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NAS CECIL FIELD, FL
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FINAL TREATABILITY STUDY AT OPERABLE UNIT 2 (OU 2) SITE 5 NAS CECIL FIELD FL
3/1/1996
ABB ENVIRONMENTAL SERVICES INC

NAS CECIL FIELD
SITE 5
TREATABILITY STUDY

FINAL REPORT

ABB Environmental Services, Inc.

NAS CECIL FIELD
SITE 5
TREATABILITY STUDY
FINAL REPORT

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NAS CECIL FIELD
SITE 5
TREATABILITY STUDY
FINAL REPORT
March, 1996

A treatability study was conducted by ABB Environmental Services, Inc. (ABB-ES) for the Department of the Navy, Southern Division, Naval Facilities Engineering Command to evaluate the feasibility of using bioremediation to reduce the concentration of Total Recoverable Petroleum Hydrocarbon (TRPH) in soil at Site 5 of Operable Unit 2 (OU 2) located at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida. The treatability test was designed to evaluate ex situ soil treatment methods, such as composting or landfarming. The rate and extent of biodegradation was measured under simulated treatment conditions. Site soil was used for testing, so results are site specific. The data generated from these tests were used to develop specific design parameters such as treatment times, nutrient requirements, and aeration schedules.

1.0 TEST OBJECTIVES

The specific goals established for the treatability testing included:

- determine if hydrocarbon degrading bacteria are present in soil,
- evaluate soil conditions and determine if amendments are required,
- measure biodegradation under simulated treatment conditions, and
- prepare recommendations for full-scale treatment conditions.

2.0 TREATABILITY TEST DESIGN

The tasks that were performed as part of the treatability testing included:

- **Initial Analysis.** Soil samples were collected from four different locations at Site 5. Chemical and microbiological analyses were performed to characterize samples. Results were reviewed and conditions were established for bench-scale biodegradation testing.

- **Design Tests.** Design tests were performed to evaluate physical parameters that may affect biodegradation. Results from these tests were used to estimate amendment applications for bench-scale testing.

- **Solid-Phase Biodegradation Test.** Soil microcosms were prepared to simulate ex-situ bioremediation treatment conditions and biodegradation was monitored by measuring TRPH levels in the soil. Soil microcosms were prepared and tested under three conditions and specific amendments included:

  - soil amended with lime, mineral nutrients (nitrogen and phosphate)
  - soil amended with lime, mineral nutrients and manure (1% by weight), and
  - soil amended with a biocide (killed control).

Soil moisture, pH and oxygen levels were maintained during the test. The rate and extent of TRPH biodegradation was measured and treatment times and amendment requirements were estimated based on the results of testing.

3.0 TREATABILITY TESTING RESULTS

3.1 Initial Sample Characterization

3.1.1 TRPH Analysis. Soil samples were collected on July 16, 1994. The samples locations were selected to represent the range of TRPH contamination at Site 5 and the results from analysis using Modified EPA Method 418.1 showed that TRPH levels of 1000 mg/kg to 18000 mg/kg (Table 3-1).

The source of petroleum appears to be similar to jet fuel/kerosene based upon results from GC Fingerprint analysis (Appendix A).

Table 3-1
Results From Initial TRPH Analysis of Soil
Modified EPA Method 418.1

Sample ID	TRPH (MG/KG)
Low	1120
Average E	11620
Average W	17620
High	18380

3.1.2 Nutrient Analysis. There was no detectable nitrogen (ammonia (<5 mg/kg) or nitrate (<1.25 mg/kg)) or ortho phosphate (<5 mg/kg) measured in soil. The soil pH was approximately 5.3.

3.1.3 Bacteria Analysis. Results from initial bacterial analysis show that bacteria capable of biodegrading petroleum hydrocarbons were present in site soil (Table 3-2). The total number of bacteria in the soil are somewhat low, however this is likely due to the low pH.

Table 3-2.
Results from Initial Bacterial Enumeration
Modified Standard Method 907B

Sample ID	Total Bacteria (x 10^3 CFU/g)	Hydrocarbon Bacteria (x 10^3 CFU/g)
Low	23	6
Average E	38	3
Average W	140	20
High	50	19

CFU = Colony Forming Units

3.2 Design Tests

3.2.1 Composite Preparation. The average concentration of TRPH in Site 5 soils designated for remediation is estimated to be 2500 mg/kg. The composite used for treatability testing was prepared by mixing soil from all four sample locations and the final concentration was approximately 5000 mg/kg. Although the TRPH concentration was above the estimated average value, the 5000 mg/kg composite was used to represent conservative conditions.

3.2.2 Moisture Capacity of Soil. The moisture holding capacity or field capacity of Site 5 composite soil was measured to establish the target moisture level range that should be maintained to during biological treatment. Generally, 40-60% of the field capacity is considered the optimal range for solid-phase landtreatment. The field capacity for soil without any added manure was measured at 30.5%, which corresponds to a soil moisture content of 12%-18%. Manure may be used to increase the field capacity of the soil and in this case the field capacity was increased by approximately 1% for every 1% (w/w

final concentration) of manure added (Table 3-3). This means more moisture can be held by the soil without becoming saturated when manure is added. If manure is used as an amendment for soil treatment, the operating moisture range will be adjusted to correspond with the field capacity of the manure amended soil.

Table 3-3
Moisture Holding Capacity Measurement

Sample ID	Moisture Holding Capacity (g water/g dry soil)
Site 5 Soil	30.4%
Site 5 Soil + Manure (1%)	31.1%
Site 5 Soil + Manure (2.5%)	32.3%
Site 5 Soil + Manure (5%)	35.0%
Site 5 Soil + Manure (10%)	41.0%
Cow Manure	99.2%

3.2.3 pH Adjustment. Lime is often used in field applications to adjust acidic soil pH to near or at neutral. The concentration of lime required to bring Site 5 soil pH to 7 was experimentally determined to be 0.8% w/w (Figure 3-1).

3.3 BIODEGRADATION TESTING

Biodegradation testing was conducted under three different conditions, two live and one control. The rate and extent of TRPH was measured to evaluate the feasibility of reducing TRPH levels to below 50 mg/kg. The results from biodegradation testing procedures and results are presented in this section.

3.3.1 Soil Microcosm Preparation.

Three soil microcosms were prepared by adding approximately 300g of soil composite into a clear glass jar (16oz) and the following specific amendments included:

- soil amended with lime, mineral nutrients (nitrogen and phosphate)
- soil amended with lime, mineral nutrients and manure (1% by weight), and
- soil amended with the biocide mercuric chloride (killed control).

Site 5 Treatability Study
Lime Addition Curve

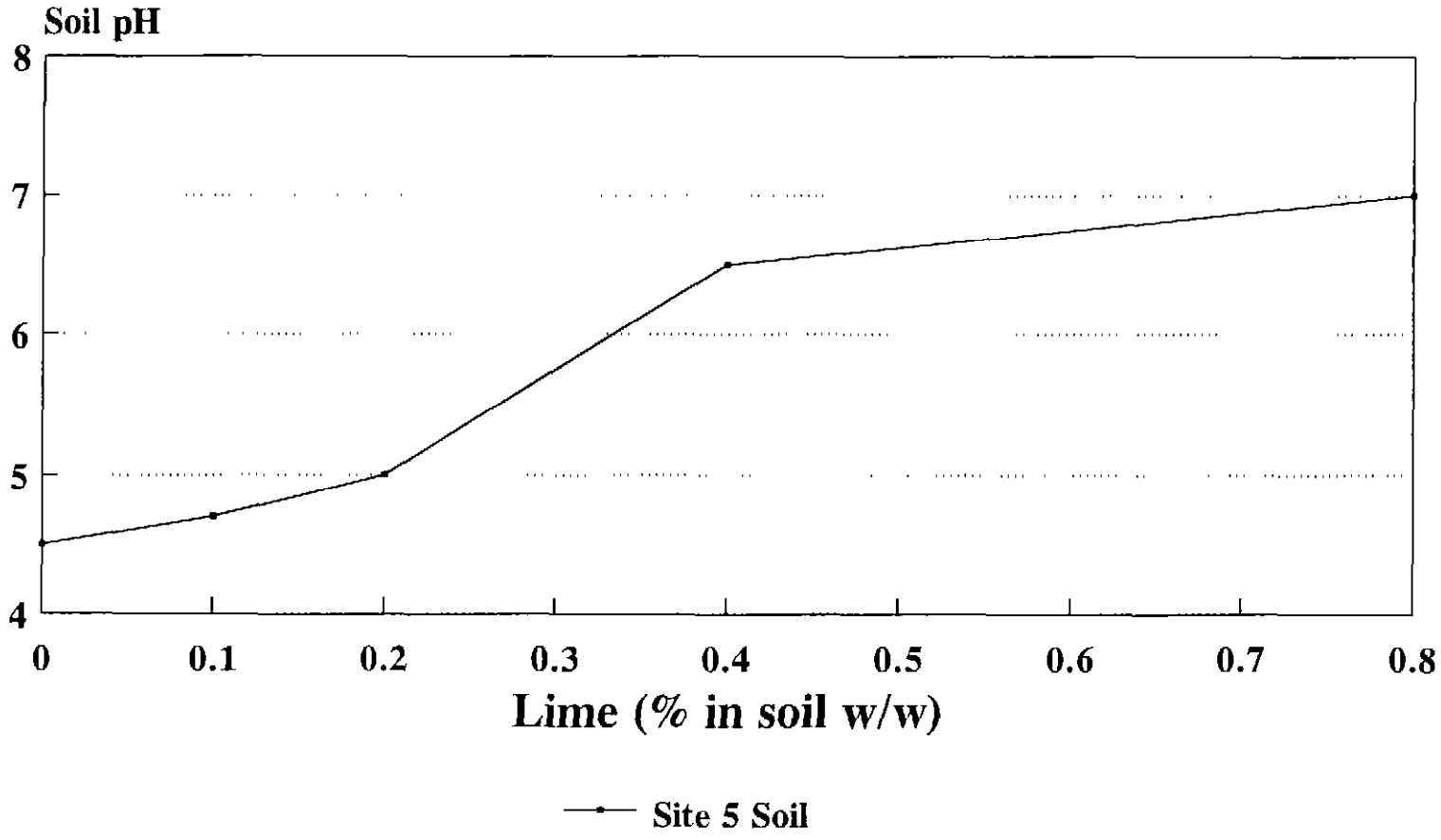


Figure 3-1

The first microcosm was amended fertilizer and lime for pH adjustment. The second test microcosm was amended with fertilizer, lime and manure. The third microcosm was amended with mercuric chloride (0.5%) and used as a control to measure abiotic losses such as volatilization.

The pH of the soil was adjusted to 7. Mineral nutrients were added in the form of dry fertilizer. The concentration of nitrogen and phosphate that was added to the soil was 90 mg/kg N and 6 mg/kg P. These levels of mineral nutrients were chosen based upon the C:N:P ratio of 100:17.6:2.4 (by weight). The amount of nitrogen and phosphate necessary to biodegrade 5000 mg/kg TRPH was too high to add at the beginning of the test because too much fertilizer could cause too drastic a change in the ionic strength of the soil and could adversely affect biological activity. Rather, nutrients required to biodegrade 1400 mg/kg carbon were added when the microcosms were prepared and additional mineral nutrients were added over the time course of the study.

Soil moisture (approximately 15%), and pH were maintained during the test. Oxygen was provided by manually mixing the soil every two to three days, simulating the agitation that would be provided to windrows at full-scale.

3.3.2 Testing Results.

TRPH Results. The results from biodegradation testing show that 98% of the TRPH was biodegraded after 95 days of treatment in the microcosm that was amended with mineral nutrients and manure. Extensive removal was also observed in the test microcosm amended with only mineral nutrients (97% after 113 days). These data show that indigenous microorganisms are capable of biodegrading TRPH. The data are presented in Table 3-4, 3-5, Figure 3-2 and Appendix Table B-1. TRPH removal rates were estimated using results obtained from the test microcosms. The data, which is summarized in Table 3-6, shows that the most rapid rate of removal was observed in the microcosm amended with manure.

After the active test period of approximately 113 days, the soil remained in the test vessels and was not actively aerated. The results from gas chromatographic analysis had shown that there was not any detectable petroleum remaining in the soil. It is likely that the remaining TRPH was from nonchromatographable carbon or biomass present in soil. However, after approximately 3 additional months, soil in the microcosms were analyzed and TRPH levels had decreased to 52 and 39 mg/kg in the manure and nutrient only microcosms, respectively. A reduction was observed in the control, but not to the extent observed in the live vessels. These data indicate that it is feasible to meet the 50 mg/kg treatment criteria, even at initial TRPH levels of 5000 mg/kg. These data also show that biodegradation will continue even after active treatment has ceased. This phenomena has been documented by:

Table 3-4
Results from TRPH Analysis of Treatability Test Microcosms
Modified EPA Method 418.1

Time	Live TRPH (MG/KG)	+ Manure TRPH (MG/KG)	Kill TRPH (MG/KG)
T=0	4950	5210	5400
T=7		4920 (6%)	
T=8	2440 (49%)		3180 (41%)
T=14		3710 (29%)	
T=16	2080 (58%)		2850 (47%)
T=21		3100 (40%)	
T=23	1630 (67%)		3060 (43%)
T=28		1990 (62%)	
T=32	1210 (76%)		2320 (57%)
T=39	890 (82%)		2250 (58%)
T=42		1184 (77%)	
T=46	613 (88%)		1547 (71%)
T=60	544 (89%)		1317 (76%)
T=77		181 (96%)	
T=95	190 (96%)	122 (98%)	736 (86%)
T=113	140 (97%)		690 (87%)
T=195[1]		50 (99%)	
T=213[1]	35 (99%)		294 (95%)

() = Percent TRPH Removed
[1] = Microcosms were not actively maintained between Days 95/113 and 195/213.

Table 3-5
Extent of TRPH Biodegradation

Condition	Starting TRPH Concentration	Final TRPH Concentration	Active Treatment Time	TRPH: 3 months after last time point (no active remediation)
Live + Nutrients	5000	140 mg/kg	113	39J mg/kg
Live + Manure	5000	120 mg/kg	95	52J mg/kg
Control	5000	700 mg/kg	113	257 mg/kg
J=Estimated Value (Below Detection Limit of 60 mg/kg)				

Table 3-6
Biodegradation Rates

Test Condition	First Order Rate Constant (k_1 day$^{-1)}$	Half Life (Days)
Live + Nutrients	0.029	24
Live + Manure/Nutrients	0.042	17
Control	0.014	50

Site 5 Treatability Study
TRPH Degradation Results

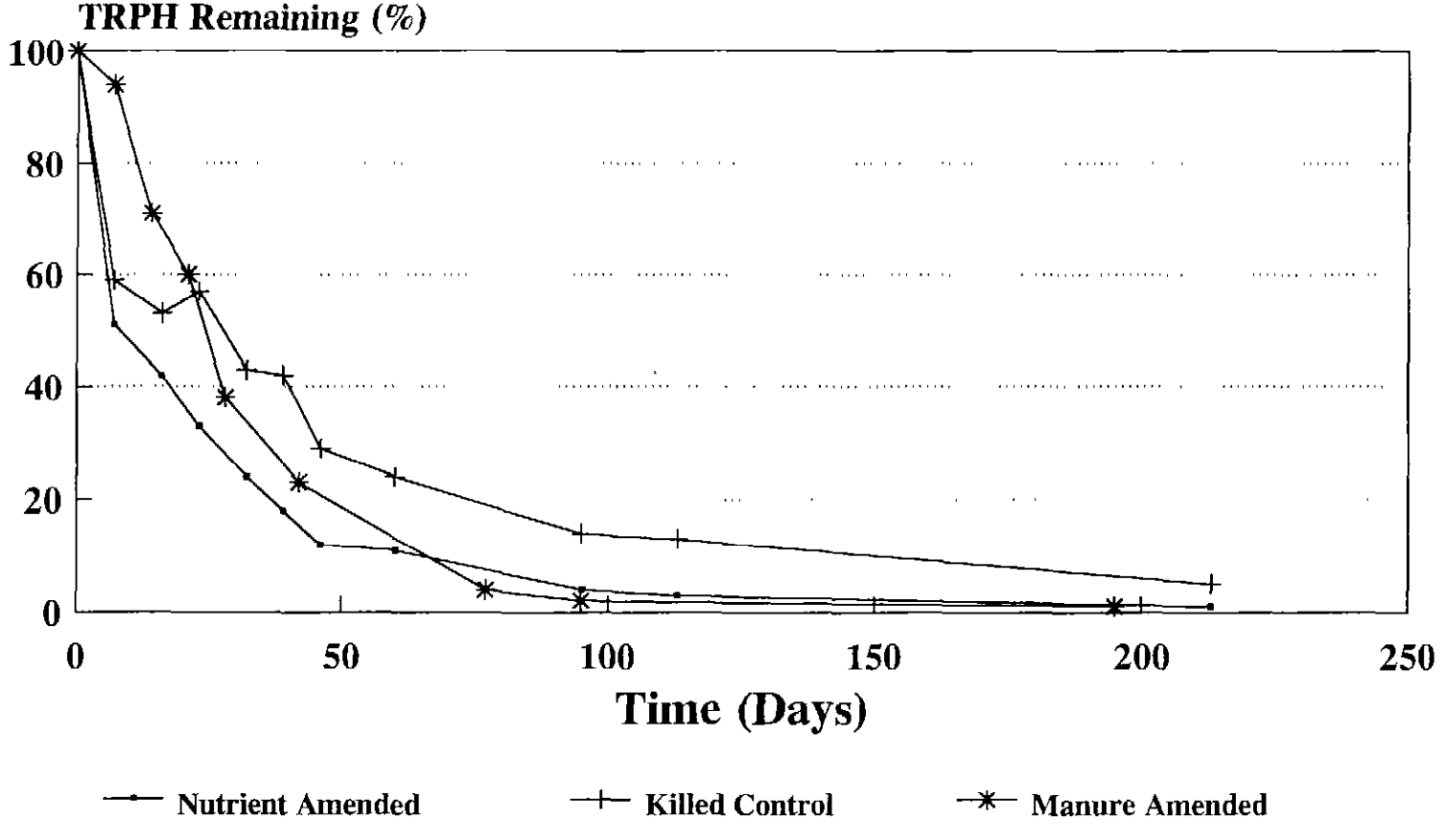


Figure 3-2

ABB-ES under field conditions at another site in Florida where biodegradation continued in soil after an initial active treatment period of 9 months (see attached reference in Appendix C). Therefore, even if TRPH levels are slightly above the treatment criteria after 90 days of treatment, further reductions would be expected even if soil was not actively treated.

Significant losses of TRPH were observed in the killed control over the testing period, but at a slower rate than those observed in the live microcosms. The TRPH half life was calculated to be 50 days, which was more than double the rates observed in the live microcosms. The losses are likely due to volatilization however, it is possible that some biological activity could have been responsible for some portion of the TRPH reduction. It is very difficult to completely sterilize soil, so localized pockets of biological activity could be present. Although the reduction of TRPH was observed in the killed control, TRPH removal occurred at a faster rate in the live microcosms.

GC/FID Results. The results from GC fingerprint analysis were reviewed to evaluate the extent of petroleum hydrocarbon degradation. Data presented in Figure 3-3 show that there was no detectable hydrocarbon remaining in the soil from the live microcosms after Day 95/113. Removal occurred at a faster rate in the live microcosms than in the killed control microcosms. The TRPH that remained in the soil at 95/113 days was likely associated with nonchromatographable biological transformation products or natural carbon in the soil that was not associated with petroleum.

Nutrient Data. Results from nutrient analysis indicated that ammonia nitrogen was utilized rapidly (Appendix D). Although fertilizer applications were frequently made, nitrogen levels dropped to non-detectable levels. Nutrient application rates need to be adjusted for full-scale treatment.

Bacteria Analysis. Samples were taken from the nutrient amended and killed control microcosms and analyzed on at different times over the course of the study for total and hydrocarbon degrading bacteria. The results, which are presented in Figures 3-4 and 3-5, indicate that a significant increase in the bacterial population was observed in both nutrient and manure amended soils. Ultimately, the total population increased by 2 orders of magnitude and the hydrocarbon degrading population by 3. No bacteria were detected in the killed control microcosm. The manure amended microcosm has a greater number of bacteria than the nutrient amended soils, which is not surprising since manure is a source of organic carbon and bacteria.

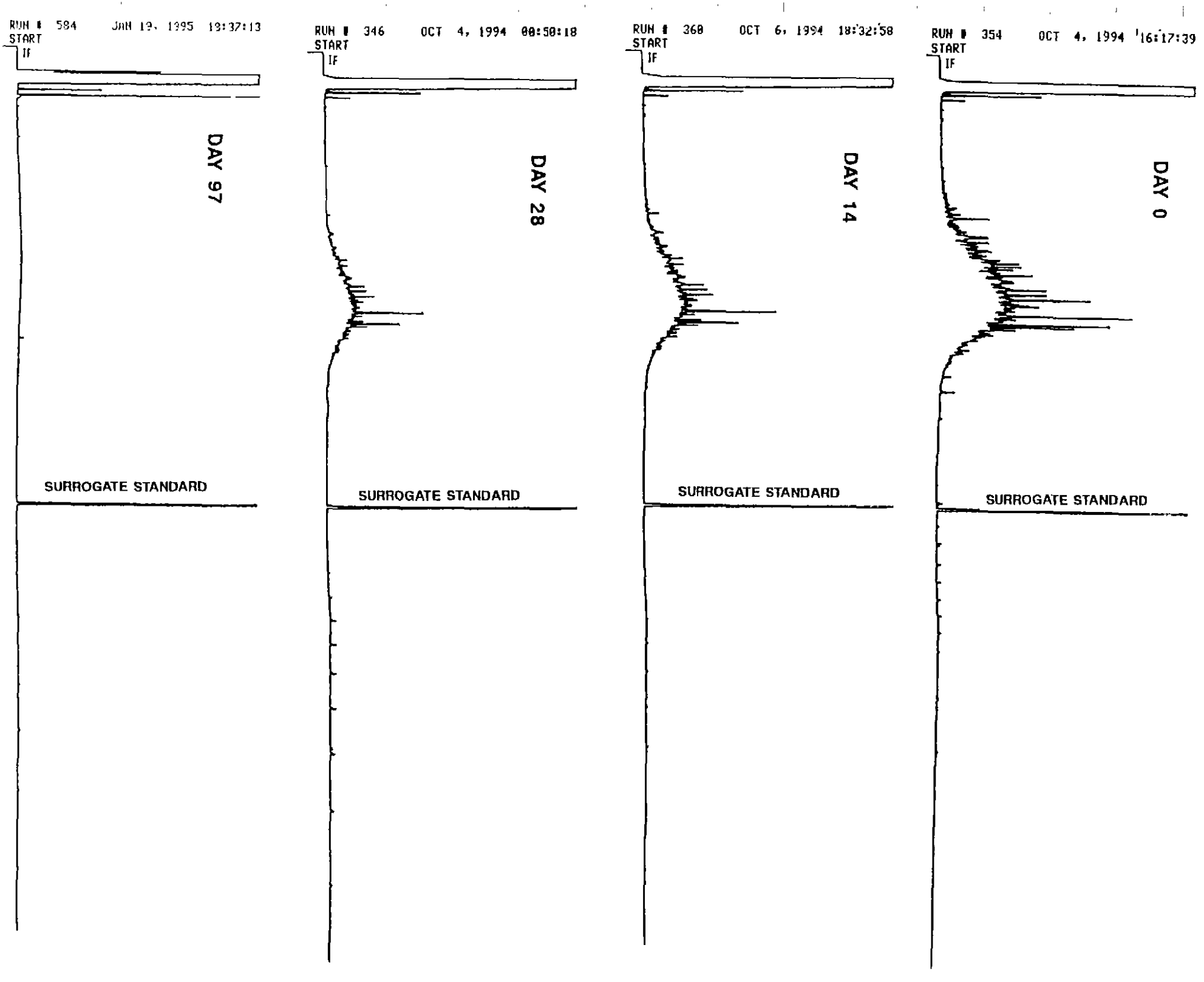


FIGURE 3-3. GC FINGERPRINTS - MANURE AMENDED

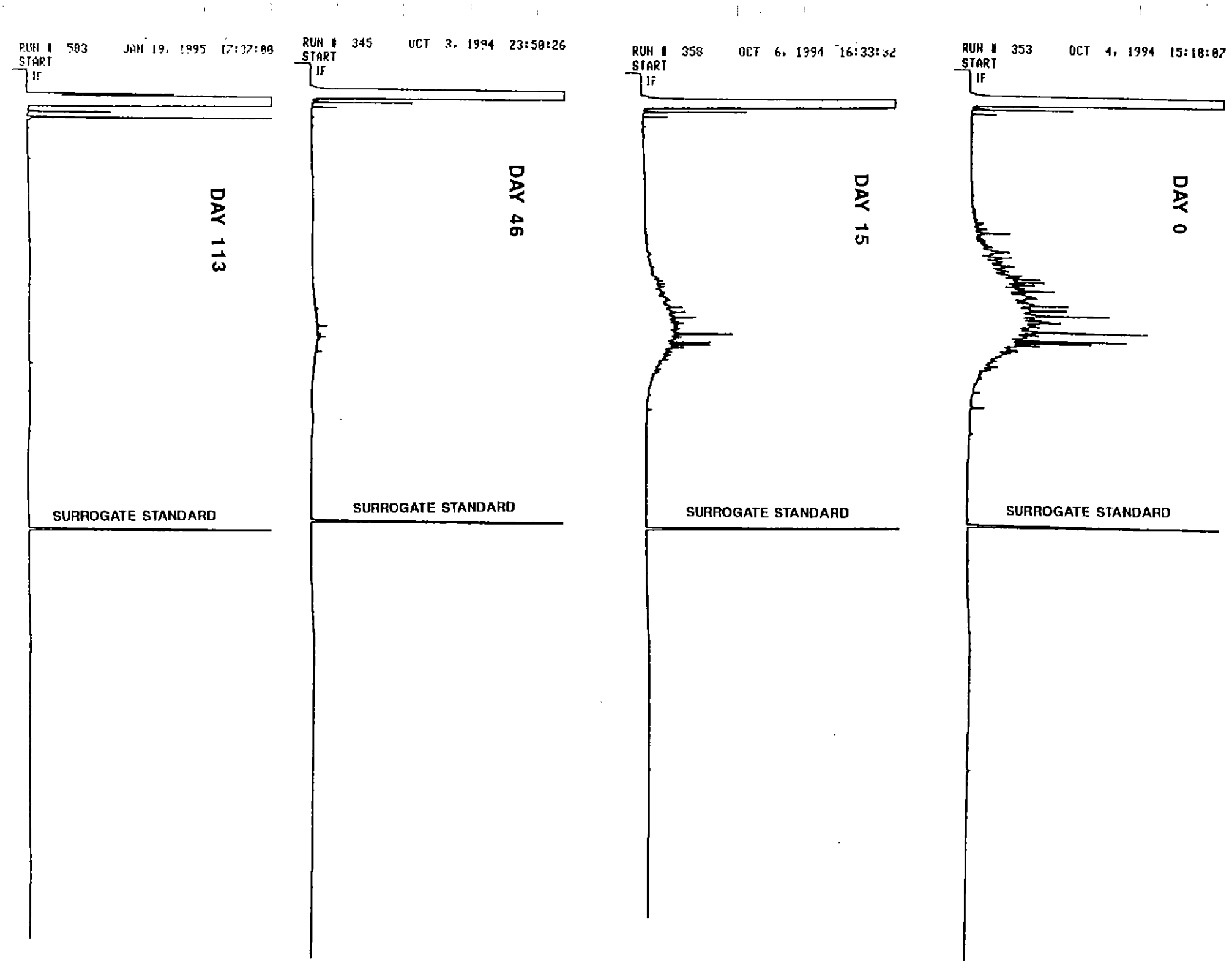


FIGURE 3-3. GC FINGERPRINTS - NUTRIENT AMENDED

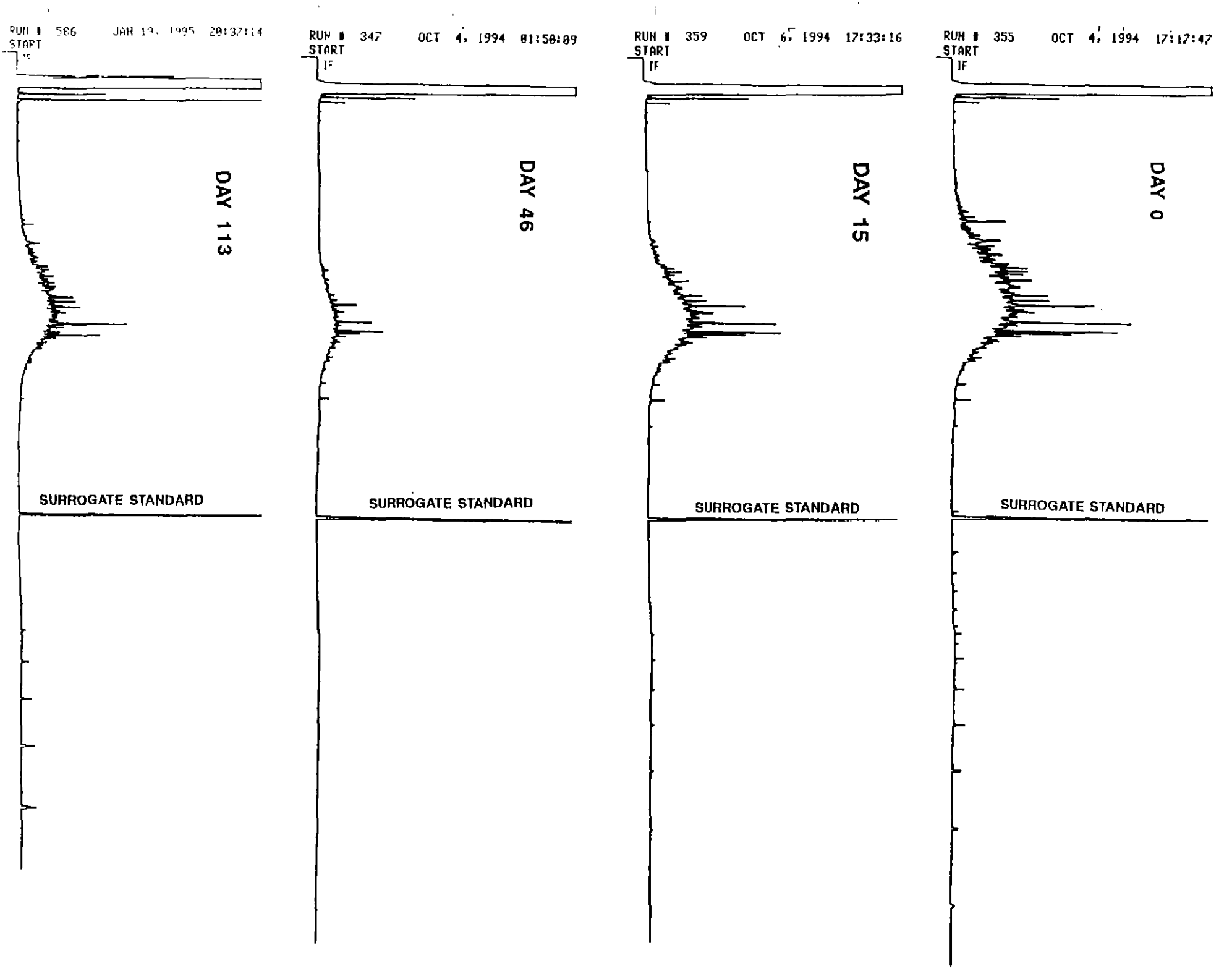


FIGURE 3-3. GC FINGERPRINTS - KILLED CONTROL

Site 5 Treatability Study
Bacteria Analysis Results

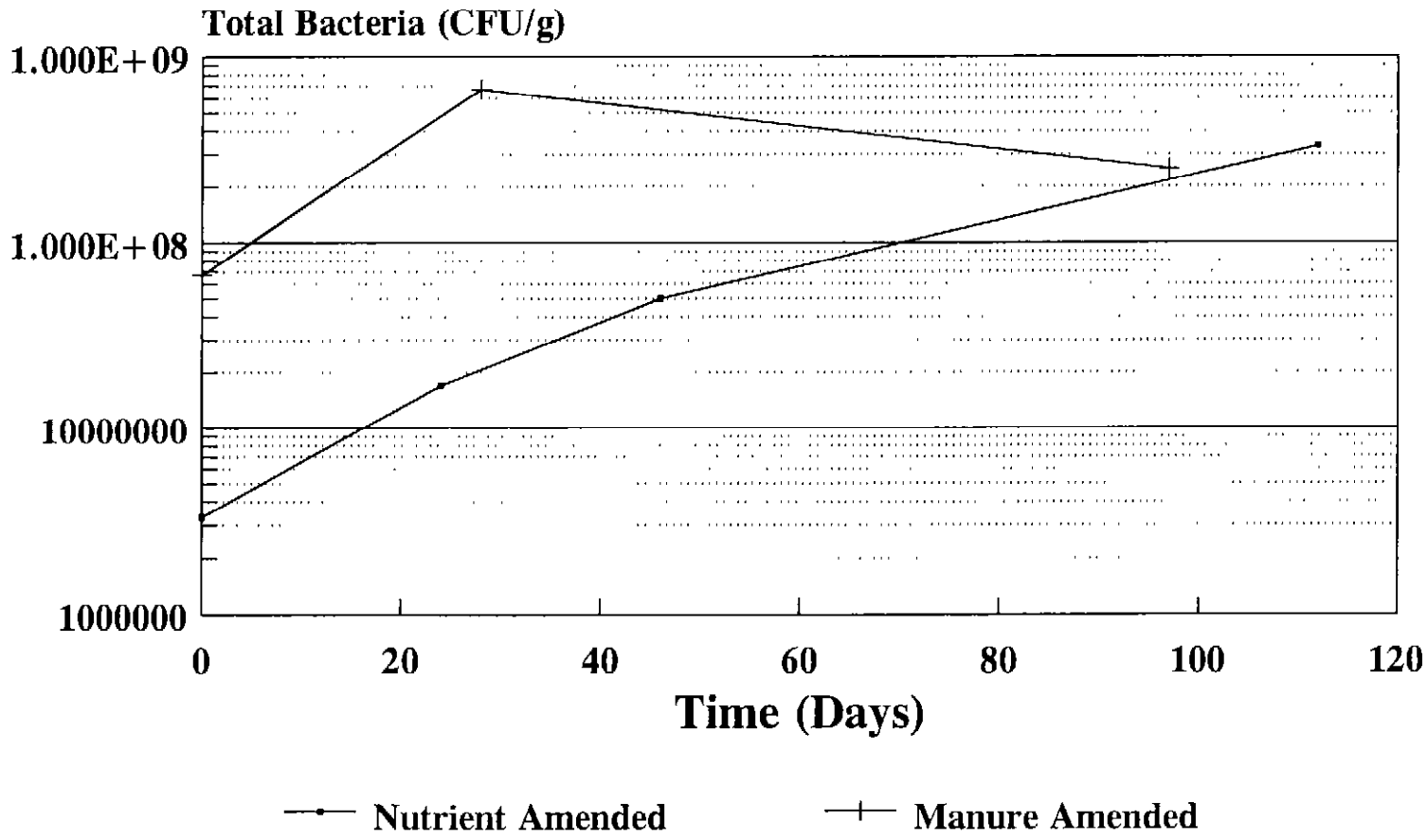


Figure 3-4

Site 5 Treatability Study
Bacteria Analysis Results

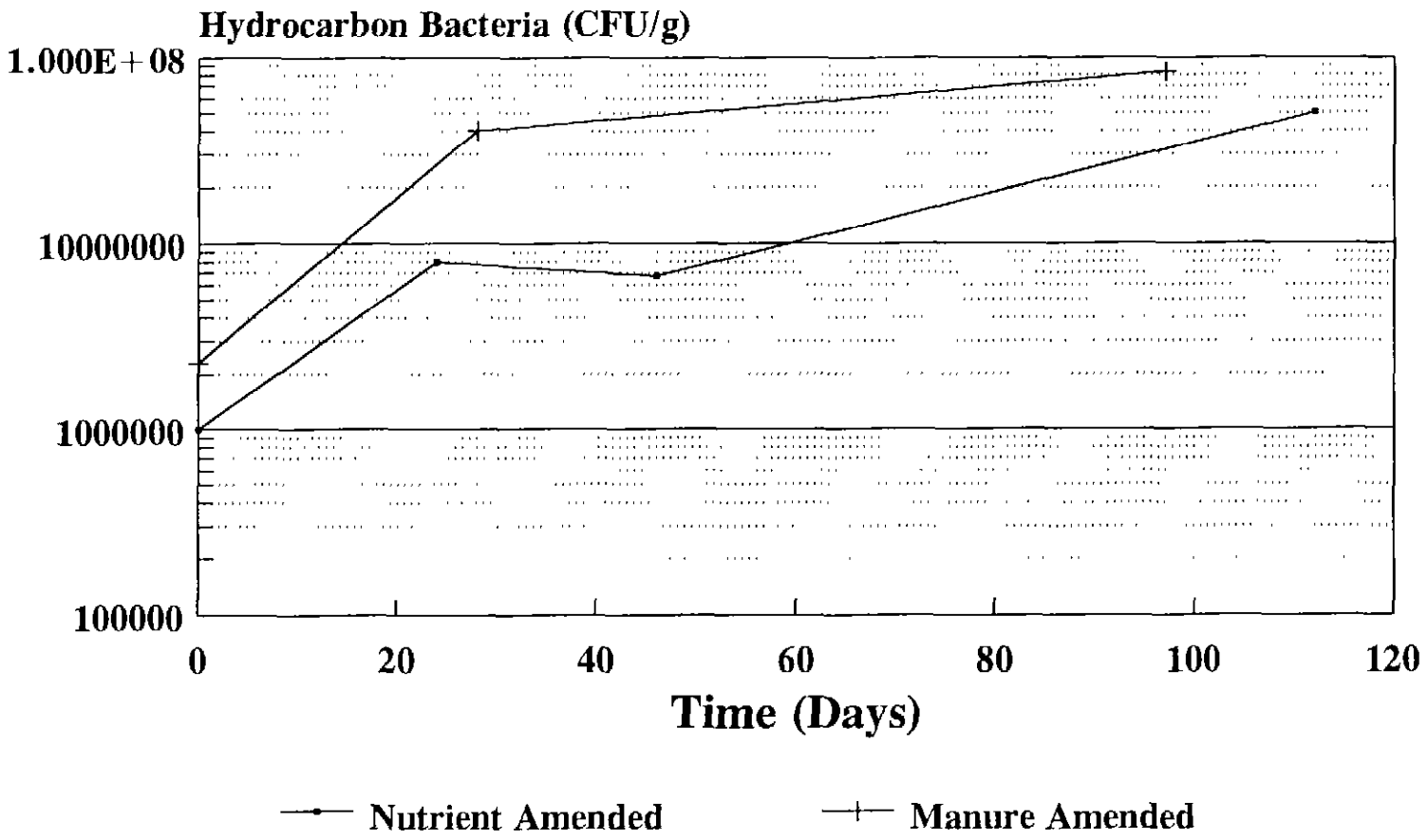


Figure 3-5

Carbon Dioxide Analysis. In order to prove that biological degradation was responsible for losses observed in landfarm microcosms, carbon dioxide analysis was performed to measure mineralization. Ten gram soil samples were removed from each of the test microcosms (Day 50) and placed in 120 ml serum bottles and sealed with a teflon lined septa and crimp top. The soil was kept at room temperature for two weeks. Headspace samples were collected and analyzed for carbon dioxide and oxygen using a gas chromatograph equipped with a thermal conductivity detector (GC/TCD).

Results from the analysis indicated that carbon dioxide was generated in the live microcosms and not in the killed control. This means that there was biological activity in the live soil microcosms and was not apparent in the killed control.

The total amount of carbon dioxide produced from the 10g of nutrient amended soil was 100 ug CO_2 or 27 ug C. During this same time period (Day 50 to 64) approximately 60 mg/kg or 600 ug/10g of TRPH based carbon was degraded in the nutrient amended microcosm. These data show that 4.5% of the TRPH removed was ultimately mineralized. Carbon dioxide levels in the manure amended soil was 111 ug of CO_2 (30 ugC) and approximately 690 mg/kg or 6900 ug/10g of TRPH based carbon was degraded over this period. Approximately 0.4% of the TRPH was mineralized in this soil. Partially oxidized TRPH and bacterial biomass are also formed as a result of TRPH biodegradation. No carbon dioxide was detected in the killed control microcosm. Oxygen levels in the headspace of the nutrient and manure amended soil were approximately 19%.

Volatile Organic Analysis. Volatile compounds such as BTEX and others detected by standard analytical techniques were not a significant fraction of the TRPH that was present in the initial Site 5 soil composites used for treatability testing. Results from volatile analysis (EPA 8010/8020) shown in Table 3-7 indicate that o-xylene was the only volatile compound measured in the soil.

PCB Analysis. The concentration of PCB's were measured in soil at the beginning and end of the study and were detected at levels below 200 ug/kg (Table 3-8). One live and the killed control microcosm was analyzed at Day 113 and the results showed that there may have been a slight reduction in the concentration of PCB in the nutrient amended microcosm.

Table 3-7
Results from Volatile Analysis
Modified EPA Method 5030 8010/8020

Analyte[1]	T=0, Soil Composite
o xylene	175E
Detection Limit	575

E=Estimated Value
[1] Results reported in this Table represent the compounds that were detected in the sample. No chlorinated aliphatics (TCE, DCE, vinyl chloride, 1,1,1 TCA, 1,1 DCE, 1,2 DCA, 1,1 DCA, methylene chloride) or other volatile aromatic compounds (benzene, toluene, ethyl benzene, m xylene) were detected above the detection limit.

Table 3-8
Results from PCB Analysis
Modified EPA Method 3550/8080

Sample ID	PCB T=0 (ug/kg)	PCB T=113 days (ug/kg)
Live	199	117
Control	166	147

NA=Not Analyzed

4.0 CONCLUSIONS

The results from the treatability testing indicate that bioremediation can be used to reduce the concentration of TRPH in petroleum contaminated soil found at Site 5. Petroleum degrading bacterial populations were present in soil. Results from biodegradation testing demonstrated that 98% of the TRPH was reduced in nutrient and manure/nutrient amended soil after 95-113 days of treatment. There was no chromatographable TRPH that remained after the active treatment period, indicating the petroleum had been completely degraded. TRPH reductions were also observed in the killed control microcosm which was likely the result of volatilization. Further TRPH degradation was observed in microcosms that were not activity tilled, and ultimately the treatment criteria of 50 mg/kg was achieved.

It is likely that the time required to reduce TRPH levels to 50 mg/kg would be reduced under active treatment conditions. Conditions that showed the most rapid rate of biodegradation was soil amended with mineral nutrients and manure.

4.1 Recommendations for Full-Scale Treatment

ABB-ES recommends that the following amendments be applied during full-scale treatment:

- Manure (dehydrated or composted cow manure), a total amount of 1% (by weight) will be mixed in with the Site 5 soil when the windrows are being constructed. The manure will provide additional moisture holding capacity as well as an additional source of bacteria and nutrients.

- The pH will be raised by adding lime to soil. Lime should initially be applied at a rate of 0.6%. Additional applications will likely be required, but those should be added based upon results from field pH tests.

- 3.7 lbs of 34:11:6 fertilizer per cubic yard of soil will be required to treat soil with an average concentration of 2500 mg/kg. This value was estimated based upon nutrient utilization observed during treatability testing. The amount used in the study was increased by 50% since nitrogen was used so rapidly. Only 25% of the estimated fertilizer should be applied initially and nitrogen and phosphate levels shall be monitored to avoid having nutrient levels fall below 5 mg/kg.

- Indigenous bacterial population was able to degrade petroleum hydrocarbons and therefore the application of a commercial blend of bacteria is not recommended.

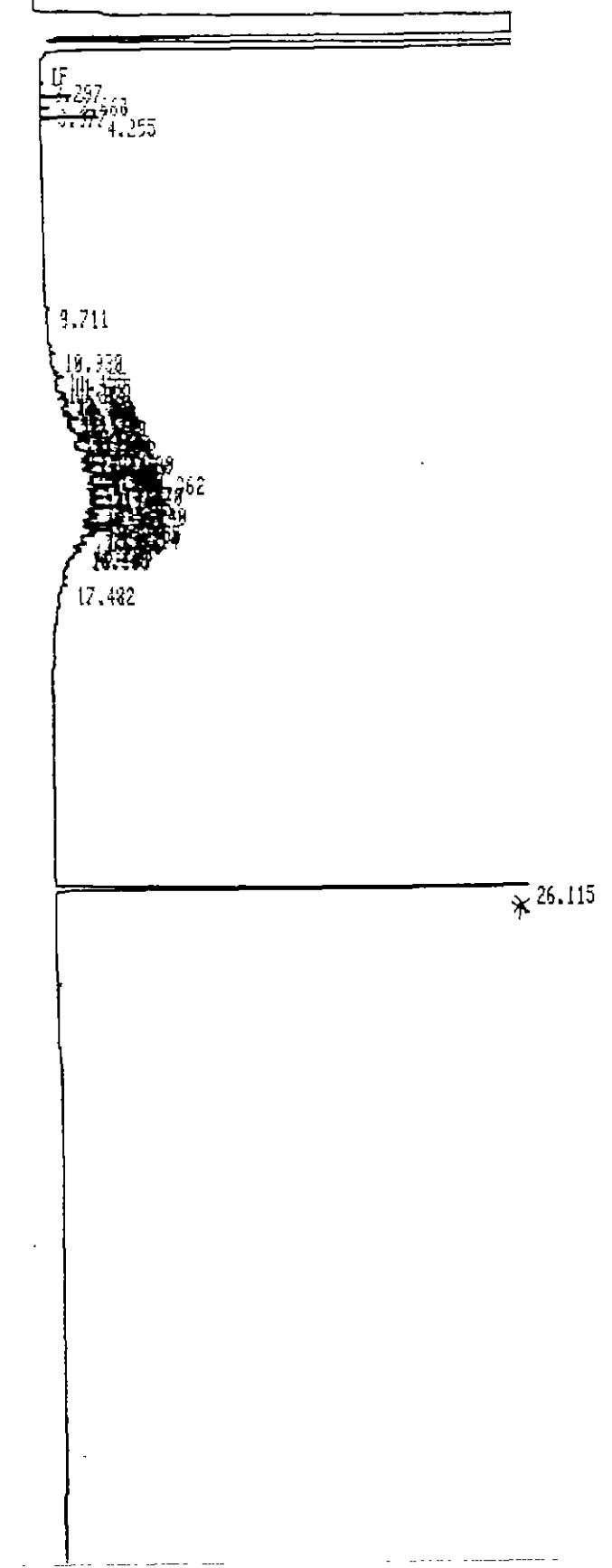
- Rapid TRPH reductions were observed over the first 30 days of testing. Therefore, oxygen demand will be highest over the same period. Soil should be turned at least twice a week to provide oxygen. Oxygen levels in soil should be monitored during treatment and aeration schedules adjusted as required.

Based upon information obtained during treatability testing, soil treatment should take approximately 90 days assuming TRPH levels are at 2500 mg/kg and the recommended treatment conditions are maintained.

APPENDIX A
Initial Sample Chromatograms

RUN PARAMETERS
ZERO = 0
ATT 2^ = 1
CHT SP = 0.5
AR REJ = 0
THRSH = 0
PK WD = 0.04

RUN # 226 JUL 30, 1994 14:23:26
START



Low Site 5
7/16/94

* Internal Standard

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THRSH = 0
PK WD = 0.04

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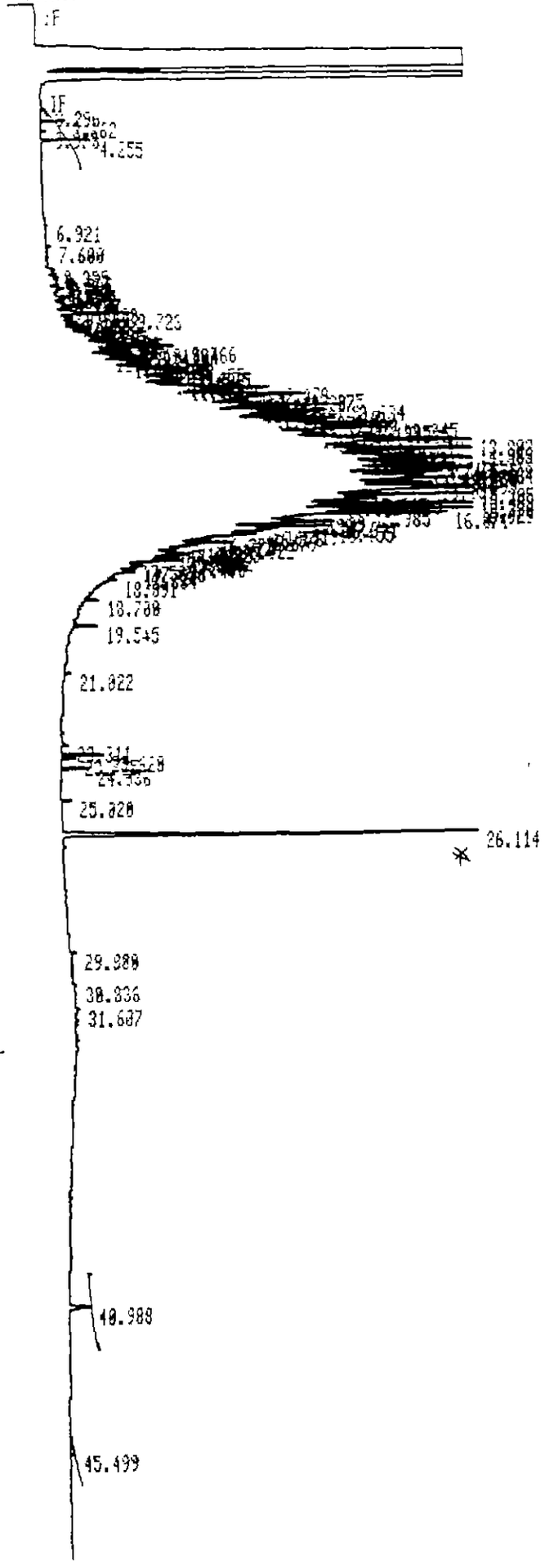
START

Average E
Site 5
7/16/94



* Internal Standard

PK WD = 0.04

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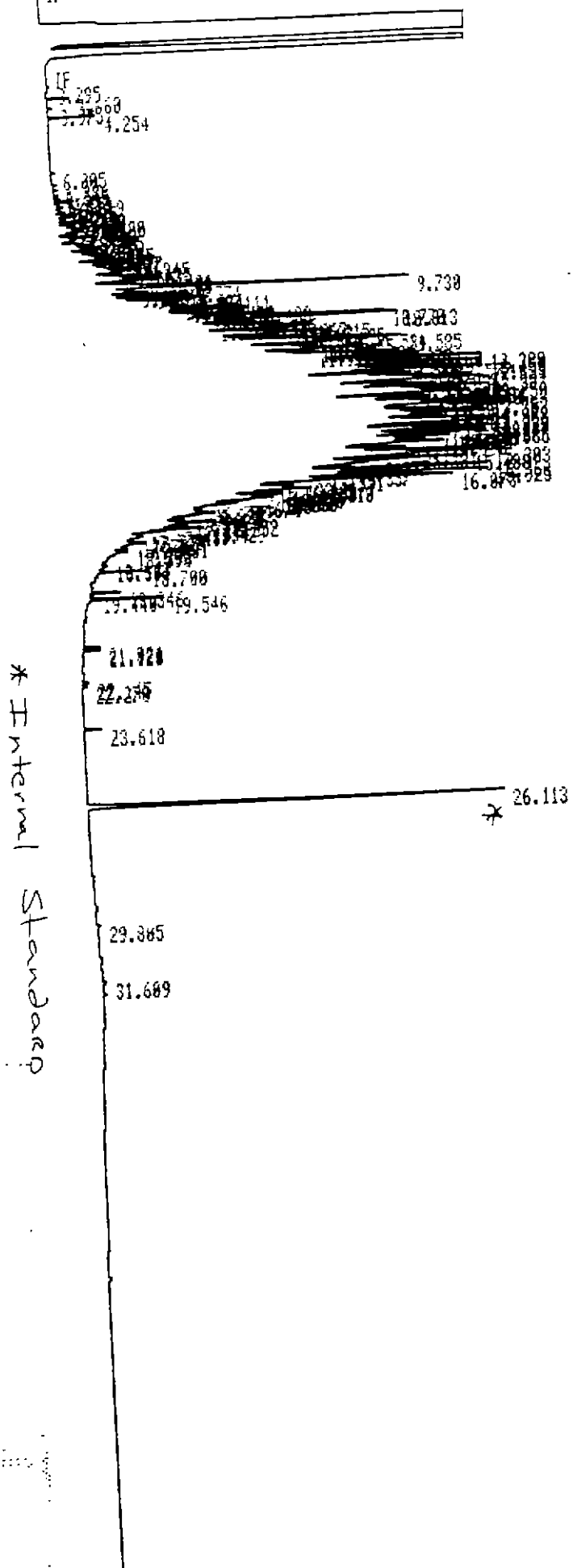
START

IF

Average W Site 5
7/16/94



* Internal Standard

High - Sites
7-16-94

RUN PARAMETERS
ZERO = 0
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CHT SP = 0.5
AR REJ = 0
THRSH = 0
PK WD = 0.04

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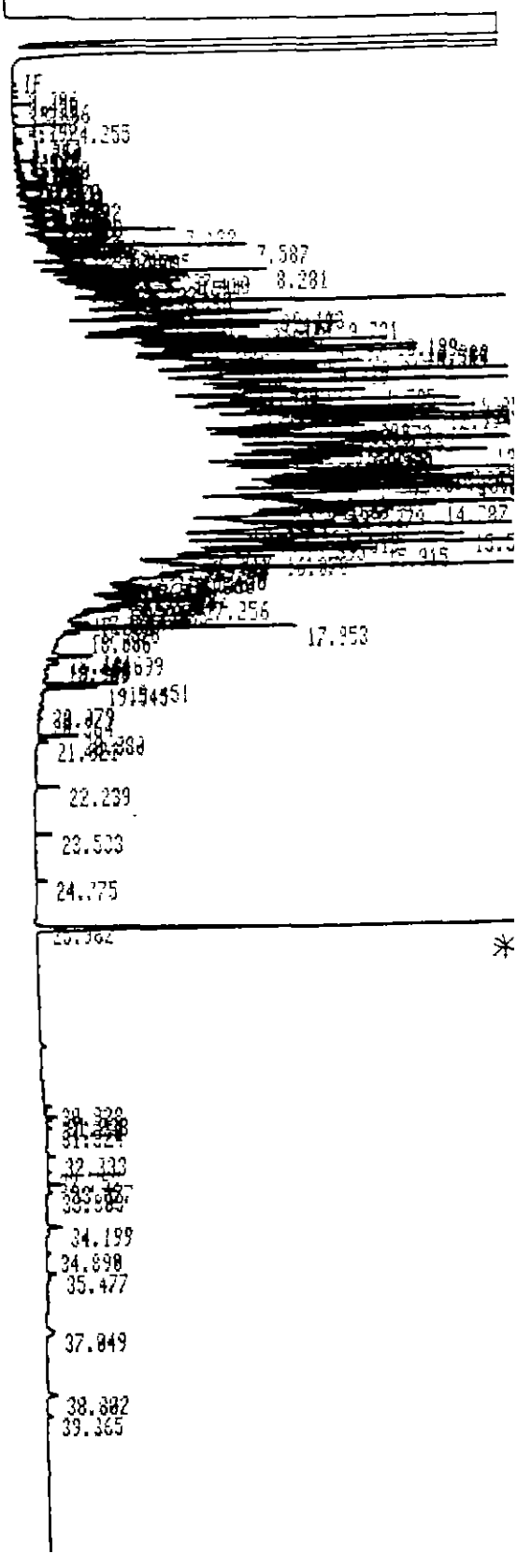

* Internal Standard

Waiting for System Readiness
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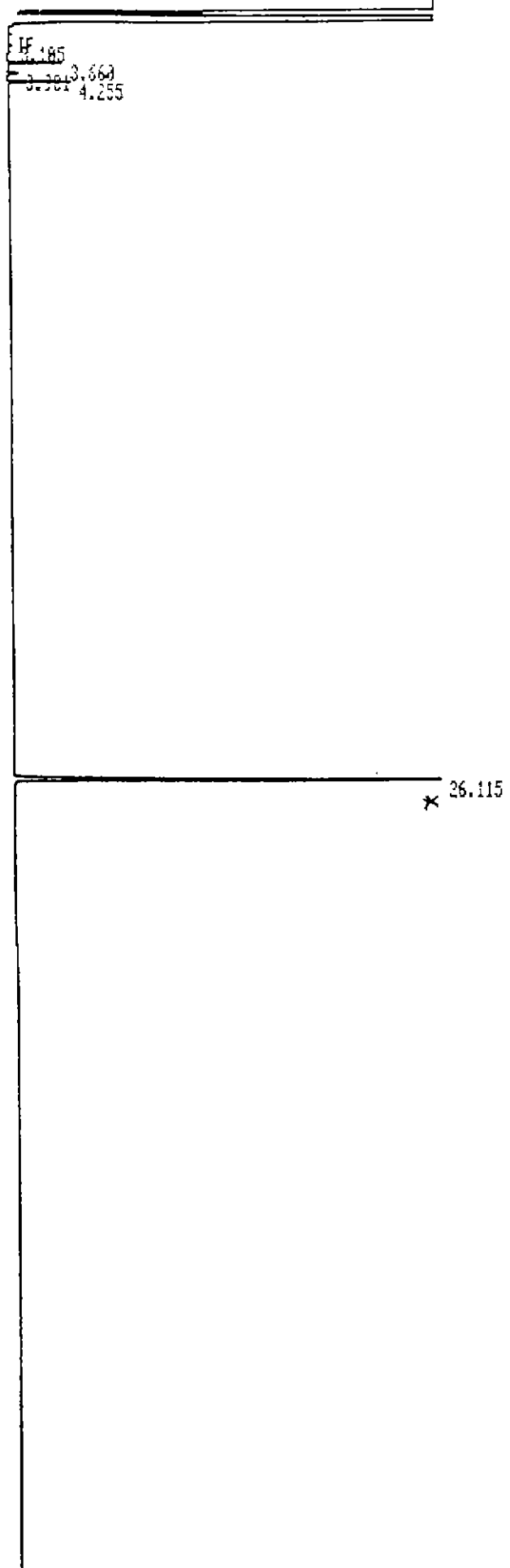

Blank

* Internal Standard

RUN # 236 JUL 30, 1994 22:55:35 JP5 (c)

START

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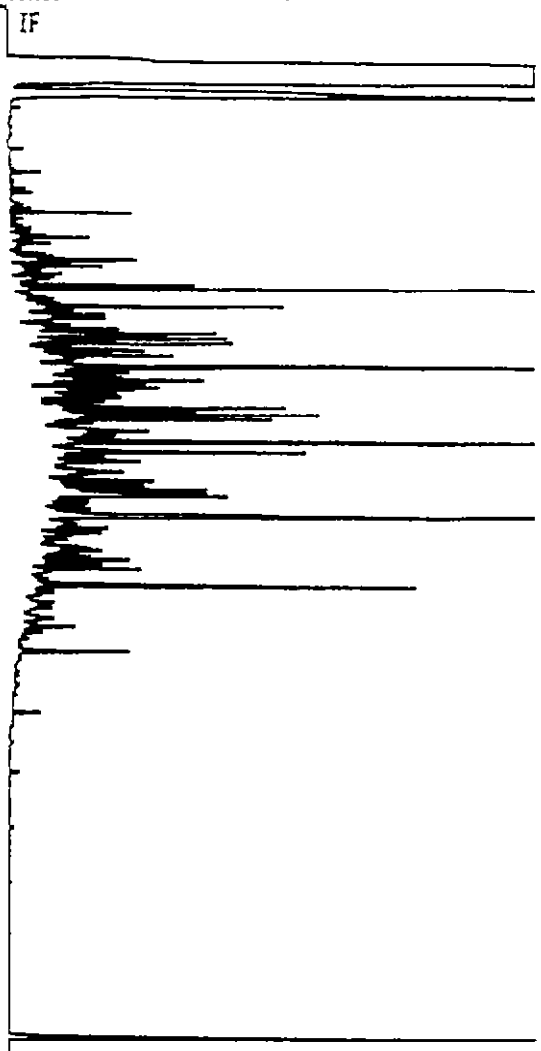

*

JP-5 STD

1STD

kerosene

* ATT 2^ 1 @
*AN H:Q8C58C9D.BNC
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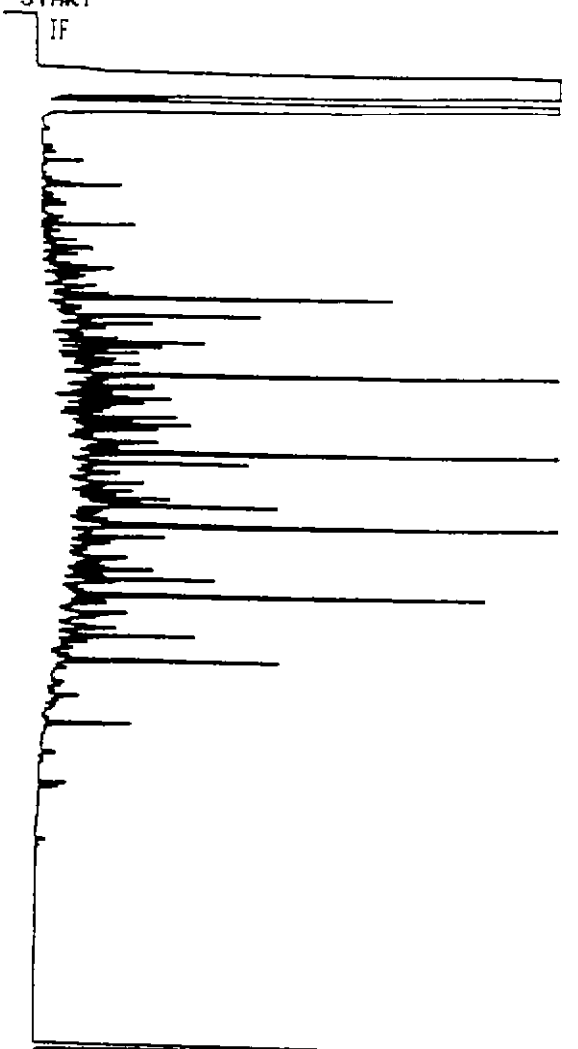

*

Kerosene STD

* 1STD

APPENDIX B
TRPH Treatability Test Results
Initial Sample Chromatograms

					APPENDIX TABLE B							
					TRPH RESULTS FROM MICROCOSM ANALYSIS							
					SITE 5 TREATABILITY STUDY							
DATE	DAY	LIVE	LIVE	AVE	KILL	KILL	AVE	DATE	DAY	MANURE	MANURE	AVE
8/15/94	0	4943	5024	4984	5311	5507	5409	9/2/94	0	4802	5618	5210
8/23/94	8	2537		2537	3252		3252	9/9/94	7	5273	4557	4915
8/31/94	16	2080		2080	3329		3329	9/16/94	14	3719	3701	3710
9/7/94	23	1628	1637	1633	3077	3035	3056	9/23/94	21	3123	3082	3103
9/16/94	32	1325	1101	1213	2328	2309	2319	9/30/94	28	2133	1846	1990
9/23/94	39	760	1022	891	2251	2246	2249	10/14/94	42	1145	1223	1184
9/30/94	56	674	552	613	1552	1541	1547	11/18/94	77	191	171	181
10/14/94	60	546	542	544	1489	1145	1317	12/5/94	95	122	123	123
11/18/94	95	190	180	185	757	715	736	3/15/95	195	52	52	52
12/5/94	113	132	147	140	881	498	690					
3/15/95	213	39			257							

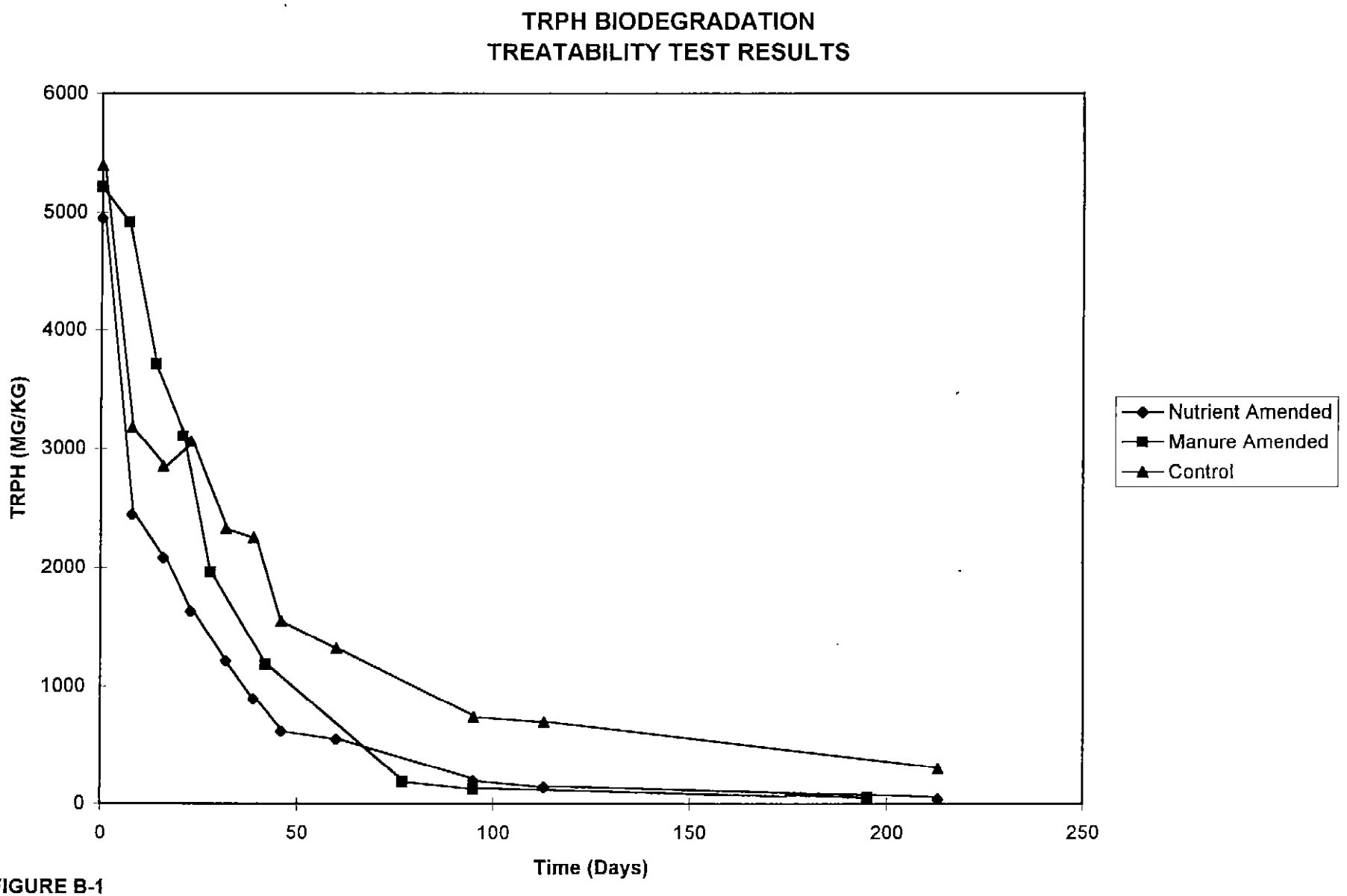

FIGURE B-1

CECTREAT.XLS

APPENDIX C
Referenced Landfarm Project

FULL SCALE BIOREMEDIATION OF A No. 6 FUEL SPILL: DATA FROM SIX MONTHS OF ACTIVE TREATMENT AND THREE YEARS OF PASSIVE TREATMENT

Samuel Fogel
ABB Environmental Services, Inc.
Bioremediation Systems Division
Wakefield, Massachusetts

Mark Jones and Rayburn Butts
Florida Power and Light
Environmental Affairs
West Palm Beach, Florida

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I. INTRODUCTION

Bioremediation is a technology which, under optimal conditions can result in destruction of a wide range of petroleum constituents. The extent of treatment that can be achieved depends on several factors such as the starting concentration of petroleum, the types of constituents, available inorganic nutrients, duration of treatment, etc. The main source of information concerning treatment of petroleum in soil has been primarily obtained from laboratory investigations in which soil samples have been well mixed.[1] While laboratory data is useful for short term evaluations, e.g., less than one year, there are, for a number of practical reasons, limits to conducting longer term laboratory evaluations.

Field remediations offer an opportunity to obtain insight into the fate of chemicals over long durations, periods of years under open conditions. In addition, insight can be gained into the question of extent of biodegradation under conditions where active soil processing and mineral nutrient additions have ceased. Not all field remediations however, provide useful information due to circumstances such as lack of uniformity of contaminations, poor data quality, etc. The majority of field remediation projects are in fact not suitable for long-term evaluations.

This paper presents a bioremediation case study in which samples were collected and analyzed from a field remediation project over a three and one-half year period. An earlier report on this work addressed only a six-month period of active bioremediation.[2] The contamination resulted from a single spill of No. 6 fuel from a storage tank into a 60,000-square-foot bermed area. Because of relatively permeable soil at the surface and an impermeable layer at 8 inches, the oil spread over the surface resulting in a relatively homogeneously contaminated site. As a result, composite samples were able to represent the site with good reproducibility. This circumstance gave us an opportunity to obtain very interesting data, cost effectively. Additional site homogenization, during the active 180-day period of remediation, subsequently allowed one composite sample to be analyzed providing representative data for the entire site.

II. NO. 6 FUEL SPILL

A large aboveground storage tank located within a bermed area was overfilled, resulting in a spill of 3,200 barrels of No. 6 Fuel to the surface soils adjacent to the tank (Figure 1). After oil recovery efforts, approximately 900 barrels remained in the surface soils. The oil was evenly dispersed over an area of 60,000 square feet and penetrated only to a depth of 6 to 8 inches due to the presence of an impermeable layer of clayey, textured soil.

TABLE 4

DATA SUMMARY: NO. 6 FUEL FIELD REMEDIATION

PARAMETER	BEFORE REMEDIATION (ppm)	MONTH 6 (ppm)	MONTH 9 (ppm)	MONTH 21 (ppm)	MONTH 33 (ppm)	PERCENT DEGRADED AT MONTH 33
TPH	60,000	23,700	18,800	12,000	10,100	83%
GC/FID	9,050	1,715	820	430	325	96%
Target PAH	2,770	--	70	40	35	99%

TABLE 6

HALF-LIVES OF NO. 6 FUEL CONSTITUENTS IN SOIL UNDER ACTIVE AND PASSIV

	CHEMICAL PARAMETER HALF-LIFE (days)			
	TOTAL GC/FID RESPONSE	TPH	C_{10} - C_{14}	RING
Active Bioremediation				
Day 0 - 180	60	110	20-40	
Passive Bioremediation				
Day 180 - 1,000	>400	450-700	--	

APPENDIX D
Nutrient Data

TABLE D-1
RESULTS FROM NUTRIENT ANALYSIS OF TEST MICROCOSMS

	AMMONIA MG/KG-N		NITRATE MG/KG-N		PHOSPHATE-PO4		pH	
DAY	LIVE	+ MANURE	LIVE	+ MANURE	LIVE	+ MANURE	LIVE	+ MANURE
0	50	63	<1.25	<1.25	23	150	5.5	
14							6.5	
38	NA	<5	NA	<1.25	NA	150		
44							7	
56	<5	NA	<1.25	NA	38	NA		
68	NA	5	NA	<1.25	NA	150		6
86	2.5	NA	<1.25	NA	30	NA	7	
96	NA	13	NA	<1.25	NA	30		
112	5	NA	<1.25	NA	25	NA		7.5
127							6.5	

Fertilizer was added and pH adjusted on Days 0, 18, 39, 51, 76 and 79
Total Amount of fertilizer added, 300 mg/microcosm