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TECHNICAL MEMORANDUM OPTIMIZATION REPORT FOR AIR SPARGING/BIOSPARGING TREATMENT SYSTEM AT NORTH FUEL FARM SITE NAS CECIL FIELD FL

6/26/2008

CH2MHILL CONSTRUCTORS INC

Optimization Report for Air Sparging/Biosparging Treatment System, North Fuel Farm Site,
Former Naval Air Station Cecil Field, Jacksonville, Florida

PREPARED FOR: NAS Cecil Field Base Cleanup Team

PREPARED BY: Julee Schoenfeld/CH2M HILL
James Edens/CH2M HILL

COPIES: Paul Favara/CH2M HILL
Sam Naik/CH2M HILL

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Introduction

CH2M HILL, Constructors, Inc. (CH2M HILL) was contracted by Naval Facilities Engineering Command Southeast (NAVFAC SE) to conduct remedial activities at the North Fuel Farm (NFF) at the former Naval Air Station (NAS) Cecil Field, Jacksonville, Florida under Response Action Contract No. N62467-01-D-0331, Contract Task Order 0060. Ongoing remedial activities include air sparge/biosparge (AS/BS) and long-term monitoring (LTM) of the petroleum contaminant plume present in groundwater at the site.

Benzene, toluene, ethylbenzene, and xylenes (BTEX), were detected in groundwater at levels exceeding the Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs) at the NFF. Of the BTEX compounds, benzene has the lowest regulatory criterion (GCTL, 1 micrograms per liter [µg/L]) and the highest solubility (1,800 milligrams per liter [mg/L]). As a result, the areal extent of benzene contamination in groundwater is often greater than that of toluene, ethylbenzene, and xylenes. Because the benzene groundwater plume at the NFF encompasses the toluene, ethylbenzene, and xylene plumes, benzene concentrations were used to identify three target treatment areas (TTAs) for petroleum contamination in groundwater.

The TTAs at the site include areas of high benzene concentration (>1,000 µg/L), areas of lesser benzene contamination (100 to 1,000 µg/L), and areas where benzene is less than the Natural Attenuation Default Concentration (NADC) of 100 µg/L, but greater than the GCTL of 1 µg/L. For the purposes of evaluation of the site contamination, the shallow zone aquifer was studied in four zones identified as 1) the water table zone (depth of 5 to 20 feet below land surface [bls]), 2) the upper intermediate zone (20 to 50 feet bls), 3) the lower intermediate zone (50 to 80 feet bls) and, 4) the deep intermediate zone (80 to 110 feet bls). The air sparging and biosparging wells were broadly divided into a shallow zone (screened at an average depth of 50 feet bls) and deep zone (screened at average depths of 80 to 110 feet bls).

At the NFF site, air sparging is being used to reduce the highest concentrations of petroleum contaminants (benzene >1000 µg/L) to levels that can be remediated using enhanced natural biological processes. Biosparging is used to reduce contaminant levels in less contaminated zones (benzene concentrations between 100 and 1,000 µg/L) by enhancing aerobic biological populations capable of degrading petroleum contaminants in site groundwater. Naturally occurring biological processes, rather than active remediation efforts, are utilized in areas with benzene concentrations below the NADC but greater than the GCTL. Contaminant concentrations in these areas are anticipated to attenuate naturally. The GCTLs are specified in Table I of Chapter 62-777, Florida Administrative Code (FAC) and the NADCs are provided in Table V of Chapter 62-777 FAC.

Contaminant concentrations in wells within the influence of the AS/BS remediation system have generally shown decreasing trends following remediation system startup in August 2005. Additionally, recent sampling events have indicated that contaminant concentrations are below the NADC in many areas of the site. A goal of the current remedial optimization effort for the site is to focus active treatment on only those areas where contaminant concentrations have not yet attained NADC levels. CH2M HILL recommends modification of the AS/BS system by optimizing the original design for the site to continue air sparging only in hot spot areas (with benzene concentrations exceeding 1,000 µg/L) and biosparging only in areas with benzene concentrations between 100 and 1,000 µg/L. Treatment will be discontinued in areas where benzene levels are now below the NADC. Groundwater monitoring will continue to be implemented using the existing monitoring well network, and possibly including additional wells. Contaminant concentrations in these areas will be observed during this period and an evaluation will be made regarding restarting the treatment system if need be, to meet the remedial objectives for the site.

Summary of Site Contaminant Conditions

The AS/BS system began operation in August 2005. Baseline sampling was performed in January 2005 and groundwater sampling to evaluate the effectiveness of the treatment system was initiated in November 2005. The monitoring program was developed to document contamination level trends, as well as to monitor for contaminant migration. Analytical results presented in the Annual O&M Status Report for the period October 2006 to May 2007 (CH2M HILL, 2007) indicate that the AS/BS system has been successful in reducing contaminant concentrations in groundwater in several portions of the treatment area.

To further evaluate the current configuration of the groundwater contaminant plume at the NFF site, the number of monitoring wells sampled during the May 2007 sampling event was expanded from 16 to 35. This sampling was conducted in accordance with the *Sampling and Analysis Plan Addendum*, *North Fuel Farm Area Groundwater Remediation Project, Former Naval Air Station Cecil Field, Jacksonville, Florida* (CH2M HILL, 2007). The analytical results from the expanded sampling event confirmed that the contaminant plume had decreased significantly in areal extent (AGVIQ-CH2M HILL JVII, 2007).

Figure 1 presents the areal extent of the plume prior to AS/BS startup in August 2005 and following October 2007 sampling. Figure 2 presents the locations of select monitoring wells that showed significant benzene concentrations prior to the commencement of treatment,

and Figures 3, 4, and 5 graphically depict benzene concentrations in groundwater sampled from these wells over time. Analytical data from the May 2007 sitewide groundwater sampling event and the October 2007 sampling event (when the 16 wells included in the routine monitoring program were sampled) confirm a significant reduction in contaminant concentrations in groundwater in several portions of the treatment area since the AS/BS treatment system began operation in July 2005. Two small areas, one surrounding monitoring well CEF-76-113S in the shallow zone and the other surrounding monitoring well CEF-76-70I in the lower intermediate zone, have shown persistent elevated benzene concentrations over the past 2 years. Monitoring wells CEF-76-98D and CEF-76-110D in the deep zone also continue to exhibit contaminant concentrations above the NADC.

Based on the revised plume configuration and the relatively few remaining exceedances of the NADCs for the contaminants of concern (COCs) at this site, CH2M HILL recommends that air sparging and biosparging be discontinued in areas where benzene concentrations have dropped below the NADC, and that air flow be focused on those areas that continue to show persistent contamination (i.e., hotspots). Consistent with treatment system design, biosparging is recommended in areas where benzene concentrations are between 100 ug/L and 1,000 ug/L and air sparging is recommended for hot spot areas with benzene concentrations exceeding 1,000 ug/L. Focus on treatment of these areas, which have shown reduced contaminant concentrations over time, will allow continued effective treatment where needed, while minimizing the associated remedial costs. Monitoring of the groundwater in the area outside the newly defined treatment areas should be conducted for 6 months to evaluate for rebound, and quarterly monitoring of the 16-well network should continue for 1 year to evaluate system effectiveness. Figure 6 shows an overlay of all the air sparging and biosparging wells in the shallow and deep zones to indicate the approximate area of influence of the sparge wells relative to the presence of the contaminant hotspots.

Dissolved Oxygen Study

A dissolved oxygen study was performed within the treatment area at the site to evaluate the oxygen transfer rate and to aid in determination of the optimal oxygen delivery rate of the AS/BS treatment system. During earlier sampling events, dissolved oxygen could not be measured immediately following system shutdown due to the presence of residual air pressure in the aquifer which would discharge contaminated water through the monitoring wellhead if the well caps were opened for sample collection. Dissolved oxygen measurements could not be collected until several days after the sparge system was shut off, resulting in low readings that did not reflect conditions during system operation. The goal of the dissolved oxygen study conducted during 2007 was to evaluate the dissolved oxygen concentrations during startup, operation, and shutdown of the AS/BS system.

Monitoring well caps were fitted with sampling ports that allowed continuous (hourly) measurements during startup, operation, and shutdown of the AS/BS system. Groundwater was extracted through the sample ports using an aboveground peristaltic pump and a flow-through cell to ensure that the extracted groundwater was representative of ambient conditions. This methodology also resulted in measuring dissolved oxygen at atmospheric pressure which could, as discussed below, impact the dissolved oxygen saturation level.

Dissolved oxygen was continuously (hourly) measured in three wells, CEF-76-113S, CEF-76-70I, and CEF-76-110D, which represent the shallow, intermediate, and deep zones, respectively, using a YSI meter. An optical dissolved oxygen meter was used to corroborate the YSI results, but it was determined to be less reliable than the YSI meter due to relatively consistent negative dissolved oxygen measurements. The YSI readings fluctuated considerably and approached or exceeded the saturation limit in all three monitoring wells, but were generally positive and were considered more consistent with the likely conditions anticipated in an aquifer that was receiving oxygen. Therefore, the YSI readings were considered to be more representative of the actual dissolved oxygen concentrations in the aquifer during the study and were used in the evaluation.

Figure 7 presents the results of the dissolved oxygen study. Along the bottom of the graph is an illustration of the AS/BS cycle. While not shown explicitly, segment BS-4 of the biosparge pulsing cycle was turned on first during the study, followed by pulse cycles BS-1, BS-2, and BS-3. Figure 8 shows the spatial relationship between the sparge points and the locations of the monitor wells used in the study.

Dissolved oxygen measurements were recorded with the AS/BS treatment system startup at 3:00 p.m. on November 19, 2007 (except for measurements at well CEF-76-110D, which were not recorded until 4:00 p.m. on November 21, 2007 due to equipment difficulties). Hourly measurements were then taken for a week during the AS/BS system operation until November 26, 2007 at 4:00 p.m. The treatment system continued operation without measurements for another week, and hourly dissolved oxygen measurements resumed on December 3, 2007 at 11:00 a.m. The treatment system was shutdown on December 3, 2007 at 3:00 p.m. and hourly measurements of dissolved oxygen continued for a week until about 3:00 p.m. on December 10, 2007 to represent the decrease in oxygen supply and the restoration of background dissolved oxygen conditions at the site.

As can be seen on Figure 7, dissolved oxygen readings fluctuated considerably, but generally dissolved oxygen appears to have been present for the entire study, particularly in the shallow and intermediate zones. Because of the range of the dissolved oxygen readings and a relatively low level of confidence in the actual numerical readings, these results were generally viewed only as an indication of whether or not oxygen was present rather than actual dissolved oxygen concentrations. Concentration trends in a particular well were not considered representative of general subsurface dissolved oxygen levels because of the complex relationship between the sparge sequence, locations, monitoring well locations, and uncertainty regarding the temporal lag between oxygen application and a measurable response in the aquifer.

Additionally, groundwater concentrations of dissolved oxygen can be influenced by the depth of the extracted groundwater. Oxygen solubility is directly proportional to the partial pressure of the oxygen gas present. According to LeChatelier's Principle, a system in non-equilibrium will seek equilibrium. Therefore, in an air/water system in which the partial pressure of oxygen is increased, diffusion of oxygen across the air-water interface will increase until the dissolved oxygen concentration in the water is in equilibrium with the overlying air. Henry's Law states that the solubility of a gas is proportional to pressure. If pressure is increased, solubility will also be increased. In general, the partial pressure of dissolved oxygen increases with water pressure as depth increases. Therefore, oxygen solubility increases with depth.

To evaluate the dissolved oxygen saturation potential at the NFF the site, the following values were used:

- Temperature
  - Shallow and intermediate zones 22°C (295.15°K)
  - Deep zone 20°C (293.15°K)
- Ambient Pressure
  - All zones 1 atm (760 mm Hg or 101.325 KPa at sea level; NAS Cecil Field is near sea level)
- Well Depth
  - Shallow and intermediate zones 50 feet bls (approximately)
  - Deep zone 80 to 110 feet bls (average depth ~95 feet)
- Depth to Water. 5 feet bls corresponds to:
  - Shallow zone 45 feet (1.3 atm of pressure head)
  - Deep zone 90 feet (2.65 atm)of pressure head
- Oxygen Saturation
  - Shallow and intermediate zones 8.8 mg/L at 1 atm and 22°C
  - Deep zone 9.2 mg/L at 1 atm and 20°C

The following equation (Thomann, 1987) was used to determine the equilibrium oxygen concentration (saturation) at a non-standard pressure (Cp):

$$C_p = C^* \times P \left[\frac{(1-P_{wv}/P)(1-\theta P)}{(1-P_{wv})(1-\theta)} \right]$$

where:

Cp = equilibrium oxygen concentration at nonstandard pressure, mg/L

C* = equilibrium oxygen concentration at standard pressure of 1 atm, mg/L

P = nonstandard pressure, atm

Pwv = partial pressure of water vapor, atm, computed from:

$$\ln P_{wv} = 11.8571 - (3840.70/T) - (216{,}961/T^2)$$

where:

T = temperature, °K

$\theta = 0.000975 - (1.426 \times 10^{-5}\, t^2)$

t = temperature, °C

Substituting the known values and solving for the equilibrium dissolved oxygen (saturation) concentration yields a value (Cp) of 37.6 mg/L at a depth of 107.5 feet bls

(110D), 25.4 at a depth of 67.5 feet bls (70I), and 17.4 mg/L at a depth of 37.5 feet at the appropriate temperatures and pressures.

Adjusting the percent saturation by the above saturation levels results in five dissolved oxygen readings above the saturation limit in the shallow zone (versus 19 unadjusted). No readings in the intermediate or deep zones were observed to be above 100 percent saturation. Figure 9 presents the dissolved oxygen concentrations and percent saturation based on the saturation limit at the collected depth.

As discussed above, groundwater was extracted using an aboveground peristaltic pump (pressure <1 atm) and the dissolved oxygen measurements were made using a flow-through cell at atmospheric pressure (~1 atm). Therefore, the dissolved oxygen levels in the extracted groundwater during the study are likely not at equilibrium when the measurements were taken and may help explain a measure of the fluctuation in dissolved oxygen observed during the study.

Generally, the dissolved oxygen levels appear to be lower in the deep zone. Dissolved oxygen concentrations also appear to be adequate for aerobic degradation throughout the entire aquifer. These data indicate that oxygen is likely being adequately delivered to site groundwater. However, due to the uncertainty associated with the actual dissolved oxygen levels, determination of the optimal oxygen delivery rate could not be conclusively determined. Future optimization efforts could include evaluation of reduced oxygen delivery cycles with extended “off” periods, although changes to the pulse cycle durations can not be accurately determined based on the available data.

Microbial Analysis

As part of the optimization and exit strategy for the site, microbial analysis was performed in October 2007 to evaluate the active biological processes occurring in the subsurface environment. Groundwater samples were collected from monitoring wells CEF-76-95S, CEF-76-70I, and CEF-76-113S, and analyzed for phospholipid fatty acids (PLFA) by Microbial Insights, Inc. Well CEF-76-95S was intended to represent the native site conditions, but the data suggest that CEF-76-95S is influenced by the AS/BS system at the site. Wells CEF-76-70I and CEF-76-113S were selected to represent areas in the shallow and intermediate zones where elevated benzene contamination still persists. A summary of the microbial data are presented in Table 1. Historical groundwater analytical results for the period 2005 to 2007 and a copy of the microbial analysis results are included in Attachment A.

Pre-treatment microbial data are not available for comparison since no microbial analysis was conducted prior to system operation, but the total biomass results suggest the presence of a robust microbial population at the site. These data also suggest that the addition of air (oxygen) to the system has likely stimulated the microbial growth within the subsurface environment at the site.

The community structure data show that the microbial population is dominated (>90 percent cell mass) by proteobacteria, general bacteria, and eukaryote bacteria. The "general" classification indicates a variety of bacteria that does not fit other categories. These bacteria are non-specific and do not provide meaningful insight into the community

structure. The general bacteria are not expected to help or hinder contaminant removal. Proteobacteria are the class of bacteria most likely responsible for aerobic degradation of site contaminants. It appears that a significant portion of the microbial population (>36 percent cell mass) consists of proteobacteria, which suggests that microbial processes are likely at least partially responsible for the reduction in contaminant concentrations at the site.

Eukaryotes are aerobic bacteria that were identified in abundance (>27 percent cell mass) in the shallow wells. They were not identified in the intermediate well. Eukaryotes prey on proteobacteria and do not contribute significantly to biodegradation. Their presence reduces the biomass of proteobacteria.

The physiological status data provide a measure of proteobacteria growth. Smaller numbers for the "slowed growth" criterion indicate higher levels of proteobacteria growth. In general, proteobacteria growth rates appear to be high.

Microbial growth rates in the intermediate well appear to be lower, perhaps due to the deeper screened interval of the well. It is also possible that the intermediate well is naturally more anoxic than the shallow wells. When the treatment system is on, there is likely adequate oxygen in the intermediate zone to support microbial growth. When the system is off, there is less available oxygen and aerobic microbial growth is less robust. The intermittent application of oxygen likely slows microbial growth and may exclude the growth of microbe communities that are unable to tolerate the anoxic periods. Aerobic eukaryotes may be among those bacteria that are more sensitive to the periodic anoxic conditions than proteobacteria, which would explain their absence in the intermediate well.

In general, the microbial data support the presence of aerobic microbial populations that perform the biological degradation of petroleum contaminants at the NFF site. This in turn suggests that sufficient oxygen is present within the treatment area. However, the microbial data also suggest that oxygen levels may drop off sharply in some areas following system shutdown based on the growth rate data, which is consistent with earlier observations at the site. The dissolved oxygen study further supports the presence of dissolved oxygen in the subsurface environment. However, the dissolved oxygen study suggests that dissolved oxygen is present for a significant period of time following treatment system shutdown. The seeming conflict in these data together with the current success of the existing treatment system precludes a recommendation that the off-cycle periods of the AS/BS system be modified.

Conclusions and Recommendations

The contaminant concentrations in wells within the influence of the AS/BS treatment system at the NFF have generally shown a decreasing trend following system startup in August 2005. Recent sampling events have also indicated that the contamination has decreased to below the NADC in many of the well sampling locations.

A dissolved oxygen study was performed at the site to assess oxygen levels throughout the remedial system operations. During the study dissolved oxygen readings fluctuated considerably, but the study indicated that generally, adequate dissolved oxygen for aerobic degradation appears to be present throughout the entire aquifer as a result of operation of the AS/BS system. A microbial analysis performed in October 2007 also provided

supporting data for the presence of biological populations capable of degrading petroleum contaminants in groundwater at the site.

As part of the remedial optimization effort for this site, CH2MHILL recommends that the AS/BS system be modified to focus specifically on current TTAs to be re-evaluated on the same basis as the original design (i.e., benzene concentrations used to define the TTA). Based on recent sampling results, the footprint of the operation of the AS/BS remediation system will be significantly reduced. The newly defined TTA includes hot spots around wells CEF-76-113S, CEF-76-70I, CEF-76-98D and CEF-76-110D. Continued air sparging is recommended for those areas with benzene concentrations above 1,000 µg/L. Continued biosparging (with pulsing) is recommended for areas with benzene concentrations above the NADC (100 µg/L), but below 1,000 µg/L. The AS/BS system will be discontinued in areas with benzene concentrations below 100 µg/l. The proposed changes in the operational parameters of the AS/BS system are expected to focus active treatment on hot spot areas, while allowing natural biodegradation to reduce concentrations to below the GCTL.

The summary of recommendations is as follows:

- Redefine TTAs for air sparge and biosparging based on most recent groundwater sampling. Discontinue AS/BS treatment of areas where benzene levels are below 100 µg/L.
- Following reconfiguration of the treatment system, monitor groundwater outside the new treatment area for 6 months to evaluate contaminant concentrations and determine the path forward for the treatment system.
- Continue sampling the existing treatment monitoring well network of 16 monitoring wells (that have been sampled during the operation of the AS/BS treatment system) for COCs and select natural attenuation parameters on a quarterly basis for 1 year beginning May 2008, to monitor for rebound and system modification effectiveness.
- One year following system optimization, evaluate the former treatment area for permanent disconnection from the AS/BS system. Modifications to the monitoring network and sampling frequency should also be evaluated at this time.

References

AGVIQ-CH2M HILL JVII. 2007. *Annual Operations and Maintenance Report, Air Sparge, Biosparge, and SVE System, North Fuel Farm Area Groundwater Remediation Project, Former Naval Air Station Cecil Field, Jacksonville, Florida, July 2005-September 2007.* February.

CH2M HILL. 2007. *Sampling and Analysis Plan Addendum*, *North Fuel Farm Area Groundwater Remediation Project, Former Naval Air Station Cecil Field, Jacksonville, Florida.* April.

Thomann, Robert V. and John A. Mueller. 1987. *Principles of Surface Water Quality Monitoring and Control*. p. 277.

Tables

TABLE 1

Air/Bio Sparging System Measurements, June to November 2007

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

Date	Air Compressor Supply Pressure (psig)	Air Compressor Temperature (^{o}F)	Receiver Tank Supply Pressure (psig)
06/08/07	99	188	100
06/28/07	102	188	100
07/13/07	104	192	104
07/18/07	104	179	104
07/26/07	99	180	99
08/17/07	108	185	105
09/05/07	108	170	105
09/21/07	105	181	105
10/17/07	107	174	107
11/19/07	108	173	106

psig - pound per square inch gauge

^{o}F - degrees Fahrenheit

TABLE 2

Groundwater Level Measurements - October 22, 2007

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

Well Identification	Water Bearing Zone	Screening Interval (feet bls)	Top of Casing Elevation (feet)	Depth to Water (feet TOC)	Water Level Elevation (feet)
372-13R	WT	1.50 - 11.50'	81.25	6.28	74.97
76-49S	UI	45.00 - 50.00'	78.14	6.52	71.62
76-50I	LI	75.00 - 80.00'	78.17	6.38	71.79
76-57S	UI	30.00 - 35.00'	77.74	6.13	71.61
76-61I	LI	65.00 - 70.00'	81.12	9.72	71.40
76-70I	LI	65.00 - 70.00'	78.21	5.85	72.36
76-86S	UI	45.00 - 50.00'	78.35	6.38	71.97
76-88S	WT	5.00 - 15.00'	78.50	5.85	72.65
76-93S	UI	25.00 - 30.00'	81.59	7.55	74.04
76-94S	WT	5.00 - 15.00'	81.59	9.83	71.76
76-95S	WT- Bkg	5.00 - 15.00'	80.88	6.59	74.29
76-98D	D	105.00 - 110.00'	81.39	11.53	69.86
76-99D	D	95.00 - 100.00'	81.69	21.45	60.24
76-100D	D	110.00 - 115.00'	80.15	8.63	71.52
76-102D	D	115.00 - 120.00'	78.55	7.15	71.40
76-104D	D	110.00 - 115.00'	79.08	8.11	70.97
76-106S	UI	25.00 - 30.00'	81.85	9.26	72.59
76-110D	D	105.00 - 110.00'	82.51	11.90	70.61
76-111I	LI	65.00 - 70.00'	82.23	10.80	71.43
76-112I	LI	50.00 - 55.00'	81.56	9.49	72.07
76-113S	UI	35.00 - 40.00'	81.22	9.57	71.65
76-116D	D	110.00 - 115.00'	82.83	11.67	71.16
76-11 XB				10.87	

Elevation is referenced to National Geodetic Vertical Datum 1929 (NGVD 1929)

bgs - below ground surface

TOC - below top of casing

NM = not measured

TABLE 3

Groundwater Analytical Results - October 2007 Routine Monitoring Event

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

	Well ID		372-13R	76-49S	76-50I	76-57S	76-61I	76-70I	76-93S	76-94S	76-95S	76-98D	76-99D	76-100D	76-104D	76-110D	76-113S	76-116D
	Sample ID		60NFF13-RWQ407	60NFF49-SWQ407	60NFF50I-WQ407	60NFF57-SWQ407	60NFF61-IWQ407	60NFF70-IWQ407	60NFF93-SWQ407	60NFF94-SWQ407	60NFF95-SWQ407	60NFF98-DWQ407	60NFF99-DWQ407	60NFF100-DWQ407	60NFF104-DWQ407	60NFF110-DWQ407	60NFF113-SWQ407	60NFF11-XcWQ407
	Sample Date		10/23/2007	10/26/2007	10/26/2007	10/26/2007	10/26/2007	10/25/2007	10/24/2007	10/24/2007	10/25/2007	10/24/2007	10/24/2007	10/25/2007	10/25/2007	10/23/2007	10/25/2007	10/25/2007
	GCTL[1]	NADC																
Volatile Organic Compounds	Units in µg/L																	
Acetone	6300	63000	5.3 JB	18	15	4.4 J	67	77 J	7.2 JB	8.4 JB	5.6 J	7.1 JB	4.4 JB	4.2 J	4.2 J	16 JB	180 J	290 J
Benzene	1	10	ND	**1.5**	**67**	**2.9**	**8.8**	**1800**	ND	ND	ND	**120**	ND	0.31 J	**3.6**	**120**	**9000**	**57 J**
Carbon disulfide	700	7000	ND	ND	ND	ND	0.42 J	ND	ND	ND	ND	ND	ND	0.36 J	ND	ND	ND	180
Chlorobenzene	100	1000	ND	ND	ND	ND	ND	6.9 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	2.7	27	0.88 JB	1.6 J	ND	0.53 J	0.51 J	ND	0.5 JB	0.63 JB	0.47 JB	0.38 JB	0.46 JB	0.56 JB	0.66 JB	0.84 JB	ND	0.6 JB
Ethylbenzene	30	300	ND	ND	0.57 J	0.36 J	1.2	7.1 J	1.9	ND	ND	0.38 J	ND	ND	ND	0.55 J	**800**	ND
Isopropylbenzene (Cumene)	0.8	8	ND	ND	0.15 J	0.27 J	**2.2**	**41**	**0.93**	ND	ND	0.24 J	ND	ND	ND	0.35 J	**72**	0.3 J
Methyl ethyl ketone (2-butanone)	4200	42000	ND	ND	3.4 J	ND	19	ND	ND	ND	ND	ND	ND	ND	ND	3.5 J	ND	21
Methyl isobutyl ketone (4-methyl-2-pentanone)	560	5600	ND	ND	ND	ND	0.81 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	5	50	ND	ND	ND	ND	ND	**14 J**	ND	ND	ND	ND	ND	ND	ND	ND	**37 J**	ND
Toluene	40	400	ND	ND	0.16 J	ND	ND	ND	1.4 JB	ND	0.61 J	0.22 JB	ND	ND	ND	ND	ND	ND
Xylenes, total	20	200	ND	ND	6.6 J	2.2 J	4.8 J	**280 J**	9.8 J	ND	ND	8.8 J	ND	ND	ND	13 J	**1600 J**	2.8 J
Polyaromatic Hydrocarbons																		
1-methylnaphthalene	28	280	ND	0.03 J	ND	ND	1.8 J	0.2	0.17	ND	ND	ND	ND	ND	ND	ND	2.7	ND
2-Methylnaphthalene	28	280	ND	0.11 J	ND	ND	2.6 J	0.16	0.23	ND	ND	0.046 J	ND	ND	ND	ND	3.6	ND
Acenaphthene	20	200	ND	0.016 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.018 J	ND
Anthracene	2100	21000	ND	0.027 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.031 J	ND	ND
Benzo(a)anthracene	0.05	0.5	ND	ND	ND	ND	ND	ND	0.032 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	280	2800	ND	ND	ND	ND	ND	ND	0.039 J	ND	ND	ND	ND	ND	ND	ND	0.034 J	ND
Fluorene	280	2800	ND	0.03 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	14	140	ND	0.044 J	0.35 J	0.18 J	11 J	**28**	0.23	ND	ND	2.1	ND	ND	ND	1 JB	**47**	0.12 J
Phenanthrene	210	2100	ND	0.032 J	ND	ND	0.29 J	ND	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	210	2100	ND	ND	ND	ND	0.022 J	ND	0.04 J	ND	ND	ND	ND	ND	ND	ND	0.029 J	ND
FL PRO																		
Total Petroleum Hydrocarbons	5000	50000	ND	ND	ND	ND	760	1600	160 J	ND	180 J	160 J	ND	ND	ND	190 J	**5600**	ND
Geochemical Parameters																		
Carbon dioxide free	NE	NE	NA	ND	NA	ND	ND	NA	NA	NA	92600	NA	274000	191000	126000	NA	NA	ND
Sulfate (as SO4)	250000	2500000	NA	**2070000**	NA	**1430000**	**10500000**	NA	NA	NA	9800	NA	**1860000**	**1630000**	**519000**	NA	NA	**10600000**
Sulfide	NE	NE	NA	ND	NA	ND	ND	NA	NA	NA	ND	NA	ND	ND	ND	NA	NA	1100 J
Total organic carbon	NE	NE	NA	17800	NA	10500	77400	NA	NA	NA	11700	NA	8400	6000	2900	NA	NA	25100
Total Inorganic Carbon	NE	NE	NA	3200	NA	4000	3000	NA	NA	NA	6800	NA	14400	15700	10700	NA	NA	3200 J

Notes:

All concentrations reported in micrograms per liter (µg/L).

1 = Ch 62-777 FAC Groundwater Cleanup Target Levels (**GCTLs**) reported in µg/L

ND - Not detected NA - Not analyzed

J - Result is estimated NE - Not Established

JB- Estimate value. The analyte was detected in the associated method and/or calibration blank.

Values Bolded are concentrations that exceed the Groundwater Target Cleanup Level (**GCTL**)

Values Shaded are concentrations that exceed Natural Attenuation Default Concentration (**NADC**)

Values Bold and Shade are concentrations that exceed both **GCTL** and **NADC**

TABLE 4
Field Parameter Measurements - October 2007 Routine Monitoring Event
North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

Well Identification	Sample Date	pH	Conductivity (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temperature (^{o}C)	ORP (mV)
372-13R	10/23/2007	7.21	225	3.10	0.42	27.21	89.6
76-49S	10/26/2007	2.04	3331	2.04	0.10	25.50	210
76-50I	10/26/2007	2.57	4567	4.52	0.09	27.37	121
76-57S	10/26/2007	2.69	2244	1.51	0.03	24.23	173.1
76-61I	10/26/2007	2.16	9734	23.30	-0.13	23.89	188
76-70I	10/25/2007	3.29	4676	3.02	-0.34	25.90	5.7
76-93S	10/24/2007	5.73	275	88.1	0.31	26.17	258
76-94S	10/24/2007	2.50	2207	0.66	0.47	25.93	476
76-95S	10/25/2007	6.12	151	88.80	1.78	25.10	56.4
76-98D	10/24/2007	3.67	7769	1.68	0.53	24.95	193
76-99D	10/24/2007	6.56	3337	3.11	0.59	23.49	299
76-100D	10/25/2007	5.98	2877	1.64	0.53	25.56	-61.5
76-104D	10/25/2007	5.27	1294	1.68	0.72	21.24	87.3
76-110D	10/23/2007	2.32	6444	5.75	0.26	25.49	390
76-113S	10/25/2007	3.11	2499	2.50	0.23	25.95	45
76-116D	10/25/2007	2.94	9815	1.56	0.10	22.94	121.4

Note: All measurements taken using direct reading instruments in the field.
% = percent
mS/cm = millisiemans per centimeter
NTU = nephelometric turbidity units
mg/L = milligrams per liter
^{o}C = degrees Celsius
ORP = oxygen reducing potential
mV = millivolts

TABLE 5

Historical Groundwater Analytical Results

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

WELL	Sample ID	Sample Date	Benzene	Ethylbenzene	Toluene	Xylenes, total	Acetone	Carbon disulfide	cis-1,2-Dichloroethene	1,2-Dichloroethane	Trichloroethene (TCE)	1-methylnaphthalene	2-Methylnaphthalene	Methyl-t-butyl-Ether	2-Hexanone	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Chrysene	Cyclohexane	Fluoranthene	Fluorene	Isopropylbenzene (Cumene)	Methyl ethyl ketone (2-butanone)	Methyl isobutyl ketone (4-methyl-2-pentanone)	methylcyclohexane	Methylene chloride	Naphthalene	Phenanthrene	Pyrene	Styrene	Petroleum Hydrocarbons
		GCTL[1]	1	30	40	20	6300	700	70	3	3	28	28	50	280	20	210	2100	0.2	0.2	0.5	4.8	NA	280	280	0.8	4200	560	NA	5	14	210	210	100	5000
		NADC	100	300	400	200	63000	7000	700	30	30	280	280	500	2800	200	2100	21000	2	2	5	48	NA	2800	2800	8	42000	5600	NA	50	140	2100	2100	1000	50000
372-13R	01-372-13R-Q1-05	1/24/2005	ND	18.3	ND	7.18	ND	1.19 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.31 J	ND	ND	**8.22**	ND	ND	2.54 J	ND	**122 J**	ND	ND	ND	**8480 JB**
	1-372-13R-Q4-05	11/18/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1.92 J**	ND	ND	ND	ND	ND	ND	ND	ND	436 JB
	1-372-13R-Q1-06	2/13/2006	ND	ND	ND	ND	3.57 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.86 JB	ND	ND	ND	ND	491 JB
	1-372-13R-Q2-06	5/15/2006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	901
	137213RQ306	8/15/2006	ND	ND	ND	ND	2.28 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190 JB
	60NFF13RWQ107	5/22/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	60NFF13RWQ407	10/23/2007	ND	ND	ND	ND	5.3 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-39D	60NFF39DWQ107	5/24/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-43S	60NFF43SWQ107	5/30/2007	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-49S	1-76-49S-Q4-05	11/17/2005	**2.2**	ND	ND	ND	10.2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-49S-Q1-06	2/16/2006	**1.61**	ND	ND	8.23	8.2 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-49S-Q2-06	5/16/2006	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.42 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	17649SQ306	8/17/2006	ND	ND	ND	8.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	60NFF49SWQ107	5/29/2007	**19**	0.19 J	ND	2.9	1.5 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5 J	ND	ND	ND	ND	ND	ND	ND	ND	170 J
	60NFF49SWQ407	10/26/2007	**1.5**	ND	ND	ND	18	ND	ND	ND	ND	0.03 J	0.11 J	ND	ND	0.016 J	ND	0.027 J	ND	ND	ND	ND	NA	ND	0.03 J	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-44I	60NFF44IWQ107	5/30/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-50I	01-76-50I-Q1-05	1/25/2005	**318**	ND	ND	**1910**	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.48 J	ND	ND	ND	ND	ND	ND	473	ND	ND	ND	ND	ND	10.8 J	ND	**141 J**	ND	ND	ND	3310 JB
	1-76-50I-Q4-05	11/21/2005	**3360 J**	ND	ND	**2400**	905	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	202 J	ND	ND	ND	ND	ND	ND	ND	**54 J**	ND	ND	ND	3080 JB
	1-76-50I-Q1-06	2/14/2006	**5020**	**71.2 J**	ND	**586**	528 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	121 J	ND	ND	ND	ND	ND	ND	**277 JB**	**21.2 J**	ND	ND	ND	1840 JB
	1-76-50I-Q2-06	5/15/2006	**7200**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12.9 J	ND	ND	ND	1050
	17650IQ206	8/15/2006	**2230 J**	15.8 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.96 J	ND	ND	ND	183 JB
	60NFF50IWQ107	5/29/2007	**20**	0.28 J	ND	4.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.84 J	ND	ND	0.31 J	ND	ND	ND	ND	0.18 JB	ND	ND	ND	190 J
	60NFF50IWQ407	10/26/2007	**67**	0.57 J	0.16 J	6.6 J	15	ND	ND	0.3 J	ND	ND	ND	ND	1.6 J	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	0.15 J	ND	ND	NA	ND	0.35 J	ND	ND	ND	ND
76-51D	60NFF51DWQ107	5/29/2007	**6.3**	ND	ND	1.6	32 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.4 JB	ND	ND	ND	ND	ND	ND	ND	220 J
76-56I	60NFF56IWQ107	5/25/2007	**3.8**	0.14 J	ND	10	42	ND	ND		ND	ND	0.047	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	280 J
76-57S	1-76-57S-Q4-05	11/17/2005	**33.6**	11.7	ND	ND	10.6 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	45.7	ND	ND	**3.46 J**	ND	ND	9.66	ND	ND	ND	ND	ND	NA
	1-76-57S-Q1-06	2/15/2006	**81.8**	6.2	ND	ND	5.15 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	ND	**2.81 J**	ND	1.16 J	4.23 J	ND	ND	ND	ND	ND	NA
	1-76-57S-Q2-06	5/17/2006	**23.7**	2.01 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.61	ND	ND	ND	ND	2.59 J	3.86 J	ND	ND	ND	ND	ND	NA
	17657SQ306	8/17/2006	**7.02**	1.72 J	ND	3.21 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.23 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	60NFF57SWQ107	5/23/2007	**1.8**	0.31 J	ND	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND	ND	0.28 J	ND	ND	0.54 J	ND	0.16 JB	ND	ND	ND	240 J
	60NFF57SWQ407	10/26/2007	**2.9**	0.36 J	ND	2.2 J	4.4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	0.27 J	ND	ND	NA	ND	0.18 J	ND	ND	ND	ND
76-60S	60NFF60SWQ107	5/22/2007	ND	ND	ND	ND	20 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-61I	1-76-61I-Q4-05	11/17/2005	ND	**36.9 J**	ND	**73.8**	38.1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	53.7 J	ND	ND	**9.41 J**	3 J	ND	42.4 J	ND	ND	ND	ND	ND	NA
	1-76-61I-Q1-06	2/15/2006	**1.36**	22.8	ND	**24.2**	ND	12.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	85.4	ND	ND	**21.9**	2.07 J	ND	80.8	ND	ND	ND	ND	ND	NA
	1-76-61I-Q2-06	5/17/2006	**1.58**	10.9	ND	18	10 J	7.53	ND	ND	ND	24.2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	41.6	ND	ND	**18.9**	ND	ND	31.3	ND	**76.5 J**	ND	ND	ND	NA
	17661IQ306	8/16/2006	ND	3.06 J	ND	5.2	ND	ND	ND	ND	ND	11 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	22.7	ND	ND	**10.9 J**	ND	ND	16	3.02 JB	**45.2 J**	ND	ND	ND	NA
	60NFF61IWQ107	5/22/2007	**9.2**	1.2	ND	4.8	73 J	ND	ND	ND	ND	1.4	2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	**3.3**	21	ND	6.7	ND	10	ND	ND	ND	1100
	60NFF61IWQ407	10/26/2007	**8.8**	1.2	ND	4.8 J	67	0.42 J	ND	ND	ND	1.8 J	2.6 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	**2.2**	19	0.81 J	NA	ND	11 J	0.29 J	0.022 J	ND	760
76-62D	60NFF62DWQ107	5/22/2007	0.25 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-65D	60NFF65DWQ107	5/30/2007	0.74 J	ND	ND	0.38 JB	47 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.1 J	ND	ND	ND	ND	ND	ND	ND	410 J
76-69S	60NFF69SWQ107	5/23/2007	0.42 J	0.16 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.24 J	ND	ND	0.38 J	ND	ND	ND	ND	0.09 JB	ND	ND	ND	ND
76-70I	01-76-70I-Q1-05	1/25/2005	**834**	**50.3**	11.1 J	**3680**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	885	ND	ND	**63.7**	ND	ND	199	ND	**40.7 J**	ND	ND	ND	**9210 JB**
	1-76-70I-Q4-05	11/21/2005	**300**	ND	ND	**2340**	804	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	422	ND	ND	**57.5 JB**	35 JB	ND	92.1 J	ND	**104 J**	ND	ND	ND	496 B
	1-76-70I-Q1-06	2/14/2006	**206**	ND	ND	**2630**	897 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	607	ND	ND	**39.9 J**	ND	ND	132	ND	**34.2**	ND	ND	ND	3780 JB
	1-76-70I-Q2-06	5/11/2006	**231**	ND	ND	**2810**	1290 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	799	ND	ND	**72.6 J**	ND	ND	198	ND	**65.3 J**	ND	ND	ND	**5170**
	17670IQ306	8/15/2006	**70.8**	ND	ND	**1320**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	172	ND	ND	**70.1**	ND	ND	52.3	**10.4 JB**	**77.4 J**	ND	ND	ND	1640 JB
	60NFF70IWQ107	5/23/2007	**1300**	6.6 J	ND	**280**	ND	ND	ND	ND	ND	0.12 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13 J	ND	ND	**52**	ND	ND	ND	ND	**24 JB**	ND	ND	ND	1700 J
	60NFF70IWQ407	10/25/2007	**1800**	7.1 J	ND	**280 J**	77 J	ND	ND	ND	ND	0.2	0.16	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	**41**	ND	ND	NA	**14 J**	**28**	ND	ND	ND	1600
76-85I	60NFF85IWQ107	5/24/2007	**7.5**	1.9 J	1.4 JB	**510**	ND	ND	ND	0.69 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	**11**	ND	ND	ND	ND	0.076 JB	ND	ND	3.7	1300
76-91S	60NFF91SWQ107	5/24/2007	ND	ND	ND	0.71 J	29 JB	ND	ND	ND	ND	0.12 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.59 JB	ND	ND	ND	370 J
76-92S	60NFF92SWQ107	5/24/2007	0.17 J	ND	ND	ND	36 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.34 J	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5

Historical Groundwater Analytical Results

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

WELL	Sample ID	Sample Date	Benzene	Ethylbenzene	Toluene	Xylenes, total	Acetone	Carbon disulfide	cis-1,2-Dichloroethene	1,2-Dichloroethane	Trichloroethene (TCE)	1-methylnaphthalene	2-Methylnaphthalene	Methyl-t-butyl-Ether	2-Hexanone	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Chrysene	Cyclohexane	Fluoranthene	Fluorene	Isopropylbenzene (Cumene)	Methyl ethyl ketone (2-butanone)	Methyl isobutyl ketone (4-methyl-2-pentanone)	methylcyclohexane	Methylene chloride	Naphthalene	Phenanthrene	Pyrene	Styrene	Petroleum Hydrocarbons
		GCTL[1]	**1**	**30**	**40**	**20**	**6300**	**700**	**70**	**3**	**3**	**28**	**28**	**50**	**280**	**20**	**210**	**2100**	**0.2**	**0.2**	**0.5**	**4.8**	**NA**	**280**	**280**	**0.8**	**4200**	**560**	**NA**	**5**	**14**	**210**	**210**	**100**	**5000**
		NADC	**100**	**300**	**400**	**200**	**63000**	**7000**	**700**	**30**	**30**	**280**	**280**	**500**	**2800**	**200**	**2100**	**21000**	**2**	**2**	**5**	**48**	**NA**	**2800**	**2800**	**8**	**42000**	**5600**	**NA**	**50**	**140**	**2100**	**2100**	**1000**	**50000**
76-93S	01-76-93S-Q1-05	1/24/2005	**1890**	**1300**	**7800**	**5610**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1340	ND	ND	**72.8 J**	ND	ND	648	ND	3.73 J	ND	ND	52.2 J	**12100 JB**
	1-76-93S-Q4-05	11/18/2005	**27.2**	**83.5**	**235**	**443**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	120	ND	ND	**9.22 J**	ND	ND	86.4	**7.85 JB**	**30.8 J**	ND	ND	5.01 J	1620 JB
	1-76-93S-Q1-06	2/13/2006	**11.8**	**75.4**	**193**	**502**	139 JB	ND	ND	ND	ND	8.96 J	6.46 J	ND	26.3 J	ND	7.28 J	ND	ND	ND	ND	ND	109	ND	ND	**4.5 J**	ND	ND	47.1	ND	**26.6 J**	ND	ND	ND	112 JB
	1-76-93S-Q2-06	5/10/2006	**37.9**	**259**	**607**	**1640**	565 JB	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	373	ND	ND	**27.7 J**	ND	ND	164	ND	**66.9 J**	ND	ND	ND	**7790 J**
	17693SQ306	8/14/2006	**23.1**	**318**	**515**	**2090**	ND	ND	ND	ND	ND	**31.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	439	ND	ND	**27.6**	ND	ND	251	**14 JB**	**93.9 J**	ND	ND	ND	4520 JB
	60NFF93SWQ107	5/15/2007	**26**	**140**	**320 JB**	**860**	30 JB	0.39 J	ND	ND	ND	6.1	6.8	ND	ND	0.11 J	ND	ND	ND	ND	ND	ND	230	ND	0.072 J	**23**	ND	ND	130	2.3 JB	9.2 JB	ND	ND	ND	5300
	60NFF93SWQ407	10/24/2007	ND	1.9	1.4 JB	9.8 J	7.2 JB	ND	ND	ND	ND	0.17	0.23	ND	ND	ND	ND	ND	ND	ND	ND	0.023 J	NA	0.039 J	ND	**0.93**	ND	ND	NA	ND	0.23	0.05	0.04 J	ND	160 J
76-94S	01-76-94S-Q1-05	1/25/2005	**3040**	**1310**	**3800**	**4850**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1340	ND	ND	**86.5 J**	ND	ND	594	ND	**193 J**	ND	ND	ND	**15500 JB**
	1-76-94S-Q4-05	11/18/2005	ND	ND	ND	ND	270 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.1	ND	ND	ND	404 JB
	1-76-94S-Q1-06	2/13/2006	0.993 J	ND	ND	ND	36 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.47 J	ND	ND	2.98 JB	ND	ND	ND	ND	200 JB
	1-76-94S-Q2-06	5/10/2006	**1.6**	ND	ND	ND	23.3 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.57 J	ND	ND	ND	0.696	ND	ND	ND	304
	17694SQ306	8/14/2006	ND	ND	ND	ND	10.4 JB	ND	1.24 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	97 JB
	60NFF94SWQ107	5/15/2007	ND	ND	ND	ND	17 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5 JB	ND	ND	ND	ND	ND
	60NFF94SWQ407	10/24/2007	ND	ND	ND	ND	8.4 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-95S	1-76-95S-Q4-05	11/16/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-95S-Q1-06	2/14/2006	ND	ND	ND	ND	2.86 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-95S-Q2-06	5/16/2006	ND	ND	ND	ND	6.39 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	17695SQ306	8/16/2006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.54 JB	ND	ND	ND	ND	NA
	60NFF95SWQ107	5/25/2007	ND	ND	ND	ND	6.7 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	60NFF95SWQ407	10/25/2007	ND	ND	0.61 J	ND	5.6 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	180 J
76-98D	01-76-98D-Q1-05	1/25/2005	**1090 J**	8.33 J	ND	**62.3**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	27.9 J	ND	ND	ND	ND	ND	11.6 J	ND	**20.3**	ND	ND	ND	811 B
	1-76-98D-Q4-05	11/21/2005	**283**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.06	ND	ND	ND	**9340 B**
	1-76-98D-Q1-06	2/14/2006	**1.54**	ND	ND	ND	5.28 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.41 JB	5.07	ND	ND	ND	82.8 JB
	1-76-98D-Q2-06	5/11/2006	**4.62**	ND	ND	ND	1.04 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	312 J
	17698DQ306	8/15/2006	**22.3**	ND	ND	6.82	15.7 JB	2.95 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.36 J	ND	ND	ND	ND	ND	ND	1.05 JB	2.18	ND	ND	ND	137 JB
	60NFF98DWQ107	5/25/2007	**91**	0.27 J	ND	7.2	ND	ND	ND	ND	ND	0.02 J	0.037 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	1 J	ND	ND	0.32 J	ND	ND	ND	ND	1.5	ND	ND	ND	330 J
	60NFF98DWQ407	10/24/2007	**120**	0.38 J	0.22 JB	8.8 J	7.1 JB	ND	ND	ND	ND	ND	0.046 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	0.24 J	ND	ND	NA	ND	2.1	ND	ND	ND	160 J
76-99D	1-76-99D-Q4-05	11/16/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-99D-Q1-06	2/15/2006	ND	ND	ND	ND	3.18 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-99D-Q2-06	5/17/2006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	17699DQ306	8/16/2006	ND	ND	ND	ND	1.59 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.62 JB	ND	ND	ND	ND	NA
	60NFF99DWQ107	5/22/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	60NFF99DWQ407	10/24/2007	ND	ND	ND	ND	4.4 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-100D	1-76-100D-Q4-05	11/17/2005	**23.2**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-100D-Q1-06	2/16/2006	**5**	ND	ND	ND	2.9 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-100D-Q2-06	5/16/2006	**1.27**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	176100DQ306	8/17/2006	**1.07**	ND	ND	ND	ND	ND	ND	ND	2.06 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	60NFF100DWQ107	5/29/2007	0.12 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.019 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.047 JB	ND	ND	ND	ND
	60NFF100DWQ407	10/25/2007	0.31 J	ND	ND	ND	4.2 J	0.36 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-103D	60NFF103DWQ107	5/30/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-104D	1-76-104D-Q4-05	11/16/2005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-104D-Q1-06	2/15/2006	ND	ND	ND	ND	2.71 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-104D-Q2-06	5/15/2006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	176104DQ306	8/17/2006	0.838 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.948 J	ND	ND	ND	ND	NA
	60NFF104DWQ107	5/29/2007	0.5 J	ND	ND	ND	2.6 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	60NFF104DWQ407	10/25/2007	**3.6**	ND	ND	ND	4.2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND
76-105I	60NFF105IWQ107	5/30/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-106S	60NFF106SWQ107	5/15/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-110D	01-76-110D-Q1-05	1/25/2005	**1150**	ND	ND	**88.8**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	499 JB
	1-76-110D-Q4-05	11/21/2005	**597**	ND	ND	**38.2 J**	ND	42.6 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**19.2 JB**	ND	ND	ND	ND	2.57 J	ND	ND	ND	2700 B
	1-76-110D-Q1-06	2/14/2006	**434**	ND	ND	**42.3 J**	26.9 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**28.6 JB**	2.55 J	ND	ND	ND	309 JB
	1-76-110D-Q2-06	5/11/2006	**559**	ND	ND	ND	169 JB	125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.31	ND	ND	ND	370
	176110DQ306	8/14/2006	**497**	ND	ND	17.1 J	59.4 JB	15.4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**9.25 JB**	3.33	ND	ND	ND	430 JB
	60NFF110DWQ107	5/30/2007	**110**	0.99 J	ND	**21 JB**	51 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.32 J	ND	ND	0.51 J	3.4 J	ND	ND	ND	1.6	ND	ND	ND	350 J
	60NFF110DWQ407	10/23/2007	**120**	0.55 J	ND	13 J	16 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.031 J	ND	ND	ND	ND	NA	ND	ND	0.35 J	3.5 J	ND	NA	ND	1 JB	ND	ND	ND	190 J

TABLE 5

Historical Groundwater Analytical Results

North Fuel Farm Site, NAS Cecil Field, Jacksonville, FL

WELL	Sample ID	Sample Date	Benzene	Ethylbenzene	Toluene	Xylenes, total	Acetone	Carbon disulfide	cis-1,2-Dichloroethene	1,2-Dichloroethane	Trichloroethene (TCE)	1-methylnaphthalene	2-Methylnaphthalene	Methyl-t-butyl-Ether	2-Hexanone	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Chrysene	Cyclohexane	Fluoranthene	Fluorene	Isopropylbenzene (Cumene)	Methyl ethyl ketone (2-butanone)	Methyl isobutyl ketone (4-methyl-2-pentanone)	methylcyclohexane	Methylene chloride	Naphthalene	Phenanthrene	Pyrene	Styrene	Petroleum Hydrocarbons
		GCTL[1]	**1**	**30**	**40**	**20**	**6300**	**700**	**70**	**3**	**3**	**28**	**28**	**50**	**280**	**20**	**210**	**2100**	**0.2**	**0.2**	**0.5**	**4.8**	**NA**	**280**	**280**	**0.8**	**4200**	**560**	**NA**	**5**	**14**	**210**	**210**	**100**	**5000**
		NADC	**100**	**300**	**400**	**200**	**63000**	**7000**	**700**	**30**	**30**	**280**	**280**	**500**	**2800**	**200**	**2100**	**21000**	**2**	**2**	**5**	**48**	**NA**	**2800**	**2800**	**8**	**42000**	**5600**	**NA**	**50**	**140**	**2100**	**2100**	**1000**	**50000**
76-111I	60NFF111IWQ107	5/22/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-112I	60NFF112IWQ107	5/15/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-113S	01-76-113S-Q1-05	1/25/2005	**7730**	**1130**	**85.3 J**	**4740**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1350	ND	ND	**87.7 J**	ND	ND	515	ND	**87.3 J**	ND	ND	62.6 J	**12700 JB**
	1-76-113S-Q4-05	11/18/2005	**7940**	**878 J**	ND	**4010**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**400 J**	ND	ND		ND	**293 J**	ND	ND	ND	**6090 JB**
	1-76-113S-Q1-06	2/13/2006	**9680**	**953 J**	ND	**1790**	569 JB	ND	ND	ND	ND	**38.6 J**	26.2 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	469 J	ND	ND	ND	ND	ND	ND	**315 JB**	**150 J**	ND	ND	ND	3510 JB
	1-76-113S-Q2-06	5/10/2006	**13100**	**1060**	ND	**1880**	545 JB	ND	ND	ND	ND	23.1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	684 J	ND	ND	ND	ND	ND	ND	ND	**103 J**	ND	ND	ND	**7290**
	176113SQ306	8/14/2006	**10500**	**1300**	ND	**2500**	ND	ND	ND	ND	ND	27.1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	518	ND	ND	ND	ND	ND	ND	**195 JB**	**157 J**	ND	ND	ND	4060 JB
	60NFF113SWQ107	5/24/2007	**9900**	**1100**	ND	**1900**	ND	ND	ND	ND	ND	4	5.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	58 J	ND	ND	**91 J**	ND	ND	ND	ND	**50 JB**	ND	ND	ND	**5400**
	60NFF113SWQ407	10/25/2007	**9000**	**800**	ND	**1600 J**	180 J	ND	ND	ND	ND	2.7	3.6	ND	ND	0.018 J	ND	ND	ND	ND	ND	ND	NA	0.034 J	ND	**72**	ND	ND	NA	**37 J**	**47**	ND	0.029 J	ND	5600
76-114S	60NFF114SWQ107	5/25/2007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
76-116D	1-76-11Xc-Q4-05	11/17/2005	**176**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-11Xc-Q1-06	2/15/2006	**324**	ND	ND	ND	13.8 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	1-76-11Xc-Q2-06	5/15/2006	**517**	ND	ND	ND	18.6 JB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA
	17611XCQ306	8/17/2006	**256**	ND	ND	ND	128 J	16.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.75 J	ND	ND	ND	ND	ND	ND	ND	ND	NA
	60NFF11XcWQ107	5/29/2007	**45**	0.17 J	ND	1.8	370 JB	150	ND	ND	ND	0.029 JB	0.049JB	ND	ND	0.036JB	ND	0.053JB	0.054JB	0.13JB	0.036JB	0.045JB	0.38 J	0.068JB	0.039 J	0.15 J	23 JB	ND	ND	ND	0.061 JB	0.054JB	0.077JB	ND	170 J
	60NFF11XcWQ407	10/25/2007	**57 J**	ND	ND	2.8 J	290 J	180	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	0.3 J	21	ND	NA	ND	0.12 J	ND	ND	ND	ND

Notes:

All concentrations reported in micrograms per liter (ug/L).

GCTL - Groundwater Cleanup Target Level

NADC - Natural Attenuation Default Concentration

1 = Ch 62-777 FAC Groundwater Cleanup Target Levels **(GCTLs)** reported in µg/L

U - The analyte was analyzed for, but not detected.

J - Result is estimated

UJ- Value non-detected estimated.

JB- Estimate value. The analyte was detected in the associated method and/or calibration blank.

Values Bolded are analytes not detected by the Lab but are above the **GCTL.**

Values Shaded Grey are hits that exceed the **NADC.**

Values Bold and Shaded Grey are hits that exceed both **GCTL** and **NADC.**

NA - Not Available at time of rule adoption

Figures

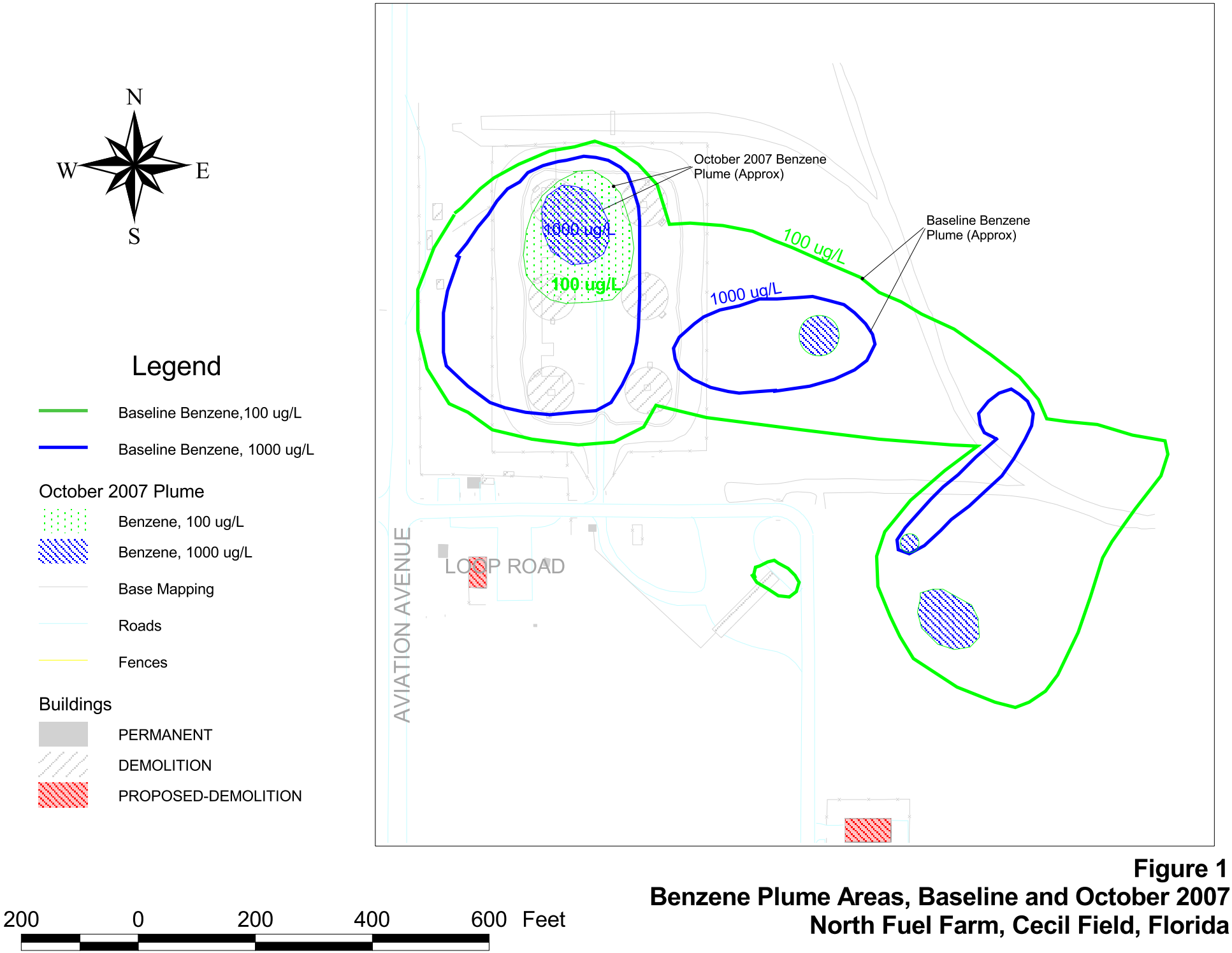
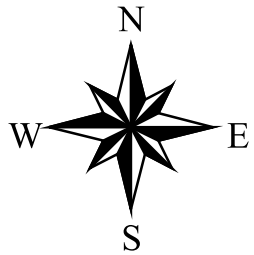


Figure 1
Benzene Plume Areas, Baseline and October 2007
North Fuel Farm, Cecil Field, Florida



Legend

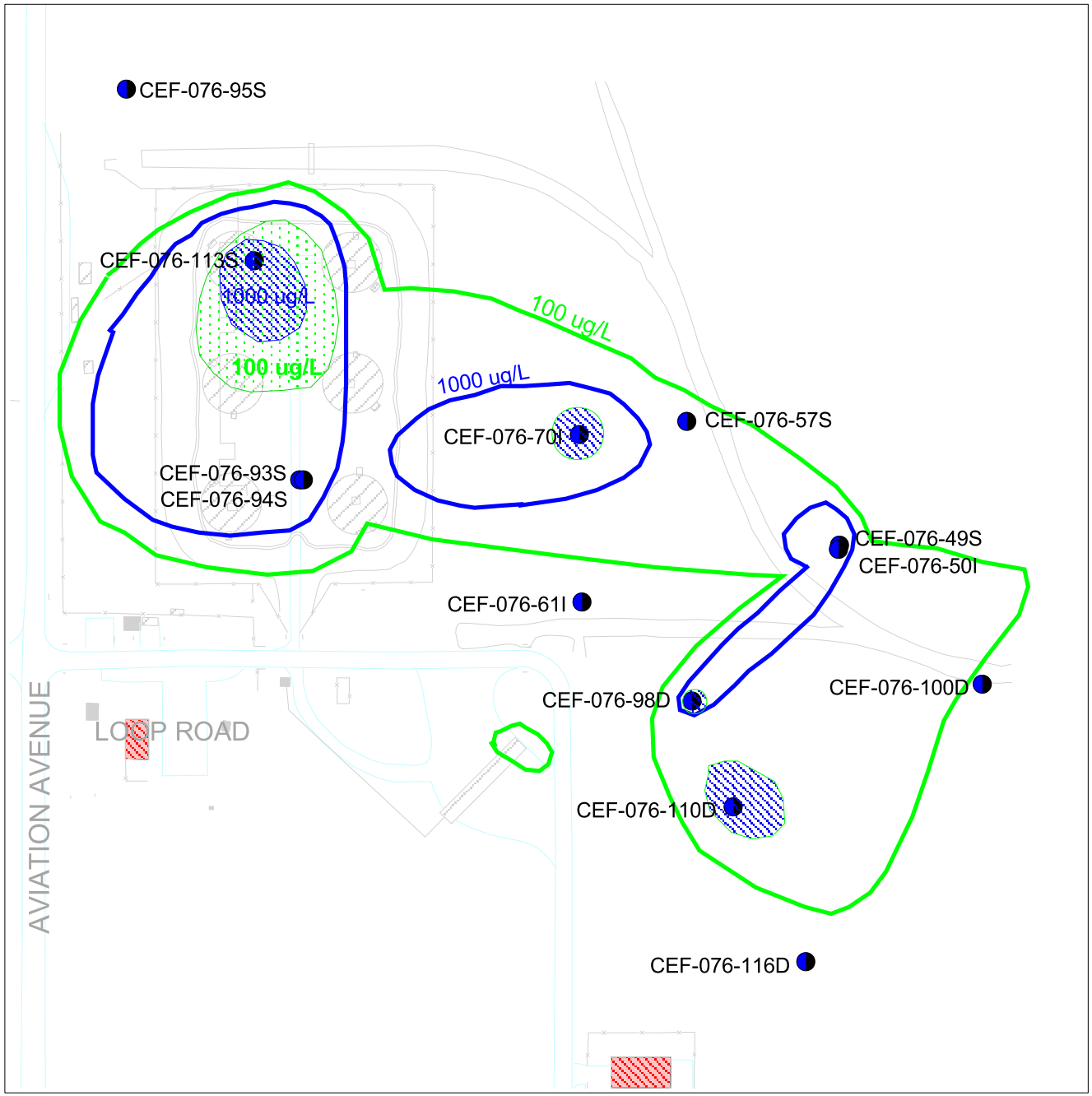
- Monitor Well Location
- Baseline Benzene,100 ug/L
- Baseline Benzene, 1000 ug/L

October 2007 Plume

- Benzene, 100 ug/L
- Benzene, 1000 ug/L
- Base Mapping
- Roads
- Fences

Buildings

- PERMANENT
- DEMOLITION
- PROPOSED-DEMOLITION



200 0 200 400 600 Feet

Figure 2
Monitor Well Locations
North Fuel Farm, Cecil Field, Florida

Figure 3
Benzene Concentrations in Shallow Wells
North Fuel Farm, Cecil Field, Florida

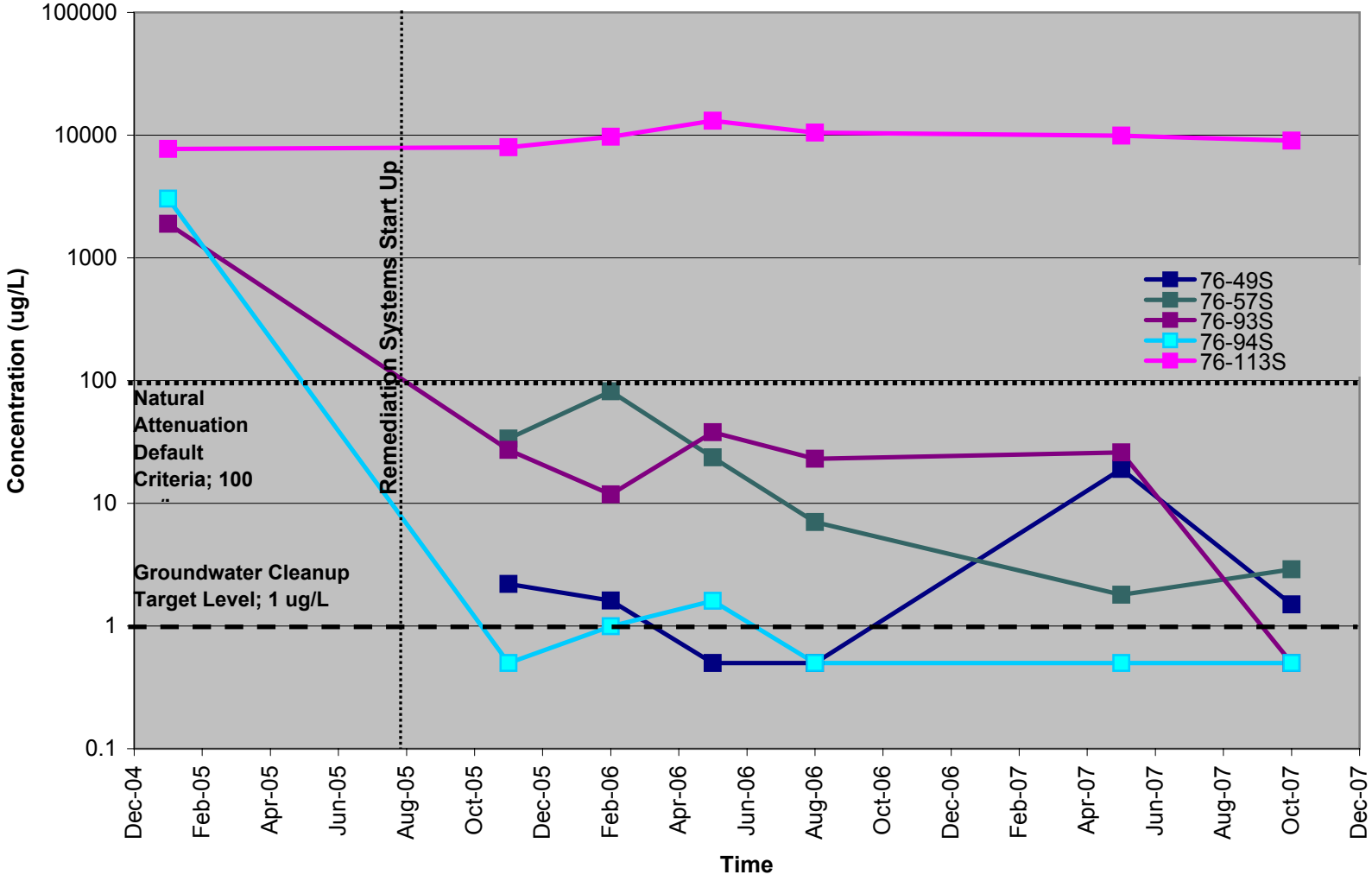


Figure 4
Benzene Concentrations in Intermediate Wells
North Fuel Farm, Cecil Field, Florida

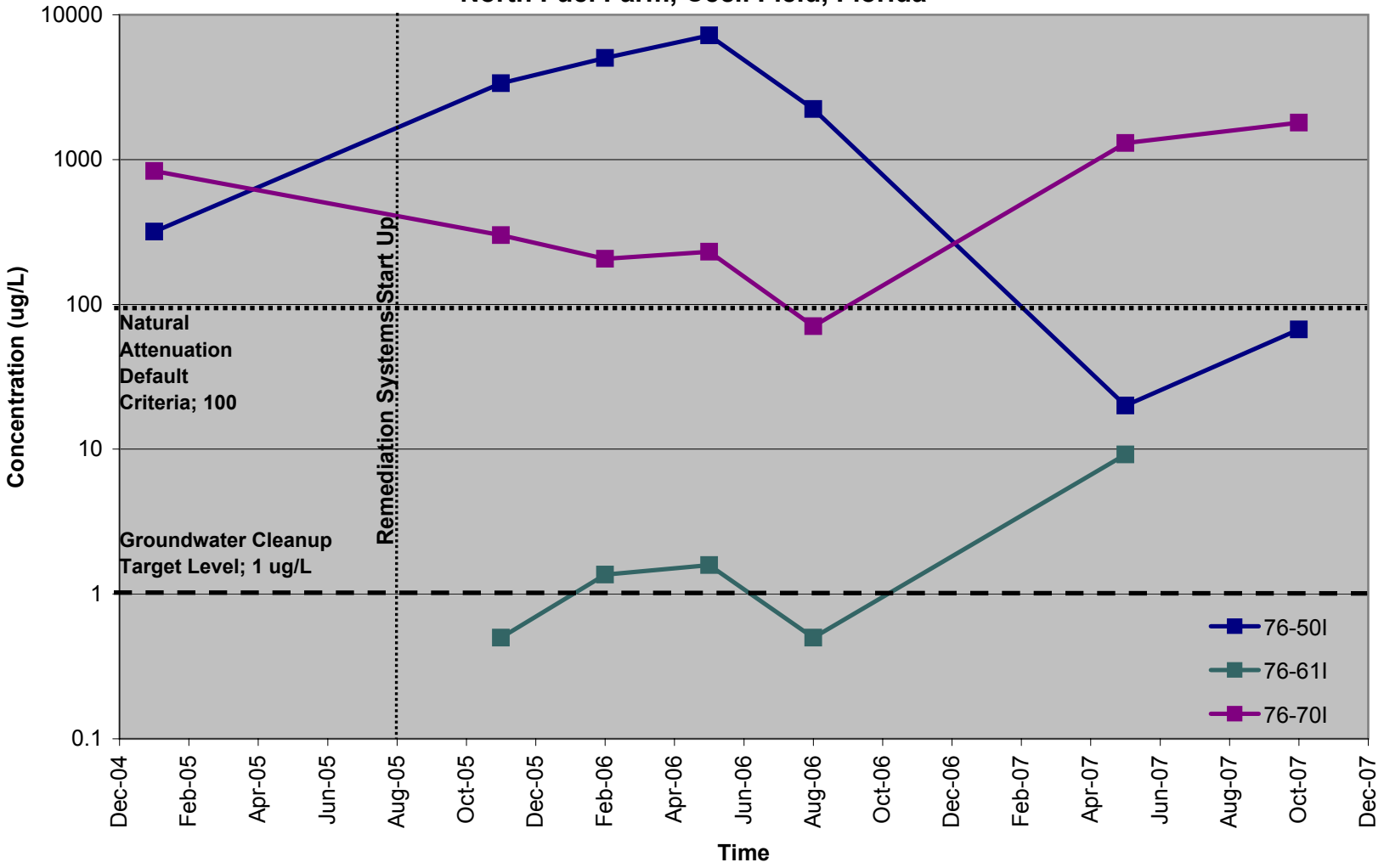
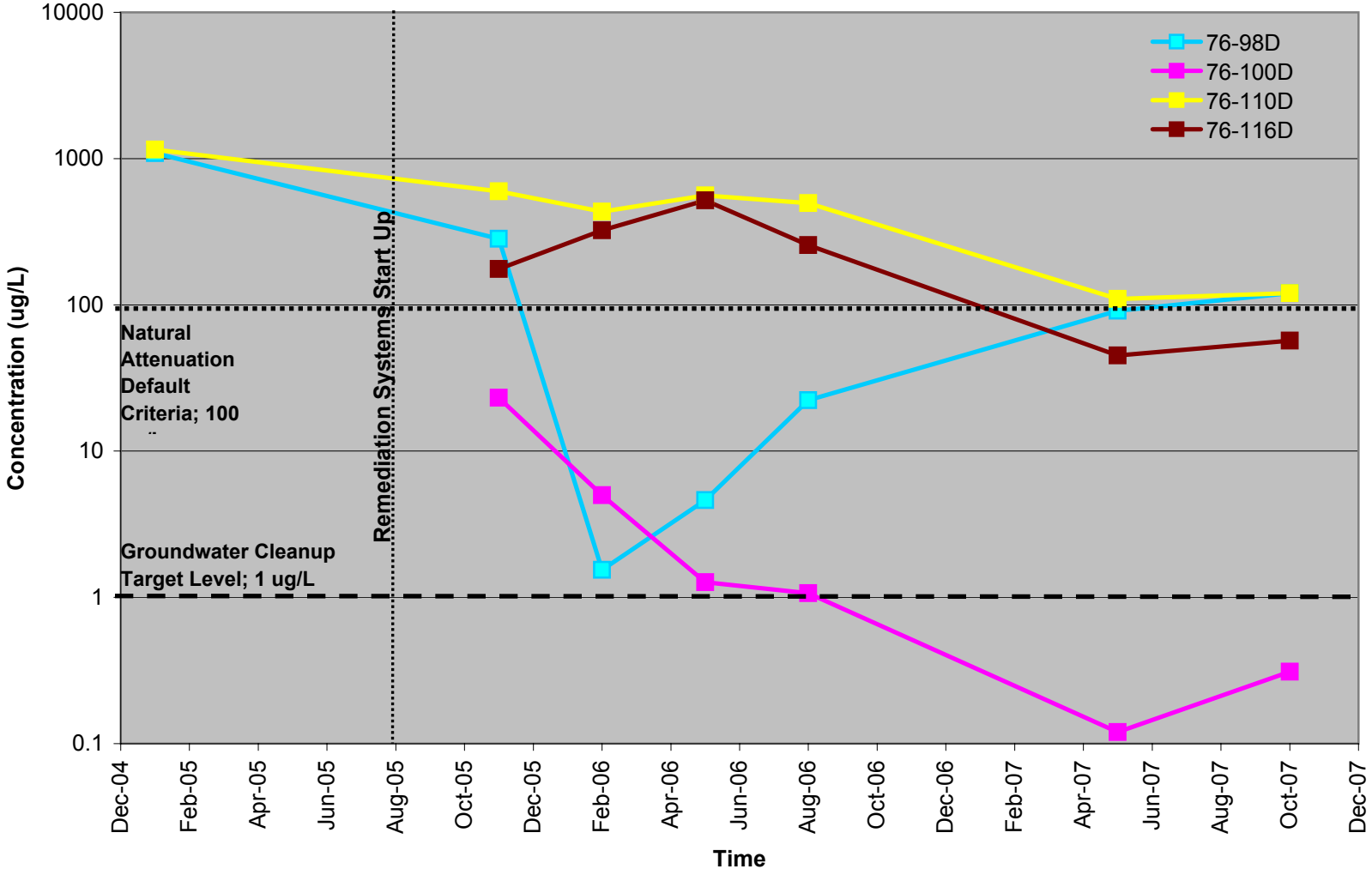
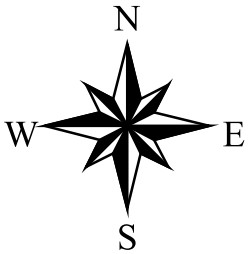


Figure 5
Benzene Concentrations in Deep Wells
North Fuel Farm, Cecil Field, Florida





Legend

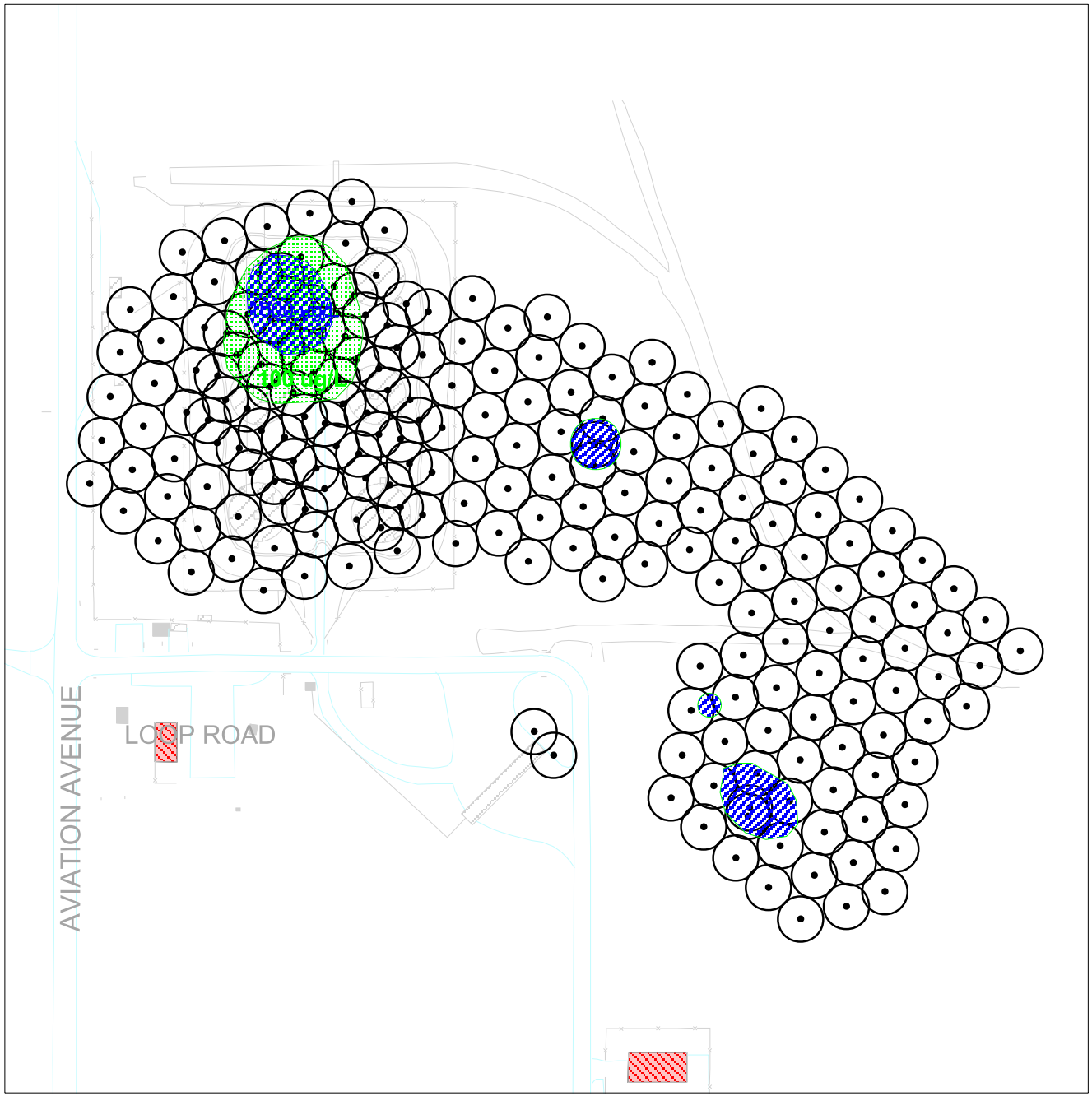
Sparge Locations (Air and Bio) and Area of Influence (Approx)

October 2007 Plume

- Benzene, 100 ug/L
- Benzene, 1000 ug/L
- Base Mapping
- Roads
- Fences

Buildings

- PERMANENT
- DEMOLITION
- PROPOSED-DEMOLITION



300 0 300 600 Feet

Figure 6
October 2007 Plume and Sparge Influence Areas
North Fuel Farm, Cecil Filed, Florida

Figure 7
Dissolved Oxygen Study
North Fuel Farm, Cecil Field, Florida

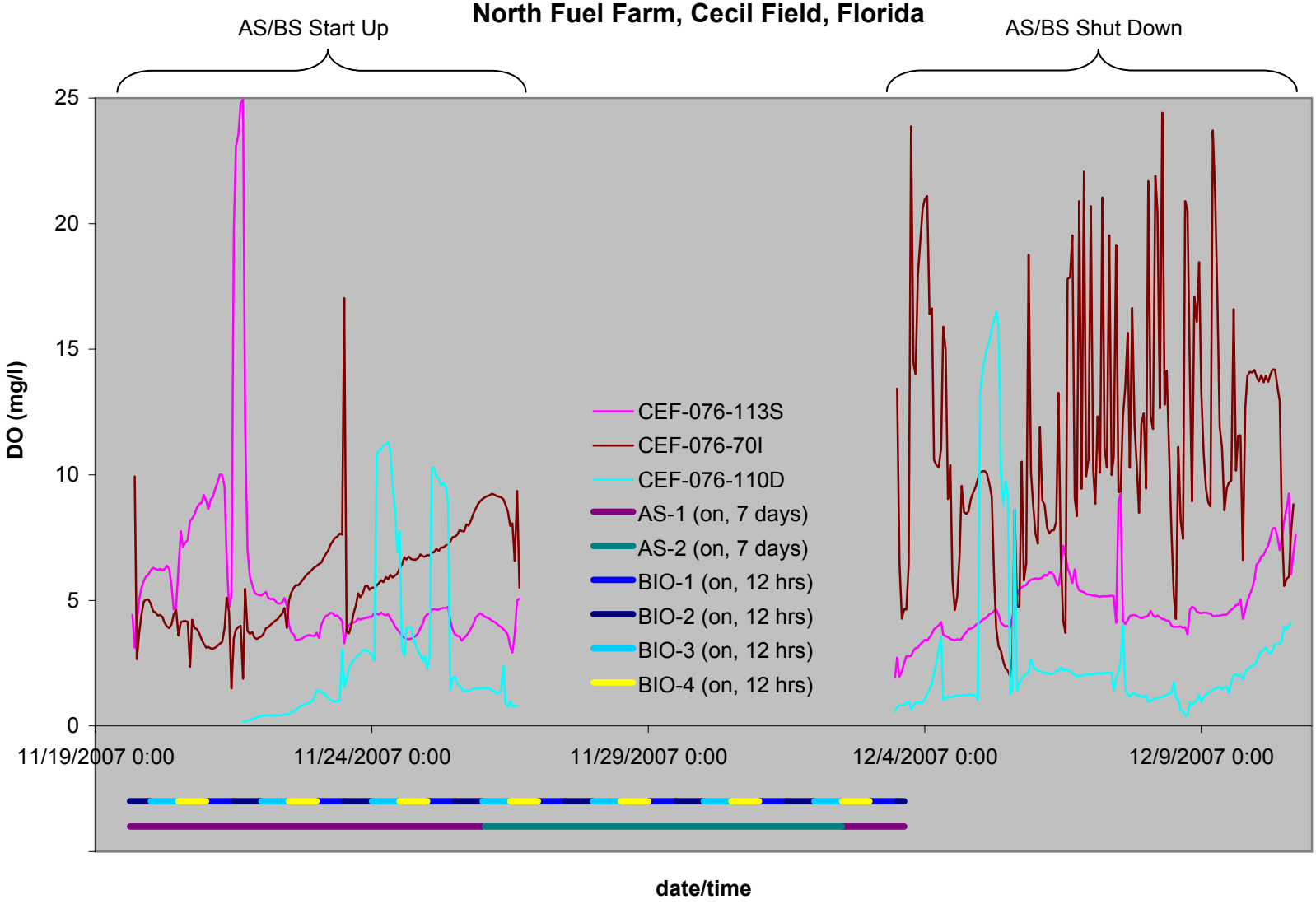
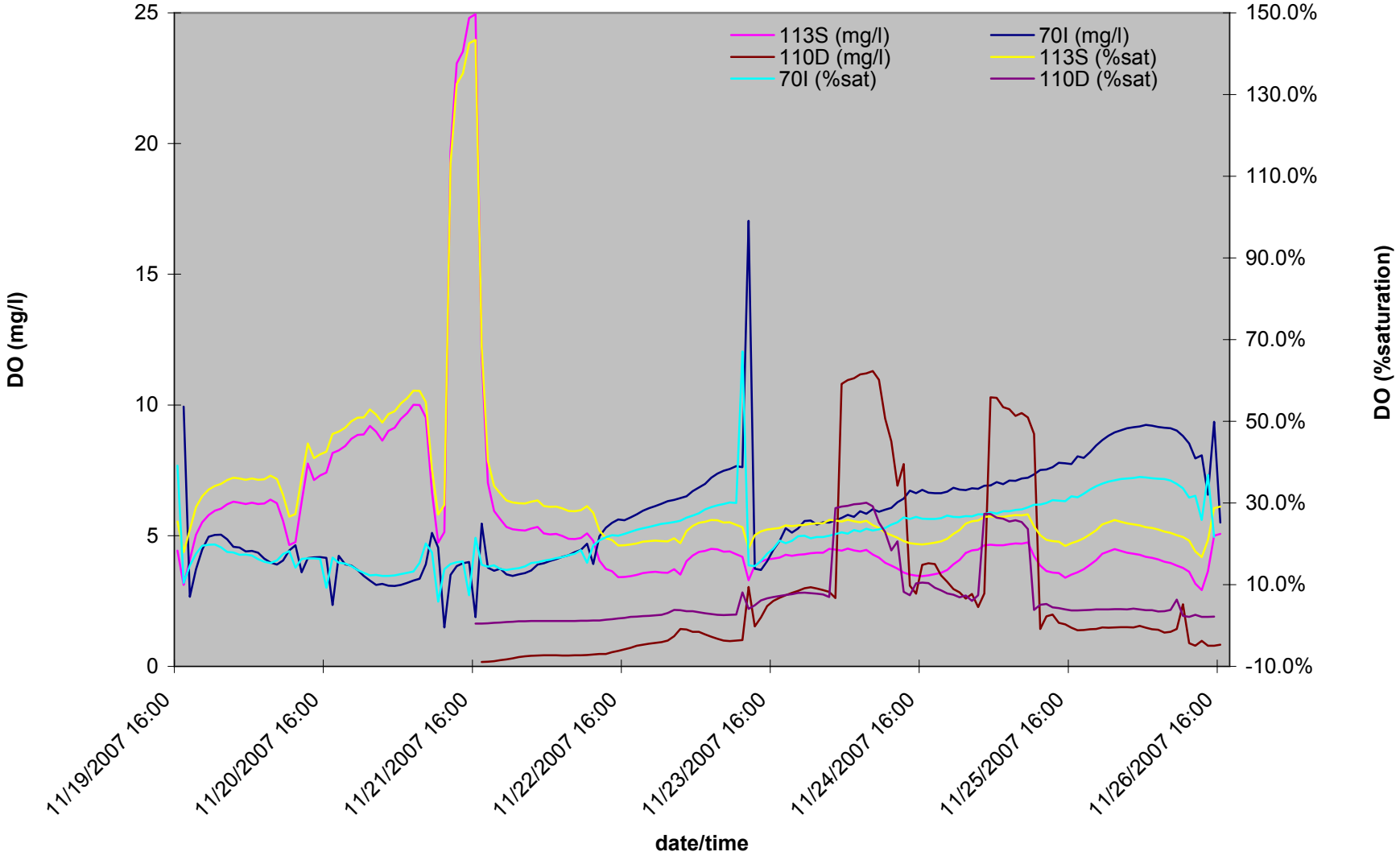


Figure 8
October 2007 Plume and Sparge Influence Areas
North Fuel Farm, Cecil Filed, Florida

Figure 9
Dissolved Oxygen/Saturation (adjusted for depth)
North Fuel Farm, Cecil Field, Florida



Attachment A
Microbial Analysis Results

2340 Stock Creek Blvd.
Rockford TN 37853-3044
Phone: (865) 573-8188
Fax: (865) 573-8133
Email: info@microbe.com

Lipid Analysis Report

Client: Bethany Garvey
CH2M HILL
115 Perimeter Center Pl
Suite 700
Atlanta, GA 30346

Phone: (770) 604-9182

Fax: (770) 604-9183

MI Identifier: 071EJ **Date Rec:** 10/26/2007 **Report Date:** 11/15/2007

Client Project #: 350277 **Client Project Name:** North Fuel Farm

Purchase Order #:

Analysis Requested: PLFA

Comments:

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

Reported By:

Reviewed By:

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

MICROBIAL INSIGHTS, INC.

2340 Stock Creek Blvd. Rockford, TN 37853-3044
Tel. (865) 573-8188 Fax. (865) 573-8133

PLFA

Client: **CH2M HILL**
Project: North Fuel Farm

MI Project Number: **071EJ**
Date Received: 10/26/2007

Sample Information

Sample Name:	**60NFF95SWQ407**	**60NFF113SWQ407**	**60NFF701IWQ407**
Sample Date:	10/25/2007	10/25/2007	10/25/2007
Sample Matrix:	Water	Water	Water

Biomass

Total Biomass (cells/mL)	**1.69E+06**	**5.85E+05**	**2.38E+06**

Community Structure (% total PLFA)

Firmicutes (TerBrSats)	**4.86**	**1.08**	**0.33**
Proteobacteria (Monos)	**40.40**	**36.18**	**64.44**
Anaerobic metal reducers (BrMonos)	**0.44**	**0.00**	**0.18**
SRB/Actinomycetes (MidBrSats)	**1.37**	**0.10**	**0.03**
General (Nsats)	**25.24**	**21.89**	**35.03**
Eukaryotes (polyenoics)	**27.66**	**40.73**	**0.00**

Physiological Status (Proteobacteria only)

Slowed Growth	**0.20**	**1.61**	**5.78**
Decreased Permeability	**0.06**	**0.37**	**0.06**

Legend:
NA = Not Analyzed NS = Not Sampled

MICROBIAL INSIGHTS, INC.

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Tel. (865) 573-8188 Fax. (865) 573-8133

PLFA

Client: **CH2M HILL**
Project: North Fuel Farm

MI Project Number: **071EJ**
Date Received: 10/26/2007

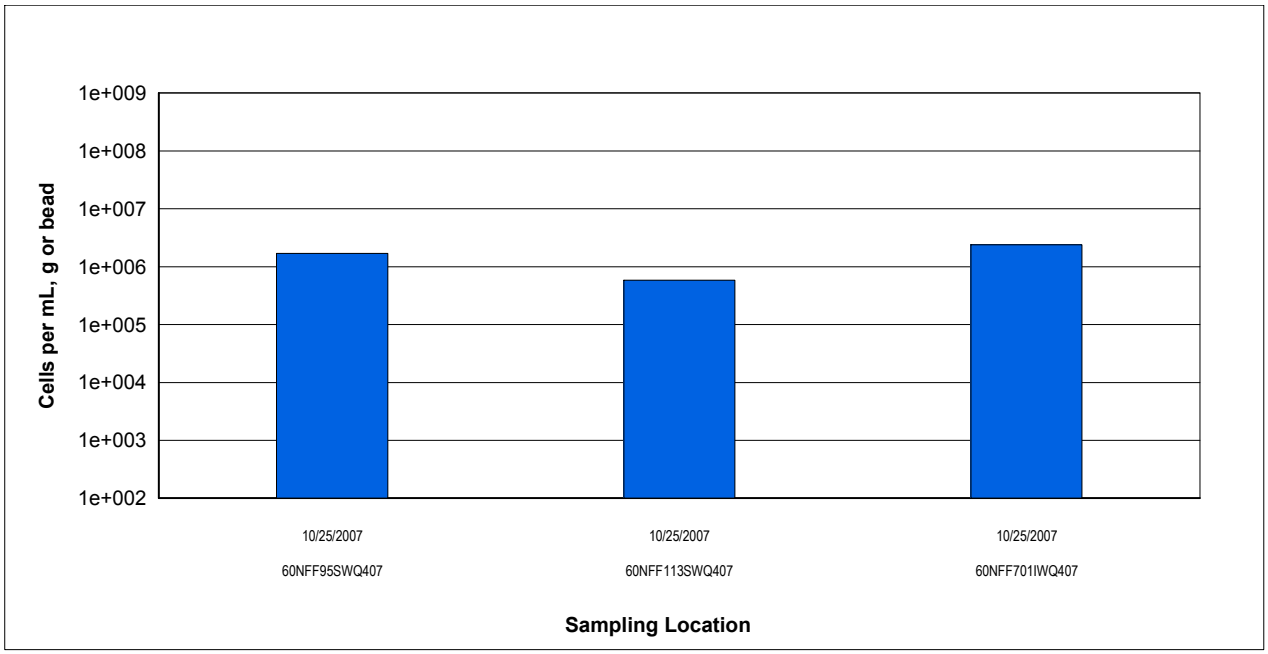

Figure 1. Biomass content is presented as a cell equivalent based on the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Total biomass is calculated based upon PLFA attributed to bacterial and eukaryotic biomass (associated with higher organisms).

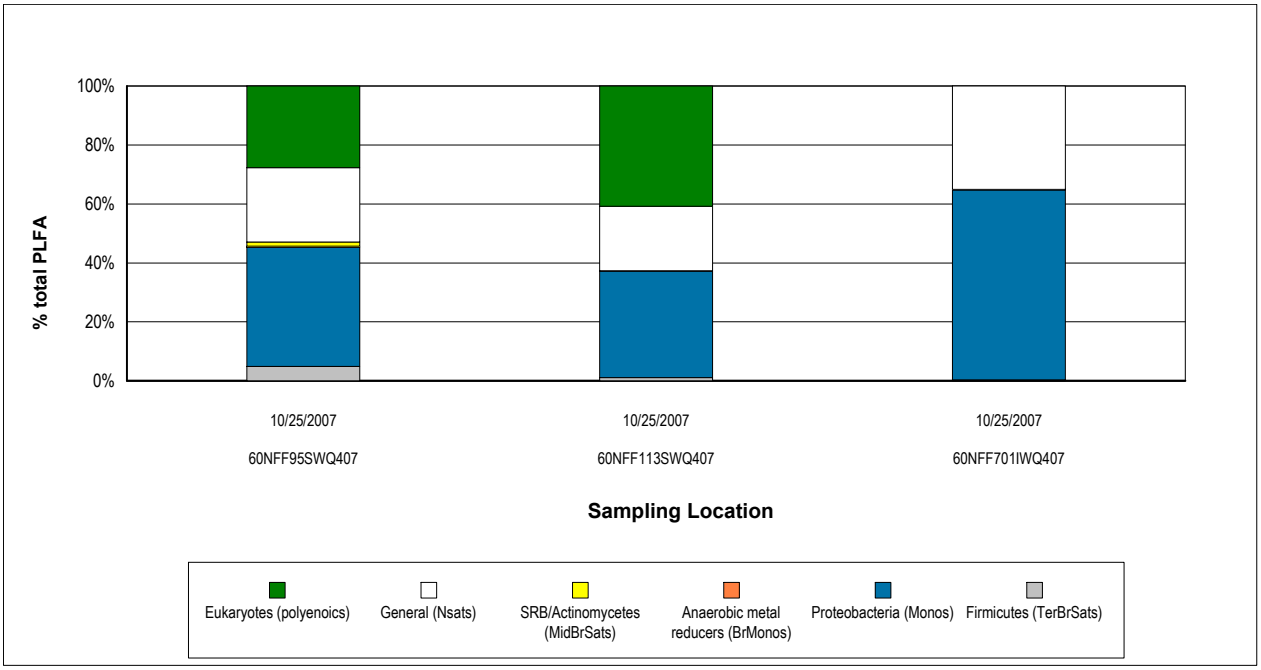

Figure 2. Relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis.

CH2MHILL Constructors, Inc.

1000 Abernathy Road, Suite 1600
Atlanta GA 30328
Tel No: (770) 604-9182
Fax No: (770) 604-9282

CHAIN-OF-CUSTODY RECORD

COC NUMBER: **350277-011** Page 1 of 1

PROJECT NAME	PROJECT NUMBER	LAB NAME AND CONTACT	RECEIVED BY	RECIPIENT 1 (Address, Tel No. , and Fax No.)
North Fuel Farm	350277	Microbial Insights Dora Ogles	Bethany Garvey / Kama White CH2M Hill Constructors, Inc.	Northpark 400, 1000 Abernathy Road, Suite 1600; Atlanta, GA 30328 (770)604-9182 / FAX:604-9282
PROJECT PHASE/SITE/TASK	CTO OR DO NUMBER	LAB PO NUMBER		RECIPIENT 2 (Address, Tel No. , and Fax No.)
North Fuel Farm Quarterly GW Sampling Event	0060			
PROJECT CONTACT	PROJECT TEL NO AND FAX NO	LAB TEL NO AND FAX NO		RECIPIENT 3 (Address, Tel No. , and Fax No.)
Sam Naik CH2M Hill Constuctors, Inc.	Ph:770-604-9182 ext 54248 Fax:770-604-9183	Ph: 865-573-8188 ext 107 Fax: 865-573-8133		

ANALYSES REQUIRED (Include Method Numbers)

ITEM	SAMPLE IDENTIFIER	SAMPLE DESCRIPTION/LOCATION	MATRIX (see codes on SOP)	DATE COLLECTED	TIME COLLECTED	DATA PKG LEVEL (see codes on SOP)	TAT (calendar days)	Phospholipid Fatty Acid Analysis (PLFA)							SAMPLE TYPE (see codes on SOP)	COMMENTS/ SCREENING READINGS	LAB ID (for lab's use)
1	60NFF95SWQ407	CEF-76-95S	W	10/25/07	1615	III/C	7/14	1							N	2 Liters	
2	60NFF113SWQ407	CEF-76-113S	W	10/25/07	1705	III/C	7/14	1							N	2 Liters	
3	60NFF70IWQ407	CEF-76-70I	W	10/25/07	1745	III/C	7/14	1							N	2 Liters	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

SAMPLER(S) AND COMPANY (please print)	COOLER AND SHIPPING NUMBER	Notes
L Lynch / J. Calixte CH2M HILL	Federal Express Tracking Numbers: 7925 8701 1610.	(level C package / 7-day prelim / 14-day TAT)

RELINQUISHED BY	DATE	TIME	RECEIVED BY	DATE	TIME
Printed Name and Signature			Printed Name and Signature		
R. Dumaop	10/25/2007	18:00	Federal Express Tracking Numbers: 7925 8701 1610.	10/25/2007	18:00
Printed Name and Signature			Printed Name and Signature Amy Terry	10-26-07	10:00
Printed Name and Signature			Printed Name and Signature		

Distribution: [ ] Original - Laboratory (To be returned with Analytical Report); [ ] Copy 1 - Project File; [ ] Copy 2 - PMO

Form CC1001, Rev 02/00

2340 Stock Creek Blvd.
Rockford TN 37853-3044
Phone (865) 573-8188
Fax: (865) 573-8133
Email: info@microbe.com

Phospholipid Fatty Acid Analysis

Interpretation Guidelines

Phospholipids fatty acids (PLFA) are a main component of the membrane (essentially the "skin") of microbes and provide a powerful tool for assessing microbial responses to changes in their environment. This type of analysis provides direct information for assessing and monitoring sites where bioremediation processes, including natural attenuation, are of interest. Analysis of the types and amount of PLFA provides a broad based understanding of the entire microbial community with information obtained in three key areas viable biomass, community structure and metabolic activity.

What is the detection limit for PLFA?

Our limit of detection for PLFA analysis is ~50 picomoles of total PLFA and our limit of quantification is ~150 picomoles of total PLFA. Samples which contain PLFA amounts at or below 50 pmol cannot be used to determine biomass, likewise samples with PLFA content below ~150 pmol are generally considered to contain too few fatty acids to discuss community composition.

How should I interpret the PLFA results?

Interpreting the results obtained from PLFA analysis can be somewhat difficult, so this document was designed to provide a technical guideline. For convenience, this guideline has been divided into the three key areas.

Viable Biomass

PLFA analysis is one of the most reliable and accurate methods available for the determination of viable microbial biomass. Phospholipids break down rapidly upon cell death (21, 23), so biomass calculations based on PLFA content do not contain 'fossil' lipids of dead cells.

How is biomass measured?

Viable biomass is determined from the total amount of PLFA detected in a given sample. Since, phospholipids are an essential part of intact cell membranes they provide an accurate measure of viable cells.

How is biomass calculated?

Biomass levels are reported as cells per gram, mL or bead, and are calculated using a conversion factor of 20,000 cells/pmole of PLFA. This conversation factor is based upon cells grown in laboratory media, and varies somewhat with the type of organism and environmental conditions.

What does the concentration of biomass mean?

The overall abundance of microbes within a given sample is often used as an indicator of the potential for bioremediation to occur, but understanding the levels of biomass within each sample can be cumbersome. The following are benchmarks that can be used to understand whether the biomass levels are low, moderate or high.

Low	Moderate	High
10^3 to 10^4 cells	10^5 to 10^6 cells	10^7 to 10^8 cells

How do I know if a change in biomass is significant?

One of the primary functions of using PLFA analysis at contaminated sites is to evaluate how a community responds following a given treatment, but how does one know if the changes observed between two events are significant? As a general rule, biomass levels which increase or decrease by at least an order of magnitude are considered to be significant. However, changes in biomass levels of less than an order of magnitude may still show a trend. It is important to remember that many factors can affect microbial growth, so factors other than the treatment could be influencing the changes observed between sampling events. Some of the factors to consider are: temperature, moisture, pH, etc. The following illustration depicts three types of changes that occurred over time and the conclusions that could be drawn.

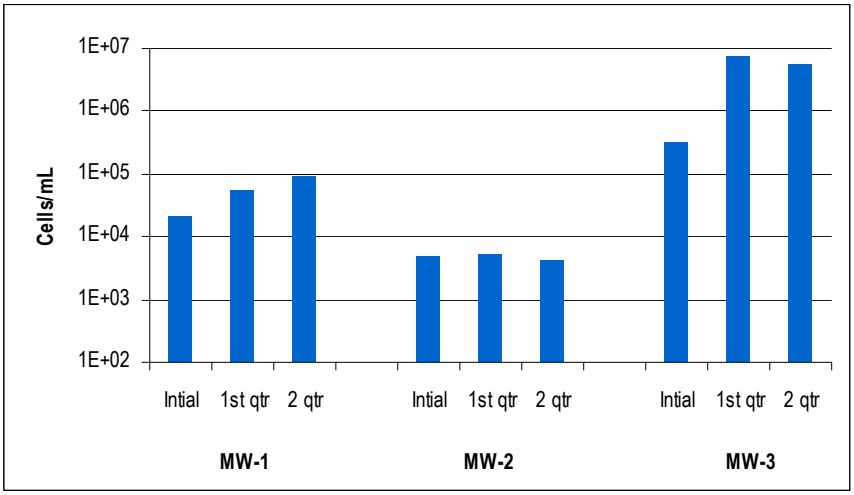

Figure 1. Biomass content is presented as a cell equivalent based on the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Total biomass is calculated based upon PLFA attributed to bacterial and eukaryotic biomass (associated with higher organisms).

Conclusions from graph above:

- MW-1 showed a trend of biomass levels increasing steadily over time, although cell concentrations were ~10^4 cells/mL at each sampling event.
- MW-2 showed no notable trends or significant changes in biomass concentrations.
- MW-3 showed a significant increase in biomass levels between the initial and 1st quarter sampling events (from ~10^5 to ~10^6 cells/mL).

Community Structure:

The PLFA in a sample can be separated into particular types, and the resulting PLFA "profile" reflects the proportions of the categories of organisms present in the sample. Because groups of bacteria differ in their metabolic capabilities, determining which bacterial groups are present and their relative distributions within the community can provide information on what metabolic processes are occurring at that location. This in turn can also provide information on the subsurface conditions (i.e oxidation/reduction status, etc.). Table 1 describes the six major structural groups used and their potential relevance to site specific projects.

Table 1. Description of PLFA structural groups.

PLFA Structural Group	General classification	Potential Relevance to Bioremediation Studies
Monoenoic (Monos)	Abundant in Proteobacteria (Gram negative bacteria), typically fast growing, utilize many carbon sources, and adapt quickly to a variety of environments.	Proteobacteria is one of the largest groups of bacteria and represents a wide variety of both aerobes and anaerobes. The majority of Hydrocarbon utilizing bacteria fall within the Proteobacteria
Terminally Branched Saturated (TerBrSats)	Characteristic of Firmicutes (Low G+C Gram-positive bacteria), and also found in Bacteriodes, and some Gram-negative bacteria (especially anaerobes).	Firmicutes are indicative of presence of anaerobic fermenting bacteria (mainly *Clostridia/Bacteriodes*-like), which produce the H_2 necessary for reductive dechlorination
Branched Monoenoic (BrMonos)	Found in the cell membranes of micro-aerophiles and anaerobes, such as sulfate- or iron-reducing bacteria	In contaminated environments high proportions are often associated with anaerobic sulfate and iron reducing bacteria
Mid-Chain Branched Saturated (MidBrSats)	Common in sulfate reducing bacteria and also Actinobacteria (High G+C Gram-positive bacteria).	In contaminated environments high proportions are often associated with anaerobic sulfate and iron reducing bacteria
Normal Saturated (Nsats)	Found in all organisms.	High proportions often indicate less diverse populations.
Polyenoic	Found in eukaryotes such as fungi, protozoa, algae, higher plants, and animals.	Eukaryotic scavengers will often rise up and prey on contaminant utilizing bacteria

Following are answers to some of the common questions about community composition and some detailed descriptions of some typical shifts which can be observed between sampling events.

How is the community structure data presented?

Community structure data is presented as percentage (%) of the total amount of PLFA. In order to relate the complex mixture of PLFA to the organisms present, the ratio of a specifc PLFA group is determined (detailed in Table 1 above), and this corresponds to the proportion of the related bacterial classification within the overall community structure. Because normal saturated PLFA are found in both prokaryotes (bacteria) and eukaryotes (fungi, protozoa, diatoms etc), their distribution provides little insight into the types of microbes that are present at a sampling location. However, high proportions of normal saturates are often associated with less diverse microbial populations.

How can community structure data be used to manage my site?

It is important to understand that microbial communities are often a mixture of different types of bacteria (e.g. aerobes, sulfate reducers, methanogens, etc) with the abundance of each group behaving like a seesaw, i.e. as the population of one group increases, another is likely decreasing, mostly due to competition for available resources. The PLFA profile of a sample provides a "fingerprint" of the microbial community, showing relative proportions of the specific bacterial types at the time of sampling. This is a great tool for detecting shifts within the community over time and also to evaluate similarities/differences between sampling locations. It is important to note that PLFA analysis of community structure is analyzing the microbes directly, not just secondary breakdown products. So this provides evidence of how the entire microbial community is responding to the treatment.

How do I recognize community shifts and what they mean?

Shifts in the community structure are indications of changing conditions and their effect on the microbial community, and, by extension on the metabolic processes occurring at the sampling location. Some of the more commonly seen shifts within the community are illustrated and discussed below:

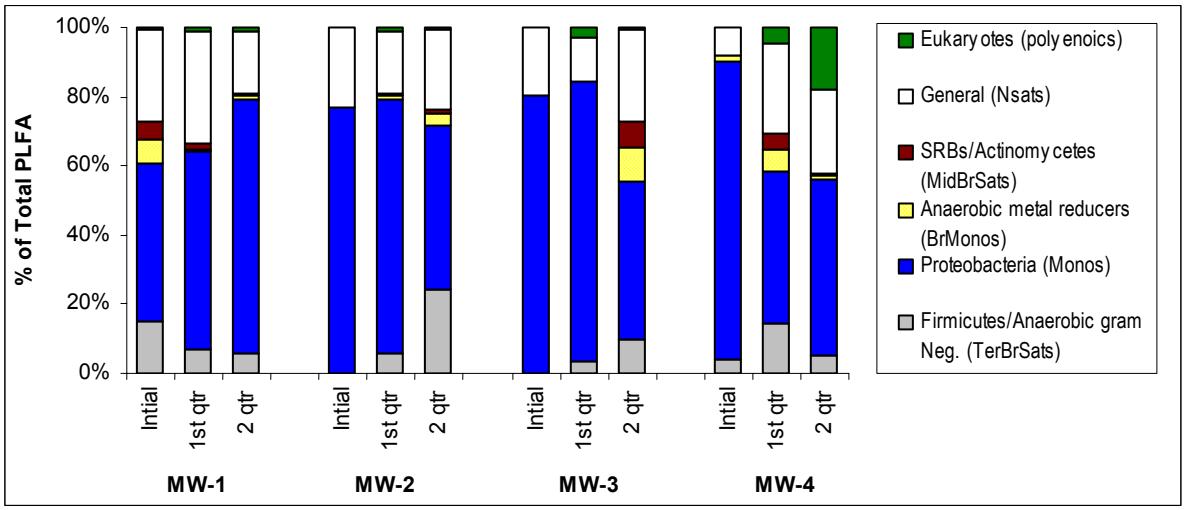

Figure 2. Relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis. See Table 1 for detailed descriptions of structural groups.

- **Increased Proteobacteria**

Proportions of Proteobacteria are of interest because it is one of the largest groups of bacteria and represents a wide variety of both aerobe and anaerobes. The majority of hydrocarbons (including benzene and naphthalene) are metabolized by some member of Proteobacteria, mainly due to their ability to grow opportunistically, quickly taking advantage of available food (i.e. hydrocarbons), and adapting quickly to changes in the environment. The detection of increased proportions of Proteobacteria coupled with increased biomass suggests that the Proteobacteria are consuming something. In situations where it is important to determine the extent to which the Proteobacteria are utilizing anaerobic or aerobic pathways, it is possible to measure relative proportions of specific biomarkers that are associated with anaerobic or aerobic pathways thus separating the Proteobacteria into different groups, based on pathways used. Sample MW-1 from Figure 2 depicts a shift in community structure where the proportion of Proteobacteria has increased over time.

- **Increased Firmicutes/Anaerobic Gram negative bacteria**

Increased proportions of Firmicutes/Anaerobic Gram negative bacteria generally indicate that conditions are becoming more reductive (i.e. more anaerobic). Proportions of Firmicutes are of particular interest in sites contaminated with chlorinated hydrocarbons because Firmicutes include anaerobic fermenting bacteria (mainly *Clostridia/Bacteriodes*-like), which produce the H_2 necessary for reductive dechlorination.

Enhanced bioremediation of chlorinated solvents often employs the injection of fermentable substrates which, when utilized by fermenting bacteria, results in the release of H_2. Engineered shifts in the microbial community can be shown by observing increased proportions Firmicutes following an injection of fermentable substrate. Through long-term monitoring of the community structure it is possible to know when re-injection may be necessary or desirable. Sample MW-2 from Figure 2 depicts a shift in community structure where the proportion of Firmicutes has increased over time.

- **Increased anaerobic metal reducing bacteria (BrMonos) and SRB/Actinomycetes (MidBrSats)**

An increase in the proportions of metal and sulfate reducing bacterial groups, especially when combined with shifts in the other bacterial groups, can provide information helpful to monitoring bioremediation. Generally, an increase in metal and sulfate reducers points to more reduced (anaerobic) conditions at the sampled location. This is especially true if there is an increase in Firmicutes at the same time. Large increases in either metal and sulfate reducers, particularly if accompanied by a decrease in Firmicutes, may suggest that conditions are becoming increasingly reduced. In this situation the metal and sulfate reducers may be out-competing dechlorinators for available H_2, thereby limiting the potential for reductive dechlorination at that location. Sample MW-3 from Figure 2 depicts a shift in community structure where the proportion of metal reducing bacteria has increased over time.

- **Increased Eukaryotes**

Eukaryotes include organisms such as fungi, protozoa, and diatoms. At a contaminated location, an increase in eukaryotes, particularly if seen with a decrease in the contaminant utilizing bacteria, suggests that eukaryotic scavengers are preying upon what had been an abundance of bacteria which were consuming the contaminant. Sample MW-4 from Figure 2 depicts a shift in community structure where the proportion of eukaryotes has increased over time.

Physiological status of Proteobacteria

The membrane of a microbe adapts to the changing conditions of its environment, and these changes are reflected in the PLFA. Toxic compounds or environmental conditions may disrupt the membrane and some bacteria respond by making *trans* fatty acids instead of the usual *cis* fatty acids (7) in order to strengthen the cell membrane, making it less permeable. Many Proteobacteria respond to lack of available substrate or to highly toxic conditions by making cyclopropyl (7) or mid-chain branched fatty acids (20) which point to less energy expenditure and a slowed growth rate. The physiological status ratios for Decreased Permeability (trans/cis ratio) and for Slowed Growth (cy/cis ratio) are based on dividing the amount of the fatty acid induced by environmental conditions by the amount of its biosynthetic precursor.

What does slowed growth or decreased permeability mean?

Ratios for slowed growth and for decreased permeability of the cell membrane provide information on the “health” of the Gram negative community, that is, how this population is responding to the conditions present in the environment. It should be noted that one must be cautious when interpreting these measures from only one sampling event. The most effective way to use the physiological status indicators is in long term monitoring and comparing how these ratios increase/decrease over time.

A marked increase in either of these ratios suggests a change in environment which is less favorable to the Gram negative Proteobacteria population. The ratio for slowed growth is a relative measure, and does not directly correspond to log or stationary phases of growth, but is useful as a comparison of growth rates among sampling locations and also over time. An increase in this ratio (i.e. slower growth rate) suggests a change in conditions which is not as supportive of rapid, “healthy” growth of the Gram negative population, often due to reduced available substrate (food). A larger ratio for decreased permeability suggests that the environment has become more toxic to the Gram negative population, requiring energy expenditure to produce *trans* fatty acids in order to make the membrane more rigid.

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