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FINAL
SITE ASSESSMENT REPORT
NICKEL AREA FUEL FARM
NAVAL AIR STATION
KEFLAVIK, ICELAND
CONTRACT TASK ORDER 0098

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
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EXECUTIVE SUMMARY

A Site Assessment Study was performed at the Nickel Area Fuel Farm (NAFF) U. S. Naval Air Station located in Keflavik, Iceland. The Site Assessment Study was performed to investigate potential petroleum hydrocarbon related contamination in surficial soils at the NAFF. The Naval Air Station is planning to construct a new fuel storage facility to better accommodate Air Station fueling needs, therefore, the NAFF has been scheduled for demolition. Assessment activities followed regulatory guidelines of the North Carolina Department of Environment, Health and Natural Resources Division of Environmental Management (DEM), due to their stringent nature, and U.S. EPA as required under the Scope of Work.

The field investigation activities commenced on April 13, 1992, and continued through April 16, 1992. Site investigation activities included reviewing background information, performing a site survey, conducting test pit excavations and soil sampling, and field screening for volatile organic compounds (VOCs).

Chemical analyses performed on the selected soil samples indicated that total petroleum hydrocarbons (TPHs) exceed the State of North Carolina action level of 10 mg/kg in three distinct areas of the NAFF (Tank Areas: 1302, 1305, and 1311). In addition to TPH, minor concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) and lead were also detected in surficial soils.

Dermal contact with soil, soil ingestion and inhalation of particulates are the primary exposure pathways of concern at the NAFF. Since vegetation in the area is sparse, there is the potential for exposure via the pathways mentioned above. In addition, none of the aboveground tanks are built on concrete pads or any other type of structural base to reduce the potential for tank leakage to contaminate the surficial soils.

Based on site assessment results, remediation of the surficial soils exhibiting elevated TPH concentrations in Tank Areas 1302, 1305, and 1311 is recommended. Based on the extent and nature of detected contaminants, excavation followed by verification sampling and on-base bioremediation is the recommended likely remediation technology.

1.0 INTRODUCTION

A site assessment was conducted by Baker Environmental, Inc. (Baker) at the Nickel Area Fuel Farm, U.S. Naval Air Station located in Keflavik, Iceland in order to investigate potential petroleum hydrocarbon related contamination in the surficial soils. The Nickel Area Fuel Farm is shown on Figure 1.

The specific objectives of the site assessment were to determine the extent and severity of potential petroleum hydrocarbon contamination in surficial soils via test pitting and sampling, perform a qualitative risk assessment of available analytical data, and evaluate potential remediation alternatives based on investigation results. The work conducted for this project followed, as possible, State of North Carolina Guidelines: (1) Comprehensive Site Assessments at UST Sites: "Basic Tanks and Minimal Elements;" and (2) "Guidelines for Remediation of Soil Contaminated by Petroleum." (per LANTDIV direction).

Field activities commenced on April 13, 1992, and continued through April 16, 1992, as required under the Scope of Work. These activities included background information review, a site survey, test pit excavation, soil sampling, and field screening for volatile organics. Appendix A contains the Project Work Plan and Site Specific Health and Safety Plan.

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2.0 SITE DESCRIPTION/HISTORY

The Naval Air Station, Keflavik supports each North Atlantic Treaty Organization (NATO) unit assigned to Iceland and is responsible as the NATO defense force for the security and defense of Iceland. The base was established in 1941.

In order to support the mission of the Naval Air Station, the Nickel Area Fuel Farm (NAFF) was constructed. The NAFF currently consists of 13 fuel tanks. Details of these tanks are shown on Table 2-1. As noted on Table 2-1, two fuel tanks (numbers 1300 and 1302) have previously been removed.

Fuel is conveyed via aboveground and below ground fuel pipelines. Other site structures include ten fuel pumphouses, various support buildings, overhead/underground electrical distribution lines, and underground water lines/aboveground hydrant system.

The NAFF site covers approximately 400 acres and is surrounded by a seven-foot chain link fence. The NAFF site is shown on Figure 1.

As the Naval Air Station is constructing a new fuel storage facility to accommodate Air Station fueling needs, the NAFF is scheduled for demolition. Appendix B contains the Demolition Basis of Design proposed for the NAFF site. Additional site specific information is discussed herein.

TABLE 2-1
NAFF TANK SUMMARY

Tank Number	Construction	Size	Contents
1300	Steel, (Removed)	15,000 Barrel	Diesel
1302	Steel, (Removed)	25,000 Barrel	JP-5
1305	Steel, Aboveground	5,000 Barrel	MOGAS
1306	Steel, Aboveground	10,000 Barrel	JP-5
1311	Steel, Aboveground	25,000 Barrel	JP-5
1326	Steel, Aboveground	40,000 Barrel	JP-5
1330	Steel, Aboveground	40,000 Barrel	JP-5
1331	Steel, Semi-buried	25,000 Barrel	JP-5
1333	Steel, Semi-buried	25,000 Barrel	JP-5
1335	Steel, Semi-buried	25,000 Barrel	JP-5
1337	Steel, Semi-buried	25,000 Barrel	JP-5
1341	Steel, Semi-buried	25,000 Barrel	JP-5
1343	Steel, Semi-buried	25,000 Barrel	JP-5
1345	Steel, Semi-buried	15,000 Barrel	JP-5
1346	Steel, Semi-buried	15,000 Barrel	JP-5

3.0 LOCAL LAND USE/SITE UTILITIES

The NAFF is located in the northeast section of the Naval Air Station. The fuel farm is bordered to the west/southwest by Reykjanes Road. The fuel farm is approximately 400 acres in size and access to the site is limited. A guarded fence surrounds the fuel farm and there are only two access gates in which clearance is required to enter.

3.1 Local Land Use

On May 5, 1992, Baker contacted Mr. Haukuu Saeraldsson, Activity Contact, regarding information on local land use. Mr. Saeraldsson was unaware of any potential effects of local land use other than the NAFF site. Mr. Saeraldsson referred Baker to Mr. Ingolfur Eyfells (Activity PWD Engineering Division) for additional information. Mr. Eyfells indicated that land use adjacent to the NAFF site is primarily residential and that effects of local land use do not appear to influence the NAFF site. Investigation results including site reconnaissance and sample analyses indicate soil contamination detected on-site is the result of NAFF activities.

In addition to military activities at the Naval Air Station, local land use in the subject area consists of mixed residential and light industry. Immediately north and to the east are local residential areas along with light industrial facilities. South of the fuel farm lies military residential areas, some of which are currently under construction.

Effects of local land use do not appear to influence the NAFF site. No potential off-site contamination sources have been identified or reported as being associated with NAFF site conditions.

3.2 Site Utilities

The NAFF is accommodated by several types of service utilities including: aboveground/below ground fuel distribution pipelines, overhead/underground electrical distribution lines, and underground water lines, one supporting an aboveground hydrant system and the other accommodating water supply needs. Figure 1 indicates fuel distribution pipelines and overhead electric line pole positions.

Aboveground and underground fuel distribution lines convey product to surrounding pumphouses, filter separators, truck fill stands and transfer stations throughout the NAFF area. Fuel distribution lines and related support structures are shown on Figure 1.

A significant amount of electrical distribution lines exist at the NAFF. Both overhead electrical distribution and supplemental underground electrical distribution lines accommodate the NAFF operation (see Figure 1 for electrical pole positions).

Non-potable and potable water lines are reported to exist at the NAFF. An underground 10-inch water supply line and an underground 8-inch water distribution line (with aboveground fire hydrants) are currently in service. These lines reportedly parallel the fuel distribution lines which distribute fuel from the NAFF to the main portion of the base (see Figure 1).

4.0 SITE TOPOGRAPHY AND SURFACE WATER FEATURES

4.1 Site Topography

The NAFF site is situated on a lava plane engineered to be relatively topographically flat. In general, the area slopes to the east towards Keflavik. Bermed or mounded areas around individual fuel tanks provide the most significant relief in the NAFF area. Minor drainage ways along NAFF roadways are also present. Terrain of the Naval Air Station ranges from 130 to 160 feet above sea level.

In addition to developed topographic features, normal fluvial action, wind, ice, and groundwater have all played a role in the sculpture of the land. As Iceland lies along the border of a tundra vegetation zone of treeless plains and one of coniferous forests, vegetative cover in the subject area is sparse. Ground cover is mainly limited to well adapted indigenous vegetation.

4.2 Surface Water

No major streams, rivers, or other surface water impoundments were observed at the NAFF area. However, surface water runoff, in part, is accommodated via drainage ways spanning parallel to various roadways within the NAFF. Although the exact drainage network was not surveyed, it appears that surface water runoff flows to the east following the general topographic slope towards Keflavik. Due to the relatively porous nature of site soils, somewhat rapid precipitation infiltration rates are expected in this area.

5.0 SITE SOILS AND GEOLOGY

5.1 Site Soils

Soils at the Naval Air Station consist of select fill and mineral and organic soil units. Soil layers are relatively thin and are underlain by basalt rock associations.

Fill materials used at the base commonly consist of volcanic rock/ash, graded aggregate and cobbles. These materials are used during area development activities.

The mineral soils are basically loess, a light to dark brown loam. Clay, sand and silt content vary considerably. Moisture content varies from damp to moist. Soils are typically loose to moderately dense.

Organic soils include primarily lithosoils. Most of the soils in this association are shallow and stoney. Organic soils are primarily found in depressions and wet slopes.

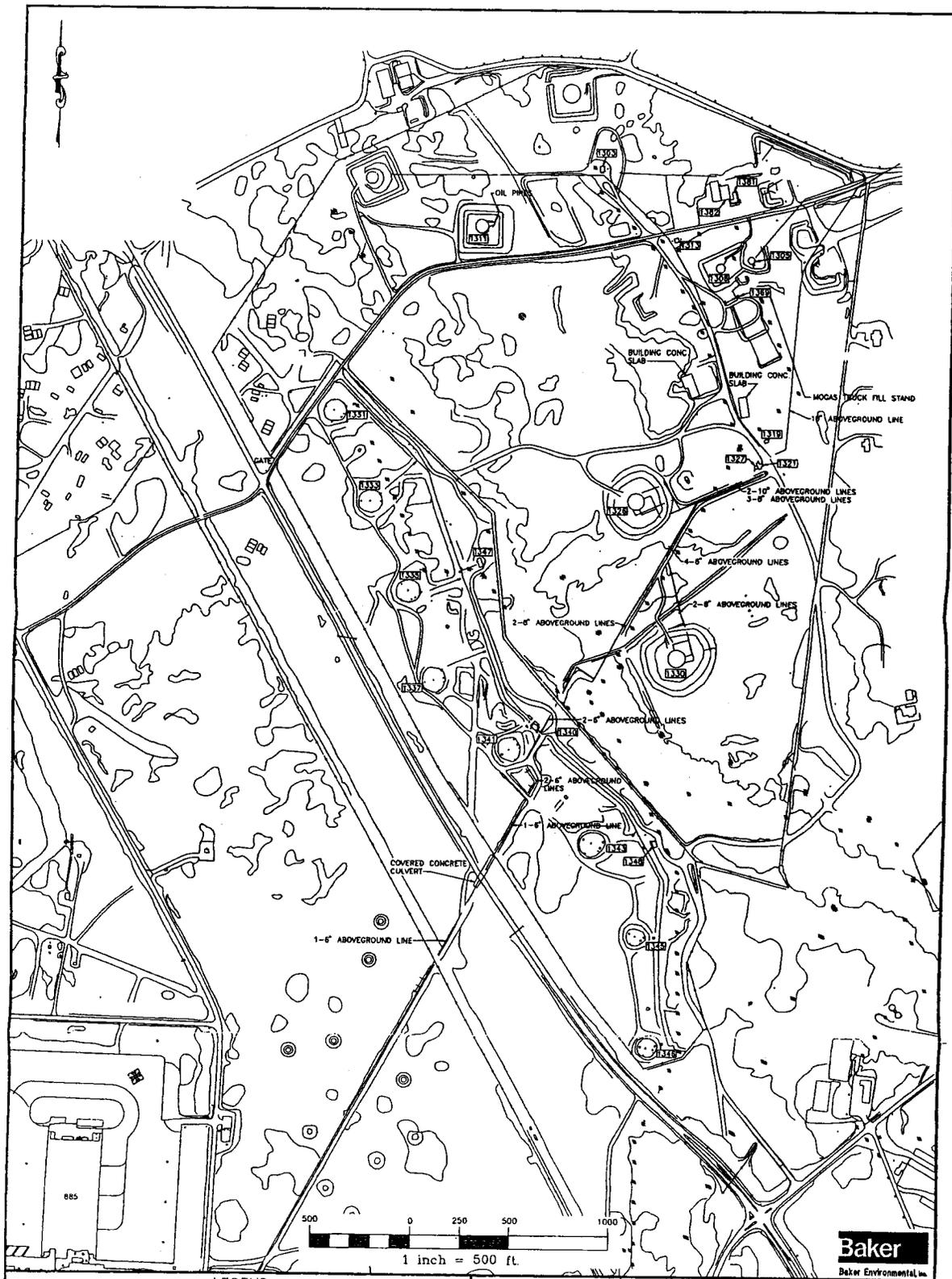
In Iceland, the soil structure is typically weak and poorly developed, thus making it susceptible to prevailing winds. The pattern of soil distribution is complex and different soils may be found over short distances. The soils often exhibit the effects of frost action, such as stone rings hummocks, earth waves, or fissures.

5.2 Site Geology

The Naval Air Station is located atop a lava plane considered to be a part of the Russo-Siberian platform. During investigation activities, volcanic rock was encountered from one to four feet below ground surface.

Lithology descriptions in this area typically include a light grey to black basalt and reddish scoria. Top of rock is visually weathered and loose. Fractured basalt and scoria is common through out this area. The volcanic rock is reported to become more competent with depth (five to ten feet) (REWAI, 1988 and Oxford University Press, 1939).

Based on existing groundwater information the water table surface is typically encountered approximately 50 feet below ground surface. The aquifer is considered to be unconfined. Both



1-2

• ELECTRIC POLE
 — FENCE

LEGEND

FIGURE 1
 SITE LOCATION MAP
 NICKEL AREA FUEL FARM
 NAVAL AIR STATION
 KEFLAVIK, ICELAND



primary and secondary porosity are exhibited by the basalt and scoria bedrock. Groundwater flow is reportedly to the east towards Keflavik.

Water quality is reported to decrease with depth. The percentage of salinity begins to increase significantly at a depth of approximately 180 feet below ground surface (REWAI, 1988). Groundwater investigation activities were not included under the scope of this assessment.

5.3 Test Pit Excavation Activities

5.3.1 General

Baker Environmental, Inc., (Baker) conducted a field investigation of the Nickel Fuel Farm between April 12 and 16, 1992. This investigation consisted of excavation of test pits to varying depths of less than about 4 feet below land surface, visual examination and description of the exposed cross-section of each pit, and sampling of soils for analysis of a variable list of pit, and sampling of soils for analysis of a variable list of chemical and physical parameters. The list of chemical analyses included:

TPH	-	total petroleum hydrocarbon compounds	44 stations
BETX	-	benzene, ethylbenzene, toluene and xylenes	28 stations
Pb	-	lead	24 stations
F	-	flashpoint	11 stations
M	-	moisture content	11 stations
pH	-	hydrogen activity	11 stations
G	-	grain-size analysis	3 stations

Appendix A contains the approved Work Plan for these activities.

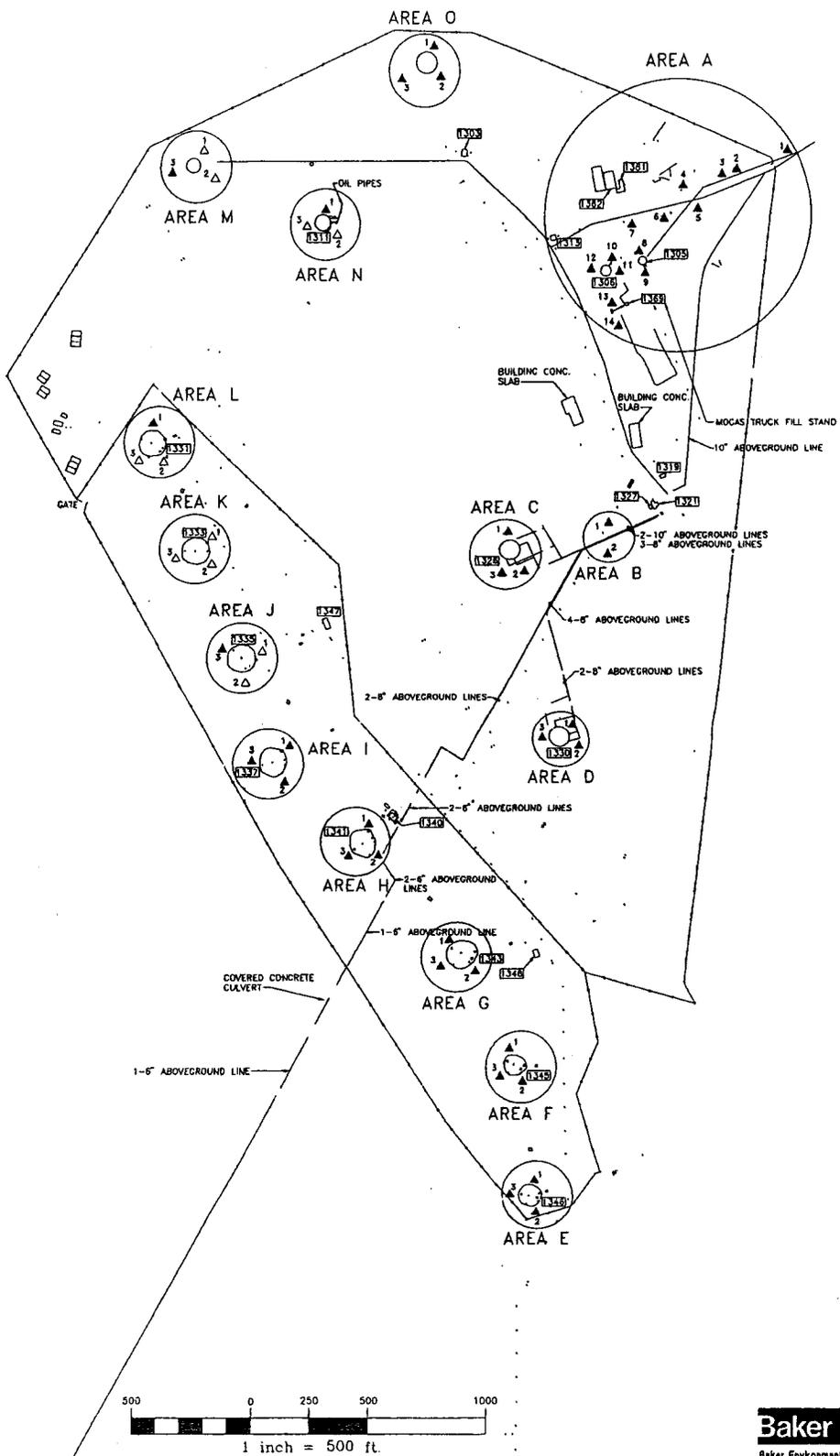
Baker was assisted by the base support contractor on April 14, 15 and 16, with that operator on standby for April 13. The operator supplied by the contractor excavated test pits at a total of

44 separate stations; the majority of these pits were closed on or before April 16. The completed logs of the visual descriptions of the test pits occupy Appendix C.

Relatively small excavations were utilized to remove sections of soil, for a detailed examination of soil characteristics (horizontal structures, color, etc.). Prior to excavation all sampling locations were cleared of utility lines and poles (subsurface, as well as above surface). The backhoe was utilized to excavate test pits to approximately three (3) feet in width and depth. A shovel was used to remove a 1-to 2-inch layer of soil from the vertical face of the pit where sampling was performed. Samples were obtained using a stainless steel trowel at the desired intervals, and a portion placed in the appropriate labeled container. Upon completion of sampling activities the test pits were backfilled.

As illustrated on Figure 2, test pit locations were grouped into areas (A through O) in order to address specific tanks/structures. Table 5-1 indicates the detected concentrations of volatile organic compounds, the depth of sampling, the identification number of the closest storage tank and a brief description of the sampling interval. The results of the analyses are discussed below in Section 6.0.

An Hnu photoionization detector was utilized to monitor volatile organic releases. As detailed in the work plan, Hnu readings were used for health and safety monitoring and identification of potential soil sample locations. Table 5-1 indicates that only 9 test pits exhibited field detections of volatile organic compounds. The majority of the readings were between one and two ppm. Stations indicating concentrations of volatile organic compounds were: A6 - 1 ppm; A7 - 1 ppm; A9 - >5; C2 - 2; D2 - 2; F2 - 2; F3 - 1; G1 - 1; and O2 - 1.



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LEGEND

- ▲ - TEST PIT LOCATION (APPROXIMATE)
- △ - TEST PIT NOT SAMPLED

FIGURE 2
TEST PIT LOCATION MAP
NICKEL AREA FUEL FARM
NAVAL AIR STATION
KEFLAVIK, ICELAND

5-4

TABLE 5-1
 SOIL SCREENING RESULTS (PID)
 TEST PITS
 NICKEL AREA FUEL FARM NAVAL AIR STATION
 KEFLAVIK, ICELAND

Sample Location	PID Reading (ppm)	Sample Depth (inches)	Tank No.	Comments
TP-A1	BG	14 - 19		Clayey, sandy silt
TP-A2	BG	20 - 24		Silty, sandy clay
TP-A3	BG	14 - 20		Silty, clayey sand
TP-A4	BG	22 - 28		Clayey, sandy silt
TP-A5	BG	14 - 21		Clayey, silty sand
TP-A6	1	18 - 28		Silty, clayey sand
TP-A7	1	19 - 22		Clayey, silty sand
TP-A8	BG	20 - 26	1305	Clay, silt, sand
TP-A9	5	12 - 20	1305	Strong odor of petroleum Silt, clay, sand, cobble fill
TP-A10	BG	8 - 14	1306	Clay, silt, sand, cobble loam
TP-A11	BG	6 - 14	1306	Clay, silt, sand, cobble
TP-A12	BG	15 - 23	1306	Clay, silt, sand
TP-A13	BG	10 - 16		Clayey, silty, sandy cobble loam
TP-A14	BG	24 - 31		Clay, silt, sand, cobble
TP-B1	BG	11 - 13		Clayey, silty sand
TP-B2	BG	6 - 10		Clay, silt, sand loam
TP-C1	BG	9 - 12	1326	Clayey, silty, sandy gravel
TP-C2	2	4 - 8	1326	Clay, silt, sand, cobble
TP-C3	BG	4 - 8	1326	Silt, clay, sand, cobble
TP-D1	BG	4 - 8	1330	Clayey, silty sand
TP-D2	2	3 - 6	1330	Clay, silt, sand, gravel
TP-D3	BG	4 - 8	1330	Clay, silt, sand, cobble

TABLE 5-1 (Continued)

**SOIL SCREENING RESULTS (PID)
TEST PITS
NICKEL AREA FUEL FARM NAVAL AIR STATION
KEFLAVIK, ICELAND**

Sample Location	PID Reading (ppm)	Sample Depth (inches)	Tank No.	Comments
TP-E1	BG	6 - 9	1346	Clayey, silty sand
TP-E2	BG	6 - 14	1346	Clayey, silty sand
TP-E3	BG	17 - 22	1346	Clayey, silty sand
TP - F1	BG	9 - 13	1345	Clayey, silty sand
TP - F2	2	12 - 19	1345	Clayey, silty sand
TP-F3	1	8 - 13	1345	Clayey, silty sand
TP-G1	1	18 - 22	1343	Clay, silt, sand, cobble
TP-G2	BG	9 - 13	1343	Clay, silt, sand, cobble
TP-G3	BG	16 - 20	1343	Clay, silt, sand, cobble
TP-H1	BG	10 - 18	1341	Clay, silt, sand, cobble
TP-H2	BG	10 - 15	1341	Clay, silt, sand, cobble
TP-H3	BG	13 - 16	1341	Clayey, silty sand
TP-I1	BG	12 - 14	1337	Clayey, silty sand
TP-I2	BG	18 - 22	1337	Clay, silt, sand, cobble
TP-I3	BG	14 - 16	1337	Clay, silt, sand, cobble
TP-J3	BG	8 - 19	1335	Clayey, silty sand
TP-L1	BG	6 - 15	1331	Clay, silt, sand, cobble
TP-M3	BG	7 - 13		Clayey, silty, sandy cobble
TP-N1	BG	3 - 8	1311	Clay, silt, sand, cobble
TP-O1	BG	4 - 11		Clayey, silty, sandy cobble
TP-O2	1	10 - 15		Clay, silt, sand, cobble
TP-O3	BG	3 - 10		Clay, silt, sand, cobble

Notes: PID = Photoionization detector
 PPM = Parts per million
 BG = Background
 Blank = Not associated with a tank

6.0 EXTENT OF CONTAMINATION

6.1 Soil Sample Collection

In order to estimate the extent of potentially contaminated soils, one grab sample was obtained from each test pit location and submitted for selected chemical analyses. All samples selected for chemical analyses were taken from depths ranging from 3 inches to 31 inches. Samples were collected based on readings obtained from an Hnu photoionization detector (PID), visual observation or the point of soil rock interface (bucket refusal).

Each sample collected was transferred into a laboratory-prepared bottle, properly labeled and stored on ice. The samples were transported via Federal Express to Solutions Laboratories, Inc., in Chesapeake, Virginia, for analysis. The analyses were performed according to the following methods: total petroleum hydrocarbons (TPH) EPA Method 8015/3550; BTEX EPA Method 8020; pH Method SW-9045; Flashpoint Method SW-1010; Lead (Total) Method SW-239.2; Moisture Content SW-160.3 and Grain Size ASTM D-422. Appropriate Chain-of-Custody documentation accompanied the samples to the laboratory. Additional details on soil sampling procedures and sample preparation are provided in Appendix A. Copies of the actual chain-of-custody forms are provided in Appendix D.

6.2 Analytical Results

Analytical results of soil samples collected at the NAFF are presented on Tables 6-1 through 6-8. Analyses were performed by Solutions Laboratories, Inc., Chesapeake, Virginia via a basic ordering agreement under Navy CLEAN's UST Program. Tables 6-1 through 6-7 group test pit sample analytical results into areas from which test pits were located. TPH, BTEX, lead (total), flashpoint, pH, and moisture content parameter results are included. Table 6-8 contains analytical results of grain size for selected test pit areas. Figure 3 depicts concentrations of detected constituents for each sample point.

A laboratory prepared report containing analytical methods/results, detection limits, QA/QC information and chain-of-custody forms is contained in Appendix D. The following section details analytical findings and the extent of soil contamination.

TABLE 6-1
TEST PIT AREAS A-1 THROUGH A-16

TEST PIT AREA	A-1	A-2	A-3	A-4
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-57	19098-1/2/3	19098-58	19098-4/5/6
LAB SAMPLE NO.	20A1	01A1/A2/A3	21A1	02A1
SAMPLE DEPTH (INCHES)	14-19	20-24	14-16	22-28
DATE COLLECTED	4/15/92	4/14/92	4/15/92	4/14/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES				
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	2.85	2.85	2.85
	U	5.78	3.72	2.85
				U
BTEX:				
benzene	-	0.002	-	0.002
toluene	-	0.002	-	0.002
ethylbenzene	-	0.002	-	0.002
xylenes, total	-	0.004	-	0.004
flashpoint (Fahrenheit)	-	>140	-	>140
pH	-	6.37	-	6.05
lead (total)	-	15.76	-	2.96
moisture content (%)	-	39.11	-	43.55

Notes:

mg/kg - milligram/kilogram

(-) - not analyzed

> - greater than

MDL - method detection limit

CONCEN. - concentration

Qualifiers:

U - analyzed for but not

detected

J - estimated value

TABLE 6-1
(cont.)
TEST PIT AREAS A-1 THROUGH A-16

TEST PIT AREA	A-5	A-6	A-7	A-16
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-59/60/61	19098-62	19098-63/64/65	19098-66
LAB SAMPLE NO.	22A1	23A1	24A1/A2/A3	25A1
SAMPLE DEPTH (INCHES)	14-21	18-28	19-22	19-22
DATE COLLECTED	4/15/92	4/15/92	4/15/92	4/15/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES				DUPLICATE OF A-7
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	1.29 J	2.85	2.47 J
		4.26	2.85	2.85 U
BTEX:				
benzene	0.002	0.002 U	0.002	0.002 U
toluene	0.002	0.00107 J	0.002	0.002 U
ethylbenzene	0.002	0.002 U	0.002	0.002 U
xylenes, total	0.004	0.004 U	0.004	0.004 U
flashpoint (Fahrenheit)	-	-	-	-
pH	-	-	-	-
lead (total)	0.005	49.76	0.005	8.2
moisture content (%)	-	-	-	-

Notes:
 mg/kg - milligram/kilogram
 (-) - not analyzed
 > - greater than
 MDL - method detection limit
 CONCEN. - concentration
 Qualifiers:
 U - analyzed for but not detected
 J - estimated value

TABLE 6-1
(cont.)
TEST PIT AREAS A-1 THROUGH A-16

TEST PIT AREA	A-8	A-9	A-10	A-15
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-67	19098-68/69/70	19098-8/9/10	19098-11/12/13
LAB SAMPLE NO.	26A1	27A1/A2/A3	03A1/A2/A3	04A1/A2/A3
SAMPLE DEPTH (INCHES)	20-26	12-20	8-14	8-14
DATE COLLECTED	4/15/92	4/15/92	4/14/92	4/14/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES				DUPLICATE OF A-10
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85 1.48 J	2.85 6454	2.85 2.85 U	2.85 2.85 U
BTEX:				
benzene	-	0.01 0.01 U	0.002 0.002 U	0.002 0.002 U
toluene	-	0.01 0.01 U	0.002 0.002 U	0.002 0.00485 U
ethylbenzene	-	0.01 0.01 U	0.002 0.002 U	0.002 0.002 U
xylenes, total	-	0.02 0.0234	0.004 0.004 U	0.004 0.004 U
flashpoint (Fahrenheit)	-	-	20 >140	20 >140
pH	-	-	- 6.11	- 6.49
lead (total)	-	0.005 7.9	0.005 25.04	- -
moisture content (%)	-	-	- 23.91	- -

Notes:
mg/kg - milligram/kilogram
(-) - not analyzed
> - greater than
MDL - method detection limit
CONCEN. - concentration
Qualifiers:
U - analyzed for but not detected
J - estimated value

TABLE 6-1
(cont.)
TEST PIT AREAS A-1 THROUGH A-16

TEST PIT AREA	A-11	A-12	A-13	A-14
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-71	19098-72	19098-15/16/17	19098-73
LAB SAMPLE NO.	28A1	29A1	05A1/A2/A3	30A1
SAMPLE DEPTH (INCHES)	6-14	15-23	10-16	24-31
DATE COLLECTED	4/15/92	4/15/92	4/14/92	4/15/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES				
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85 U	2.85 U	2.85 U	2.85 U
BTEX:				
benzene	-	-	0.002 U	-
toluene	-	-	0.002 U	-
ethylbenzene	-	-	0.002 0.00215	-
xylenes, total	-	-	0.004 U	-
flashpoint (Fahrenheit)	-	-	20	-
pH	-	-	-	-
lead (total)	-	-	6.57	-
moisture content (%)	-	-	0.005 13.97	-
	-	-	13.1	-

Notes:
 mg/kg - milligram/kilogram
 (-) - not analyzed
 > - greater than
 MDL - method detection limit
 CONCEN. - concentration
 Qualifiers:
 U - analyzed for but not detected
 J - estimated value

TABLE 6-2
TEST PIT AREAS B-1, B-2 AND C-1 THROUGH C-3

TEST PIT AREA	B-1	B-2	C-1	C-2	C-3
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-74	19098-18/19/20	19098-75	19098-24/25/26	19098-76/77/78
LAB SAMPLE NO.	31A1	06A1/A2/A3	32A1	08A1/A2/A3	33A1/A2/A3
SAMPLE DEPTH (INCHES)	11-13	6-10	9-12	4-8	4-8
DATE COLLECTED	4/15/92	4/14/92	4/15/92	4/14/92	4/15/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES					
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	2.85 U	2.85	2.85 U	2.85 U
BTEX:					
benzene	-	0.002	-	0.002	0.002 U
toluene	-	0.002	-	0.002	0.002 U
ethylbenzene	-	0.002	-	0.002	0.002 U
xylenes, total	-	0.004	-	0.004	0.004 U
flashpoint (Fahrenheit)	-	20	-	20	-
pH	-	6.56	-	6.48	-
lead (total)	-	2.73	-	187.1	0.005
moisture content (%)	-	9.67	-	11.37	-

Notes:

mg/kg - milligram/kilogram

(-) - not analyzed:

> - greater than

MDL - method detection limit

CONCEN. - concentration

Qualifiers:

U - analyzed for but not

detected

J - estimated value

TABLE 6-3
TEST PIT AREAS D-1 THROUGH D-3 AND E-1 THROUGH E-3

TEST PIT AREA	D-1	D-2	D-3	E-1	E-2	E-3
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-79	19098-80/81/82	19098-21/22/23	19098-83	19098-27/28/29	19098-84
LAB SAMPLE NO.	34A1	35A1/A2/A3	07A1/A2/A3	36A1	09A1/A2/A3	37A1
SAMPLE DEPTH (INCHES)	4-8	3-6	4-8	6-9	6-14	17-22
DATE COLLECTED	4/15/92	4/15/92	4/14/92	4/15/92	4/14/92	4/15/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES						
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	2.85 U	2.85 U	2.85 U	2.85 U	2.85 U
BTEX:						
benzene	-	0.002 U	0.002 U	-	0.002 U	-
toluene	-	0.002 U	0.002 U	-	0.002 U	-
ethylbenzene	-	0.002 U	0.002 U	-	0.002 U	-
xylenes, total	-	0.004 U	0.004 U	-	0.004 U	-
flashpoint (Fahrenheit)	-	-	20	-	20	-
pH	-	-	> 140	-	> 140	-
lead (total)	-	-	6.58	-	-	-
moisture content (%)	-	0.005	27.99	-	0.005	-
			11.07			

Notes:

mg/kg - milligram/kilogram

(-) - not analyzed

> - greater than

MDL - method detection limit

CONCEN. - concentration

Qualifiers:

U - analyzed for but not

detected

J - estimated value

TABLE 6-4
TEST PIT AREAS F-1 THROUGH F-4 AND G-1 THROUGH G-3

TEST PIT AREA	F-1	F-2	F-4	F-3	G-1	G-2	G-3
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-85	19098-86/87/88	19098-89/90	19098-91	19098-92	19098-93/94/95	19098-96
LAB SAMPLE NO.	38A1	39A1/A2/A3	40A1	41A1	42A1	43A1/A2/A3	44A1
SAMPLE DEPTH (INCHES)	9-13	12-19	12-19	8-13	18-22	9-13	16-20
DATE COLLECTED	4/15/92	4/15/92	4/15/92	4/15/92	4/15/92	4/16/92	4/16/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES			DUPLICATE OF F-2				
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	2.85 U	2.85 U	2.85 J	2.85 U	2.85 U	2.85 U
BTEX:							
benzene	-	0.002	0.00141 J	-	-	0.002	-
toluene	-	0.002	0.002 U	-	-	0.002	-
ethylbenzene	-	0.002	0.002 U	-	-	0.002	-
xylenes, total	-	0.004	0.004 U	-	-	0.004	-
flashpoint (Fahrenheit)	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-
lead (total)	-	0.005	0.005	3.1	-	0.005	4.22
moisture content (%)	-	-	-	-	-	-	-

Notes:

mg/kg - milligram/kilogram

(-) - not analyzed

> - greater than

MDL - method detection limit

CONCEN. - concentration

Qualifiers:

U - analyzed for but not

detected

J - estimated value

TABLE 6-6
TEST PIT AREAS I-1 THROUGH I-4 AND J-3

TEST PIT AREA	I-1	I-2	I-4	I-3	J-3	L-1
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-101	19098-102/103/104	19098-105	19098-106	19098-37/38/39	19098-40/41/42
LAB SAMPLE NO.	47A1	48A1/A2/A3	50A1	50A1	12A1/A2/A3	13A1/A2/A3
SAMPLE DEPTH (INCHES)	12-14	18-22	18-22	14-16	8-19	6-15
DATE COLLECTED	4/16/92	4/16/92	4/16/92	4/16/92	4/14/92	4/14/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES		DUPLICATE OF I-2				
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85 U	2.85 U	-	2.85 U	2.85 J	2.85 U
BTEX:						
benzene	-	0.002 U	0.002 U	-	0.002 U	0.002 U
toluene	-	0.002 U	0.002 U	-	0.002 U	0.002 U
ethylbenzene	-	0.002 U	0.002 U	-	0.002 U	0.002 U
xylenes, total	-	0.004 U	0.004 U	-	0.004 U	0.004 U
flashpoint (Fahrenheit)	-	-	-	-	20	> 140
pH	-	-	-	-	-	6.37
lead (total)	-	0.005	6.18	-	0.005	8.1
moisture content (%)	-	-	-	-	-	18.51

Notes:
 mg/kg - milligram/kilogram
 (-) - not analyzed
 > - greater than
 MDL - method detection limit
 CONCEN. - concentration
 Qualifiers:
 U - analyzed for but not detected
 J - estimated value

TABLE 6-7
TEST PIT AREAS M-3, N-1, N-4 AND O-1 THROUGH O-3

TEST PIT AREA	M-3	N-1	N-4	O-1	O-2	O-3
SAMPLE MEDIUM	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-47/48/49	19098-43/44/45	19098-46	19098-50/51/52	19098-56	19098-53/54/55
LAB SAMPLE NO.	16A1/A2/A3	14A1/A2/A3	15A1	17A1/A2/A3	19A1	18A1/A2/A3
SAMPLE DEPTH (INCHES)	7-13	3-8	3-8	4-11	10-15	3-10
DATE COLLECTED	4/14/92	4/14/92	4/14/92	4/14/92	4/14/92	4/14/92
CONCENTRATION UNITS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BLANKS OR DUPLICATES			DUPLICATE OF N-1	4-11	10-15	3-10
CHEMICAL	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.	MDL CONCEN.
TPH	2.85	2.85 U	2.85	2.85	2.85	2.85
		115.58	51.07	336.98	2.85	2.85
BTEX:						
benzene	0.002	0.002 U	0.002	0.002	0.00043 J	0.002
toluene	0.002	0.00507	0.002	0.002	0.002 U	0.002
ethylbenzene	0.002	0.002 U	0.002	0.002	0.002 U	0.002
xylenes: total	0.004	0.004 U	0.004	0.004	0.004 U	0.004
flashpoint (Fahrenheit)	-	-	-	-	-	-
pH	-	-	-	-	-	-
lead (total)	0.005	31.33	0.005	20.22	-	0.005
moisture content (%)	-	-	-	-	-	-
						2.85
						2.85
						0.002
						0.002
						0.002
						0.004
						-
						-
						3.77

Notes:
 mg/kg - milligram/kilogram
 (-) - not analyzed
 > - greater than
 MDL - method detection limit
 CONCEN. - concentration
 Qualifiers:
 U - analyzed for but not detected
 J - estimated value

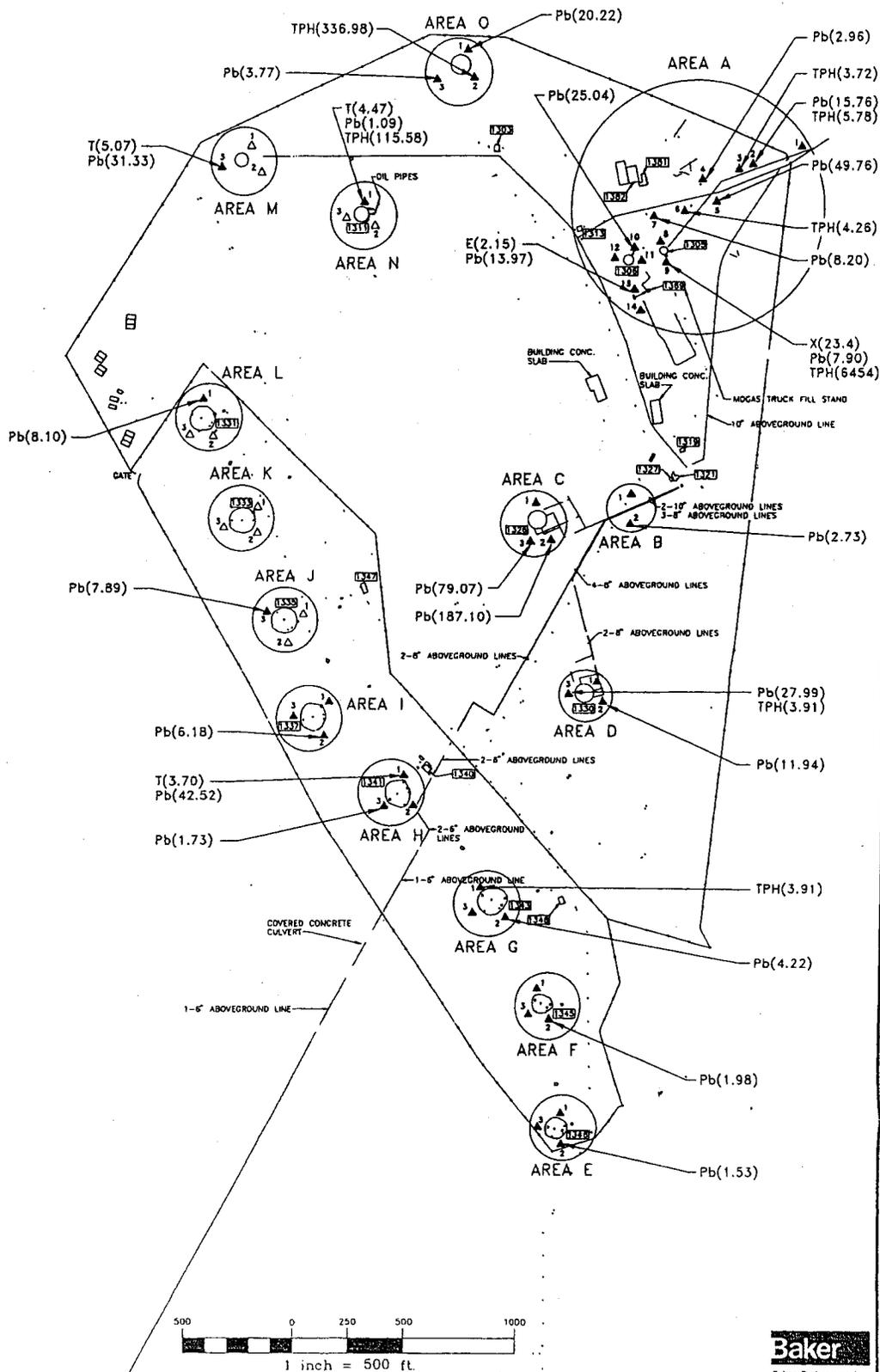
TABLE 6-8
GRAIN SIZE RESULTS
TEST PIT AREAS A-4, A-10 AND H-1

TEST PIT AREA	A-4	A-10	H-1
SAMPLE MEDIUM	SOIL	SOIL	SOIL
BAKER SAMPLE NO.	19098-7	19098-14	19098-33
LAB SAMPLE NO.	02A4	03A4	10A4
SAMPLE DEPTH (INCH)	22-28	8-14	10-18
DATE COLLECTED	4/14/92	4/14/92	4/14/92
% PASSING SIEVE OF:			
4.75 MM	4.93	6.81	1.76
2.36 MM	8.76	8.24	12.79
1.18 MM	5.05	8.36	6.67
841 microns	36.11	7.8	4.32
595 microns	0.2	17.31	19.89
300 mm	36.4	17.09	22.5
150 mm	6.51	6.89	12.26
75 mm	1.02	1.06	19.2

Notes:

MM - millimeters

mm - micrometers



LEGEND

- ▲ - TEST PIT LOCATION (APPROXIMATE)
- △ - TEST PIT NOT SAMPLED
- T(4.47) - TOLUENE (ug/kg)
- E(2.15) - ETHYLBENZENE (ug/kg)
- X(23.4) - XYLENES (ug/kg)
- Pb(2.96) - LEAD (mg/kg)
- TPH(3.72) - TOTAL PETROLEUM HYDROCARBONS (mg/kg)

FIGURE 3
TEST PIT INVESTIGATION RESULTS
NICKEL AREA FUEL FARM

NAVAL AIR STATION
 KEFLAVIK, ICELAND

NOTE: TE. . . LOCATIONS WITHOUT CONCENTRATION LEVELS INDICATES CONTAMINANT NOT

6.3 QA/QC Analytical Review Summary

This summary covers the review of 44 soil samples and six duplicates, collected April 14-16, 1992. The samples were sent to Solutions Laboratories, Inc., located in Chesapeake, Virginia.

Analytical Methodology Comments

The results for the analyses are reported in mg/kg or µg/kg. Additional parameters were reported as flashpoint (°F), moisture content (%) and pH.

- Signed chain-of-custody records were included.
- All samples were extracted and analyzed within holding times.
- Two matrix spike/matrix spike duplicate analyses were performed for benzene, toluene and ethylbenzene.
- Twelve sets of volatile method blanks were analyzed, eleven soils and one water. All matrix spike and relative percent difference (RPD) values were acceptable, indicating precision and accuracy.
- The TPH analyses had five duplicates performed with it. Each of the duplicate analyses was considered acceptable.
- BTEX parameters had three duplicates performed, all of which were considered acceptable.
- Flashpoint and pH had one duplicate analysis performed which was considered acceptable.
- Lead had two duplicate analyses performed, all of which were considered acceptable.
- Three trip blanks accompanied the samples to the lab. Parameters of concern were not detected in the trip blank samples.

- Samples flagged with a (J) have the associated numerical value as an estimated quantity because the reported concentrations were less than the associated detection limits or quality control criteria were not met.

Conclusion

- All data is acceptable.

6.4 Extent of Contamination

As indicated in Tables 6-1 through 6-8, soil contamination at the site consists of primarily petroleum hydrocarbons. This appears to be the result of fuel handling activities at the NAFF. The highest TPH concentrations were detected at test pits A-9 (6,454 mg/kg, 12-20 inches), N-1 (115.58 mg/kg, 3-8 inches) and O-2 (336.98 mg/kg, 10-15 inches). These concentrations exceeded the DEM guideline action level of 10 mg/kg and proposed cleanup level based on the Site Sensitivity Evaluation (SSE) score (see Appendix E). The SSE evaluates the sensitivity of groundwater to contamination by the release of petroleum related substances from the Vadose Zone. The TPH levels detected in these areas were well below the action level of 10 mg/kg. These low levels of TPH may be attributed to loading/unloading operations and/or rainfall runoff.

As depicted in Tables 6-1 through 6-7, BTEX, flashpoint, pH, and lead (total) chemical analyses were also performed on selected samples. All of the soil samples analyzed for flashpoint had values greater than 140°F and pH results indicate slightly acidic soils (5.13 to 6.85 range). Total lead concentrations were consistently detected throughout the NAFF site. None of the samples were classified as a hazardous material based on flashpoint and pH. BTEX and total lead concentrations detected are below removal action levels (see Table 7-3).

Analytical results for physical analyses (moisture content and grain size analysis) in general, indicate damp to wet silty, clayey sand material throughout the NAFF site.

Based on analytical results and regulatory guidelines, the extent of soil contamination related to NAFF activities appears to be limited to elevated TPH concentrations in areas surrounding Test Pit A-9 (Area A), test pit N-1 (Area N) and test pit O-2 (Area O) as shown on Figure 3.

7.0 PRELIMINARY EXPOSURE ASSESSMENT

This section discusses the preliminary exposure assessment performed for the NAFF. Per the directive of North Carolina's UST regulations, the issues addressed herein include: (1) qualitative fate and transport assessment for the contaminants found at the site; (2) identification of major contaminants found at the site; (3) qualitative evaluation of potential human exposure pathways for the most mobile and/or toxic contaminants detected; and (4) identification of potential receptors at greatest risk from the existing contamination. The violation of the 2L Standard (North Carolina Water Quality Standards) at supply wells as the "risk threshold" is not addressed, since groundwater evaluation was not a part of this investigation.

7.1 Fate and Transport of Contaminants Found at the Site

The compounds detected at the NAFF include compounds associated with petroleum storage and use, such as Total Petroleum Hydrocarbons (TPHs) including polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylenes (BTEX), and lead. The fate and transport of these compounds is presented below.

7.1.1 Fate and Transport of Petroleum (Including TPH and BTEX) in the Environment

Petroleum products are complex mixtures of hydrocarbons; more than one hundred compounds can be found in a typical fuel mixture (EPRI, 1989). Each constituent has different chemical and physical properties that control the ultimate fate and transport of the petroleum products in soil. In general, when petroleum hydrocarbons (PHCs) are released into unsaturated soils, they tend to migrate vertically under the force of gravity, with some slight lateral spread (Schwendeman, 1989). This migration pathway may be interrupted by adsorption to soil particles, inhibition by a geologic formation, (i.e., low transmissive capability) or by cultural features (i.e., pipe channels or foundations).

The subsurface transport of contaminants is also controlled by complex interactions between chemical, physical, and biological processes. Some conditions which effect migration are:

- Soil texture
- Soil uniformity or non-uniformity

- Soil layer configuration
- Depth to water table
- Soil structure
- Flow stability
- Soil moisture

Due to these complexities, mathematical models have been developed to estimate chemical movement in soils. One model, the Seasonal Soil Compartment Model (SESOIL), developed for the U.S. Environmental Protection Agency's (EPA) Office of Toxic Substances, has been useful in determining the mobility and fate of certain chemicals. SESOIL results have classified organic compounds into four categories (EPRI, 1989):

- Chemicals which preferentially adsorb onto soil particles
- Chemicals which volatilize rapidly
- Chemicals which pose an immediate threat to groundwater supplies
- Chemicals for which there is no dominant migration pathway

The major implication of this model is that lighter PHCs are more likely to volatilize, while heavier PHCs will tend to bind tightly to soil particles.

The environmental partitioning of petroleum constituents and examples of various migration pathways are presented in Tables 7-1 and 7-2, respectively. As is evident, BTEX have multiple migration pathways. Their chemical nature is such that these compounds are volatile, adsorb to soil particles, and are soluble. In contrast, the heavier PHCs, such as PAHs, tend to adsorb to soil particles and become immobilized (i.e., benzo(a)pyrene is 100% adsorbed to soil particles). It can, therefore, be assumed that the lighter constituents of oils (i.e., BTEX), may be found in air, soils, and/or groundwater, while the heavier constituents of oils (i.e., TPH and PAHs), will usually be found only in soils.

7.1.2 Fate and Transport of Lead in the Environment

Lead and lead compounds can be present in air, water and soil. Lead is persistent in soil with low mobility. Very little of the lead in soils is transported to surface or groundwater. The fate of lead in soils is affected by the specific or exchange adsorption at mineral interfaces, the precipitation of soluble solid phases, and the formation of stable organic-metal complexes or chelates with soil organic matter. These processes are dependent on soil pH, organic content of

TABLE 7-1

CATEGORIES OF MIGRATION PATHWAYS

Adsorb to Soil Particles	Volatilize in Air	Solubilize in Groundwater	Multiple Pathways
Benzo(a)Pyrene Phenanthrene Benzo(a)Anthracene	(n)Hexane (n)Heptane (n)Pentane 1-Pentene	Phenol	Benzene Ethylbenzene Naphthalene Toluene (o)Xylene

Source: EPRI, 1989

TABLE 7-2

**RELATIVE ENVIRONMENTAL PARTITIONING OF CONSTITUENTS
BASED ON SESOIL RESULTS**

Petroleum Compound	Adsorption Onto Soil Particles (%)	Volatilization (%)	Soluble Portion in Groundwater and Soil Moisture (%)
Benzene	3	62	35
Ethylbenzene	21	59	20
(n)Heptane	0.1	99.8	0.1
(n)Hexane	0.1	99.8	0.1
(n)Pentane	0.1	99.8	0.1
Benzo(a)Anthracene	100	0	0
Benzo(a)Pyrene	100	0	0
Naphthalene	61	8	31
Phenanthrene	88	2	10
1-Pentene	0.1	99.8	0.1
Phenol	9	0.01	91
Toluene	3	77	20
(o)Xylene	15	54	31

Source: EPRI, 1989

soil, the presence of inorganic colloids and iron oxides, ion-exchange characteristics, and the amount of lead in the soil.

The amount of lead which goes into solution is dependent upon pH of the water and the dissolved salt content. Once lead migrates into surface and groundwater, it has a tendency to form compounds of low solubility with the major ions of natural waters. In aquatic systems, lead is associated with suspended solids and sediments. Lead that is released into the atmosphere exists primarily in particulate form and is transported by atmospheric dispersion; it is then transformed by physical and/or chemical properties and removed from the atmosphere by wet and dry deposition.

Elemental lead is not volatile and therefore volatilization is not an important transport process from soils and water; however, there are some organic forms of lead which are very volatile (ATSDR for Lead, 1987).

7.2 Identification of Major Contaminants

The analytical data for soil samples collected at the NAFF site is presented in Appendix D. Tables 6-1 through 6-8 summarize the surficial soil analytical results. Sample depths range from 3 to 6 inches (sample D-2) to 24 to 31 inches (sample A-14). No other environmental media were sampled during this field program.

There are certain data qualifiers presented in these tables and in the following sections. A "J" qualifier, applied to organic chemicals, suggests that although the compound was identified, the concentration reported is estimated. A "U" qualifier suggests that the compound was not detected at the Method Detection Limit. A summary of the detected data is presented below.

The soil data show that TPH concentrations were detected in fourteen (14) of the forty-four (44) soil samples collected. The TPH concentrations for these 14 samples ranged from 0.3 J mg/kg (J-3, 8-19 inches) to 6,454 mg/kg (A-9, 12-20 inches).

Benzene, toluene, ethylbenzene and xylene were analyzed in twenty-four (24) of the soil samples. Benzene was detected twice, (F-2, 0.00141J mg/kg, 12-19 inches and O-1, 0.00043J mg/kg, 4-11 inches). Toluene was detected in 5 of the twenty-four soil samples. The detected values ranged from 0.00189J mg/kg (A-2, 20-24 inches) to 0.00507 mg/kg (M-3, 7-13 inches). Ethylbenzene and xylene were both detected at one sampling location,

ethylbenzene at a concentration of 0.00215 mg/kg (A-13, 10-16 inches), and xylene at a concentration of 0.0234 mg/kg (A-9, 12-20 inches).

Lead (total) was analyzed in twenty-four (24) soil samples. Lead was detected in all twenty-four samples, (A2,4,5,7,9,10,13; B-2; C-2,3; D-2,3; E-2; F-2; G-2; H-1,3; I-2; J-3; L-1; M-3; N-1; O-1,3). Detected concentrations ranged from 1.09 mg/kg (N-1, 3-8 inches) to 187.1 mg/kg (C-2, 4-8 inches).

7.3 Identification of Human Exposure Pathways

Dermal contact with soil, soil ingestion and inhalation of particulates would be the primary exposure pathways of concern at the NAFF. Because the vegetation in the area is sparse (as a result of soil infertility), the potential for soil exposure via all the aforementioned pathways exists. In addition, none of the aboveground tanks are built on concrete pads or any other type of flooring base to reduce the potential for tank leakage to contaminate the surficial soils.

7.4 Identification of Receptors

Potential receptors identified at the NAFF currently include the on-site civilian and military personnel. In addition, since the fuel farm is slated for closure and a residential area is proposed for the site, future residential populations are also considered as potential receptors. As such, the most sensitive receptor would be children and the primary pathway of concern would be soil ingestion.

7.5 Development of Action Levels

Normally in a qualitative assessment of contaminated surficial soils, detected concentrations of metals would be compared to background levels (naturally occurring levels of metals present in an environment similar to the environment under investigation) to determine whether elevated concentrations have been detected. At the present time, however, soil research pertaining to the delineation of background metal concentrations in Reykjavik, Iceland is limited (Dr. Bjarni Helgason, Institute of Applied Agricultural Research, Iceland, May 1992). Therefore, a background level of lead is not currently available to compare with lead levels detected at the NAFF. As a result, another approach has been taken to assess the risk of lead, if any, at the NAFF. This involves the development of site-specific risk-based

action levels calculated for the most sensitive receptor and exposure pathway - soil ingestion by children.

Action levels, as defined by the proposed rule for Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities (EPA, 1990), are health- and environmental-based levels determined by the U.S. Environmental Protection Agency (EPA) to be indicators for protection of human health and the environment (EPA 1990). The EPA has proposed using action levels to trigger a Corrective Measures Study (designed to evaluate potential remedial alternatives for identified releases) whenever concentrations of hazardous constituents in groundwater, surface water, soils or air are exceeded for that particular medium. The EPA has provided the risk-based formulas and the recommended assumptions for use in deriving the action levels for contaminants at hazardous waste sites. The portion of the proposed rule highlighting the method to calculate an action level for soil ingestion by children has been included in Appendix F, along with the calculations for the action levels derived for BTEX and lead. The action levels are presented in Table 7-3.

In addition to calculating an action level for lead the Office of Solid Waste and Emergency Response (OSWER) issued a directive pertaining to interim soil cleanup levels for total lead (OSWER, 1989). The directive was issued due to concerns related to the bioavailability of lead in that it occurs in various chemical forms and what role bioavailability should play in assessing health risks posed by exposure to lead in soil. Five-hundred to 1000 parts per million, as measured by protocols developed by the CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) Contract Laboratory Program, has been established as a guideline at CERCLA sites until an EPA-verified reference dose or cancer potency factor for lead can be developed. This guidance is considered to be protective for human health direct contact at residential settings.

7.6 Risk Evaluation

The maximum concentrations for all BTEX values detected at the NAFF did not exceed the action levels derived for these constituents. Two of the lead values detected exceeded the calculated action level of 55.2 mg/kg, both of these samples were located in Area C, C-2 (187.1 mg/kg, 4-8 inches in depth) and C-3 (79.07 mg/kg, 4-8 inches depth). However, due to the bioavailability concerns of lead and the OSWER clean-up guidelines of 500 to 1000 ppm, lead does not appear to be a health hazard at the NAFF. Three samples exceeded the action

TABLE 7-3

ACTION LEVELS FOR LEAD AND BTEX

Chemical	Action Level* (mg/kg)	Maximum Concentration (mg/kg)
Benzene	24	1.41E-03
Toluene	16,000	5.07E-03
Ethylbenzene	8,000	2.15E-03
Xylenes	160,000	2.34E-02
Lead	55.2	187.1

Notes:

- * Derived according to the guidelines of the proposed Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities, 1990.

level of 10.0 mg/kg for TPH in soil; A-9 (6,454 mg/kg, 12-20 inches in depth), N-1 (115.58 mg/kg, 3-8 inches in depth), and O-2 (336.98 mg/kg, 10-15 inches in depth).

Typically, in a human health risk evaluation of surficial soils, samples from the top 0-6 inches of soil are collected, analyzed, and assessed for potential exposure. However, as the area is slated to become a residential area, grading and construction activities may result in soils currently at depth (6 inches and deeper) becoming surface soils. Therefore, the sampling program conducted at the NAFF included collection and analysis of soils at varying depths. Based on the information presented herein, the following areas and primary contaminants of concern will be considered in the remediation assessment:

- Area A - TPH
- Area N - TPH
- Area O - TPH

8.0 REMEDIATION ASSESSMENT

Consistent with the scope of work, the findings of the Site Assessment conducted at the NAFF will be utilized to develop and evaluate alternative remedial measures. This section of the Site Assessment Report discusses the type and extent of soil contamination in the vicinity of the fuel tanks and evaluates applicable technological alternatives for soil remediation. A remediation scheme may consist of a single technology or a combination of technologies capable of addressing the site specific contamination at the NAFF.

8.1 Objectives

The objectives of this Remediation Assessment are as follows:

- Evaluate whether soils require remediation.
- Identify areas requiring remediation.
- Identify and evaluate technologies applicable for soil remediation.

Several remedial technologies were evaluated with respect to their ability to mitigate TPH contamination detected in soils within the NAFF.

8.2 Potential/Feasibility of Remediation

TPH concentrations greater than 10 mg/kg were detected in test pits A-9, N-1, and O-2 all of which are located in the northern parcel of the Nickel Area Fuel Farm. Benzene, ethylbenzene, toluene and total xylenes were also detected in very low concentrations in soils throughout the northern portion of the fuel farm. This was confirmed via field observations, PID screening and analytical results, described in Sections 5 and 6 of this report. In addition, relatively low levels of lead were consistently detected in various locations throughout the site. Based on site assessment results, remediation is recommended only for soils in test pit areas A, N and O (see Figure 3).

Soil remediation requirements for TPHs were determined via the SSE scoring methodology developed by DEM (see Appendix E). As mentioned earlier, the SSE is utilized to evaluate the sensitivity of groundwater to contamination by the release of petroleum related substances. The "in-situ" soil cleanup levels for TPH are determined by the SSE score. The higher the SSE

score the lower the TPH soil cleanup level and the lower the SSE score the higher the TPH soil cleanup level. The SSE score is based on North Carolina DEM guidance. The sensitivity evaluation is typically applicable to sites where remaining "in-situ" soils contain between 10 and 100 mg/kg TPH and meet the following criteria:

- Soils are located ≥ 5 feet from the seasonal high water table or top of bedrock.
- Soil does not create a human exposure pathway via ingestion, absorption, or inhalation.

The overall remediation goal is determined based on applicable regulatory requirements and the implementation feasibility of the remediation alternative. The proposed final result for the NAFF is the reduction of TPH in the soil to an acceptable regulatory level based on North Carolina guidelines for remediation of soil contaminated by petroleum. Based on NAFF's SSE score of 37 (Appendix E), a maximum soil cleanup of 35 ppm for TPH should be achieved. It should be noted that this method is typically applicable to in-situ remediation technologies.

8.3 Potential Remediation Alternatives

This section includes a brief description of soil remediation alternatives which may be applicable to the Nickel Area Fuel Farm Site. Information regarding the respective remedial technologies was obtained from documents developed by the EPA.

8.3.1 Soil Remediation Technologies

Soil Remediation technologies used singular or in combinations are considered to be source control alternatives. Some commonly implemented soil remediation methods are:

- No action
- Excavation followed by one of the technologies listed below:
 - ▶ Bioremediation
 - ▶ Low Temperature Thermal Treatment
 - ▶ Infrared Thermal Destruction
 - ▶ Soil Washing

Due to the military construction (MILCON) project regarding the demolition and closure of the NAFF, and future land development plans, in-situ remediation technologies were not considered as a remediation alternative.

8.3.1.1 No Action

This alternative means that no remedial action is taken and is included in this study as a baseline for comparison with the other considered alternatives. However, despite the title of "No Action," activity at the Nickel Area Fuel Farm may continue with the implementation of a monitoring program. Should the monitoring indicate a deterioration of site conditions as a result of the "No Action" alternative, direct action becomes advisable. The costs associated with this alternative are for potential monitoring activities.

8.3.1.2 Excavation

Excavation is not a stand-alone alternative and is usually practiced in combination with another procedure or process. The volume of soil to be excavated is usually estimated by field screening soils with air monitoring instrumentation and analytical results from sampling operations. Post-excavation sampling is usually conducted to confirm that all of the contaminated soil has been fully excavated. The excavated area is then filled with certified clean fill. Excavation poses a potential hazard through the release of VOCs to the atmosphere.

The costs associated with excavation include the removing of soil, the potential for shoring, post-excavation sampling and backfilling of the excavation. Additional costs are incurred for follow-up treatment or disposal of the contaminated soil.

8.3.1.3 Bioremediation

Bioremediation is a proven technology for treating soils and other media by utilizing microorganisms to degrade organic material. An oxygen source and naturally occurring microbes are mixed with nutrients, (primarily phosphates and nitrogen) and are added to the soil or waste to be treated. Given sufficient residence time, the microbe/nutrient mixture promotes degradation of soil contaminants. Bioremediation is suitable for treatment of contamination caused by petroleum hydrocarbons, aromatics, halogenated aromatics, phenols, organophosphates, and many herbicides and pesticides. About 85% of the organic constituent can be degraded over a period of six to twelve months. This technology can be practiced in

engineered land treatment cells or as landfarming. In landfarming, contaminated soil is excavated and laid in 6 to 12 inch lifts, tilled and treated with nutrients. This technology can also be practiced, in a few instances, in-situ. Bioremediation has been used by the petroleum industry for the past two to three decades to treat oily sludges. The tilling provides oxygen needed to promote the reaction. Reaction time can be reduced from months to days using a bioreactor.

Bioremediation costs vary widely depending on site conditions and extent-of-contamination, but are relatively less expensive than other alternatives.

8.3.1.4 Low Temperature Thermal Treatment

Low temperature thermal treatment (LTTT) is a demonstrated ex-situ process that provides evaporation of VOCs from contaminated soil without heating the soil matrix to combustion. Typical temperatures for LTTT are from 200°F to 1,000°F. This technology utilizes a thermal processor, an indirect heat exchanger to dry and heat contaminated soils, to strip the moisture and VOCs from the soil. Water is sprayed on the processed soil to provide cooling and to minimize dust emissions. The thermal processor is equipped with a self-contained burner which is typically fired by fuel oil. The LTTT process requires an emissions control system for the off-gas and a water treatment system for the condensate generated from cooling the off-gas. Contaminant removal efficiencies in excess of 95 percent can be achieved.

The costs associated with the LTTT include excavation, fuel requirements, equipment, post excavation sampling, and backfilling of the excavation. The operating cost of the thermal processor unit is relatively inexpensive relative to incineration, depending on the type and extent-of-contamination.

8.3.1.5 Infrared Thermal Destruction

The electric infrared incineration technology³ is a mobile thermal processing system that utilizes electrically powered silicon carbide rods to heat organic wastes to combustion temperatures. Any remaining combustibles are incinerated in an afterburner. One configuration for this mobile system is comprised of four components: an electric-powered infrared primary chamber, a gas-fired secondary combustion chamber, an emissions control system, and a control center. Volatile gases from the primary chamber flow into the secondary chamber, which uses higher temperatures (up to 1800°F), greater residence time, turbulence,

and supplemental energy to destroy the gases. Gases from the secondary chamber are ducted through the emissions control system. In the emissions control system, the particulates are removed in a venturi scrubber. This technology is suitable for soils or sediments with organic contaminants.

Economic analysis and observation suggest a variable cost range depending on waste feed, excluding soil excavation, feed preparation, profit and any disposal costs associated with the ash generated from burning.

8.3.1.6 Soil Washing

Soil washing is primarily a physical process whereby the contaminants, which are physically and chemically adhered to the smaller particles (i.e., clay, silt and humus) are separated from larger particles (i.e., sand and gravel). This separation results in a volume reduction of contaminated soil. Soil washing is conducted as a two-step process. First the soil is excavated, "washed" and screened with an appropriate washing solution (usually an aqueous solution with surfactants and/or chelants if necessary). The result of the initial wash is a "clean" coarse soil fraction and a contaminated slurry of wash water and fine soil particles. The coarse material can usually be returned to the original site. The second step, treatment of the fines, is highly dependent upon the type of contamination present. The fines can be dewatered and stabilized or incinerated with the resultant filtrate sent to a Publicly Owned Treatment Works (POTW). Soil washing is applicable to the treatment of heavy metals, halogenated aliphatics (e.g., trichloroethylene, trichloroethanes and chloroform), aromatics (e.g., benzene, toluene, cresol, and phenols), and volatile hydrocarbons such as gasoline.

The costs associated with soil washing widely vary depending on contaminants and the extent-of-contamination. Bench and pilot scale testing would be required to assess all implementability considerations.

8.4 Recommended Technologies

8.4.1 Soil

Based on site history and results of soil sampling, it appears that soil contamination resulted from active and former storage tanks in the Nickel Area Fuel Farm. Five soil remediation

alternatives were discussed in Section 8.3. The first alternative considered was to take no action. Four additional alternatives were briefly evaluated for their application to the site.

The no action alternative was eliminated from further consideration because it does not comply with LANTDIV objectives and does not reduce the effects of the contaminants to the environment.

Based on soil conditions and extent of contamination, excavation in conjunction with bioremediation appears to be the most appropriate alternative for the remediation of TPH detected in soils of the NAFF. Additional costs associated with bioremediation are excavation, post-excavation sampling, and backfilling. The additional alternatives discussed in Section 8.3.1.1 through 8.3.1.6 (excavation in combination with LTTT, infrared thermal destruction and soil washing) may be eliminated from further consideration due to secondary concerns (i.e., air emissions, waste water generation) and/or economic feasibility.

The relative costs associated with the recommended alternatives for treating contaminated soils can be more accurately determined following further study. Bench and/or pilot scale testing would be required to assess all implementability considerations. Although site soils are generally granular, loose, moist and only slightly acidic, additional considerations will include climate and temperature.

Per discussions with LANTDIV personnel, an existing on-base facility may be used to accommodate bioremediation treatment cell or landfarming activities. In-situ treatment of contaminated soil is not recommended because of the lack of a confining unit beneath the site soils. Excavation should be focused on soils in and around test pits areas A, N, and O, and their associated tank structures.

9.0 CONCLUSIONS

The following conclusions are based on the results of the NAFF site assessment:

- Soil samples collected from three test pits at the NAFF site were detected to have TPH concentrations greater than the guideline action level of 10 mg/kg (Test Pits: A-9, N-1, and O-2).
- Based on cited regulatory guidelines, detections of BTEX and lead in site soils do not require action.
- No offsite sources appear to be contributing to the soil contamination detected onsite.
- Remediation of soils in test pit areas A-9, N-1 and O-2 is recommended.
- Excavation followed by onbase bioremediation is the recommended remediation technology based on site conditions, implementability, cost factors and proposed activity plans. Bench and pilot scale testing will provide specific bioremediation requirements.

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