

FINAL

**Intrinsic Remediation Treatability Study Addendum
for Site ST-29**



**Patrick Air Force Base
Florida**

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base, Texas
San Antonio, Texas**

and

**Patrick Air Force Base
Florida**

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14 September 1999

Mr. Jerry Hansen
Technical Program Manager
AFCEE/ERT
3207 North Road, Bldg. 532
Brooks AFB, TX 78235-5363

Subject: Responses to AFCEE Comments on the Draft Intrinsic Remediation
Treatability Study for Site ST-29, Patrick AFB, Florida (Contract F41624-92-
D-8036-0025)

Dear Mr. Hansen:

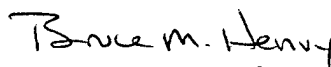
Enclosed please find two copies of the September 1999 Final Intrinsic Remediation Treatability Study (TS) for Site ST-29, Patrick AFB, Florida. This report was prepared by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence Technology Transfer Division (AFCEE/ERT) and Patrick Air Force Base (AFB).

The intent of the TS Addendum was to determine the role of natural attenuation in remediating fuel contamination in groundwater at Site ST-29. The draft TS Addendum was submitted to AFCEE in July 1999. Comments on the draft TS Addendum were received from AFCEE as reviewed by Jon Atkinson (dated 09 September 1999). Responses to these comments were prepared by Parsons ES and are attached to this letter.

If you have any questions or comments regarding this package, please do not hesitate to contact me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.


Bruce M. Henry, P.G.
Project Manager

Enclosures

c.c. Mr. Ed Worth – Patrick AFB (two copies)
Mr. Don Kampbell – USEPA NRMRL (two copies)



**Responses to AFCEE Comments on the Draft Addendum to the Intrinsic
Remediation Treatability Study for Site ST-29, Patrick AFB, Florida**

GENERAL COMMENTS

Comment 1) Page 5, Sec 2.0, Para 1, Sent 1: Manganese is listed but does not appear on Table 1A. This apparent discrepancy should be resolved.

Parsons ES Response: *Manganese was not analyzed for in January 1996. Section 2.0 will be amended to indicate that manganese was only analyzed for in 1998.*

Comment 2) Pages 5 and 6, Tables 1A and 1B: For the analyte "Alkalinity," the typo "Biocarbonate" should be corrected.

Parsons ES Response: *The tables will be corrected as indicated.*

Comment 3) Page 13, Table 4: Here, and throughout the document (e.g., p. 18, para 1) recommend reporting all analytical results to no more than three significant figures (e.g., 1,860 ug/L of toluene) to better reflect accuracy and certainty of these measurements.

Parsons ES Response: *Analytical results will be reported to three significant figures throughout the document.*

Comment 4) Page 16, Fig 3: For the January 1996 BTEX plume, the highest mapped concentration (50 ug/L) is two orders of magnitude lower than the highest mapped concentration (5,000 ug/L) for the other three depicted plumes. This apparent discrepancy should be resolved.

Parsons ES Response: *Agreed. Insufficient data was collected in January 1996 to determine the maximum BTEX concentrations within the groundwater plume (e.g., no data for monitoring point cluster CPT-03). Based on maximum concentrations of BTEX measured in 1994, 1995, and 1998, dashed (inferred) BTEX isopleths for 500 ug/L and 5,000 ug/L will be added to the January 1996 map.*

Comment 5) Page 20, Sec 2.2, Para 3: Recommend annotating the computer codes (e.g., BIOPLUME II, MODFLOW) that were used in the computer modeling efforts.

Parsons ES Response: *The computer code for BIOPLUME II was used in the modeling effort for the TS, and will be annotated in Section 2.2.*

**Responses to AFCEE Comments on the Draft Addendum to the Intrinsic
Remediation Treatability Study for Site ST-29, Patrick AFB, Florida
(Continued)**

Comment 6) Page 21, Sec 2.3, Line 11: Recommend changing "may indicated" to "may indicate."

Parsons ES Response: *The text will be changed as indicated.*

Comment 7) Page 35, Sec 2.5, Para 1, Line 4: "sulfate" should be replaced by "methane."

Parsons ES Response: *The text will be changed as indicated.*

**FINAL
ADDENDUM TO THE
INTRINSIC REMEDIATION TREATABILITY STUDY FOR SITE ST-29**

**AT
PATRICK AIR FORCE BASE
FLORIDA**

September 1999

**Prepared for:
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS**

**AND
PATRICK AIR FORCE BASE
FLORIDA**

**Prepared by:
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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AFESC	Air Force Engineering and Services Center
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CaCO ₃	calcium carbonate
CVOCs	chlorinated volatile organic compounds
DO	dissolved oxygen
ES	Engineering-Science, Inc.
ESE	Environmental Science & Engineering, Inc.
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
Fe ²⁺	ferrous iron
Fe ³⁺	ferric iron
ft/day	feet per day
ft/ft	foot/foot
ft amsl	feet mean sea level
ft/yr	feet per year
IRP	Installation Restoration Program
LTM	long-term monitoring
mg/L	milligrams per liter
MOGAS	motor vehicle gasoline
MTBE	methyl tertiary-butyl ether
mV	millivolts
NRMRL	National Risk Management Research Laboratory
ORP	oxidation/reduction potential
Parsons ES	Parsons Engineering Science, Inc.
PCA	Petroleum Contamination Assessment
ppmv	parts per million, volume per volume
SVE	soil vapor extraction
TMBs	trimethylbenzenes
TOC	total organic carbon
TS	Treatability Study
TVPH	total volatile petroleum hydrocarbons
USEPA	US Environmental Protection Agency
UST	underground storage tank

1.0 INTRODUCTION

This report was prepared for the Air Force Center for Environmental Excellence (AFCEE) by Parsons Engineering Science, Inc. (Parsons ES) as an addendum to the *Final Intrinsic Remediation Treatability Study (TS) for Site ST-29, Patrick Air Force Base (AFB), Florida (Parsons ES, 1995)*. The TS was conducted to evaluate the use of intrinsic remediation with long-term monitoring (LTM) for remediation of fuel hydrocarbon contamination dissolved in groundwater at Site ST-29. The Final TS included data for two sampling events conducted in March 1994 and March 1995. This addendum summarizes the results of two additional sampling events conducted in January 1996 and March 1998 by researchers from the US Environmental Protection Agency (USEPA) National Risk Management Research Laboratory (NRMRL) Subsurface Protection and Remediation Division. Additional data collected by CH2M Hill in May 1995 also are included in this analysis.

The main emphasis of this summary is to evaluate changes in dissolved benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations, BTEX plume extent, and natural attenuation mechanisms through time. Results, calculations, and predictions presented in the TS (Parsons ES, 1995) are used as the basis for comparison. Data collected in January 1996 and March 1998 are presented in Appendix A.

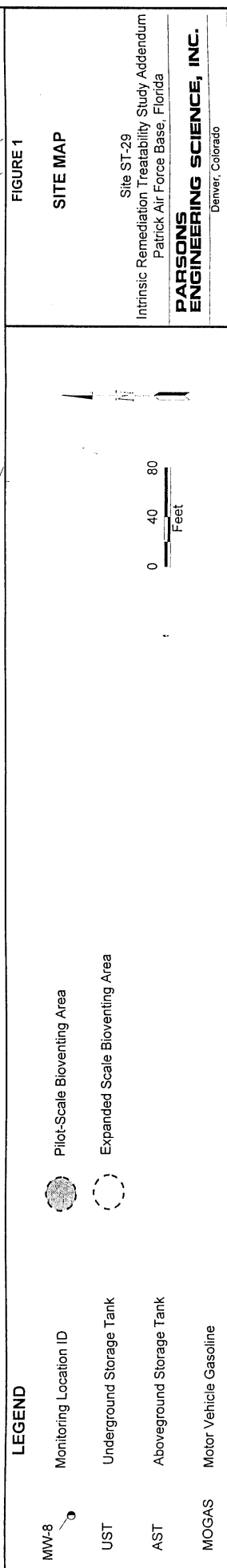
1.1 Facility Background

Patrick AFB lies on a narrow barrier island off the eastern coast of Florida in Brevard County. Site ST-29 is located in the north-central section of Patrick AFB, approximately 400 feet west of the northeastern end of the northeast/southwest runway. Site ST-29 consists of the BX Service Station, including a small food market (Building 736), a gasoline dispensing area, and a car wash facility (Building 737) (Figure 1). The BX Service Station has been in operation since 1954. Four 10,000-gallon fiberglass motor vehicle gasoline (MOGAS) underground storage tanks (USTs) and one 1,000-gallon waste oil aboveground storage tank (AST) are currently used to dispense or store petroleum products.

1.2 Operational and Site Investigation History

In 1973, five 5,000-gallon MOGAS USTs previously located northeast of Building 736 (the BX Service Station) were removed (Figure 1), and the excavations were backfilled with sand. In the same year, the MOGAS tanks were replaced with five 10,000-gallon fiberglass USTs. One of the 10,000-gallon MOGAS USTs and product lines from another of the 10,000-gallon fiberglass USTs were discovered to be leaking in 1985. Between 1985 and 1986, an estimated 700 gallons of unleaded gasoline was released into the subsurface as a result of the leaking lines and tank. In 1986, the leaking 10,000-gallon MOGAS UST was removed, leaving four MOGAS USTs in operation. A 500-gallon waste oil UST also was removed and replaced in February 1992 with a 1,000-gallon waste oil AST.

The Air Force Installation Restoration Program (IRP) was initiated at Patrick AFB in 1984 when the Air Force Engineering and Services Center (AFESC) retained



Environmental Science & Engineering, Inc. (ESE) to conduct a records search of previous Base activities (Phase I of the IRP) (ESE, 1984). Phase II (stage 1) IRP work at Patrick AFB began in 1985 and the BX Service Station (ST-29) was identified and added to the IRP for Phase II (stage 2) activities (ESE, 1988). Phase II (stage 2) work involved two monitoring events (November 1988 to January 1989 and October to November 1989) to determine fluctuations in groundwater levels at the site (ESE, 1991). A Phase II (stage 3) program at the BX Service Station was performed by O'Brien & Gere Engineers, Inc. (1992) in accordance with the Florida Department of Environmental Protection (FDEP) Petroleum Contamination Assessment (PCA) guidelines, as outlined in Chapters 17-770.600 and 17-770.630 of the Florida Administrative Code (FAC). The objective of the Phase II (stage 3) investigation was to evaluate the nature and extent of contamination at the site and to make remedial recommendations.

A soil gas survey was conducted by Engineering-Science, Inc (ES, now Parsons ES) at the BX Service Station in January 1993 (ES, 1993), prior to installation of a pilot bioventing system. A 20-foot by 20-foot grid was laid out in the area where previous sampling had determined that soil hydrocarbon contamination was present. Total volatile petroleum hydrocarbons (TVPH) exceeded 10,000 parts per million, volume per volume (ppmv) at locations adjacent to the north and east sides of the car wash (Building 737) at Site ST-29.

1.3 Remedial Activities

A pilot scale bioventing system consisting of one horizontal vent well and five soil gas monitoring points was installed and tested at the site in March 1993. The pilot-scale bioventing system was installed in an area north of Building 737 (Figure 1) to treat soil contaminated with residual BTEX. Due to high levels of TVPH in soil gas, a soil vapor extraction (SVE) pilot test was performed from October 1993 to January 1994. The pilot-scale air injection bioventing system was then run from January 1994 through July 1995. The pilot-scale system was expanded with a full-scale bioventing system in June 1995. The full-scale bioventing system was in operation at the site from June 1995 to July 1998, at which time confirmation sampling was performed. Based on results of the confirmation sampling, it was recommended that the bioventing system operation be discontinued. Details regarding the results of the bioventing system were presented in a confirmation sampling and analysis report (Parsons ES, 1999).

2.0 RESULTS

In January 1996 and March 1998, researchers from the USEPA NRMRL collected groundwater samples from 13 and 14 monitoring locations, respectively at Site ST-29. Locations CPT-4S, -4D, -09S, -12S, -16DD, -18S were sampled during both the January 1996 and March 1998 events.

Samples were analyzed in the field for oxidation/reduction potential (ORP), dissolved oxygen (DO), conductivity, temperature, pH, carbon dioxide, manganese (1998 only), sulfide and alkalinity. Additional sample volume was analyzed at the USEPA NRMRL in Ada, Oklahoma for nitrate+nitrite, ammonia, chloride, sulfate, methane, ethane, ethene, total organic carbon (TOC), BTEX, trimethylbenzenes (TMBs), and methyl tert-butyl

ether (MTBE). Samples were also analyzed for total fuel carbon, phenols and aliphatic acids, and chlorinated volatile organic compounds (CVOCs) in 1996. CVOCs were not detected in any groundwater samples collected in January 1996. The analytical methods used in January 1996 and March 1998 are summarized in Tables 1A and 1B. Copies of laboratory results and field notes are provided in Appendix A.

2.1 Flow Direction and Gradient

Depth to groundwater was measured at monitoring locations in March 1994 and January 1996. Groundwater elevations were not recorded in March/May 1995 or March 1998. Monitoring point construction details are summarized in Table 2, and groundwater elevation data collected at the site are summarized in Table 3. Groundwater elevation contour maps for March 1994 and January 1996 are shown on Figure 2.

Shallow groundwater at Site ST-29 is present at depths of 4 to 5 feet below ground surface (bgs). Groundwater at Site ST-29 generally flows to the west towards the Banana River (Parsons ES, 1995). The horizontal hydraulic gradient measured in March 1994 was approximately 0.002 foot per foot (ft/ft), with an average groundwater velocity calculated to be 0.43 foot per day (ft/day), or 157 feet per year (ft/yr). The water table in January 1996 was an average of 0.4 feet higher than in March 1994. The January 1996 data suggest a northwesterly groundwater flow direction. However, insufficient data were collected to accurately determine the flow direction and gradient during this sampling event.

Vertical hydraulic gradients measured in nested monitoring point pairs in 1994 range from approximately 0.004 ft/ft in a downward direction at CPT-22 and CPT-03, to approximately 0.0015 to 0.0123 ft/ft in an upward direction at CPT-04, CPT-26, and CPT-24. No vertical gradients were present at CPT-23 and CPT-25 in 1994. This information indicates the presence of a downward hydraulic gradient in or near the source area, with a transition to an upward gradient to the west of the source area in March 1994. A similar downward vertical gradient was observed in January 1996 at CPT-03, but the vertical gradient at CPT-04 shifted from upward in 1994 to downward in 1996.

2.2 Dissolved BTEX Contamination

Analytical results for fuel hydrocarbons detected at the site are provided in Table 4. In order to evaluate trends in dissolved BTEX concentrations and distribution through time, the areal distributions of dissolved BTEX for March 1994, March 1995, January 1996, and March 1998 are presented on Figure 3. Vertical distributions along the primary flow path of dissolved BTEX for each sampling event are presented on Figure 4. As defined by the 5 microgram per liter ($\mu\text{g/L}$) concentration isopleth, the March 1998 BTEX plume appears to be approximately 450 feet long, compared to approximately 650 feet long in March 1994 (Figure 3). Given an advective groundwater velocity of approximately 156 ft/yr and an estimated retardation coefficient for benzene of 2.6 (Parsons ES, 1995), the plume potentially could have migrated a minimum of 240 feet in the four years from March 1994 to March 1998 (not accounting for the effects of dispersion, which would elongate the plume even further). However, monitoring data indicate that the plume extents for March/May 1995, January 1996, and March 1998 are less than March 1994.

TABLE 1A
SUMMARY OF GROUNDWATER ANALYTICAL METHODS
JANUARY 1996
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Analyte	Method	Field (F) or Fixed-Base Laboratory (L)
Oxidation\Reduction Potential	Direct Reading Meter	F
Dissolved Oxygen	Direct Reading Meter	F
Conductivity	Direct Reading Meter	F
Temperature	Direct Reading Meter	F
pH	Direct Reading Meter	F
Ferrous Iron	Colorimetric, Hach Method 8146 or equivalent	F
Hydrogen Sulfide	Colorimetric, Hach Method 8131 or equivalent	F
Alkalinity (Carbonate [CO ₃ ²⁻] and Bicarbonate [HCO ₃ ⁻])	Titrimetric, Hach Method 8221 or equivalent	F
Nitrate + Nitrite	EPA Method 353.1	L
Conductivity	EPA Method 120.1	L
Sulfate	Waters Capillary Electrophoresis Method N-601	L
Methane, Ethane and Ethene	RSKSOP-175 ^{a/} and RSKSOP-147	L
Total Organic Carbon	RSKSOP-102	L
BTEX ^{b/} , TMBs ^{c/} , and Total Fuel Carbon	RSKSOP-133	L
CVOCs ^{d/} , MTBE ^{e/} , and 1,2-Dibromoethane	RSKSOP-148	L
Phenols and Aliphatic Acids	RSKSOP-177	L

^{a/} RSKSOP = Robert S. Kerr Laboratory (now known as NRMRL) standard operating procedure.

^{b/} BTEX = benzene, toluene, ethylbenzene, and xylenes.

^{c/} TMBs = trimethylbenzenes.

^{d/} CVOCs = chlorinated volatile organic compounds.

^{e/} MTBE = methyl tertiary-butyl ether.

TABLE 1B
SUMMARY OF GROUNDWATER ANALYTICAL METHODS
MARCH 1998
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Analyte	Method	Field (F) or Fixed-Base Laboratory (L)
Oxidation\Reduction Potential	Direct Reading Meter	F
Dissolved Oxygen	Direct Reading Meter	F
Conductivity	Direct Reading Meter	F
Temperature	Direct Reading Meter	F
pH	Direct Reading Meter	F
Ferrous Iron	Colorimetric, Hach Method 8146 or equivalent	F
Carbon Dioxide	Titrimetric, Hach Method 1436-01 or equivalent	F
Manganese	Colorimetric, HACH Method 8034, or equivalent	F
Sulfide	Colorimetric, Hach Method 8131 or equivalent	F
Alkalinity (Carbonate [CO ₃ ²⁻] and Bicarbonate [HCO ₃ ⁻])	Titrimetric, Hach Method 8221 or equivalent	F
Nitrate + Nitrite	Lachat FIA Method 10-107-04-2-A	L
Ammonia	Lachat FIA Method 10-107-06-1	L
Chloride	Waters Capillary Electrophoresis Method N-601	L
Sulfate	Waters Capillary Electrophoresis Method N-601	L
Methane, Ethane and Ethene	RSKSOP-175 ^{a/} and RSKSOP-194	L
Total Organic Carbon	RSKSOP-102	L
BTEX ^{b/} , TMBs ^{c/} , and MTBE ^{d/}	RSKSOP-122	L

^{a/} RSKSOP = Robert S. Kerr Laboratory (now known as NRMRL) standard operating procedure.

^{b/} BTEX = benzene, toluene, ethylbenzene, and xylenes.

^{c/} TMBs = trimethylbenzenes.

^{d/} MTBE = methyl tertiary-butyl ether.

TABLE 2
MONITORING POINT CONSTRUCTION SUMMARY^{a/}
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Well Location ID	Easting	Northing	Ground Elevation (ft amsl) ^{b/}	Total Depth (ft bioc) ^{c/}	Bottom of Well (ft amsl)	Top of		Bottom of		Screen Midpoint (ft amsl)	
						Screen (ft bgs) ^{d/}	Screen (ft amsl)	Screen (ft bgs)	Screen (ft amsl)	Screen (ft amsl)	Screen (ft amsl)
CPT-01	1423363	626491	7.02	8.28	-1.26	5.00	2.02	8.28	-1.26	0.38	
CPT-02D	1423346	626455	7.07	13.42	-6.35	10.14	-3.07	13.42	-6.35	-4.71	
CPT-02S	1423346	626455	7.07	7.65	-0.58	4.37	2.70	7.65	-0.58	1.06	
CPT-03D	1423319	626420	6.55	19.04	-12.49	15.76	-9.21	19.04	-12.49	-10.85	
CPT-03M	1423319	626420	6.55	14.10	-7.55	10.82	-4.27	14.10	-7.55	-5.91	
CPT-03S	1423319	626420	6.55	7.87	-1.32	4.59	1.96	7.87	-1.32	0.32	
CPT-04D	1423133	626443	6.57	11.54	-4.97	8.26	-1.69	11.54	-4.97	-3.33	
CPT-04S	1423133	626443	6.57	9.92	-3.35	6.64	-0.07	9.92	-3.35	-1.71	
CPT-05S	1423266	626423	6.26	8.00	-1.74	4.72	1.54	8.00	-1.74	-0.10	
CPT-06S	1423248	626381	6.26	8.00	-1.74	4.72	1.54	8.00	-1.74	-0.10	
CPT-07S	1423235	626354	6.36	NA ^{d/}	NA	NA	NA	NA	NA	NA	
CPT-08S	1423262	626343	6.48	8.00	-1.52	4.72	1.76	8.00	-1.52	0.12	
CPT-09D	1423240	626428	6.35	15.00	-8.65	11.72	-5.37	15.00	-8.65	-7.01	
CPT-09S	1423240	626428	6.35	8.00	-1.65	4.72	1.63	8.00	-1.65	-0.01	
CPT-10S	1423271	626454	6.26	8.00	-1.74	4.72	1.54	8.00	-1.74	-0.10	
CPT-11S	1423247	626464	6.37	8.00	-1.63	4.72	1.65	8.00	-1.63	0.01	
CPT-12D	1423203	626433	6.43	16.00	-9.57	12.72	-6.29	16.00	-9.57	-7.93	
CPT-12S	1423203	626433	6.43	8.00	-1.57	4.72	1.71	8.00	-1.57	0.07	
CPT-13S	1423223	626442	6.41	17.49	-11.08	14.21	-7.80	17.49	-11.08	-9.44	
CPT-14D	1423213	626415	6.36	16.73	-10.37	13.45	-7.09	16.73	-10.37	-8.73	
CPT-16DD	1423300	626427	6.14	45.00	-38.86	41.72	-35.58	45.00	-38.86	-37.22	
CPT-16S	1423300	626427	6.14	8.00	-1.86	4.72	1.42	8.00	-1.86	-0.22	
CPT-18D	1423051	626448	6.58	16.00	-9.42	12.72	-6.14	16.00	-9.42	-7.78	
CPT-18DD	1423051	626448	6.58	40.00	-33.42	36.72	-30.14	40.00	-33.42	-31.78	
CPT-18S	1423051	626448	6.58	8.00	-1.42	4.72	1.86	8.00	-1.42	0.22	
CPT-19D	1422983	626457	6.39	16.00	-9.61	12.72	-6.33	16.00	-9.61	-7.97	
CPT-19S	1422983	626457	6.39	8.00	-1.61	4.72	1.67	8.00	-1.61	0.03	

TABLE 2 (Continued)
MONITORING POINT CONSTRUCTION SUMMARY^{a/}
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Well Location ID	Easting	Northing	Ground Elevation (ft amsl) ^{b/}	Total Depth (ft btoc) ^{c/}	Bottom of Well (ft amsl)	Top of Screen (ft bgs) ^{d/}	Top of Screen (ft amsl)	Bottom of Screen (ft bgs)	Bottom of Screen (ft amsl)	Screen Midpoint (ft amsl)
CPT-20D	1423034	626345	6.40	16.00	-9.60	12.72	-6.32	16.00	-9.60	-7.96
CPT-20S	1423034	626345	6.40	8.00	-1.60	4.72	1.68	8.00	-1.60	0.04
CPT-21D	1423226	626518	6.49	15.30	-8.81	12.02	-5.53	15.30	-8.81	-7.17
CPT-21S	1423226	626518	6.49	8.00	-1.51	4.72	1.77	8.00	-1.51	0.13
CPT-22D	1423328	626362	6.75	13.45	-6.70	10.17	-3.42	13.45	-6.70	-5.06
CPT-22S	1423328	626362	6.75	8.05	-1.30	4.77	1.98	8.05	-1.30	0.34
CPT-23D	1423151	626319	6.57	13.50	-6.93	10.22	-3.65	13.50	-6.93	-5.29
CPT-23S	1423151	626319	6.57	7.00	-0.43	3.72	2.85	7.00	-0.43	1.21
CPT-24D	1422903	626386	5.89	13.00	-7.11	9.72	-3.83	13.00	-7.11	-5.47
CPT-24S	1422903	626386	5.89	6.50	-0.61	3.22	2.67	6.50	-0.61	1.03
CPT-25D	1423761	626129	6.60	13.00	-6.40	9.72	-3.12	13.00	-6.40	-4.76
CPT-25S	1423761	626129	6.60	6.50	0.10	3.22	3.38	6.50	0.10	1.74
CPT-26D	1423180	626387	6.47	13.50	-7.03	10.22	-3.75	13.50	-7.03	-5.39
CPT-26S	1423180	626387	6.47	7.00	-0.53	3.72	2.75	7.00	-0.53	1.11
MW-1/PPOL2-1	1423390	626502	6.92	13.40	NA	NA	NA	NA	NA	NA
MW-2	NA	NA	NA	13.40	NA	NA	NA	NA	NA	NA
MW-4	NA	NA	NA	12.30	NA	NA	NA	NA	NA	NA
MW-5	NA	NA	NA	12.70	NA	NA	NA	NA	NA	NA
MW-6/PPOL2-6	1423352	626515	6.39	54.90	NA	NA	NA	NA	NA	NA
MW-11/PB5	NA	NA	7.39	15.45	-8.06	NA	NA	NA	NA	NA
PPOL2-5	NA	NA	NA	12.51	NA	NA	NA	NA	NA	NA

^{a/} Construction summary data is not available for the following wells: MW-3,-7,-8,-9,-10,-12,-100,-101,-102,-103.

^{b/} ft amsl = feet above mean sea level.

^{c/} ft btoc = feet below top of casing.

^{d/} ft bgs = feet below ground surface.

^{e/} NA = not available.

TABLE 3
GROUNDWATER ELEVATION DATA
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Sample Location	Datum ^{a/} Elevation (ft amsl) ^{b/}	Sample Date	Depth to Water (ft btoc) ^{c/}	Groundwater Elevation (ft amsl)
CPT-02S	6.61	3/27/1994	4.93	1.68
		1/30/1996	4.48	2.13
CPT-03S	6.26	3/27/1994	4.57	1.69
		1/30/1996	4.11	2.15
CPT-03D	6.23	3/27/1994	4.59	1.64
		1/30/1996	4.16	2.07
CPT-04S	5.99	3/27/1994	4.46	1.53
		1/30/1996	4.06	1.93
CPT-04D	6.01	3/27/1994	4.46	1.55
		1/30/1996	4.11	1.90
CPT-09S	6.13	3/27/1994	4.35	1.78 ^{d/}
		1/30/1996	4.00	2.13
CPT-12S	5.90	3/27/1994	4.40	1.50
		1/30/1996	4.06	1.84
CPT-16DD	NA ^{e/}	1/30/1996	3.86	NA
CPT-18S	6.11	3/27/1994	4.69	1.42
		1/30/1996	4.38	1.73
CPT-18DD	NA	1/30/1996	4.55	NA
CPT-22S	6.35	3/27/1994	4.50	1.85
CPT-22D	6.32	3/27/1994	4.49	1.83
CPT-23S	5.94	3/27/1994	4.30	1.64
CPT-23D	5.84	3/27/1994	4.20	1.64
CPT-24S	5.49	3/27/1994	4.52	0.97
CPT-24D	5.44	3/27/1994	4.46	0.98
CPT-25S	6.43	3/27/1994	5.66	0.77
CPT-25D	6.49	3/27/1994	5.72	0.77
CPT-26S	5.89	3/27/1994	4.25	1.64 ^{d/}
CPT-26D	5.79	3/27/1994	4.13	1.66
MW-1/PPOL2-1	7.47	3/25/1994	5.33	2.14
MW-6/PPOL2-6	6.64	3/25/1994	4.93	1.71
MW-11/PB5	10.86	3/23/1994	8.75	2.11
PPOL2-5	7.48	3/25/1994	5.36	2.12

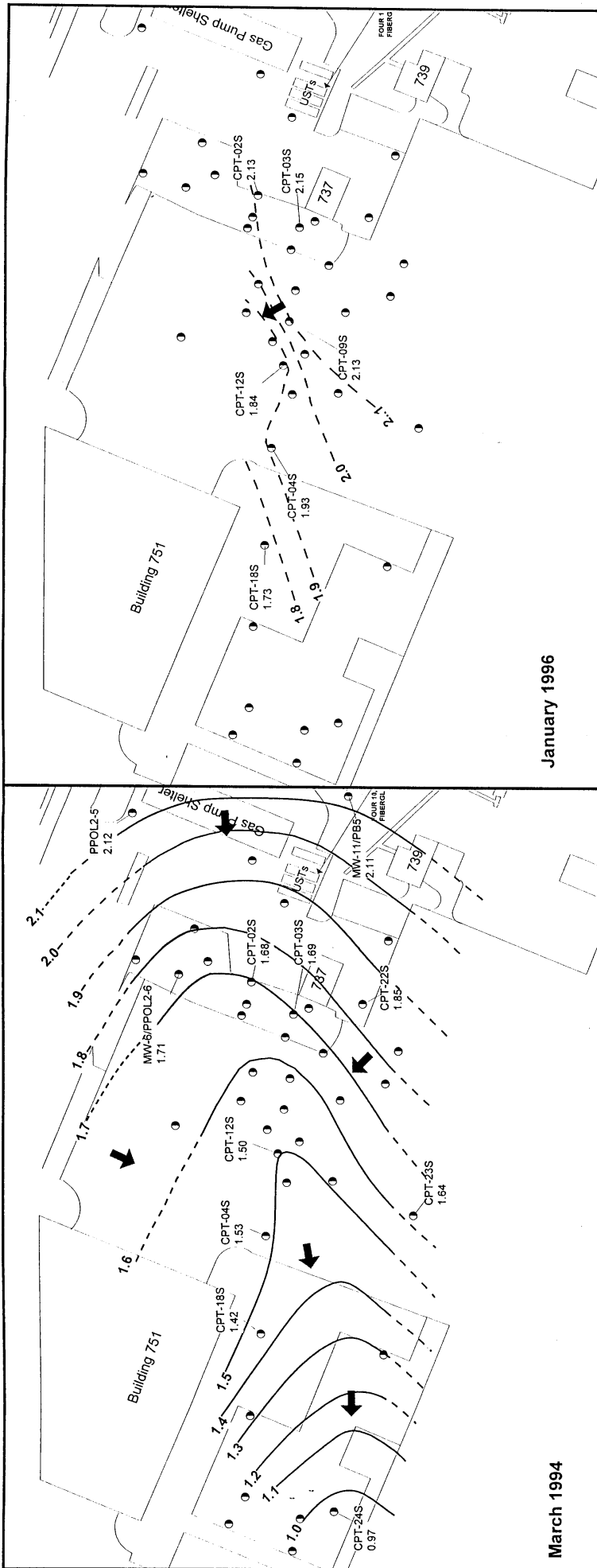
^{a/} Datum is top of well casing.

^{b/} ft amsl = feet above mean sea level.

^{c/} ft btoc = feet below top of casing.

^{d/} Data are suspect and not used for contouring groundwater elevations.

^{e/} NA = not available.



LEGEND

Monitoring Well/Point and Water Table Elevation
in Feet Above Mean Sea Level (ft amsl)

Water Table Elevation Contour (ft amsl)

Inferred Direction of Groundwater Flow

MOGAS

Motor Vehicle Gasoline

UST

Underground Storage Tank

NOTE: Elevation contours are based
on the shallowest screened interval
at monitoring well/point pairs.

FIGURE 2

GROUNDWATER ELEVATIONS

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

**PARSONS
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Denver, Colorado

TABLE 4
FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Sample Location	Sample Date	Benzene (µg/L) ^d	Toluene (µg/L)	Ethylbenzene (µg/L)	p-Xylene (µg/L)	m-Xylene (µg/L)	o-Xylene (µg/L)	Total Xylene (µg/L)	Total BTEX ^e (µg/L)	1,3,5 TMB ^h (µg/L)	1,2,4 TMB (µg/L)	1,2,3 TMB (µg/L)	Fuel Carbon (µg/L)	MTBE ^d (µg/L)
CPT-01	Mar-94	<1 ^e	2.42	<1	<1	<1	<1	<1	2.42	<1	<1	<1	NA ^g	NA
CPT-02S	Mar-94	375	18.9	165	166	353	119	638	1,200	71.2	NA	86.3	NA	NA
Mar-95		167	6.25	133	95.7	156	8.58	260	566	44.0	203	89.2	NA	NA
Mar-95 (Dup) ^e		156	6.37	135	107	168	9.36	285	583	48.0	202	90.0	NA	NA
Jan-96		64.3	5.20	53.3	4.40	8.40	3.50	16.3	139	1.50	45.5	37.9	1,500	514
CPT-02D	Mar-94	1.50	1.70	1.10	1.40	2.60	1.40	5.40	9.70	<1	NA	1.30	NA	NA
CPT-03S	Mar-94	724	737	823	1,220	2,410	1,390	5020	7,304	347	NA	403	NA	NA
Mar-95		1,500	1,530	2,250	2,860	3,470	2,500	8,820	14,100	777	2,900	851	NA	NA
Jan-96		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	101
Jan-96 (Dup)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	128
Mar-98		692	1,860	3,960	5,150	6,470	4,320	15,900	22,450	1,250	4,860	942	NA	<1
CPT-03M	Mar-94	207	15.6	40.5	42.2	24.0	7.50	73.7	337	2.80	NA	16.0	NA	NA
Mar-95		134	14.0	21.8	58.2	32.4	32.1	123	293	7.75	30.7	18.6	NA	NA
Jan-96		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.60
Mar-98		215	240	1,050	1,510	1,060	1,040	3,610	5,110	374	1,590	276	NA	3.50
CPT-03D	Mar-94	1.80	1.10	<1	<1	1.40	<1	1.40	4.30	<1	NA	<1	NA	NA
Mar-95		31.0	<1	10.5	22.5	2.96	1.39	26.8	68.3	1.40	1.97	2.87	NA	NA
Mar-95 (Dup)		30.3	0.99	10.4	17.8	1.12	2.05	21.0	62.6	1.42	1.64	3.26	NA	NA
Jan-96		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15.9
Mar-98		1.50	<1	<1	<1	<1	ND ^h	<1	1.50	<1	<1	<1	NA	<1
CPT-04S	Mar-94	<1	6.00	<1	<1	<1	<1	<1	6.00	<1	<1	<1	NA	NA
Mar-95		<1	0.97	<1	1.06	1.22	1.30	3.58	4.55	1.27	ND	1.84	NA	NA
Mar-95 (Dup)		<1	ND	<1	<1	0.99	ND	0.99	0.99	ND	1.70	1.42	NA	NA
Jan-96		ND	ND	<1	<1	<1	<1	<1	ND	ND	ND	ND	<1	1.40
Mar-98		<1	<1	3.70	3.20	2.20	<1	5.40	9.10	<1	1.80	<1	NA	1.20
CPT-04D	Mar-94	<1	3.70	<1	<1	<1	<1	<1	3.70	<1	<1	<1	NA	NA
Mar-95		<1	1.00	<1	1.06	1.13	1.35	3.54	4.54	1.11	ND	1.98	NA	NA
Jan-96		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	53.3
Mar-98		1.30	2.30	ND	1,170	ND	4.80	1,180	1,180	2.00	10.2	1.80	NA	2.50
CPT-05S	Mar-94	<1	1.20	<1	<1	<1	<1	<1	1.20	<1	NA	<1	NA	NA
CPT-06S	Mar-94	<1	11.1	<1	1.30	2.30	<1	3.60	14.7	<1	NA	<1	NA	NA
CPT-07S	Mar-94	<1	3.90	<1	<1	1.00	<1	1.00	4.90	<1	NA	<1	NA	NA
CPT-08S	Mar-94	<1	2.80	<1	<1	<1	<1	<1	2.80	<1	<1	<1	NA	NA
CPT-09S	Mar-94	2.00	4.00	<1	<1	<1	<1	<1	6.00	<1	<1	<1	NA	NA
Mar-95		1.09	<1	1.29	1.82	1.73	1.45	5.00	7.38	1.09	2.46	3.60	NA	NA
Jan-96		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mar-98		<1	ND	<1	<1	<1	<1	<1	ND	ND	ND	<1	NA	2.80

TABLE 4 (Continued)
FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
 INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
 SITE ST-29
 PATRICK AFB, FLORIDA

Sample Location	Sample Date	Benzene (µg/L) ^d	Toluene (µg/L)	Ethylbenzene (µg/L)	p-Xylene (µg/L)	m-Xylene (µg/L)	o-Xylene (µg/L)	Total Xylene (µg/L)	Total BTX ^e (µg/L)	1,3,5-TMB ^b (µg/L)	1,2,4-TMB ^b (µg/L)	1,2,3-TMB (µg/L)	Fuel Carbon (µg/L)	MTBE ^d (µg/L)
CPT-09D	Mar-94	427	14.1	2.90	11.7	12.1	9.70	33.5	478	<1	NA	9.40	NA	NA
	Mar-95	44.8	4.35	0.98	4.81	4.01	5.36	14.2	64.3	1.38	1.45	7.26	NA	NA
	Jan-96	28.9	10.4	1.90	6.20	5.50	6.50	18.2	59.4	1.20	1.20	7.80	914	353
	Mar-98	14.1	6.90	<1	4.40	7.50	6.00	17.9	38.9	<1	1.20	5.80	NA	31.3
CPT-10S	Mar-94	<1	3.10	<1	<1	<1	<1	<1	3.10	<1	<1	<1	NA	NA
CPT-11S	Mar-94	<1	1.00	<1	<1	<1	<1	<1	1.00	<1	<1	<1	NA	NA
CPT-12S	Mar-94	<1	1.10	<1	<1	1.20	<1	1.20	2.30	<1	NA	<1	NA	NA
	Mar-95	<1	ND	<1	<1	1.08	<1	1.08	1.08	ND	ND	1.27	NA	NA
	Jan-96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mar-98	ND	ND	ND	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-12D	Mar-94	93.5	5.90	<1	8.40	7.00	3.70	19.1	119	<1	NA	4.10	NA	NA
	Mar-95	<1	<1	<1	1.21	1.33	0.99	3.53	3.53	1.15	1.33	2.75	NA	NA
	Jan-96	5.00	5.20	ND	8.90	5.20	5.00	19.1	29.3	<1	1.60	5.40	625	348
	Mar-98	5.00	6.80	<1	14.9	6.70	4.90	26.5	38.3	<1	<1	4.10	NA	68.4
CPT-13S	Mar-94	<1	8.40	<1	10.4	5.40	3.10	18.9	29.3	<1	NA	6.70	NA	NA
CPT-14D	Mar-94	960	16.6	11.5	39.2	36.8	44.2	120	1,110	15.3	NA	23.0	NA	NA
CPT-16S	Mar-94	1.00	1.90	<1	<1	<1	<1	<1	2.90	<1	<1	<1	NA	NA
CPT-16DD	Mar-94	<1	1.90	<1	<1	<1	<1	<1	1.90	<1	<1	<1	NA	NA
	Mar-95	<1	<1	<1	<1	1.03	<1	1.03	1.03	ND	ND	ND	NA	NA
	Jan-96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mar-98	ND	ND	<1	<1	<1	<1	<1	ND	ND	<1	ND	NA	ND
CPT-18S	Mar-94	<1	1.70	2.30	3.80	6.60	4.00	14.4	18.4	1.40	NA	1.60	NA	NA
	Mar-95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Jan-96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mar-98	ND	ND	<1	<1	<1	ND	<1	ND	ND	<1	ND	NA	ND
CPT-18D	Mar-94	8.30	2.10	<1	<1	<1	<1	<1	10.4	<1	<1	<1	NA	NA
	Mar-95	ND	ND	ND	<1	<1	ND	<1	ND	ND	ND	ND	NA	NA
	Mar-98	<1	<1	1.20	1.30	1.10	<1	2.40	3.60	ND	<1	ND	NA	ND
	Mar-94	<1	3.50	<1	<1	<1	<1	<1	3.50	<1	<1	<1	NA	NA
CPT-18DD	Mar-94	<1	3.50	<1	<1	<1	<1	<1	3.50	<1	<1	<1	NA	NA
	Mar-95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	Jan-96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mar-94	<1	<1	1.10	1.50	2.70	<1	4.20	5.30	<1	NA	<1	NA	NA
CPT-19S	Mar-94	<1	<1	<1	<1	<1	<1	<1	1.50	<1	<1	<1	NA	NA
CPT-19D	Mar-94	1.50	<1	<1	<1	<1	<1	<1	1.50	<1	<1	<1	NA	NA
CPT-20S	Mar-94	<1	2.10	<1	1.50	2.70	1.80	6.00	8.10	<1	NA	1.00	NA	NA
CPT-20D	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA

TABLE 4 (Concluded)
FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
 INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
 SITE ST-29
 PATRICK AFB, FLORIDA

Sample Location	Sample Date	Benzene (µg/L) ^{a/}	Toluene (µg/L)	Ethylbenzene (µg/L)	p-Xylene (µg/L)	m-Xylene (µg/L)	o-Xylene (µg/L)	Total Xylene (µg/L)	Total BTEX ^{b/} (µg/L)	1,3,5 TMB ^{b/} (µg/L)	1,2,4 TMB (µg/L)	1,2,3 TMB (µg/L)	Fuel Carbon (µg/L)	MTBE ^{d/} (µg/L)
CPT-21S	Mar-94	NA	5.10	<1	<1	<1	<1	<1	5.10	<1	NA	<1	NA	NA
	Mar-95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
CPT-21D	Mar-94	NA	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
	Mar-95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
CPT-22S	Mar-94	NA	1.90	<1	<1	<1	<1	<1	1.90	<1	<1	<1	NA	NA
CPT-22D	Mar-94	1.50	<1	<1	<1	<1	<1	<1	1.50	<1	<1	<1	NA	NA
CPT-23S	Mar-94	<1	<1	<1	<1	1.70	<1	1.70	1.70	<1	NA	<1	NA	NA
CPT-23D	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
CPT-24S	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
CPT-24D	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
CPT-25S	Mar-94	<1	2.10	2.30	4.10	6.90	3.50	14.5	18.9	1.70	NA	1.50	NA	NA
CPT-25D	Mar-94	<1	1.00	<1	<1	1.40	<1	1.40	2.40	<1	NA	<1	NA	NA
MW-1/PPOL	Mar-94	<1	<1	<1	<1	1.40	<1	1.40	1.40	<1	<1	<1	NA	NA
MW-4	May-95	ND	ND	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA
MW-6/PPOL	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
MW-6	May-95	ND	ND	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA
MW-7	May-95	ND	ND	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA
MW-8	May-95	140	85.0	270	NA	NA	NA	2,450	2,950	NA	NA	NA	NA	NA
MW-9	May-95	37.0	ND	46.0	NA	NA	NA	NA	83.0	NA	NA	NA	NA	NA
Mar-98 (Dup)	Mar-98	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	ND
	Mar-98 (Dup)	<1	ND	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	ND
MW-10	May-95	180	ND	360	NA	NA	NA	NA	540	NA	NA	NA	NA	NA
MW-11/PB5	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
	May-95	ND	ND	ND	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA
MW-12	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
	May-95	210	ND	700	NA	NA	NA	2,310	3,220	NA	NA	NA	NA	NA
MW-100	Mar-94	4.10	<1	<1	1.10	1.00	<1	2.10	6.20	<1	<1	<1	NA	NA
	Mar-95	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
MW-101	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
MW-102	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA
MW-103	Mar-94	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	NA	NA

^{a/} BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes.

^{b/} TMB = Trimethylbenzene.

^{c/} MTBE = Methyl tert-butyl ether.

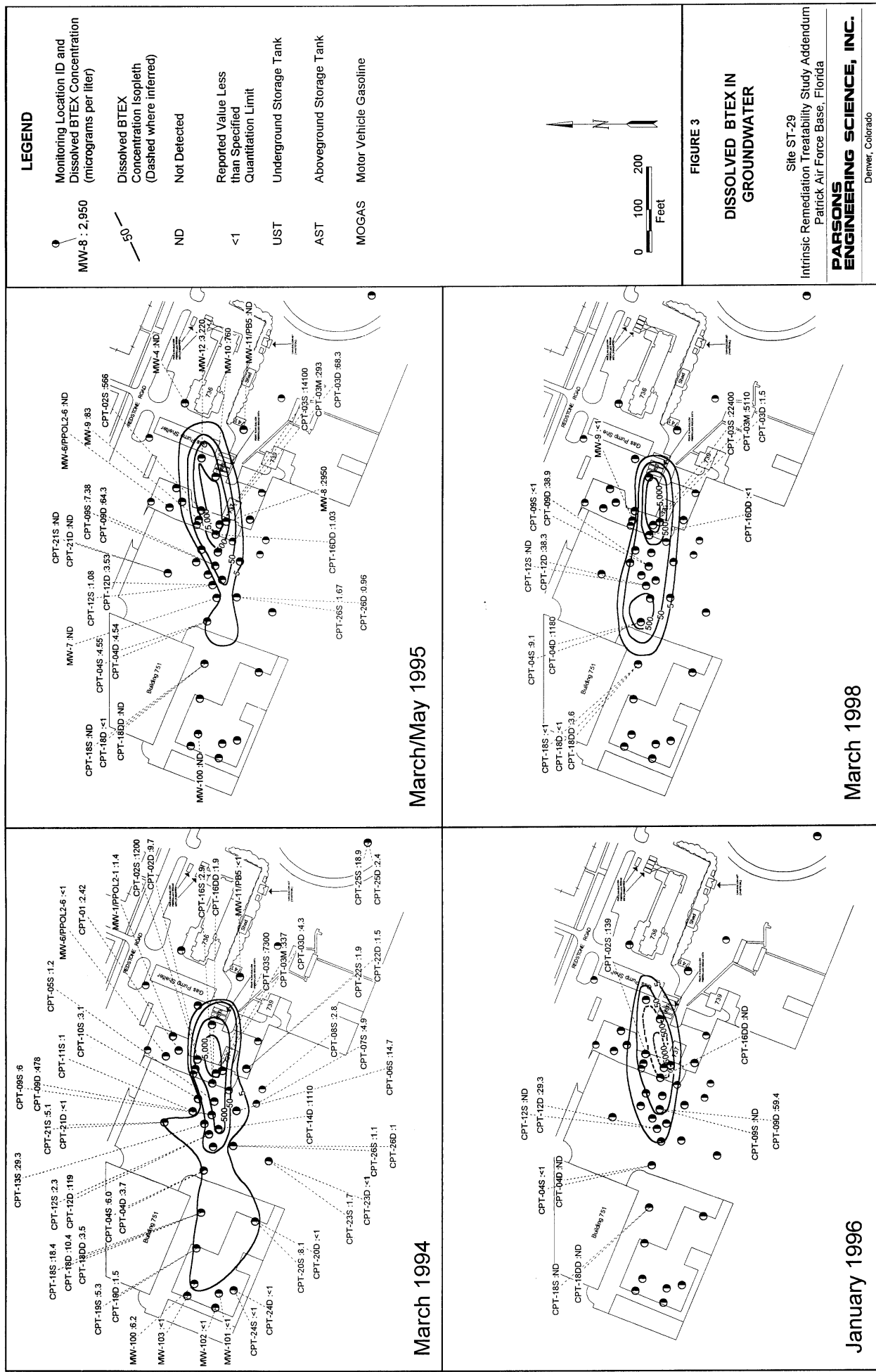
^{d/} µg/L = micrograms per liter.

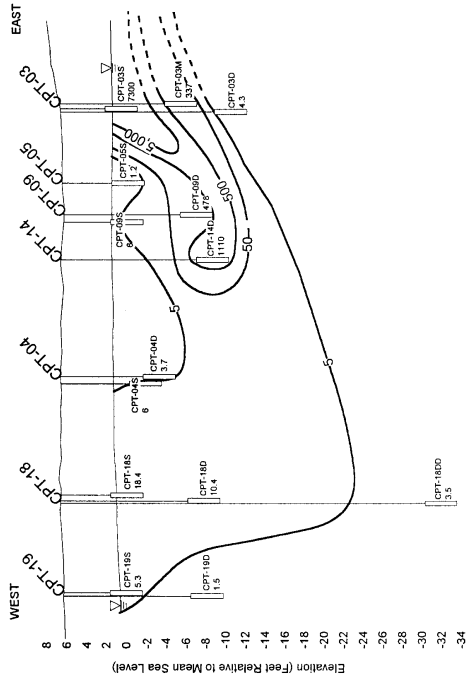
^{e/} <1 = Below limit of quantitation (1 µg/L).

^{f/} NA = Data not available or sample not analyzed for this parameter.

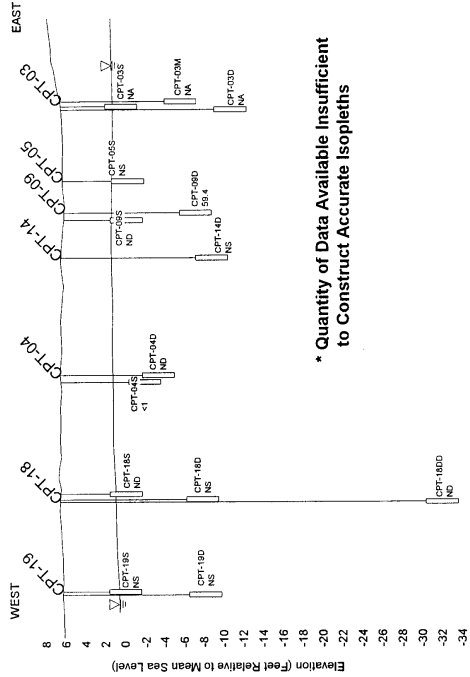
^{g/} Dup = Duplicate Sample.

^{h/} ND = Compound not detected at the method detection limit.

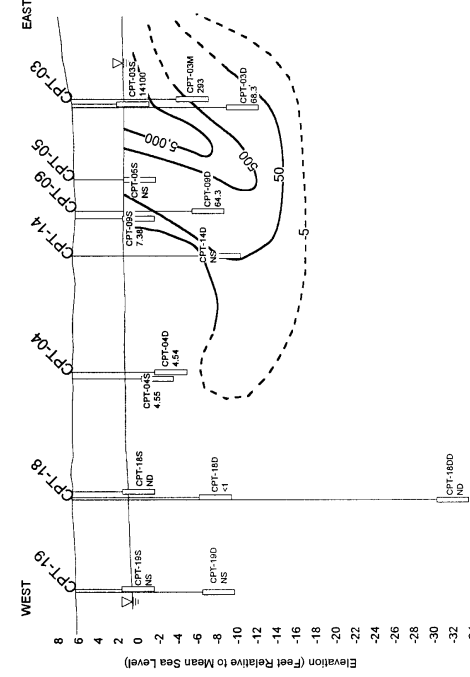




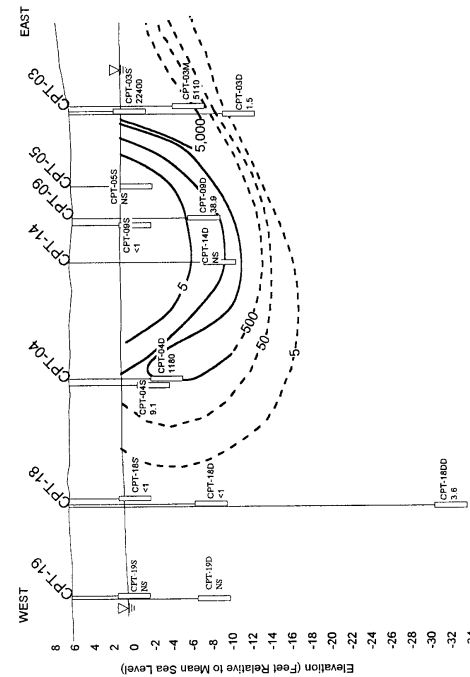
March 1994



January 1996



March/May 1995



March 1998

LEGEND

- CPT-4S Monitoring Location ID
- 1.53 Concentration of Dissolved BTEX (micrograms per liter)
- 1.5 Dissolved BTEX Concentration Isoleth (Dashed where inferred)
- ND Not Detected
- NS Not Sampled
- Approximate Groundwater Surface

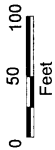


FIGURE 4

CROSS-SECTION OF DISSOLVED BTEX IN GROUNDWATER

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

Plume shrinkage provides strong evidence supporting the occurrence of biodegradation, particularly along the perimeter of the plume.

The cross-sectional representations of the total BTEX plume in Figure 4 show the changes in vertical and horizontal distribution of the plume along the primary flow path between 1994 and 1998. Due to the limited data available for January 1996, no contour lines are presented for this date. The total BTEX concentration at CPT-04D has increased from 1.2 µg/L in 1994 to 1,180 µg/L in 1998, indicating downgradient migration of the plume core (Figure 4). The plume core appears to travel beneath monitoring points CPT-09D and CPT-14D before migrating upward toward CPT-04D.

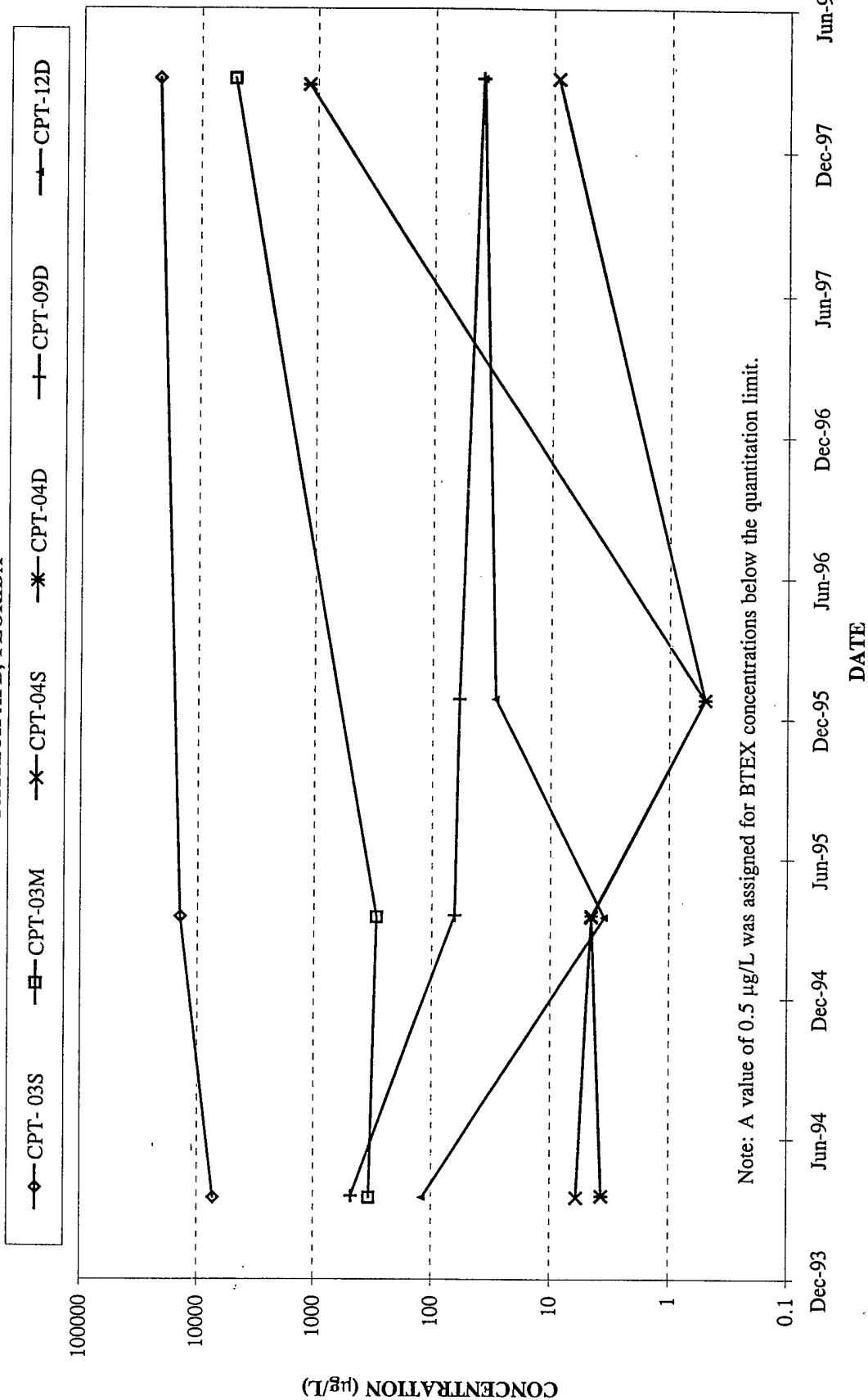
The vertical extent of the March 1998 BTEX plume is defined near the source area by the well screen intervals of monitoring cluster CPT-03. Groundwater sampled from CPT-03D decreased in BTEX concentration from 68.3 µg/L to 1.5 µg/L between March 1995 and March 1998. The vertical extent of the BTEX plume appears to be decreasing in the area of CPT-03, although monitoring points at CPT-03 were not sampled during January 1996. The vertical extent of the BTEX plume in the downgradient direction is indicated by the monitoring point cluster at CPT-18. While low concentrations (less than or equal to 3.6 µg/L) of BTEX have been detected in CPT-18DD, BTEX concentrations at CPT-18S and CPT-18D were not detected in 1998.

Figure 5 is a plot of temporal changes in dissolved BTEX concentrations in monitoring points sampled along the approximate longitudinal centerline of the dissolved BTEX plume. Figure 5 illustrates that dissolved BTEX concentrations have increased from 1994 to 1998 along the center line of the plume at monitoring points CPT-03S, CPT-03M, and CPT-04D. In March 1998, the highest dissolved BTEX concentration detected was in monitoring point CPT-03S at a concentration of 22,400 µg/L (Table 4). Monitoring point CPT-03S is located approximately 100 feet downgradient from the UST area at Site ST-29 (Figure 3). The dissolved BTEX concentration detected at well CPT-03S in March 1998 represents an increase from March 1994 and March 1995, when concentrations of 7,300 µg/L and 14,100 µg/L, respectively, were detected.

Dissolved BTEX concentrations near the source area are increasing, indicating that residual fuel hydrocarbons still exist in source area soils. Residual soil contamination may persist within the capillary fringe or saturated smear zone, which is unaffected by bioventing. The increase in average groundwater elevation of 0.4 foot from March 1994 to January 1996 (Section 2.1) would increase the volume of saturated soil in the source area, decrease the volume of unsaturated soil subject to the effects of bioventing, and result in increased dissolution of BTEX into the groundwater.

In the downgradient direction there has been a notable increase in total BTEX at monitoring point CPT-04D. BTEX at CPT-04D increased from low levels (less than 5 µg/L) in 1994, 1995, and 1996 to 1,180 µg/L in March 1998. Although the overall extent of the BTEX plume has not increased since 1994, concentrations of BTEX within the plume have increased. This increase in concentrations could potentially result in future expansion of the plume.

FIGURE 5
 DISSOLVED BTEX IN SELECTED WELLS ALONG THE PLUME AXIS
 MARCH 1994 TO MARCH 1998
 INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
 SITE ST-29
 PATRICK AFB, FLORIDA



Two groundwater model simulations were completed using the Bioplume II modeling code during the TS (Parsons ES, 1995). A conservative model that did not consider reductions in the source concentrations (worst-case scenario), predicted that the BTEX plume would stabilize approximately 30 years after 1994 (2024) with the leading edge approximately 1,400 feet beyond the source area (or approximately 700 to 800 feet beyond the toe of the 1994 BTEX plume).

The second model simulation assumed that BTEX loading rates were significantly reduced by bioventing over a three year period. This model was used to simulate the expected reduction due to operation of the full-scale bioventing system installed at the site in June 1995. Model results, as described in the TS report, indicate that after 3 years of bioventing, the plume front would only migrate about 100 feet downgradient from the 1994 plume extent. After 5 years of bioventing, the model predicts that the plume front would retreat to the 1994 plume extent. Model results indicate that the BTEX plume would be completely degraded seven years after bioventing begins.

Actual monitoring results indicate that the models underestimated the maximum concentration of dissolved BTEX that would be present in the plume over time, but that the downgradient extent of the plume is conservatively overestimated by both models (especially the no-source-reduction model). While the extent of the BTEX plume has not increased, the bioventing system does not appear to have a significant impact on total dissolved BTEX concentrations. While bioventing is effective in reducing soil BTEX concentrations in the vadose zone, the lack of an impact on dissolved BTEX concentrations suggests that a residual source of BTEX (i.e., a smear zone) persists, most likely within the capillary fringe or saturated zone.

2.3 MTBE

All groundwater samples collected in January 1996 and March 1998 were analyzed for MTBE (Figure 4). MTBE is a fuel oxygenate used to enhance fuel octane rating and to reduce emissions. The maximum MTBE concentration detected was at monitoring point CPT-02S (514 µg/L) in January 1996. Monitoring point CPT-02S was not sampled in 1998. With the exception of CPT-09S, MTBE concentrations decreased at monitoring points sampled in both 1996 and 1998. For example, MTBE concentrations at sampling location CPT-09D decreased from 353 µg/L in January 1996 to 31.1 µg/L in March 1998. Likewise, MTBE concentrations at CPT-12D decreased from 348 µg/L in January 1996 to 68.4 µg/L in 1998. The decrease in MTBE concentrations may indicate that MTBE is naturally attenuating at the site. Conversely, because MTBE is often recalcitrant, the observed concentration decreases may indicate that the contaminant source is being preferentially depleted of MTBE due to its high solubility.

2.4 Chlorinated Volatile Organic Compounds

All groundwater samples collected in January 1996 were analyzed for CVOCs. In no instances were any CVOCs detected in the thirteen samples collected during this sampling event (Appendix A). Samples collected during the March 1998 sampling event were not analyzed for CVOCs.

2.5 Inorganic Chemistry and Geochemical Indicators of Biodegradation

As discussed in the TS, microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous oxidation/reduction reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at Site ST-29 are natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are utilized as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states and include oxygen, nitrate, manganese, ferrous iron, sulfate, and carbon dioxide. Microorganisms preferentially utilize electron acceptors while metabolizing fuel hydrocarbons (Bouwer, 1992). DO is utilized first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms use electron acceptors in the following order of preference: nitrate, manganese, ferric iron, sulfate, and finally carbon dioxide. Anaerobic destruction of the BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990).

Oxidation-Reduction Potential

ORP, a measure of the relative tendency of a solution to accept or transfer electrons, was measured at 13 monitoring locations during the January 1996 sampling event and at 12 locations during the March 1998 sampling event. The dominant electron acceptor being reduced by microbes during BTEX oxidation can be correlated to the ORP of the groundwater. Site ORPs from 1994 to 1998 are summarized on Table 5. In January 1996, the ORP measured at Site ST-29 ranged from -154 millivolts (mV) at CPT-03M, to -45 mV at CPT-16DD. In general, the ORPs measured in March 1998 were lower than in previous sampling periods, ranging from -313 mV (CPT-03S) to -110 mV (CPT-18D). ORP data suggest that dissolved BTEX at the site may be subjected to a variety of biodegradation processes, including aerobic respiration, denitrification, iron reduction, and sulfate reduction. However, many authors have noted that field ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some ORP couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994).

The areal distributions of ORP at the site in 1994, 1995, 1996, and 1998 are presented on Figure 6. Comparison of Figure 3 with Figure 6 illustrates that areas with elevated total BTEX concentrations have lower ORP, with the lowest ORP values occurring in the core of the plume. The correlation between decreased ORP and elevated BTEX concentrations is a strong indication that biodegradation of the BTEX compounds is occurring.

Temporal changes in ORP at several monitoring locations from March 1994 to March 1998 are plotted on Figure 7. The monitoring locations plotted on Figure 7 are located along the approximate longitudinal centerline of the dissolved BTEX plume. In general, ORP decreased from March 1994 to March 1995, increased from March 1995 to January 1996, and then decreased again from January 1996 to March 1998. Comparison of Figure 5 and Figure 7 show that changes in ORP measured at monitoring locations are generally

TABLE 5
GROUNDWATER GEOCHEMICAL DATA
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
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Sample Location	Sample Date	ORP ^a (mV) ^d	Dissolved Oxygen (mg/L) ^e	Nitrate+ Nitrite (mg/L)	Ammonia (mg/L)	Manganese (mg/L)	Ferrous Iron (mg/L)	Sulfate (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Dioxide (mg/L)	Methane (mg/L)	Ethylene (mg/L)	Ethane (mg/L)	TOC ^b (mg/L)	Alkalinity (as CaCO ₃ ^e) (mg/L)	Chlorides (mg/L)	Temperature (°C) ^d	pH	Conductivity (µs/cm) ^g
CPT-01	Mar-94	NA ^b	0.4	0.13	NA	NA	NA	4.37	NA	NA	4.99	NA	NA	14.0	NA	44.4	24.7	NA	NA
CPT-02S	Mar-94	-156	0.2	0.12	NA	NA	1.6	<0.5 ^d	0.2	NA	15.0	NA	NA	16.9	498	42.6	24.7	6.7	1,060
	Mar-95	-231	0.1	0.06	3.83	<0.1	1.1	1.13	NA	420	12.8	NA	NA	14.9	404	62.7	NA	6.54	998
	Mar-95 (Dup) ^f	-225	0.1	0.07	3.79	<0.1	1.1	1.08	NA	416	14.2	NA	NA	16.3	407	67.7	NA	6.53	995
	Jan-96	-60	0.2	<0.05	NA	NA	1.2	<0.5	0.5	NA	NA	NA	NA	14.9	480	NA	24.7	7.5	870
CPT-02D	Mar-94	-190	0.6	0.13	NA	NA	0.4	<0.5	0.4	NA	5.95	NA	NA	6.8	330	45.7	24.7	7.1	771
CPT-03S	Mar-94	-208	0.1	14.8	NA	NA	1.2	118	0.1	NA	14.0	NA	NA	63.1	520	132	26.4	6.7	1,730
	Mar-95	-357	<0.1	<0.05	18.2	<0.1	0.1	14	NA	780	15.5	NA	NA	182	920	129	NA	6.72	2,010
	Jan-96	-152	<0.1	<0.05	NA	NA	0.6	10.0	30	NA	NA	NA	NA	119	500	NA	NA	NA	1,270
	Mar-98	-313	<0.1	0.25	1.29	0.1	0.1	12.6	35	130	22.1	ND	0.019	30.7	240	64.5	23.3	7.5	NA
CPT-03M	Mar-94	-50	0.2	0.11	NA	NA	0.3	2.52	0	NA	3.16	NA	NA	10.9	398	40.7	26.4	7.1	898
	Mar-95	-343	<0.1	0.06	6.13	<0.1	<0.05	19.6	NA	338	12.4	NA	NA	35.8	447	42.6	NA	6.77	1,020
	Jan-96	-145	0.1	<0.05	NA	NA	<0.1	15.7	6	NA	NA	NA	NA	10.4	290	NA	25.1	6.9	662
	Mar-98	-276	<0.1	<0.1	3.91	<0.1	0.1	46.4	8	105	16.8	ND	0.010	24.2	320	40.9	24.4	7.0	NA
CPT-03D	Mar-94	-255	NA	0.12	NA	NA	0.4	<0.5	1	NA	1.63	NA	NA	5.4	315	41.6	NA	7.3	721
	Mar-95	-348	0.1	0.08	1.18	<0.1	<0.05	15.7	5	144	2.57	NA	NA	13.8	341	46.5	NA	7.02	787
	Mar-95 (Dup)	-347	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.04	786
	Jan-96	-154	0.1	<0.05	NA	NA	<0.1	16.5	6	NA	NA	NA	NA	9.1	280	NA	26.4	7.2	599
	Mar-98	-306	0.1	<0.1	1.36	0.1	0.1	5.53	5	75	3.42	ND	<0.002	11.9	260	33.9	25.5	7.2	NA
	Mar-98 (Dup)	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.40	ND	NA	NA	NA	NA	NA	NA	NA
CPT-04S	Mar-94	-286	0.3	0.19	NA	NA	0.6	<0.5	0.5	NA	7.66	NA	NA	6.6	215	12.5	26.9	6.9	469
	Mar-95	-289	0.1	0.07	3.6	<0.1	0.1	1.17	1	138	11.6	NA	NA	7.5	263	15.8	NA	6.85	543
	Mar-95 (Dup)	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.6	NA	NA	7.5	NA	NA	NA	NA	NA
	Jan-96	-124	0.3	<0.05	NA	NA	<0.1	4.26	2	NA	NA	NA	NA	4.2	170	NA	24.8	7.1	522
	Mar-98	-288	0.2	<0.1	2	<0.1	<0.1	6.21	3	70	11.1	ND	ND	5.23	220	15.4	25.1	7.2	464
CPT-04D	Mar-94	-266	0.2	0.09	NA	NA	0.6	1.47	0.2	NA	3.76	NA	NA	5.6	212	12.4	26.1	7.2	457
	Mar-95	-325	<0.1	0.07	2.53	<0.1	0.1	2.98	5	90	5.10	NA	NA	7.8	259	18.4	NA	7.04	540
	Jan-96	-114	0.1	<0.05	NA	NA	0.2	21.5	12	NA	NA	NA	NA	4.9	260	NA	25.2	6.9	654
	Mar-95 (Dup)	NA	NA	NA	NA	NA	NA	21.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mar-98	-286	0.1	<0.1	2.11	0.1	0.2	12.7	5	70	8.50	ND	ND	6.21	200	17	25.4	8.0	497
CPT-05S	Mar-94	-160	1.1	0.17	NA	NA	0.1	6.86	0.1	NA	4.86	NA	NA	12	215	23.6	26.4	7.3	488
CPT-06S	Mar-94	-278	0.2	0.13	NA	NA	0.3	7.03	1.5	NA	6.60	NA	NA	3.8	148	47.8	25.1	7.6	437
CPT-07S	Mar-94	-250	0.2	0.12	NA	NA	1	2.52	1.2	NA	6.34	NA	NA	3.4	254	30.2	25.3	7.2	577
CPT-08S	Mar-94	-60	0.2	0.1	NA	NA	1.9	8.51	0	NA	1.74	NA	NA	10.1	420	44.7	25.0	7.1	974
CPT-04D	Mar-94	-266	0.2	0.09	NA	NA	0.6	1.47	0.2	NA	3.76	NA	NA	5.6	212	12.4	26.1	7.2	457
	Mar-95	-325	<0.1	0.07	2.53	<0.1	0.1	2.98	5	90	5.10	NA	NA	7.8	259	18.4	NA	7.04	540
	Jan-96	-114	0.1	<0.05	NA	NA	0.2	21.5	12	NA	NA	NA	NA	4.9	260	NA	25.2	6.9	654
	Jan-96 (Dup)	NA	NA	NA	NA	NA	NA	21.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mar-98	-286	0.1	<0.1	2.11	0.1	0.2	12.7	5	70	8.50	NA	NA	6.21	200	17	25.4	8.0	497
CPT-05S	Mar-94	-160	1.1	0.17	NA	NA	0.1	6.86	0.1	NA	4.86	NA	NA	12	215	23.6	26.4	7.3	488
CPT-06S	Mar-94	-278	0.2	0.13	NA	NA	0.3	7.03	1.5	NA	6.60	NA	NA	3.8	148	47.8	25.1	7.6	437

TABLE 5 (Continued)
GROUNDWATER GEOCHEMICAL DATA
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Sample Location	Sample Date	ORP ^d (mV) ^e	Dissolved Oxygen (mg/L) ^e	Nitrate+ Nitrite (mg/L) ^e	Ammonia (mg/L)	Manganese (mg/L)	Iron (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Carbon Dioxide (mg/L)	Methane (mg/L)	Ethylene (mg/L)	Ethane (mg/L)	TOC ^{ai} (mg/L)	Alkalinity (as CaCO ₃) (mg/L)	Chlorides (mg/L)	Temperature (°C) ^g	pH	Conductivity (µs/cm) ^h
CPT-07S	Mar-94	-250	0.2	0.12	NA	NA	1	2.52	1.2	NA	6.34	NA	NA	3.4	254	30.2	25.3	7.2	577
CPT-08S	Mar-94	-60	0.2	0.1	NA	NA	1.9	8.51	0	NA	1.74	NA	NA	10.1	420	44.7	25.0	7.1	974
CPT-09S	Mar-94	-24	0.2	0.1	NA	NA	0.2	6.64	0	NA	3.80	NA	NA	10.2	340	14.3	27.3	7.3	530
Mar-95	-279	0.1	0.07	1.71	<0.1	1.52	1	1.52	1	80	5.82	NA	NA	3	180	9.46	NA	7.38	391
Jan-96	-130	0.2	<0.05	NA	NA	0.1	1.45	16	NA	NA	NA	NA	NA	1.5	170	NA	24.0	6.9	386
Mar-98	-234	<0.1	<0.1	1.09	<0.1	7.88	2	25	4.50	ND	ND	ND	ND	3.12	130	7.64	24.2	7.2	312
CPT-09M	Jan-96	-142	0.2	<0.05	NA	NA	0.1	1.71	18	NA	NA	NA	NA	26.7	350	NA	25.3	7.2	706
CPT-09D	Mar-94	-200	0.3	0.11	NA	NA	0.2	15.3	0.6	NA	4.24	NA	NA	12	422	34.7	27.8	7.1	938
Mar-95	-293	0.1	0.06	3.85	<0.1	2.23	5	284	9.84	NA	NA	NA	NA	21.8	469	51.1	NA	6.78	995
Mar-98	-260	<0.1	<0.1	2.32	<0.1	3.69	2	70	10.1	ND	0.008	16.9	320	38.7	320	38.7	25.2	8.2	775
Mar-98 (Dup)	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.4	0.008	NA	NA	NA	NA	NA	NA	NA	NA
CPT-10S	Mar-94	-60	0.1	0.13	NA	NA	0.2	9.5	0	NA	3.49	NA	NA	21.3	192	26.6	26.0	7.3	460
CPT-11S	Mar-94	-35	0.1	0.15	NA	NA	0.4	15.9	0	NA	4.24	NA	NA	NA	210	12.7	25.9	7.2	508
CPT-12S	Mar-94	30	0.9	0.1	NA	NA	0.1	8.38	0	NA	5.37	NA	NA	10.5	266	15.2	27.3	7	564
Mar-95	-306	<0.1	0.07	4.04	<0.1	0.98	1	142	12.3	NA	NA	NA	NA	6.1	220	14.4	NA	7.05	498
Jan-96	-120	0.1	<0.05	NA	NA	0.2	<0.5	0.2	NA	NA	NA	NA	NA	1.7	180	NA	24.4	7	474
CPT-12D	Mar-94	10	0.4	0.12	NA	NA	0.1	3.86	0.1	NA	0.983	NA	NA	8.1	329	28.1	27.1	7.2	715
Mar-95	-340	<0.1	0.05	2.37	<0.1	49.7	5	202	0.882	NA	NA	NA	NA	10.9	359	56.9	NA	6.93	946
Jan-96	-136	0.1	<0.05	NA	NA	0.1	2.85	14	NA	NA	NA	NA	NA	14.8	320	NA	26.0	7.1	940
Mar-98	-275	<0.1	<0.1	2.13	<0.1	7.7	7	90	7.64	ND	0.006	12.4	360	47.2	360	47.2	26.0	7.8	NA
CPT-13S	Mar-94	-230	0.1	0.12	NA	NA	0.3	6.94	0.6	NA	2.04	NA	NA	7.2	362	35.5	25.7	7.3	801
CPT-14D	Mar-94	-240	0.3	0.11	NA	NA	0.3	3.68	0.6	NA	8.79	NA	NA	12.8	460	34.6	25.5	7	906
CPT-16S	Mar-94	-190	0.1	0.13	NA	NA	0.4	8.23	0.1	NA	0.781	NA	NA	9.4	231	37.9	25.5	7	776
CPT-16DD	Mar-94	NA	2.7	NA	NA	NA	NA	0.3	NA	NA	NA	NA	NA	NA	NA	NA	26.7	NA	NA
Mar-95	-288	0.1	<0.05	16.9	<0.1	1200	NA	<0.05	NA	238	0.074	NA	NA	4.6	307	9.830	NA	7.13	26,900
Jan-96	-45	0.2	<0.05	NA	NA	<0.1	278	0.3	NA	NA	NA	NA	NA	4.2	380	NA	26.9	7.2	8,700
Mar-98	-184	<0.1	<0.1	17	0.1	1020	<0.1	110	0.023	NA	NA	NA	NA	6.99	360	10,000	25.9	7.8	NA
CPT-16S	Mar-94	-190	0.1	0.13	NA	NA	0.4	8.23	0.1	NA	0.781	NA	NA	9.4	231	37.9	25.5	7	776
CPT-16DD	Mar-94	NA	2.7	NA	NA	NA	NA	0.3	NA	NA	NA	NA	NA	NA	NA	NA	26.7	NA	NA
Mar-95	-288	0.1	<0.05	16.9	<0.1	1200	NA	<0.05	NA	238	0.074	NA	NA	4.6	307	9.830	NA	7.13	26,900
Jan-96	-45	0.2	<0.05	NA	NA	<0.1	278	0.3	NA	NA	NA	NA	NA	4.2	380	NA	26.9	7.2	8,700
Mar-98	-184	<0.1	<0.1	17	0.1	1020	<0.1	110	0.023	NA	NA	NA	NA	6.99	360	10,000	25.9	7.8	NA
CPT-18S	Mar-94	25	2	0.12	NA	NA	0.5	86	0	NA	NA	NA	NA	7.8	286	36.6	26.6	6.9	834
Mar-95	-287	0.1	0.07	0.35	<0.1	59.6	0.7	110	3.38	NA	NA	NA	NA	4	276	18.3	NA	6.85	675
Jan-96	-85	0.3	<0.05	NA	NA	0.3	43.3	0.6	NA	NA	NA	NA	NA	3.3	220	NA	24.7	6.9	551
Mar-98	NA	NA	NA	<0.1	0.47	<0.1	10.8	0.4	70	4.09	ND	ND	ND	6.82	240	10.3	NA	7.8	NA
CPT-18D	Mar-94	-60	0.3	0.11	NA	NA	0.3	1.85	0.2	NA	4.56	NA	NA	5.6	294	15	26.1	7.1	620
Mar-95	-316	0.1	0.07	1.52	<0.1	1.08	2	98	6.12	NA	NA	NA	NA	5.8	289	29.6	NA	6.87	652
Mar-98	-262	<0.1	<0.1	1.4	<0.1	2.05	2.5	50	7.56	ND	ND	ND	ND	6.47	220	20.4	26.1	7.5	740

TABLE 5 (Concluded)
GROUNDWATER GEOCHEMICAL DATA
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA

Sample Location	Sample Date	ORP ^d (mV) ^e	Dissolved Oxygen (mg/L) ^e	Nitrate+ Nitrite (mg/L) ^e	Ammonia (mg/L)	Manganese (mg/L)	Ferrous Iron (mg/L)	Sulfate (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Dioxide (mg/L)	Methane (mg/L)	Ethylene (mg/L)	Ethane (mg/L)	TOC ^b (mg/L)	Alkalinity (as CaCO ₃) ^c (mg/L)	Chlorides (mg/L)	Temperature (°C) ^f	pH	Conductivity (µs/cm) ^g
CPT-18DD	Mar-94	NA	2.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	27.3	NA	NA
	Mar-95	-171	0.2	<0.05	16.2	<0.1	0.1	967	<0.1	276	0.068	NA	NA	NA	4.2	335	9,080	NA	26,500
	Jan-96	-55	0.3	<0.05	NA	NA	0.1	245	0.1	NA	NA	NA	NA	NA	5.3	270	NA	26.7	11,000
	Mar-98	-110	<0.1	<0.1	16.8	<0.1	0.1	1040	0.1	100	0.030	NA	NA	NA	6.74	340	8,900	27.4	260
	Mar-98 (Dup)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.029	ND	ND	NA	NA	NA	NA	NA	NA
CPT-19S	Mar-94	41	NA	0.11	NA	NA	0.1	8.85	0	NA	0.924	NA	NA	10.3	335	37.4	NA	7	800
CPT-19D	Mar-94	-50	0.2	0.1	NA	NA	0.2	1.51	0.2	NA	2.14	NA	NA	7.3	328	33.7	26.6	7.1	744
CPT-20S	Mar-94	23	1.5	0.1	NA	NA	0.3	25.5	0	NA	1.28	NA	NA	3.6	148	9.83	25.0	7	368
CPT-20D	Mar-94	-44	0.3	0.07	NA	NA	0.2	<0.5	0.1	NA	1.11	NA	NA	8.6	380	52	25.7	7.1	842
CPT-21S	Mar-94	20	3.2	0.29	NA	NA	0.2	25.5	0	NA	2.41	NA	NA	7.6	245	26.6	26.0	7.1	610
	Mar-95	-239	0.1	0.08	2.94	NA	0.6	0.52	0.7	190	0.86	NA	NA	4.9	177	12.3	NA	6.92	381
CPT-21D	Mar-94	-20	0.2	0.14	NA	NA	0.2	13.3	0.1	NA	0.46	NA	NA	6.1	304	29.8	26.4	7.2	716
	Mar-95	-307	<0.1	0.07	0.47	NA	0.1	38.8	5	96	0.749	NA	NA	NA	287	28.2	NA	7.18	674
CPT-22S	Mar-94	-153	0.3	0.07	NA	NA	1.2	128	0	NA	3.22	NA	NA	10	450	66.6	25.5	6.8	1,270
CPT-22D	Mar-94	-287	0.1	0.12	NA	NA	0.2	NA	5	NA	0.866	NA	NA	11.4	415	NA	25.4	6.9	936
CPT-23S	Mar-94	54	3.5	0.12	NA	NA	0.2	<0.5	0	NA	1.99	NA	NA	6.4	346	23.4	26.5	6.9	757
CPT-23D	Mar-94	-167	0.4	0.1	NA	NA	0.2	1.49	0.2	NA	2.28	NA	NA	8.2	332	36.1	26.7	7.1	779
CPT-24S	Mar-94	30	1.7	0.12	NA	NA	0.1	<0.5	0	NA	2.20	NA	NA	5.6	190	6.63	25.7	7	358
CPT-24D	Mar-94	-60	0.3	0.1	NA	NA	0.1	3.61	0.1	NA	0.686	NA	NA	2.8	192	5.46	26.0	7.5	376
CPT-25S	Mar-94	53	3.7	0.12	NA	NA	<0.05	51.9	0	NA	0.147	NA	NA	15.7	157	28	25.0	7.3	664
CPT-25D	Mar-94	62	NA	0.12	NA	NA	<0.05	6.16	0	NA	1.56	NA	NA	15.7	371	54.7	NA	7.1	892
CPT-26S	Mar-94	-20	2.2	0.12	NA	NA	0.3	1.22	0	NA	3.57	NA	NA	5	264	15.1	26.0	7.6	558
	Mar-95	-269	0.1	0.07	1.01	<0.1	0.3	0.94	0.7	154	9.01	NA	NA	3.4	202	13.2	NA	6.87	440
CPT-26D	Mar-94	-293	0.2	0.11	NA	NA	0.4	19.8	3	NA	2.96	NA	NA	8.3	311	44.9	26.2	7	751
	Mar-95	-342	0.1	0.06	2.61	<0.1	<0.05	3.31	5	192	3.76	NA	NA	9.5	357	51.2	NA	6.88	837
MW-9	Mar-98	-115	0.3	<0.1	<0.1	<0.1	0.1	4	<0.1	50	0.048	ND	ND	2.9	130	2.68	21.9	7.6	NA
MW-100	Mar-94	-241	0.5	0.12	NA	NA	0.1	16.3	0.2	NA	2.82	NA	NA	18.6	331	24.9	25.9	7.2	607
	Mar-95	-253	<0.1	0.07	0.23	<0.1	0.3	10	0.3	132	NA	NA	NA	3.3	205	15.2	NA	7.32	429
MW-101	Mar-94	-247	0.3	0.13	NA	NA	0.1	5.75	0.8	NA	2.31	NA	NA	9	287	21.6	26.5	7.2	533
MW-102	Mar-94	-281	0.2	0.12	NA	NA	0.1	3.51	0.5	NA	3.26	NA	NA	7.6	250	17.9	25.8	7.2	523
MW-103	Mar-94	-271	0.1	0.11	NA	NA	0.1	4.69	1	NA	5.29	NA	NA	2.6	209	12.5	25.4	7.4	445
PB5/MW-11	Mar-94	-140	0.2	0.1	NA	NA	<0.05	4.45	NA	NA	4.41	NA	NA	NA	291	51.4	24.9	7.1	743
PPOL2-1/M	Mar-94	-220	0.1	<0.05	NA	NA	0.6	3.2	0.7	NA	5.33	NA	NA	NA	305	44	26.3	7.1	747
PPOL2-6/M	Mar-94	-230	0.2	<0.05	NA	NA	NA	1.150	0.8	NA	0.034	NA	NA	NA	334	10,200	27.2	7	30,100

^a ORP = Oxidation Reduction Potential.

^b TOC = Total Organic Carbon.

^c CaCO₃ = Calcium Carbonate.

^d mV = millivolts.

^e mg/L = milligrams per liter.

^f °C = Degrees Celsius.

^g µs/cm = microsiemens per centimeter.

^h NA = not analyzed.

ⁱ "u" = analyte detected at a concentration less than quantitation limit.

^j Dup = Duplicate sample.

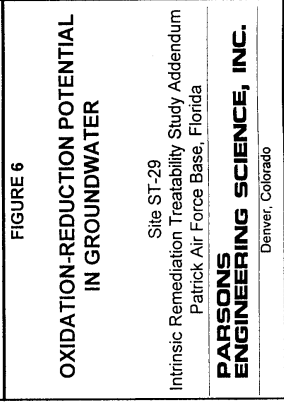
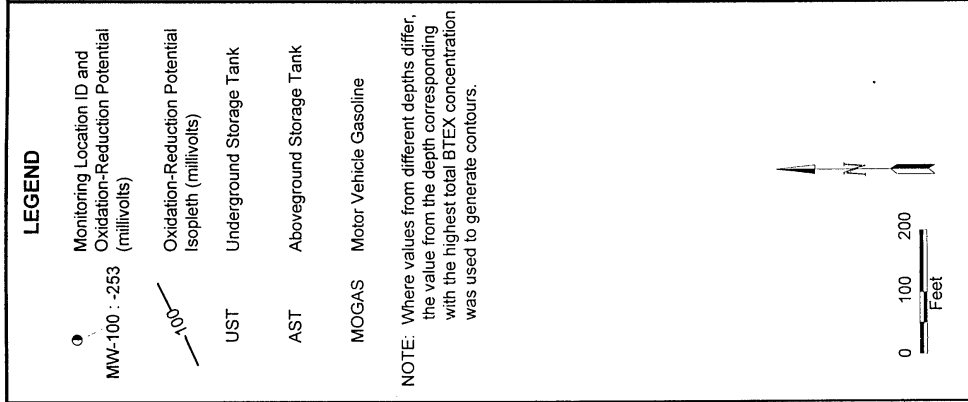
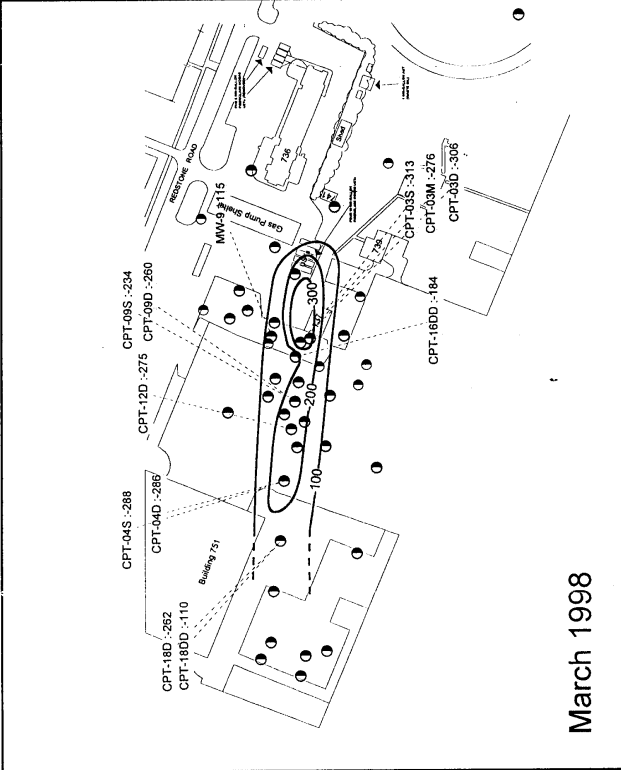
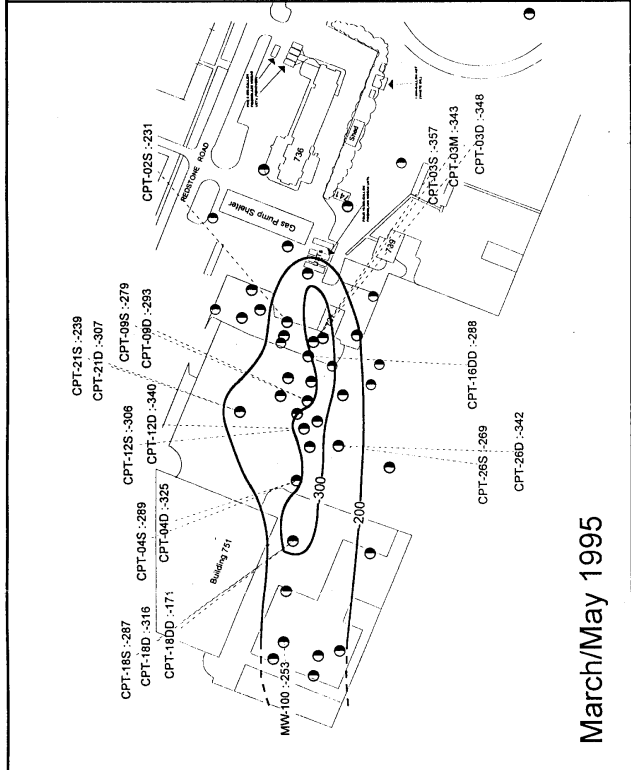
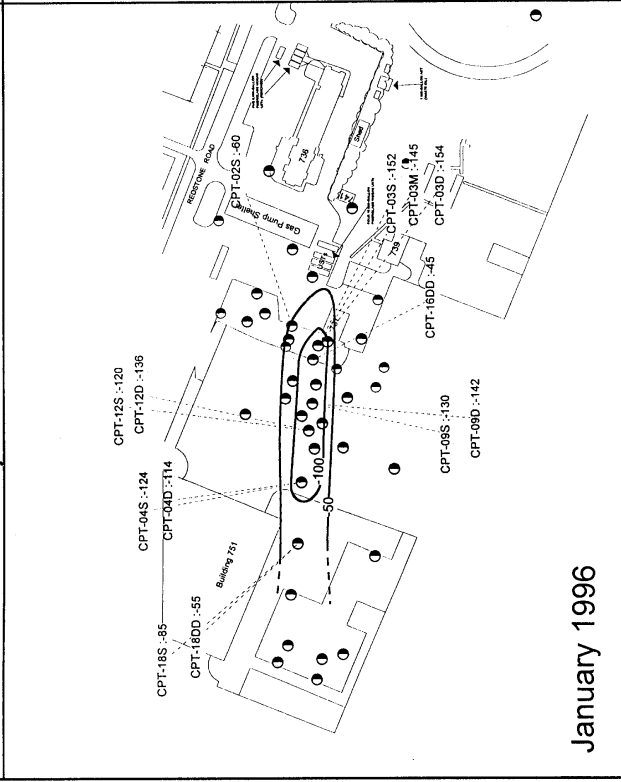
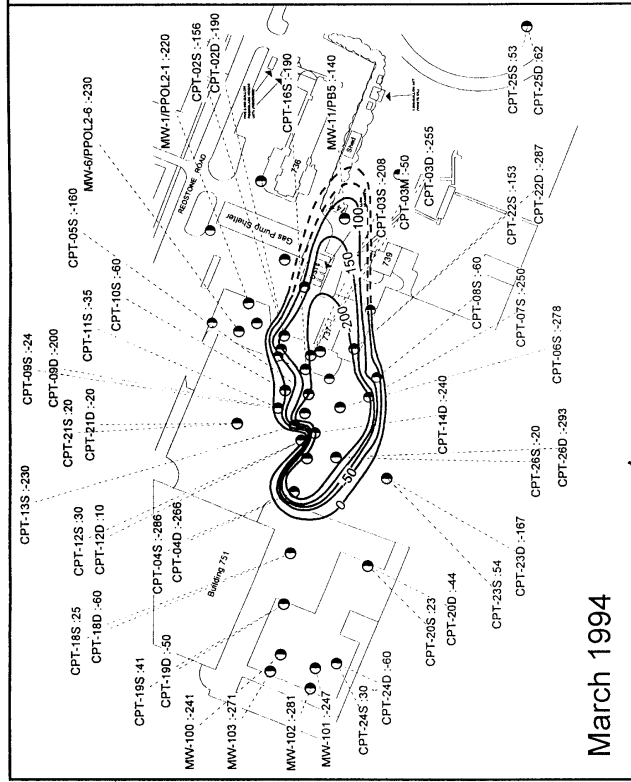
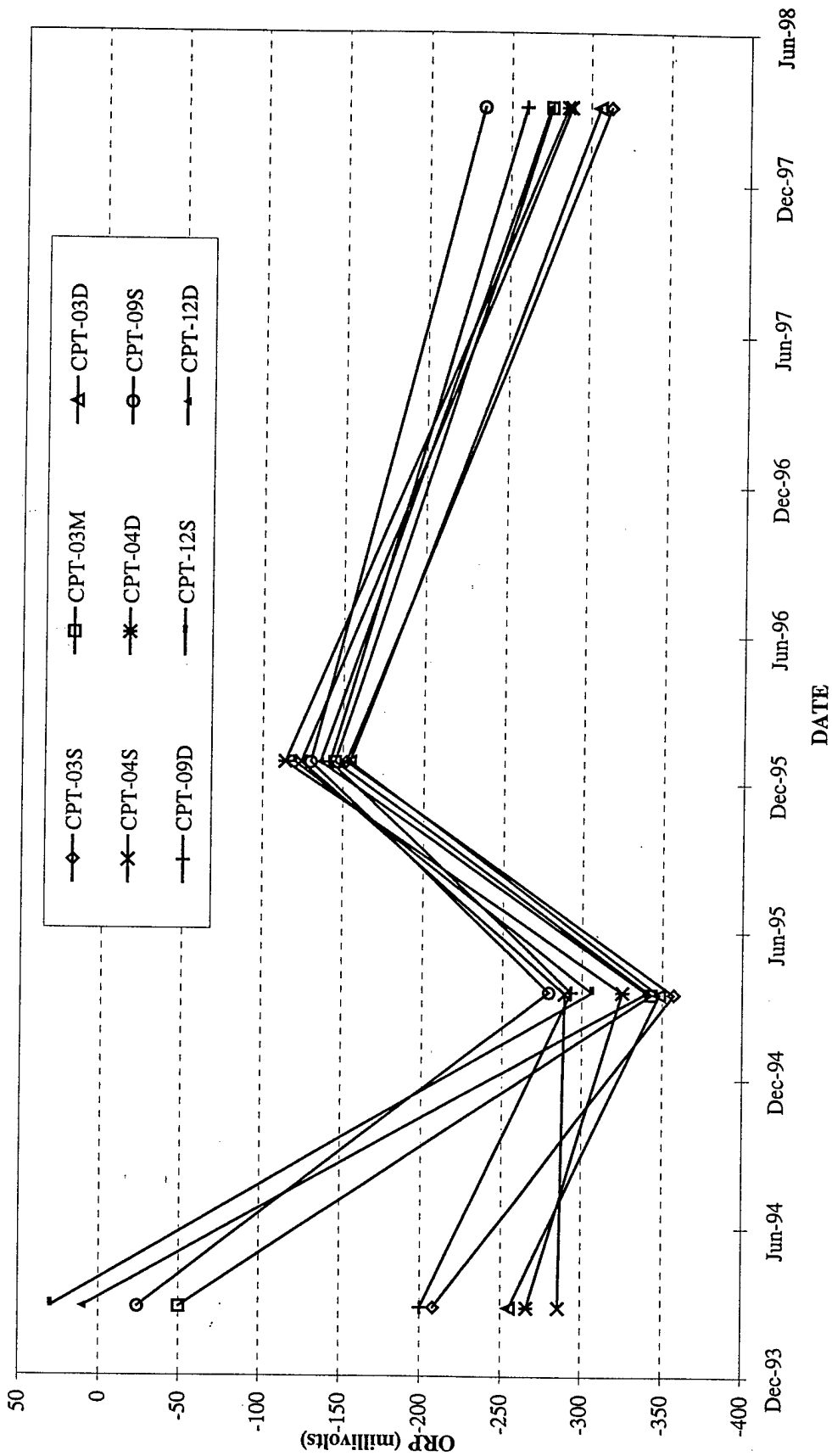


FIGURE 7
 OXIDATION-REDUCTION POTENTIAL OVER TIME
 MARCH 1994 TO MARCH 1998
 INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
 SITE ST-29
 PATRICK AFB, FLORIDA



inversely correlated to changes in BTEX concentration over the same time period (i.e., increases in ORP correspond to decreases in BTEX concentration, and vice versa). While the measurement of ORP in the field is sensitive to sampling protocol and equipment, an increase in ORP could be interpreted to be a result of decreased microbial activity due to decreasing dissolved BTEX concentrations, and vice-versa.

Dissolved Oxygen

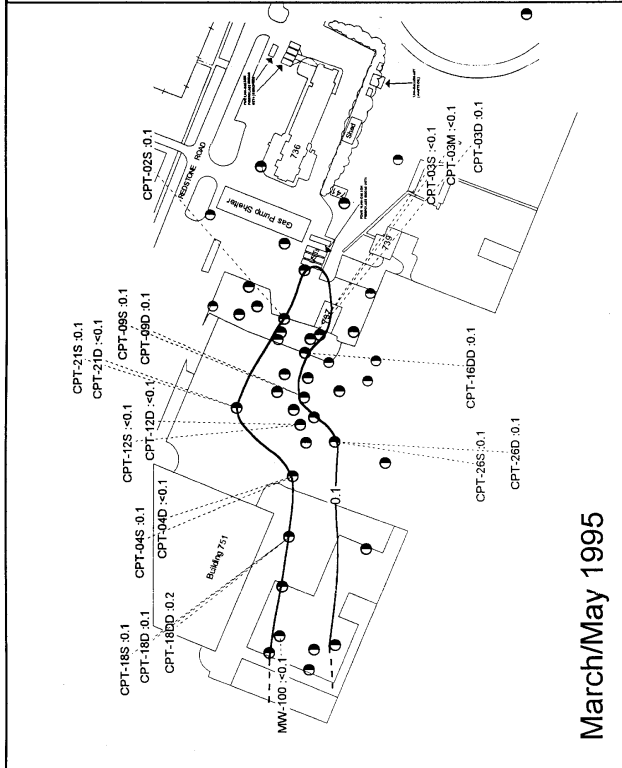
DO data collected at the site from 1994 to 1998 are summarized in Table 5. The areal distributions of DO at the site in 1994, 1995, 1996, and 1998 are presented on Figure 8, and the vertical distributions of DO within the plume core in 1994, 1995, 1996, and 1998 are plotted on Figure 9. DO concentrations range from less than 0.1 milligram per liter (mg/L) within the core of the BTEX plume to as high as 3.7 mg/L (CPT-25S in March 1994) outside of the BTEX plume. Comparison of Figures 3 and 4 with Figures 8 and 9 shows graphically that areas with elevated total BTEX concentrations have decreased DO concentrations. The correlation between depleted DO and elevated BTEX concentrations is a strong indication that aerobic biodegradation of the BTEX compounds has occurred at the site. The greatest aerobic activity is expected to occur at the upgradient perimeter of the source area and along the fringes of the plume, because these are areas where BTEX-contaminated groundwater interacts with groundwater containing measurable concentrations of DO.

Nitrate+Nitrite

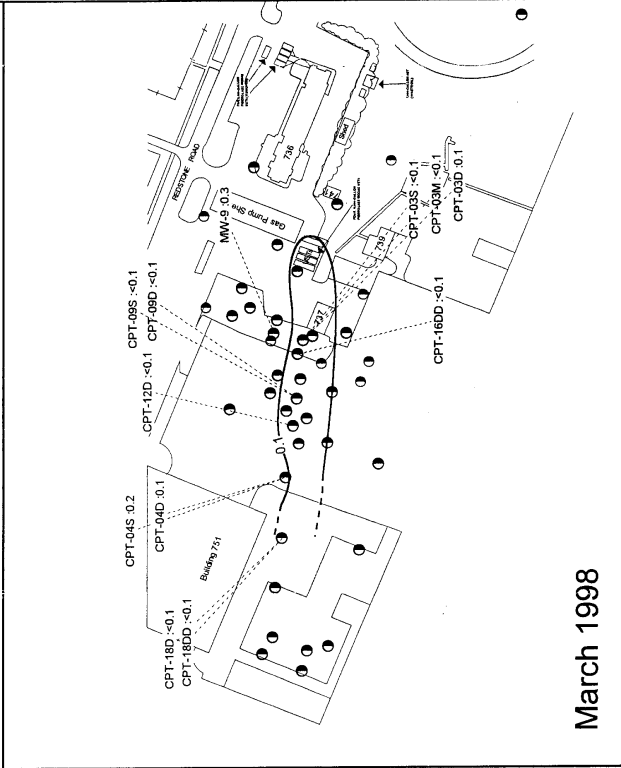
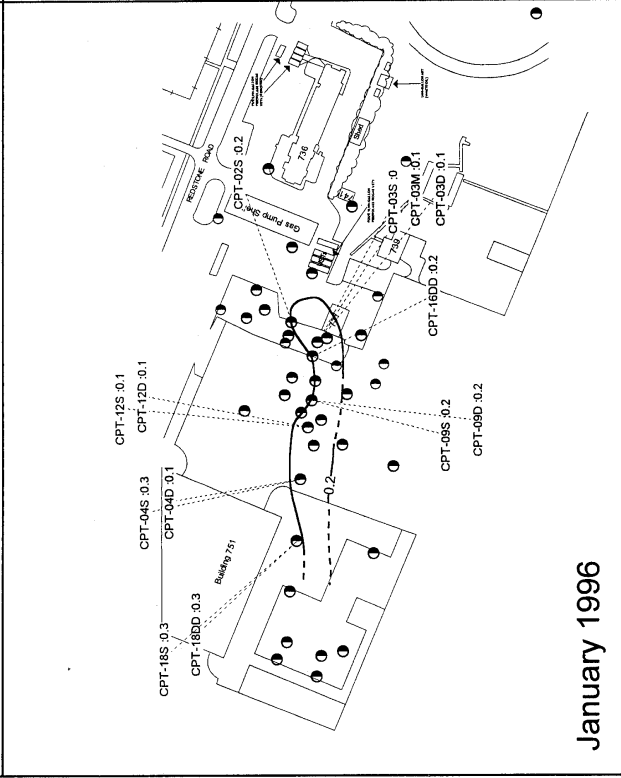
After DO has been depleted in a microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Nitrate concentrations below background in areas with high organic carbon and low DO concentrations are indicative of denitrification. Nitrate plus nitrite (as nitrogen) data collected from monitoring locations at the site from 1994 to 1998 are summarized in Table 5. All nitrate concentrations in January 1996 were less than the detection limit of 0.05 mg/L. In March 1994, the highest nitrate+nitrite concentrations were detected within the BTEX plume. In contrast, the lowest concentrations of nitrate+nitrite detected in March 1995 and March 1998 were detected within the BTEX plume, suggesting that some BTEX degradation via denitrification was occurring. In any event, the overall lack of nitrate in groundwater at Site ST-29 indicates that denitrification is not contributing significantly to BTEX attenuation.

Manganese

Manganese data collected at the site from 1995 and 1998 are summarized in Table 5. Groundwater samples collected at the site during the March 1994 and January 1996 sampling events were not analyzed for manganese. A correlation between depleted manganese and elevated BTEX concentrations is an indication of the biodegradation of BTEX compounds by the process of manganese reduction. However, all manganese concentrations detected in samples from monitoring wells at Site ST-29 were 0.1 mg/L or less. Therefore, the lack of manganese in groundwater at Site ST-29 indicates that manganese reduction is not contributing significantly to BTEX attenuation.



March/May 1995



March 1998

MW-100 : 0.5
Monitoring Location ID and
Dissolved Oxygen Concentration
(milligrams per liter)

Dissolved Oxygen Concentration
Isopleth (milligrams per liter)

< 0.1
Reported Value Less Than
Specified Detection Limit

Underground Storage Tank

Aboveground Storage Tank

MOGAS Motor Vehicle Gasoline

NOTE: Where values from different depths differ, the value from the depth corresponding with the highest total BTEX concentration was used to generate contours.

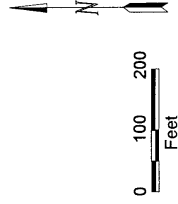


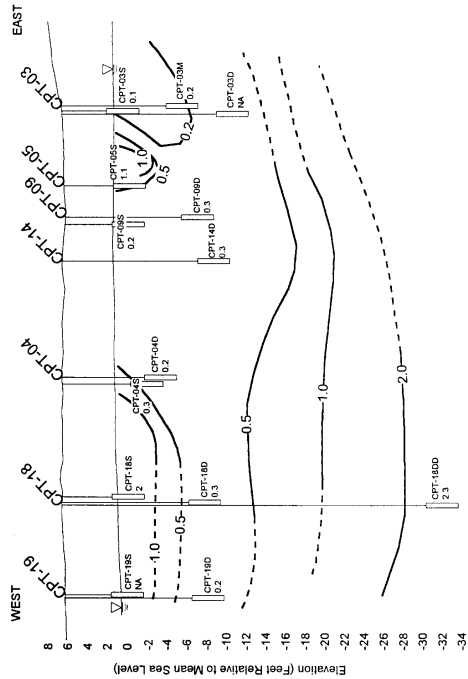
FIGURE 8

DISSOLVED OXYGEN IN GROUNDWATER

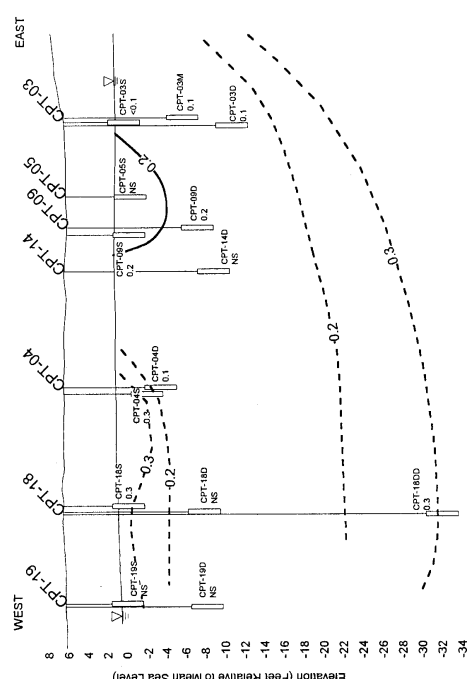
Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

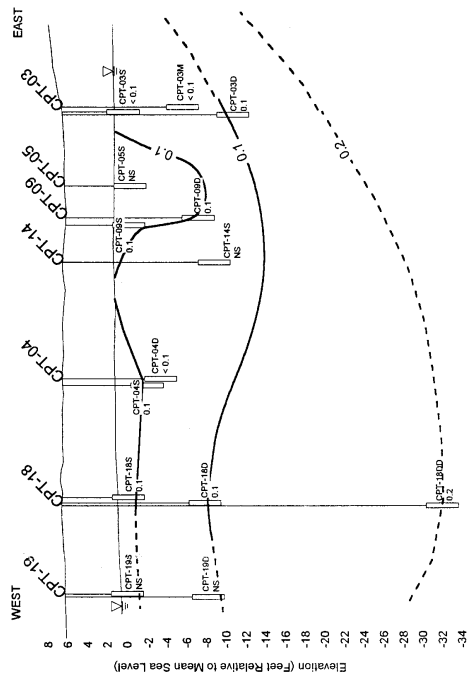
Denver, Colorado



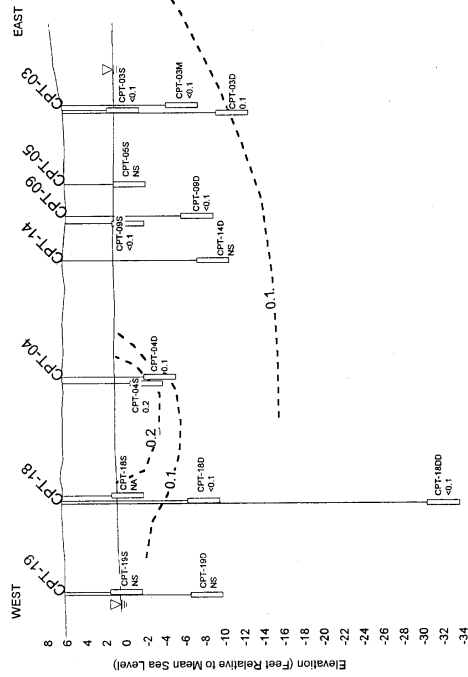
March 1994



January 1996



March/May 1995



March 1998

LEGEND

- CPT-4S
Monitoring Location Screen and
Dissolved Oxygen Concentration
(milligrams per liter)
- 1.53
Dissolved Oxygen
Concentration Isoleth
(Dashed where Inferred)
- NA
Data Not Available
- NS
Not Sampled
- Approximate Groundwater Surface



FIGURE 9

CROSS-SECTION OF DISSOLVED OXYGEN IN GROUNDWATER

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Ferrous Iron

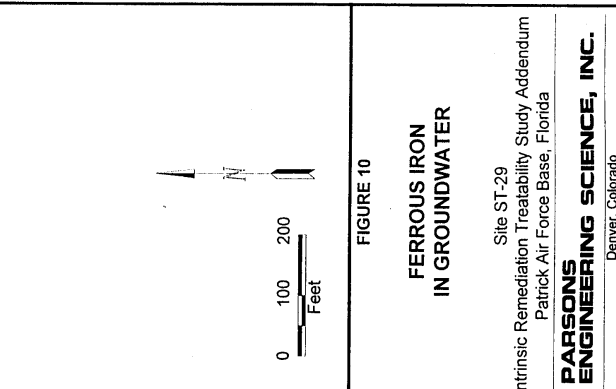
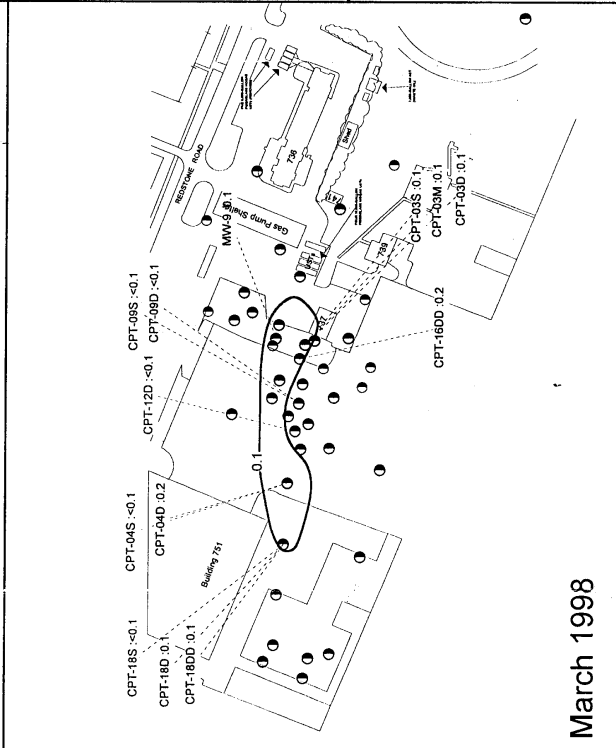
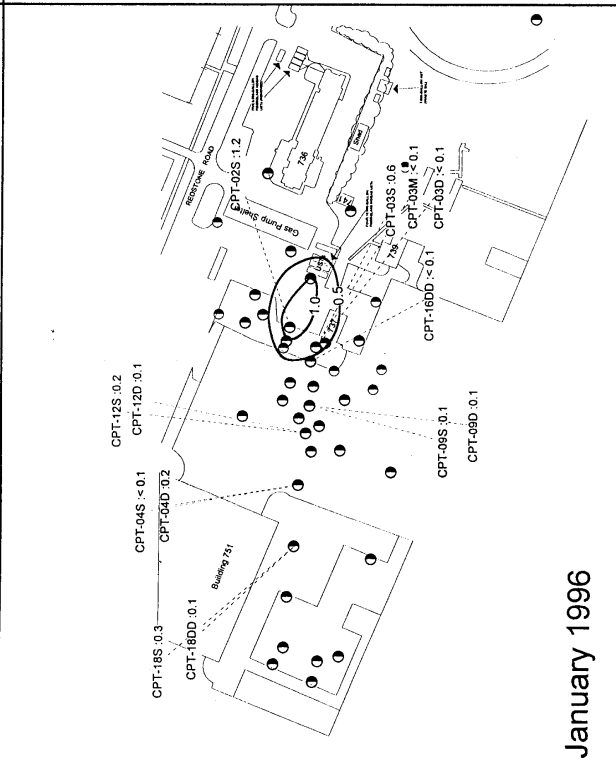
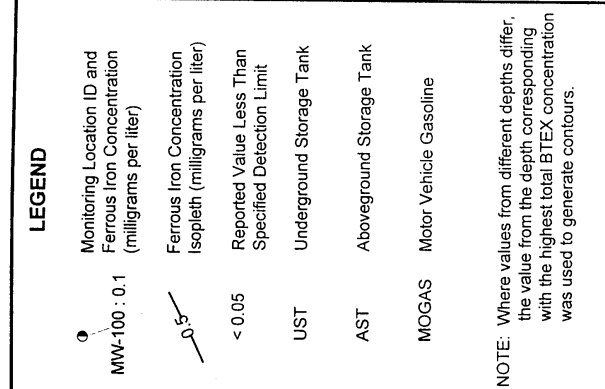
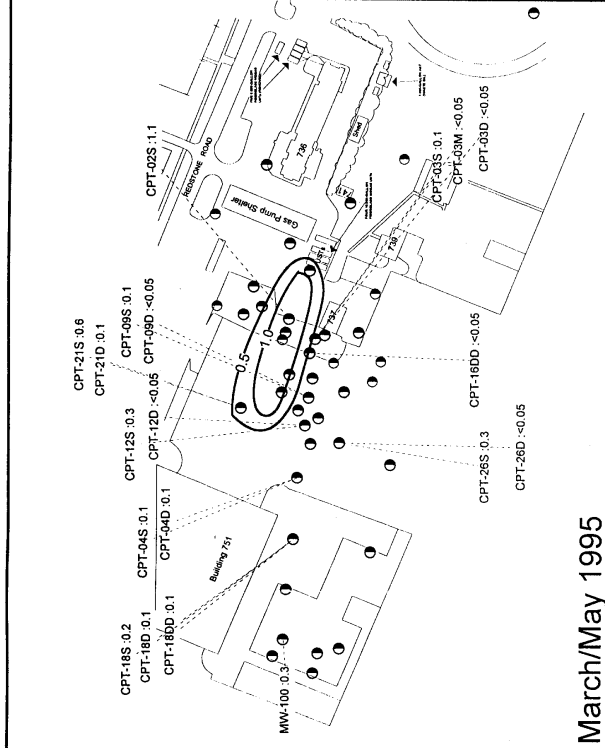
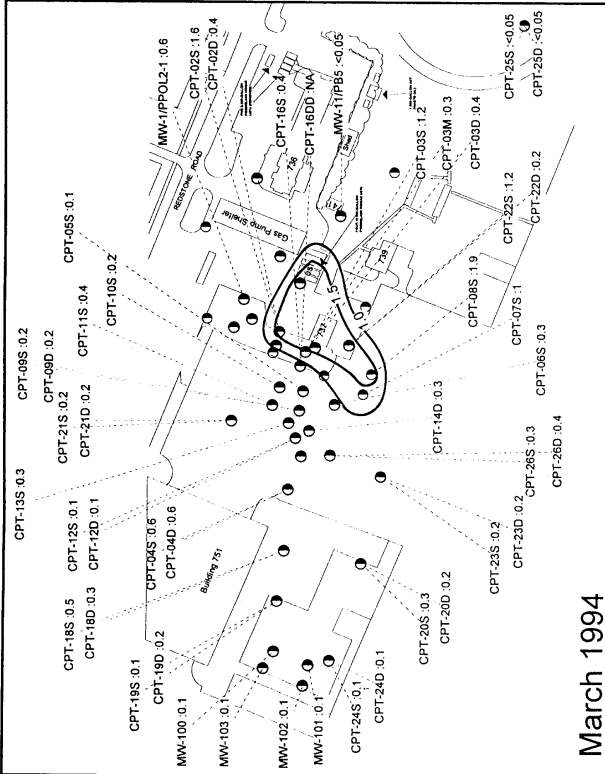
Dissolved ferrous iron (Fe^{+2}) is the reduced form of iron and is a byproduct of the oxidation of organic carbon (e.g., BTEX) via ferric iron (Fe^{+3}) reduction. Ferrous iron data collected at the site from 1994 to 1998 are summarized in Table 5. The areal distributions of ferrous iron at the site in 1994, 1995, 1996, and 1998 are presented on Figure 10. Comparison of Figure 3 with Figure 10 shows that areas with elevated total BTEX concentrations have elevated ferrous iron concentrations, with the highest ferrous iron concentrations occurring in the core of the dissolved BTEX plume, particularly in and around the source area. The continuing correlation between elevated ferrous iron and elevated BTEX concentrations is a strong indication that anaerobic biodegradation of the BTEX compounds has occurred over time at the site. However, ferrous iron concentrations in March 1998 were relatively low, suggesting that the process was less prominent at that time. The data are insufficient to ascertain whether this is a continuing trend.

The greatest anaerobic activity is expected to occur within the core of the plume, because this is the area where BTEX-contaminated groundwater is likely to be depleted of DO. Several sources suggest that the reduction of ferric iron to ferrous iron cannot proceed without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993); therefore, the presence of ferrous iron in the plume core strongly suggests that ferric iron is being used as an electron acceptor at the site during biodegradation of BTEX compounds.

Sulfate

Sulfate may also be used as an electron acceptor during microbial degradation of natural or anthropogenic organic carbon under anaerobic conditions (Grbic-Galic, 1990). This ORP reaction is commonly called sulfate reduction, which results in a decrease in groundwater sulfate concentrations. Sulfate concentration data measured at the site between 1994 and 1998 are summarized in Table 5. The TS report (Parsons ES, 1995) concluded that sulfate concentrations did not exhibit an inverse relationship with BTEX concentrations, and that sulfate concentrations were elevated in areas containing elevated BTEX concentrations. These conclusions are generally supported by the more recent sampling data collected in 1995, 1996, and 1998. Sulfate concentrations in contaminated areas are generally similar to or higher than sulfate concentrations detected in upgradient and cross-gradient areas in 1994. For example, the sulfate concentrations at CPT-03S in March 1998 (12.6 mg/L) was higher than the concentration at CPT-03D (5.53 mg/L), despite the fact that the dissolved BTEX concentrations in CPT-03S and -03D were 22,400 $\mu\text{g/L}$ and 1.5 $\mu\text{g/L}$, respectively. Similarly, the March 1998 sulfate concentration at CPT-04D (12.7 mg/L) (BTEX = 1,180 $\mu\text{g/L}$) was higher than at CPT-04S (6.2 mg/L) (BTEX = 9.1 $\mu\text{g/L}$). The background sulfate concentration in March 1994 was generally less than 5 mg/L.

The sulfate data do suggest that sulfate reduction may be occurring in very localized areas. For example, the January 1996 sulfate concentration at CPT-02S (BTEX = 139 $\mu\text{g/L}$) was less than 0.5 mg/L.



Methane

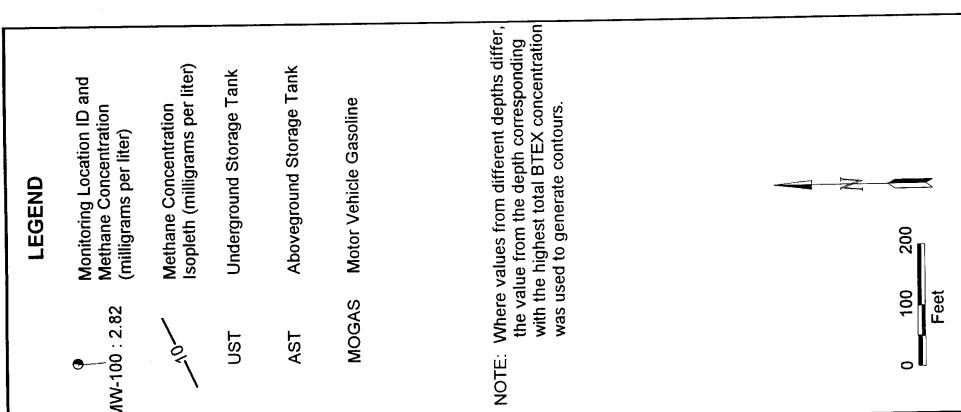
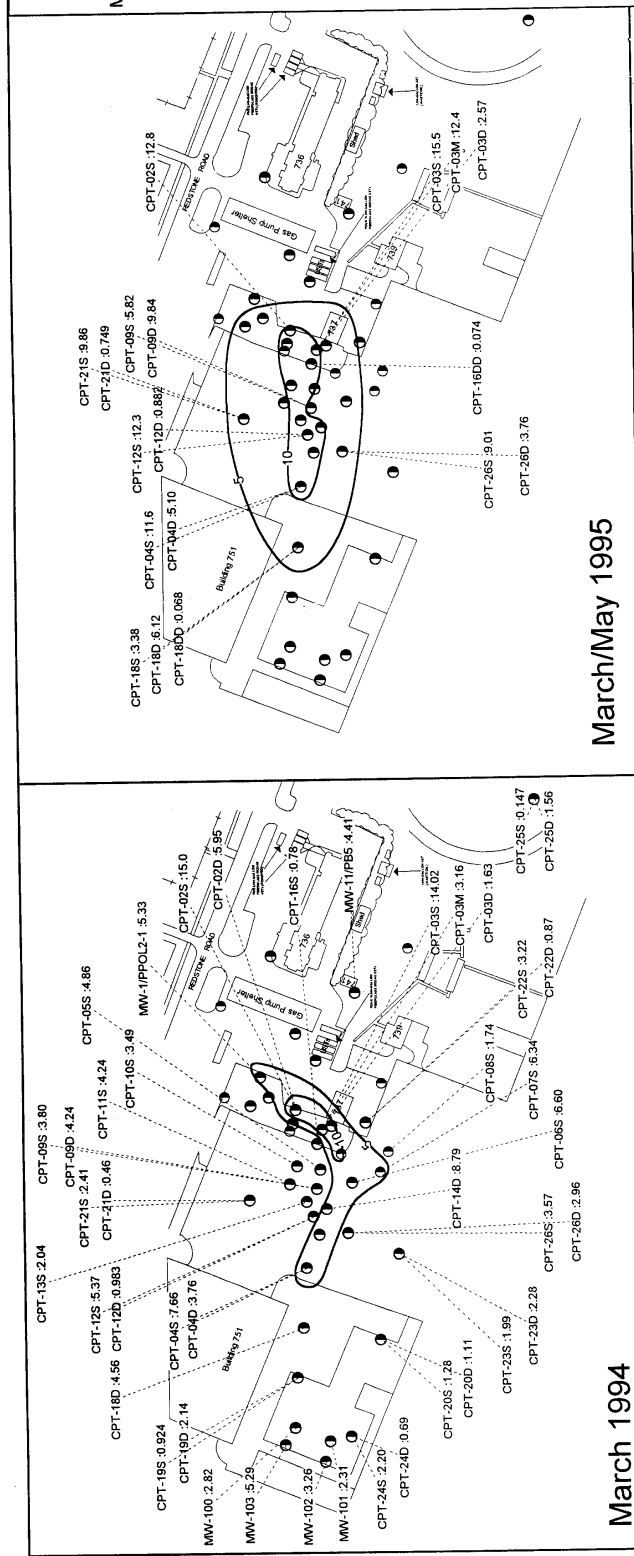
The presence of methane in BTEX-contaminated groundwater indicates that anaerobic biodegradation of BTEX is occurring via the microbially mediated process of methanogenesis (carbon dioxide reduction). Methane data collected at the site between 1994 and 1998 are summarized in Table 5. The areal distributions of methane at the site in March 1994, March 1995, and March 1998 are presented on Figure 11. Groundwater samples were not analyzed for methane during 1996. Comparison of Figure 3 with Figure 11 shows graphically that areas with elevated total BTEX concentrations have elevated methane concentrations, with the highest methane concentrations occurring in the core of the dissolved BTEX plume immediately downgradient from the USTs. The continued correlation between elevated methane and elevated BTEX concentrations is a strong indication that anaerobic biodegradation of the BTEX compounds continues to occur at the site. The greatest methanogenic activity is expected to occur within the core of the plume, because this is the area where BTEX-contaminated groundwater is more likely to be depleted of DO and other electron acceptors (e.g., ferric iron and sulfate). Comparison of methane concentrations over time at five sampling locations that were sampled in 1994, 1995, and 1998 (CPT-03S, CPT-09D, CPT18D, CPT-04S, CPT-04D) indicate that concentrations have been stable to increasing, indicating that the occurrence of methanogenesis has not diminished over time.

Alkalinity

Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. Total alkalinity (measured as calcium carbonate [CaCO_3]) of groundwater samples collected at the site from 1994 to 1998 is summarized in Table 5. Groundwater contaminated by fuel hydrocarbons often exhibits total alkalinity that is higher than that of groundwater in background areas. An increase in alkalinity relative to background concentrations suggests that additional buffering capacity was generated to address acids produced during biodegradation of BTEX. Increases in alkalinity above background concentrations can be observed at Site ST-29. Alkalinities generally are below 300 mg/L in areas with low or non-detectable concentrations of dissolved BTEX, while more highly contaminated areas generally have alkalinity greater than 300 mg/L. The highest concentration of alkalinity detected at Site ST-29 was 920 mg/L at CPT-03S (March 1995). CPT-03S is located approximately 100 ft downgradient from the suspected source area, and has been the most contaminated well at the site. Groundwater from this monitoring point also had the highest alkalinity measured during the 1994 and 1996 sampling events. The data indicate that the alkalinity is sufficient to continue buffering the groundwater pH against the effects of biologically mediated BTEX oxidation reactions.

3.0 CONCLUSIONS

Results from groundwater monitoring conducted during January 1996 and March 1998 indicate that natural attenuation of BTEX continues at Site ST-29. The areal extent of the BTEX plume migration does not appear to have increased since 1994; rather, the plume extent appears to be stable or diminishing slightly. The distribution of electron acceptors/metabolic byproducts that are involved in biologically mediated redox reactions



January 1996

NO DATA AVAILABLE

indicate that microbially-mediated redox reactions are continuing to occur within the BTEX plume. Data suggest that degradation of dissolved BTEX at the site is occurring via the biodegradation processes of aerobic respiration, methanogenesis, and to a lesser extent, iron reduction. Sulfate reduction also appears to be occurring, but only in very localized portions of the plume.

Monitoring results indicate that the Bioplume II models presented in the TS report (Parsons ES, 1995) underestimated the maximum concentration of dissolved BTEX that would be present in the plume over time, but that the downgradient extent of the plume is conservatively overestimated by both models. While the extent of the BTEX plume has not increased, the bioventing system does not appear to have had a significant impact on total dissolved BTEX concentrations. Although bioventing is effective in reducing soil BTEX concentrations in the vadose zone, the continued presence of elevated dissolved BTEX concentrations suggests that a residual source of BTEX persists within the capillary fringe or saturated zone (i.e., a smear zone). An increase in the average groundwater elevation of 0.4 foot from March 1994 to January 1996 further has increased the volume of saturated soil in the source area, decreased the volume of unsaturated soil subject to the effects of bioventing, and enhanced the dissolution of BTEX into the groundwater.

LTM should be continued to confirm stabilization of the dissolved BTEX plume and to document the continuing occurrence of microbially mediated biodegradation. LTM also is required to assess the effect of increasing dissolved BTEX concentrations with time along the center line of the plume (monitoring points CPT-03S, CPT-03M, and CPT-04D) on plume stability. If more rapid remediation is required, the engineering remediation of contaminated soils below the average water table (e.g., via biosparging) is recommended.

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APPENDIX A
ANALYTICAL DATA



Ref: 96\LB16

February 9, 1996

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Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

Please find attached the analytical results for Service Request SF-2-186 requesting the analysis of Patrick AFB groundwater samples to be analyzed by purge-and-trap/GC-FID:PID for Benzene, Toluene, Ethylbenzene, p-, m-, & o-Xylene, 1,3,5-, 1,2,4-, & 1,2,3-Trimethylbenzene, and Total Fuel Carbon. We obtained your 10 groundwater samples in duplicate, in capped, 40 mL VOA autosampler vials on February 5, 1996, and they were analyzed on February 7-8, 1996. Samples were stored at 4°C until analyzed. All samples were acquired and processed using the Millennium data system. A 5 place (1-500 ppb) external standard curve was used to quantitate the samples for the compounds of interest.

RSKSOP-133, "Simultaneous Analysis of Aromatics and Total Fuel Carbon by Dual Column-Dual Detector for Ground Water Samples" was used for these analyses. Autosampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Lisa R. Black

xc: R. L. Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley *JS*

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB	Fuel Carbon
10 PPB	9.9	9.7	9.5	9.7	9.5	9.6	9.5	9.5	9.6	N/A
CPT-2S	64.3	5.2	53.3	4.4	8.4	3.5	1.5	45.5	37.9	1500
CPT-86-4D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-4S	ND	ND	BLQ	BLQ	BLQ	BLQ	ND	ND	ND	BLQ
CPT-86-16DD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-18DD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-18S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-12S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-12S Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-12M D	5.0	5.2	ND	8.9	5.2	5.0	BLQ	1.6	5.4	625
CPT-86-9S	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CPT-86-9M	28.9	10.4	1.9	6.2	5.5	6.5	1.2	1.2	7.8	914
QC, OBSERVED, PPB	46.8	45.5	49.5	46.2	46.4	46.6	45.9	46.0	46.5	N/A
QC, TRUE VALUE, PPB	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	N/A

ND = None Detected; BLQ = Below Limit of Quantitation, 1 ppb; N/A = Not Analyzed

MANAGEMENT TECHNOLOGY

Ref: 96-JH10/vg

February 14, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

DISSOLVED
GASES

THRU: S.A. Vandegrift ✓

Dear Don:

Find attached results for methane, ethylene and ethane on samples received February 5, 1996 under Service Request #SF-2-186 mod. 1: Samples were prepared and calculations done as per RSKSOP-175. Analyses were performed as per RSKSOP-147.

If you have any questions concerning this data, please contact me.

Sincerely,

Jeff Hickerson

Jeff Hickerson

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

Patrick AFB - 1996 data

SR# SF-2-186
MOD 1

ANALYSIS PERFORMED 2-8-96

SAMPLE	METHANE	ETHYLENE	ETHANE
--------	---------	----------	--------

LAB BLANK	BLQ	ND	ND
EPA-83-1	9.48	ND	ND
EPA-83-2	16.19	ND	BLQ
EPA-83-3	3.75	ND	BLQ
EPA-83-4	11.68	ND	BLQ
* LAB DUP	10.71	ND	ND
EPA-83-7	7.50	ND	ND
* FIELD DUP	7.38	ND	ND
10 PPM CH4	10.00	NA	NA
100 PPM CH4	100.11	NA	NA
1000 PPM CH4	999.93	NA	NA
1% CH4	1.02	NA	NA
10% CH4	10.00	NA	NA
20% CH4	20.28	NA	NA
10 PPM C2H4	NA	10.21	NA
100 PPM C2H4	NA	99.98	NA
10 PPM C2H6	NA	NA	10.24
100 PPM C2H6	NA	NA	99.98

LIMITS OF QUANTITATION.

METHANE	ETHYLENE	ETHANE
---------	----------	--------

0.001	0.003	0.002
-------	-------	-------

SAMPLE UNITS ARE mg/L.

STANDARDS UNITS CORRESPOND
TO THE SAMPLE COLUMN.

BLQ DENOTES BELOW LIMIT OF QUANTITATION.

ND DENOTES NONE DETECTED.

NA DENOTES NOT ANALYZED.

MANAGEMENT TECHNOLOGY

Ref: 96-TH4/vg
96-JRD5/vg

February 12, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

INORGANICS

THRU: S.A. Vandegrift SV

Dear Don:

Attached are the results of 13 Patrick AFB samples submitted to MERSC as part of Service Request #SF-2-186. The samples were received February 5, 1996 and analyzed immediately. The methods used for analysis were EPA Methods 353.1 for NO₂ and NO₃, 120.1 for Conductivity and Waters capillary electrophoresis Method for N-601 for SO₄. Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Tim Hensley
Tim Hensley

Justin Daniel
Justin Daniel

cc: R.L. Cosby

G.B. Smith

J.L. Seeley *JS*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	Conductivity	mg/l NO ₃ ⁻ +NO ₂ ⁻ (N)	mg/l SO ₄ ⁻²
CPT-3D	693	<.05	16.5
CPT-3D Dup	692	----	----
CPT-3I	695	<.05	15.7
CPT-3S	1675	<.05	10.0
CPT-2S	928	<.05	<.5
CPT-86-4D	660	<.05	21.5
CPT-86-4D Dup	----	----	21.9
CPT-86-4S	482	<.05	4.26
CPT-86-9M	990	<.05	1.71
CPT-86-9M Dup	990	----	----
CPT-86-9S	378	<.05	1.45
CPT-86-12M	988	<.05	2.85
CPT-86-12S	465	<.05	<.5
CPT-86-12S Dup	----	<.05	----
CPT-86-16DD	28,600	<.05	278
CPT-86-18DD	26,200	<.05	245
CPT-86-18S	633	<.05	43.3
Blank	----	<.05	<.5
AQC	----	5.96	54.2
AQC T.V.	----	6.00	52.0
Spike Rec.	----	97%	105%



Ref: 96/JAD20

May 13, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift ✓

Dear Don:

As requested in Service Request # SF-2-186, headspace GC/MS analysis of 13 Patrick AFB water samples for Chlorinated volatile organics, MTBE and 1,2-Dibromoethane was completed. The samples were received on February 5, 1996 and analyzed on March 19, 1996. RSKSOP-148 (Determination of Volatile Organic Compounds in Water by Automated Headspace Gas Chromatography/Mass Spectrometry (Saturn II Ion Trap Detector) was used for this analysis.

An internal standard calibration method was established for the 12 compounds. The standard curves were prepared from 1.0 to 200 ppb. The lower calibration limits were 1.0 ppb.

The method detection limit (MDL) for 1,2-Dibromoethane for these analyses was determined, according to RSKSOP-148, to be 0.09 ppb.

A dilution corrected quantitation report for the samples, lab duplicates, field duplicates, QC standards and lab blanks is presented in table 1-2.

If you should have any questions, please feel free to contact me.

Sincerely,

John Allen Daniel

xc: R.L. Cosby
G.B. Smith
D.D. Fine
J.L. Seeley
J.T. Wilson

ManTech Environmental Research Services Corporation

CHLORINATED
VOAS, MTBE
& BrCH₂-CH₂Br

Table 1. Quantitation Report for S.R.# SF-2-186 from Patrick AFB.

Concentration = ppb

Compound	CPT-2S	CPT-2S 1/4 Dil Field Dup	CPT-3S	CPT-3S 1/40 Dil Field Dup	CPT-3I	CPT-3D	CPT-86 4S	CPT-86 4D	CPT-86 9S	CPT-86 9MD
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYL-Tert-BUTYL ETHER	*****	514	101	128	7.6	15.9	1.4	53.3	ND	*****
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	-ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VINYL CHLORIDE	CPT-86 9MD 1/4 Dil Field Dup	CPT-86 12S	CPT-86 12S Lab Dup	CPT-86 12MD	CPT-86 12MD 1/2 Dil Field Dup	CPT-86 16DD	CPT-86 18S	CPT-86 18DD	QC0319D 50 ppb	QC0319E 20 ppb
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	**	21.7
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	**	22.8
METHYL-Tert-BUTYL ETHER	ND	ND	ND	ND	ND	ND	ND	ND	**	20.4
1,1-DICHLOROETHANE	353	ND	ND	*****	348	ND	ND	ND	47.1	**
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	**	22.4
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	**	21.2
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	**	20.8
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	**	20.3
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	**	21.6
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	45.7	23.3
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND	ND	ND	**	15.4
									45.8	**

ND = None Detected Dil = Dilution Dup = Duplicate ***** = Above Calibration Limit(200 ppb) ** = Not in QC QC = Quality Control Std.

Table 2. Quantitation Report for S.R. # SF-2-186 from Patrick AFB.

Concentration = ppb

Compound	QC0319F 200 ppb	QC0319G 100 ppb	QC0319H 50 ppb	QC0319I 20 ppb	QC0319J 200 ppb	QC0319K 100 ppb	BL0319A	BL0319B
VINYL CHLORIDE	**	96.7	**	23.5	**	102	ND	ND
1,1-DICHLOROETHENE	**	98.9	**	23.7	**	93.4	ND	ND
1,2-DICHLOROETHENE	**	89.6	**	21.0	**	92.7	ND	ND
METHYL-tert-BUTYL-ETHE	182	**	52.2	**	175	**	ND	ND
1,1-DICHLOROETHANE	**	96.2	**	23.1	**	108	ND	ND
1,2-DICHLOROETHANE	**	90.7	**	21.3	**	106	ND	ND
1,1,1-TRICHLOROETHANE	**	98.7	**	22.6	**	96.5	ND	ND
CARBON TETRACHLORIDE	**	94.7	**	22.1	**	91.3	ND	ND
1,2-DICHLOROETHANE	**	91.1	**	22.2	**	120	ND	ND
TRICHLOROETHENE	213	110	50.9	25.1	177	100	ND	ND
TETRACHLOROETHENE	**	76.4	**	16.9	**	77.4	ND	ND
1,2-DIBROMOETHANE	214	**	59.6	**	203	**	ND	ND

ND = None Detected ** = Not in QC QC = Quality Control Std BL = Blank

MANAGEMENT TECHNOLOGY

Ref: 96-SH10/vg

February 13, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift ^{SV}

Dear Don:

Attached are TOC results for 14 liquids submitted February 9, 1996 under Service Request #SF-2-186. Sample analysis was begun and completed February 12, 1996 using RSKSOP-102.

Blanks, duplicates and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower
Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley *JS*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

KAMPBELL--PATRICK--SF-2-186

SAMPLE	MG/L TOC
CPT-2S	14.9
CPT-3D REP 2	9.1
CPT-3I	10.4
CPT-3S REP 1	119
CPT-3S REP 1 DUP	119
CPT-3S REP 2	141
CPT-86-4D	4.9
CPT-86-4S	4.2
CPT-86-9M	26.7
CPT-86-9S	1.5
CPT-86-12M	14.8
CPT-86-12S	1.7
CPT-86-16D	4.2
CPT-86-18DD	5.3
CPT-86-18S	3.3
WFO34-II	6.1

WFO34-II t.v.=6.30

Ref: 96-DF10

Feb. 26, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

As requested in Service Request SF-2-186, GC/MS analysis for phenols and aliphatic/aromatic acids was done on water samples from well sites, CPT-86-3S and -3D, at Patrick AFB. Derivatization of the sample was done by Amy Zhao on Feb. 8, 1995. The extract was analyzed by GC/MS on Feb. 23, 1996. RSKERL SOP 177 was used for the extraction, derivatization and GC/MS analysis of the samples.

Table I provides the concentrations of the phenols and aliphatic/aromatic acids found in the Patrick AFB samples. A derivative and extraction blank and a 50 ppb spiked extraction blank are also included. 3,4- and 3,5-dimethyl benzoic acid were found at the highest concentration at 670 and 262 ppb, respectively. Methybenzoic acids, dimethylphenols and cresols were found in the sample and are quantified in Table I. Please note that 2-ethylhexanoic acid was present in one of the extraction blanks at levels higher than found in the samples.

Enclosed please find chromatograms of the PFB derivative of compounds found in water sample CPT-86-3S. Each of the peaks listed in Table I are labelled in the chromatogram. Other chromatograms show ions characteristic of C₇, C₈, C₉, and C₁₀ aliphatic acids.

If you should have any questions, please feel free to contact me.

Sincerely,

Dennis D. Fine

Dennis D. Fine

cc: J. Seeley
G. Smith
R. Cosby
D. Fine

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Table L. Quantitative Report and QC Data for Phenols and Aliphatic and Aromatic Acids
for Samples from Patrick AFB (Service Request SF-2-180).

Concentration ppb

	CPT-86-3S	CPT-86-30	Extraction Blank	Extraction Blank	Standard Blank	Standard Blank	Standard Blank
1 PROPANOIC ACID - PFB	18	...	8	81	8	46	8
2 2-METHYLPROPANOIC ACID - PFB	14	...	...	...	...	20	...
3 TRIMETHYL ACETIC ACID - PFB	6	...	...	...	...	12	...
4 BUTYRIC ACID - PFB	15	6	18	...	14	40	20
5 2-METHYLBUTYRIC ACID - PFB	10	...	...	...	...	...	...
6 3-METHYLBUTYRIC ACID - PFB	9	...	...	...	...	...	...
7 3,3-DIMETHYLBUTYRIC ACID - PFB	19	...	...	NF.	NF.	...	...
8 PENTANOIC ACID - PFB	20	12	64	9	47	15	70
9 2,3-DIMETHYLBUTYRIC ACID - PFB	...	...	...	NF.	NF.	...	...
10 2-ETHYLBUTYRIC ACID - PFB	...	NF.	...	NF.	NF.	...	...
11 2-METHYLPENTANOIC ACID - PFB	...	NF.	...	...	NF.	NF.	...
12 3-METHYLPENTANOIC ACID - PFB	5	...	...	NF.	NF.	...	...
13 4-METHYLPENTANOIC ACID - PFB	...	NF.	...	NF.	NF.	...	...
14 HEXANOIC ACID - PFB	31	18	75	25	20	18	73
15 2-METHYLHEXANOIC ACID - PFB	...	NF.	...	NF.	NF.	...	...
16 PHENOL - PFB	31	7	...	...	...	NF.	NF.
17 CYCLOPENTANECARBOXYLIC ACID - PFB	10	NF.	NF.	NF.	NF.	NF.	...
18 5-METHYLHEXANOIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	...
19 o-CRESOL - PFB	9	NF.	NF.	NF.	NF.	NF.	NF.
20 2-ETHYLHEXANOIC ACID - PFB	387	281	47	5	24	70	54
21 HEPTANOIC ACID - PFB	8	...	19	9	5	12	15
22 m-CRESOL - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
23 p-CRESOL - PFB	43	NF.	NF.	NF.	NF.	NF.	NF.
24 1-CYCLOPENTENE-1-CARBOXYLIC ACID - PFB	...	NF.	...	NF.	NF.	NF.	NF.
25 o-ETHYLPHENOL - PFB	7	NF.	NF.	NF.	NF.	NF.	...
26 CYCLOPENTANEACETIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
27 2,6-DIMETHYLPHENOL - PFB	21	NF.	NF.	NF.	NF.	NF.	NF.
28 2,5-DIMETHYLPHENOL - PFB	45	NF.	NF.	NF.	NF.	NF.	NF.
29 CYCLOHEXANECARBOXYLIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
30 3-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	...
31 2,4-DIMETHYLPHENOL - PFB	37	NF.	NF.	NF.	NF.	NF.	NF.
32 3,5-DIMETHYLPHENOL & m-ETHYLPHENOL - PFB	25	NF.	NF.	NF.	NF.	NF.	NF.
33 OCTANOIC ACID - PFB	...	...	10	5	...	7	8
34 2,3-DIMETHYLPHENOL - PFB	154	...	NF.	NF.	NF.	NF.	NF.
35 p-ETHYLPHENOL - PFB	7	...	NF.	NF.	NF.	NF.	NF.
36 BENZOIC ACID - PFB	19	71	7	8	5	5	6
37 3,4-DIMETHYLPHENOL - PFB	18	NF.	NF.	NF.	NF.	NF.	NF.
38 m-METHYLBENZOIC ACID - PFB	45	NF.	...	NF.	NF.	NF.	NF.
39 1-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB	NF.	NF.	NF.	NF.	NF.	NF.	NF.
40 CYCLOHEXANEACETIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
41 2-PHENYLPROPANOIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
42 o-METHYLBENZOIC ACID - PFB	...	NF.	NF.	NF.	NF.	NF.	NF.
43 PHENYLACETIC ACID - PFB	8	NF.	NF.	...	NF.	NF.	NF.
44 m-TOLYLACETIC ACID - PFB	49	...	...	...	...	...	...
45 o-TOLYLACETIC ACID - PFB	27	NF.	NF.	NF.	NF.	NF.	NF.
46 2,6-DIMETHYLBENZOIC ACID - PFB	5	NF.	NF.	NF.	NF.	NF.	NF.
47 p-TOLYLACETIC ACID - PFB	14	NF.	NF.	NF.	NF.	NF.	NF.
48 p-METHYLBENZOIC ACID - PFB	28	...	NF.	NF.	NF.	NF.	NF.
49 3-PHENYLPROPANOIC ACID - PFB	135	...	NF.	NF.	NF.	NF.	NF.
50 2,5-DIMETHYLBENZOIC ACID - PFB	5	NF.	NF.	NF.	NF.	NF.	...
51 DECANOIC ACID - PFB	21	NF.	...	NF.	NF.	NF.	NF.
52 2,4-DIMETHYLBENZOIC ACID - PFB	...	...	5	...	...	10	...
53 3,5-DIMETHYLBENZOIC ACID - PFB	NF.	...	NF.	NF.	NF.	NF.	...
54 2,3-DIMETHYLBENZOIC ACID - PFB	262	...	NF.	NF.	NF.	NF.	NF.
55 4-ETHYLBENZOIC ACID - PFB	79	NF.	NF.	NF.	NF.	NF.	NF.
56 2,4,6-TRIMETHYLBENZOIC ACID - PFB	40	NF.	NF.	NF.	NF.	NF.	NF.
57 3,4-DIMETHYLBENZOIC ACID - PFB	92	9	NF.	NF.	NF.	NF.	NF.
58 2,4,5-TRIMETHYLBENZOIC ACID - PFB	670	...	NF.	NF.	NF.	NF.	NF.
59	87	NF.	NF.	NF.	NF.	NF.	NF.

... Indicates concentration of extract was below lowest calibration standard (5 ppb).
NF. Indicates not found.

Patrick AFB SF-2-186 Water Samples 1/30/96

Sample	Depth feet	TOC mg/L	D.O. mg/L	Temp. °C	pH	ORP mV	Fe++ mg/L	H ₂ S mg/L	Alk. mg/L CO ₂	Cond. µS
CPT-86-16DD	3.86	0.2	26.9	7.2	-45	<.1	0.3	380	8700	
-2S	4.48	0.2	24.7	7.5	-60	1.2	0.5	490	870	
-3S	4.11	0.0	23.6	6.9	-152	0.6	30.	500	1270	
-3D	4.16	0.1	26.4	7.2	-154	<.1	6.0	280	599	
-3M	N.M.	0.1	25.1	6.9	-145	<.1	6.0	290	662	
-18S	4.38	0.3	24.7	6.9	-85	0.3	0.6	220	551	
-18DD	4.55	0.3	26.7	7.5	-55	0.1	0.1	270	11000	
~~-4S~~	4.06	0.3	24.8	7.1	-124	<.1	2.0	170	522	
-4D	4.11	0.1	25.2	6.9	-114	0.2	12.	260	657	
-12S	4.06	0.1	24.4	7.0	-120	0.2	0.2	180	474	
-12M	N.M.	0.1	26.0	7.1	-136	0.1	14.	320	940	
-9S	4.00	0.2	24.0	6.9	-130	0.1	16.	170	386	
-9M	N.M.	0.2	25.3	7.2	-142	0.1	18.	350	706	

Monitoring wells									
well	include TOC	mg/L D.O.	°C Temp	pH	ORP	Fe ^{II}	H ₂ S	ALK	ms Cond.
86-16DD	3.96'	0.2	26.9	7.2	-45	<.1	0.3	380	8.7ms
86-25	4.48	0.2	24.7	7.5	-60	1.2	0.5	480	870ms
86-35	4.11	2.0	23.6	6.9	-152	0.6	30	500	1272ms
86-3D	4.16	0.1	26.4	7.2	-154	<.1	6.0	280	599ms
86-3M screen pt Tubing		0.1	25.1	6.9	-45	<.1	6.0	290	662ms
86-185	4.38'	0.3	24.7	6.9	-85	0.3	0.6	220	551ms
86-18DD	4.55'	0.3	26.7	7.5	-55	0.1	0.1	270	11.0ms
86-45	4.06	0.3	24.8	7.1	-124	<.1	2.0	170	522ms
86-4D	4.11'	0.1	25.2	6.9	-114	0.2	12.	260	654ms
86-125	4.06	0.1	24.4	7.0	-120	0.2	0.2	180	474ms
86-12M small Tubing		0.1	26.0	7.1	-136	0.1	14.	320	940ms
86-95	4.00	0.2	24.0	6.9	-130	0.1	16.	170	386ms
86-9M small Tubing		0.2	25.3	7.2	-142	0.1	18	350	706ms

FR

Continued on Page _____

Read and Understood By _____

Signed _____

Date _____

Signed _____

Date _____

MANTECH

Ref: 98-MB20
March 20, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: Steve Vandegrift *SV*

Dear Don:

Please find attached the analytical results for Service Request SF-4-312 requesting the analysis of aqueous samples from Patrick AFB, FL to be analyzed for MTBE, BTEXXX and TMBs. The 14 samples were received in capped, 40 mL VOA vials on March 17, 1998. The samples were analyzed on March 18 and 19, 1998. All samples were acquired using the Millennium data system. A 6 point (1-1200 ppb) external calibration curve was used to determine the concentration for all compounds.

RSKSOP-122 "Analysis of Volatile Aromatic Hydrocarbons" with Separation of Xylene Isomers by Purge & Trap Gas Chromatography" was used for these analyses. Auto-sampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Mark Blankenship

Mark Blankenship

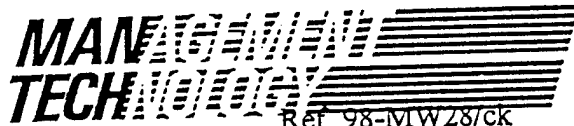
xc: R.L. Cosby
J.L. Seeley *JS*
G.B. Smith

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

AMPLE NAME	MTBE	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB
IC, OBSERVED, 20 PPB	21.3	22.0	21.9	21.8	21.7	21.4	22.6	23.0	22.4	19.5
IC, TRUE VALUE, 20 PPB	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
00 PPB STD	100.8	107.1	112.6	113.3	112.5	102.7	114.0	103.5	106.3	113.5
IC LAB BLANK	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PT-86-3D	BLQ	1.5	BLQ	BLQ	BLQ	BLQ	ND	BLQ	BLQ	BLQ
PT-4D	2.5	1.3	2.3	ND	1170.4	ND	4.8	2.0	10.2	1.8
PT-4S	1.2	BLQ	BLQ	3.7	3.2	2.2	BLQ	BLQ	1.8	BLQ
PT-18D	ND	BLQ	BLQ	1.2	1.3	1.1	BLQ	ND	BLQ	ND
PT-18M	1.5	ND	ND	BLQ	BLQ	BLQ	BLQ	ND	BLQ	ND
PT-18S	ND	ND	ND	BLQ	BLQ	BLQ	ND	ND	BLQ	ND
PT-18DD	ND	ND	ND	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
AW-9	ND	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
AW-9 DUPLICATE	ND	BLQ	ND	BLQ	BLQ	BLQ	BLQ	BLQ	1.2	5.8
AW-9D	31.3	14.1	6.9	BLQ	4.4	7.5	6.0	BLQ	1.2	1100.0
000 PPB STD	1043.0	1099.0	1104.0	1124.0	1115.0	1102.0	1093.0	1098.0	1106.0	ND
3C LAB BLANK	ND	ND	ND	ND	ND	ND	ND	ND	ND	BLQ
AW-9S	2.8	BLQ	ND	BLQ	BLQ	BLQ	BLQ	ND	ND	4.1
2PT-12D	68.4	5.0	6.8	BLQ	14.9	6.7	4.9	BLQ	BLQ	ND
2PT-12S	ND	ND	ND	ND	BLQ	ND	ND	ND	ND	275.9
2PT-86-3M	3.5	214.7	240.0	1045.1	1509.4	1055.1	1042.4	373.9	1586.7	942.0
2PT-86-3S	BLQ	691.8	1864.2	3957.1	5153.2	6466.4	4316.7	1249.5	4861.6	

ND = None Detected; BLQ = Below Limit of Quantitation, 1ppb



Ref. 98-MW28/ck
98-BS26/ck

March 31, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74821-1198

THRU: S.A. Vandegrift *SV*

Dear Don:

Attached are the results of 14 field samples from Patrick AFB submitted to MERSC as part of S.R. #SF-4-312. The samples were received 3/18/98 and analyzed 3/19/98. The methods used for analysis were Lachat FIA methods 10-107-06-1-A for NH_3 , 10-107-04-2-A for $\text{NO}_2 + \text{NO}_3$, and Waters capillary electrophoresis method N-601 for Cl and SO_4 .

Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples, and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Mark White

Brad Scroggins

xc: R.L. Cosby
J.L. Seeley *JS*
G.B. Smith *GS*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

PATRICK AFB

<u>Sample</u>	<u>mg/L</u> <u>Cl⁻</u>	<u>mg/L</u> <u>SO₄⁻²</u>	<u>mg/L</u> <u>NO₂⁻+NO₃⁻(N)</u>	<u>mg/L</u> <u>NH₃(N)</u>
CPT-4D	17.0	12.7	<.1	2.11
CPT-45	15.4	6.21	<.1	2.00
CPT-86-3S	64.5	12.6	.25	1.29
CPT-86-3M	40.9	46.4	<.1	3.91
CPT-86-3D	33.9	5.53	<.1	1.36
CPT-18S	10.3	10.8	<.1	.47
CPT-18M	20.4	2.05	(<.1)(<.1)	(1.38)(1.42)
CPT-18D	8900	1040	<.1	16.8
CPT-86-16DD	10,000	1020	<.1	17.0
MW-9	2.68	4.00	<.1	<.1
CPT-9S	7.64	7.88	<.1	1.09
CPT-9D	38.7	3.69	<.1	2.32
CPT-12S	NS	NS	NS	NS
CPT-12D	47.2	7.70	<.1	2.13
BLANK	<.05	<.05	<.1	<.1
AQC	34.7	45.0	.60	.26
TRUE VALUE	34.8	44.0	.62	.26
-SPIKE REC.	103%	104%	104%	101%

NS= NO SAMPLE



Ref: 98-LH25

March 27, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift *SV*

Dear Don:

As requested in Service Request #SF-4-312, gas analysis was performed for methane, ethylene, and ethane on samples from Patrick AFB. The samples were received on March 17, 1998. The analyses were performed on March 17 and 18, 1998. These analyses were performed as per RSKSOP-194, and the calculations were done as per RSKSOP-175.

If you should have any questions, please feel free to contact me.

Sincerely,

Lisa Hopkins

xc: R.L. Cosby
J.T. Wilson
K. Hurt
G.B. Smith
J.L. Seeley *JS*

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	Methane	Ethylene	Ethane
100ppm CH4	92.2	**	**
100ppm C2H4	**	105.1	**
100ppm C2H6	**	**	110.9
HPHe	**	**	**
Lab Blank	**	**	**
CPT-4S	11.1	**	**
CPT-4D	8.50	**	**
CPT-86-3S	22.1	**	0.019
CPT-86-3M	16.8	**	0.010
CPT-86-3D	3.42	**	*
CPT-86-3D	3.40	**	**
Lab Dup			
MW-9	0.048	**	**
CPT-9S	4.50	**	**
CPT-9D	10.1	**	0.008
CPT-9D	10.4	**	0.008
Field Dup			
10ppm C2H6	**	**	10.4
100ppm CH4	92.3	**	**
100ppm C2H4	**	90.2	**
100ppm C2H6	**	**	101.9

Lower Limit of Quantitation

0.001 0.003 0.002

Units for the samples are mg/L dissolved in water.
Units for the standards are parts per million.

** denotes None Detected.

* denotes Below Limit of Quantitation.

SF-4-312 03/18/98
Patrick AFB

Sample	Methane	Ethylene	Ethane
100ppm CH4	96.5	**	**
100ppm C2H4	**	106.7	**
100ppm C2H6	**	**	109.7
HPHe	**	**	**
Lab Blank	**	**	**
CPT-12D	7.64	**	0.006
CPT-86-16DD	0.023	**	**
CPT-18S	4.09	**	**
CPT-18MD	7.56	**	**
CPT-18DD	0.030	**	**
CPT-18DD	0.029	**	**
Field Dup			
10ppm CH4	10.4	**	**
100ppm CH4	93.3	**	**
100ppm C2H4	**	99.0	**
100ppm C2H6	**	**	105.3

Lower Limit of Quantitation

0.001 0.003 0.002

Units for the samples are mg/L dissolved in water.
Units for the standards are parts per million.

** denotes None Detected.

* denotes Below Limit of Quantitation.



Ref: 98-SH23

March 23, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

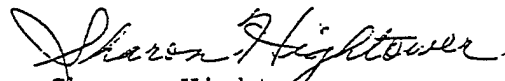
THRU: S.A. Vandegrift SV

Dear Don:

Attached are TOC results for 13 Patrick liquids submitted March 19, 1998 under Service Request #SF-4-312. Sample analysis was begun March 19, 1998 and completed March 19, 1998 using RSKSOP-102.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,


Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley 13

KAMPBELL PATRICK SF-4-312

SAMPLE	MG/L TOC
CPT-4D	6.21
CPT-4S	5.23
CPT86-3S	30.7
CPT86-3M	24.2
CPT86-3D	11.9
CPT18S	6.82
CPT18M	6.47
CPT18D	6.74
CPT-86-16DD	6.99
MW-9	2.90
CPT-9S	3.12
CPT-9D	16.9
CPT-12D	12.4
WS38	5.07

WS38 std t.v.=4.92

PATRICK AIR FORCE BASE

[illegible]