RECOVERY)	CORES: RUN NO.	CORES: NO. AND SIZE OF CORE PIECES	CORES: % RECOVERY	CORES: RQD	SOIL DESCRIPTION OR ROCK LITHOLOGY	SYMBOL	ROCK STRUCTURE	SAMPLER AND BIT	CASING TYPE	BLOWS/FOOT ON CASING	TEST RESULTS: DEPTH IN FEET FROM	TEST RESULTS: DEPTH IN FEET TO	TEST RESULTS: PERMAEABILITY CM./SEC.

DRILLING CONTR

RL

LOGGED BY

DATE

CHK'D BY

printed on recycled paper

Figure 3.2
Geologic Boring Log

3.1.2.4 Borehole Abandonment

Any boring not be completed as a monitoring well will be abandoned by backfilling with bentonite chips or a portland cement/sodium bentonite grout mixture to within approximately 3 feet of ground surface. If portland cement/sodium bentonite grout is used, the bentonite content of the grout will not exceed 8 percent by dry weight. If standing water is present in the boring, the grout mixture will be placed using a tremie pipe placed below the static water level near the bottom of the boring. The grout mixture will be pumped through the tremie pipe until undiluted grout is present in the boring near ground surface.

Twenty-four hours after abandonment, the field hydrogeologist, or his designate, will check the abandoned site for grout settlement and specify additional grout, or backfill the hole to ground surface with clean native soil, or concrete, as necessary.

3.1.2.5 Monitoring Well Installation

Ground water monitoring wells will be installed in the 11 borings. Except where specified, the entire thickness of the sand interval will be screened. Detailed well installation procedures are described in the following paragraphs. A typical well completion diagram is included as Figure 3.3.

3.1.2.5.1 Well Materials Decontamination

Well completion materials will be inspected by the field hydrogeologist and determined to be clean and acceptable prior to use. If not factory sealed, casing, screen and casing plugs and caps will be cleaned with a high-pressure, steam/hot water cleaner using approved water prior to use. Pre-packaged sand, bentonite, and portland cement will be used in well construction, and the bags will be inspected for possible external contamination before use. Materials that cannot be cleaned to the satisfaction of the field hydrogeologist will not be used.

3.1.2.5.2 Well Casing

Upon completion of drilling to the proper boring termination depth, a monitoring well casing will be installed. Well construction details will be noted on a Monitoring Well Installation Record form as shown in Figure 3.4. This information will become part of the permanent field record for the site.

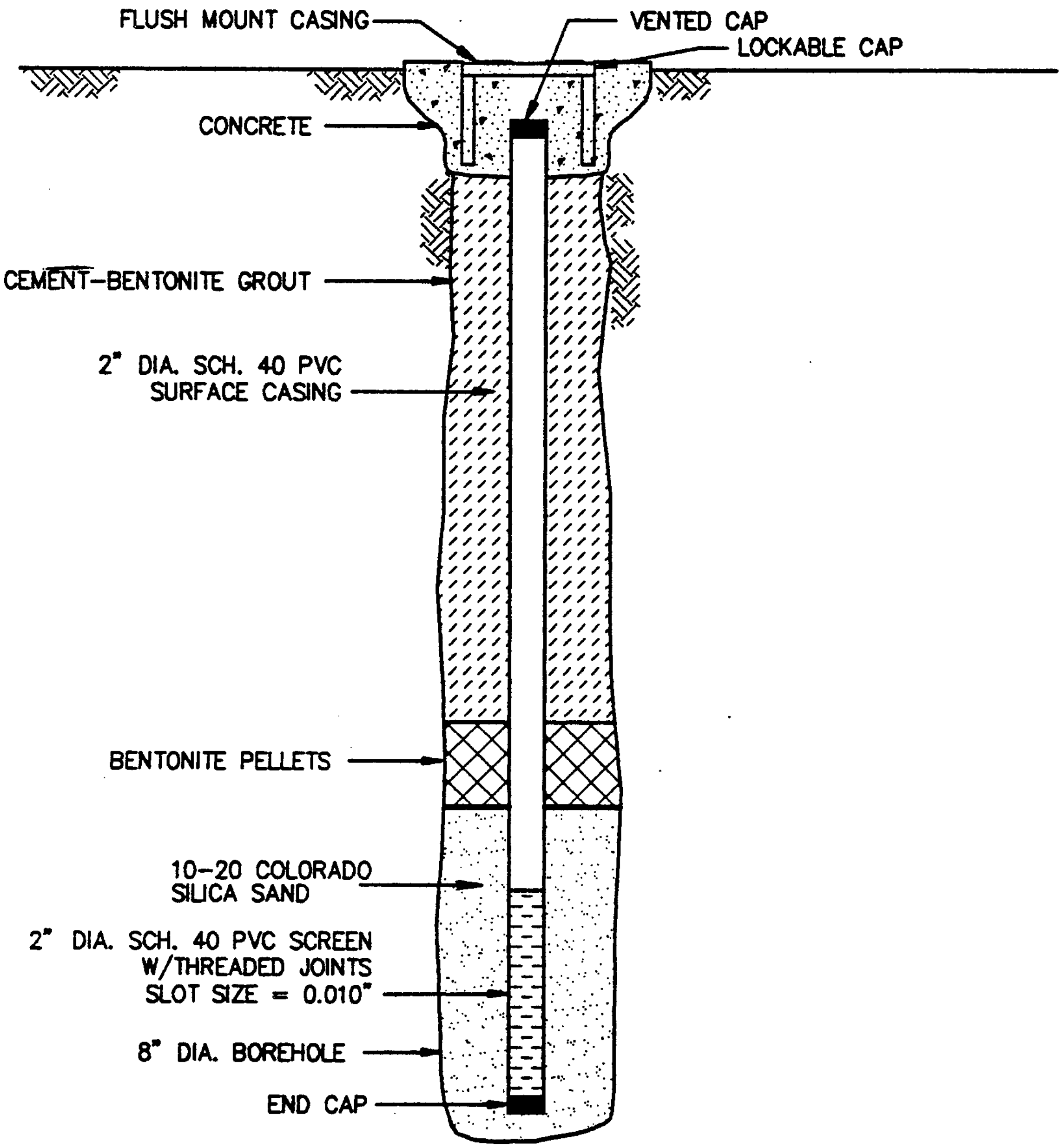


FIGURE 3.3

TYPICAL MONITORING WELL COMPLETION DIAGRAM

EE/CA
HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN0416, 08/13/93 at 13:30

Well No. ____________

Boring No. X-Ref: ____________

MONITOR WELL CONSTRUCTION SUMMARY

Survey Coords: ____________ Elevation Ground Level ____________

____________ Top of Casing ____________

Drilling Summary:

Total Depth ____________

Borehole Diameter ____________

Casing Stick-up Height: ____________

Driller ____________

Rig ____________

Bit(s) ____________

Drilling Fluid ____________

Protective Casing ____________

Construction Time Log:

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling				
Geophys. Logging:				
Casing:				
Filter Placement:				
Cementing:				
Development:				

Well Design & Specifications

Basis: Geologic Log ____ Geophysical Log ____

Casing String (s): C = Casing S = Screen.

Depth	String(s)	Elevation
____ - ____		____ - ____
____ - ____		____ - ____
____ - ____		____ - ____
____ - ____		____ - ____
____ - ____		____ - ____

Casing: C1 ____________

C2 ____________

Screen: S1 ____________

S2 ____________

Filter Pack: ____________

Grout Seal: ____________

Bentonite Seal: ____________

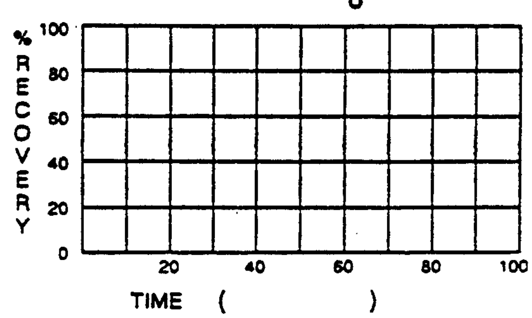
Well Development:

Stabilization Test Data:

Time	p H	Spec. Cond.	Temp (C)

Recovery Data:

Q= S_o=



Comments: ____________

Figure 3.4 Monitoring Well Installation Record

SITE NAME ____________

LOCATION

W/O

SUPERVISED BY ____________

Blank well casing will be constructed of Schedule 40 polyvinyl chloride (PVC) with an ID of 2 inches. All well casing sections will be flush-threaded; glued joints will not be used. The casing at each well will be fitted with a threaded bottom plug and a top cap constructed of the same type of material as the well casing. The top cap will be vented to maintain ambient atmospheric pressure within the well casing.

The field hydrogeologist will verify and record the boring depth, the lengths of all casing sections, and the depth to the top of all well completion materials placed in the annulus between the casing and borehole wall. All lengths and depths will be measured to the nearest 0.1 foot.

3.1.2.5.3 Well Screen

Well screens will be constructed of flush-threaded, Schedule 40 PVC with an ID of 2 inches. The slots in the screens will be factory slotted with 0.010-inch openings. Each well will be screened so that seasonal fluctuations of the water table can be measured. Except where specified, the entire thickness of the sandy interval of the shallow aquifer will be screened, and the water level in an unconfined aquifer will be allowed to fluctuate within the screened interval. The position of the screen will be selected by the field hydrogeologist after consideration is given to the geometry and hydraulic characteristics of the stratum in which the well will be screened.

3.1.2.5.4 Sand Filter Pack

A graded sand filter will be placed around the screened interval and will extend approximately 2 feet above the top of the screen. The sand filter will consist of 10-20 Colorado silica sand.

3.1.2.5.5 Annular Sealant

An annular seal will be placed above the gravel pack using sodium bentonite pellets. The pellet seal will be a minimum of 2 feet thick and will be hydrated in place with potable water. The pellet seal will be overlain by a portland cement/sodium bentonite grout that will extend from the top of the pellet seal to approximately 4.5 feet bgs. The portland cement/sodium bentonite grout will consist of one 94-pound sack of cement and about 5 pounds of bentonite for each 7 gallons of water used. The bentonite content of the portland cement/bentonite will not exceed 8 percent by dry weight. The grout will be overlain by concrete that will extend to the ground surface. To reduce heaving of the newly-installed monitoring well caused by freeze-thaw processes, it is imperative that the uppermost concrete seal extend to at least the maximum frost line, which in this part of Utah is approximately 4 feet.

3.1.2.5.6 Flush-Mount Protective Cover

Each monitoring well will be completed with an at-grade protective cover. In areas where pavement is present, the at-grade cover will be cemented in place using concrete which will be blended to the existing pavement. In areas where pavement is not already present, a 6-inch thick, 2-foot-diameter concrete pad will be constructed around the protective cover. In either case, the concrete immediately surrounding the well cover will be sloped gently away from the protective casing to facilitate runoff during precipitation events.

3.1.2.6 Well Development

Before any new well can be considered in proper condition for monitoring water levels or taking water samples, it must be developed. Development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen.

Well development will be accomplished using dedicated disposable bailers. The bailer will be regularly lowered to the bottom of the well so that fines which have accumulated in the bottom are agitated and removed from the well in the development water.

Development will be continued until a minimum of 10 casing volumes of water have been removed from the well and the water pH, temperature, and specific conductivity have stabilized. If the development water still is turbid after removal of ten casing volumes, development will be continued until the water becomes clear or the turbidity of the water produced has been stable after the removal of several casing volumes.

The development procedure specifies that 10 casing volumes of water be removed from the well. However, some wells completed in marginal aquifers will go dry during well development prior to the recovery of 10 casing volumes. In these low productivity wells, development activity may have to be staged over a period of time to allow water to refill the well bore. In the event 10 casing volumes of water cannot be recovered, the water volume recovered will be noted in the development records stating this deficiency.

Clean development waters will be discharged at the drilling site in a manner to control excessive ponding. Visibly or PID-indicated contaminated waters will be collected in 55-gallon drums and transported to the Hill AFB water treatment plant for treatment and disposal.

3.1.2.7 Well Development Records

A record of well development will be maintained for each well. The well development record will be maintained in a bound field notebook by the field hydrogeologist. Figure 3.5 is an example of the well development record. A summary well development record form will be prepared for each well and submitted with the EE/CA report. Development records will include:

- Well Number;
- Date and time of development;
- Development method;
- Pre-development water level and well depth;
- Volume of water produced;
- Description of water produced;
- Post-development water level and well depth; and
- Field analytical measurements, including pH and specific conductivity.

3.1.2.8 Water Level Measurements

Water levels at the monitoring wells will be measured within a short time interval so that the water-level data are comparable. Water levels in the wells will not be measured until they are developed and the water level has stabilized. The depth to water below the measurement datum will be made using an electric water level probe to the nearest 1/8 inch (0.01 ft). In addition, water level measurements will be made in select piezometers at the site.

3.1.2.9 Well Location and Datum Survey

The location and elevation of the new wells will be surveyed by a registered surveyor soon after well completion. The horizontal location will be measured relative to established Hill AFB coordinates. Horizontal coordinates will be measured to the nearest

Figure 3.5
WELL DEVELOPMENT RECORD

Page__ of__

Job Number________________ Job Name____________________
Location________________ By________________ Date________
Well Number________________ Measurement Datum________________

Pre-Development Information

Time (Start):

Water Level: Total Depth of Well:

Water Characteristics

Color________________ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material________________
pH__________ Temperature(°F °C) __________
Specific Conductance(µS/cm)________________

Interim Water Characteristics

Gallons Removed

pH

Temperature (°F °C)

Specific Conductance(µS/cm)

Post-Development Information

Time (Finish):

Water Level: Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color________________ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material________________
pH__________ Temperature(°F °C) __________
Specific Conductance(µS/cm)________________

Comments:

c:\forms\develop.doc

0.01 foot. Vertical location of the ground surface adjacent to the well casing, the measurement datum (top of the interior casing), and the top of the outer well casing will be measured relative to a U.S.G.S. mean sea level datum. The ground surface elevation will be measured to the nearest 0.1 foot and the measurement datum, outer casing, and surveyor's pin (if present) elevation will be measured to the nearest 0.01 foot.

3.1.3 Site Restoration

After well installation and sampling is complete, each well site will be restored as close to its original condition as possible. Clean drill cuttings brought to the surface will be placed in 55-gallon drums for disposition by Hill AFB personnel. Visibly contaminated cuttings will be placed in 55-gallon drums, and two composite samples will be collected and analyzed as described in Section 3.1.2.3. These drums will be stored onsite pending results of the soil analytical testing, and transported to the ET Technologies, Inc. in Salt Lake City by Hill AFB personnel for proper disposition. Visibly or PID-indicated contaminated development waters and sampling purge waters will be stored in 55 gallon drums and transported to the base water treatment facility for treatment.

3.2 GROUND WATER SAMPLING

This section describes the scope of work required for collecting ground water quality samples at the 11 new wells and near existing CPT penetrometer locations using the Geoprobe® sampling apparatus. All water samples collected from ground water monitoring wells will be obtained using dedicated, disposable bailers. In order to maintain a high degree of quality control during this sampling event, the procedures described in the following sections will be followed.

Ground water sampling will be conducted by qualified scientists and technicians trained in the conduct of well sampling, records documentation, and chain-of-custody procedures. In addition, sampling personnel will have thoroughly reviewed this plan prior to sample acquisition and will have a copy of the plan available onsite for reference.

For this project, ground water samples will be collected in two phases. Phase one will consist of collecting ground water samples near existing CPT locations using the Geoprobe®. This phase of the ground water sampling process is described in Section 3.2.3.1 and will occur during the week of 2 August 1993. The second phase of ground water sampling is described in Section 3.2.3.2 and will occur during the week of 16 August 1993.

Activities that will occur during ground water sampling are summarized below:

- Assembly and preparation of equipment and supplies;
- Inspection of the well integrity (for monitoring well sampling), including
  - Protective cover, cap and lock,
  - External surface seal and pad,
  - Well stick-up, cap, and datum reference,
  - Internal surface seal,
  - Condition of bladder pump if present;
- Ground water sampling, including
  - Water-level measurements,
  - Visual inspection of borehole water,
  - Well casing evacuation,
  - Sampling;
- Sample preservation and shipment, including
  - Sample preparation,
  - Onsite measurement of physical parameters,
  - Sample labeling;
- Completion of sampling records;
- Completion of chain-of-custody records; and
- Sample disposition.

Detailed ground water sampling and sample handling procedures are presented in following sections.

3.2.1 Ground Water Sampling Locations

Ground water samples will be collected from existing and newly installed monitoring wells using a disposable bailer and near existing CPT locations using the Geoprobe® ground water sampling equipment.

3.2.1.1 Geoprobe® Sampling Locations

Ground water samples will be collected using the Geoprobe® sampling apparatus near 14 existing CPT locations (CPT-8, CPT-9, CPT-11, CPT-17, CPT-18, CPT-23, CPT-29, CPT-31, CPT-33, CPT-34, CPT-36, CPT-38, CPT-39, and CPT-43).

3.2.1.2 Monitoring Well Sampling Locations

Eleven new monitoring wells will be installed near existing cone penetrometer locations CPT-13, CPT-14, CPT-15, CPT-20, CPT-21, CPT-26, CPT-27, CPT-28 (two wells; one shallow in clay, and one deeper in the sandy interval), CPT-30, and CPT-37. After completion of well installation and development activities, these wells will be sampled using dedicated bailers.

3.2.2 Preparation for Sampling

All equipment to be used for sampling will be assembled and properly cleaned and calibrated (if required) prior to arriving in the field. In addition, all record keeping materials will be gathered prior to leaving the office.

3.2.2.1 Equipment Cleaning

All portions of sampling and test equipment that will contact the sample will be thoroughly cleaned before use. This includes water-level probe and cable, lifting line, test equipment for on-site use, and other equipment or portions thereof which will contact the samples. Based on the types of sample analyses to be conducted, the following cleaning protocol will be used:

- Clean with potable water and phosphate-free laboratory detergent;
- Rinse with potable water;
- Rinse with distilled or deionized water;
- Rinse with reagent-grade methanol;
- Air dry the equipment prior to use.

Any deviations from these procedures will be documented in the field scientist's field notebook and on the ground water sampling form.

If pre-cleaned dedicated sampling equipment is used, the cleaning protocol specified above will not be required. EPA Mobile Laboratory-supplied sample containers will be cleaned and sealed by the laboratory and therefore will not need to be cleaned in the field. The type of container provided and the method of container decontamination will be in the EPA Mobile Laboratory's permanent record of the sampling event.

3.2.2.2 Equipment Calibration

As required, field analytical equipment will be calibrated according to the manufacturer's specifications prior to field use. This applies to equipment used for onsite chemical measurements of pH, electrical conductivity, and temperature.

3.2.3 Sampling Procedures

Special care will be taken to prevent contamination of the ground water and extracted samples. The two primary ways in which sample contamination can occur are through contact with improperly cleaned equipment and by cross-contamination through insufficient cleaning of equipment between wells. To prevent such contamination, the water level probe and cable used to determine static water levels and well total depth will be thoroughly cleaned before and after field use and between uses at different sampling locations according to the procedures presented in Section 3.1.1.1. In addition to the use of properly cleaned equipment, a clean pair of new, disposable nitrile gloves will be worn each time a different well is sampled.

The following paragraphs present the procedures that comprise ground water sample acquisition from both ground water monitoring wells and the Geoprobe®. These activities will be performed in the same order as presented below. Exceptions to this procedure will be noted in the field scientist's field notebook.

3.2.3.1 Geoprobe® Ground Water Sampling

3.2.3.1.1 Sampling Interval and Method

The sampling depth and interval will be specified prior to driving the Geoprobe® sampling rods into the ground. The ES field hydrogeologist will verify the sampling depth by measuring the length of each Geoprobe® sampling rod prior to insertion into the ground. A disposable drive tip will be placed at the tip of the Geoprobe® sampling rods. This tip will be threaded on the up-hole end to allow attachment of 3/8-inch, high-density polyethylene (HDPE) tubing. After reaching the desired depth, the 3/8-inch HDPE tubing will be threaded through the center of the hollow Geoprobe® sampling rods and secured to the drive point. The polyethylene tubing will be perforated at the down-hole end using a 1/16-inch drill bit at 1/4-inch intervals which are alternately offset at 90 degree angles. The Geoprobe sampling rods will then be pulled back approximately 1 foot to allow ground water to enter the perforated end of the polyethylene tubing. When the rod is pulled up, the sampling tip will remain at the probe termination depth, and the 1-foot perforated interval of the polyethylene tubing will be exposed to ground water. The ground water sample will be acquired using a peristaltic pump, as described in Section 3.2.3.1.4.

3.2.3.1.2 Preparation of Location

Prior to starting the sampling procedure, the area around the well will be cleared of foreign materials, such as brush, rocks, debris, etc. This will prevent sampling equipment from inadvertently contacting foreign materials near the sampling point.

3.2.3.1.3 Water-Level and Total Depth Measurements

Prior to removing any water from the Geoprobe® sampling location the static water will be measured. A manometer with hollow HDPE will be inserted into the HDPE through which the ground water sample will be acquired until the manometer indicates that ground water has been reached. The HDPE attached to the manometer will then be marked at the level of the ground surface and removed from the ground. The depth to water will be determined by placing a tape measure next to the HDPE and measuring the length from the base of the tubing to the ground level mark to the nearest 0.1 foot. The sampling depth will be measured to the nearest 0.1 foot by noting the length of each section of Geoprobe®sampling rod placed in the ground.

3.2.3.1.4 Sample Extraction

A peristaltic pump will be used to extract ground water samples from the Geoprobe® sampling point. Prior to sample collection, ground water will be purged until dissolved oxygen and temperature readings have stabilized. The sample will be transferred directly to the appropriate sample container. The water should be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample.

Unless other instructions are given by the analytical laboratory, sample containers will be completely filled so that no air space remains in the container. Excess water collected during sampling will be placed in a 55-gallon drum and transported to the Hill AFB water treatment plant for disposal and treatment.

3.2.3.2 Ground Water Monitoring Well Sampling

3.2.3.2.1 Preparation of Location

Prior to starting the sampling procedure, the area around the well will be cleared of foreign materials, such as brush, rocks, debris, etc. These procedures will prevent sampling equipment from inadvertently contacting debris around the monitoring well.

3.2.3.2.2 Water-Level and Total Depth Measurements

Prior to removing any water from the well the static water level will be measured. An electrical water level probe will be used to measure the depth to ground water below the datum to the nearest 0.01 foot. After measuring the static water level, the water level probe will be slowly lowered to the bottom of the well and the total well depth will be measured to the nearest 0.01 foot. Based on these measurements the volume of water to be purged from the well can be calculated.

3.2.3.2.3 Well Bore Evacuation

The volume of water contained within the well casing at the time of sampling will be calculated, and three times the calculated volume will be removed from the well. All purge water will be placed in 55-gallon drums and transported to the Hill AFB treatment plant for disposal and treatment. The empty drums will be rinsed with hot water and returned to base personnel for reuse. Dedicated disposable bailers will be used for well evacuation.

If a well is evacuated to a dry state during purging, the well will be allowed to recharge and the sample will be collected as soon as sufficient water is present in the well to obtain the necessary sample quantity. Sample compositing, or sampling over a lengthy period by accumulating small volumes of water at different times to eventually obtain a sample of sufficient volume, will not be allowed.

3.2.3.2.4 Sample Extraction

Dedicated, disposable, polyethylene bailers will be used to extract ground water samples from the well. The bailer will be lowered into the water gently to prevent splashing and extracted gently to prevent creation of an excessive vacuum in the well. The sample will be transferred directly to the appropriate sample container. The water sample will be transferred from the bailer by discharging the sample from the bottom. The water should be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample.

Unless other instructions are given by the analytical laboratory, sample containers will be completely filled so that no air space remains in the container. Excess water collected during sampling will be placed into the 55-gallon drums used for well purge waters and transported to the Hill AFB treatment plant for disposal and treatment.

3.2.4 Onsite Chemical Parameter Measurement

3.2.4.1 Dissolved Oxygen Measurements

Except where the EPA Mobile Laboratory can obtain dissolved oxygen (DO) measurements from collected ground water samples, DO measurements will be taken using a meter with a downhole oxygen sensor. DO measurements will be taken immediately following ground water sample acquisition. Where DO measurements will be taken in wells which have not been sampled, the well will be purged as described in Section 3.2.3.1.3 prior to taking the DO measurement.

3.2.4.2 pH, Temperature, and Specific Conductance

Because the pH, temperature, and specific conductance of a ground water sample can change significantly within a short time following sample acquisition, these parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made in a clean glass container separate from those intended for laboratory analysis and the measured values will be recorded in the ground water sampling record.

3.2.5 Sample Handling

This section describes the handling of samples from the time of sampling until the samples arrive at the laboratory.

3.2.5.1 Sample Preservation

The EPA Mobile Laboratory will add any necessary chemical preservatives prior to shipping the containers to the site. Samples will be properly prepared for transportation to the EPA Laboratory by placing the samples in a cooler containing ice to maintain a shipping temperature of 4 degrees centigrade (°C).

3.2.5.2 Sample Container and Labels

Sample containers and appropriate container lids will be provided by the EPA Mobile Laboratory. The sample containers will be filled as described in Sections 3.1.1.4 and 3.1.2.3 and the container lids will be tightly closed. The sample label will be firmly attached to the container side, and the following information will be legibly and indelibly written on the label:

- Facility name;
- Sample identification;
- Sample type (ground water, surface water, etc.);
- Sampling date;
- Sampling time;
- Preservatives added; and
- Sample collector's initials.

3.2.5.3 Sample Shipment

After the samples are sealed and labeled, they will be packaged for transport to the EPA Mobile Laboratory. The following packaging and labeling procedures will be followed:

- Package sample so that it will not leak, spill, or vaporize from its container;
- Label shipping container with
  - Sample collector's name, address, and telephone number;
  - Laboratory's name, address, and telephone number;
  - Description of sample;
  - Quantity of sample; and
  - Date of shipment.

The packaged samples will be delivered to the EPA Mobile Laboratory. Delivery will occur shortly after sample acquisition.

3.2.5.4 Chain-of-Custody Control

After the samples have been collected, chain-of-custody procedures will be followed to establish a written record of sample handling and movement between the sampling site and the EPA Mobile Laboratory. Each shipping container will have a chain-of-custody form completed in triplicate by the sampling personnel. One copy of this form will be kept by the sampling contractor after sample delivery to the analytical laboratory, and the other two copies will be retained at the laboratory. One of the laboratory copies will become a part of the permanent record for the sample and will be returned with the sample analytical results. The chain-of-custody will contain the following information:

- Sample identification number;
- Sample collector's printed name and signature;
- Date and time of collection;
- Place and address of collection;
- Sample matrix;
- Chemical preservatives added;
- Analyses requested;
- Signatures of individuals involved in the chain of possession; and
- Inclusive dates of possession.

The chain-of-custody documentation will be placed inside the shipping container so that it will be immediately apparent to the laboratory personnel receiving the container, but will not be damaged or lost during transport. The shipping container will be sealed so that it will be obvious if the seal has been tampered with or broken.

3.2.5.5 Sampling Records

In order to provide complete documentation of the sampling event, detailed records will be maintained by the field hydrogeologist. At a minimum, these records will include the following information:

- Sample location (facility name);
- Sample identification;
- Sample location map or detailed sketch;
- Date and time of sampling;
- Sampling method;
- Field observations of
  - Sample appearance,
  - Sample odor;
- Weather conditions;
- Water level prior to purging;
- Total well depth;
- Purge volume;
- Water level after purging;
- Well condition;
- Sampler's identification;
- Field measurements of pH, temperature, and specific conductivity; and
- Any other relevant information.

Ground water sampling information will be recorded on a ground water sampling form. Figure 3.6 shows an example of the ground water sampling record.

3.2.6 Laboratory Analyses

Laboratory analyses will be performed on all ground water samples and the QA/QC samples described in Section 5. The analytical methods for this sampling event are listed in Table 3.1.

Prior to sampling, arrangements will be made with the EPA Mobile Laboratory to provide a sufficient number of appropriate sample containers for the samples to be

Figure 3.6
Ground Water
Sampling Record

SAMPLING LOCATION ____________
SAMPLING DATE(S)______________

GROUND WATER SAMPLING RECORD - MONITORING WELL ________________
(number)

REASON FOR SAMPLING: [ ] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: _____________, 19___ _________ a.m./p.m.
SAMPLE COLLECTED BY: ___________________ of __________________
WEATHER:____
DATUM FOR WATER DEPTH MEASUREMENT (Describe):___________________
____
____

MONITORING WELL CONDITION:

[ ] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS:_____________________________________
INNER PVC CASING CONDITION IS:_________________________________
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):_______________
____
____

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH___________________________
Items Cleaned (List):_____________________________________
____
____

2 [ ] WATER DEPTH ____________________________FT. BELOW DATUM
Measured with:____

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance:____
Odor:____
Other Comments:____

4 [ ] WELL EVACUATION:
Method:____
Volume Removed:____
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:_______________________________
Other comments:____________________________

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:______________________________
[ ] Pump, type:______________________________
[ ] Other, describe:______________________________
____

Sample obtained is [ ] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

Temp: __________ ° ______ Measured with:______________
pH: ______________ Measured with:______________
Conductivity: __________ Measured with:______________
Other: ______________________________
____

7 [ ] SAMPLE CONTAINERS (material, number, size):______________
____
____
____

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: Method____________ Containers:____________
Method____________ Containers:____________
Method____________ Containers:____________

[ ] Preservatives added:

Method____________ Containers:____________
Method____________ Containers:____________
Method____________ Containers:____________
Method____________ Containers:____________

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:______________________________
____
____
____
____

collected. All containers, preservatives, and shipping requirements will be consistent with EPA Mobile Laboratory protocol or those reported in Appendix A of this plan.

EPA Mobile Laboratory personnel will specify the necessary QC samples and notify the laboratory so that they can prepare these bottles. For samples requiring chemical preservation, preservatives will be added to containers by the laboratory prior to shipping. Shipping containers, ice chests with adequate padding, and cooling media will be sent by the laboratory to the site. Sampling personnel will fill the sample containers and return the samples to the laboratories.

3.3 AQUIFER TESTING

Slug tests will be conducted to estimate the hydraulic conductivity of the shallow saturated zone. A slug test is a single-well hydraulic test used to determine the hydraulic conductivity of an aquifer in the immediate vicinity of the tested well . Slug tests can be used for both confined and unconfined aquifers that have a transmissivity of less than 7,000 square feet per day (ft^2/day). Slug testing can be performed using either a rising head or a falling head test; in this case both methods will be used in sequence.

3.3.1 Definitions

- **Hydraulic Conductivity (K)**. A quantitative measure of the ability of porous material to transmit water; defined as the volume of water that will flow through a unit cross-sectional area of porous or fractured material per unit time under a unit hydraulic gradient.
- **Transmissivity (T)**. A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and the saturated thickness.
- **Slug Test**. Two types of testing are possible; a rising head or falling head test. A slug test consists of adding a slug of water or a solid cylinder of known volume to the well to be tested or removing a known volume of water or cylinder and measuring the rate of recovery of water level inside the well. The slug of a known volume acts to raise or lower the water level in the well.
- **Rising Head Test**. A test used in an individual well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the well and measuring the rate of recovery of the water level. The water level may be lowered by pumping, bailing or removing a submerged slug from the well.

- **Falling Head Test**. A test used in an individual well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the well by insertion of a slug or quantity of water, and then measuring the rate of drop in the water level.

3.3.2 Equipment

The following equipment is needed to conduct a slug test:

- Teflon®, PVC ,or metal slugs
- One-quarter inch nylon or polypropylene rope
- Electric water level indicator
- Pressure transducer/sensor
- Field logbook/forms
- Automatic data recording instrument (such as the Hermit Environmental Data Logger, In-Situ, Inc. Model SE1000B or equal)

3.3.3 Test Methods, General

Aquifer hydraulic conductivity tests (slug tests) are accomplished by either removal of a slug or quantity of water (rising head) or introduction of a slug (falling head), and then allowing the water level to stabilize while taking water level measurements at closely spaced time intervals.

Prior to testing, the monitoring well must be thoroughly developed as described in Section 3.1.2.6 and water levels allowed to stabilize. Slug testing will proceed only after water level measurements show that static water level equilibrium has been achieved. During the slug test, the water level change should be influenced only by the introduction (or subtraction) of the slug volume. Other factors, such as inadequate well development, extended pumping, etc., may lead to inaccurate results. It is up to the field hydrogeologist to decide when static equilibrium has been reached in the well. The pressure transducer, slugs, and any other down-hole equipment will be decontaminated prior to and immediately after the performance of the slug test using the procedures described in Section 3.2.2.1.

3.3.5 Falling Head Test

The falling head test is the first step in the two-step slug-testing procedure. The following paragraphs describe the falling head test.

1. Decontaminate all down-hole equipment prior to initiating the test.
2. Open the well. Where wells are located within the 100 year flood plain, and equipped with water tight caps, the well should be unsealed at least 24 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
3. Prepare the Aquifer Test Data form (Figure 3.7) with entries for:
   - Borehole/Well number.
   - Project number.
   - Project name.
   - Aquifer testing team.
   - Climatic data.
   - Ground surface elevation.
   - Top of well casing elevation.
   - Identification of measuring equipment being used.
   - Page number.
   - Static water level.
   - Date.
   - Time intervals (0,1,3,5,7,9,10, and 12 minutes and every three minutes thereafter through 60 elapsed minutes, then in 10 minute intervals for the next hour, and in 30 minute intervals for the next 3 hours).
4. Measure the static water level in the well to the nearest 0.01 foot.
5. Lower the decontaminated pressure transducer into the well and allow the displaced water to return to its static level. This can be determined by making

Figure 3.7
Aquifer Test Data Form

Page ________ of ____

Owner ______________________ Address ______________________ County ____________ State ________

Date ______________ Company performing test ______________________ Measured by ______________

Well No ______________ Distance from pumping well ________ Type of test ______________________ Test No ________

Measuring equipment ____

Time Data	Water Level Data	Discharge Data	Comments on factors affecting test data
Pump on: Date ____ Time ____ (t) Pump off: Date ____ Time ____ (t') Duration of aquifer test: Pumping ______ Recovery ______	Static water level ______ Measuring point ______ Elevation of measuring point ______	How Q measured ______ Depth of pump/air line ______ Previous pumping? Yes ____ No ____ Duration ______ End ______	

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		

periodic water level measurements until the static water level in the well is within 0.01 foot of the original static water level.

6. Lower the decontaminated slug into the well to just above the water level in the well.
7. Turn on the data logger and quickly lower the slug below the water table being careful not to disturb the pressure transducer. Follow the Owners Manual for proper operation of the data logger.
8. Terminate data recording when the water level stabilizes in the well. Remove the pressure transducer and slug from the well and decontaminate.

3.3.6 Rising Head Test

After completion of the falling head test, the rising head test will be performed. The following paragraphs describe the rising head slug test procedure.

1. Measure the static water level in the well to the nearest 0.01 foot to ensure that it has returned to the static water level.
2. Initiate data recording and quickly withdraw the slug from the well. Follow the Owners Manual for proper operation of the Data Logger.
3. Terminate data recording when the water level stabilizes in the well. Remove the pressure transducer from the well and decontaminate.

3.3.7 Slug Test Data Analysis

Data obtained during slug testing will be analyzed using AQTESOLV and the method of Hvorslev (1951) for confined aquifers or the method of Bouwer and Rice (1976) and Bouwer (1989) for unconfined conditions. The standard slug test form (Figure 3.8) is based on equations and test methods developed by Hvorslev (1951). Figure 3.9 is the Bouwer and Rice Analysis Data Form. Figure 3.10 contains the dimensionless parameters A, B, and C used for the Bouwer and Rice Analysis.

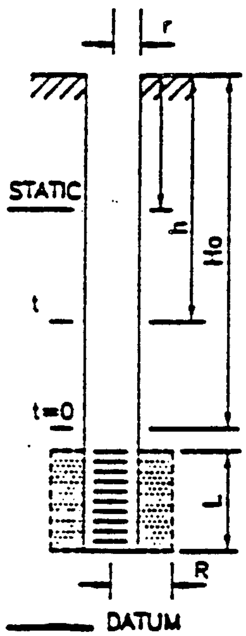
Figure 3.8
Standard Slug Test Form/
Hvorslev Analysis

HVORSLEV'S METHOD FOR K

PROJECT ______________ LOCATION ______________

WELL NUMBER ______________ ELEVATION ______________

DATE ______________



STATIC HEAD ______

PIPE RADIUS (r) ______

BORE HOLE RADIUS (R) ______

SATURATED SCREEN LENGTH (L) ______

HYDRAULIC CONDUCTIVITY:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K= ______________

TIME (MIN)	WATER DEPTH (FT)	RECOVERY TO STATIC ±(WATER DEPTH−STAT)	$\frac{h}{Ho}$
STATIC		—	—
00		(Ho)	1.00
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	
		(h)	

K= __________ FT/MIN K= __________ FT/DAY K= __________ CM/SEC

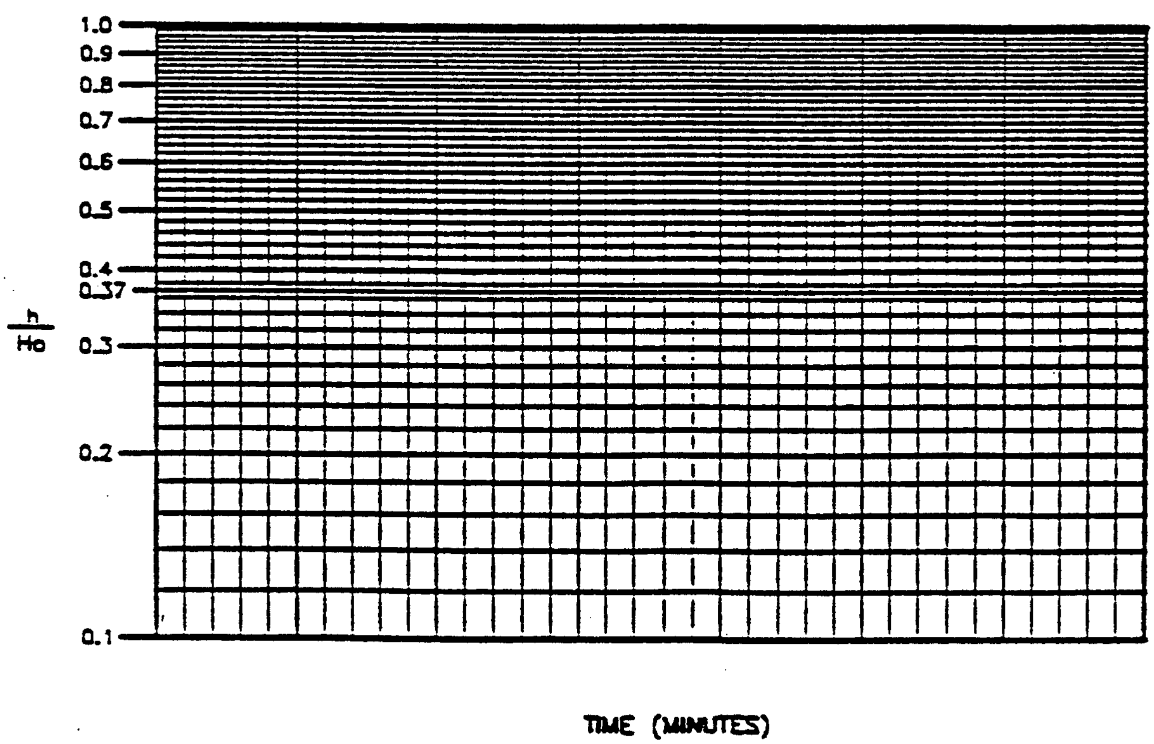


Figure 3.9
Bouwer and Rice Analyses
Data Form

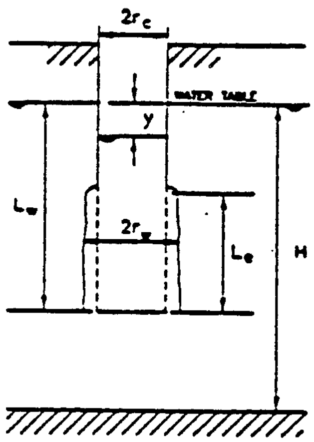
BOUWER AND RICE METHOD FOR K

(Reference: GROUNDWATER – May, June 1989, Vol. 27, No. 3)

PROJECT ____________________ LOCATION ____________________

WELL NUMBER ______________ ELEVATION ____________________

DATE ______________________



STATIC HEAD ______

PIPE RADIUS (r_c) ______

BORE HOLE RADIUS (r_w) ______

SATURATED SCREEN LENGTH (L_e) ______

WELL DEPTH ______

HYDRAULIC CONDUCTIVITY:
(ASSUME $L_w = H$)

$$K = \frac{(r'_c)\ \ln(R_e/r_w)}{2L_e} \left[\frac{1}{t}\right] \ln\left[\frac{y_0}{y_t}\right]$$

K= ____________________

TIME (MIN)	WATER DEPTH (FT)	y_t (WATER DEPTH–STAT)
STATIC		______
00		

K=__________ FT/MIN K=__________ FT/DAY K=__________ CM/SEC

WHERE: $*r'_c = [(1-n)r_c^2 + nr_w^2]$
n = POROSITY (~30%)

* r'_c TAKES INTO ACCOUNT THE RADIUS OF THE WELL AND THE THICKNESS AND POROSITY OF THE GRAVEL PACK. POROSITY OF THE GRAVEL PACK (n) IS ESTIMATED AT 30%. USE THIS EQUATION IF A GRAVEL PACK IS PRESENT.

ASSUME $L_w = H$: $\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{(L_e/r_w)}\right]^{-1}$ C = 1.4

ASSUME $L_w < H$: $\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ \ln[(H-L_w)/r_w]}{(L_e/r_w)}\right]^{-1}$

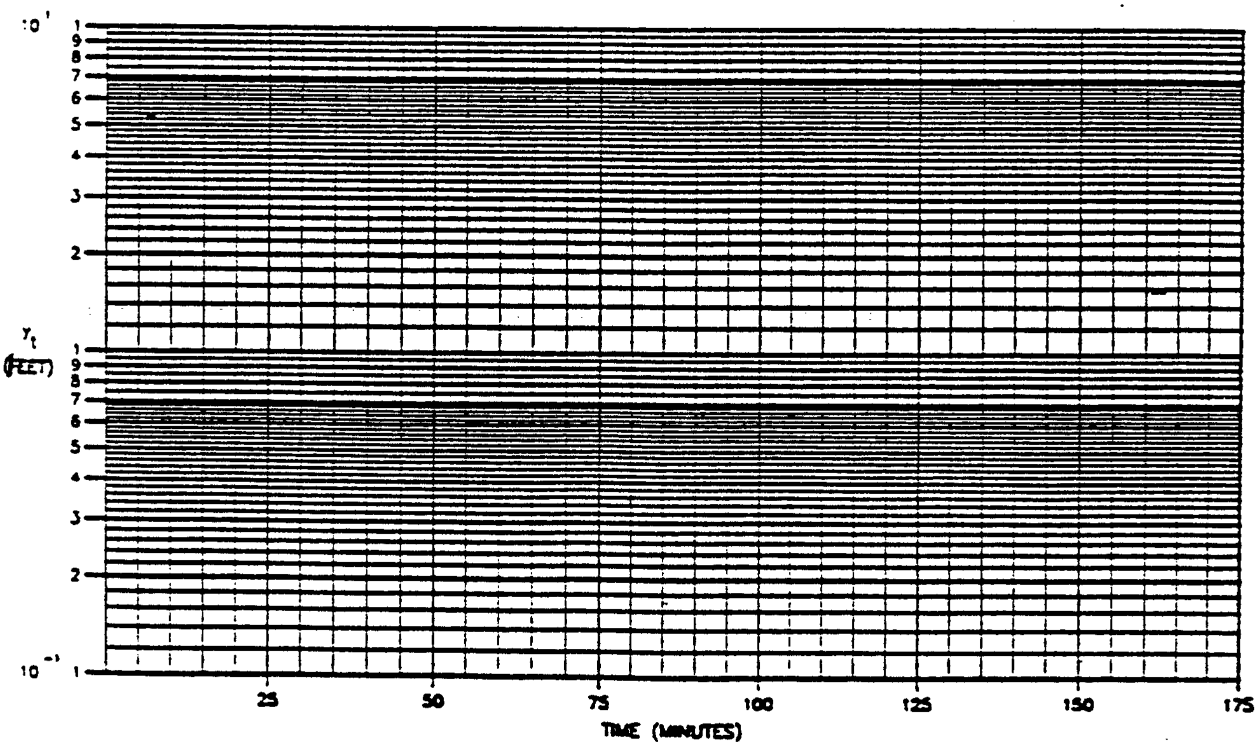
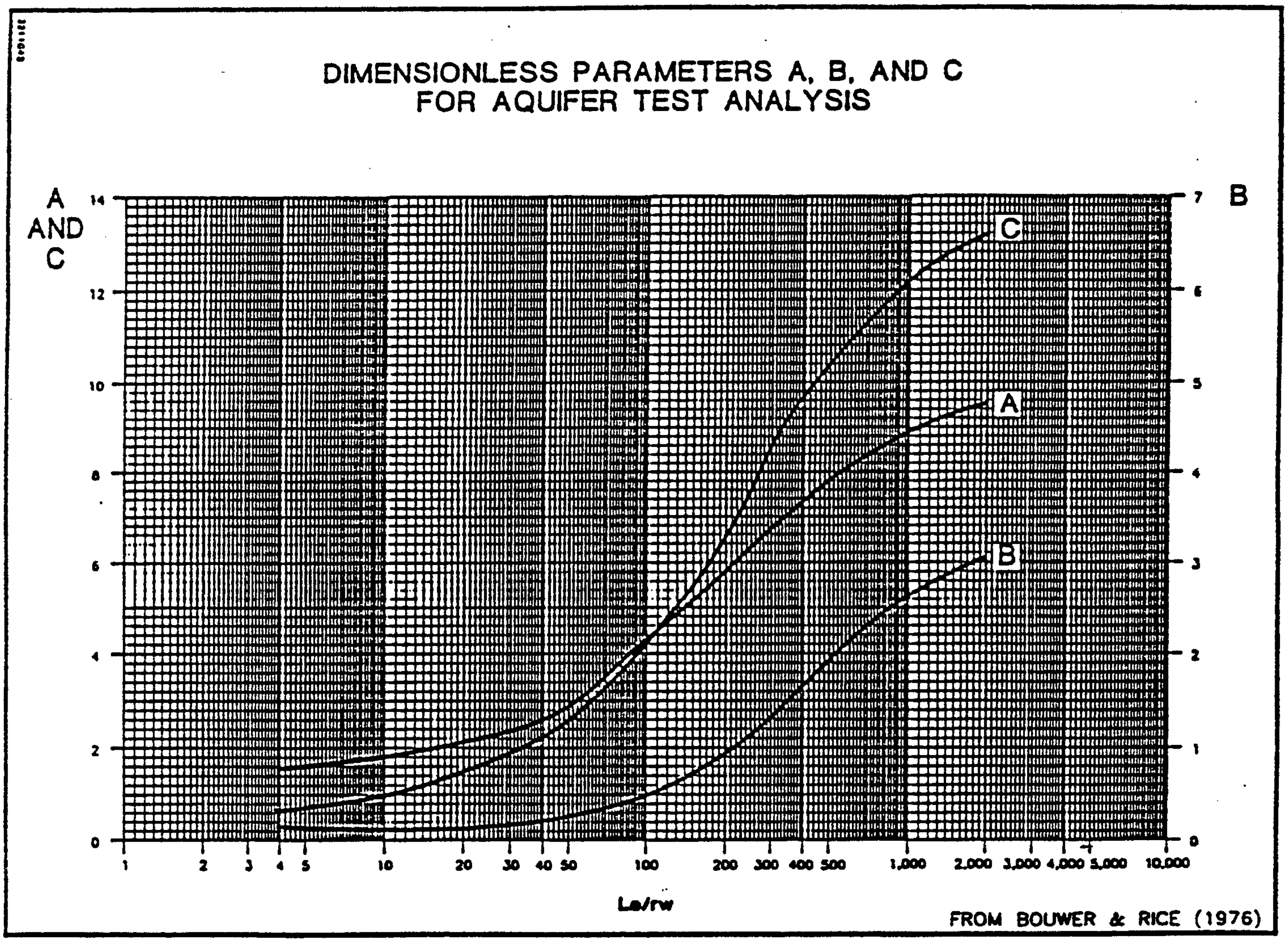


Figure 3.10
Bouwer and Rice Analyses
Dimensionless Parameters



SECTION 4

REMEDIAL OPTION EVALUATION AND EE/CA REPORT

Upon completion of field work, the Bioplume II® numerical ground water model will be used to determine the fate and transport of fuel hydrocarbons dissolved in ground water at the site. Based upon model predictions of contaminant concentration and distribution through time, and upon potential exposure pathways, the potential risk to human health and the environment will be assessed. If it is shown that natural attenuation of BTEX compounds is sufficient to reduce the potential risk to human health and the environment to acceptable levels, ES will recommend implementation of the natural attenuation with long-term monitoring remedial option. If natural attenuation is chosen, ES will prepare a site-specific long-term monitoring plan which will specify the location of point-of-compliance monitoring wells and sampling frequencies.

If the natural attenuation remedial option is deemed inappropriate for use at this site, institutional controls such as ground water or land use restrictions will be evaluated to determine if they will be sufficient to reduce the risk to human health and the environment to acceptable levels. If institutional controls are deemed inappropriate, remedial options which could reduce risks to acceptable levels will be evaluated and the most appropriate remedial option selected. Potential remedial options include free-product recovery, ground water pump-and-treat, and air sparging.

Upon completion of Bioplume II® modeling and remedial option selection, a report detailing the results of the modeling and remedial option selection will be prepared. This report will follow the outline presented in Figure 4.1 and will contain an introduction, site description, identification of remediation objectives, description of remediation alternatives, an analysis of remediation alternatives, and the recommended remedial approach. This report will also contain the results of the site characterization activities described herein and a description of the Bioplume II® model developed for this site.

FIGURE 4.1

EXAMPLE EE/CA REPORT OUTLINE

INTRODUCTION

SITE DESCRIPTION
- Background
- Soil and Ground Water Characteristics
- Site Contamination

IDENTIFICATION OF REMEDIATION OBJECTIVES
- Potential Pathways for Human/Ecological Contact
- Chemical-Specific Applicable or Relevant and Appropriate Requirements (ARARs.)

DESCRIPTION OF REMEDIATION ALTERNATIVES
- Natural Attenuation/Long-Term Monitoring
- Alternative 2 (Site Specific)
- Alternative 3 (Site Specific)

ANALYSIS OF REMEDIATION ALTERNATIVES
- Protectiveness (BioPlume® Model Results & Discussion)
- Implementability
  - *Technical*
  - *Administrative (Political)*
- Cost
  - *Capital Costs*
  - *Operating Costs*
  - *Present Worth Cost*

RECOMMENDED REMEDIATION APPROACH
- How does the chosen technology offer adequate protection for less cost.

APPENDIX A: Supporting Data and Documentation

APPENDIX B: Site Specific BioPlume II® Model Input and Results

SECTION 5

QUALITY ASSURANCE/QUALITY CONTROL

Field QA/QC procedures will include collection of field duplicates and rinseate, field and trip blanks; decontamination of the water level probe and cable; use of analyte appropriate containers; and chain-of-custody procedures for sample handling and tracking. All samples to be transferred to the EPA Mobile Laboratory will be clearly labeled to indicate sample number, location, matrix (e.g., ground water), and analyses requested. Samples will be preserved in accordance with the analytical methods to be used, and water sample containers will be packaged in coolers with ice to maintain a shipping temperature of 4 °C.

All field sampling activities will be recorded in a bound, sequentially paginated field notebook in permanent ink. All sample collection entries will include the date, time, sample locations and numbers, notations of field observations, and the sampler's name and signature. Field QC samples will be collected in accordance with the program described below, and as summarized in Table 5.1.

QA/QC sampling will include collection and analysis of duplicate samples, rinseate blanks, field/trip blanks, and matrix spike samples. Internal laboratory QC analyses will involve laboratory control samples (LCSs) and laboratory method blanks (LMBs). QA/QC objectives for each of these samples, blanks, and spikes are described below.

One duplicate water sample will be taken for every 10 or less ground water samples. Duplicate water samples will be analyzed for VOCs.

One rinseate sample will be collected for every 10 or less water samples. Because disposable bailers are proposed for this sampling event, the rinseate sample will consist of a sample of distilled water poured into a bailer and subsequently transferred into a sample container provided by the laboratory. Rinseate samples will be analyzed for VOCs.

TABLE 5.1

QA/QC Sample Types	Frequency Collected and/or Analyzed	Analytical Methods
Duplicates	2 Samples (10%)	VOCs
Rinseate Blanks	2 Samples (10%)	VOCs
Field Blanks	1 Sample (5%)	VOCs
Trip Blanks	One per shipping cooler	VOCs
Matrix Spike Samples	Once per sampling event	VOCs
Laboratory Control Sample	Once per method per medium	Laboratory Control Charts (Method Specific)
Laboratory Method Blanks	Once per method per medium	Laboratory Control Charts (Method Specific)

A field blank will be collected for every 20 or less water samples to assess the effects of ambient conditions in the field. The field blank will consist of a sample of distilled water poured into a laboratory-supplied sample container while sampling activities are underway. The field blank will be analyzed for VOCs.

A trip blank will be analyzed to assess the effects of ambient conditions and conditions on sampling results during the transportation of samples. The trip blank will be prepared by the laboratory and will be transported inside one of the coolers containing samples. This sample will be analyzed for VOCs.

Matrix spikes will be prepared in the laboratory and used to establish matrix effects for samples analyzed for VOCs.

LCSs and LMBs will be prepared internally by the laboratory and will be analyzed each day samples from the site are analyzed. Samples will be re-analyzed in cases where the LCS or LMB are out of the control limits. Control charts for LCSs and LMBs will be developed by the laboratory and monitored for the analytical methods used.

SECTION 6

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APPENDIX A

CONTAINERS, PRESERVATIVES, PACKAGING, AND SHIPPING REQUIREMENTS FOR GROUND WATER SAMPLES

Table 8.2a: Containers, Preservation, Packaging, and Shipping Requirements For ASC Ground-Water Samples

Analysis	Bottles and Jars	Preservation	Holding Time	Volume of Sample	Shipping	Normal Packaging
GROUND WATER Low Concentration (ICL Organics)						
ICL VOCs	Two 40-ml vials with Teflon-lined caps	Cool to 4°C	10 days	Fill completely	Delivered daily	Bubble pack
ICL Semivolatiles	Two 1-liter glass bottles with Teflon-lined lids	Cool to 4°C	5 days until extraction, 40 days after extraction	Fill 90% full	Delivered daily	Bubble pack
ICL Pesticides/PCBs	Two 1-liter amber glass bottles with Teflon-lined lids	Cool to 4°C	5 days until extraction, 40 days after extraction	Fill 75% full	Delivered daily	Bubble pack
PCDDs/PDDFs	Two 1-liter amber glass bottles with Teflon-lined lids	Cool to 4°C	30 days until extraction, 45 days after extraction	Fill 90% full	Delivered daily	Bubble Pack
Herbicides	Two 1-liter amber glass bottles with Teflon-lined lids	Cool to 4°C	7 days to extraction, 30 days after extraction	Fill 90% full	Delivered daily	Bubble Pack
Carbamates	Two 1-liter amber glass bottles with Teflon-lined lids	Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble Pack
Ethylene dibromide	Two 40-ml vials with Teflon-lined caps	Cool to 4°C	5 days	Fill completely	Delivered daily	Bubble Pack
Ethylene glycol	Two 40-ml vials with Teflon-lined caps	Cool to 4°C	14 days	Fill completely	Delivered daily	Bubble Pack
Low Concentration (ICL Inorganics)						
ICL Metals	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, cool to 4°C	6 months except Hg 28 days	Fill 90% full	Delivered daily	Bubble pack

Table 8.2a: (continued)
(Page 2 of 5)

Analysis	Bottles and Jars	Preservation	Holding Time	Volume of Sample	Shipping	Normal Packaging
Low Concentration (ICL Inorganics) continued						
Cyanide	One 1-liter polyethylene bottle	Filter immediately, 0.6 g ascorbic acid NAOH to pH >12, cool to 4°C,	14 days	Fill 90% full	Delivered daily	Bubble pack
Low Concentration (Organics and Inorganics)						
Ammonia	One 1-liter polyethylene bottle	H_2SO_4 to pH <2 Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Boron	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2 Cool to 4°C	6 months	Fill 90% full	Delivered daily	Bubble pack
Fluoride	One 1-liter polyethylene bottle	Filter immediately, Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Sulfate	One 1-liter polyethylene bottle	Filter immediately, Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Sulfide	One 1-liter polyethylene bottle	Filter immediately, Zinc acetate and sodium hydroxide to pH >9 Cool to 4°C	7 days	Fill 90% full	Delivered daily	Bubble pack
Chloride	One 1-liter polyethylene bottle	Filter immediately, Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Bromide	One 1-liter polyethylene bottle	Filter immediately, Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Nitrate/Nitrite	One 1-liter polyethylene bottle	Filter immediately, H_2SO_4 to pH <2 Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Alkalinity	One 1-liter polyethylene bottle	Cool to 4°C	14 days	Fill 90% full	Delivered daily	Bubble pack

Table 8.2a: (continued)
(Page 3 of 5)

Analysis	Bottles and Jars	Preservation	Holding Time	Volume of Sample	Shipping	Normal Packaging
Total Phosphorus	One 1-liter polyethylene bottle	H_2SO4 to pH <2 Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Total Organic Carbon	One 1-liter glass bottle	H_2SO_4 to pH <2 Cool to 4°C	28 days	Fill completely	Delivered daily	Bubble pack
Total Organic Halides	Two 1-liter glass bottles	H_2SO_4 to pH <2 0.008% NaS_2O_3 if residual chlorine present, cool to 4°C	7 days	Fill completely	Delivered daily	Bubble pack
Chemical Oxygen Demand	One 1-liter polythylene bottle	H_2SO_4 to pH <2 Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Biological Oxygen Demand	One 1-liter polythylene bottle	Cool to 4°C	48 hours	Fill completely	Delivered daily	Bubble pack
Total Suspended Solids	One 1-liter polythylene bottle	Cool to 4°C	7 days	Fill completely	Delivered daily	Bubble pack
Total Dissolved Solids	One 1-liter polythylene bottle	Cool to 4°C	48 hours	Fill 90% full	Delivered daily	Bubble pack
Corrosivity	One 1-liter glass bottle	Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
pH	One 1-liter glass bottle	Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Specific Conductance	One 1-liter polyethylene bottle	Cool to 4°C	28 days	Fill 90% full	Delivered daily	Bubble pack
Radionuclides:						
Gross alpha and beta	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2 Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Gamma scan	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2 Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack

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Table 8.2a: (continued)
(Page 4 of 5)

Analysis	Bottles and Jars	Preservation	Holding Time	Volume of Sample	Shippping	Normal Packaging
Americium-241	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Plutonium-239/240	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Plutonium-241	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Strontium-90	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Tritium	One 40-ml vial with teflon lined cup	Filter immediately, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Uranium-234	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Uranium-235	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Uranium-238	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Radium-226	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack
Radium-228	Two 1-liter polyethylene bottles	Filter immediately, HNO_3 to pH <2, Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack

Table 8.2a: (continued)
(Page 5 of 5)

Analysis	Bottles and Jars	Preservation	Holding Time	Volume of Sample	Shipping	Normal Packaging
Thorium-232	One 1-liter polyethylene bottle	Filter immediately, HNO_3 to pH <2 Cool to 4°C	6 months	Fill 90% Full	Delivered daily	Bubble pack

Note: Parameters with similar containers and preservation requirements may be combined

APPENDIX B

GROUND WATER ANALYTICAL RESULTS

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte	MW870A-01	MW-570 (Duplicate)	CPT-42	CPT-43
BTEX (µg/L)				
Benzene	305	222	<1.0	<1.0
Toluene	690	660	<1.0	<1.0
Ethylbenzene	132	102	<1.0	<1.0
Xylenes	2,303	2,396	<1.0	<1.0
TPH (mg/L)	11.9	7.5	<1.0	<1.0

µg/L Micrograms/liter
mg/L Milligrams/liter
-- Not analyzed

Water samples were analyzed according to EPA SW-846 Methods 8020/602 and 8015 Modified.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Volatiles - Priority Pollutants	CPT-7 (μg/L)	MW-5 (μg/L)	MW-27 Blind Dup of MW-5 (μg/L)	MW-10 μg/L)	MW-11 (μg/L)	MW-12 (μg/L)	Trip Blank 10/1/92 (μg/L)	CPT-10 (μg/L)	CPT-14 (μg/L)
Chloromethane	*71	4J	<100	<10	<10	<10	<10	<10	<500,000
Vinyl Chloride	<500	<100	<100	<10	<10	<10	<10	<10	<500,000
Bromomethane	<500	<100	<100	<10	<10	<10	<10	<10	<500,000
Chloroethane	<500	<100	<100	<10	<10	<10	<10	<10	<500,000
Trichlorofluoromethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Acrolein	<5,000	<1,000	<1,000	<100	<100	<100	<100	<100	<1,000,000
1,1-Dichloroethene	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Methylene Chloride	<250	<50	<50	<5	<5	11	<5	12	<250,000
Acrylonitrile	<5,000	<1,000	<1,000	<100	<100	<100	<100	<100	<1,000,000
1,1-Dichloroethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
1,2-Dichloroethene (total)	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Chloroform	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
1,1,1-Trichloroethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Carbon Tetrachloride	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Benzene	680	74	76	<5	26	10	<5	<5	<250,000
1,2-Dichloroethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Trichloroethene	<250	<50	8	<5	<5	<5	<5	<5	<250,000
1,2-Dichloropropane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Bromodichloromethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
2-Chloroethylvinyl ether	<500	<100	<100	<10	<10	<10	<10	<10	<500,000
cis-1,3-Dichloropropene	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Toluene	*34J	<50	<50	17	33	<5	<5	11	<250,000
trans-1,3-Dichloropropene	<250	<50	<50	<5	<5	<5	<5	<5	<250,000

TABLE 5

GROUNDWATER ANALYTICAL RESULTS (CONTINUED)

Analyte Volatiles - Priority Pollutants	CPT-7 (µg/L)	MW-5 (µg/L)	MW-27 Blind Dup of MW-5 (µg/L)	MW-10 µg/L)	MW-11 (µg/L)	MW-12 (µg/L)	Trip Blank 10/1/92 (µg/L)	CPT-10 (µg/L)	CPT-14 (µg/L)
1,1,2-Trichloroethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Tetrachloroethene	*<50J	2J	3J	<5	<5	<5	<5	<5	<250,000
Dibromochloromethane	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Chlorobenzene	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
Ethylbenzene	1,400	160	150	<5	21	29	<5	16	1,400,000
Xylenes (Total)	5,700	900	890	110	180	300	<5	160	13,000,000
Bromoform	<250	<50	<50	<5	<5	<5	<5	<5	<250,000
1,1,2,2-Tetrachloroethane	*<50J	<50	2J	<5	<5	<5	<5	<5	<250,000

µg/L Micrograms/liter
J Estimated value
* In an attempt to lower detection limits, a 1 ml aliquot was analyzed outside the holding time.

Water samples were analyzed according to EPA SW-846 Method 8240.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Volatiles - Organic Compounds	870-WS-1/32' (µg/L)	870-WS-1/42' (µg/L)	870-WS-1/92' (µg/L)	870-WS-2/49' µg/L)	MW-40 Blind Dup of 870-WS-2/49' (µg/L)	870-WS-2/59' (µg/L)	870-WS-2/69' (µg/L)	CPT-40 (µg/L)	Trip Blank 11/23/93 (µg/L)
Chloromethane	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Vinyl Chloride	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Bromomethane	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chloroethane	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Fluorotrichloromethane	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-Dichloroethene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dichloromethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	10.7
trans-1,2-Dichloroethene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon Tetrachloride	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzene	17.4	30.5	27.0	8.4	6.5	24.0	43.5	<1.0	<1.0
1,2-Dichloroethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trichloroethene (TCE)	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichloropropane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromodichloromethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,3-Dichloropropene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-1,3-Dichloropropene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Toluene	1.8	113	59.3	13.8	7.8	68.0	71.7	<1.0	<1.0
Tetrachloroethene (PCE)	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorodibromomethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorobenzene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ethylbenzene	<1.0	56.4	21.6	4.5	1.7	50.7	38.2	<1.0	<1.0
Bromoform	<2.0	<20.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
m,p-Xylene	4.9	369	107	30.2	12.2	294	258	<1.0	<1.0
o-Xylene/Styrene*	1.3	103	36.4	9.4	3.4	93.7	63.6	<1.0	<1.0

TABLE 5

GROUNDWATER ANALYTICAL RESULTS
(CONTINUED)

Analyte Volatiles - Organic Compounds	870-WS-1/32' (µg/L)	870-WS-1/42' (µg/L)	870-WS-1/92' (µg/L)	870-WS-2/49' µg/L)	MW-40 Blind Dup of 870-WS-2/49' (µg/L)	870-WS-2/59' (µg/L)	870-WS-2/69' (µg/L)	CPT-40 (µg/L)	Trip Blank 11/23/93 (µg/L)
1,1,2,2-Tetrachloroethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2-Trichloroethane	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3-Dichlorobenzene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,4-Dichlorobenzene	<1.0	<10.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

µg/L Micrograms/liter

Water samples were analyzed according to EPA Method 601/602.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Volatiles - Organic Compounds	CPT-7 (µg/L)	SGS-1 (µg/L)
1,1,2-Trichloroethane (1,1,2-T)	<500	<5
1,1-Dichloroethylene (1,1DCE)	<500	<5
1,1-Dichloroethane	<500	<5
1,2-Dichlorobenzene	<500	<5
1,2-Dichloroethane	<500	<5
1,2-Dichloropropane	<500	<5
1,3-Dichlorobenzene	<500	<5
1,4-Dichlorobenzene (p-DCB)	<500	<5
2-Butanone (MEK)	<10,000	<100
2-Chloroethylvinylether	<1,000	<10
2-Hexanone	<10,000	<100
4-Methyl-2-Pentanone (MIBK)	<1,000	<10
Acetone	<1,000	<100
Acrolein	<1,000	<10
Acrylonitrile	<500	<10
Benzene	<500	7.7
cis-1,2-Dichloroethene	<500	<5
Chlorobenzene	<500	<5
cis-1,3-Dichloropropene	<500	<5
Bromoform	<500	<5
Chloroform (Trichloromethane)	<500	<5
Chloroethane	<1,000	<10
Carbon Disulfide	<500	<5
Carbon Tetrachloride	<500	<5
Dibromochloromethane	<500	<5
Dichlorobromomethane	<500	<5
Ethyl benzene	1,800	5.5
Methyl Bromide	<1,000	<10
Methyl Chloride	<1,000	<10
Methylene Chloride	<3,000	<30

TABLE 5

GROUNDWATER ANALYTICAL RESULTS
(CONTINUED)

Analyte Volatiles - Organic Compounds	CPT-7 (µg/L)	SGS-1 (µg/L)
m,p-Xylenes	4,600	8.8
o-Xylene	1,900	19
1,1,2,2-Tetrachloroethane	<500	<5
Tetrachloroethylene (PCE)	<500	18
Styrene	<500	<5
trans-1,2-Dichloroethene	<500	<5
1,1,1-Trichloroethane	<500	<5
Trichloroethylene (TCE)	<500	<5
Trichlorofluoromethane	<1,000	<10
trans-1,3-Dichloropropene	<500	<5
Tetrahydrofuran	<10,000	<100
Toluene	<500	<5
Vinyl Chloride (VC)	<1,000	<10
Vinyl Acetate	<10,000	<100

µg/L Micrograms/liter

All samples were analyzed according to EPA SW-846 Method 8240.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Volatile Organic Compounds (TCL)	MW-6 (µg/L)	MW-7 (µg/L)	MW-27 Blind Dup of MW-7 (µg/L)
Chloromethane	<50	<10	<10
Vinyl Chloride	<50	<10	<10
Bromomethane	<50	<10	<10
Chloroethane	<50	<10	<10
1,1-Dichloroethene	<25	<5	<5
Acetone	<100	<20	<20
Carbon Disulfide	<25	<5	<5
Methylene Chloride	<25	<5	<5
1,1-Dichloroethane	<25	<5	<5
Vinyl Acetate	<25	<5	<5
2-Butanone	<100	<20	<20
1,2-Dichloroethene (total)	<25	<5	<5
Chloroform	<25	<5	<5
1,1,1-Trichloroethane	<25	<5	<5
Carbon Tetrachloride	<25	<5	<5
Benzene	<25	<5	<5
1,2-Dichloroethane	<25	<5	<5
Trichloroethene	<25	<5	<5
1,2-Dichloropropane	<25	<5	<5
Bromodichloromethane	<25	<5	<5
cis-1,3-Dichloropropene	<25	<5	<5
4-Methyl-2-Pentanone	<25	<10	<10
Toluene	<25	<5	<5
trans-1,3-Dichloropropene	<25	<5	<5
1,1,2-Trichloroethane	<25	<5	<5
Tetrachloroethene	<25	<5	<5
2-Hexanone	<50	<10	<10
Dibromochloromethane	<25	<5	<5
Chlorobenzene	<25	<5	<5
Ethybenzene	<25	<5	<5
Xylenes (total)	<25	<5	<5
Styrene	<25	<5	<5
Bromoform	<25	<5	<5
1,1,2,2-Tetrachloroethane	<25	<5	<5

µg/L Micrograms/liter

Water samples were analyzed according to EPA CLP.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Semi-Volatiles (TCL)	MW-6 (µg/L)	MW-7 (µg/L)	MW-27 Blind Dup of MW-7 (µg/L)
N-Nitrosodimethylamine	<20	<20	<20
Phenol	<20	<20	<20
Bis (2-chloroethyl) ether	<20	<20	<20
2-Chlorophenol	<20	<20	<20
1,3-Dichlorobenzene	<20	<20	<20
1,4-Dichlorobenzene	<20	<20	<20
Benzyl Alcohol	<40	<40	<40
1,2-Dichlorobenzene	<20	<20	<20
2-Methylphenol	<20	<20	<20
Bis (2-chloroisopropyl) ether	<20	<20	<20
4-Methylphenol	<20	<20	<20
3- or 4-Methylphenol	<20	<20	<20
Hexachloroethane	<20	<20	<20
n-Nitrosodi-n-propylamine	<20	<20	<20
Nitrobenzene	<20	<20	<20
Isophorone	<20	<20	<20
2,4-Dimethylphenol	<20	<20	<20
2-Nitrophenol	<20	<20	<20
Benzoic Acid	<100	<100	<100
Bis (2-chloroethoxy) methane	<20	<20	<20
2,4-Dichlorophenol	<20	<20	<20
1,2,4-Trichlorobenzene	<20	<20	<20
Naphthalene	<20	<20	<20
4-Chloroaniline	<40	<40	<40
Hexachlorobutadiene	<20	<20	<20
4-Chloro-3-Methylphenol	<20	<20	<20
2-Methylnaphthalene	<20	<20	<20
Hexachlorocyclopentadiene	<20	<20	<20
2,4,6-Trichlorophenol	<20	<20	<20
2,4,5-Trichlorophenol	<20	<20	<20
2-Chloronaphthalene	<20	<20	<20
2-Nitroaniline	<100	<100	<100
2,6-Dinitrotoluene	<20	<20	<20
Acenaphthylene	<20	<20	<20
3-Nitroaniline	<100	<100	<100
2,4-Dinitrophenol	<100	<100	<100
Acenaphthene	<20	<20	<20
4-Nitrophenol	<100	<100	<100
2,4-Dinitrotoluene	<20	<20	<20
Dibenzofuran	<20	<20	<20
Diethylphthalate	<20	<20	<20
4-Chlorophenyl phenyl ether	<20	<20	<20
Fluorene	<20	<20	<20

TABLE 5

GROUNDWATER ANALYTICAL RESULTS
(CONTINUED)

Analyte Semi-Volatiles (TCL)	MW-6 (µg/L)	MW-7 (µg/L)	MW-27 blind dup. of MW-7 (µg/L)
4-Nitroaniline	<40	<40	<40
4,6-Dinitro-2-methylphenol	<100	<100	<100
n-Nitrosodiphenylamine	<20	<20	<20
4-Bromophenyl phenyl ether	<20	<20	<20
Hexachlorobenzene	<20	<20	<20
Pentachlorophenol	<100	<100	<100
Phenanthrene	<20	<20	<20
Anthracene	<20	<20	<20
Carbazole	<20	<20	<20
Di-n-butylphthalate	<20	<20	<20
Fluoranthene	<20	<20	<20
Pyrene	<20	<20	<20
Butylbenzylphthalate	<20	<20	<20
Bis (2-ethylhexyl) phthalate	<20	<20	<20
3,3'-Dichlorobenzidine	<40	<40	<40
Benzo (a) anthracene	<20	<20	<20
Chrysene	<20	<20	<20
Di-n-octyl phthalate	<20	<20	<20
Benzo (b) fluoranthene	<20	<20	<20
Benzo (k) fluoranthene	<20	<20	<20
Benzo (a) pyrene	<20	<20	<20
Indeno (1,2,3-c,d) pyrene	<20	<20	<20
Dibenz (a,h) anthracene	<20	<20	<20
Benzo (g,h,i) perylene	<20	<20	<20

µg/L Micrograms/liter

Water samples were analyzed according to EPA CLP.

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte Pesticides and PCBs (TCL)	MW-6 (µg/L)	MW-7 (µg/L)	MW-27 Blind Dup of MW-7 (µg/L)
Alpha BHC	<0.10	<0.10	<0.10
Beta BHC	<0.10	<0.10	<0.10
Delta BHC	<0.10	<0.10	<0.10
Gamma BHC - Lindane	<0.10	<0.10	<0.10
Heptachlor	<0.10	<0.10	<0.10
Aldrin	<0.10	<0.10	<0.10
Heptachlor Epoxide	<0.10	<0.10	<0.10
Endosulfan I	<0.10	<0.10	<0.10
Dieldrin	<0.10	<0.10	<0.10
p,p'-DDE	<0.10	<0.10	<0.10
Endrin	<0.10	<0.10	<0.10
Endosulfan II	<0.10	<0.10	<0.10
p,p'-DDD	<0.10	<0.10	<0.10
Endosulfan Sulfate	<0.10	<0.10	<0.10
p,p'-DDT	<0.10	<0.10	<0.10
Endrin ketone	<0.10	<0.10	<0.10
alpha-Chlordane	<0.10	<0.10	<0.10
gamma-Chlordane	<0.10	<0.10	<0.10
Methoxychlor	<0.50	<0.50	<0.50
Toxaphene	<1.0	<1.0	<1.0
Aroclor-1016	<1.0	<1.0	<1.0
Aroclor-1221	<1.0	<1.0	<1.0
Aroclor-1232	<1.0	<1.0	<1.0
Aroclor-1242	<1.0	<1.0	<1.0
Aroclor-1248	<1.0	<1.0	<1.0
Aroclor-1254	<1.0	<1.0	<1.0
Aroclor-1260	<1.0	<1.0	<1.0

µg/L Micrograms/liter

Water samples were analyzed according to EPA SW-846 Method 8081

TABLE 5

GROUNDWATER ANALYTICAL RESULTS

Analyte - Metals (TCL)	MW-6 (mg/L)	MW-7 (mg/L)	MW-27 Blind Dup of MW-7 (mg/L)
Aluminum	1.43	33.6	26.1
Antimony	<0.25	<0.25	<0.25
Arsenic	<0.010	<0.010	<0.010
Barium	0.71	0.20	0.19
Beryllium	<0.005	<0.005	<0.005
Cadmium	<0.005	<0.005	<0.005
Calcium	4.2	267	225
Chromium	<0.05	0.13	0.07
Cobalt	<0.05	0.05	0.05
Copper	0.02	0.07	0.05
Iron	1.43	75.4	67.8
Lead	<0.05	<0.04	<0.04
Magnesium	84	55	45
Manganese	1.62	1.36	1.13
Mercury	<0.0005	<0.005	<0.005
Nickel	<0.04	0.05	0.05
Potassium	3.95	0.509	0.513
Selenium	0.008	<0.005	<0.005
Silver	<0.01	<0.01	<0.01
Sodium	703	456	455
Thallium	<0.1	<0.002	<0.002
Vanadium	0.07	0.25	0.15
Zinc	0.06	0.29	0.23
Cyanide	<0.005	<0.005	<0.005

mg/L Milligrams/liter

All water samples were analyzed according to EPA CLP.