INTERIM REMEDIAL ACTION
BURNING GROUND NO. 3 AND
UNLINED EVAPORATION POND
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

PILOT STUDY REPORT - PHASE II

PREPARED FOR

UNITED STATES ARMY CORPS OF ENGINEERS
TULSA DISTRICT

PREPARED BY

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1.0 INTRODUCTION

1.1 General

This report summarizes the results of the Phase II Work for the Interim Remedial Action (IRA) at Burning Ground 3 and the Unlined Evaporation Pond (UEP), also referred to as LHAAP 18 & 24. The site is located within Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. This report is submitted by Dow Environmental Inc. (DEI) formerly, AWD Technologies, Inc. (AWD) in partial fulfillment of the requirements of Contract No. DACA56-93-D-0016, Delivery Order No. 0002 for the U.S. Army Corps of Engineers (USACE), Tulsa District.

1.2 Site Description and Background

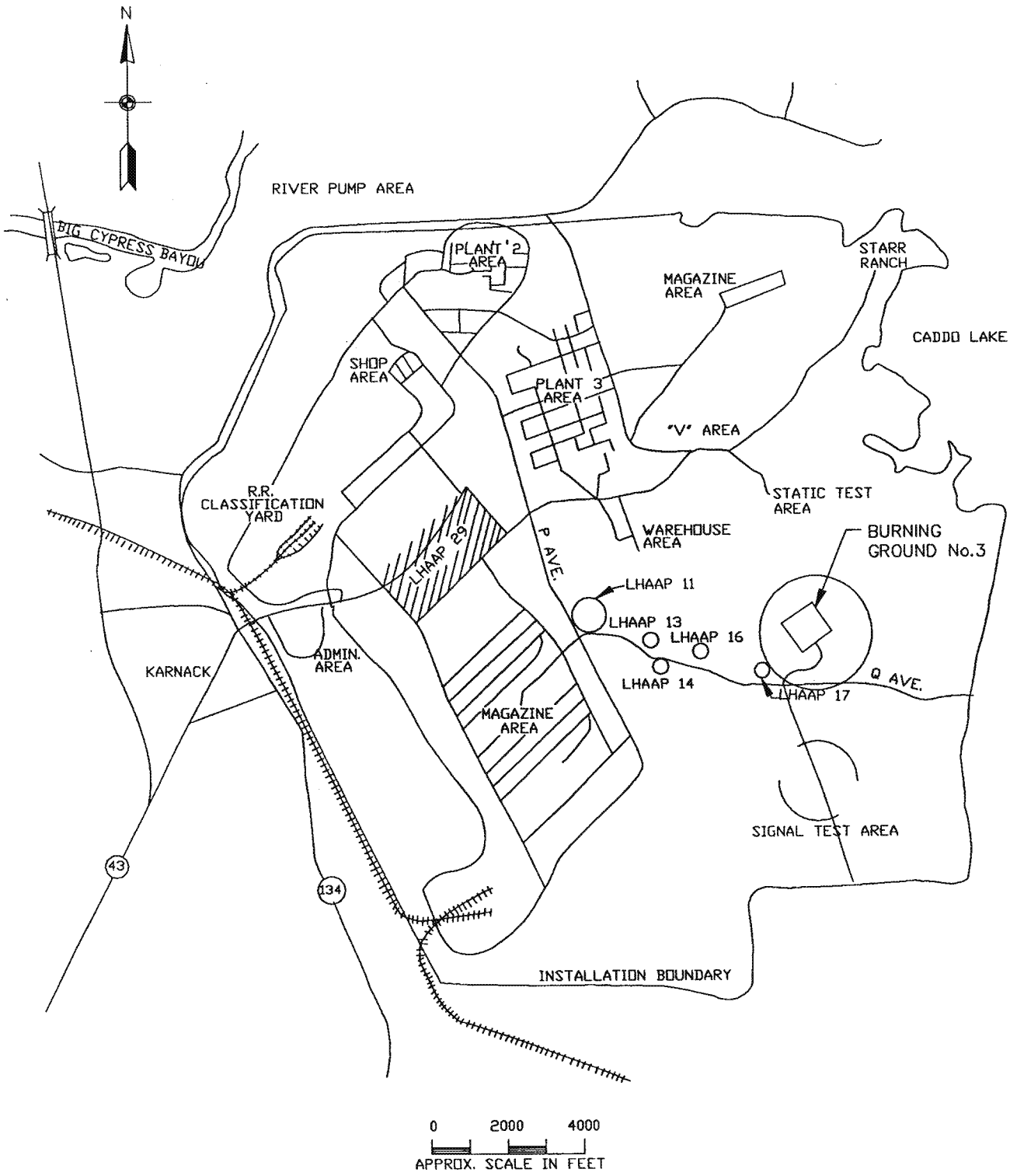
The LHAAP 18 & 24 site is an operable unit of the LHAAP Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site and also a Resource Conservation and Recovery Act (RCRA) site. The site consists of a fenced 34.5-acre secured area located in the southeast quadrant of LHAAP at the end of Avenue Q, as shown on Figure 1-1. This site has been used for the treatment, storage, and disposal of solid and liquid explosive, pyrotechnic, and combustible solvent wastes using open burning pits, the UEP, stockpiles of solvent soaked sawdust, and burial trenches.

In summary, high concentrations of solvents, primarily trichloroethylene and methylene chloride, and heavy metals, such as barium, have been detected within subsurface soils, buried waste and the uppermost water-bearing zone at the site. This contamination is attributed to waste management practices dating back to the early 1950s. Based on previous investigations performed at the site, an IRA is planned for the removal and/or control of contaminants sources within the upper groundwater and unsaturated zone.

DEI conducted Phase I of the IRA between November 8 and December 17, 1993. The Phase I work consisted of confirmation sampling required in order to complete site characterization and of treatment technologies verifications to determine suitable technologies to treat onsite contamination.

1.3 Summary of Activities

The objective of the Phase II work was to determine the effectiveness of different systems for groundwater extraction. The implementation of the Phase II work provided data and information



US Army Corps of Engineers
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LOCATION MAP
FOR BURNING GROUND No. 3 AND UEP
(LHAAP 18 & 24)

LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS

FIGURE NUMBER

1-1

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regarding construction methods (i.e. problems/solutions) of the extraction systems, groundwater flow values, and groundwater quality parameters.

The Phase II Work included the following tasks:

- Task 1 - Groundwater sampling and testing of 48 monitoring wells and the vertical extraction well (VEW) designated EW-1 which was installed during the implementation of the Phase I work.

- Task 2 - Construction of the western half of the planned temporary staging and storage area to the south of the burning ground site;

- Task 3 - Construction of two sections of a pilot Interceptor Collection Trench (ICT);

- Task 4 - Installation of a pilot horizontal extraction well (HEW);

- Task 5 - Groundwater flow testing that included two forms of groundwater withdrawal techniques, gravity flow and vacuum enhanced liquid extraction. Testing was performed on the ICT, HEW, and VEW;

- Task 6 - Groundwater sampling and testing of 48 monitoring wells and EW-1 following the completion of the flow tests in July/August and in October/November, 1994.

The field work for the Phase II activities was conducted between March 8 and August 12, 1994. The following sections describe the results of implementing the Phase II tasks.

2.0 RESULTS OF PILOT STUDY

2.1 Task 1 - Groundwater Sampling Prior to initiation of construction

Groundwater sampling was performed at EW-1 and 48 monitoring well locations. The objective of this sampling program was to obtain a "snapshot" of the existing contaminant plume condition prior to implementing the Phase II work. The well locations are shown on Figure 2-1. The analytical testing program for groundwater samples is presented in Table 2-1. Groundwater sampling and testing was performed in accordance with the protocols outlined in the Chemical Data Acquisition Plan (CDAP). The analytical testing was conducted by PDP Analytical Services (PDP) of Spring, Texas.

In general, the groundwater plume, with methylene chloride and trichloroethylene as the main contaminants, was found to have extended beyond what the Fall 1993 sampling event had shown and that concentrations of methylene chloride and/or trichloroethylene had increased in many monitoring wells especially outside the fenced area of Burning Ground 3. Field measurements taken during groundwater sampling are included in Appendix A.1. Detected contaminant concentrations are presented in Tables 2-2 through 2-5. The groundwater levels elevation contours are shown on Figure 2-2. The Methylene Chloride and trichloroethylene isoconcentration contours for this sampling round are presented in Figures 2-3 and 2-4, respectively. The analytical reports are included in Appendix A.2. and the validated analytical data are included in Appendix A.3.

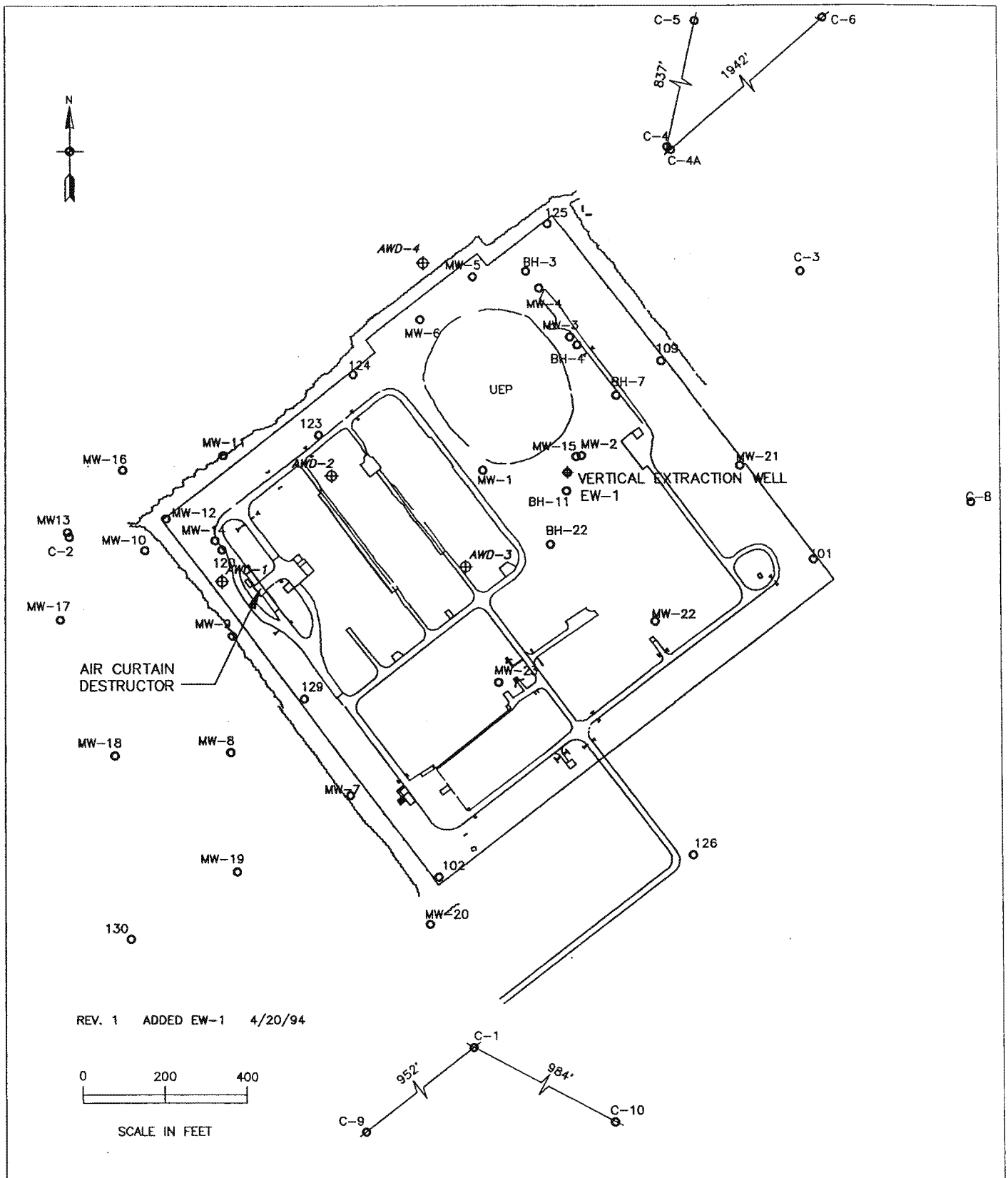
Two rounds of confirmation resampling and testing were conducted at wells C4, C4A, C5, C6, C2, MW10, MW13, and MW16 on May 20, 21, and 22, and on June 7 and 8, 1994. Data from this confirmation testing program are included in Appendix A.4. The additional testing program confirmed that the plume has extended beyond the fenced area of Burning Ground 3; however, concentrations of methylene chloride and trichloroethylene were found to be lower than detected levels for the March/April sampling round as shown in Table 2-6.

2.2 Task 2 - Construction of Temporary Staging and Storage Area

The planned Temporary Staging and Storage Area (TSSA) is to be located outside and to the south of the fenced Burning Ground 3 site as shown on Figure 2-5. Due to limited availability of funds, only about half (western half) of the TSSA, including a contractor staging area, was built during Phase II of the IRA. The construction of the western half of the TSSA included clearing, grubbing, grading, placement of clean fill material, placement of a geotextile layer, and the placement of a six inches thick gravel layer over the geotextile. The construction work was conducted by Palestine Contractors, of Marshall, Texas under subcontract to DEI.

The original ground in the area was very soft and wet during construction which created difficult conditions for maneuvering construction equipment. Several pieces of equipment were stuck in the mud when an attempt was made to remove trees and stumps prior to the grading of the site. Therefore, a decision was made by DEI and the USACE to cut the onsite trees flush with the ground surface and leave the stumps inplace. In addition, it was decided to use clean fill material to bridge over and stabilize the soft ground.

The fill placement, which ranged in thickness between three and five feet, proceeded along with the clearing and tree removal operation in order to provide a stable working platform for



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MONITORING WELLS
BURNING GROUND No.3 AND UEP
(LHAAP 18 & 24)

LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS

FIGURE NUMBER

2-1

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TABLE 2-1 SAMPLING PARAMETERS FOR LHAAP BURNING GROUND 3 AND UEP PHASE II			
Sampling Matrix	**Sampling Location**	**Chemical Parameters**	**Physical Parameters**
Groundwater	48 Monitoring Wells	pH; conductivity, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), nitrate, nitrite, sulfate, and chloride.	
Groundwater	During Flow Tests as follows: - VEW 5/7/94 to 5/10/94, - HEW 5/31, and - ICT 6/14	alkalinity, hardness, total dissolved solids, total suspended solids, silica, VOCs, SVOCs, explosives, total metals, ammonia, nitrate, nitrite, sulfate, chloride, oil and grease, and total petroleum hydrocarbons.	
Groundwater	During Flow Tests at VEW, HEW, and ICT for all dates not listed above	total suspended solids, silica, VOCs, and total metals.	
Soil	Soil borings along ICT sections and HEW. Also, 2 samples during construction of ICT	VOCs, SVOCs, explosives, antimony, arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, thallium, nitrate, sulfate, and chloride	Visual classification, moisture content, gradation, plastic limit, and liquid limit tests
Vapor	During VELE Tests	VOCs	

TABLE 2-2
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, MARCH-APRIL, 1994
VOCs, microgram/liter

WELL No.	VOLATILE ORGANIC COMPOUNDS																	
	MEC	TCE	1,1-DCA	1,1-DCE	1,2-DCA	VC	ACETONE	CF	PCE	1,2-DCE	EBZ	STYRENE	TOLUENE	BENZENE	XYLENES	CTC	1,1,1-TCA	1,1,2-TCA
126	13	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW22	5900	1900	ND	ND	ND	ND	6300	ND	ND	430	ND	ND	ND	ND	ND	ND	ND	ND
MW15	645	ND	ND	ND	ND	ND	7200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2	10550000	1520000	310	4700	ND	550	3400	1500	ND	8200	ND	ND	ND	ND	ND	ND	ND	183
EW1	87000	9800	ND	ND	ND	ND	9800	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW1	444000	171000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4	80	1100	ND	ND	ND	140	ND	ND	ND	180	ND	ND	ND	ND	ND	ND	ND	ND
MW5	32	126	16	ND	ND	16	ND	ND	ND	31	ND	ND	ND	ND	ND	ND	ND	ND
MW6	22	40	ND	ND	5	8	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	ND
MW21	1270000	8400	ND	ND	ND	ND	160000	ND	ND	500	ND	ND	ND	ND	ND	ND	ND	ND
109	400	250	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
125	600	ND	ND	ND	ND	ND	1100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123	40	16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD2	28000	11400	ND	ND	620	ND	38	10	ND	20	ND	ND	25	ND	ND	ND	ND	ND
AWD3	175	610	ND	6	4	ND	280	8	5	610	ND	ND	ND	ND	ND	10	ND	ND
MW23	820	980	ND	ND	43	ND	190	3	ND	50	ND	ND	ND	ND	ND	ND	ND	ND
C4A	2000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4	270	60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C5	1800	130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C6	300	90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C7	7	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C9	26	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10	690	122	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C3	15	45	ND	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	ND	ND	ND	ND
C8	4	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
102	3	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	1700	15000	ND	ND	150	ND	ND	120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW8	390	8200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
129	26	1560	28	ND	ND	ND	7	3	ND	15	ND	ND	ND	ND	ND	ND	ND	ND
MW9	950	3600	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD1	19300	69000	44	1100	5	560	ND	15	30	109000	1000	170	40	10	80	ND	370	5
120	273000	42000	62	310	44	ND	35	70	ND	ND	ND	ND	42	7	ND	ND	27	8
MW14	2200	12400	34	120	23	ND	ND	4	ND	400	ND	ND	ND	ND	ND	ND	10	3
MW12	140	4000	ND	19	14	ND	ND	ND	ND	110	ND	ND	ND	ND	ND	ND	3	ND
130	ND	12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW18	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW17	10	32	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW13	590	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C2	480	210	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW10	2100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW16	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW11	59	82	ND	ND	6	ND	ND	ND	ND	5	ND	ND	ND	ND	ND	ND	ND	ND
124	31	3	ND	ND	ND	ND	14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD4	58	25	ND	ND	ND	ND	ND	ND	ND	6	ND	ND	ND	ND	ND	ND	ND	ND
MW19	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW20	6	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C1	33	30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3	243000	4500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTE:
MEC = Methylene Chloride 1,1-DCA = 1,1-Dichloroethane 1,2-DCA = Dichloroethane PCE = Tetrachloroethylene EBZ = Ethylbenzene 1,1,1 - TCA = 1,1,1 - Trichloroethane
TCE = Trichloroethylene 1,1-DCE = 1,1-Dichloroethene CF = Chloroform 1,2-DCE = Total-1,2-Dichloroethene CTC = Carbon tetrachloride 1,1,2 - TCA = 1,1,2 - Trichloroethane

TABLE 2-3
LHAAP 18&24, BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, MARCH-APRIL, 1994
METALS, mg/l

Well No.	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
126	0.7100	ND	ND	3.2300	ND	ND	105.0000	ND	0.0160	ND	1.0800	ND
MW22	0.2000	ND	ND	1.9600	ND	ND	99.2000	ND	ND	ND	0.2500	ND
MW15	ND	ND	ND	0.2450	ND	ND	11.2000	ND	ND	ND	2.3000	ND
MW2	ND	ND	ND	3.6800	ND	ND	96.4000	ND	0.0200	ND	0.0000	ND
EW1	ND	ND	ND	0.3290	ND	ND	8.9000	ND	ND	ND	0.1000	ND
MW1	ND	ND	ND	4.5400	ND	ND	122.0000	ND	0.0310	ND	0.0000	ND
MW4	ND	ND	ND	0.1520	ND	ND	54.8000	ND	ND	ND	0.0000	ND
MW5	ND	ND	ND	1.4300	ND	ND	35.3000	ND	ND	ND	0.0000	ND
MW6	ND	ND	ND	0.8850	ND	ND	33.6000	ND	ND	ND	6.3400	ND
MW21	0.3000	ND	ND	6.6000	ND	ND	164.0000	0.0180	0.0520	ND	0.5900	ND
109	0.2200	ND	ND	1.0300	ND	ND	53.7000	ND	ND	ND	0.5200	ND
125	2.6000	ND	ND	0.1880	ND	ND	2.5000	ND	ND	ND	3.6200	ND
123	0.5400	ND	ND	0.1650	ND	ND	16.3000	ND	ND	ND	0.4640	ND
AWD2	3.6200	ND	ND	0.1770	ND	ND	4.3000	0.0180	0.0110	ND	3.7800	ND
AWD3	0.1800	ND	ND	0.2530	ND	ND	36.2000	ND	0.0330	ND	66.5000	ND
MW23	ND	ND	ND	1.7300	ND	ND	52.9000	0.0670	0.0100	ND	2.3700	ND
C4A	ND	ND	ND	0.1010	ND	ND	14.8000	ND	ND	ND	4.1000	ND
C4	ND	ND	ND	0.2060	ND	ND	18.9000	ND	ND	ND	1.4700	ND
C5	ND	ND	ND	0.0780	ND	ND	12.2000	ND	ND	ND	2.4000	ND
C6	ND	ND	ND	1.1000	ND	ND	33.2000	ND	0.0160	ND	32.8000	ND
C7	0.2800	ND	0.0050	0.1260	ND	ND	16.4000	ND	ND	ND	0.2200	ND
C9	ND	ND	ND	0.3200	ND	ND	628.0000	ND	ND	ND	0.0000	ND
C10	ND	ND	ND	0.5920	ND	ND	75.0000	ND	ND	ND	0.3810	ND
C3	0.1300	ND	ND	1.1200	ND	ND	51.9000	ND	ND	ND	93.6000	ND
C8	1.5000	ND	ND	4.4300	ND	ND	202.0000	ND	ND	ND	1.6000	ND
102	0.7800	ND	ND	0.2500	ND	ND	3.9400	ND	ND	ND	0.7400	ND
MW7	ND	ND	ND	0.1280	ND	ND	20.6000	0.2910	ND	ND	0.9500	ND
MW8	ND	ND	ND	0.2220	ND	ND	7.6000	ND	0.0100	ND	0.0000	ND
129	0.1500	ND	ND	0.0600	ND	ND	2.9000	ND	ND	ND	0.2100	ND
MW9	0.6100	ND	ND	0.0450	ND	ND	2.6000	ND	ND	ND	0.5700	ND
AWD1	5.6900	ND	0.0130	0.9150	ND	ND	2.8000	0.0530	ND	ND	5.7000	ND
120	0.9300	ND	ND	0.2700	ND	ND	31.6000	ND	0.1840	ND	3.3400	ND
MW14	ND	ND	ND	1.6500	ND	ND	78.8000	ND	ND	ND	159.0000	ND
MW12	0.2100	ND	ND	0.2440	ND	ND	36.1000	ND	0.0360	ND	65.2000	ND
130	ND	ND	ND	0.2170	ND	ND	64.0000	ND	ND	ND	0.1600	ND
MW18	ND	ND	0.0050	0.2480	ND	ND	7.6000	ND	ND	ND	26.7000	ND
MW17	ND	ND	ND	0.3100	ND	ND	38.1000	0.0160	0.0300	ND	3.9700	ND
MW13	ND	ND	ND	0.3400	ND	ND	28.7000	ND	ND	ND	65.0000	ND
C2	ND	ND	ND	0.3970	ND	ND	19.2000	ND	ND	ND	48.2000	ND
MW10	ND	ND	ND	0.6580	ND	ND	24.7000	ND	ND	ND	54.8000	ND
MW16	ND	ND	ND	0.3360	ND	ND	15.3000	ND	ND	ND	31.3000	ND
MW11	0.1500	ND	ND	0.0860	ND	ND	4.8000	ND	ND	ND	0.2500	ND
124	2.2000	ND	0.0110	0.8150	0.0067	ND	19.8000	ND	0.0450	ND	60.8000	ND
AWD4	0.5300	ND	ND	0.3220	ND	ND	9.6000	0.0460	ND	ND	1.1200	ND
MW19	0.0000	ND	ND	0.0000	ND	ND	142.0000	ND	ND	ND	112.0000	ND
MW20	0.5300	ND	ND	0.2380	ND	ND	21.0000	ND	ND	ND	0.3800	ND
C1	0.3000	ND	ND	0.5460	ND	ND	72.5000	ND	ND	0.0450	0.5500	ND
MW3	ND	ND	ND	1.7100	ND	ND	37.6000	ND	0.0180	ND	ND	ND

TABLE 2-3 (CONTINUE)
LHAAP 18&24, BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, MARCH-APRIL, 1994
METALS, mg/l

Well No.	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thalium	Vanadium	Zinc
126	84.3000	0.2350	ND	ND	ND	ND	ND	345.0000	0.0050	ND	0.0540
MW22	40.1000	0.0450	ND	ND	ND	ND	ND	364.0000	ND	ND	ND
MW15	6.7000	0.3450	ND	ND	ND	ND	ND	70.6000	ND	ND	0.0280
MW2	80.8000	0.9660	ND	ND	ND	ND	ND	297.0000	ND	ND	ND
EW1	6.6000	0.3580	ND	ND	ND	ND	ND	102.0000	ND	ND	0.0560
MW1	110.0000	2.1700	ND	ND	ND	ND	ND	384.0000	ND	ND	0.0310
MW4	55.0000	0.2470	ND	ND	ND	ND	ND	461.0000	ND	ND	ND
MW5	37.4000	0.0750	ND	ND	ND	ND	ND	128.0000	ND	ND	0.0300
MW6	25.3000	0.2340	ND	ND	ND	ND	ND	130.0000	ND	ND	0.0250
MW21	131.0000	2.9600	ND	0.0770	ND	ND	ND	458.0000	ND	ND	0.0600
109	40.0000	0.1050	ND	ND	ND	ND	ND	346.0000	ND	ND	0.0410
125	1.9000	0.0430	0.0002	ND	ND	ND	ND	24.4000	ND	0.0100	0.0480
123	9.3000	0.0120	ND	ND	ND	ND	ND	10.2000	ND	ND	0.0830
AWD2	3.6000	0.1400	ND	ND	ND	ND	ND	79.4000	ND	ND	0.0610
AWD3	22.9000	1.8900	ND	0.0660	ND	ND	ND	187.0000	ND	ND	0.2190
MW23	41.6000	0.1940	ND	0.4200	ND	ND	ND	280.0000	ND	ND	0.0290
C4A	2.8000	0.1730	ND	ND	ND	ND	ND	86.8000	ND	ND	0.0790
C4	4.1000	0.2110	ND	ND	ND	ND	ND	19.9000	ND	ND	0.0520
C5	2.9000	0.2000	ND	ND	ND	ND	ND	66.8000	ND	ND	0.0320
C6	21.4000	1.3200	ND	ND	ND	ND	ND	256.0000	ND	ND	0.0330
C7	9.3000	0.0110	ND	ND	ND	ND	ND	112.0000	ND	ND	0.0220
C9	470.0000	0.5600	ND	ND	ND	ND	ND	1590.0000	ND	ND	ND
C10	31.7000	0.2330	ND	ND	ND	ND	ND	250.0000	ND	ND	0.0600
C3	30.5000	1.9900	ND	ND	ND	ND	ND	121.0000	0.0050	ND	0.0780
C8	151.0000	0.1200	ND	ND	ND	ND	ND	819.0000	0.0050	ND	ND
102	2.8000	0.0210	ND	ND	ND	ND	ND	13.6000	ND	ND	0.0330
MW7	15.3000	0.0710	ND	0.2900	ND	ND	ND	332.0000	ND	ND	ND
MW8	6.2000	0.1070	ND	ND	ND	ND	ND	97.3000	ND	ND	ND
129	1.9000	0.0690	ND	ND	ND	ND	ND	52.4000	ND	ND	0.0470
MW9	1.3000	0.0700	ND	ND	ND	ND	ND	15.0000	ND	ND	ND
AWD1	7.5000	0.3580	ND	ND	8.7000	ND	ND	92.4000	ND	0.0110	0.0400
120	44.1000	1.6000	ND	0.0840	ND	ND	ND	1080.0000	ND	ND	0.1650
MW14	46.8000	3.5200	ND	ND	7.6000	ND	ND	407.0000	ND	ND	0.0660
MW12	23.1000	1.8700	ND	0.0740	ND	ND	ND	180.0000	ND	ND	0.2200
130	43.0000	0.5240	ND	ND	ND	ND	ND	927.0000	ND	ND	0.0530
MW18	4.2000	0.4940	ND	ND	ND	ND	ND	66.6000	ND	ND	0.0250
MW17	14.3000	0.5860	ND	0.1600	ND	ND	ND	110.0000	ND	ND	0.0440
MW13	10.5000	1.1400	ND	ND	ND	ND	ND	81.5000	ND	ND	ND
C2	11.8000	1.2100	ND	ND	ND	ND	ND	91.0000	ND	ND	ND
MW10	14.0000	1.2300	ND	ND	ND	ND	ND	106.0000	ND	ND	0.0200
MW16	88.0000	0.5730	ND	ND	ND	ND	ND	60.8000	ND	ND	ND
MW11	2.4000	0.0490	ND	ND	ND	ND	ND	21.1000	ND	ND	0.0300
124	17.2000	1.5000	ND	ND	ND	ND	ND	19.4000	ND	0.0590	0.1300
AWD4	8.3000	0.0770	ND	0.0880	ND	ND	ND	65.1000	ND	ND	0.0280
MW19	80.5000	2.4400	ND	ND	ND	ND	ND	1370.0000	ND	ND	ND
MW20	4.9000	0.0710	ND	0.0610	ND	ND	ND	37.5000	ND	ND	0.0980
C1	54.6000	0.0420	ND	ND	ND	ND	ND	329.0000	ND	ND	0.0490
MW3	35.1000	5.1400	ND	ND	ND	ND	ND	280.0000	ND	ND	ND

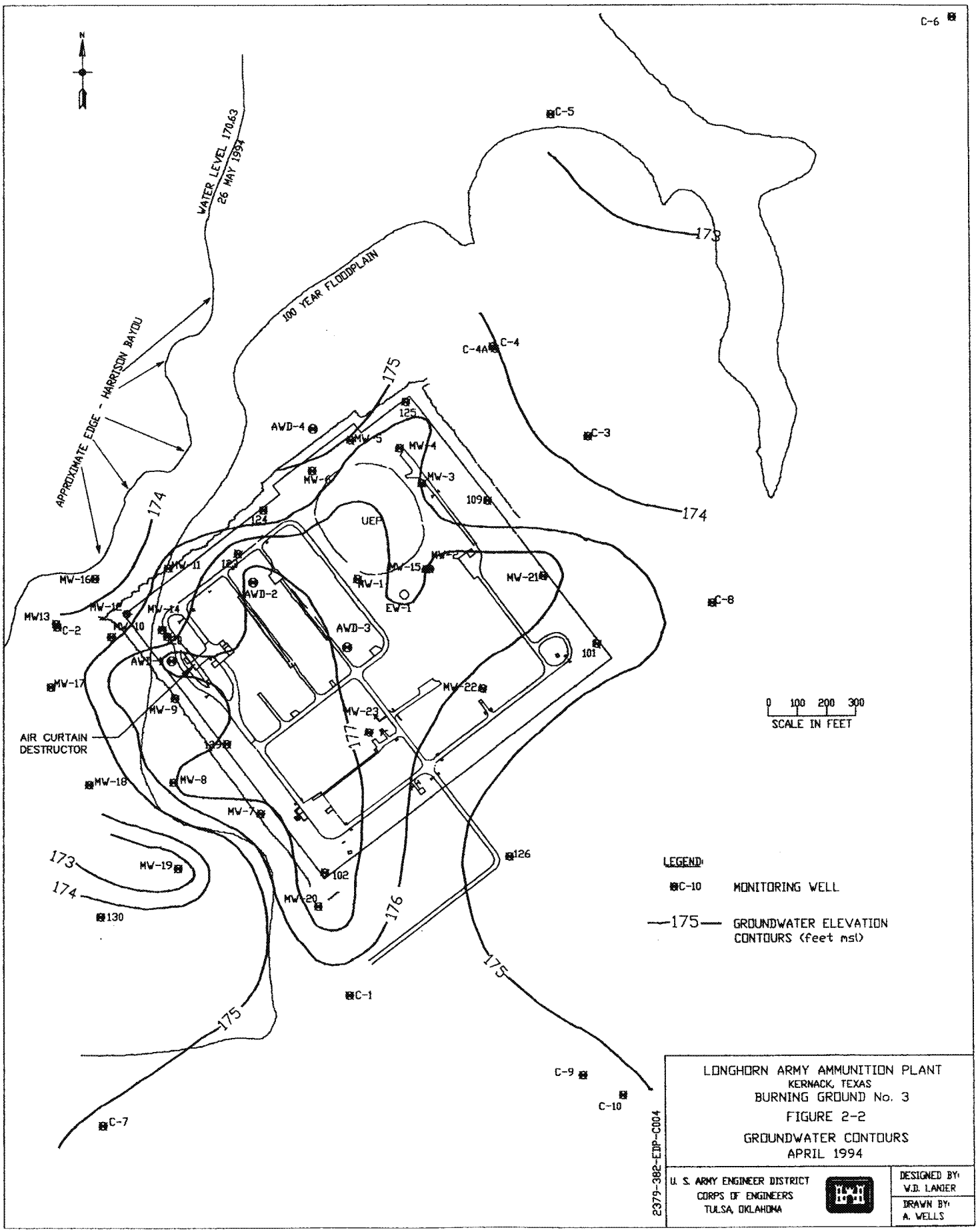
TABLE 2-4
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, MARCH-APRIL, 1994
EXPLOSIVES, micrograms/liter

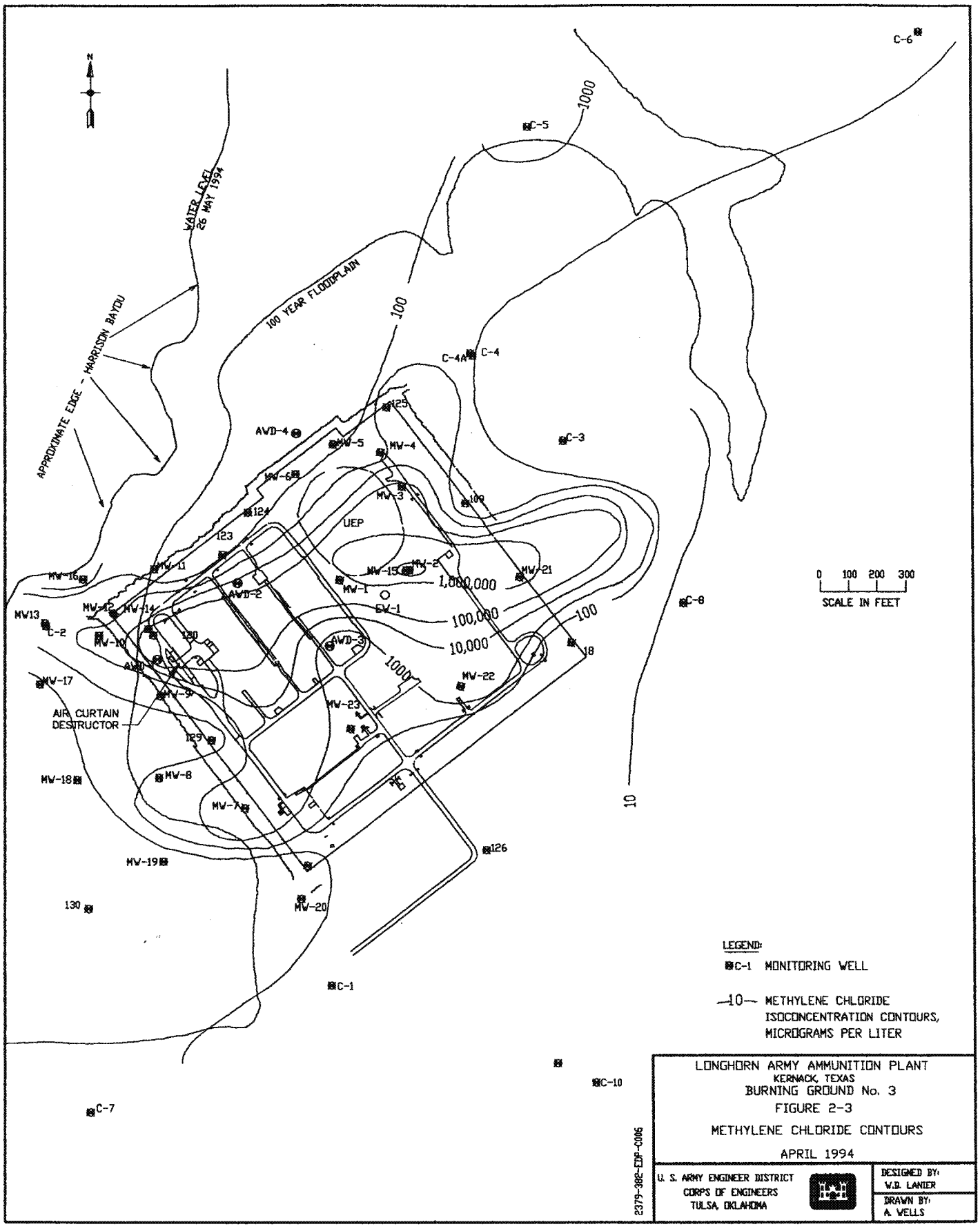
WELL No.	EXPLOSIVES COMPOUND										
	1,3-DNB	2,4-DNT	HMX	NB	2-NT	3-NT	4-NT	RDX	Tetryl	1,3,5-TNB	2,4,6-TNT
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2	ND	ND	ND	ND	ND	ND	ND	1.57J	ND	ND	ND
EW1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
109	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD3	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.43J	ND
MW23	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C7	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.63J	ND
C9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10	1.39	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
102	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
129	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD1	ND	ND	ND	ND	ND	ND	ND	13.0J	ND	0.49J	ND
120	ND	0.21J	ND	0.42J	ND	ND	ND	16.0J	ND	0.52J	4.70J
MW14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
124	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.39	ND

Note: ND = Non-Detect

TABLE 2–5
LHAAP 18 & 24, Burning Ground 3 & UEP
Summary of Groundwater Monitoring , March–April, 1994
Wet Chemistry, mg/l

Well No.	Chloride	Nitrate	Sulfate
126	1090.00	ND	ND
MW22	833.00	ND	11.00
MW15	160.00	ND	8.00
MW2	790.00	16.00	ND
EW1	128.00	10.60	ND
MW1	1420.00	0.20	ND
MW4	753.00	ND	43.00
MW5	363.00	4.10	5.00
MW6	310.00	ND	10.00
MW21	1420.00	ND	6.00
109	931.00	0.50	12.00
125	35.00	1.80	19.00
123	7.00	2.77	9.00
AWD2	99.00	0.45	41.00
AWD3	18.00	0.98	77.00
MW23	594.00	1.20	11.00
C4A	78.00	ND	10.00
C4	53.00	ND	ND
C5	57.00	0.14	16.00
C6	523.00	ND	7.00
C7	80.00	0.76	33.00
C9	4010.00	0.10	176.00
C10	496.00	0.54	8.00
C3	514.00	ND	ND
C8	2280.00	0.20	ND
102	7.00	1.30	69.00
MW7	436.00	3.70	70.00
MW8	167.00	2.00	32.00
129	32.00	1.00	66.00
MW9	14.00	0.24	18.00
AWD1	74.00	1.30	21.00
120	518.00	0.60	55.00
MW14	1140.00	ND	45.00
MW12	528.00	1.70	63.00
130	1390.00	0.70	209.00
MW18	124.00	ND	10.00
MW17	239.00	ND	22.00
MW13	144.00	0.18	8.00
C2	195.00	0.15	7.00
MW10	316.00	0.10	28.00
MW16	186.00	ND	7.00
MW11	18.00	0.20	34.00
124	7.00	0.66	113.00
AWD4	106.00	0.53	19.00
MW19	2450.00	0.18	443.00
MW20	11.00	0.00	24.00
C1	762.00	0.16	20.00
MW3	505.00	0.10	12.00


N
WATER LEVEL 170.63
26 MAY 1994
100 YEAR FLOODPLAIN
APPROXIMATE EDGE - HARRISON BAYOU
AIR CURTAIN DESTRUCTOR
UEP
EW-1
AWD-1
AWD-2
AWD-3
AWD-4
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11
MW-12
MW-14
MW-15
MW-16
MW-17
MW-18
MW-19
MW-20
MW-21
MW-22
MW-23
MW13
C-1
C-2
C-3
C-4
C-4A
C-5
C-6
C-7
C-8
C-9
C-10
101
102
109
123
124
125
126
129
130
173
174
175
176
177
0 100 200 300
SCALE IN FEET
LEGEND:
C-10 MONITORING WELL
175 GROUNDWATER ELEVATION CONTOURS (feet msl)
LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No. 3
FIGURE 2-2
GROUNDWATER CONTOURS
APRIL 1994
U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA
DESIGNED BY: W.D. LANIER
DRAWN BY: A. WELLS
2379-382-EDP-C004

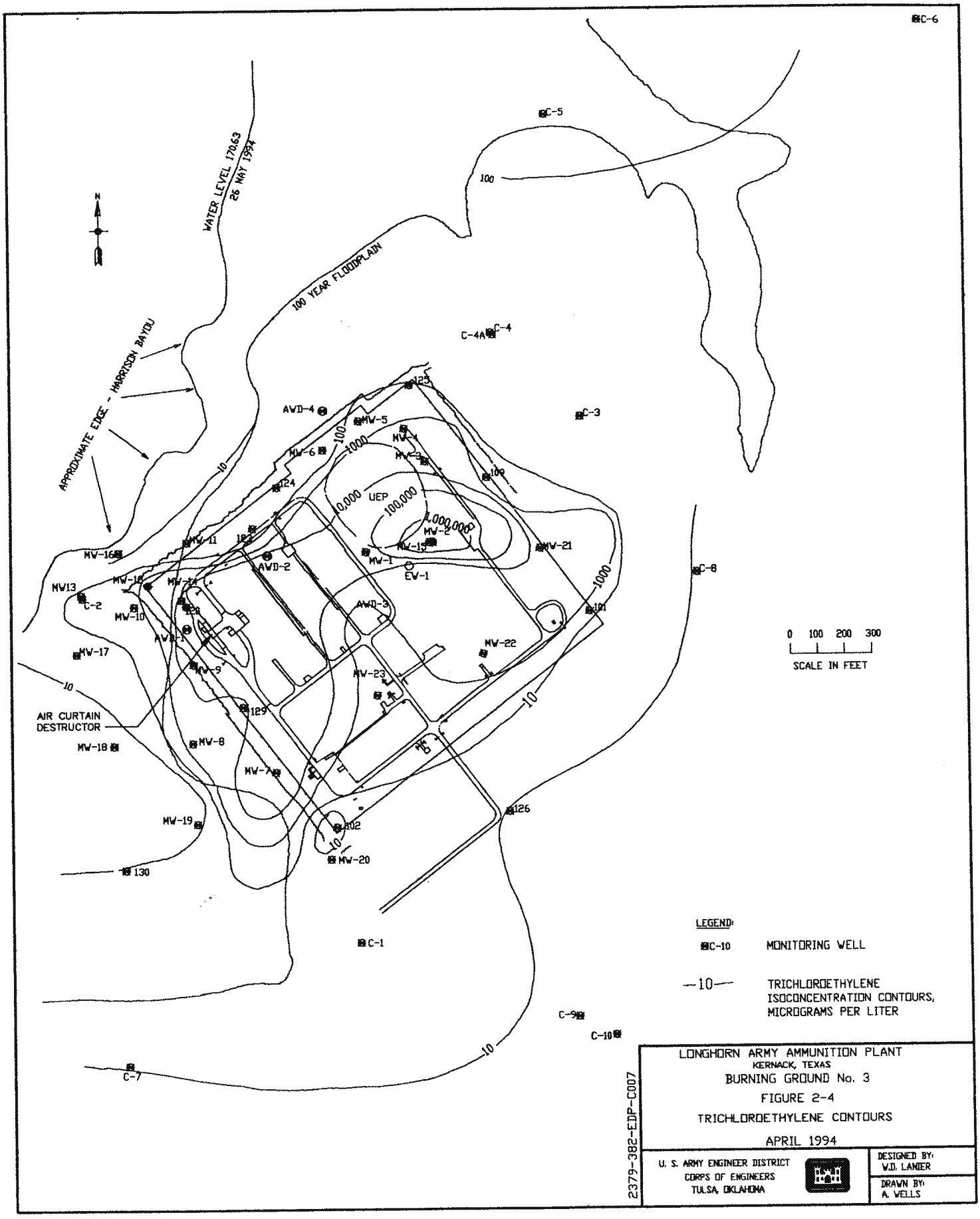


LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No. 3
FIGURE 2-3
METHYLENE CHLORIDE CONTOURS
APRIL 1994

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DESIGNED BY: W.D. LANIER
DRAWN BY: A. WELLS

2379-382-EDF-C006



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No. 3
FIGURE 2-4
TRICHLOROETHYLENE CONTOURS
APRIL 1994

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

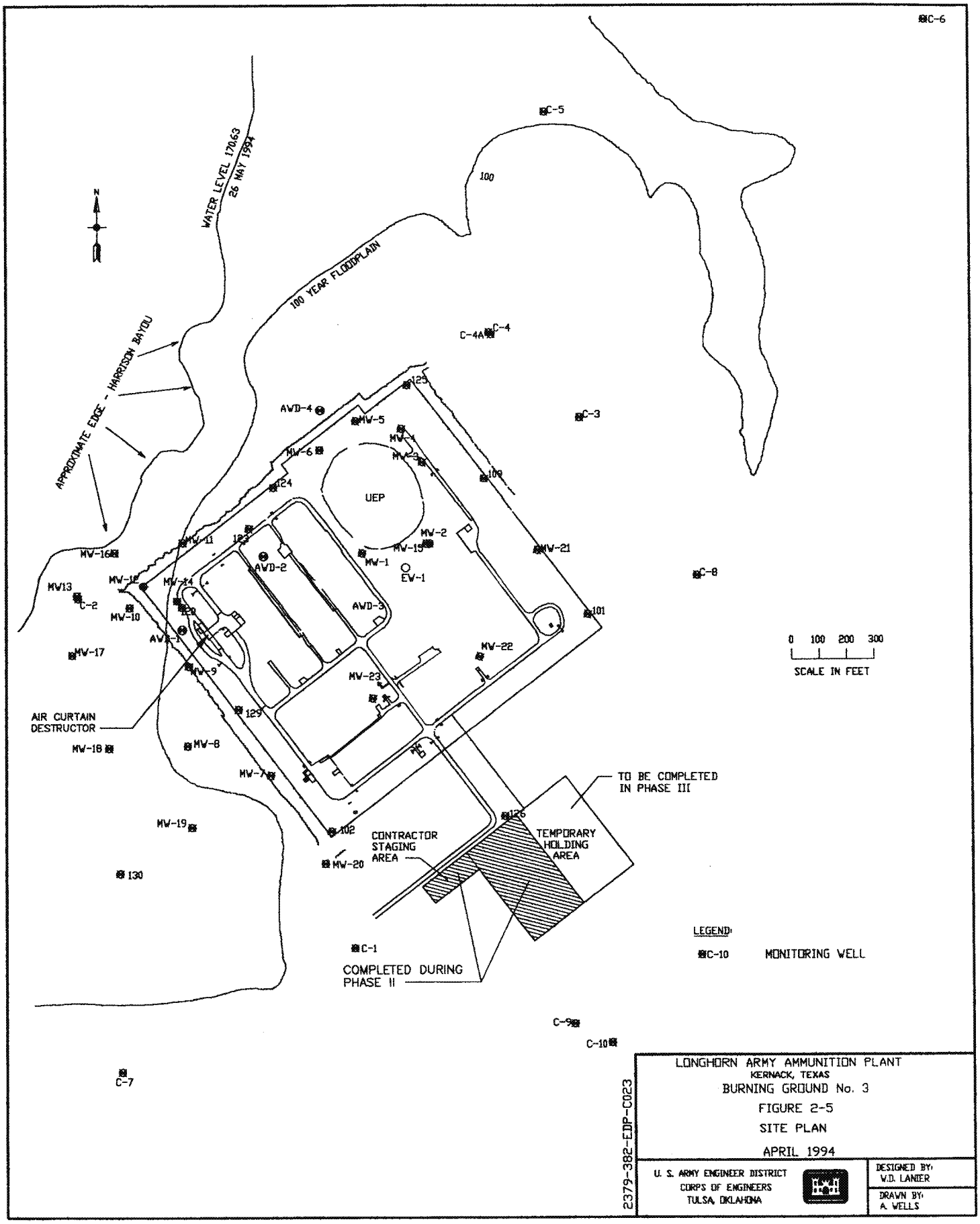
DESIGNED BY: W.D. LANIER
DRAWN BY: A. WELLS

TABLE 2-6
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING
CONFIRMATION SAMPLING DATA COMPARISON

VOLATILE ORGANICS COMPOUNDS, microgram/liter

WELL No.	MARCH-APRIL, 1994		MAY, 1994		JUNE, 1994	
	MEC	TCE	MEC	TCE	MEC	TCE
MW2	10550000	1520000			8280000	320000
C4A	2000	ND	5	8	21	ND
C4	270	60	3	6	7	4
C5	1800	130	2	2	5	ND
C6	300	90	30	17	5	8
MW13	590	ND	ND	2	ND	ND
C2	480	210	1	5	4	ND
MW10	2100	ND	1	14	4	10
MW16	5	ND	ND	3	ND	ND

NOTE:
MEC = Methylene Chloride
TCE = Trichloroethylene
ND = None Detect



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No. 3
FIGURE 2-5
SITE PLAN
APRIL 1994

2379-382-EDP-C023

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DESIGNED BY: W.D. LANIER
DRAWN BY: A. WELLS

clearing equipment. The abandonment of tree stumps in place is not expected to cause any structural problems in this area in the future, since the construction of any structure in the area is not planned. This portion of the TSSA will only be used for storage of soil containers and for soil treatment using mobile systems. However, the stumps in the area of the second half of the TSSA will have to be removed, since this area will be occupied by a permanent groundwater treatment plant. The second half of the TSSA will be completed during Phase III of the IRA.

The clean fill was imported from a site in Karnack, Texas outside of LHAAP. Prior to importing this material, representative samples were collected and sent to the firm of Heller, Lewis, and House (HLH) in Longview, Texas for geotechnical testing. The samples were tested for moisture content, Atterbeg Limits, and shrinkage limit. The test results, which are included in Appendix B.1, indicated that the materials at the borrow pit are not expansive (swelling clays) and that they are acceptable for the project. Following this testing program, three representative samples were collected and tested for moisture-density relation by HLH. The laboratory test results which were used in the field to monitor fill placement, are presented in Appendix B.2. Field compaction test results, obtained by HLH, are included in Appendix B.3.

A layer of geotextile fabric, Exxon GTF 300, was placed over the compacted clean fill layer. A six inches gravel layer was placed over the geotextile fabric in a single lift. The material was delivered by trucks from Boorhelm-Fields in Idabell, Oklahoma. Two particle size analyses and one compaction test were performed by HLH on representative samples of the gravel. The test results are included in Appendix B.4. The gravel was spread using a bulldozer and was compacted with a self-propelled vibratory compactor. A 50-foot wide strip along the southern end of the TSSA was not covered with geotextile and gravel due to very wet and soft conditions. This portion of TSSA was topographically high and required little to no fill for grading.

A drainage ditch was cut along the western edge of the TSSA. Sections of 18-inch galvanized corrugated steel pipe were installed at the entrance of the contractor staging area, the entrance of the TSSA, and in between both of these areas in order to convey storm waters away from the site.

2.3 Task 3 - Construction of The Interceptor Collection Trench (ICT).

The ICT consists of two sections ICT-1 and ICT-2. These sections were located east and northeast of the onsite Air Curtain Destructor (ACD) as shown on Drawing II-1. The trench sections extended to the lower semi-confining, retardation layer. The purpose of the trench was to evaluate the effectiveness of such a collection system in dewatering soils of low hydraulic conductivity. The construction of the ICT included the following steps:

2.3.1 Geophysical Survey

An Electromagnetic Terrain (EM) conductivity survey was conducted in the area where the ICT was built by Subsurface Detection Investigations Incorporated (SDII) of Largo, Florida under a subcontract to DEI. The EM survey is a useful remote sensing technique that results in the delineation of the perimeters of buried waste trenches and the detection of buried metal objects (if any) through measurements of subsurface conductivity contrasts. This survey was mainly conducted for health and safety reasons since the area surrounding the proposed ICT location may have been used historically for the burial of facility wastes.

The EM method measures the electrical conductivity of subsurface materials. The conductivity is determined by inducing (from a transmitter) a time-varying magnetic field and measuring (with a receiver) the amplitude and phase shift of an induced secondary magnetic field. The secondary magnetic field is created by subsurface conductive materials behaving as an inductor as the primary magnetic field is passed through them.

SDII findings were documented in a report that is included as Appendix C.1. They indicated the potential presence of several areas with buried metallic debris. The main suspected area was located to the southeast of section ICT-2. No major anomalies were detected along the axes of the ICT. However, the ICT subcontractor and DEI personnel took extra caution during the excavation of the upper few feet of the ground in the areas were buried metals may be present based on this geophysical study. In those areas, excavation of the ICT proceeded very slowly with no personnel allowed within the vicinity of the trench. No metallic debris or buried waste was encountered during the excavation of the ICT sections.

2.3.2 Soil Borings and Temporary Groundwater Monitoring Wells/Piezometers

Soil borings, designated SBT-1 through SBT-7, were drilled along the axes of the ICT sections at about 50 to 75-foot intervals as shown on Drawing II-1, prior to the initiation of trench excavation and construction. The borings were used to define the subsurface conditions including the depth of the semi-confining layer on which the trench will rest, and to collect soil samples for chemical and physical characterization. Each borehole was drilled to the depth of the lower semi-confining layer. This depth was determined by conducting continuous soil sampling throughout the depth of the borehole.

Soil samples for chemical analyses were obtained at five-feet intervals using a three-inch split spoon. In addition, soil samples were obtained for physical testing and characterization. The analytical and geotechnical testing program for collected soil samples is listed in Table 2-1. Table 2-7 presents a summary of the detected chemical concentrations in the tested soil samples. As mentioned above, no buried waste was encountered during the excavation of the ICT sections. Soil contamination based on the collected samples appear to be minimal in the area and is confined to the interface of the semiconfining layer and the overlying shallow aquifer material and may have been caused by the contaminated groundwater in the aquifer. Appendix C.2 contains the results of the chemical analyses. The results of the geotechnical testing program are included in Appendix C.3.

Temporary groundwater monitoring wells (piezometers) were installed in each borehole. These piezometers were used to monitor the static water levels prior the construction of the ICT sections. The screen section and riser pipe of each of the temporary monitoring wells were two inches in diameter and consisted of schedule 40 PVC. Detailed boring logs are included in Appendix C.4.

Subsurface information collected from the boreholes and the temporary monitoring wells was used to develop two subsurface cross sections shown on Figures 2-6 and 2-7. These cross sections show the potential elevation of the semi-confining retardation layer on which the ICT sections rest. The final design for the ICT sections was presented to the USACE Tulsa District for approval prior to proceeding with its installation. As can be seen from these cross sections, the groundwater level was about 0.5 to 5 feet from ground surface along Section ICT-1 and 3 to 10 feet along Section ICT-2. The shallow groundwater along the western edge of ICT-1

TABLE 2-7
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF SOIL ANALYSES FOR INTERCEPTOR TRENCH
DETECTED CONCENTRATIONS, in milligram/kilogram
MARCH/APRIL 1994

Sample Number	SBT1	SBT1	SBT1	SBT1	SBT1	SBT1 QC	SBT1	SBT2	SBT2	SBT2	SBT2	SBT3	SBT3	SBT3	SBT3	SBT3	SBT4	SBT4	SBT4
Depth (ft)	5-7	9-11	13-15	19-21	25-27	25-27	29-31	5-7	9-11	15-17	17-19	5-7	9-11	15-17	19-21	23-25	5-7	10-12	15-17
VOLATILE ORGANICS																			
1,1,1-TCA	ND	0.3	0.04	ND	0.16	0.23	0.018	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,-TCA	ND	ND	ND	ND	ND	0.005	0.007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	ND	0.017	0.17	0.11	0.015	0.018	0.019	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DCE	ND	ND	0.13	0.24	0.39	0.45	0.57	ND	0.024	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.006
1,2 DCA	0.005	0.008	0.43	0.99	1.8	2	3	ND	0.1	0.04	0.003	ND	ND	0.016	0.005	0.032	ND	0.005	0.45
2-Butanone	ND	ND	ND	ND	ND	ND	0.036	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	0.007	0.006	ND	0.033	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	0.032	ND	ND	0.12	0.017	ND	0.047	0.036	0.27	0.092	0.049	0.042	0.032	0.033	0.057	0.04	0.027	0.038	0.16
Benzene	ND	ND	ND	ND	ND	ND	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	0.005	0.016	0.018	0.021	0.044	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.005
Ethylbenzene	ND	ND	ND	ND	0.005	0.006	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MEC	0.18	0.112	5.18	9.2	9.5	9.5	11.9	0.06	0.4	0.17	0.067	0.055	0.038	0.05	0.034	0.19	0.022	0.03	6.7
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	ND	ND	0.011	0.021	0.039	0.053	0.036	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	0.016	0.047	0.023	0.026	0.164	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.023
Total Xylenes	ND	ND	0.006	0.005	0.008	0.006	0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total-1,2-DCE	0.1	ND	7.7	0.004	0.6	0.76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
TCE	0.17	0.073	3.8	6.5	7.5	8.1	8.6	ND	1.4	0.04	ND	ND	ND	0.04	ND	0.01	ND	0.056	2.7
Vinylchloride	ND	0.032	0.19	0.012	0.029	0.032	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SEMI-VOLATILE ORGANICS																			
BEP	1.076	0.842	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.125	ND
DBP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.471
TOTAL METALS																			
Aluminum	11800	1460	1350	2330	2020	1530	1260	1060	481	844	1040	2530	2570	1950	1170	1520	9210	5650	8070
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.73	1.4	ND	ND	ND	ND
Barium	69.5	72.5	29.4	36.3	27.6	22.5	21.1	67	38.1	33.3	12.3	60.5	45.8	113	73.7	120	63.2	54.3	84.9
Beryllium	0.87	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	170	87.5	111	235	219	219	223	394	124	399	427	790	473	965	956	994	535	373	578
Chromium	9.9	2.3	3.2	3.8	3.4	2.9	4.4	1.6	ND	2.4	4.7	3.7	1.9	2.5	ND	1.2	9.1	8.6	13.5
Cobalt	8.1	2.4	1.5	3.1	3.3	2.9	1.5	4.6	ND	2	1.2	1.4	6.2	2	1.4	4.3	3.4	5.3	6.1
Copper	6.4	ND	ND	ND	ND	ND	ND	ND	ND	2.5	ND	ND	2.9	3.7	ND	2.8	4.5	5	5.9
Iron	14300	1680	853	3660	2430	1890	1530	417	388	865	598	4820	4790	4600	1840	966	6930	12400	13300
Lead	10.7	4.5	4.4	3	3.1	2.8	2.7	3.7	3.2	4.5	2	3.7	3.8	3.2	3.6	2.5	7.4	13.1	12.2
Magnesium	918	376	231	469	484	450	319	400	206	426	364	786	836	1190	782	990	1070	968	1340
Manganese	117	9.1	8.3	5.1	11.9	10.8	9.7	5.4	6.3	4.5	1.8	6.7	69.8	22.3	16.7	55	17.2	79.6	57.9
Nickel	8.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.3	10	13.7
Potassium	367	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	268	ND	ND	686	ND	770
Sodium	1240	143	89.9	241	89.8	96.8	118	1150	ND	259	333	66	207	1530	1100	109	291	165	298
Vanadium	23.7	3.8	2.8	7.1	5.8	4.4	3.9	1.3	ND	2.8	2.8	8.8	7.1	9.4	3.9	3.3	13.9	16.1	18.1
Zinc	19.2	8.8	8.6	11.9	13.5	11.9	8.5	6.6	4.4	9.5	5.4	4.7	13.5	16.9	12.3	13.4	22.9	27.2	34.5
WET CHEMISTRY																			
Chloride	53	53	35	35	44	35	53	71	18	80	62	ND	27	35	71	89	ND	18	35
Nitrate as N	12.5	12.5	5.5	12	12.8	5.2	2.9	17.5	1.6	12.5	2	2.5	3.3	3.2	24.4	1.3	17	23	6.5
pH	5.42	5.47	4.81	4.52	4.39	4.39	4.4	4.89	5.18	5.16	6.25	6.14	4.97	5.02	7.42	5.23	4.22	5.49	4.97
Sulfate	5400	2550	1030	5990	3540	1920	80	1300	214	506	317	213	216	422	2740	111	4030	4310	5750

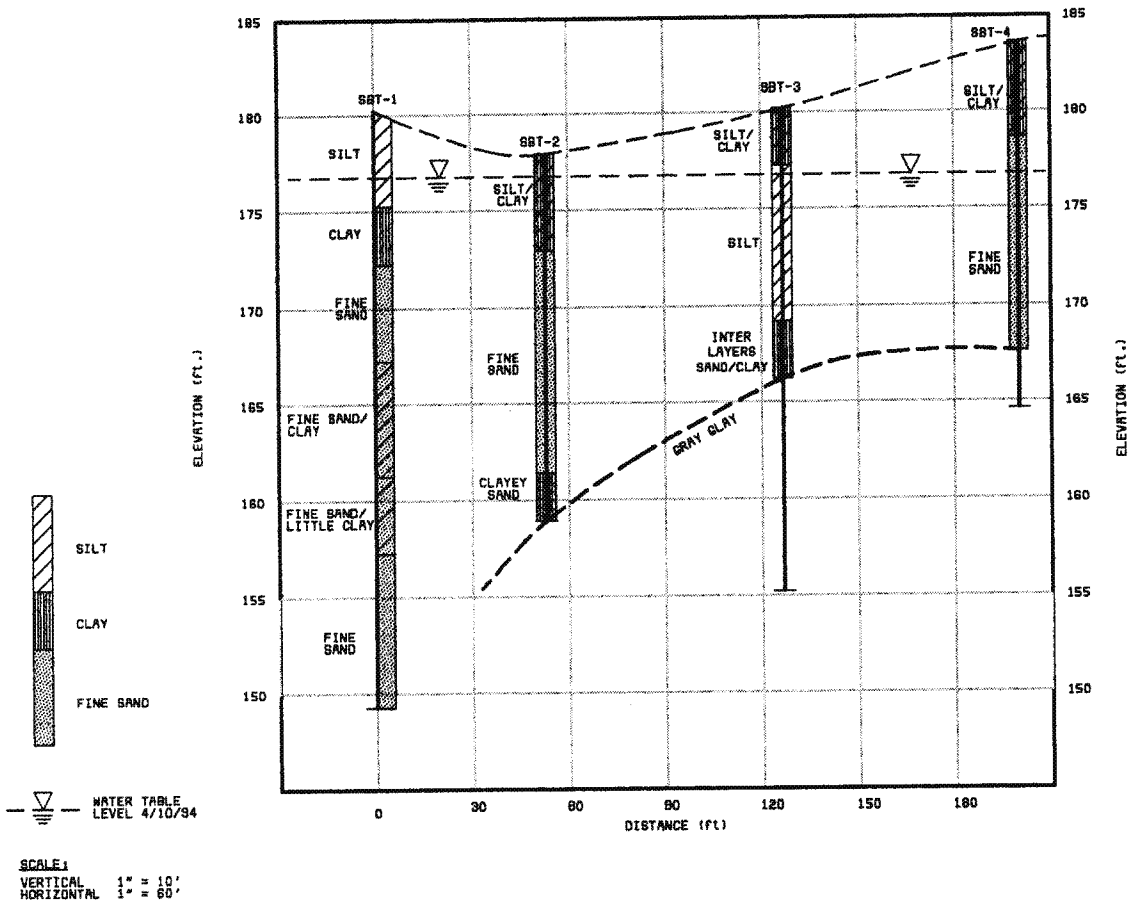
EXPLOSIVES: All samples indicated less than detection limits present.

TABLE 2-7 CONTINUED
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF SOIL ANALYSES FOR INTERCEPTOR TRENCH
DETECTED CONCENTRATIONS, in milligram/kilogram
MARCH/APRIL 1994

Sample Number	SBT5	SBT5	SBT5 QC	SBT5	SBT6	SBT6	SBT6	SBT6	SBT6	SBT7	SBT7	SBT7	SBT7	SBT7 QC	SBT7	ICT1	ICT1	ICT2	ICT2
Depth (ft)	5-7	9-11	9-11	14-16	5-7	10-12	15-17	19-21	23-25	5-7	10-12	15-17	19-21	19-21	25-27	16	18	13	23
VOLATILE ORGANICS																			
1,1,1-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.035
1,1,2,-TCA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DCA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1 DCE	ND	ND	ND	ND	ND	ND	ND	0.008	0.007	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.23
1,2 DCA	ND	ND	ND	ND	ND	ND	ND	0.42	0.19	ND	ND	ND	0.1	0.049	ND	0.007	0.012	0.46	1.8
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	0.053	0.041	0.054	0.047	0.031	0.036	0.056	0.05	0.05	ND	0.05	0.012	ND	ND	0.025	0.12
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	0.26
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MEC	0.066	0.047	0.036	0.026	0.019	0.028	0.026	0.22	0.028	0.029	0.025	0.014	0.34	0.093	0.023	0.02	0.022	7	29.7
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.019
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	ND
Total Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total-1,2-DCE	ND	ND	ND	ND	ND	ND	ND	0.007	ND	ND	ND	ND	ND	ND	ND	0.006	0.006	ND	0.89
TCE	0.038	0.14	0.46	ND	ND	ND	ND	1.6	0.86	ND	0.003	ND	0.26	0.18	ND	0.16	0.086	3.9	12.7
Vinylchloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SEMI-VOLATILE ORGANICS																			
BEP	ND	1.027	1.164	ND	ND	ND	ND	ND	0.536	ND	ND	ND	ND	ND	ND	1.012	ND	ND	ND
DBP	ND	ND	0.454	ND	0.434	0.582	0.576	0.437	0.516	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL METALS																			
Aluminum	11600	4700	2990	2490	3830	7040	3990	3500	4050	17700	7100	2860	11000	17100	5720	6350	4860	7250	2890
Arsenic	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	0.92
Barium	84.2	63.3	91.7	18.9	26.1	46.3	21.9	53.8	49.7	90.3	43.8	26.7	124	194	57.1	41.3	35.2	101	37.3
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.64	ND	ND	0.73	0.76	ND	ND	ND	ND	ND
Calcium	331	595	346	652	129	112	713	693	808	324	127	243	1290	1820	539	125	257	703	253
Chromium	10.7	7.6	4.4	3.6	8.6	7.8	3.8	4	5.4	16.4	7.4	3.6	13.1	19	7.7	7.5	14.9	10.7	4.5
Cobalt	3.1	4.2	2.9	7.7	2.9	4.5	4.1	3	9.2	7	4.5	1.6	5.5	7.1	9.4	2.5	2.8	6.8	2.4
Copper	4.3	3.7	3.2	3.5	ND	5.3	3.4	3.4	4.6	8.4	4.4	2.7	6.7	7.7	4	2.8	5.1	4.8	ND
Iron	6190	3530	4770	2880	6490	3810	3560	6990	10600	16800	11300	2560	18700	16900	12000	3920	18500	12700	2960
Lead	11.1	12	8.2	12.3	5.5	7	5.7	6.6	7.5	11.7	8.3	6.5	13.3	5.1	11.6	2.8	5.5	6	3.8
Magnesium	975	967	632	691	309	808	861	777	921	1690	714	363	1820	2690	767	646	571	1610	358
Manganese	11.5	11	20.6	104	36.1	16.4	16.5	22.1	103	62	45.9	8.3	44.2	41.9	176	12.2	16.3	83.8	33.4
Nickel	6.3	5.1	ND	ND	ND	ND	ND	5.6	9.4	14.8	9.8	ND	11.9	16.3	8.5	ND	ND	12.9	ND
Potassium	ND	ND	ND	ND	ND	ND	ND	ND	ND	960	ND	ND	606	935	ND	ND	ND	657	ND
Sodium	204	485	147	500	ND	90	142	179	198	100	72.2	232	223	565	105	161	186	215	114
Vanadium	15.6	12.1	13.4	7.4	12.4	12.1	9.6	11.9	13.9	29	13.5	6.7	20.6	24.7	14.7	10.1	16.3	17.3	6.5
Zinc	17.9	16.2	15.6	12.5	7.9	22.1	15.9	16	23.7	35.6	24.5	8.7	31.6	43.8	19.7	16.4	21.7	40.1	13.5
WET CHEMISTRY																			
Chloride	53	18	35	35	ND	ND	18	89	89	35	ND	27	80	27	80	53	89	64	18
Nitrate as N	12	53	35	55	ND	ND	25	11	11	8	2.9	4.4	56	12	4.1	0.7	1	28	0.51
pH	4.58	6.19	5.94	5.05	4.51	4.51	4.62	4.7	5.07	4.37	4.62	4.67	4.65	4.39	4.98	5.07	4.35	7.49	5.56
Sulfate	2420	6600	7460	12400	125	167	4090	2470	1860	2080	567	731	1800	3330	665	230	299	2140	556

EXPLOSIVES: All samples analyzed indicated non detectable concentrations present.

NOTE:
MEC = Methylene Chloride
TCE = Trichloroethene
PCE = Tetrachloroethene
1,1,1-TCA = 1,1,1-Trichloroethane
1,1,2-TCA = 1,1,2-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
1,2-DCA = 1,2-Dichloroethane
BEP = Bis(2-ethylhexyl)phthalate
DBP = Di-n-Butylphthalate
ND = None Detected



LONGHORN ARMY AMMUNITION PLANT

KERNACK, TEXAS

BURNING GROUND No.3

FIGURE 2-6

SECTION ICT - 1

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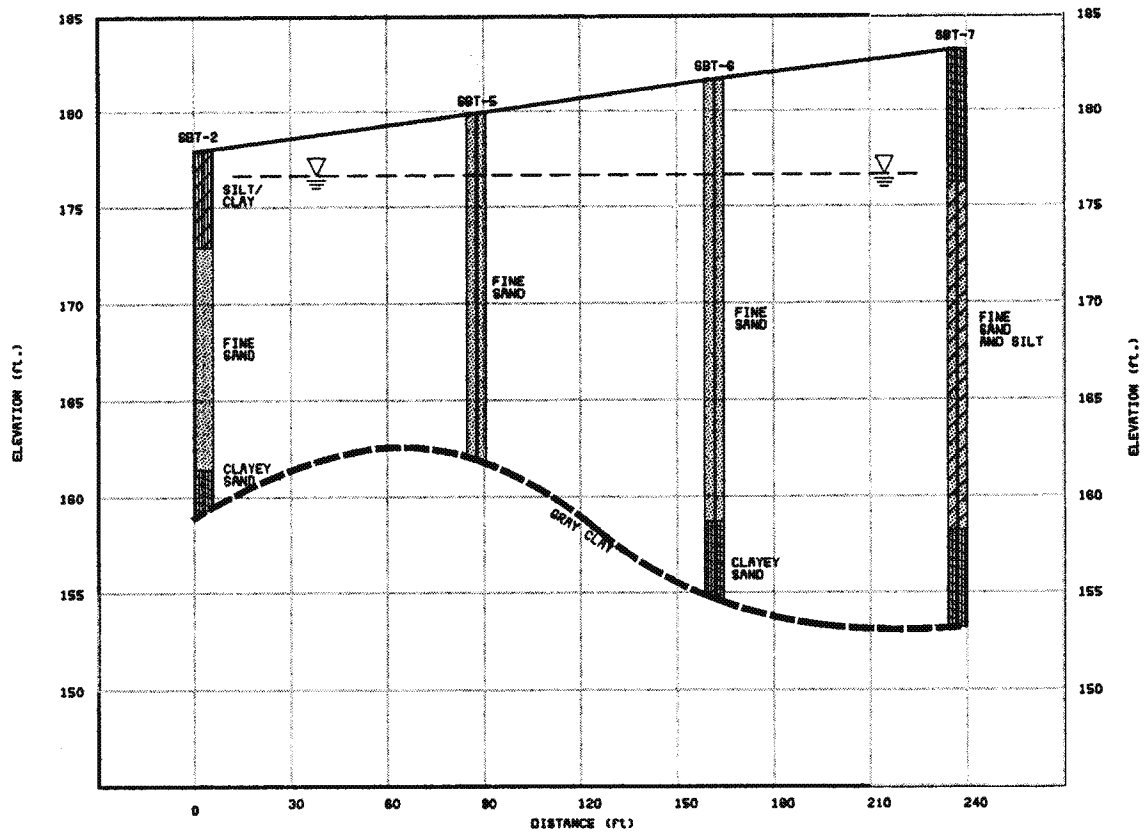
DRAWN BY: E. PIEDRAMARTEL



SILT

CLAY

FINE SAND

WATER TABLE
LEVEL 4/10/94

SCALE:
VERTICAL 1" = 5'
HORIZONTAL 1" = 30'

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No.3
FIGURE 2-7
SECTION ICT - 2
FEBRUARY 1995

DOW
Dow Environmental

DESIGNED BY: A. B. ONK

DRAWN BY: E. PIEDRAMARTEL

caused ground stability problems during the excavation of this section as described below.

2.3.3 Construction of the ICT

The ICT was constructed by Inquip Associates, Inc. of Fairfax Virginia under subcontract to DEI, using the Bio-Polymer (BP) slurry trench technology. This method of drain construction uses basic slurry trench technology, however, instead of bentonite clay slurry, a guar-gum (or a similar material) based slurry is used to maintain the open trench. This type of slurry breaks down chemically and biologically following the backfilling of the trench with the desired water collection system. This method of drain construction did not require trench entry by workers since once a trench section was dug to the desired depth, the components of the water collection system (i.e. pipe laterals, filter fabric, and gravel) were placed under slurry.

All excavated soil and any liquid or solid waste generated during the construction of the ICT were collected in appropriate containers. These containers consisted of frac tanks for liquid wastes and roll-off boxes with metal covers for solid wastes. The frac tanks have been stored at the burning ground in the vicinity of EW-1 and the roll-off boxes have been stored at the TSSA. Spill control measures were also used to prevent the migration of any generated waste beyond the limits of the excavation.

Two methods were used for the construction of the ICT as follows:

- Section ICT-1 had a geocomposite drainage filter (GUNNET by Gundle) installed vertically in the middle of the trench with a coarse sand backfill on each side of the filter. A groundwater collection pipe (perforated HDPE with a six inches diameter) was wrapped around by the geocomposite filter and placed at the bottom of the trench. Appropriate sumps and clean-out pipes were also placed in the open trench prior to the placement of the sand backfill on both sides of the geocomposite filter. Steel I-beams were used on both sides of the filter material in order to keep it in the middle of the trench. Due to the construction difficulties discussed below, the length of this section was limited to 125 feet instead of 250 feet as planned.

- Section ICT-2 was backfilled with coarse sand having a permeability of $K=10^{-2}$ cm/sec. A groundwater collection pipe (six inches perforated HDPE) was placed at the bottom of the trench along with appropriate sumps and clean-out pipes prior to the placement of the sand. This section extended 250 feet as planned.

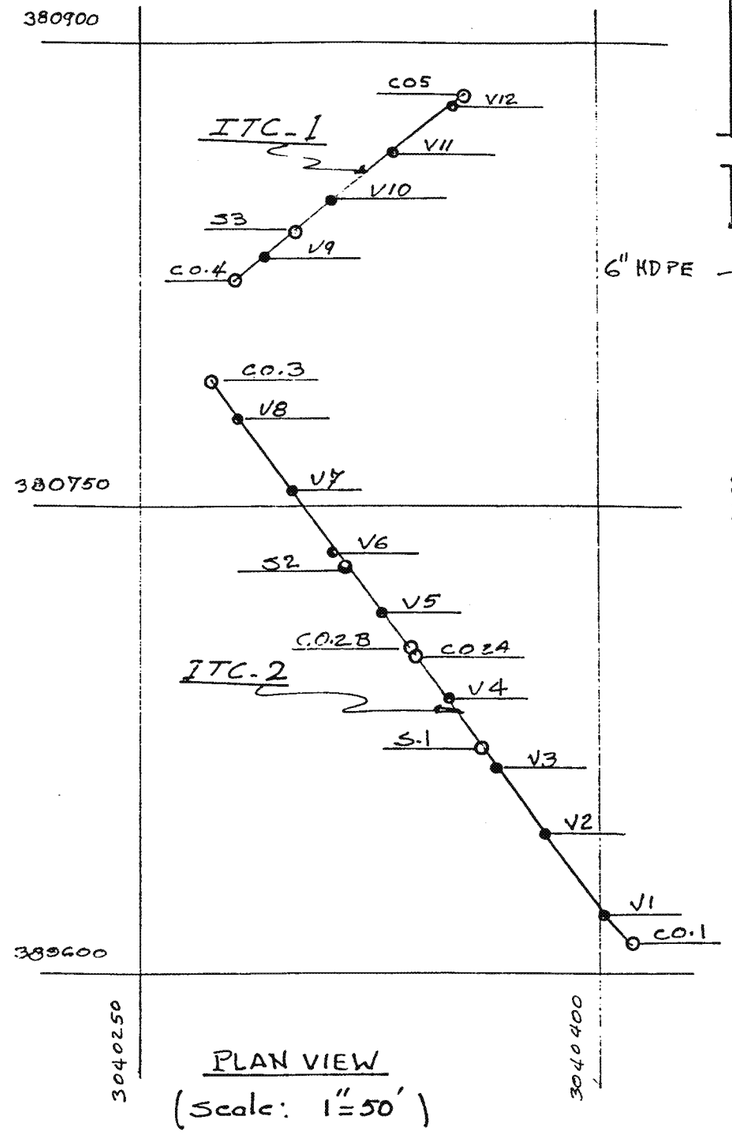
The riser pipes for the groundwater collection system consisted of six-inch diameter HDPE casings and screens. The screens extended from the bottom of the sump to about 12 inches below the top of the ICT drainage material. The riser pipes were placed beside the drain pipe and extended above the ground surface.

A separate three-inch diameter HDPE piping system was installed in each trench section for the distribution of additional vacuum to the trench during the vacuum enhanced groundwater tests. An as built diagram is shown on Figure 2-8.

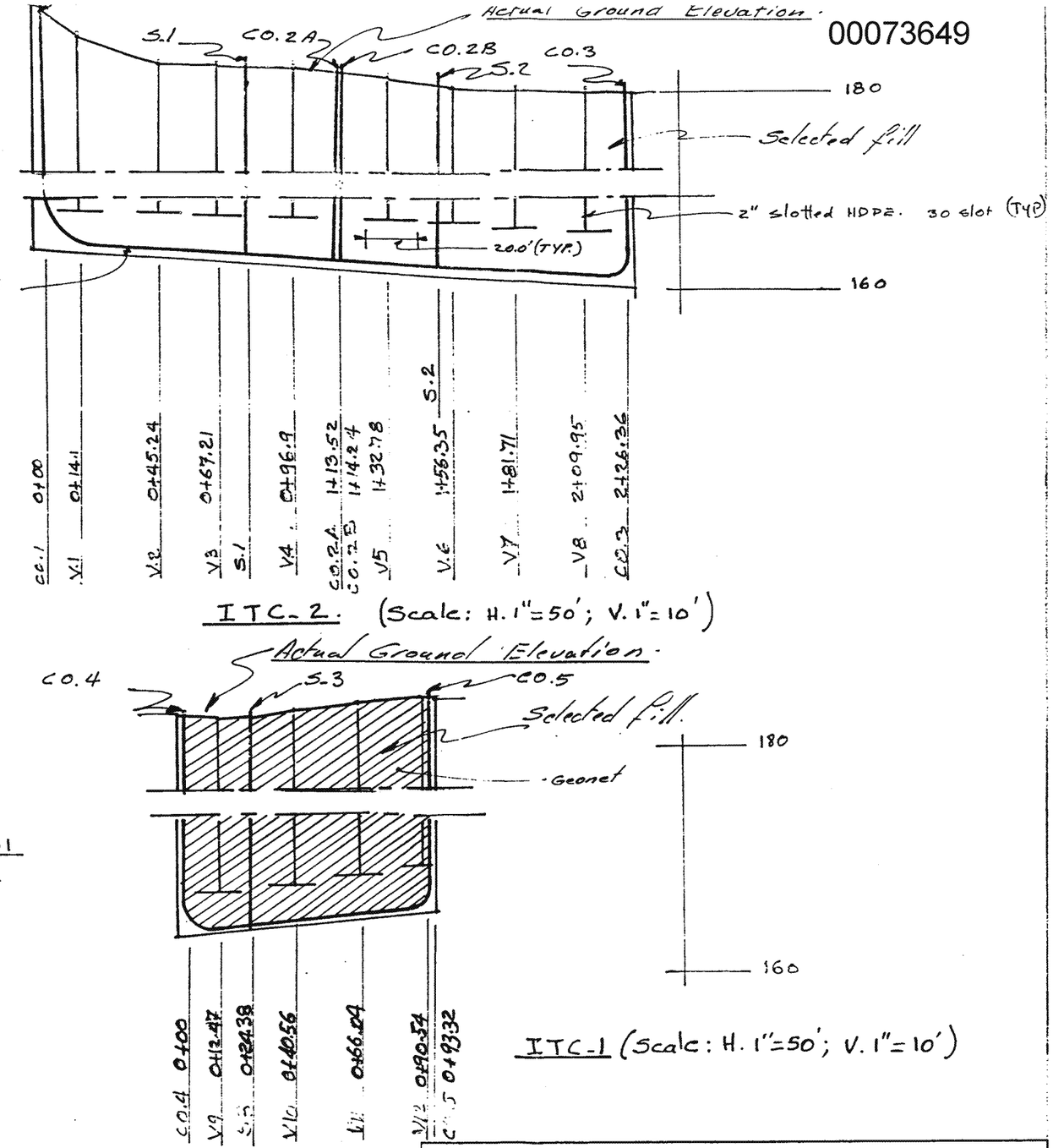
Difficulties encountered during the construction of ICT-1 were as follows:

The shallow groundwater level at the western edge of Section ICT-1, which resulted less

Designation	Station	Groud Elevation	Top of riser pipe Elevation	Invert Pipe Elevation
ITC-01				
CO.04	0+00.00	182.40	184.20	163.20
V.9	0+12.47	182.39	184.39	163.36
S.3	0+24.38	182.49	184.34	163.51
V.10	0+40.56	182.87	184.82	163.72
V.11	0+66.04	183.05	185.10	164.04
V.12	0+90.54	183.45	185.10	164.35
CO.05	0+93.32	183.39	184.79	164.39
ITC-O2				
CO.01	0+00.00	186.60	184.42	167.60
V.1	0+14.00	183.15	184.86	167.16
V.2	0+45.24	182.30	183.44	166.20
V.3	0+67.21	182.26	183.80	165.49
S.1	0+78.76	182.35	185.65	165.13
V.4	0+96.90	182.10	184.34	164.56
CO.02A	1+13.52	181.55	182.72	164.04
CO.02B	1+14.24	181.55	182.29	164.02
V.5	1+32.52	181.10	183.70	163.44
S.2	1+52.60	181.06	182.80	162.81
V.6	1+56.35	180.54	182.50	162.70
V.7	1+81.71	180.23	182.05	161.90
V.8	1+89.95	180.14	181.64	161.64
CO.03	2+26.36	180.04	182.29	160.50



PLAN VIEW
(Scale: 1"=50')



NOTES:

CO: Clean Out

V: Vaccum Pipe (horizontal Vaccum pipe is 5.0' above Interceptor Pipe Invert.)

S: Sump. (Sump pipe riser)

PROVIEDE BY: INQUIP ASSOCIATES, INC.

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No.3
FIGURE 2-8
INTERCEPTOR COLLECTION TRENCH SECTIONS
FEBRUARY 1995

Dow Environmental

DESIGNED BY: A. B. ONK

DRAWN BY: E. PIEDRAMARTEL

than the desired differential between the water level and slurry level in the trench, created stability problems during the excavation of the trench and resulted in the collapse of about 75 feet of excavation. This portion of ICT-1 was abandoned following its collapse. This action was taken after it was determined that lowering of the water table in the area several feet (6 to 8 feet) is necessary in order to achieve stability of excavation. Such dewatering may have been possible for this short section of trench, however, it would not be practical and/or cost effective to use dewatering for the construction of a site wide ICT system during Phase III of the IRA. Another option to increase stability in this area would have been the construction of a working platform by placing 6 to 8 eight feet of fill over the area were the trench was to be built. Such a platform would have resulted in a free board above the groundwater level and a stable trench due to a height differential between the groundwater elevation and the slurry level close to the top of the trench. This option was not used in the case of the collapsed portion of ICT-1 due to schedule constraints and due to the fact that such a platform would block the runoff of surface water in the area and create muddy conditions during the flow testing of the ICT sections. However, a thin platform (1 to 3 feet thick) was built along the installed section of ICT-1 in order to level the trench surface and maintain slurry in the trench. The platform was built from the same imported backfill material as the TSSA.

The installation of the geocomposite filter in the eastern portion of ICT-1 necessitated the opening of the entire trench section, 125 feet, in order to lower the drain pipe and filter material in-place. The trench remained open and stable during the installation of the drainage system. This approach may be used for short sections of trench, however, for a trench several hundred feet long, it would not be possible to open the entire trench prior to installing a similar drainage system due to the biodegradable nature of the slurry. Therefore, if the use of a geocomposite filter is required in future ICT sections, such ICT will have to be built of short overlapping trenches about 100 feet long. In addition to trench stability considerations, the installation of the geocomposite filter proceeded slowly and required a large number of I-beams to stretch it and maintain it (to the extent possible) in the middle of the trench. This problem may be avoided by constructing a steel frame per section of ICT at the ground surface, attaching the filter material and piping systems to the frame, and lowering the entire system in one piece into the open trench.

The placement of the wet sand backfill on both sides of the filter material using tremie pipes proceeded very slowly and required the withdrawal and cleanup of pipes several times prior to the completion of the ICT section. Such problems would cause delay during the construction of longer ICT sections during Phase III. A solution to this problem may be the use of pea gravel instead of sand.

Difficulties encountered during the construction of ICT-2 were as follows:

The backfilling of this section of ICT proceeded along with its excavation. However, the excavation activity ahead of the saturated sand backfilling operation applied suction pressures on the sand and caused it to run toward the area being excavated. The running of the sand backfill caused the displacement of the sumps, cleanouts, and vacuum application pipes. This problem was evident during the placement of piping systems and backfill in the southern half of ICT-2. The other half of the trench was backfilled following completion of excavation and minor-to-no problems were encountered during the backfilling of this portion of trench. The displacement of the sand and piping systems caused considerable delay in construction and resulted in a badly damaged sump (sump No. 1). These difficulties

may be avoided in the future by either using coarser material to backfill the trench or by building the trench in short, i.e. 100-foot, overlapping sections. The coarser material such as gravel may allow the hydrostatic forces caused by the saturated conditions and the suction forces of the excavation equipment to dissipate faster than the coarse sand, thus resulting in less running of backfill material and less damage to piping systems. Alternatively, the construction of an ICT using short overlapping sections would allow the backfilling of the trench without any disturbance due to excavation. In addition, rigid pipes such as stainless steel should be used instead of flexible HDPE pipes for riser sumps. As discussed below, the use of separate piping for the application of vacuum was not successful, and its use is not recommended in future ICTs at the site.

A thin platform was also built along the axis of ICT-2 (1 to 4 feet thick) mainly in the area of low original ground surface elevation along the northern third of ICT-2. This platform was necessary to maintain the excavation slurry in the trench and to provide some trench stability, especially in the vicinity of SBT-5 where the groundwater was close to ground surface. The platform was built from the same imported backfill material as the TSSA. The construction of such platform during the installation of the Phase III ICT sections will be necessary if similar conditions are encountered. This will increase the cost of the installation.

The effectiveness of the ICT sections was evaluated based on the results of the gravity flow and the vacuum enhanced liquid extraction testing as discussed in Section 2.5. These results were based on field monitoring of water levels in existing onsite monitoring wells, in some of the SBT1 through SBT7 piezometers installed prior to the construction of the ICT sections, and six new piezometers designated AWD7, AWD8, AWD9, AWD10, AWD16, and AWD17. The new piezometers, which were installed in the vicinity of the ICT following its construction as shown on Drawing II-1, consisted of two-inch, Schedule 40 PVC casings and screens. The piezometer screens extended from the top of the semi-confining layer on which the trench sections rest to about three feet from the existing ground surface. The piezometer riser pipes extended to about two feet above ground surface.

2.4 TASK 4 - Installation of Horizontal Extraction Well (HEW).

The purpose of the HEW was to evaluate the potential extraction of groundwater from a large horizontal area located under the ACD and surrounding support facilities. The construction of the HEW included the following steps:

2.4.1 Soil Borings and Temporary Groundwater Monitoring Wells/Piezometers

Soil borings, designated AWD-11 through AWD-13, were drilled along a direction parallel to the axis of the HEW at the locations shown on Drawing II-1, prior to the initiation of drilling for the horizontal well. The borings were used to define the subsurface conditions including the depth of the semi-confining retardation layer on which the screened portion of the well rests. The borings were also used to collect soil samples for chemical and physical characterization. Each borehole was drilled to the depth of the lower semi-confining layer. This depth was determined by conducting continuous soil sampling throughout the depth of the borehole. The depth of each borehole was verified by the U.S. Army Corps of Engineers, Tulsa District. Any drilled portion of the semi-confining layer was grouted using bentonite grout upon completion of the borehole. Detailed boring logs are included in Appendix D.1.

Soil samples for chemical analyses were obtained at five-feet intervals using a three-inch split spoon. In addition, soil samples were obtained for physical testing and characterization at the same intervals as for chemical analyses. The analytical and geotechnical testing program for collected soil samples is listed in Table 2-1. Appendix D.2 contains the results of the chemical analyses. The results of the geotechnical testing program are included in Appendix C.3. Soil contamination based on the collected samples appears to be minimal in the area and is confined to the interface of the semi-confining layer and the overlying shallow aquifer material and may have been caused by the contaminated groundwater in the aquifer. Table 2-8 presents a summary of the detected chemical concentrations in the tested soil samples.

Temporary groundwater piezometers were installed in each borehole. These piezometers were used to monitor the static water levels prior to proceeding with the installation of the HEW. The screen section and riser pipe of each of the piezometers were two inches in diameter and consisted of schedule 40 PVC. These piezometers were also used to measure water levels during the gravity flow and vacuum enhanced flow testing discussed below.

Subsurface information collected from the boreholes and the temporary monitoring wells was used to develop a subsurface cross section shown on Figure 2-9. This cross section shows the potential elevation of the semi-confining retardation layer on which the HEW rests. The final design for the HEW was presented to the USACE Tulsa District for approval prior to proceeding with its installation.

2.4.2 Installation of HEW

The HEW was installed by Eastman Cherington of Houston Texas under subcontract to DEI. The HEW was installed at an approximate depth of 25 feet below the ground surface. It extended about 227 feet including a 120-foot screen section. The HEW head was located to the south of the on-site ACD as shown on Drawing II-1. This location of well head was based on available space to accommodate the large number of equipment required for the installation of the HEW, and on available drilling distances for the drilling equipment to turn to a horizontal level under the ACD. Initial well head locations to the west and north of the ACD were not used due to limitation in space and drilling distance. The well was installed in a northeast direction under the ACD. It consisted of a six-inch HDPE riser pipe and a prepacked six-inch slotted HDPE screen with slot size of 0.01 inch. The screen section extended along the entire length of the horizontal section of the well. As built diagrams of the HEW are included in Appendix D.4.

All generated soil cuttings and any liquid or solid waste generated during the construction of the HEW were collected in appropriate containers. These containers consisted of frac tanks for liquid wastes and roll-off boxes with metal covers for solid wastes. The frac tanks have been stored at the burning ground in the vicinity of EW-1, and the roll-off boxes have been stored at the TSSA. Spill control measures were also used to prevent the migration of any generated waste beyond the limits of the drilling operation.

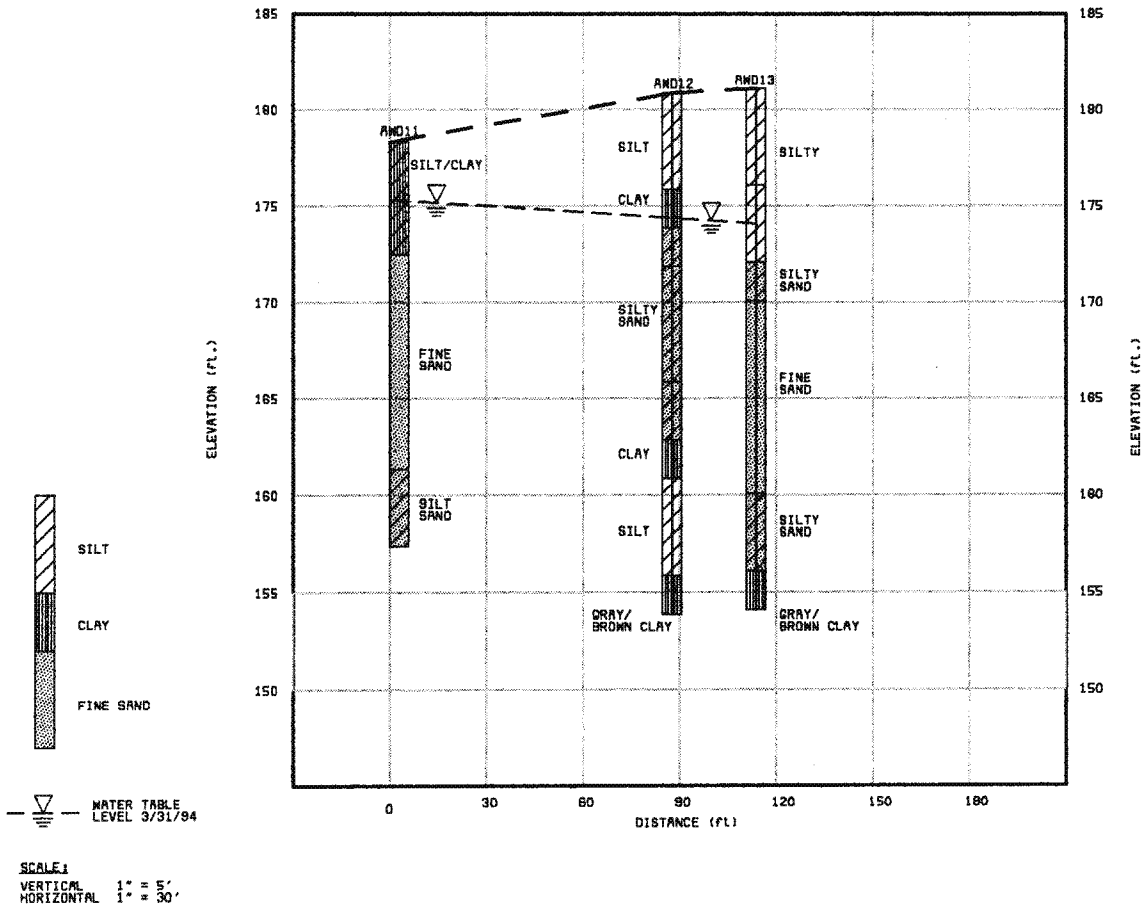
Difficulties encountered during the installation of the HEW were as follows:

- Ground fracturing occurred along most of the HEW line during drilling operations. The fine subsurface soils collected on the outside of the drilling rods and blocked the circulation of drilling fluid which was being pushed into the hole under pressure. This

TABLE 2-8
LHAAP 18&2 BURNING GROUND 3 & UEP
SUMMARY OF SOIL ANALYSIS FOR SAMPLES COLLECTED FROM HORIZONTAL EXTRACTION WELL LOCATION
DETECTED CONCENTRATIONS ALONG HEW, in milligram/kilogram
MARCH/APRIL 1994

Sample Number	AWD11	AWD11 QC	AWD11	AWD11 QC	AWD11	AWD11	AWD12	AWD12	AWD12	AWD12	AWD12	AWD13	AWD13	AWD13	AWD13	AWD13
Depth (ft)	5-7	5-7	9-11	9-11	15-17	19-21	5-7	9-11	15-17	19-21	25-27	5-7	9-11	15-17	19-21	25-27
VOLATILE ORGANIC COMPOUNDS																
1,1,1-TCA	ND	ND	0.39	0.23	0.066	ND	ND	ND	ND	ND	ND	ND	0.043	0.33	0.019	ND
1,1 DCE	ND	ND	0.14	0.17	0.035	ND	ND	ND	ND	0.034	ND	ND	ND	0.065	ND	ND
1,2 DCA	ND	ND	0.13	0.068	0.019	ND	ND	ND	ND	0.095	ND	ND	ND	ND	ND	ND
Acetone	0.075	0.099	0.13	0.13	0.66	ND	0.092	0.08	ND	0.44	ND	0.055	ND	0.21	0.16	0.255
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.04	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.038	0.14	0.09
MEC	0.11	0.106	20.1	9.06	27	0.46	0.093	0.32	0.11	30	25	0.65	0.085	0.1	0.27	3.47
Styrene	ND	ND	1.1	0.79	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	0.095	0.074	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.28	ND	ND	0.03	ND	ND
Total-1,2-DCE	ND	ND	4.01	ND	ND	ND	ND	ND	ND	1.04	ND	ND	1.6	12.6	0.72	0.36
TCE	0.03	0.019	24.1	22.7	7.1	0.14	0.023	0.1	0.06	19.2	2	0.35	0.26	8.86	1.59	1.24
Vinylchloride	ND	ND	0.034	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	ND	ND
SEMI-VOLATILE ORGANIC COMPOUNDS																
BEP	2.914	3.573	0.601	ND	ND	2.784	1.65	0.581	ND	2.281	ND	2.636	0.624	0.756	2.315	1.814
DBP	ND	ND	0.711	ND	ND	0.616	ND	ND	ND	0.598	ND	0.41	0.427	0.442	0.549	0.266
TOTAL METALS																
Aluminum	19700	10600	2370	2420	5590	9560	11000	1820	5490	4680	8110	10500	5630	5870	5860	4760
Arseniuc	3	2.4	ND	ND	0.9	0.7	5	ND	2.9	1.6	ND	3.1	1	1.5	1	3.5
Barium	592	64.1	101	96.1	127	44.7	70	50.6	116	69.4	161	209	57.7	95	91.4	53.6
Beryllium	ND	ND	ND	ND	ND	0.62	ND	ND	ND	ND	0.82	ND	ND	ND	ND	ND
Calcium	126	57.7	66	73	356	1160	196	100	358	768	1480	461	221	172	535	594
Chromium	17.3	9.5	3.3	3.3	7	13.3	10.1	3.1	7.5	11.6	13.6	8.6	4.5	7	9	7.6
Cobalt	3.6	3	1.5	1.5	2.4	5.2	4.2	2.3	3.6	5.7	4.7	7.4	1.8	2.4	4.8	7.9
Copper	6.6	4	ND	ND	3.4	7.6	3.8	ND	4.1	7.3	14	3.6	ND	3.8	4.3	5.8
Iron	17800	10600	2570	2230	4260	15800	10100	1730	7530	9010	6900	10600	4340	4620	4860	16200
Lead	7.7	6	2.4	2.7	4.2	8.7	8.4	2.5	4.3	8.2	15	11	4.1	4.7	6.7	7
Magnesium	1080	701	279	292	732	1680	776	324	839	873	1890	697	573	608	688	707
Manganese	55.5	34.4	16.4	14.8	13.6	20.3	84.3	18.3	24.8	12.4	44.2	198	41.9	23.8	25.8	141
Nickel	8.9	6.4	ND	ND	5	12.2	5.4	ND	5.8	8.4	10.9	6.1	ND	ND	6.2	9.6
Potassium	949	ND	ND	ND	ND	663	ND	ND	ND	ND	ND	740	ND	ND	ND	ND
Sodium	2190	862	214	208	725	876	150	49.4	78.2	118	164	458	90.6	169	132	76.9
Vanadium	31.2	16.3	5.3	4.7	11.7	28.9	16.6	4.2	20.5	10.7	19	18.6	8	15.3	10.4	14.2
Zinc	27.7	18	7.9	7.9	17.4	35.2	15.4	7.6	19.6	28.3	38.5	16.5	12.3	14.9	22.2	26.6
WET CHEMISTRY																
Chloride	53	53	53	35	106	310	27	18	18	53	89	53	35	35	35	35
Nitrate as N	96	98	33	28	176	100	30	0.9	39	45	2	53	3.7	30	21	3.4
pH	5.12	5.07	4.99	4.9	4.87	5.08	5.11	5.37	5.29	6.1	6.96	7.69	7.36	6.54	5.24	5.5
Sulfate	1840	2040	1840	2020	5000	8830	5800	209	3030	9100	206	11500	405	4860	2930	428

EXPLOSIVES: All samples analyzed indicated non detectable concentrations present.



LONGHORN ARMY AMMUNITION PLANT

KERNACK, TEXAS

BURNING GROUND No.3

FIGURE 2-9

SUB-SURFACE CROSS-SECTION FROM AWD11 - AWD13

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blockage contributed to the fracturing. The fracturing caused drilling fluids to run up to the ground surface and spill over the area of operation. This spillage was managed at all times in order to prevent contamination to the surrounding environment. About 1,000 bags of sand were used to control the problems caused by fracturing. These bags were placed in a roll-off box following the installation of the HEW and are being handled like all other solid waste generated during Phase II of IRA. It may difficult to avoid this problem in future applications at the site, especially with shallow wells where the overburden is limited and does not provide a balance to the drilling fluid pressures. However, a very slow speed of drilling and the removal and cleaning of drilling rods every few feet of drilling may reduce the amount of drilling fluids blockage and thus the amount of fracturing. This solution will cause an increase in the cost of drilling and will be time consuming.

- The well bore was lost several times during the drilling operations. This problem appears to have been caused by the high speed of drilling over the first two days of the work. It also appears to have been related to the drilling equipment which was difficult to maneuver due to the shallow nature of the well. The drilling contractor is responsible for solving this problem. However, it should be noted that such a problem causes delays and eventually impacts the cost of the project.

- The development of the well proceeded at a very slow rate. The groundwater flow during development was very slow. Eastman Cherrington redeveloped the well on May 27 and 28 and installed a submersible pump in it. The subcontractor attributed this problem to the fine nature of the soils in which the screen was installed and the shallowness of the well. It was also suggested by the subcontractor that a regular well screen be used with a conventional gravel packed instead of the prepacked screen. However, maintaining the borehole open for such an application may be difficult.

The effectiveness of the HEW was evaluated based on the results of the gravity flow and the vacuum enhanced liquid extraction testing as described below in Section 2.5. These results were based on field monitoring of water levels in existing onsite monitoring wells and piezometers, and two new piezometers that were installed in the vicinity of the HEW. The two new piezometers, AWD-14 and AWD-15, were installed at the locations shown on Drawing II-1. They consisted of 2-inch, Schedule 40 PVC casings and screens. The piezometer screens extended from the top of the semi-confining layer on which the HEW rests to about 3 feet from the existing ground surface. The piezometer riser pipes extended to about two feet above ground surface.

2.5 Task 5 - Groundwater Flow Testing

2.5.1 Gravity Flow Testing

A gravity flow test was conducted at the VEW, HEW, and the ICT. The duration of the pumping at each extraction system took into account the effects of delayed yield. The test included the measurements of flow rates, flow volumes, and water level readings in surrounding monitoring wells. The results of the flow tests are to be utilized in the design of a groundwater extraction and treatment system for the IRA.

Water levels in the pumping well and observation wells were recorded using automatic data loggers. Manual water levels were also recorded. The manual measurements were used to supplement the data from the automatic data loggers and were used as a back-up in the event of data logger failure. The manual measurements also allowed the field staff to observe the behavior of the pumping well and aquifer on a continuous basis. The water levels were also monitored after the stoppage of pumping, during aquifer recovery. The pumped groundwater was collected in frac tanks onsite for treatment during Phase III of the IRA. The frac tanks have been stored to the south of the UEP in the vicinity of the VEW. The following is a brief description for the results of flow testing:

2.5.1.1 Vertical Extraction Well Gravity Flow Test

The gravity flow test at the VEW occurred between May 7 and May 13, 1984. The test was preceded on May 6 by a sand free test and a step drawdown test. The sand free test indicated that the well had been properly developed. The step drawdown test resulted in the selection of one gallon per minute (gpm) as the flow rate for the gravity test. The manual water level readings and the data logger readings are included in Appendices D.1 and D.2, respectively. Figure 2-10 shows the sustained pumping rate during the test. The rate started at one gpm and ended at about 0.8 gpm. Figures 2-11 through 2-14 show plots of drawdown versus (vs) distance from pumping well, and drawdown vs time of the pumping well EW-1 and monitoring wells AWD-5 and MW-2, respectively. Piezometers AWD-5 and AWD-6 were installed at the locations shown on Drawing II-1, prior to the start of the flow test in order to better monitor the influence of pumping at the VEW. Figure 2-11 shows the positions of the cone of depression after pumping for 24 hours, 48 hours, 72 hours, and 96 hours. It also shows that the radius of influence due to the withdrawal of water from EW-1 is about 800 feet after 96 hours of pumping. The water level in the pump well and monitoring wells was influenced by the heavy rains that fell during the performance of the flow test as can be seen from the plotted data on Figures 2-12, 2-13, and 2-14. This rain and the fluctuation of the pumping rate influenced the interpretation of data also as shown on these figures. The aquifer transmisivity,T, of 2,030 gallon per day per foot (gpd/ft) and storativity, S, of 2.06×10^{-3} calculated from the distance drawdown graph (Figure 11) may be most representative of site conditions.

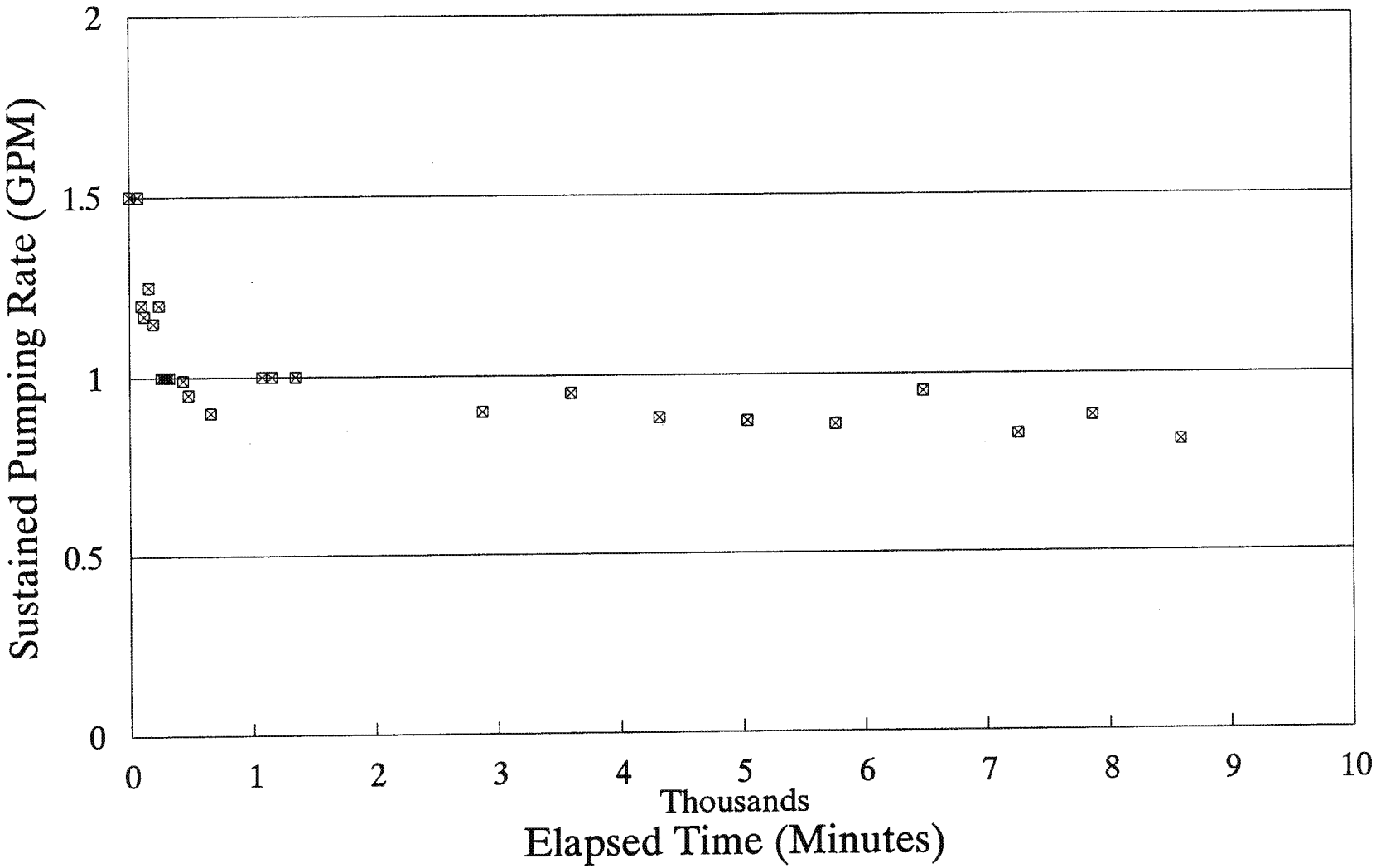
One sample of the extracted water was taken each day for laboratory analysis. The samples were analyzed for different parameters as indicated in Table 2-1. Table 2-9 presents a summary of detected parameters. The analytical results are included in Appendix D.3.

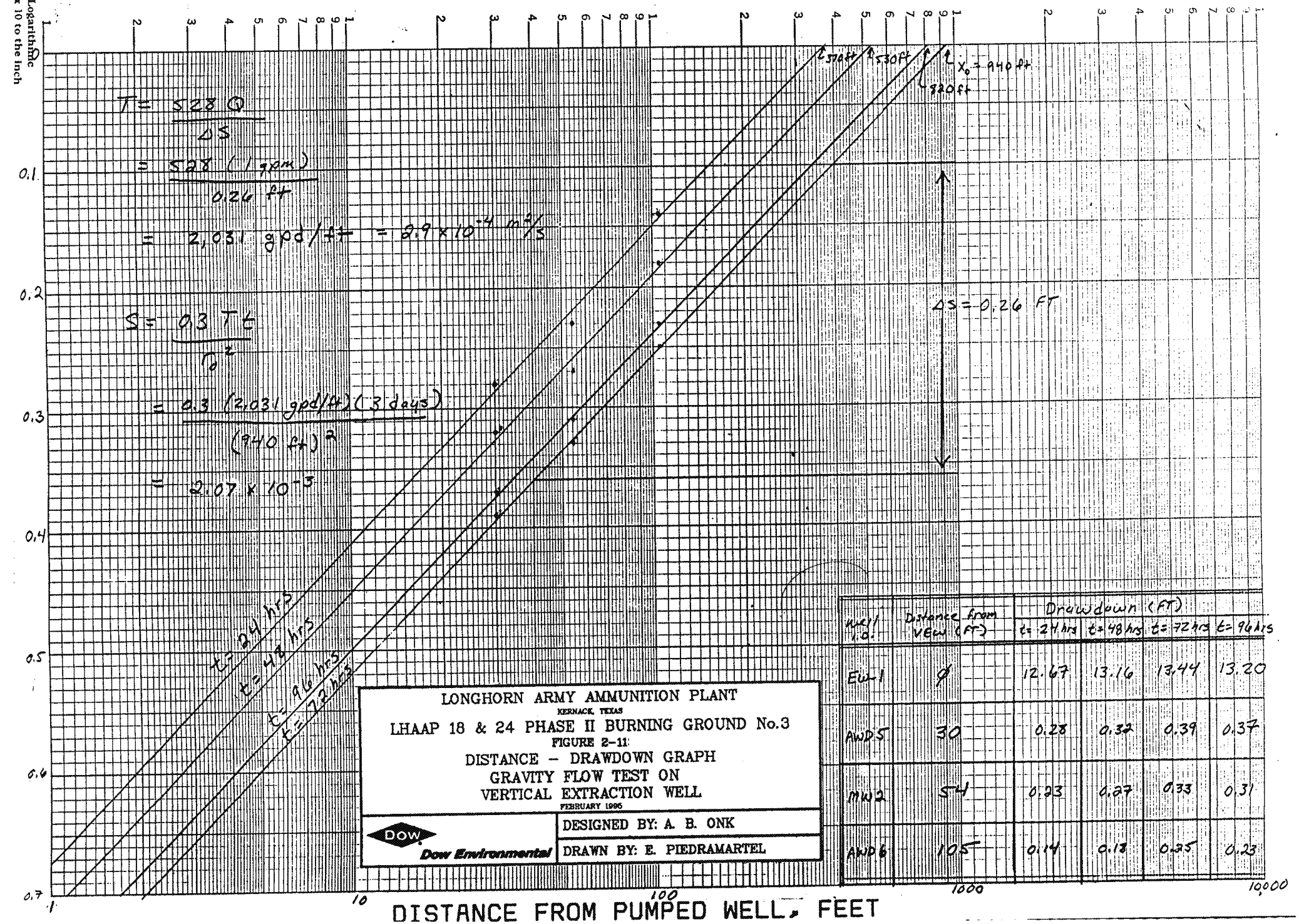
2.5.1.2 Horizontal Extraction Well Gravity Flow Test

The gravity flow test at the HEW occurred between May 29 and June 3, 1994. The test was preceded on May 26 through May 28 by the redevelopment of the well by Eastman Cherrington who also conducted a sand free test and a step drawdown test following redevelopment. The sand free test indicated that the well had been properly developed. The step drawdown test resulted in the selection of a 0.7 gpm as the flow rate for the gravity test. However, as can be seen from Figure 2-15, which shows the sustained pumping rate during the test, the flow rate decreased over time and was about 0.3 gpm at the end of the test. Figure 2-16 presents a distance-drawdown plot which reflects the positions of the cone of depression after pumping for 24 hours, 72 hours, and 118 hours. Piezometers AWD-11, AWD-12 and AWD-13 which were installed prior to HEW and located near its axis had maximum drawdowns of 0.51, 0.94, and 0.69 feet, respectively. The manual water level readings and the data logger readings are

Figure 2–10, Pumping Rate vs Time, VEW, Gravity Flow Test

LHAAP 18&24 Phase II Pilot Tests





Well I.D.	Distance from Well (FT)	Drawdown (FT) t = 24 hrs	t = 48 hrs	t = 72 hrs	t = 96 hrs
EW-1	0	12.67	13.16	13.44	13.20
AWD5	30	0.28	0.32	0.39	0.37
MW2	54	0.23	0.27	0.33	0.31
AWD6	105	0.14	0.18	0.25	0.23

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-11
DISTANCE – DRAWDOWN GRAPH
GRAVITY FLOW TEST ON
VERTICAL EXTRACTION WELL
FEBRUARY 1995

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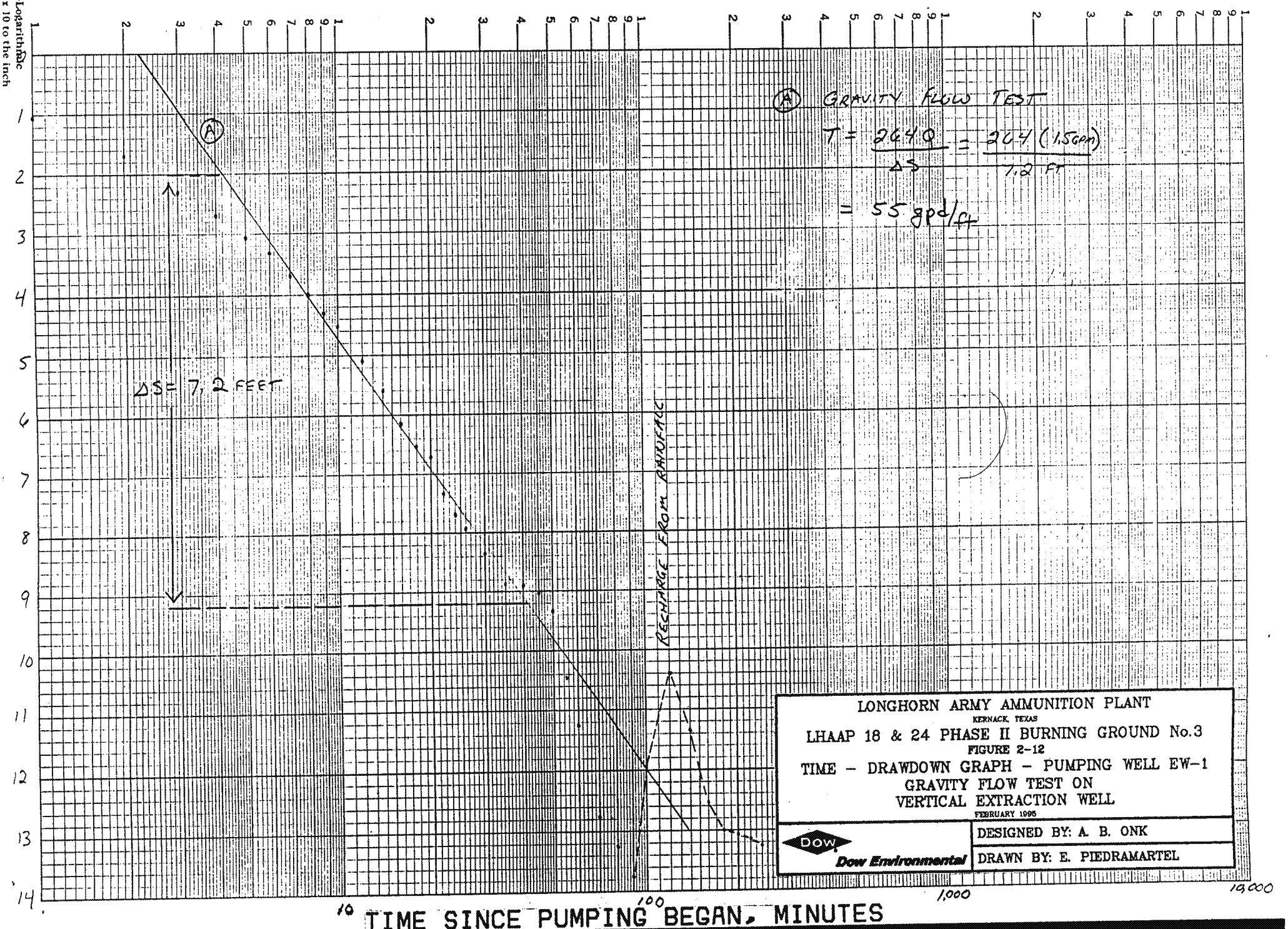

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-12
TIME – DRAWDOWN GRAPH – PUMPING WELL EW-1
GRAVITY FLOW TEST ON
VERTICAL EXTRACTION WELL
FEBRUARY 1996

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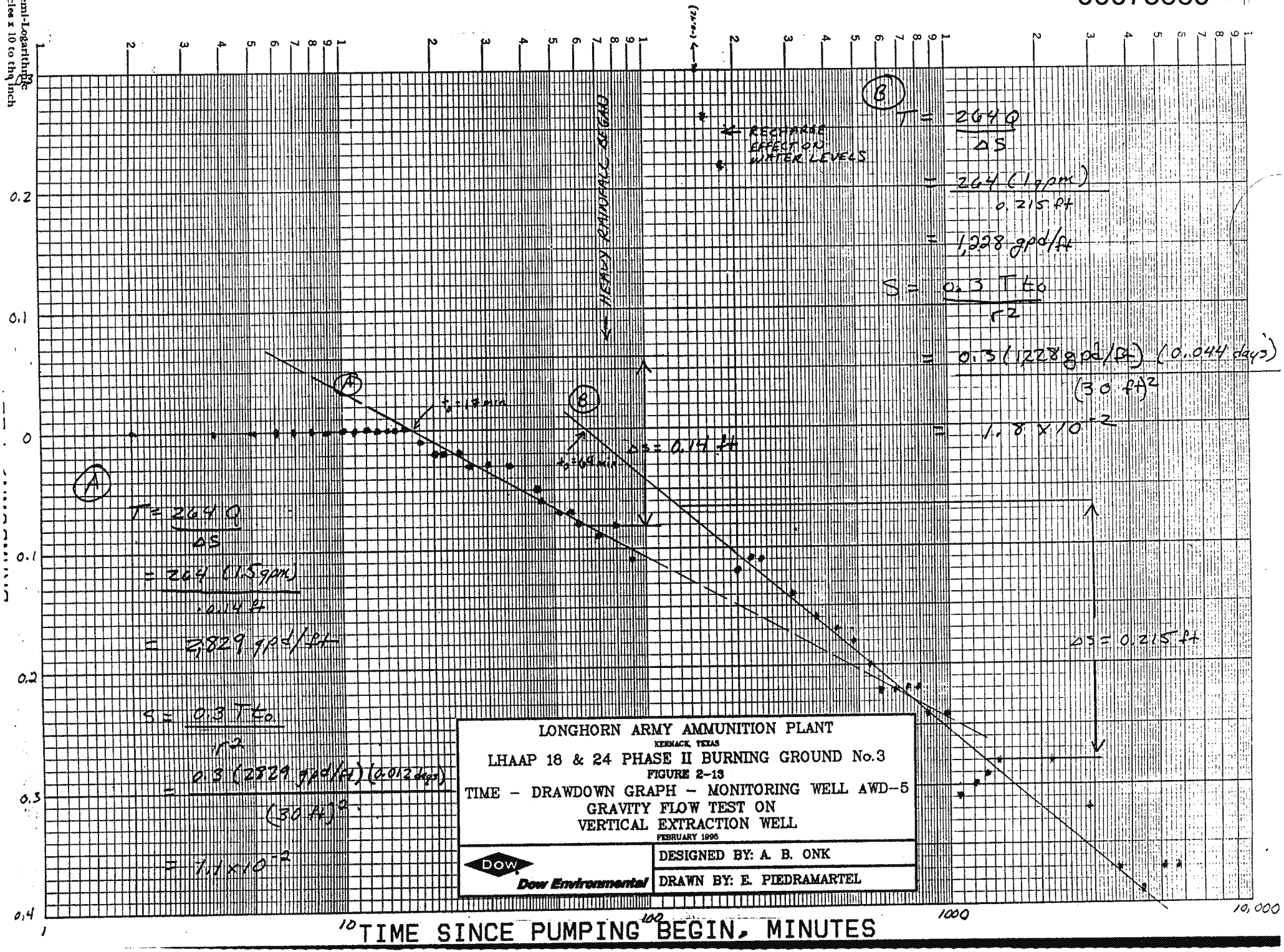

LONGHORN ARMY AMMUNITION PLANT
KERMACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-13
TIME – DRAWDOWN GRAPH – MONITORING WELL AWD-5
GRAVITY FLOW TEST ON
VERTICAL EXTRACTION WELL
FEBRUARY 1995

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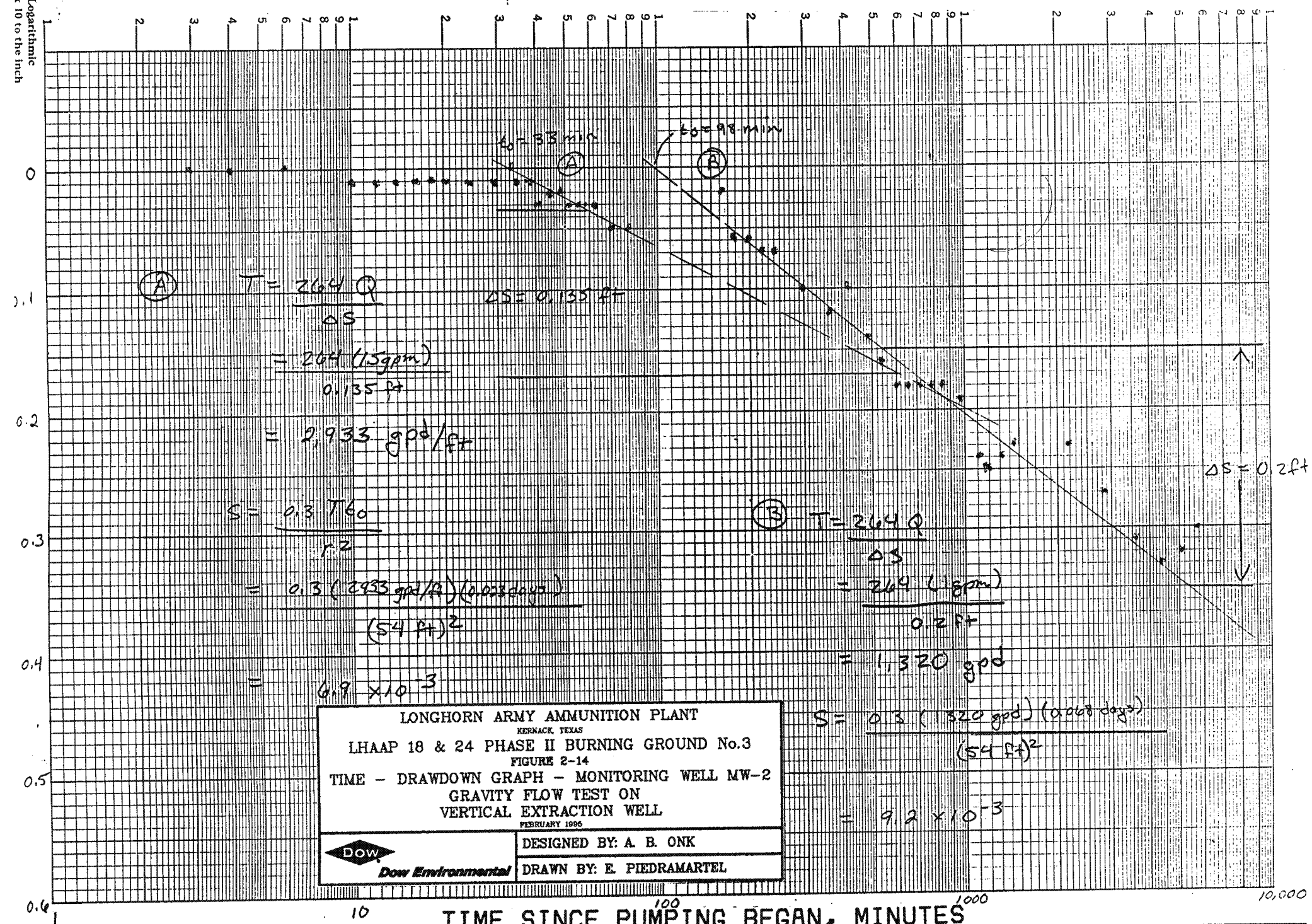
DRAWN BY: E. PIEDRAMARTEL



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-14
TIME – DRAWDOWN GRAPH – MONITORING WELL MW-2
GRAVITY FLOW TEST ON
VERTICAL EXTRACTION WELL
FEBRUARY 1995

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DRAWN BY: E. PIEDRAMARTEL

TABLE 2-9
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER ANALYSES DURING FLOW TESTING
DETECTED CONCENTRATIONS AT VEW, in microgram/liter
MAY, 1994

DATE OF SAMPLING	VOLATILE ORGANIC COMPOUND		SEMIVOLATILES					
	METHYLENE CHLORIDE	TRICHLORO-ETHELYNE	2-2-METHYL-NAPHTHALENE	2-METHYLPHENOL	BENZOIC ACID	BIS (2-ETHYLHEXYL) PHTHALATE	DIMETHYL PHTHALATE	NAPHTHALENE
05/07/94	1020000				149		15	
05/08/94	2150000			8	548		30	
05/09/94	2340000		5	6	458		20	6
05/10/94	4064250	235750			7	24	15	
05/10/94*	2895800	198800	6		392		21	7
05/11/94	3934200	127200						
05/12/94	2332600	109200						
05/13/94	2441000	105800						
05/19/94	1215400							
05/20/94	526000	53000						
05/22/94	1120000	72000						
05/23/94	977000	60000						
05/23/94	919000	42000						
05/24/94	1260000	76750						
05/24/94	1100000*							
05/24/94	1300000	65000						

*QUALITY CONTROL

DATE OF SAMPLING	WET CHEMISTRY PARAMETER									
	ALKALINITY	AMMONIA AS N	TOTAL HARDNESS	SILICA	TDS	TSS	CHLORIDE	NITRATE	NITRITE	SULFATE
05/07/94	155000	459	309000	51000	1310000	5000	510000	1100000		44000
05/08/94	118000	328	221000	53000	1060000		300000	190000		3800000
05/09/94	122000	312	250000	53000	1110000		290000	170000		210000
05/10/94	139000	750	251000	50000	1330000	238000	4800	800	30	ND
05/10/94*	153000	1100	352000	50000	1420000	8000	3700	600	ND	ND
05/11/94						ND				
05/12/94						ND				
05/13/94						ND				
05/19/94						190000				
05/20/94						4050000				
05/22/94						5000				
05/23/94						ND				
05/23/94						6000				
05/24/94*						ND				
05/24/94						ND				

NOTE: ND = NOT DETECTED

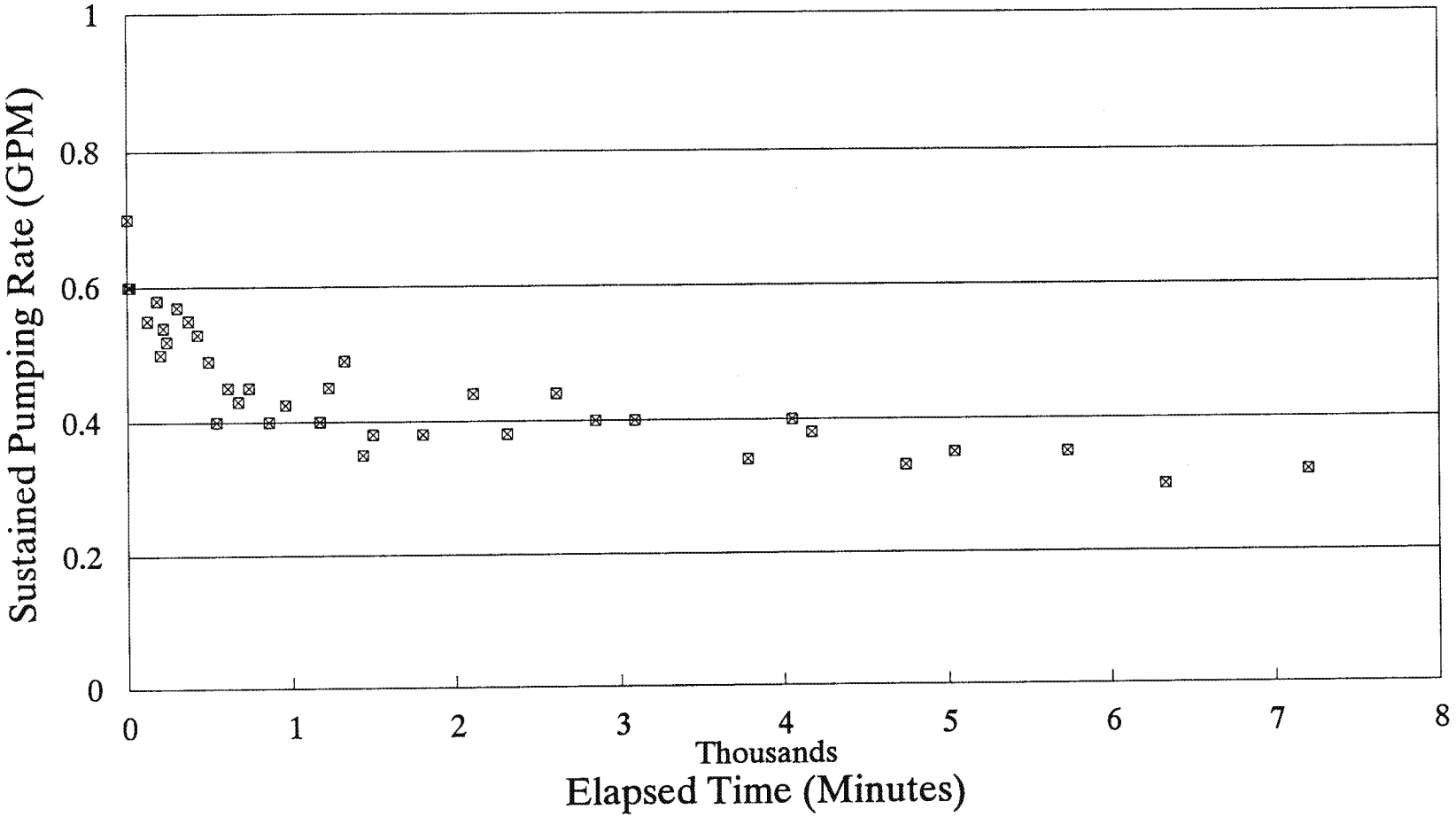
DATE OF SAMPLING	TOTAL METALS			TPH/OIL&GREASE	
	BARIUM	LEAD	MERCURY	TPH	O&G
05/07/94	688			ND	5430
05/08/94	1410			ND	ND
05/09/94	1600	6		ND	ND
05/10/94	1620	7		ND	5570
05/10/94*				ND	ND
05/11/94	1920	5			
05/12/94	1770	5			
05/13/94	1720	5			
05/19/94	1090	6			
05/20/94	1630	8	0.2		
05/22/94	1260	6			
05/23/94	1270				
05/23/94	1360				
05/24/94*	1370				
05/24/94	1350				

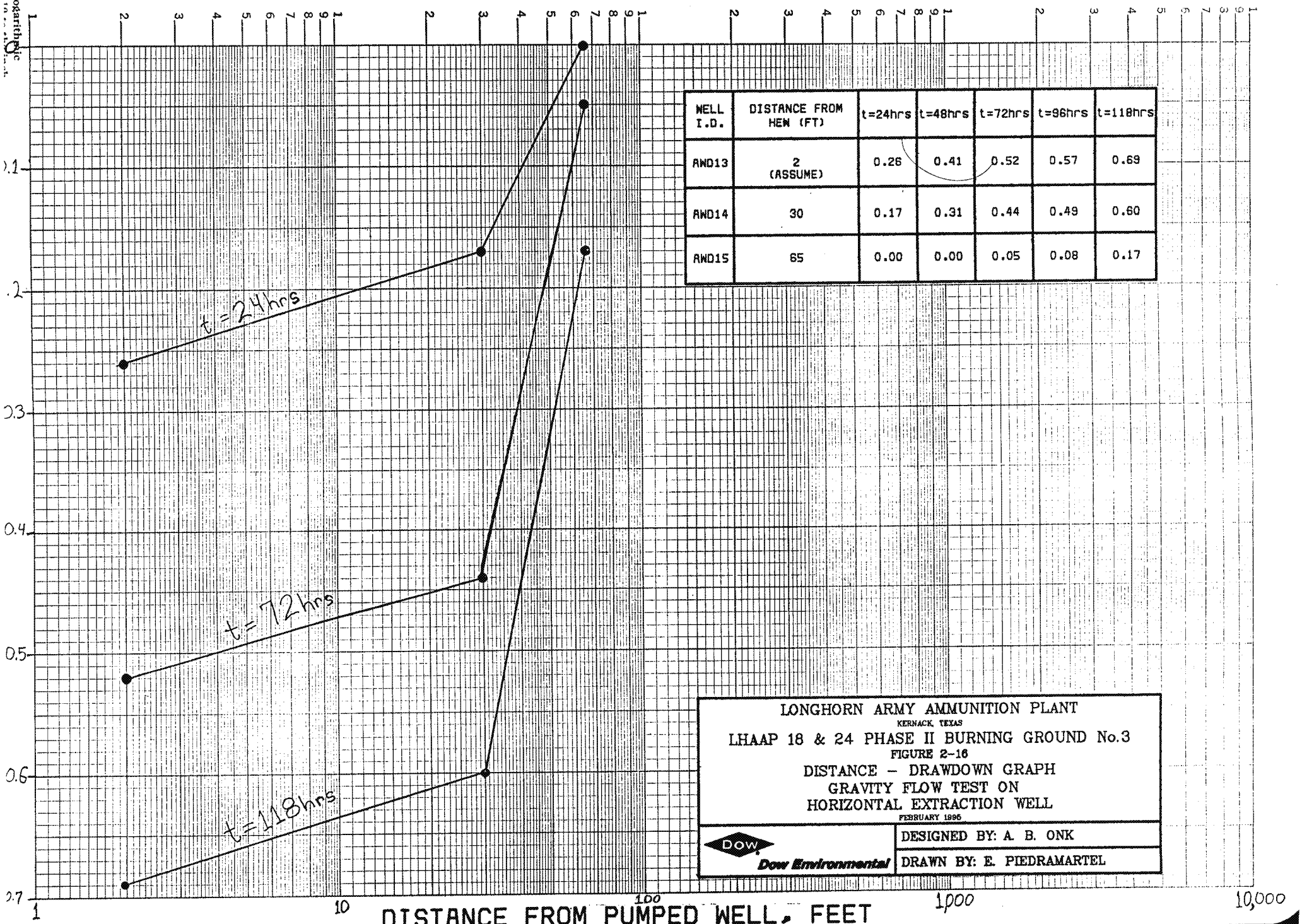
TPH = TOTAL PETROLEUM HYDROCARBON
O&G = OIL AND GREASE
ND = NOT DETECTED

NOTE: * QUALITY CONTROL

Figure 2–15, Pumping Rate vs Time, HEW, Gravity Flow Test

LHAAP 18&24 Phase II Pilot Tests





WELL I.D.	DISTANCE FROM HEW (FT)	t=24hrs	t=48hrs	t=72hrs	t=96hrs	t=118hrs
AWD13	2 (ASSUME)	0.26	0.41	0.52	0.57	0.69
AWD14	30	0.17	0.31	0.44	0.49	0.60
AWD15	65	0.00	0.00	0.05	0.08	0.17

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-16
DISTANCE - DRAWDOWN GRAPH
GRAVITY FLOW TEST ON
HORIZONTAL EXTRACTION WELL
FEBRUARY 1995

DOW Dow Environmental

DESIGNED BY: A. B. ONK
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One sample of the extracted water was taken each day for laboratory analysis. The samples were analyzed for different parameters as indicated in Table 2-1. Table 2-10 presents a summary of detected parameters. The analtytical results are included in Appendix E.3

2.5.1.3 Interceptor Collection Trench Gravity Flow Test

The gravity flow test at the ICT occurred between June 13 and June 20, 1994. The test was preceded on June 11 and 12 with the installation of pumps and site preparation. Also, a sand free test and a step drawdown test were conducted at sumps 1, 2, and 3 on June 12, 1994. The sand free tests indicated that the ICT sections had been properly developed. The step drawdown tests resulted in the selection of 1.5, 2, and 3 gpm as the starter flow rates for the gravity test at sumps 1, 2, and 3, respectively. However, as can be seen from Figure 2-17 which shows the sustained pumping rate during the test at sumps 2 and 3, higher flow rates were achieved at both of these sumps. The last measured flow rates in these sumps were 4.2 gpm and 3.75 gpm, respectively. In order to evaluate the effect of pumping from sump 3 in ICT-1 on the surrounding area including sump 2 in ICT-2 and visa versa, pumping at sump 3 started on June 13 and ended on June 18, and pumping at sump 2 started on June 15 and ended on June 19. The flow rate at sump 1 decreased rapidly and could not be sustained. The pump at sump 1 was turned off on June 16, since little to no flow was being pumped out of it. The riser pipe for sump 1 was damaged during installation due to the difficulties encountered during the installation of ICT-2 as described in Section 2.3.3 above.

Figure 2-18 presents a distance-drawdown plot which reflects the positions of the cone of depression after pumping under a constant rate of 3 gpm at sump 3 for one hour, six hours, 12 hours, and 23 hours. This figure also shows that radius of influence (distance from the sump for zero drawdown) increased with time and was about 212 feet after 23 hours of pumping. However, the increase was minimal after 12 hours. Three time-drawdown graphs, along with transmisivity and storage coefficient calculations, are presented on Figures 2-19, 2-20, and 2-21 for monitoring wells AWD-10, AWD-16, and AWD-17, respectively. These graphs represent monitoring data in these wells, which are located along the north-south axis of sump 3, during the first day of pumping from sump 3 at a rate of 3 gpm. The calculated aquifer transimisivities, with an average of 507 gpd/ft, were smaller than the potential representative transmisivitty of 2,031 gpd/ft (see Section 2.5.1.1). This difference could be attributed to the fact that the theory assumes a homogeneous aquifer, which is not the case here due to the presence of coarse material in the trench compared to the fine natural soils at the site. Figure 2-22 also presents a distance-drawdown plot which reflects the positions of the cone of depression after pumping under a constant rate of 4 gpm at sumps 2 and 3 for 24 hours, 48 hours, and 72 hours. As can be seen from this figure, the radius of influence was about 330 feet after 72 hours of pumping from both sumps. The graphs on Figure 2-23 present the measured drawdown using a data logger and transducers at several monitoring wells located near the ICT. The manual water level readings and the data logger readings are included in Appendices F.1 and F.2, respectively.

One sample of the extracted water was taken each day for laboratory analysis. The samples were analyzed for different parameters as indicated in Table 2-1. Table 2-11 presents a summary of detected parameters. The analytical results are included in Appendix F.3.

TABLE 2–10
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER ANALYSES DURING FLOW TESTING
DETECTED CONTAMINANTS AT HEW, in microgram/liter
MAY AND JUNE, 1994

DATE OF SAMPLING	VOLATILE ORGANIC COMPOUND	
	METHYLENE–CHLORIDE	TRICHLORO–ETHYLENE
05/29/94	28400	1600
05/30/94	991000	129000
05/31/94	875000	119000
06/01/94	767000	127000
06/01/94*	817000	120000
06/02/94	748000	107000
06/03/94	681000	99300
	* QUALITY CONTROL	

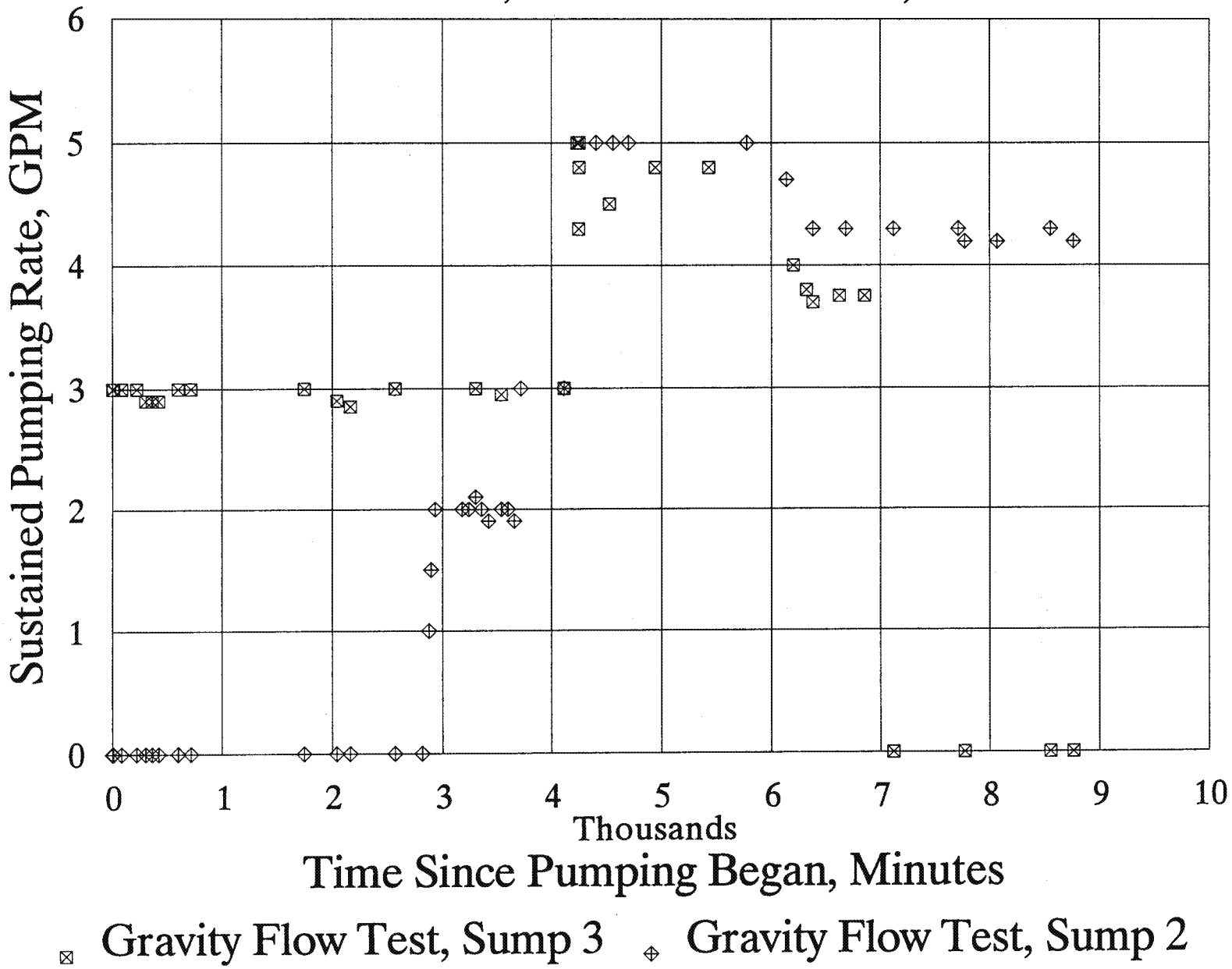
DATE OF SAMPLING	TOTAL METALS		TPH/OIL &GREASE	
	BARIUM	NICKEL	TPH	O&G
05/29/94	5250	68		
05/30/94	4780	71		
05/31/94	4500	70	ND	10900
06/01/94	4510	66		
06/01/94*	4540	74		
06/02/94	4360	63		
06/03/94	4150	56		
	* QUALITY CONTROL		ND = NON DETECT	

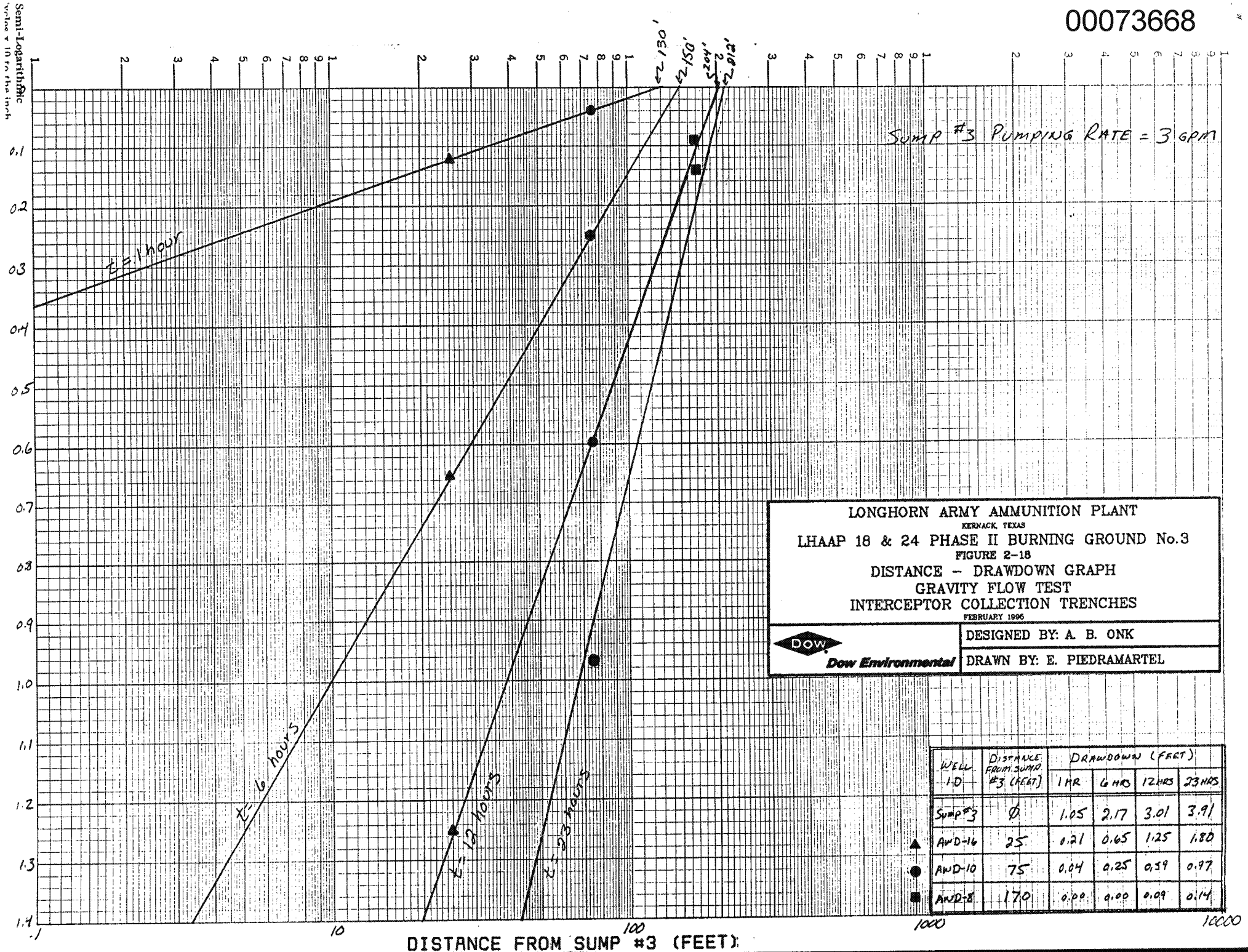
NOTE: SEMIVOLATILES WERE NOT DETECTED IN A SAMPLE TAKEN ON 05/31/94

DATE OF SAMPLING	WET CHEMISTRY							
	ALKALINITY	AMMONIA AS N	HARDNESS	SILICA	TDS	TSS	CHLORIDE	SULFATE
05/29/94						6000		
05/30/94						6000		
05/31/94	180000	21800	548000	38000	1840000	22000	1600000	19000
06/01/94						14000		
06/01/94*						12000		
06/02/94						12000		
06/03/94						12000		
	* QUALITY CONTROL							

Figure 2–17, Pumping Rate vs Time, ICT, Gravity Flow Tests

LHAAP 18&24, Phase II Pilot Tests, June 1994





LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-18
DISTANCE – DRAWDOWN GRAPH
GRAVITY FLOW TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1996

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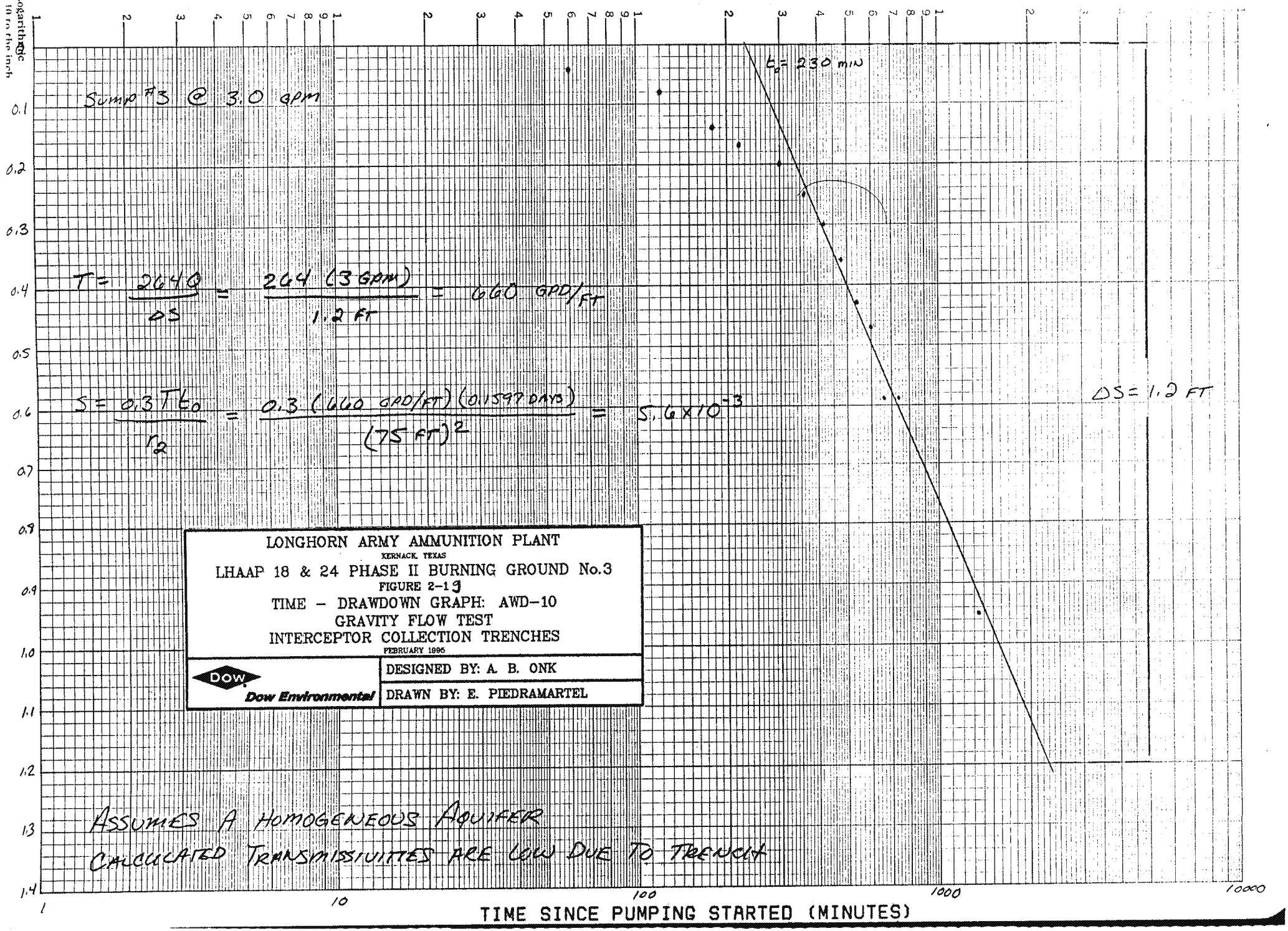
DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

WELL I.D.	DISTANCE FROM SUMP #3 (FEET)	DRAWDOWN (FEET) 1 HR	6 HRS	12 HRS	23 HRS
SUMP #3	Ø	1.05	2.17	3.01	3.91
▲ AWD-16	25	0.21	0.65	1.25	1.80
● AWD-10	75	0.04	0.25	0.59	0.97
■ AWD-8	170	0.00	0.00	0.09	0.14



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-19
TIME - DRAWDOWN GRAPH: AWD-10
GRAVITY FLOW TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1995

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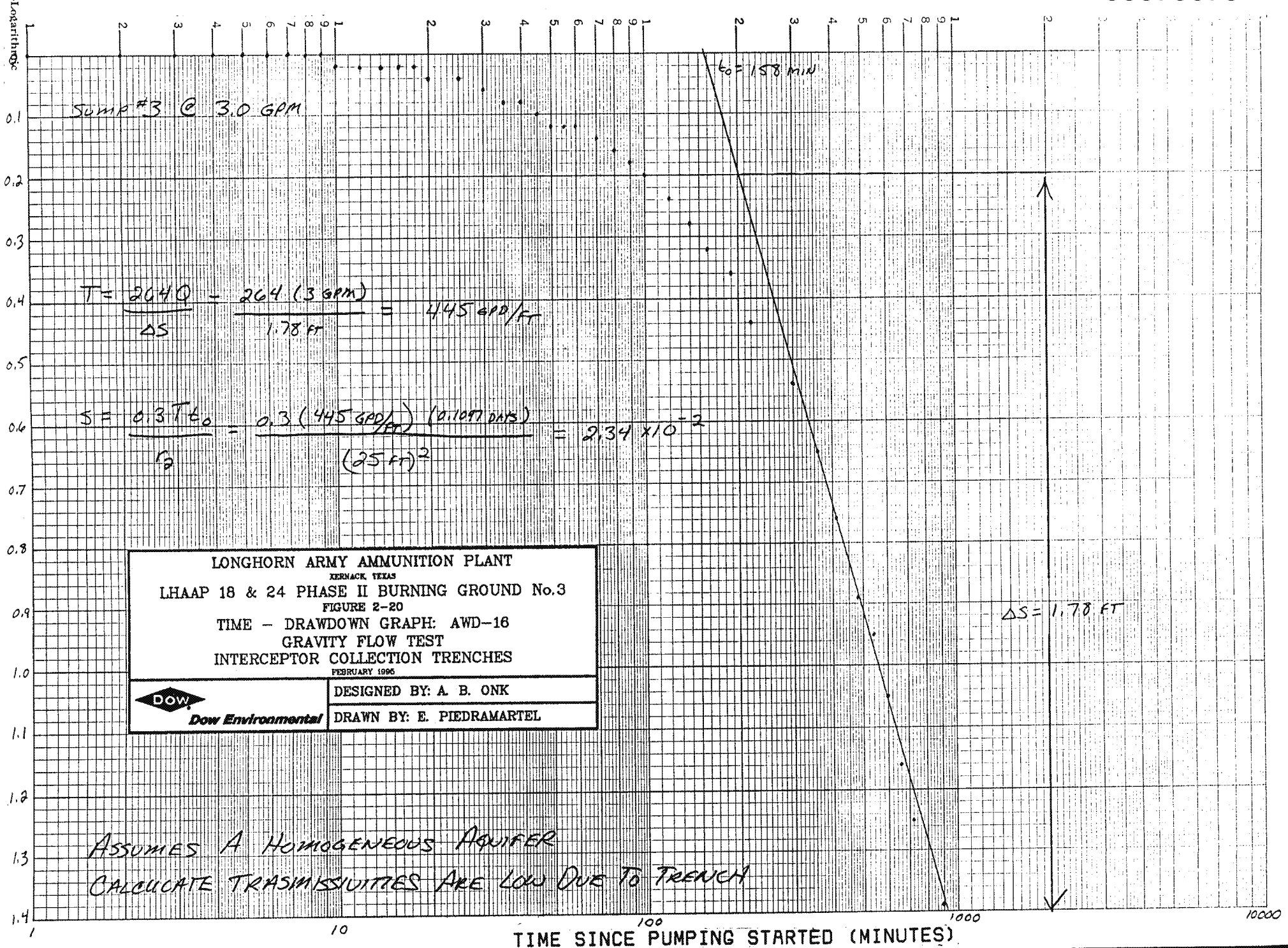
DRAWN BY: E. PIEDRAMARTEL

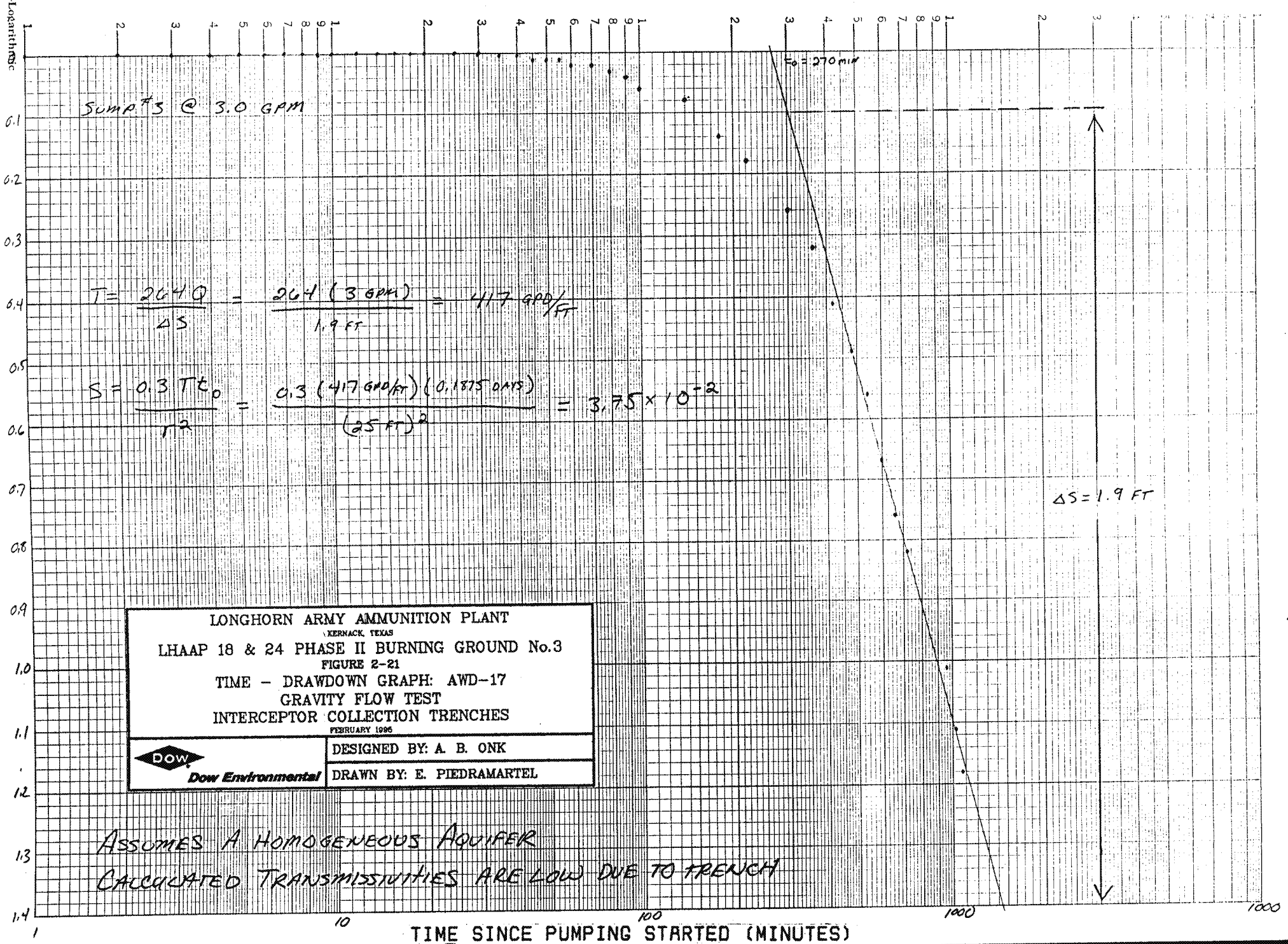


LONGHORN ARMY AMMUNITION PLANT
KERMACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-20
TIME – DRAWDOWN GRAPH: AWD-16
GRAVITY FLOW TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1995

Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

ASSUMES A HOMOGENEOUS AQUIFER
CALCULATE TRASMISSIVITIES ARE LOW DUE TO TRENCH

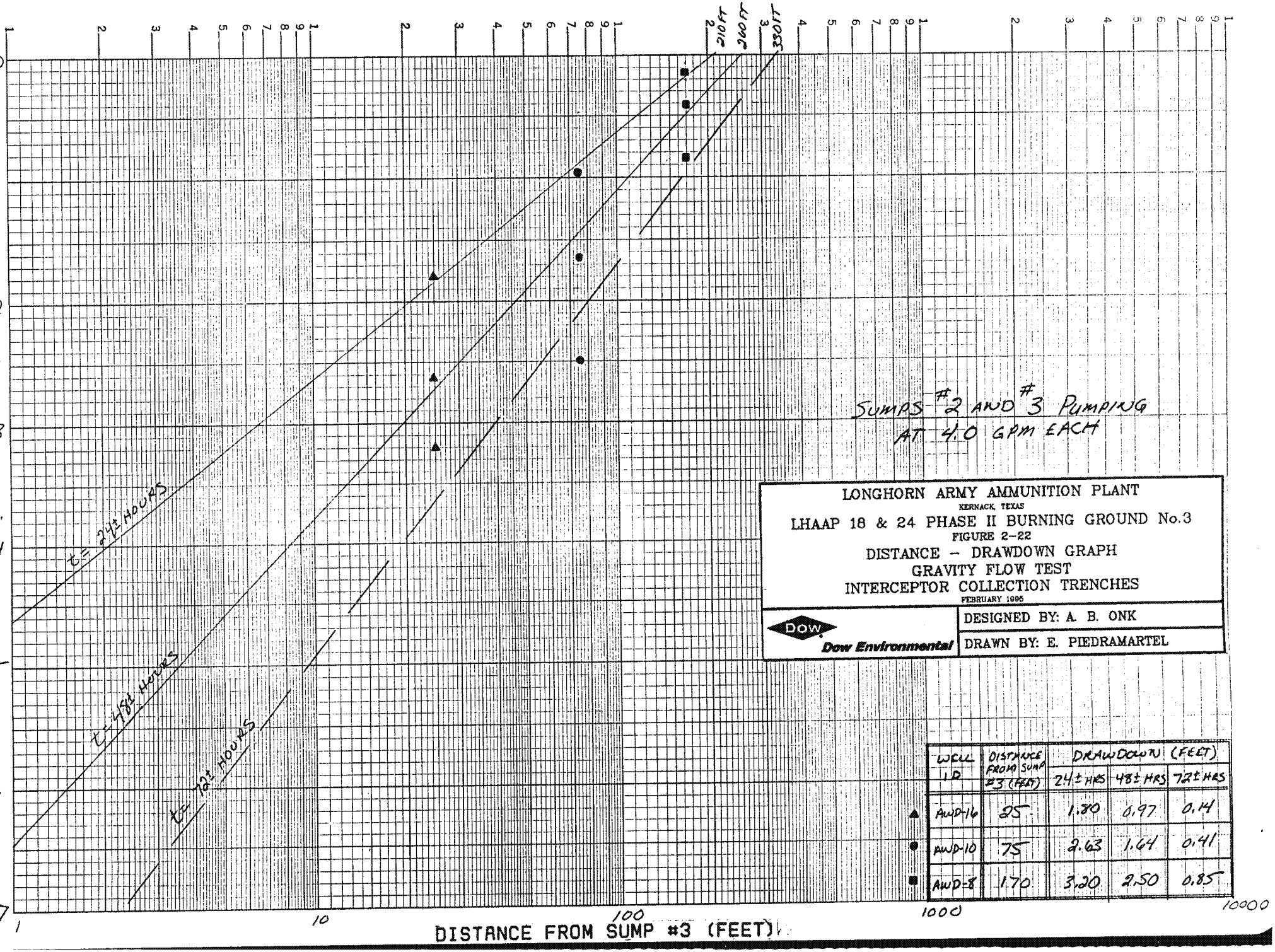


LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-21
TIME – DRAWDOWN GRAPH: AWD-17
GRAVITY FLOW TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1996

DOW Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

ASSUMES A HOMOGENEOUS AQUIFER
CALCULATED TRANSMISSIVITIES ARE LOW DUE TO TRENCH



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-22
DISTANCE - DRAWDOWN GRAPH
GRAVITY FLOW TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1995

DOW Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

	WELL I.D.	DISTANCE FROM SUMP #3 (FEET)	DRAWDOWN (FEET) 24± HRS	48± HRS	72± HRS
▲	AWD-16	25	1.80	0.97	0.14
●	AWD-10	75	2.63	1.64	0.41
■	AWD-8	170	3.20	2.50	0.85

Figure 2–23, Drawdown In Monitoring Wells During Gravity Flow Test at the ICT

LHAAP 18&24, Phase II Pilot Tests, June 1994

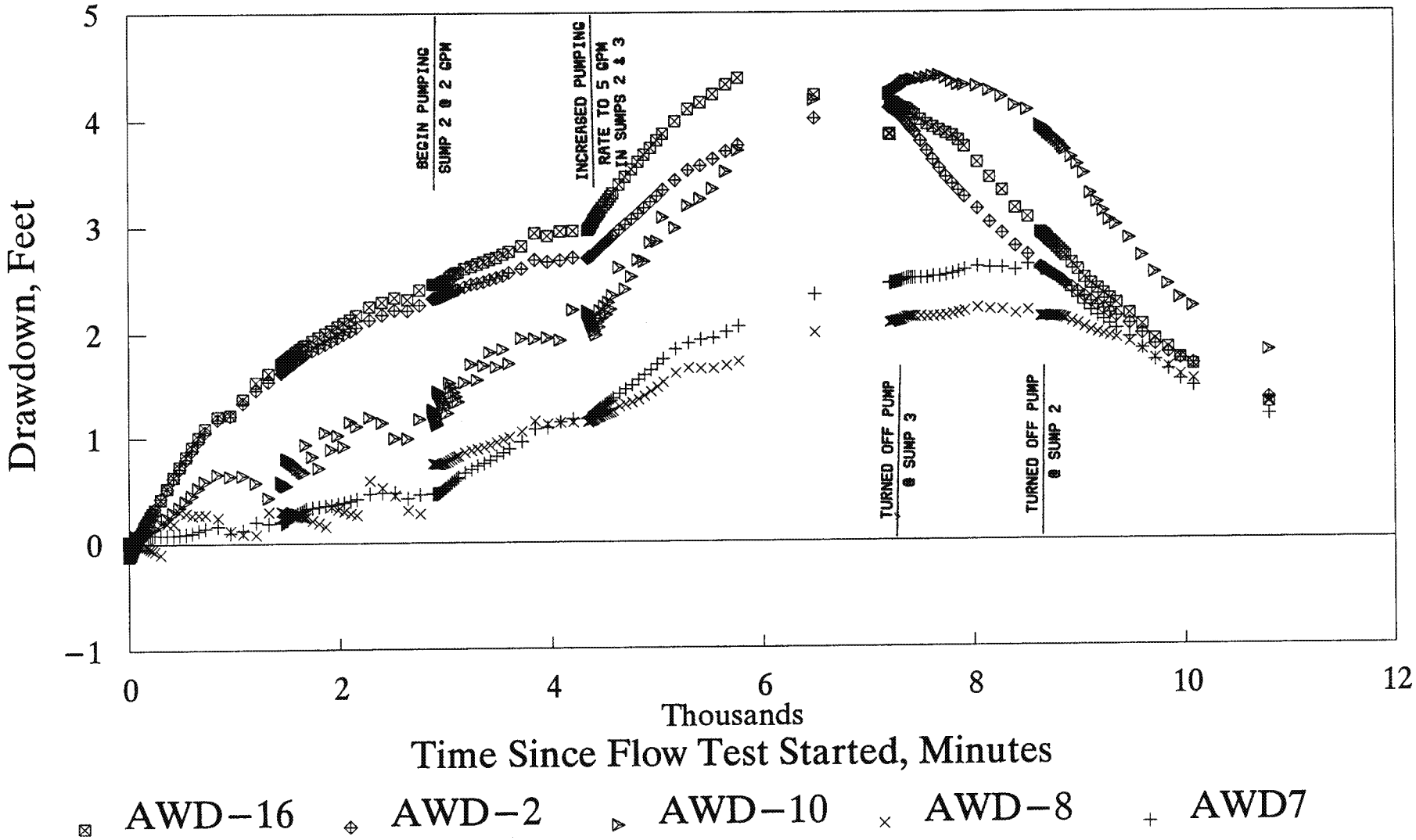


TABLE 2-11
LHAAP 18 & 25 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER ANALYSIS DURING FLOW TESTING
DETECTED CONCENTRATIONS IN THE ICT SUMPS, in micrograms/liter
June, 1994

DATE OF SAMPLING	SUMP NO.	VOLATILE ORGANIC COMPOUNDS						SEMI-VOLATILES		TOTAL METALS			
		MEC	TCE	1,2-DCA	2-BUTANONE	ACETONE	CF	4-Methyl-phenol	PHENOL	ARSENIC	BARIUM	LEAD	NICKEL
6/14/94	3	1700	640	ND	ND	ND	ND	640	220	ND	1130	10	84
6/15/94	1&3	1977	2379	ND	ND	1035	ND			16	869	16	73
6/16/94	2&3	3896	1753	ND	ND	ND	ND			8	1090	ND	62
6/16/94	2&3 QC									8	110	ND	63
6/17/94	2&3	8785	4485	330	277	750	ND			8	98	6	52
6/18/94	2&3	19452	9220	1416	ND	ND	ND			ND	830	ND	ND
6/19/94	2	47	639	ND	ND	589	ND			14	1220	ND	65
6/24/94	2	ND	840	42	ND	708	15			14	1180	ND	54
6/25/94	2	11162	6680	ND	ND	ND	ND			11	690	7	ND
6/26/94	2&3	13784	7583	ND	ND	ND	ND			ND	564	6	ND
6/27/94	2&3	21511	12140	ND	ND	ND	ND			10	557	ND	ND
6/28/94	2&3	22379	11979	ND	ND	ND	ND			12	623	7	ND
6/28/94	2&3 QC	20675	10844	ND	ND	ND	ND			11	626	7	467

DATE OF SAMPLING	SUMP NO.	WET CHEMISTRY PARAMETERS										
		ALKALINITY	NH4 as N	HARDNESS as CaCO3	SILICA	TDS	TSS	OIL/GREASE	CHLORIDE	NITRATE	NITRITE	SULFATE
6/14/94	3	310000	720	572000	44200	1430000	ND	87400	300000	10000	1000	500000
6/15/94	1&3						ND					
6/16/94	2&3						ND					
6/16/94	2&3 QC						ND					
6/17/94	2&3						ND					
6/18/94	2&3						ND					
6/19/94	2						ND					
6/24/94	2						28000					
6/25/94	2						36000					
6/26/94	2&3						46000					
6/27/94	2&3						32000					
6/28/94	2&3						32000					
6/28/94	2&3						32000					

NOTE:
MEC = Methylene Chloride
TCE = Trichloroethene
TDS = Total Dissolved Solids
1,2-DCA = 1,2-Dichloroethane
4-MP = 4-Methylphenol
TSS = Total Suspended Solids
CF = Chloroform
NH4 as N = Ammonia as N
ND = none detected

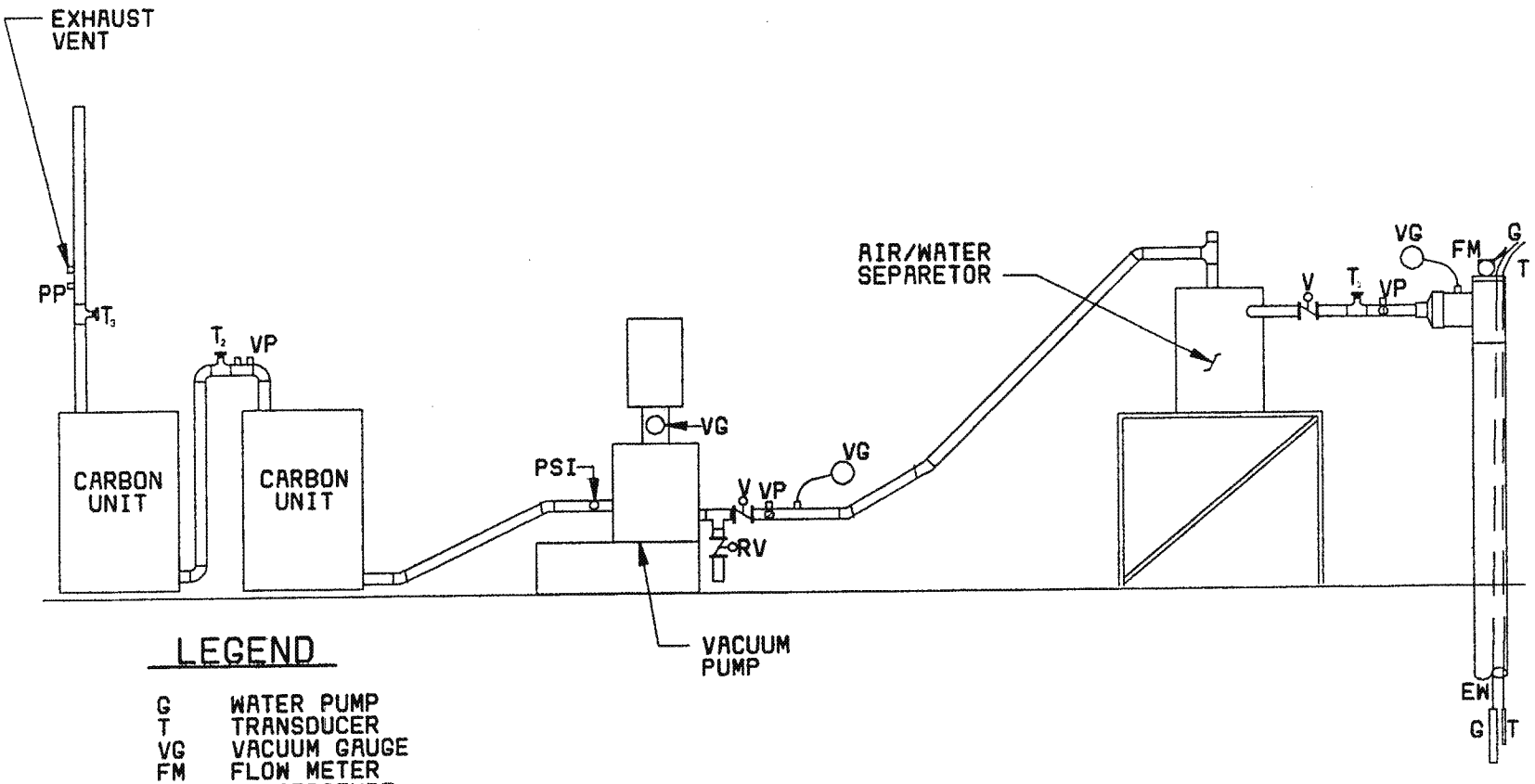
2.5.2 Vacuum Enhanced Liquid Extraction

Vacuum enhanced liquid extraction (VELE) was performed on the VEW, HEW, and ICT following the completion of the gravity flow tests at each of the extraction systems and after the water levels had stabilized for two days. The VELE was conducted on each extraction system separately. The VELE test provided data on the potential of increasing the groundwater flow in the aquifer toward the extraction systems. Groundwater flow and drawdown monitoring were conducted during the VELE tests as discussed in Section 2.5.1 above. In addition Extracted vapor concentrations and obtainable vapor flow rates were collected from this test. However, the radius of influence of the vacuum pressures and soil permeability to air flow could not be calculated since no differential pressure readings were observed in the closest monitoring wells to any of the groundwater extractions systems. This lack of response to the vacuum pressures in the monitoring wells is due to the low permeability (fine) soils of the surface aquifer at the site. It also supports the decision made about not evaluating in situ vapor extraction as a potential technology for source material and soil treatment, during the planning of Phase I of the IRA.

The system for the test included the extraction well(s), observation wells, piping, an air blower, flow meter and controllers, vacuum gauges, sampling ports, an air/water separator, and a vapor treatment system consisting of two 55-gallon activated carbon canisters installed in series. Four canisters were used and then stored at the TSSA. Figure 2-24 shows a schematic of the system used for the VEW which was similar to the ones used later for the HEW and ICT.

2.5.2.1 Vertical Extraction Well VELE Test

The VELE test at the VEW was run under three different vacuum pressures applied at the well head as shown on Figure 2-24. These pressures were 70, 110, and 90 inches of water. In addition to the groundwater flow and drawdown monitoring discussed in Section 2.4.1.2 above, test monitoring included vapor flow rates, temperatures and pressure readings, and vapor sampling for every applied pressure. Figure 2-25 presents the sustainable flow rate with time for all three vacuum pressures. It also compares sustainable flow rates during the gravity with those during the VELE test. As can be seen from Figure 2-25, the flow rate during VELE was higher than during gravity flow testing. The difference was greater when the 70 and then the 110 inches of water vacuum were first applied. However, this difference decreased with time which may imply that in the long term VELE and gravity flow would yield similar flow rates. As can also be seen from Figure 2-25, higher vacuum (110 inch of water) did not result in either higher or stable flow rate after few hours from applying this rate of pressure. A lower vacuum rate, such as 90 inches of water, appeared to generate a more stable flow condition than the 110 inches of water. Figure 2-26 through 2-28 show plots of drawdown vs distance from the pumping well, and drawdown vs time at monitoring wells MW-2 and AWD-5, respectively. Figure 2-26 shows the positions of the cone of depression after pumping 6 hours, 12 hours, 18 hours, and 24 hours under 70 inches of water vacuum. This figure also shows that the radius of influence due to the withdrawal of water from EW-1 was about 205 feet which is 165 feet less than the radius of influence measured during the gravity flow test at the same well and after the same period of pumping. However, the drawdown in adjacent wells (AWD-5, MW-2, and AWD-6) was about twice what it was during the gravity flow test after 24 hours of pumping. Therefore, the data indicates that the influence from VELE was mainly in the vicinity of the well, and that by having a shorter radius of influence, additional wells may be needed to capture the plume and create a hydraulic barrier under VELE. The manual water level readings and the



LEGEND

G	WATER PUMP
T	TRANSDUCER
VG	VACUUM GAUGE
FM	FLOW METER
T_2	TEMPERATURE
V	VALVE
VP	VACUUM PORT
PP	PRESSURE PORT
RV	RELIEF VALVE

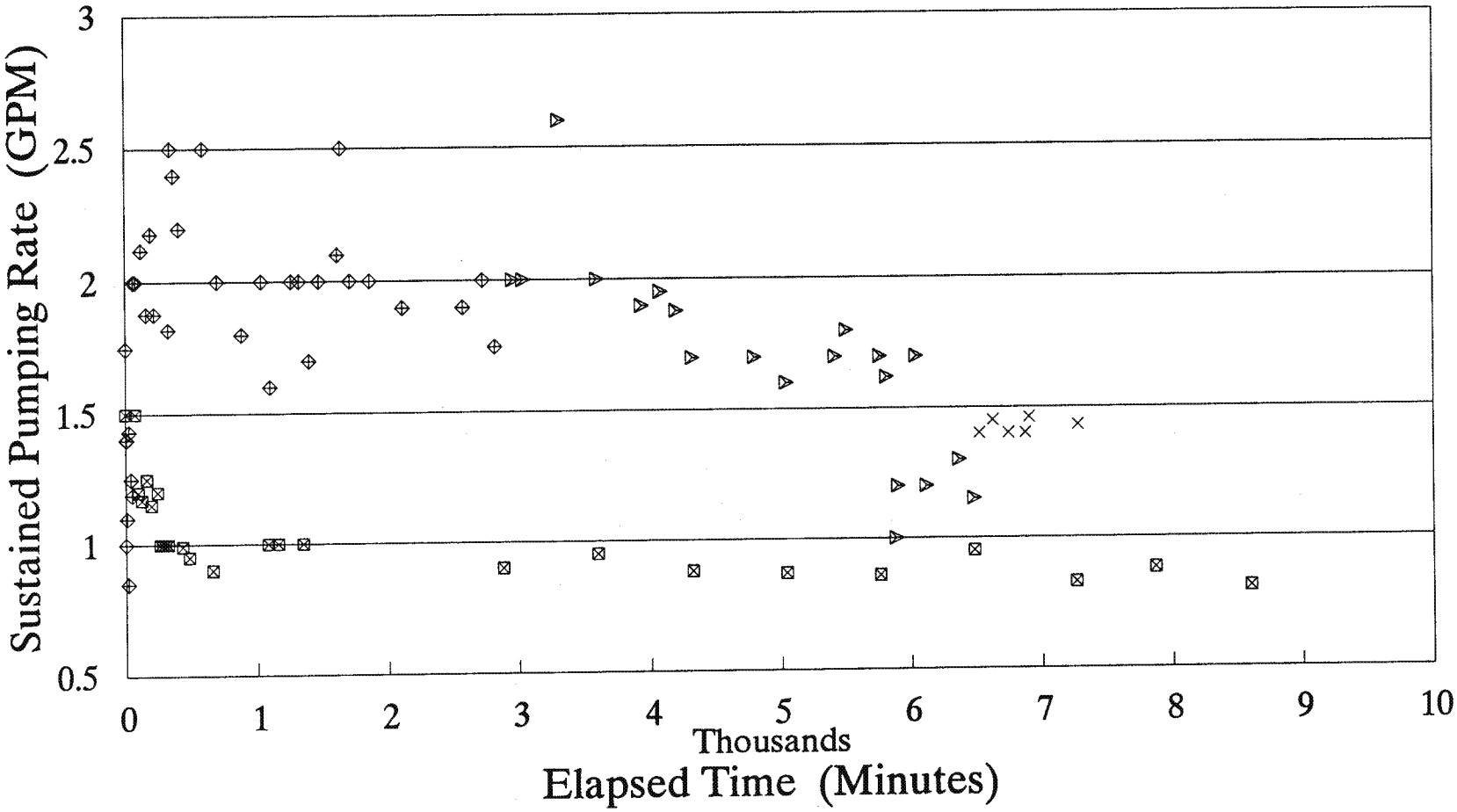
LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No.3
FIGURE 2-24
VACUUM APPLICATION SCHEMATIC
FEBRUARY 1995

Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: S. HANLON

Figure 2–25, Pumping Rate vs. Time, Vertical Extraction Well, EW–1

LHAAP 18&24 Phase II Pilot Tests

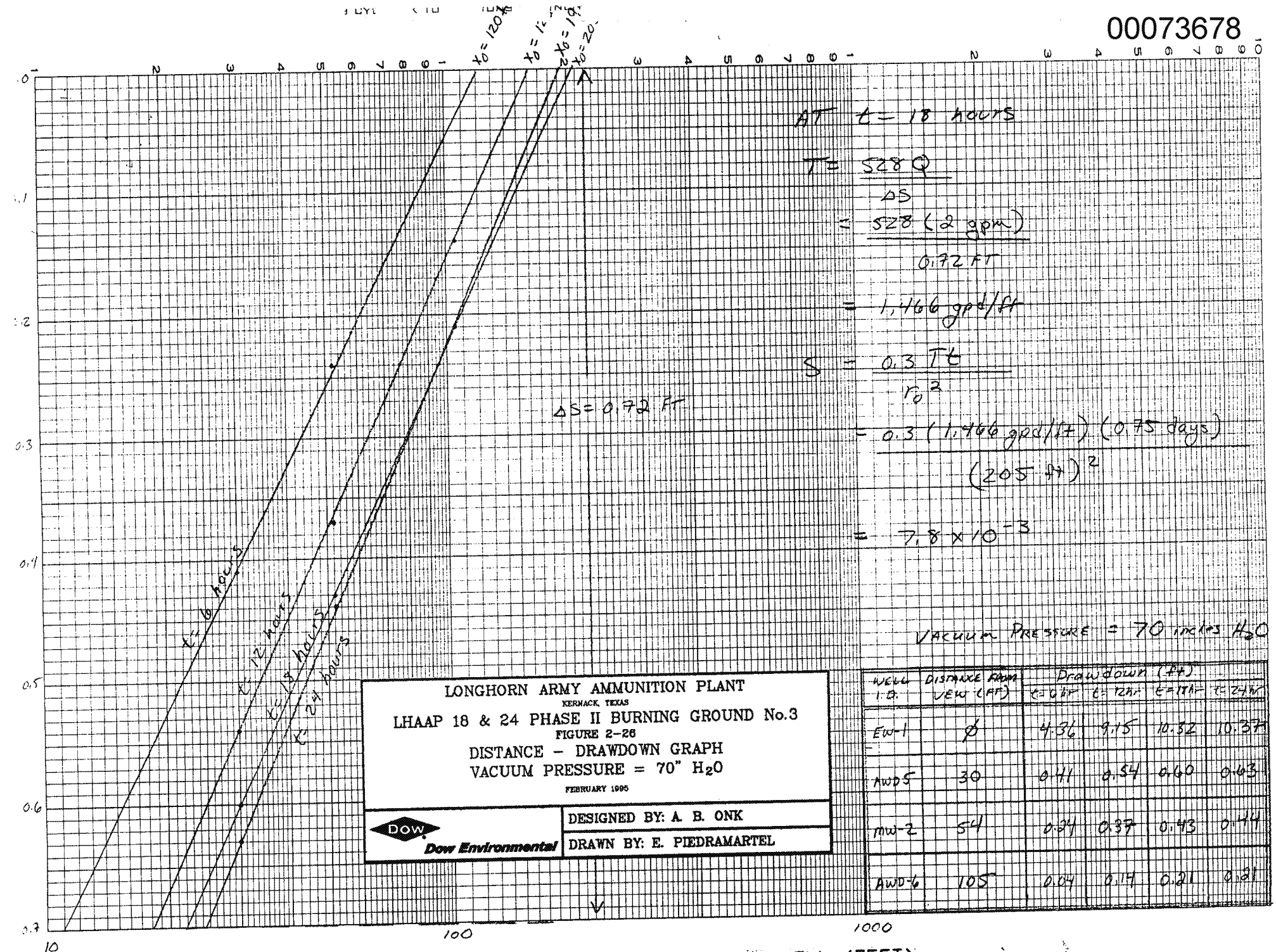


Gravity Flow Test

VELE Test Under 70" of H2O Vacuum

VELE Test Under 110" of H2O Vacuum

VELE Flow Under 90" of H2O Vacuum



AT $t = 18$ hours

$$T = \frac{528\,Q}{\Delta S} = \frac{528\,(2\text{ gpm})}{0.72\text{ FT}} = 1{,}466\text{ gpd/ft}$$

$$S = \frac{0.3\,Tt}{r_0^2} = \frac{0.3\,(1{,}466\text{ gpd/ft})\,(0.75\text{ days})}{(205\text{ ft})^2} = 7.8 \times 10^{-3}$$

VACUUM PRESSURE = 70 inches H_2O

WELL I.D.	DISTANCE FROM VEW (FT)	Drawdown (ft) t = 6 hr	t = 12 hr	t = 18 hr	t = 24 hr
EW-1	Ø	4.36	9.15	10.52	10.37
AWD5	30	0.41	0.54	0.60	0.63
MW-2	54	0.24	0.37	0.43	0.44
AWD-6	105	0.04	0.14	0.21	0.21

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-26
DISTANCE - DRAWDOWN GRAPH
VACUUM PRESSURE = 70" H_2O
FEBRUARY 1995

DOW Dow Environmental

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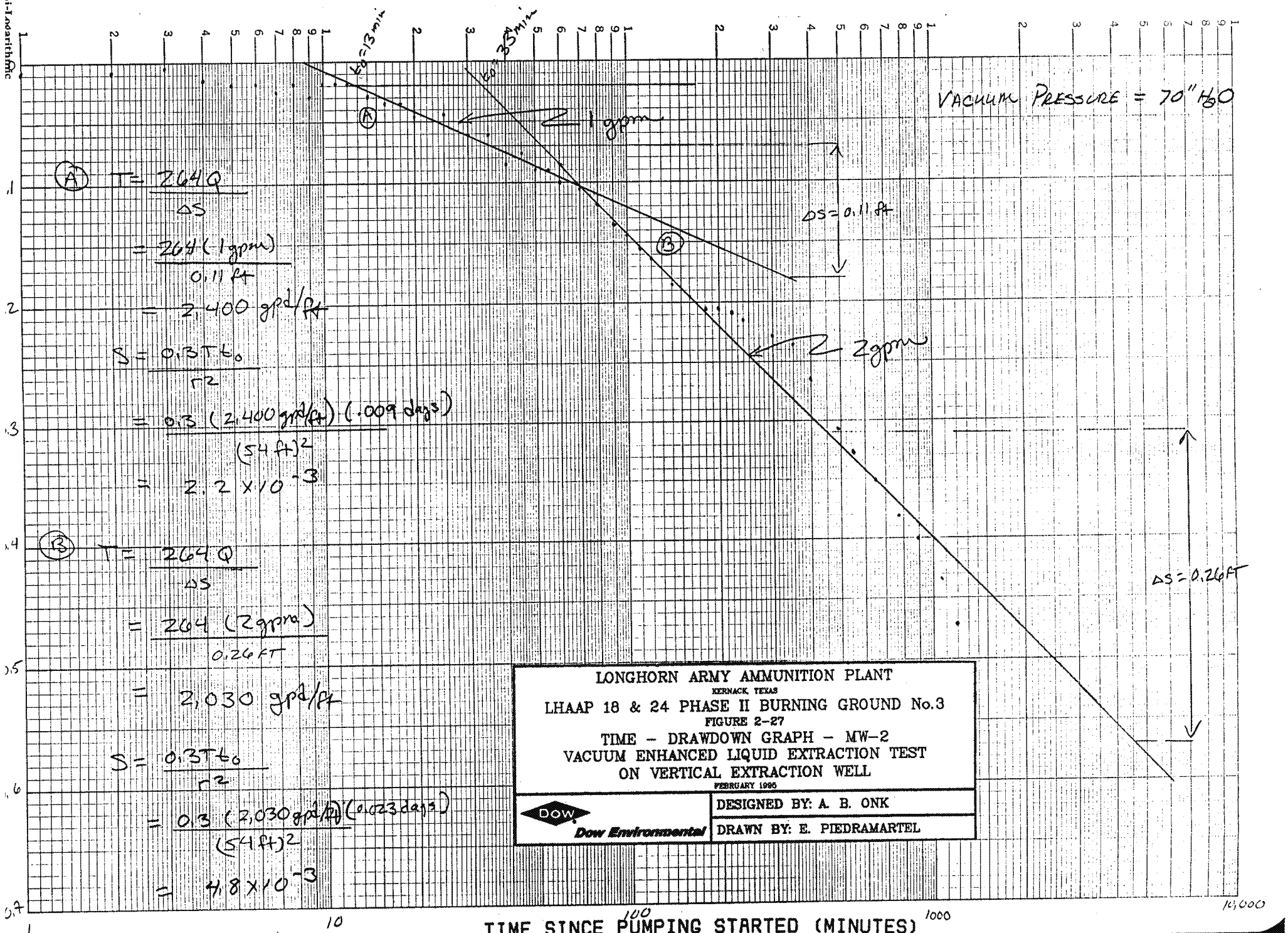
DRAWN BY: E. PIEDRAMARTEL



(A) $T = \frac{264Q}{\Delta S}$

$= \frac{264(1\text{ gpm})}{0.11\text{ ft}}$

$= 2{,}400\text{ gpd/ft}$

$S = \frac{0.3Tt_0}{r^2}$

$= \frac{0.3(2{,}400\text{ gpd/ft})(.009\text{ days})}{(54\text{ ft})^2}$

$= 2.2 \times 10^{-3}$

(B) $T = \frac{264Q}{\Delta S}$

$= \frac{264(2\text{ gpm})}{0.26\text{ FT}}$

$= 2{,}030\text{ gpd/ft}$

$S = \frac{0.3Tt_0}{r^2}$

$= \frac{0.3(2{,}030\text{ gpd/ft})(0.023\text{ days})}{(54\text{ ft})^2}$

$= 4.8 \times 10^{-3}$

LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-27
TIME - DRAWDOWN GRAPH - MW-2
VACUUM ENHANCED LIQUID EXTRACTION TEST
ON VERTICAL EXTRACTION WELL
FEBRUARY 1995

DOW Dow Environmental

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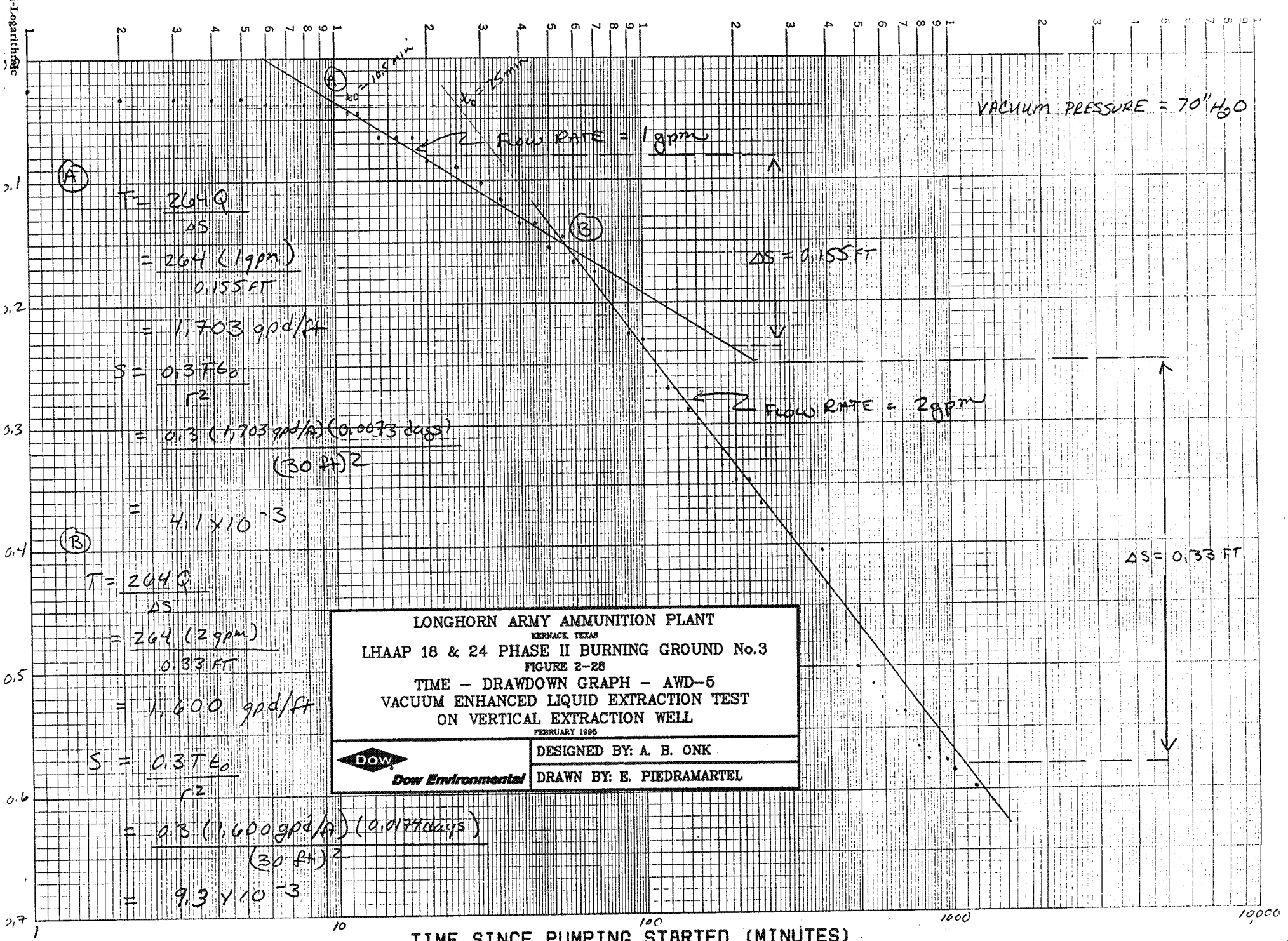
DRAWN BY: E. PIEDRAMARTEL



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-28
TIME – DRAWDOWN GRAPH – AWD-5
VACUUM ENHANCED LIQUID EXTRACTION TEST
ON VERTICAL EXTRACTION WELL
FEBRUARY 1995

DOW Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

data logger readings for this test are included in Appendices G.1 and G.2, respectively.

As during the gravity flow test, one sample of the extracted water was taken each day for laboratory analysis. Detected parameters are listed in Table 2-9. The analytical results for the groundwater samples are included in Appendix G.3.

Air flow and vacuum rates were continuously monitored at the well head using a flow meter and vacuum gauges, respectively. Temperature readings were also made from sensors located at the well head and after each carbon canister. The data for this monitoring is included in Appendix G.4. A vapor/air sample was collected for laboratory analysis from three different sampling ports on a daily basis. The ports were located at the extraction well head and after each carbon unit. One background air sample was taken on May 19, 1994 at a location about 400 feet upwind from the well. The samples were analyzed as listed for VOCs in Table 2-1 by PDP. No VOCs were detected in the background sample. The only detected contaminant from the VEW samples was trichloroethylene in concentrations of 29 ppb and 79 ppb in samples collected at the well head on May 22 and May 24, respectively. The analytical reports are included in Appendix G.5.

2.5.2.2 Horizontal Extraction Well VELE Test

The VELE test at the HEW was not successful due to mechanical and electrical supply problems. Two attempts were made to run VELE at the HEW. The first attempt took place on June 9, 1994. The VELE test was started at 18:00 hours at a vacuum rate of 50 inches of water. However, at 19:00 the system shut down due to a generator problem and failure of the vacuum pump. The groundwater pumping rate during this one hour of VELE application decreased from about one gpm at the beginning of the test to about 0.5 gpm at the system shut down. The generator was fixed by an electrical contractor, and a new vacuum pump was installed on June 10, 1994. The second attempt at applying VELE started at 16:15 hours on June 10, 1994. However, this attempt was interrupted by the failure of the second vacuum pump at 20:40 hours on the same date. The groundwater flow rate at the system shut down was about 0.5 gpm. It was difficult to pin point the reason for the failures of the vacuum pumps, and a decision was made by the USACE Tulsa District onsite representative and DEI to abandon the test at the HEW for the time being and to start the gravity flow test at the ICT. The high flow rates encountered during the testing of the ICT, which showed that an ICT system would be more effective at the site than a series of HEWs under either gravity or VELE flow conditions, and schedule constraints resulted in the elimination of another attempt at applying VELE at the HEW.

The manual water level readings and the data logger readings for this limited test are included in Appendices H.1 and H.2, respectively. Due to the short periods under which this test was run, which were mainly late in the day or at night, air and groundwater samples were not collected for laboratory testing. The equipment set up for this test was similar to the one shown on Figure 2-24.

2.5.2.3 Interceptor Collection Trench VELE Test

The VELE test at sumps 2 and 3 of the ICT occurred between June 22 and July 1, 1994. Prior to applying any vacuum to either sump, gravity flow pumping at the rate of 4 gpm was used to lower the water level in the trenches and surrounding areas for about 24 hours. This lowering

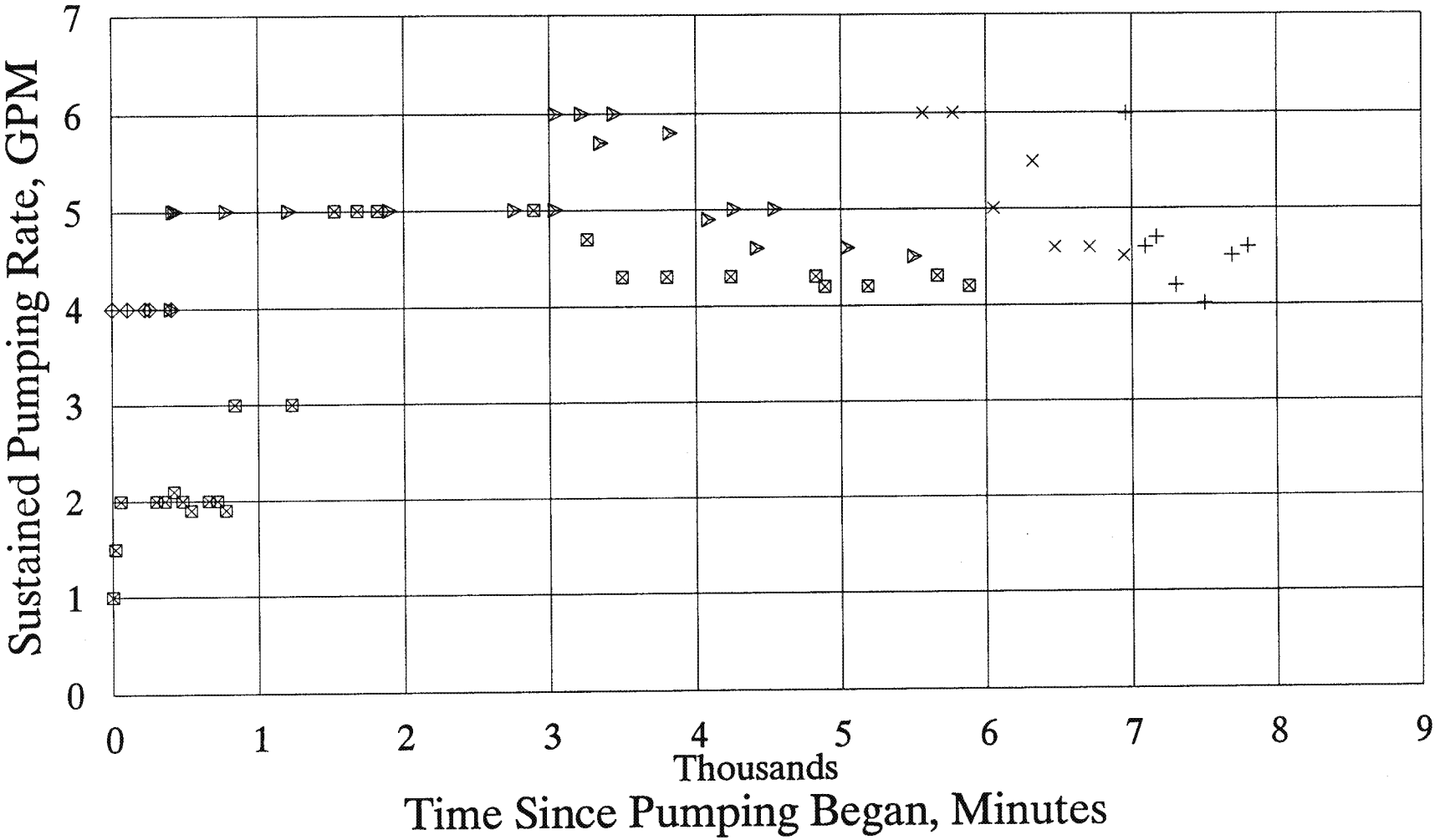
of the water level, mainly in the two sumps was deemed essential in order to prevent the water from being pulled into the VELE piping system under vacuum.

A vacuum pressure of 50 inches of water was applied at sump 3 located in section ICT-1 on June 23, 1994 at 16:30 in the afternoon. However, by 17:07 hours on the same day the groundwater pump in this sump shutoff. At that time, the vacuum was turned off, and the malfunctioning pump was replaced. Prior to replacing the pump, the sump was redeveloped to sand free conditions, since it was realized by the monitoring geologist that sand may have been pulled into the sump under the vacuum pressures. Groundwater pumping was restarted at sump 3 on June 24, 1994 at 10:49 hours, and 50 inches of vacuum was reapplied at 19:00 hours on the same date. However, the newly installed pump also shut off three hours after reapplying vacuum at sump 3. This problem at sump 3 continued throughout the duration of the VELE test. Groundwater pumping and vacuum applications were discontinued on June 28, 1994 at 12:00 hours. The problems at sump 3 during the VELE may be attributed to the geocomposite that was installed along the center line of the trench section or possibly to a crack in the sump HDPE casing. As discussed above in Section 2.4.3, the HDPE pipe used as the sumps riser in the ICT section was flexible and was difficult to maintain under the slurry pressure and the sand backfill. The presence of the geocomposite, which acted like a conduit for vacuum pressures throughout the trench and possibly contributed to vacuum pressure loss, required the application of the maximum available vacuum pressure at the vacuum pump, about 175 inches of water, in order to achieve a vacuum pressure of 50 to 60 inches of water at the sump. Vacuum was applied at the rate of 50 inches of water to vents 9 and 10, installed at ICT-1, as shown on Figure 2-8, along with sump 3 in order to investigate the possibility of increasing the groundwater flow rate toward sump 3, on June 27, 1994 at 09:25. However, up to 12:05 hours on the same date, the water level available water for pumping in sump 3 did not change which implied that the vacuum at the vents would not improve the outcome of the VELE test at sump 3. Vacuum to vents 9 and 10 was turned off at 12:05. Following this, Vent 9 was opened to the atmosphere in order to investigate the potential for also improving the flow rate toward sump 3. However, this action caused an immediate loss of vacuum in the system due to the presence of the geocomposite in ICT-1 which acted like a conduit in the entire trench section. Vent 9 was immediately closed following the loss of vacuum in the system. Therefore, it was determined that the additional vents placed for the application of vacuum or to open to atmosphere would not be beneficial for trench sections similar to ICT-1.

The test at Sump 2 located in section ICT-2 was run under three different vacuum pressures applied at the sum riser head from June 23 to June 29. These pressures were about 50, 75, and 95 inches of water. No mechanical and or vacuum leakage problems were encountered during the application of vacuum at sump 2. Figure 2-29 presents the sustainable flow rate with time for all three vacuum pressures at sump 2. It also compares sustainable flow rates during the gravity with those during the VELE test. As can be seen from Figure 2-29, the flow rate following the application of a particular vacuum rate was higher than during gravity flow testing. However, this difference decreased with time and became negligible which may imply that in the long term VELE and gravity flow would yield equivalent flow rates in a similar ICT. Figure 2-30 shows plots of drawdown vs distance in monitoring wells adjacent to the ICT sections. These plots, which would consist of straight lines under gravity flow testing conditions, do not reflect a clear trend which may be due to the turbulent conditions created by applying vacuum at the sumps. The manual water level readings and the data logger readings for this test are included in Appendices I.1 and I.2, respectively.

Figure 2−29, Pumping Rate vs Time, ICT, VELE Tests @ Sump 2

LHAAP 18&24, Phase II Pilot Tests, June 1994



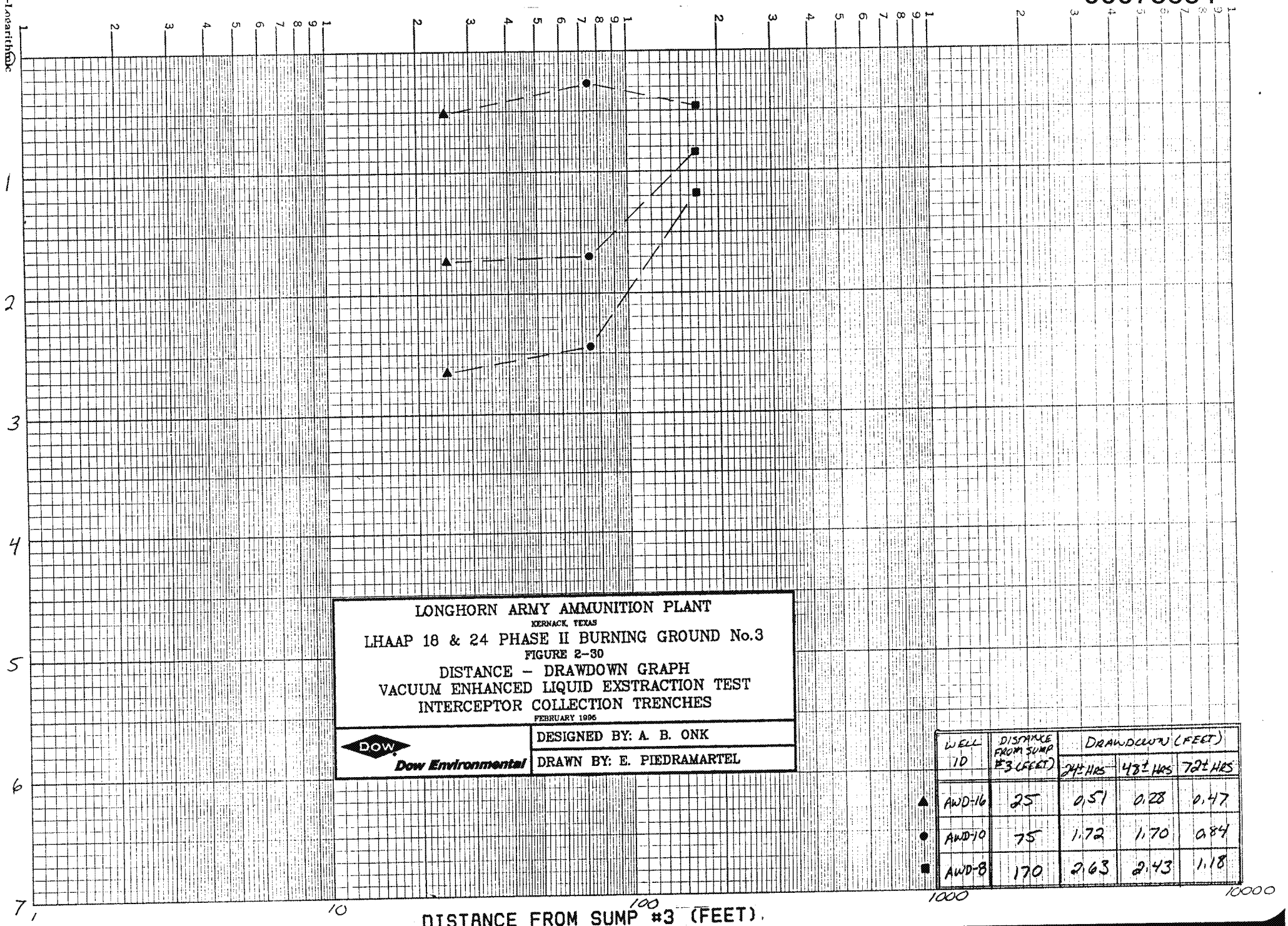
Gravity Flow Test

VELE Under 0 " of H2O Vacuu

VELE Under 50" of H2O Vacuu

VELE Under 75" of H2O Vacuu

VELE Under 100" of H2O Vacu



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
LHAAP 18 & 24 PHASE II BURNING GROUND No.3
FIGURE 2-30
DISTANCE - DRAWDOWN GRAPH
VACUUM ENHANCED LIQUID EXSTRACTION TEST
INTERCEPTOR COLLECTION TRENCHES
FEBRUARY 1996

DOW
Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: E. PIEDRAMARTEL

	WELL ID	DISTANCE FROM SUMP #3 (FEET)	DRAWDOWN (FEET) 24± HRS	48± HRS	72± HRS
▲	AWD-16	25	0.51	0.28	0.47
●	AWD-10	75	1.72	1.70	0.84
■	AWD-8	170	2.63	2.43	1.18

As during the gravity flow test, one sample of the extracted water was taken each day for laboratory analysis. Detected parameters are listed in Table 2-11. The analytical results for the groundwater samples are included in Appendix I.3.

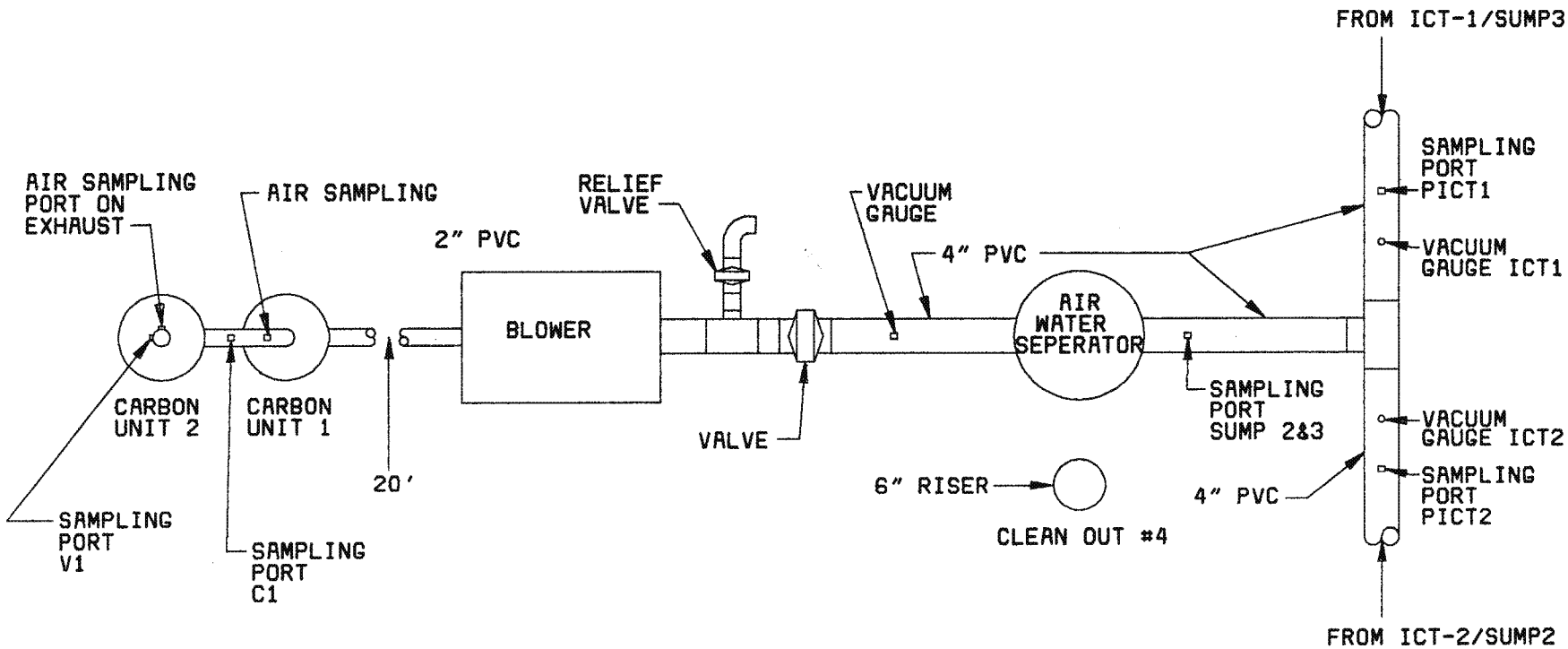
Air flow and vacuum rates were continuously monitored at the sumps head and other sampling ports using a flow meter and vacuum gauges, respectively. Temperature readings were also made from sensors located at the well head and after each carbon canister. The data for this monitoring is included in Appendix I.4. A composite vapor/air sample was collected for laboratory analysis from different sampling ports on a daily basis. The sampling ports locations are shown on Figure 2-31 which shows the equipment set-up for the VELE test at the ICT. One background air sample was taken on June 28, 1994 at a location about 500 feet upwind from the ICT. The samples were analyzed as listed for VOCs in Table 2-1 by PDP. No VOCs were detected in the background sample. Table 2-12 presents detected concentrations from the samples taken at the ICT. The analytical reports are included in Appendix I.5.

2.6 Task 6 - Groundwater Sampling, July-August and October-November 1994

Groundwater sampling was performed at EW-1 and 48 monitoring well locations, following the completion of the flow tests at the VEW, HEW, and ICT in July and August 1994. It was also performed in October-November 1994. The objective of this sampling program was to obtain a "snapshot" of the existing contaminant plume condition following the implementation of the Phase II work, and as part of quarterly sampling program. The well locations are shown on Figure 2-1. The analytical testing program for groundwater samples is presented in Table 2-1. Groundwater sampling and testing were performed in accordance with the protocols outlined in the Phase I Chemical Data Acquisition Plan (CDAP). The analytical testing was conducted by PDP Analytical Services (PDP) of Spring, Texas.

For the July-August sampling round, the groundwater plume, with methylene chloride and trichloroethylene as the main contaminants, was found to have decreased in area, especially outside the Burning Ground No. 3 fence. Field measurements taken during this round of groundwater sampling during this sampling round are included in Appendix J.1. Detected contaminant concentrations are presented in Tables 2-13 and 2-14. The analytical data is included in Appendix J.2, and the validated analytical data is included in Appendix J.3.

For the October-November sampling round, the plume condition was found to be similar to what it was during July-August. Field measurements taken during groundwater sampling are included in Appendix K.1. Detected contaminant concentrations are presented in Tables 2-15 and 2-16. The analytical data is included in Appendix K.2, and the validated analytical data is included in Appendix K.3.



LONGHORN ARMY AMMUNITION PLANT
KERNACK, TEXAS
BURNING GROUND No.3
FIGURE 2-31
DETAIL OF BLOWER SETUP
V.E.L.E. ICT 1 & 2
NOT TO SCALE
MARCH 1995

Dow Environmental

DESIGNED BY: A. B. ONK
DRAWN BY: S. HANLON

TABLE 2-12
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF AIR/VAPOR MONITORING DURING VECE AT ICT/m
JUNE 1994
Detected VOC's in ppb

Sample ID	AIR/VAPOR from ICT			
Date Sampled	Acetone	Methylene Chloride	Trichloroethene	COMMENTS
6/24/94	ND	ND	ND	Sump 2 & 3
6/25/94	ND	ND	ND	Sump 2
6/26/94	ND	ND	54	Sump 2 & 3
6/27/94	118	54	259	Sump 2 & 3
6/28/94	ND	ND	17J	Sump 2
Sample ID	**C1 following first carbon unit**			
Date Sampled	Acetone	Methylene Chloride	Trichloroethene	COMMENTS
6/24/94	ND	ND	ND	
6/25/94	ND	ND	ND	
6/26/94	ND	ND	ND	
6/27/94	ND	ND	ND	
6/28/94	ND	ND	21J	
Sample ID	**V1 following second carbon unit**			
Date Sampled	Acetone	Methylene Chloride	Trichloroethene	COMMENTS
6/24/94	ND	ND	ND	
6/25/94	ND	ND	ND	
6/26/94	ND	ND	ND	
6/27/94	ND	ND	ND	
6/28/94	ND	ND	ND	
Sample ID	**BG Background Air**			
Date Sampled	Acetone	Methylene Chloride	Trichloroethene	COMMENTS
6/28/94	ND	ND	ND	

BG Background ND None Detected
J Compound Detected Below Method Detection Limits

TABLE 2–13
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, July 1994
DETECTED VOCs in microgram/liter

WELL No.	VOLATILE ORGANIC COMPOUNDS																
	MEC	TCE	1,1–DCA	1,1–DCE	1,2–DCA	VC	ACETONE	CF	PCE	1,2–DCE	EBZ	STYRENE	TOLUENE	BENZENE	XYLENES	CTC	1,1,1 TCA
126																	
MW22	1936	1490	ND	8	ND	66	ND	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW15	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2	26720000	284900	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EW1	26667	5467	ND	ND	ND	ND	10440	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW1	458250	49950	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4	12	907	11	ND	ND	141	ND	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW5	6	71	ND	ND	ND	13	ND	ND	ND	ND	ND	ND	NQ	ND	ND	ND	ND
MW6	23	45	ND	ND	ND	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW21	739600	10500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
109	ND	333	4	ND	ND	22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
125	ND	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123	20	14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD2	19953	9693	ND	ND	726	ND	ND	14	ND	ND	ND	ND	16	ND	ND	ND	ND
AWD3	105	1356	ND	ND	ND	ND	ND	ND	ND	ND	23	5	ND	ND	ND	26	ND
MW23	71	654	ND	ND	37	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C8																	
102	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	ND	20046	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW8	ND	7148	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
129	ND	2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW9	ND	2543	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD1	54650	87600	43	865	ND	640	ND	14	46	127	1662	295	49	12	49	ND	356
120	190279	25642	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW14	1224	6575	18	58	ND	ND	ND	ND	ND	7	ND	ND	ND	ND	ND	ND	ND
MW12	299	2935	14	20	ND	ND	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
130																	
MW18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW17	ND	31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW10	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW11	ND	165	ND	ND	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
124	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD4	ND	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW19																	
MW20																	
C1	249	118	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3	ND	788	9	7	ND	41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTE:
MEC = Methylene Chloride
TCE = Trichloroethene
1,1–DCA = 1,1–Dichloroethane
1,1–DCE = 1,1–Dichloroethene
1,2–DCA = 1,2–Dichloroethane
VC = Vinylchloride
CF = Chloroform
PCE = Tetrachloroethene
1,2–DCE = Total –1,2–Dichloroethene
EBZ = Ethylbenzene
CTC = Carbon Tetrachloride
1,1,1 TCA = 1,1,1 Trichloroethane
ND = Non–Detect

TABLE 2-14
LHAAP 18&24, BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, July 1994
METALS, mg/l

	METAL COMPOUND										
Well No.	Antimony	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium
126											
MW22	ND	ND	1.86	ND	0.03	ND	ND	0.065	ND	ND	ND
MW15	ND	ND	0.245	ND	ND	ND	ND	ND	ND	ND	ND
MW2	ND	ND	3.84	ND	ND	ND	ND	ND	ND	ND	ND
EW1	ND	ND	0.277	ND	0.012	ND	ND	ND	ND	ND	ND
MW1	ND	ND	4.55	ND	ND	ND	ND	ND	ND	ND	ND
MW4	ND	ND	0.158	ND	ND	ND	ND	ND	ND	ND	ND
MW5	ND	ND	1.27	ND	ND	ND	ND	0.044	ND	ND	ND
MW6	ND	0.006	0.918	ND	ND	ND	ND	ND	ND	ND	ND
MW21	ND	ND	5.25	ND	0.026	ND	ND	0.08	ND	ND	ND
101	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
109	ND	ND	0.878	ND	ND	ND	ND	ND	ND	ND	ND
125	ND	ND	0.094	ND	ND	ND	ND	ND	ND	ND	ND
123	ND	ND	0.174	ND	ND	ND	ND	ND	ND	ND	ND
AWD2	ND	ND	0.169	ND	0.018	ND	ND	ND	ND	ND	ND
AWD3	ND	ND	0.15	ND	0.185	ND	ND	0.083	ND	ND	ND
MW23	ND	ND	1.96	ND	0.042	ND	ND	0.2	ND	ND	ND
C4A	ND	ND	0.135	ND	ND	ND	ND	ND	ND	ND	ND
C4	ND	ND	0.176	ND	ND	0.005	ND	ND	ND	ND	ND
C5	ND	ND	0.074	ND	ND	0.006	ND	ND	ND	0.012	ND
C6	ND	ND	1.11	ND	ND	ND	ND	ND	ND	0.016	ND
C7	ND	ND	0.177	ND	ND	ND	ND	ND	ND	ND	ND
C9	ND	ND	0.28	ND	ND	ND	ND	ND	ND	ND	ND
C10	ND	ND	0.481	ND	ND	ND	ND	ND	ND	ND	ND
C3	ND	ND	0.906	ND	ND	ND	ND	ND	ND	0.01	ND
C8											
102	ND	ND	0.066	ND	ND	ND	ND	ND	ND	ND	ND
MW7	ND	ND	0.122	ND	ND	ND	ND	0.072	ND	ND	ND
MW8	ND	ND	0.242	ND	ND	ND	ND	ND	ND	ND	ND
129	ND	ND	0.125	ND	ND	ND	ND	ND	ND	ND	ND
MW9	ND	ND	0.046	ND	0.01	ND	ND	ND	ND	ND	ND
AWD1	ND	0.016	0.977	ND	ND	ND	ND	ND	0.01	ND	ND
120	ND	ND	0.178	ND	ND	ND	ND	ND	ND	ND	ND
MW14	ND	ND	1.17	ND	ND	ND	ND	ND	ND	ND	ND
MW12	ND	ND	0.236	ND	ND	ND	ND	0.057	ND	ND	ND
130											
MW18	ND	ND	0.253	ND	ND	ND	ND	ND	ND	ND	ND
MW17	ND	ND	0.334	ND	0.08	ND	ND	0.11	ND	ND	ND
MW13	ND	ND	0.447	ND	ND	ND	ND	ND	ND	ND	ND
C2	ND	ND	0.379	ND	ND	ND	ND	ND	ND	ND	ND
MW10	ND	ND	0.629	ND	ND	ND	ND	ND	ND	ND	ND
MW16	ND	ND	0.258	ND	ND	ND	ND	ND	ND	ND	ND
MW11	ND	ND	0.076	ND	ND	ND	ND	ND	ND	ND	ND
124	ND	0.008	0.059	ND	ND	ND	ND	ND	ND	ND	ND
AWD4	ND	ND	0.692	ND	0.093	ND	ND	ND	ND	ND	ND
MW19											
MW20											
C1	ND	ND	0.544	ND	ND	ND	ND	ND	ND	ND	ND
MW3	ND	ND	1.68	ND	ND	ND	ND	ND	ND	ND	ND

Note: ND = Non-Detect

TABLE 2-15
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, November 1994
DETECTED VOCs in microgram/liter

WELL No.	VOLATILE ORGANIC COMPOUND																
	MEC	TCE	1,1-DCA	1,1-DCE	1,2-DCA	VC	ACETONE	CF	PCE	1,2-DCE	EBZ	STYRENE	TOLUENE	BENZENE	XYLENES	CTC	1,1,1 TCA
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW22	ND	1200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW15	120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2	6848000	368800	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EW1	5497500	193300	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW1	362100	21414	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4	ND	845	ND	ND	ND	119	ND	ND	ND	134	ND	ND	ND	ND	ND	ND	ND
MW5	ND	92	ND	ND	ND	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6	ND	31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW21	615450	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
109	ND	380	ND	ND	ND	ND	ND	ND	ND	70	ND	ND	ND	ND	ND	ND	ND
125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD2	3665	6510	ND	ND	460	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD3	689	264	ND	ND	ND	ND	548	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW23	ND	753	ND	ND	ND	ND	ND	ND	ND	23	ND	ND	ND	ND	ND	ND	ND
C4A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
102	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	17	16250	ND	56	121	ND	ND	74	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW8	ND	7663	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
129	ND	2030	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	45	ND	84	ND
MW9	ND	4621	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD1	1621J	78500	58J	ND	14J	363J	ND	14J	63J	42000	1761J	276J	58J	13J	177J	ND	448J
120	171480	33060	60	241J	38J	ND	ND	73J	ND	503J	ND	ND	44J	8J	ND	ND	ND
MW14	ND	1028	5	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW12	ND	2520	9	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW17	ND	31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW13	31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW11	ND	125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
124	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AWD4	ND	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3	ND	870	ND	ND	ND	ND	ND	ND	ND	53	ND	ND	ND	ND	ND	ND	ND

NOTE:
MEC = Methylene Chloride
TCE = Trichloroethene
1,1-DCA = 1,1-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
1,2-DCA = 1,2-Dichloroethane
VC = Vinylchloride
CF = Chloroform
PCE = Tetrachloroethene
1,2-DCE = Total -1,2-Dichloroethene
EBZ = Ethylbenzene
CTC = Carbon Tetrachloride
1,1,1 TCA = 1,1,1 Trichloroethane
ND = Non-Detect

TABLE 2–16
LHAAP 18&24 BURNING GROUND 3 & UEP
SUMMARY OF GROUNDWATER MONITORING, November 1994
DETECTED CONCENTRATIONS OF METALS in milligrams/liter

Well No.	Arsenic	Barium	Chromium	Lead	Nickel	Selenuim
126	ND	5.57	ND	ND	ND	ND
MW22	ND	2.07	0.048	ND	0.057	ND
MW15	0.006	0.226	ND	ND	ND	ND
MW2	ND	3.62	ND	ND	ND	ND
EW1	ND	0.248	0.006	ND	ND	ND
MW1	ND	4.04	ND	ND	ND	ND
MW4	ND	0.172	ND	ND	ND	ND
MW5	ND	1.29	ND	ND	ND	ND
MW6	0.013	0.813	ND	ND	ND	ND
MW21	ND	5.71	ND	ND	ND	ND
101	ND	0.293	ND	ND	ND	ND
109	ND	1.12	ND	ND	ND	ND
125	ND	0.17	ND	ND	ND	ND
123	ND	0.152	ND	ND	ND	ND
AWD2	ND	0.14	0.022	ND	ND	ND
AWD3	ND	0.063	0.021	ND	ND	ND
MW23	ND	2.02	0.026	ND	0.11	ND
C4A	ND	0.162	0.01	ND	ND	ND
C4	ND	0.159	ND	ND	ND	ND
C5	ND	0.084	ND	ND	ND	ND
C6	ND	1.12	ND	ND	ND	ND
C7	ND	0.111	ND	ND	ND	ND
C9	ND	0.27	ND	ND	ND	0.046
C10	ND	0.496	ND	ND	ND	ND
C3	ND	0.857	ND	ND	ND	ND
C8	ND	4.63	ND	ND	ND	ND
102	ND	0.072	ND	ND	ND	ND
MW7	ND	0.126	ND	ND	0.11	ND
MW8	ND	0.257	ND	ND	ND	ND
129	ND	0.12	ND	ND	ND	ND
MW9	ND	0.054	ND	ND	ND	ND
AWD1	0.014	0.898	0.048	ND	0.057	0.007
120	ND	0.182	0.048	ND	0.063	ND
MW14	ND	0.811	0.014	ND	0.042	ND
MW12	ND	0.233	0.048	ND	0.07	ND
130	ND	0.217	ND	ND	ND	ND
MW18	ND	0.245	ND	ND	ND	ND
MW17	ND	0.336	ND	ND	0.084	ND
MW13	ND	0.402	0.026	ND	0.043	ND
C2	ND	0.381	ND	ND	ND	ND
MW10	ND	0.586	ND	ND	ND	ND
MW16	ND	0.333	ND	ND	ND	ND
MW11	ND	0.066	ND	ND	ND	ND
124	0.003	0.063	ND	ND	ND	ND
AWD4	ND	0.6	0.054	ND	0.11	ND
MW19	ND	0.066	ND	ND	ND	0.0076J
MW20	ND	0.29	0.024	0.01	ND	ND
C1	ND	0.493	ND	ND	ND	ND
MW3	ND	1.55	ND	ND	ND	ND

Note: ND = Non–Detect

3.0 CONCLUSION AND RECOMMENDATIONS

The objective of the Phase II work was met by the implementation of the different tasks described above. This work has resulted in the following:

- Three updates to the plume condition in the shallow groundwater aquifer were developed;

- The ICT sections produced the highest groundwater pumping rates under both gravity flow and VELE, followed by the VEW and then the HEW. There was little difference as far as pumping rates between sections ICT-1 and ICT-2. However, section ICT-1 was half as long as and shallower than section ICT-2. ICT-2 was backfilled with sand, while section ICT-1 had a geocomposite drainage layer installed along its center line and throughout its depth along with a sand backfill on both sides of the geocomposite. The construction of section ICT-1 was more complicated than section ICT-2 due to the installation of the geocomposite drainage layer and the very shallow depth of the water table which caused trench stability problems. Some difficulties were also encountered during the construction of section ICT-2 due to the flowing of the sand backfill toward the section under excavation.

  The use of ICT sections during Phase III of the IRA is recommended. However, the difficulties encountered during the installation of the pilot ICT sections and the limited depth to which an ICT can be extended must be taken into account during the planning of the Phase III work. Difficulties such as the use of sand as backfill material, the geocomposite drainage layer, and the flexible piping should be considered. In addition, the requirement of building platforms in areas of near surface groundwater in order to maintain trench stability and its potential cost impact should also be evaluated.

  The option of using pea gravel to backfill the ICT sections with a geotextile fabric layer placed along the walls and bottom of the trench should be considered as an alternative to backfilling the trench sections with sand and/or sand and geocomposite. In addition, the construction of trench sections by building short (100 to 200 feet) segments in order to maintain trench stability should also be considered. This action is recommended especially if a geocomposite drainage layer is to be used similar to section ICT-1.

  The use of stainless steel screen and pipe sections to build the ICT sumps is recommended instead of the HDPE material used during this pilot work. The steel material will be easier to handle during installation and would not get damaged as the HDPE material did during the Phase II work.

- The VEW produced low flow rates under gravity flow conditions. A slightly deeper well may have produced better flow rates. The use of VEW wells during Phase III should be considered, especially in locations where it would be difficult and may be impossible to install an ICT section. However, prior to installing any VEW, it is recommended that an exploratory boring be drilled at the desired location and soil samples be taken for grain size analysis in order to size the well screen and diameter as efficiently as possible. This exploratory work should result in the installation of more efficient vertical extraction wells.

- The HEW produced a relatively low flow rate and difficulties were encountered during its installation. These conditions could be attributed to the shallow depth at which it was installed. The HEW may be pumped during the Phase III work to assist in lowering the water table in the vicinity of the ACD where source materials will be excavated and treated. The use of the HEW, as part of the network of pumping trenches and wells, may be considered based on its production rate while being used to lower the water table during excavation in its vicinity. Additional HEWs are not recommended for the IRA.

- Slightly higher flow rates were measured during the VELE test than during the gravity test at the VEW. However, these rates appeared to decrease with time and the effect of the vacuum pressures appeared to have centered in the immediate area surrounding the well. At the ICT, there was little difference between the flow rates obtained during the VELE and gravity tests. The application of VELE at the HEW was not successful due to mechanical problems. However, the flow rate during the short period at which VELE was used at the HEW appeared to have been very close to the rates obtained during the gravity flow test.

  The VELE is not recommended for application at ICT sections during Phase III of the IRA due to the little difference in the measured flow rates during the gravity and VELE tests and difficulties encountered during this pilot work, including the complications at section ICT-1 where the geocomposite acted as a big conduit that required very high rates of vacuum in order to maintain a reasonable vacuum rate at sump 3.

  The use of VELE at vertical extraction wells during Phase III may be considered. However, due to the potential spreading of the vertical extraction wells, maintenance of a VELE system will be challenging and may be cost prohibitive. In addition, its difficult to predict the amount of contaminants that will be pulled from the ground and emitted into the atmosphere, especially in highly contaminated areas. Such emissions may not be desired and may complicate the implementation of the Phase III work under the Texas Air Control Board Standard Exemptions listed in 30 Texas Administrative Code (TAC) 116.