

ENGINEERING-SCIENCE, INC.

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June 24, 1994

Mr. Marty Faile
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, Texas 78235-5357

RE: AFCEE Bioventing Test Initiative Final Tables

Dear Marty:

Please find attached final tables and site figures for several sites at which 12 months of bioventing pilot testing have been completed. Specifically, final tables are attached for Offutt AFB sites - Building 528, Building 30, and the POL Storage Area; Whiteman AFB - Aboveground Soil Pile; Kirtland AFB - Site FT-13; and Kelly AFB - Site S-4.

Only one table is included for the Whiteman AFB Aboveground Soil Pile. Oxygen concentrations in soil gas in the soil pile remained near atmospheric for the duration of the pilot test and therefore, no respiration tests were performed. Based on the nature of the soil, a silty clay, and contaminant distribution, ES recommends the soil pile be mixed with a bulking agent such as wood chips or straw. Mixing would homogenize the soil which consists of clods of silty clay that are typically heterogeneously contaminated. Mixing would distribute the petroleum hydrocarbons through out the soil creating more surface area for biodegradation processes. The bulking agent would create voids spaces to ensure adequate supply of oxygen and allow drainage of excess moisture from the pile. Based on observed soil gas conditions, the passive aeration design that is currently in place should be adequate to maintain sufficient oxygen concentrations. However, if a bulking agent is added and/or the pile is homogenized, further soil gas surveys are recommended to monitor oxygen concentrations.

Please call me or Doug Downey at (303) 831-8100 if you have any questions.

Sincerely,

ENGINEERING-SCIENCE, INC.



Brian Blicher
Environmental Engineer

DISTRIBUTION STATEMENT A

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c.c.: Doug Downey
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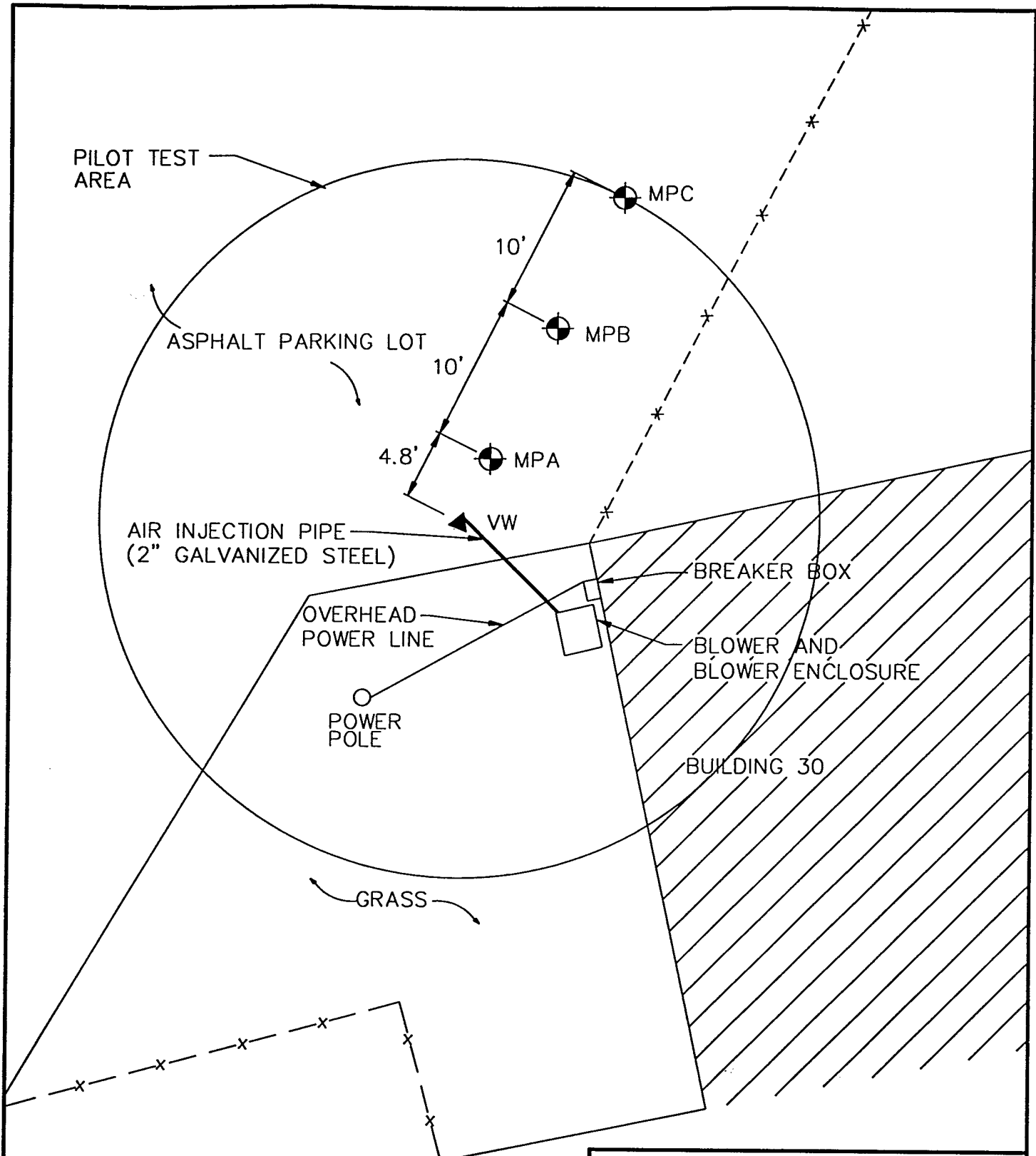


FIGURE 1
 AS-BUILT VENT WELL,
 MONITORING POINT AND
 BLOWER LOCATIONS
 BUILDING 30

OFFUTT AFB, NEBRASKA
 ENGINEERING-SCIENCE, INC.
 Denver, Colorado

LEGEND

- VAPOR MONITORING POINT
- VENT WELL
- FENCE

0 10 20
 FEET



TABLE 1
BUILDING 30
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location-Depth	Initial			6-Month ^{b/}			1-Year		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.00090	180	NS ^{c/}	NS	NS	NS	0.00042	100	NS
MPA-4.5	NS	NS	8.06	0.00013	29	15.5	NS	NS	6.50
MPA-9.5	NS	NS	8.11	NS	NS	16.8	NS	NS	8.06
MPB-9.5	0.069	16,000	NS	0.0013	310	2.56	0.00052	120	NS
MPC-5	0.12	27,000	NS	0.00036	83	NS	NS	NS	NS
MPC-9.5	0.14	31,600	NS	0.0016	360	NS	0.0010	240	NS

^{a/} Milligrams hydrocarbons per kilogram soil per year


^{b/} Moisture content an average of initial and final readings.


^{c/} NS = Not Sampled.

REV01:6/20/94

LEGEND

 UST

 01-VW1 INJECTION WELL

 01-MPA MONITORING POINT

 POWER POLE

 LPD-MW1 EXISTING MONITORING WELL

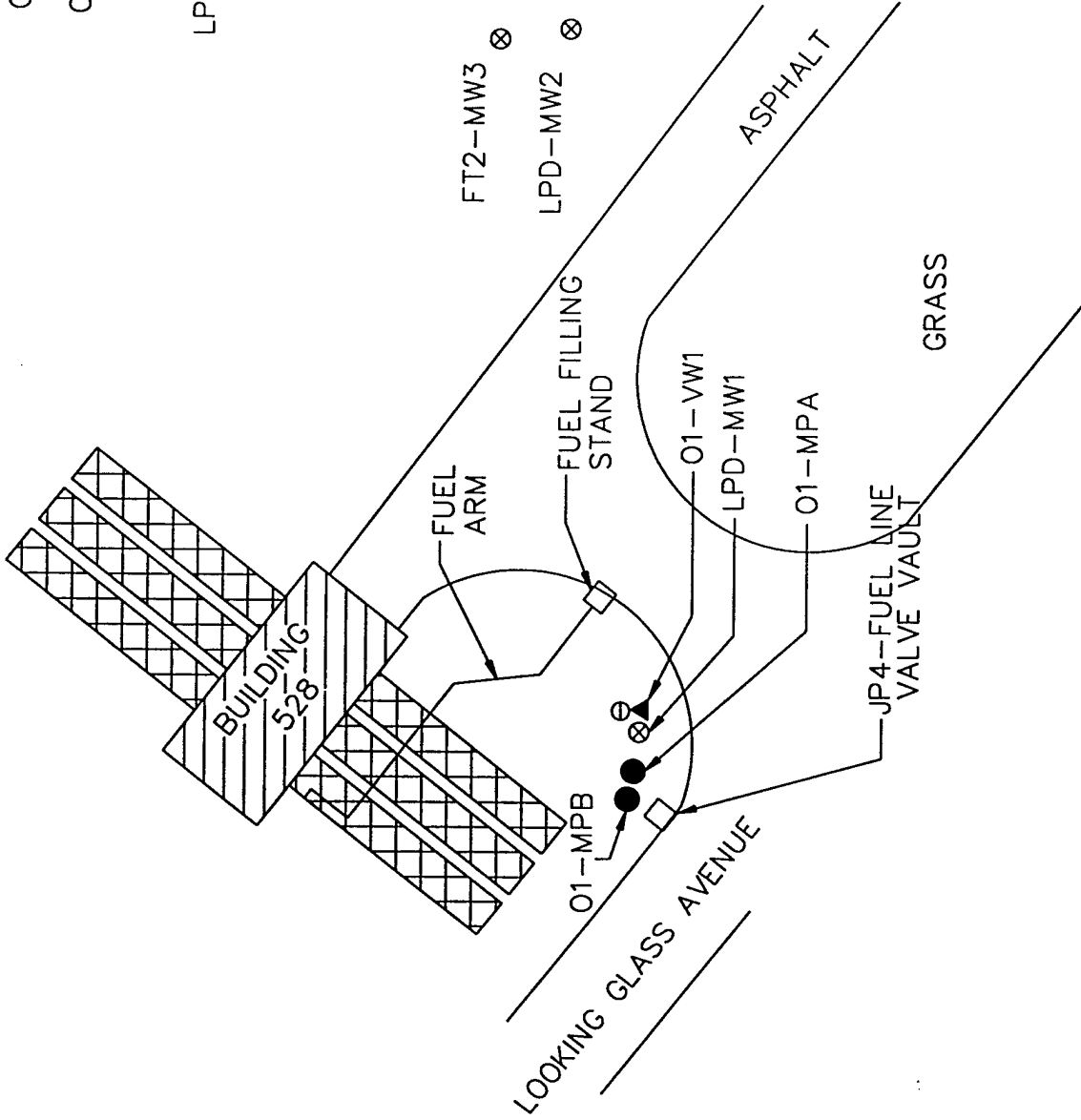


FIGURE 1
 VENT WELL, MONITORING POINT
 AND BLOWER LOCATIONS
 BUILDING 528
 OFFUTT A.F.B., NEBRASKA

ENGINEERING-SCIENCE, INC.
 Denver, Colorado

TABLE 1
BUILDING 528
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location - Depth	Initial			6 - Month ^{b/}			1 - Year		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW1	0.015	4,200	NS	NS ^{c/}	NS	NS	NS	NS	NS
MW1	0.018	5,000	NS	0.00058	230	NS	0.0040	1,000	NS
MPA-4	NS	NS	NS	0.0011	430	NS	0.000031	7.0	NS
MPA-7	0.011	3,100	NS	0.00099	390	NS	NS	NS	NS
MPB-4	NS	NS	21.6	0.0042	1500	NS	0.0021	550	5.50
MPB-7	0.013	3,700	20.0	0.0064	2300	NS	NS	NS	5.00




^{a/} Milligrams hydrocarbons per kilogram soil per year

^{b/} Moisture content an average of initial and final readings.

^{c/} NS = Not Sampled.

REV01-6/20/94

LEGEND

- SS1-MW2  EXISTING MONITORING WELL
-  VAPOR MONITORING POINT
-  VENT WELL
- X-- FENCE

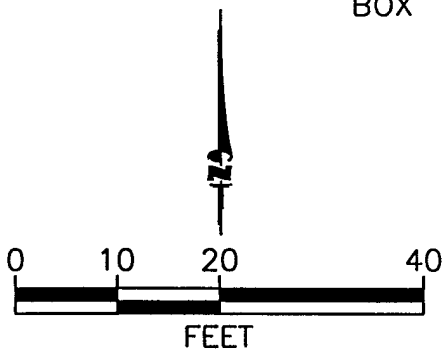
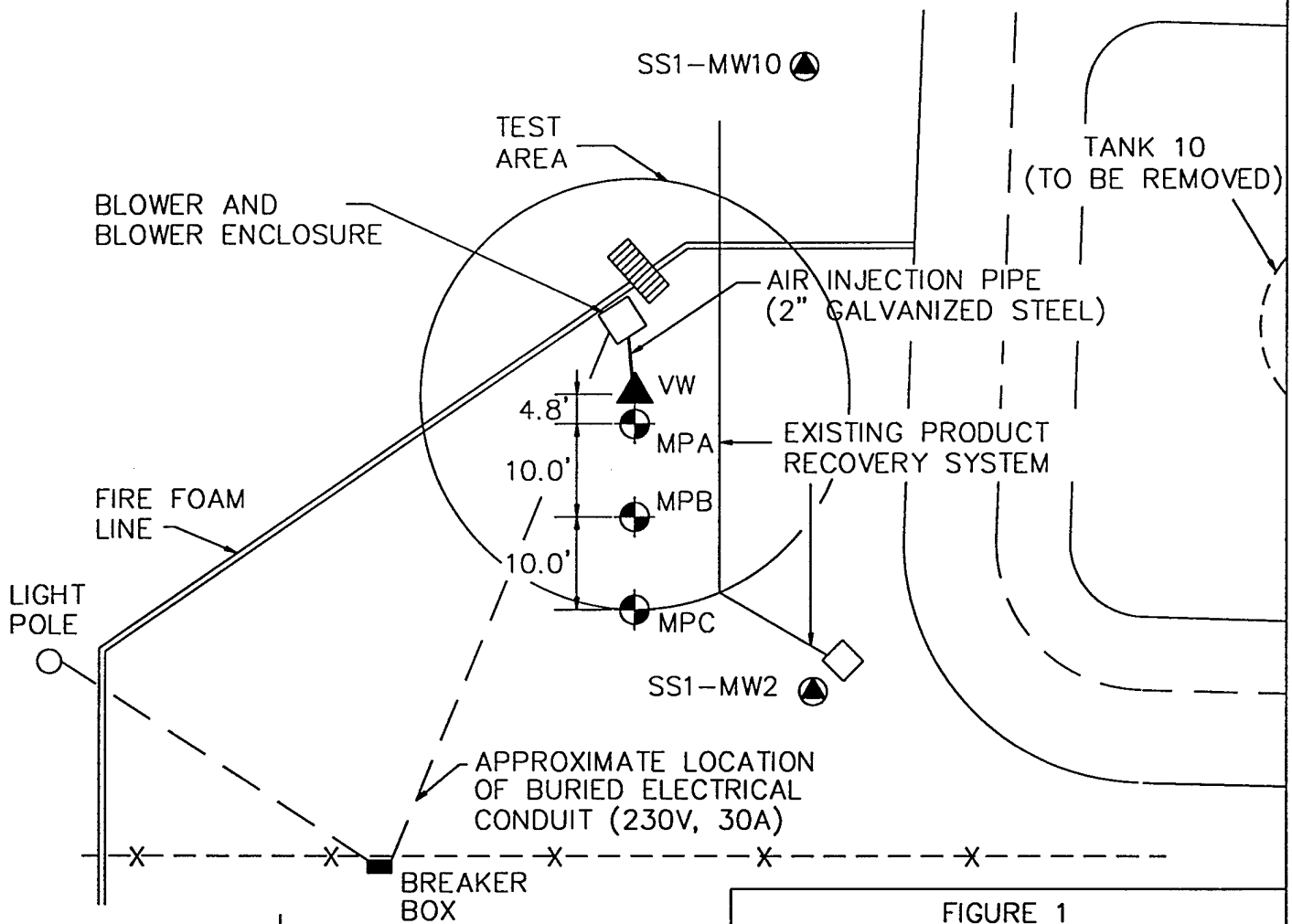
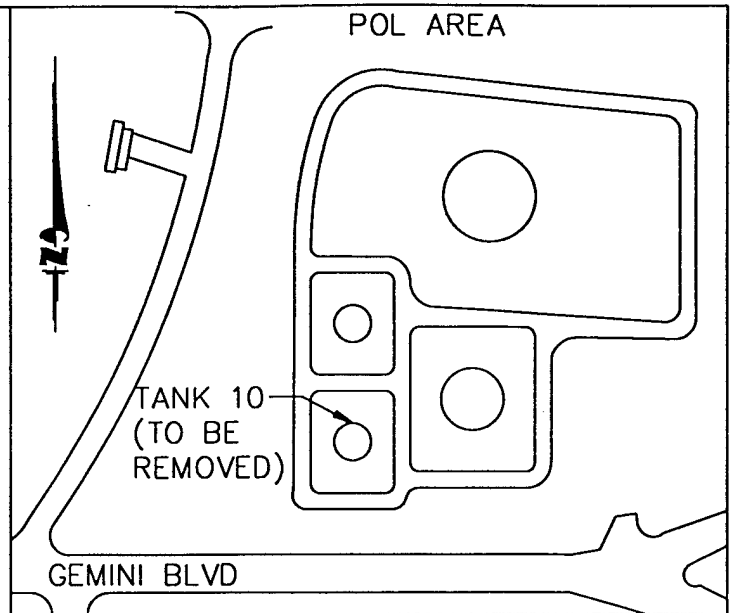


FIGURE 1

AS-BUILT VENT WELL,
MONITORING POINT,
AND BLOWER LOCATIONS

POL STORAGE AREA

OFFUTT AFB, NEBRASKA

ENGINEERING-SCIENCE, INC.
Denver, Colorado




TABLE 1
POL STORAGE AREA
RESPIRATION AND DEGRADATION RATES
OFFUTT AFB, NEBRASKA

Location - Depth	Initial			6-Month ^{b/}			1-Year		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.033	7,100	NS ^{c/}	NS	NS	NS	0.0077	5,100	NS
MPA-4	NS	NS	6.94	NS	NS	NS	NS	NS	6.50
MPA-7	NS	NS	8.22	NS	NS	NS	0.0075	5,000	6.67
MPC-4	0.0013	260	NS	NS	NS	NS	NS	NS	NS

^{a/} Milligrams hydrocarbons per kilogram soil per year

^{b/} Six month test not conducted as all monitoring points were below ground water.

^{c/} NS = Not Sampled.

REV01:6/17/94

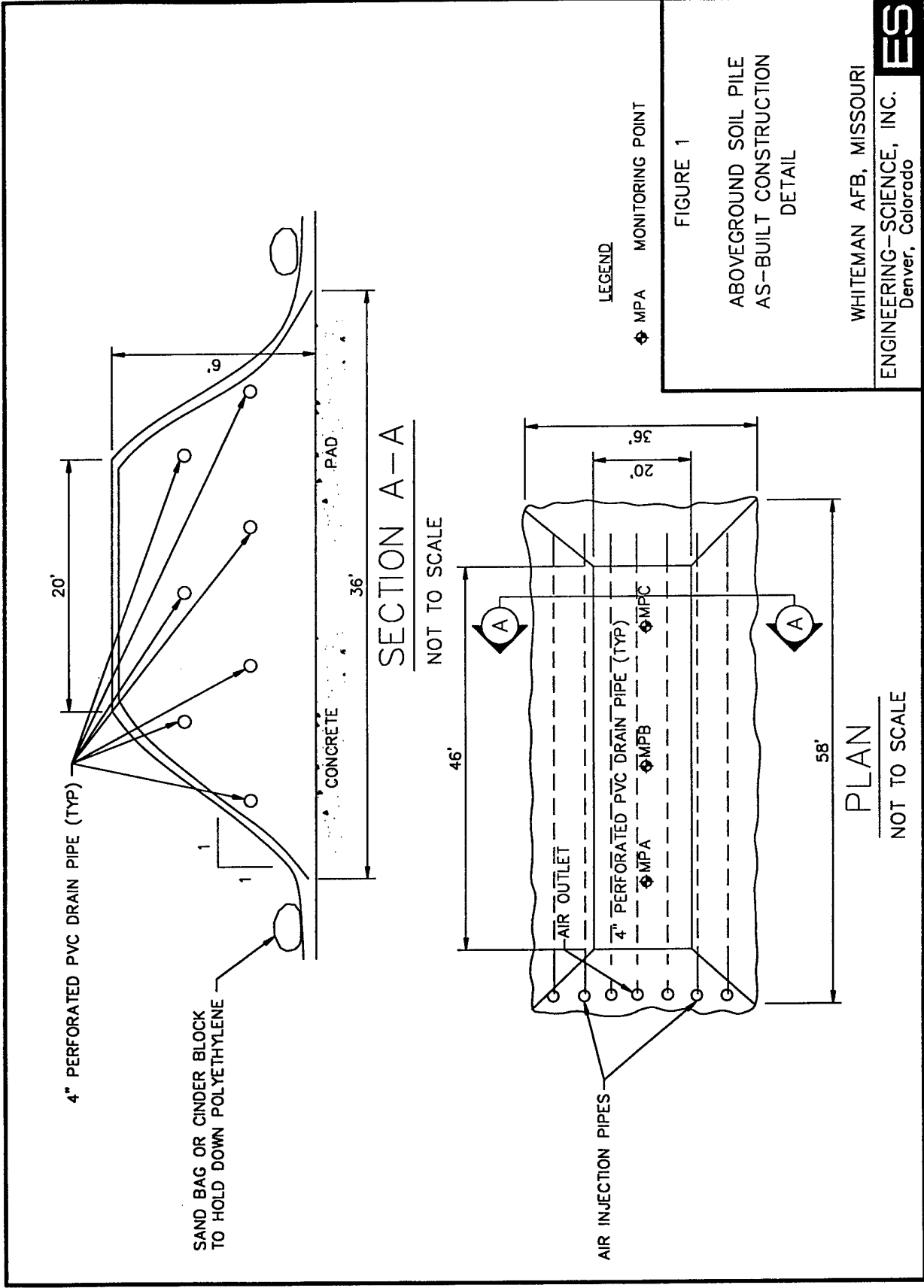


FIGURE 1

ABOVEGROUND SOIL PILE
AS-BUILT CONSTRUCTION
DETAIL

WHITEMAN AFB, MISSOURI

ENGINEERING-SCIENCE, INC.
Denver, Colorado



TABLE 1
ABOVEGROUND SOIL PILE
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
WHITEMAN AFB, MISSOURI

Analyte (Units) ^{a/}	Sample Location - Depth (feet below ground surface)					
	MPA-4.5		MPB-4.5		MPC-4.5	
	Initial	1-Year	Initial	1-Year	Initial	1-Year
Soil Gas Hydrocarbons						
TVH (ppmv)	NS ^{b/}	NS	NS	NS	NS	NS
Benzene (ppmv)	NS	NS	NS	NS	NS	NS
Toluene (ppmv)	NS	NS	NS	NS	NS	NS
Ethylbenzene (ppmv)	NS	NS	NS	NS	NS	NS
Xylenes (ppmv)	NS	NS	NS	NS	NS	NS
Soil Hydrocarbons						
	MPA		MPB		MPC	
	Initial ^{c/}	1-Year ^{d/}	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	5,245	638	3,236	1,400	396	196
Benzene (mg/kg)	<0.00375	<0.15	NS	<0.079	NS	<0.077
Toluene (mg/kg)	<0.003	<0.15	NS	<0.079	NS	0.22
Ethylbenzene (mg/kg)	0.0055	<0.15	NS	<0.079	NS	<0.077
Xylenes (mg/kg)	0.012	<0.21	NS	<0.11	NS	0.20
Moisture (%)	20.34	17.3	15.24	20.6	17.96	18.9
Temperature (°C)	NS	NS	NS	NS	9.83	7.83

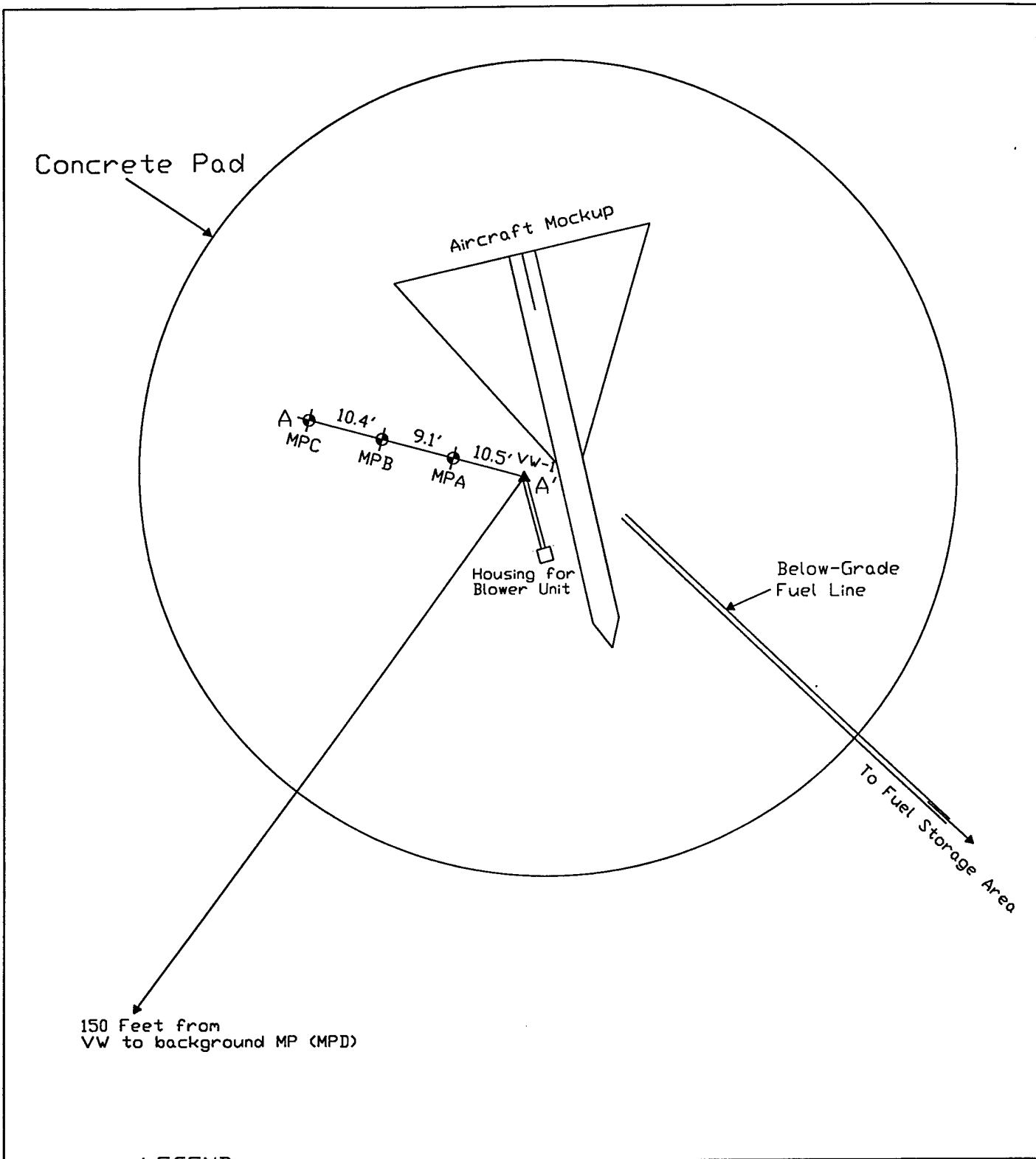
^{a/}TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/}NS = Not sampled.

^{c/}Initial soil samples were collected on April 19 and 20, 1993. The sample from MPA was taken from 4 feet below the top of the soil pile, samples from MPB and MPC were composite samples from the top of the pile to 5 feet below the top of the pile.

^{d/}Final soil samples were collected on April 6, 1994. Samples from MPA and MPB were composites from the top of the soil pile to 5 feet below the top of the pile. The sample from MPC was taken from 4 feet below the top of the pile.

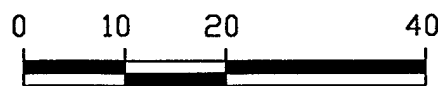


150 Feet from
VW to background MP (MPD)

LEGEND

- ▲ Vent Well (Air Injection)
- ⊕ Vapor Monitoring Point

A - A' Location of Geologic Section



SCALE: 1" = 20'



FIGURE 1
 VENT WELL/
 VAPOR MONITORING
 POINT LOCATIONS
 FORMER FIRE TRAINING AREA
 (FT-13)
 KIRTLAND AFB, NEW MEXICO
 ENGINEERING-SCIENCE, INC.
 Denver, Colorado



TABLE 1
SITE FT-13
RESPIRATION AND DEGRADATION RATES
KIRTLAND AFB, NEW MEXICO

Location - Depth	Initial (Apr. 1993)			3 - Month (Jun. 1993)			6 - Month (Nov. 1993)		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)
VW-1 (5-30)	0.0012	300	NS ^{c/}	0.00014	34	NS	0.00014	34	NS
MPA-6	NS	NS	12.0	NS	NS	20.4	NS	NS	18.5
MPA-15	0.0011	280 ^{d/}	NS	0.00014	34 ^{d/}	NS	0.00015	37 ^{d/}	NS
MPA-24	0.00058	140 ^{d/}	16.3	NS	NS	14.6	NS	NS	16.2
MPB-24	0.00088	220 ^{d/}	NS	0.00017	42 ^{d/}	NS	0.00010	25 ^{d/}	NS
MPC-24	0.0013	310 ^{d/}	NS	0.00034	84 ^{d/}	NS	0.00016	39 ^{d/}	NS

Location - Depth	9 - Month (Feb. 1994)			12 - Month (May 1994)		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW-1 (5-30)	0.000059	15	NS	0.000030	7.4	NS
MPA-6	NS	NS	10.3	NS	NS	15.8
MPA-15	0.00014	34 ^{d/}	NS	0.000094	23 ^{d/}	NS
MPA-24	NS	NS	14.4	NS	NS	14.7
MPB-24	0.000069	17 ^{d/}	NS	0.000062	15 ^{d/}	NS
MPC-24	0.000096	24 ^{d/}	NS	0.000099	24 ^{d/}	NS

a/ Milligrams of hydrocarbons per kilogram of soil per year

b/ Assumes moisture content of the soil is average of initial and final moistures.

c/ NS= Not Sampled.

TABLE 2
SITE FT - 13
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
KIRTLAND AFB, NEW MEXICO

Analyte (Units) ^{a/}	Sample Location (Depth, feet below ground surface)					
	VW1 (5-30)		MPA-15		MPC-24	
Soil Gas Hydrocarbons	Initial ^{b/}	1-Year ^{c/}	Initial	1-Year	Initial	1-Year
TVH (ppmv)	870	15	16000	550	22000	1500
Benzene (ppmv)	0.63	<0.002	45	<0.013	12	0.024
Toluene (ppmv)	5.7	<0.002	110	<0.013	53	<0.016
Ethylbenzene (ppmv)	1.8	0.008	9.1	0.195	14	0.11
Xylenes (ppmv)	7.2	0.037	33	0.45	63	1.2

Soil Hydrocarbons	VW1 (15-17)		MPA (2-4)		MPB (5-7)		MPC (10-12)		MPD (15-17)	
	Initial ^{d/}	1-Year ^{e/}	Initial	1-Year	Initial	1-Year	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	6534	8850	1200	6490	1338	3750	<4.0	6.7	<4.0	NS ^{f/}
Benzene (mg/kg)	<3.0	<0.14	<0.83	<0.14	<3.1	<.074	<0.002	<0.0005	<0.0004	NS
Toluene (mg/kg)	13	4.9	3.4	3.2	20	0.80	0.007	<0.0005	0.0016	NS
Ethylbenzene (mg/kg)	18	3.9	5.8	13	14	12	<0.002	<0.0005	0.00041	NS
Xylenes (mg/kg)	110	20	38	97	80	33	0.012	0.0030	<0.0015	NS

Moisture (%)	7.6	7.8	16.1	10.6	10.7	15.0	10.4	12.2	6.5	NS
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^{a/}TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/}Initial soil gas samples collected on 4/7/93.

^{c/}1-Year soil gas samples collected on 5/24/94 and 5/25/94.

^{d/}Initial soil samples collected on 4/5/93 and 4/6/93.

^{e/}1-Year soil samples collected on 5/24/94.

^{f/}NS = Not Sampled.

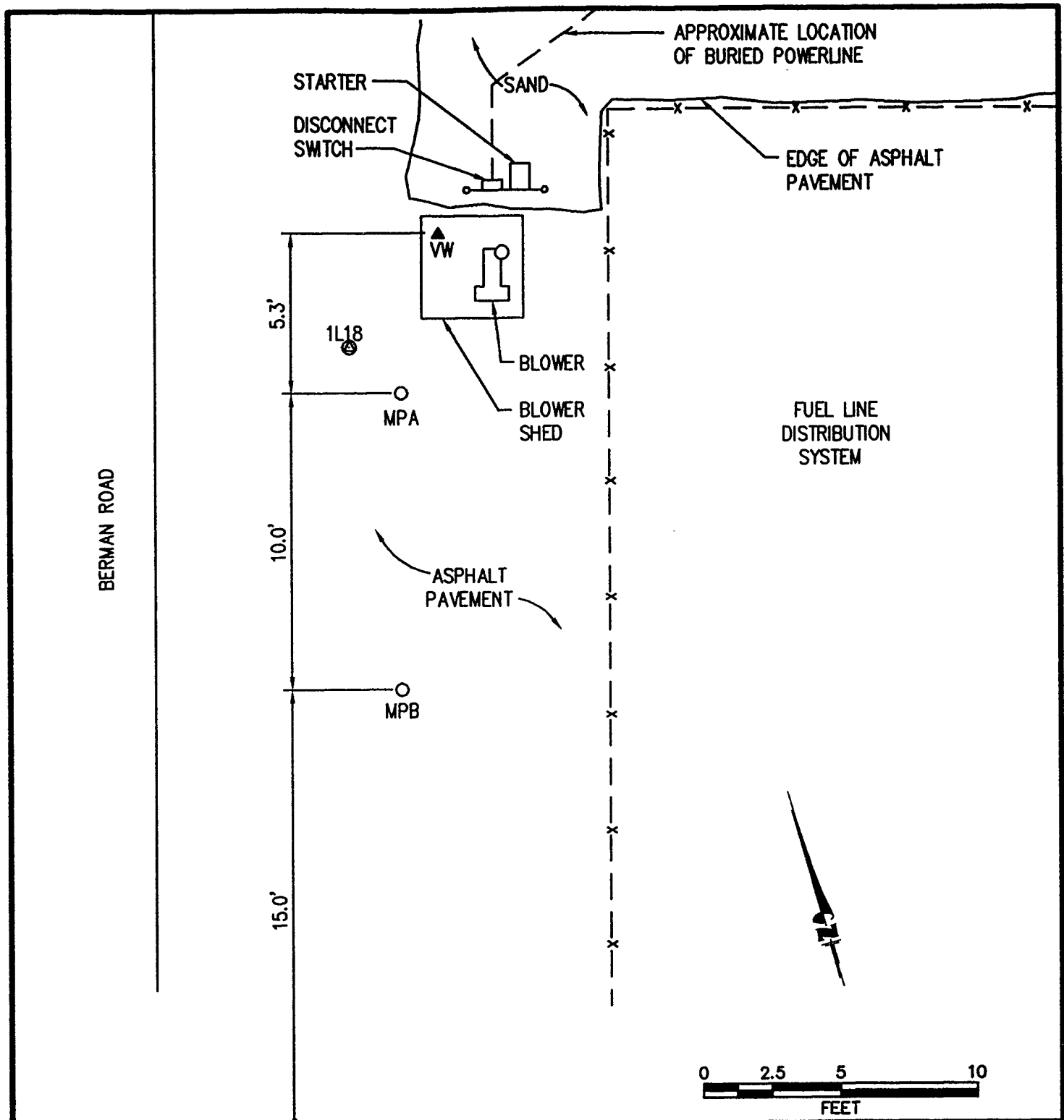


FIGURE 1

**SITE S-4
AS-BUILT SITE PLAN**

KELLY AFB, TEXAS

ENGINEERING-SCIENCE, INC.

Denver, Colorado

TABLE 1
SITE S-4
RESPIRATION AND DEGRADATION RATES
KELLY AFB, TEXAS

Location - Depth, feet bgs	Initial = December 1992			6 - Month = June 1993			1 - Year = January 1994		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate ^{b/} (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW-7-17	.041	12000	NS ^{c/}	.0013	290	NS	NS	NS	NS
MPA-5	NS	NS	20.4	NS	NS	27.4	NS	NS	18.2
MPA-12.5	.046	1900	23.2	.0041	210	25.2	.0021	160	24.4
MPB-9	.033	9800 ^{d/}	NS	.0019	420 ^{d/}	NS	.0011	160 ^{d/}	NS
MPB-12.5	.035	5500	NS	.0054	900	NS	.0026	430	NS
MPC-9	NS	NS	NS	.0033	740 ^{d/}	NS	.0018	260 ^{d/}	NS
MPC-12.5	.042	7900 ^{e/}	NS	.012	2200 ^{e/}	NS	NS	NS	NS

a/ Milligrams of hydrocarbons per kilogram of soil per year.

b/ Assumes moisture content of the soil is average of initial and final moistures.

c/ NS = Not Sampled.

d/ Degradation rate calculated assuming MPB-9 and MPC-9 soil moisture content the same as VW.

e/ Degradation rate calculated assuming MPC-12.5 soil moisture content the same as MPB-12.5.

