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Background Study for Metals, Pesticides, and Herbicides Report

Joint Readiness Training Center
and Fort Polk
Fort Polk, Louisiana

Prepared for:

U.S. Army Corps of Engineers
Tulsa District
Tulsa, Oklahoma
Under Contract No. DACA56-94-D-0015,
Delivery Order 11, Modification # 2

Prepared by:

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Acronyms

AOC	Area of Concern
ANOVA	Analysis of Variance
ASTM	American Standard for Testing and Analysis
CDAP	Chemical Data Acquisition Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DPT	Direct Push Technology
EPA	Environmental Protection Agency
HSWA	Hazardous and Solid Waste Amendments
IWS	Installation Wide SWMUs
LCL	Lower Confidence Limit
LDEQ	Louisiana Department of Environmental Quality
MDL	Method Detection Limit
ND	Not Detected
PQL	Practical Quantitation Limit
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SOPs	Standard Operating Procedures
SWMU	Solid Waste Management Unit
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UTLs	Upper Tolerance Limits
UXO	Unexploded Ordnance

Executive Summary

The purpose of this report is to document the results of a statistical analysis of background (naturally occurring) data (chemical) in soils or "background study" at Fort Polk, Louisiana as an option (Modification # 2) to the original delivery order (# 11) under U.S. Army Corps of Engineers Tulsa District, Contract No. DACA56-94-D-0015. A total of 120 soil samples were collected from 64 borings completed at Fort Polk. 28 borings were completed at North Fort Polk, 28 borings at South Fort Polk, and eight borings at the 45th EOD range.

Sampling activities were conducted at Fort Polk from January 26 to February 9, 1998. These activities included the collection of surface and subsurface soil samples from 64 borings at various locations throughout the installation. These areas were virtually unaffected by any installation activities and were considered to be removed from any potential sources of contamination.

The surface samples collected were analyzed for organic herbicides, organochlorine pesticides, and metal constituents. The subsurface samples were analyzed for metal constituents only. These analytical results were statistically evaluated to determine "background" concentrations of these constituents in different soil types. This data was used to establish site-specific background concentrations that will be used for comparison to existing and future soil data collected at Fort Polk.

Since analytes did show a significant difference between surface and subsurface soil concentrations in previous background studies performed at Fort Polk, and the exposure pathways are different for surface and subsurface soil contamination, surface and subsurface soils were segregated, as well as coarse and fine-grained soils, for this background study. It is recommended that they be segregated for further investigations. Because information will not always be available about the granularity of future samples, UTLs and other summary statistics are also provided for the combined granularities.

Differences in metals concentrations were statistically significant between the fine and coarse-grained soils; fine-grained soils tended to have higher concentrations than in coarse-grained soils. No significant differences were observed for herbicides or pesticides, though there were few detected results for these analytes.

1.0 Introduction

In November 1980, Fort Polk submitted a Resource Conservation and Recovery Act (RCRA) Part A permit application to EPA Region VI for the operation of its open burn/open detonation (OB/OD) unit and received interim status for the unit. A RCRA Part B, Subpart X permit application was submitted to EPA Region VI in November 1988 to preserve the interim status of the OB/OD unit. A revised application was submitted in March 1993 to incorporate post-1988 Subpart X permitting requirements. EPA Region VI and the Louisiana Department of Environmental Quality (LDEQ) jointly issued a RCRA Part B, Subpart X permit to Fort Polk in June 1995.

Under authority of the 1984 Hazardous and Solid Waste Amendments (HSWA), EPA was authorized to conditionally require a RCRA Part B permittee to initiate corrective action at Solid Waste Management Units (SWMUs) and areas of concern (AOCs). Therefore, prior to issuing the operating permit, EPA conducted a RCRA Facility Assessment (RFA) at the Installation in December 1993 to identify all SWMUs and AOCs.

Based on the findings of the RFA, 31 SWMUs and 2 AOCs were targeted to require investigation to determine if there has been any release of hazardous constituents to the environment. The HSWA portion of the permit identifies these SWMUs and AOCs and contains specific requirements for the corrective action process. The Installation-Wide SWMU (IWS) Phase I and II RCRA Facility Investigations (RFI) were recently completed at Fort Polk, Louisiana and included the investigation of 30 SWMUs. SWMU 17 (Mill Creek Landfill) and the AOCs were investigated separately.

1.1 Site Description

Fort Polk is located in the west central portion of Louisiana, in Vernon Parish, near the communities of Leesville and Pitkin (Figure 1.1-1). Fort Polk was established in 1941 and has been activated and deactivated several times dependent upon its mission. Since 1960, Fort Polk has remained an active military installation and is currently home to the Joint Readiness Training Center and Fort Polk. At present, approximately 18,000 military and civilian personnel live within a 3-mile radius of Fort Polk. The Installation has maintained an active Installation Restoration Program since 1983.

The Installation consists of two separate noncontiguous posts: the Main Post and the Peason Ridge Training Area, which is located approximately 5 miles north of the Main Post. Two cantonment areas, North Fort Polk and South Fort Polk, are located within the Main Post.

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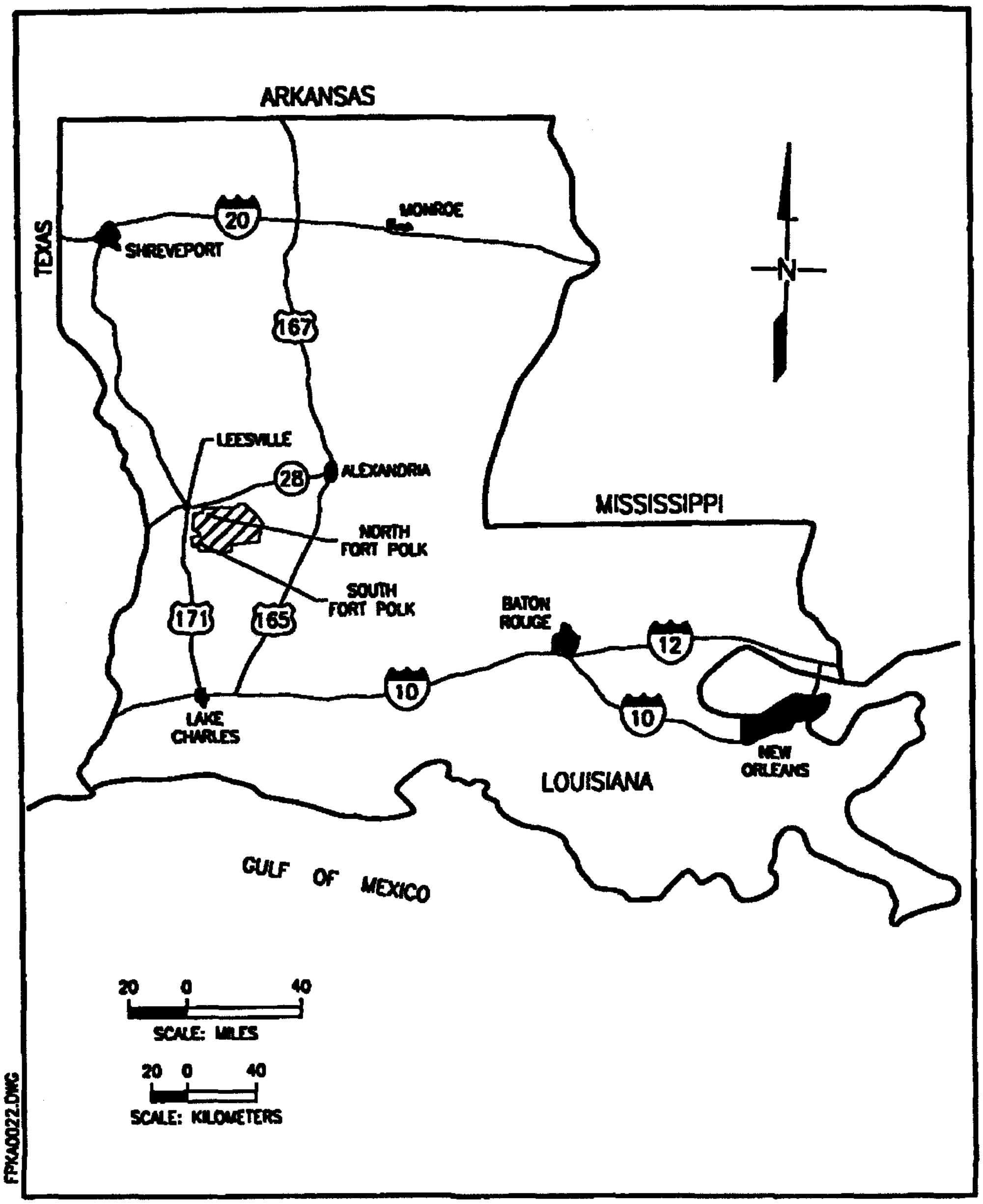

Figure 1.1-1 Location of Fort Polk, Louisiana

1.2 Technical Approach

The purpose of the Background Study was to use a statistical approach to evaluate and characterize the different soil types throughout the Fort Polk Installation and to determine the "background" levels for herbicides, pesticides and metals by depth and granularity. This data may be used for comparison of both existing data and future data collected from soils.

2.0 *Environmental Setting*

The following section describes the environmental setting of Fort Polk, Louisiana. These discussions were compiled from existing Installation records, published literature, and previous reports.

2.1 Physiography

Fort Polk is located in Vernon Parish (west central Louisiana) about 6 miles southeast of Leesville, Louisiana (Figure 2.1-1). The Army installation encompasses approximately 151,780 acres of which almost 85,000 acres lie within the Kisatchie National Forest in a rolling hill setting covered with second-growth timber (U.S. Army Environmental Hygiene Agency, 1989). The land surface elevation ranges from about 250 feet to almost 400 feet above mean sea level (U.S. Army Corps of Engineers, July, 1985).

The climate in the area is generally mild, with winter temperatures seldom less than 30 degrees Fahrenheit (F) and summer temperatures seldom more than 95 degrees F. The average rainfall is about 54 inches per year with the greatest precipitation generally occurring in May and the least occurring in October.

2.2 Surface Water

Fort Polk is situated on a local topographic high, and surface drainage generally radiates outward from the Installation. The principal streams in Vernon Parish include the Calcasieu River, Bayou Anacoco, and Bayou Castor (Figure 2.2-1). Two reservoirs, Lake Vernon and Anacoco Lake, are located in the Bayou Anacoco drainage basin to the west and northwest of Fort Polk (USGS, 1989).

The Sabine River forms the western boundary of Vernon Parish as part of the Louisiana-Texas state line. Several perennial creeks flow southward from Fort Polk and are tributaries to larger streams. These perennial creeks include Drakes Creek and Whiskey Chitto Creek. Surface drainage from the Mill Creek Landfill flows into Drake's Creek tributaries to the south and west and Whiskey Chitto Creek tributaries to the north and east.

Some of the low-lying areas in flood plains are usually inundated to form swampy areas. Seasonal springs and seeps are also relatively common near the base of hills at contacts between underlying clay strata and overlying sand.

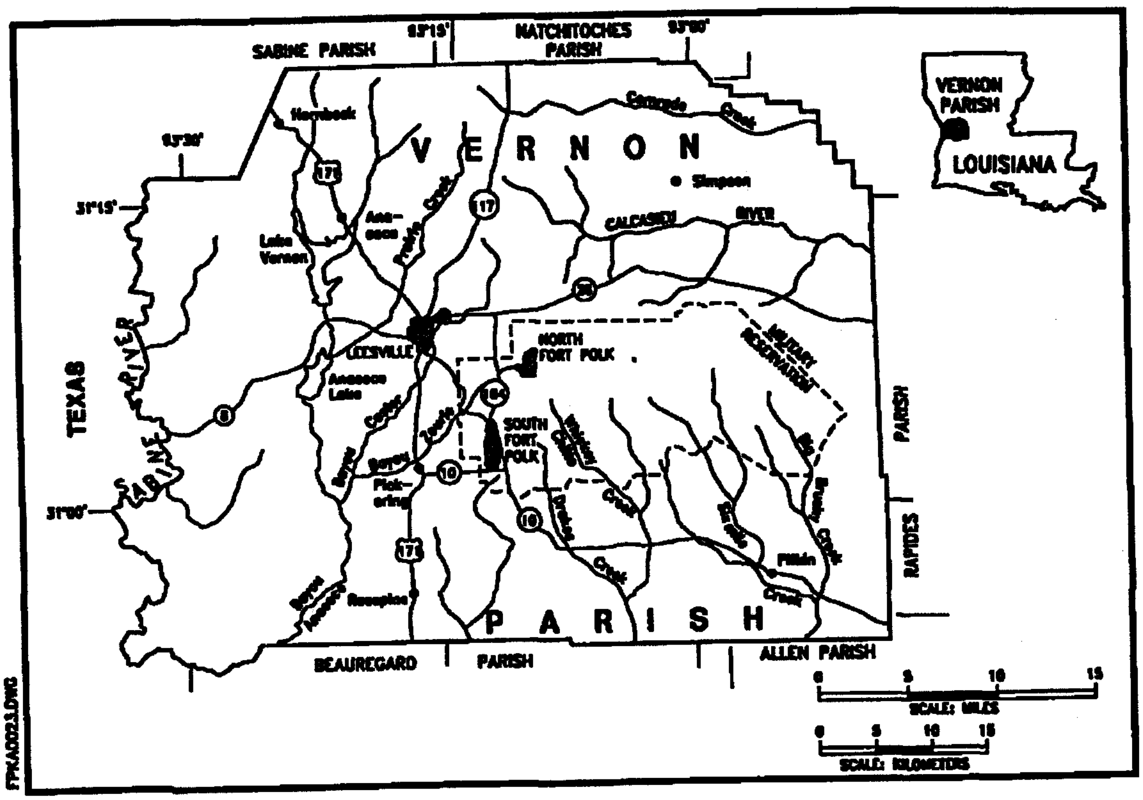

Figure 2.1-1 Physiographic Map of Fort Polk

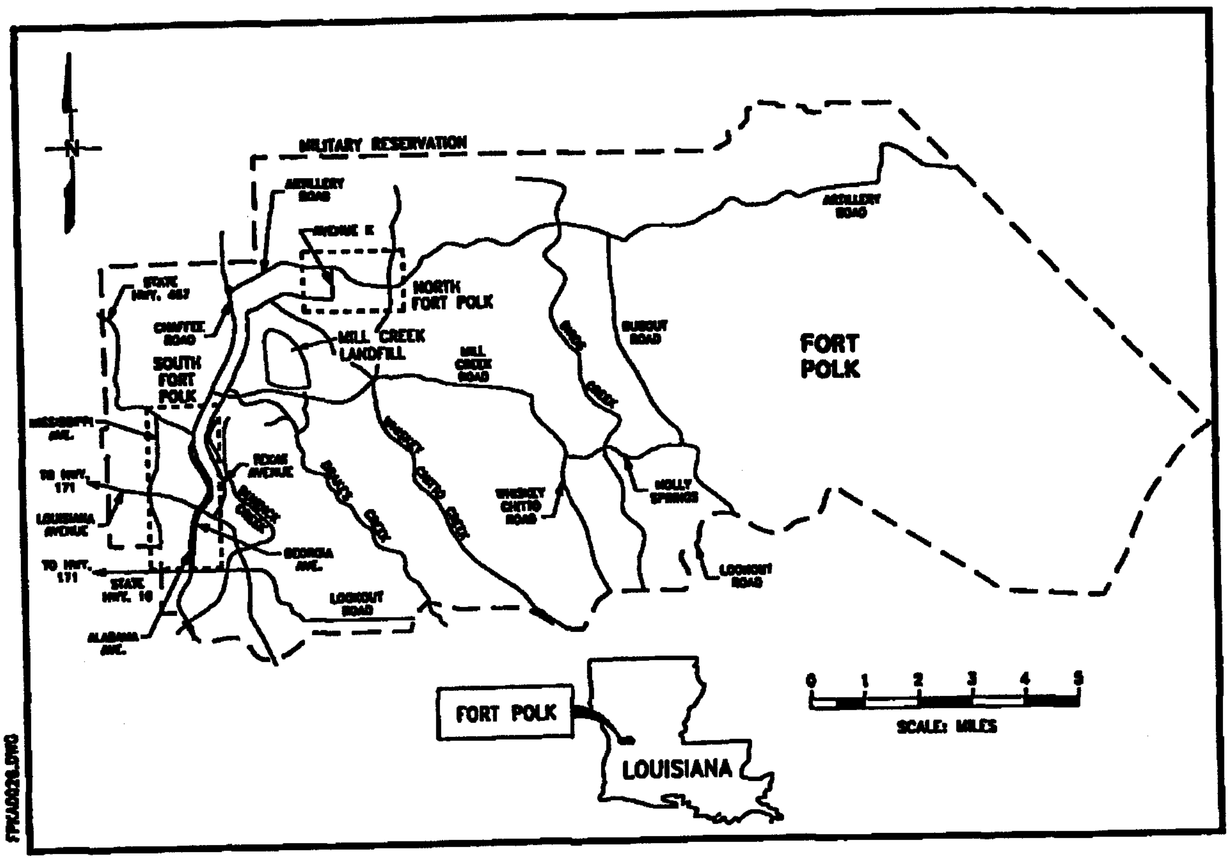

Figure 2.2-1 Principal Streams at Fort Polk, Louisiana (From U.S.G.S., 1989)

2.3 Soils

With the exception of exposed clay soils in the northern one-third of the Fort Polk area, the entire surface of Fort Polk is mantled with a fine-grained sand topsoil (U.S. Army Engineers Waterways Experiment Station, 1978). The sand topsoil is underlain at varying depths by sandy clay that may be locally underlain by fine-grained sandstone or siltstone. A relatively thick layer of plastic clay occurs at the surface or at a shallow depth below the surface in the northern one-third of Fort Polk. Stream flood plains are predominantly silty and sandy soils that are underlain by silty clay.

For the most part, the sandy soils of the Fort Polk area are well drained, creating erosional problems (United States Soil Conservation Service, 1994). Soils of the flood plains and low stream terraces are well drained throughout most of the year, but may become saturated and remain poorly drained for prolonged periods during the rainy season.

The Geologic units that generally occur within 100 feet of the surface in the Fort Polk installation area are Quaternary alluvial deposits and the Blounts Creek and Castor Creek Members of the Miocene age Fleming Formation. Figure 2.3-1 shows the areal extent of these units.

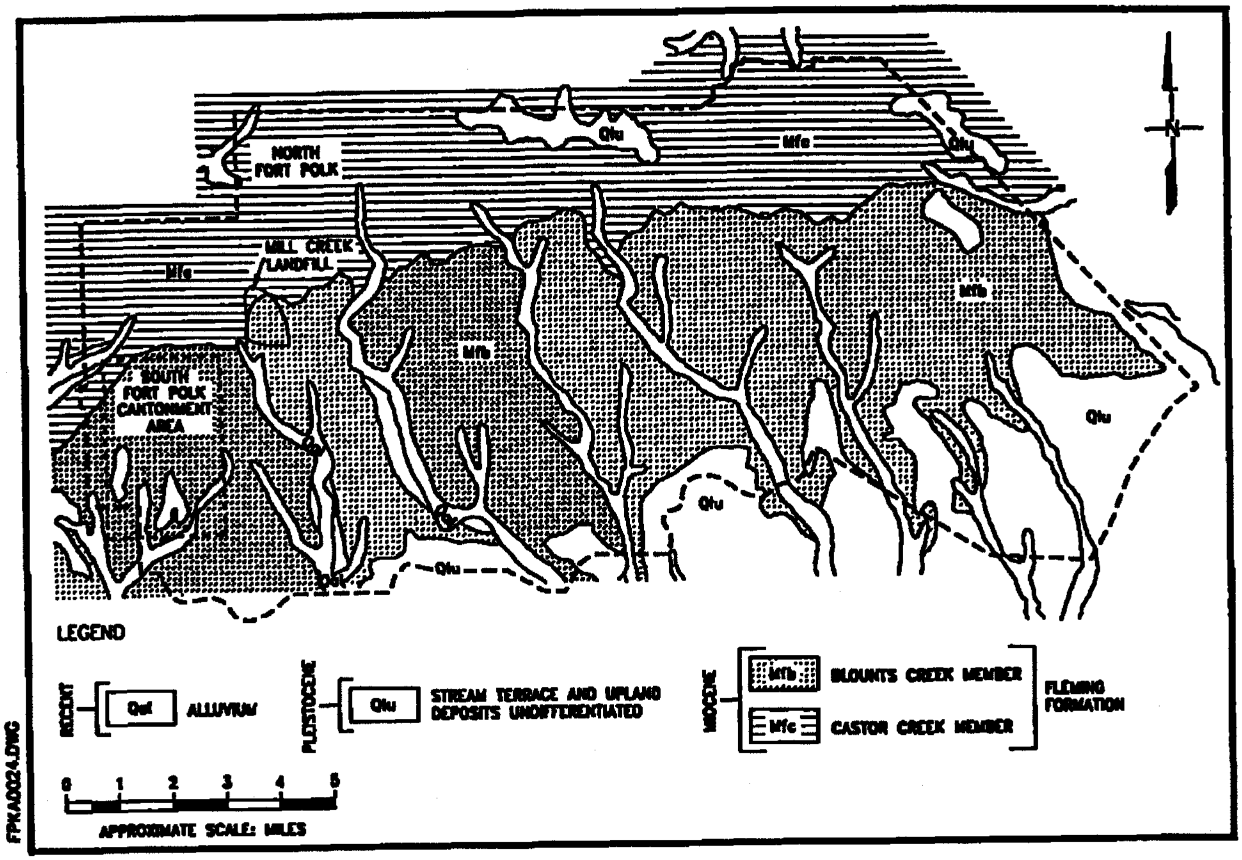

Figure 2.3-1 Surficial Geology of Fort Polk, Louisiana (From Thomas, 1978)

3.0 Methodology

This section describes the activities completed during the Background Study field effort. A total of 64 soil borings were completed to a maximum depth of 10 feet below ground surface (bgs). From each of these soil borings, one surface soil sample (0-2 feet bgs) was collected and analyzed for pesticides (EPA Test Method 8081), herbicides (EPA Test Method 8151), total metals (EPA Test Method 6010) and mercury (EPA Test Method 7471). A second sample was collected from a depth greater than 2 feet bgs and analyzed for total metals (EPA Test Method 6010) and mercury (EPA Test Method 7471). A total of 120 soil samples were collected and submitted for chemical analysis. Eight of the subsurface soil samples were inadvertently discarded during sampling (placed with soil cuttings in 55-gallon drums). These samples were all second interval samples; three were classified as fat clay (CH), and five were lean clay (CL).

Soil sample collection followed the standard operating procedures (SOPs) included in Appendix A of the Background Study for Metals, Pesticides and Herbicides Workplan (October 1997). Soil samples collected from the boring locations are shown on Figures 3.1-1, 3.1-2, and 3.1-3. These areas were selected under the assumption that they were unaffected by installation activities and operations and therefore would represent chemical concentrations native to soils in these areas. Quality Assurance/Quality Control (QA/QC) samples were collected in accordance to the Chemical Data Acquisition Plan (CDAP) located in Appendix C of the Workplan.

3.1 Field Sampling

Field sampling activities included the collection of surface and subsurface soil samples for chemical analysis. The objectives of the field sampling were to collect samples from soils at locations geographically distributed throughout Fort Polk, and away from potential sources of contamination. The sampling approach and methodology of the Background Study was designed to replicate the sampling approach of the Phase I and Phase II RFI. Because of this, surface soil samples were collected from the 0-2 foot bgs interval.

The soil boring locations were selected with consideration of the following:

- Upgradient topographic location with relation to SWMUs;
- No visible evidence of contamination in the surface or subsurface;
- Distance from production area sources and past waste disposal sites;
- Favorable access for drilling equipment; and
- Absence of physical obstructions (utilities, etc.).

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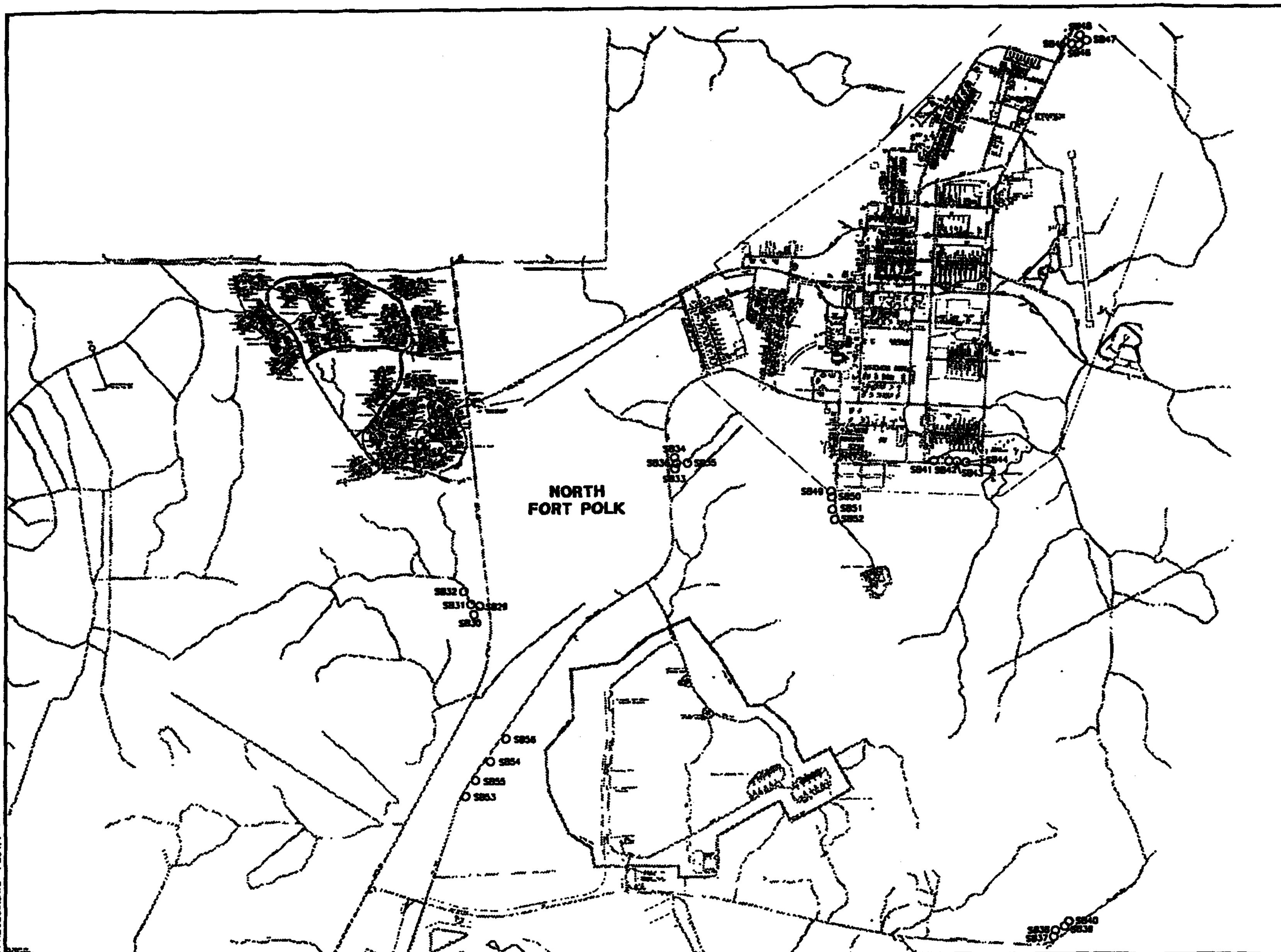

FIGURE 3.1-1

NORTH FORT BORING LOCATIONS

BACKGROUND STUDY REPORT
FORT POLK, LOUISIANA

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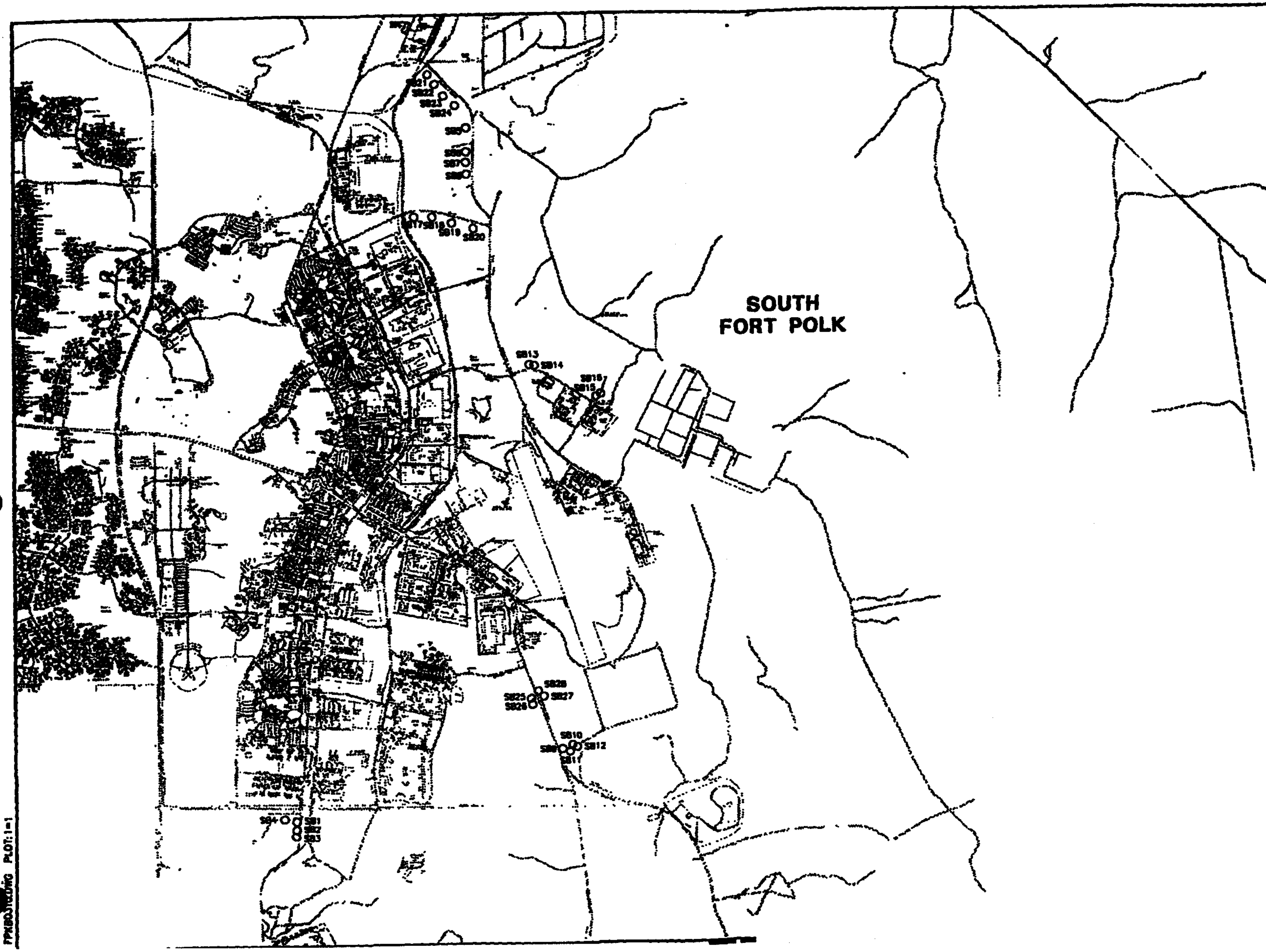

FIGURE 3.1-2

SOUTH FORT BORING LOCATIONS

BACKGROUND STUDY REPORT
FORT POLK, LOUISIANA

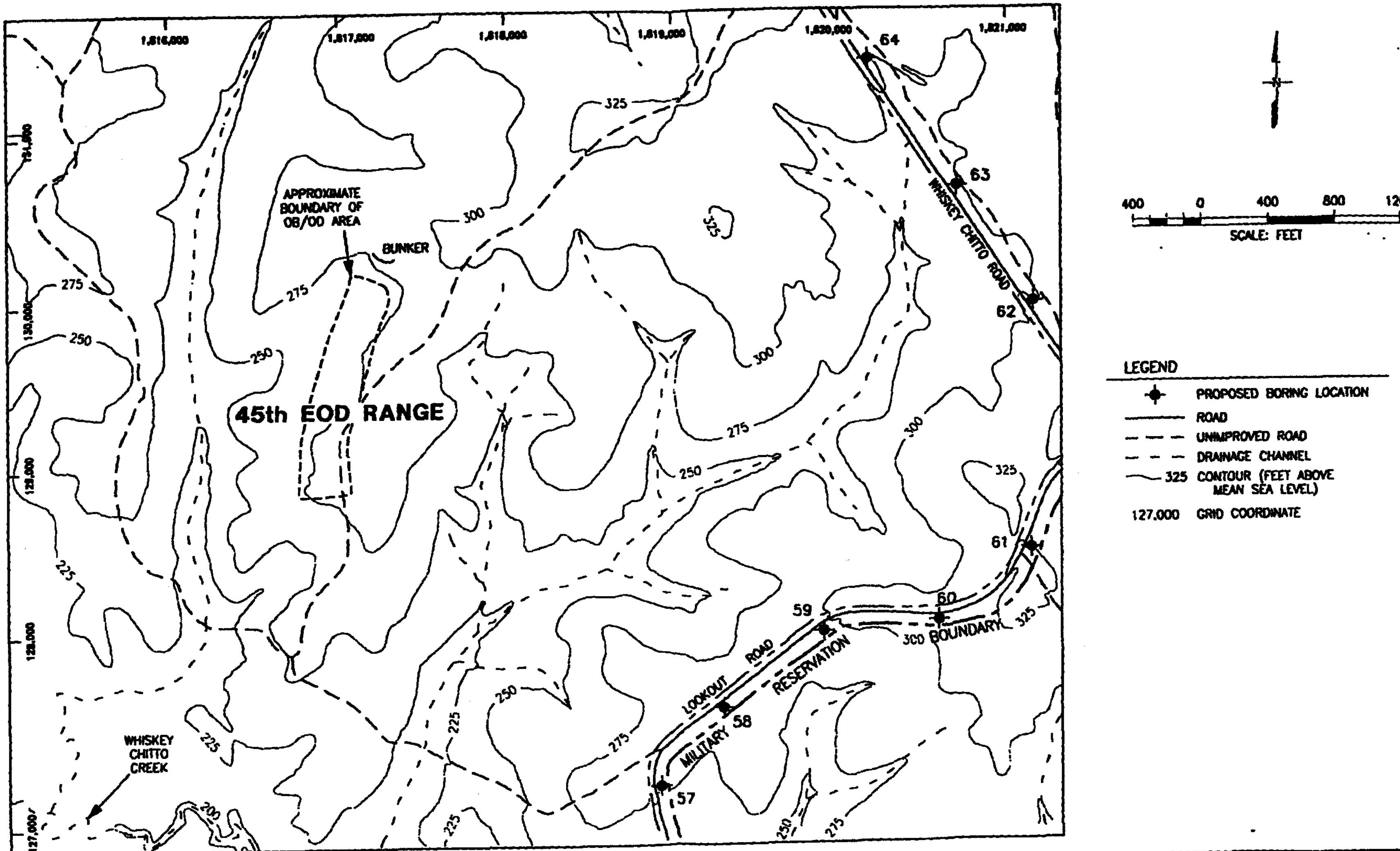

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FIGURE 3.1-3

Radian and Fort Polk personnel jointly determined the position of all of the sampling and borehole locations in accordance with the workplan.

3.2 Field Procedures

All sampling, sample handling, equipment decontamination, and documentation were performed in accordance with the SOPs located in Appendix A of the Background Study Workplan. Soil boring logs were created for each boring. Because of the length of the holding time for the subsurface soil samples, the samples were kept on ice (i.e. < 4° C) until all samples were collected. At that time at least one subsurface sample from each boring was selected for analysis. The strategy was to collect eight samples from each of the six soil types common to this area (CH, CL, ML, SC, SM and SP).

3.2.1 Surface Soil Sample Collection

Surface soil samples were collected from within the first 24 inches of the soil profile using a Direct Push Technology (DPT) drilling rig. Samples were collected and containerized in accordance with the CDAP in the Background Study Workplan.

3.2.2 Subsurface Soil Sample Collection

The DPT borings were advanced to a maximum depth of 10 feet bgs for the collection of soil samples. The soil samples were collected to give the widest dispersion among soil types that were possible. Seventeen fat clay (CH), seventeen lean clay (CL), seven silt (ML), eight clayey sand (SC), five silty sand (SM) and two sand (SP) samples were collected and submitted for chemical analysis (Tables 3.2-1 and 3.2-2). Samples were collected from above groundwater and in accordance to the CDAP in the Workplan. The boreholes were continuously logged by a geologist. The boring logs are located in Appendix A of this report. The boreholes were plugged and abandoned using bentonite.

3.2.3 QA/QC Sample Collection

QA samples consisted of field samples collected in the same type of sample containers and in the same manner as the surface and subsurface soil samples. QA soil sample duplicates (10% of samples) were collected from the same, homogenized soil sample as the field sample. QA samples were shipped to the USACE designated laboratory (Environmental Testing & Consulting, Inc.) and analyzed for the same laboratory parameters as the field samples.

Table 3.2-1
Background Study Sample Summary

Boring #	N1 Date	N1 Time	N1 MS/MSD	N1 Duplicate	N1 Rinsate	N2 Depth	N2 Time	N2 MS/MSD	N2 Duplicate	N2 Rinsate
SB1	2/5/98	1430	☑	☐	☐	2-4	1430	☐	☐	☐
SB2	2/5/98	1450	☐	☐	☑	4-6	1455	☐	☐	☐
SB3	2/5/98	1505	☐	☑	☐	6-8	1510	☐	☐	☐
SB4	2/5/98	1530	☐	☐	☐	8-10	1540	☐	☐	☐
SB5	2/3/98	1640	☐	☐	☐	2-4	1640	☐	☐	☐
SB6	2/3/98	1700	☐	☐	☐	4-6	1705	☐	☐	☐
SB7	2/4/98	0830	☐	☐	☐	2-4	0830	☐	☐	☐
SB8	2/4/98	0900	☐	☐	☐	8-10 *	0910	☐	☐	☐
SB9	2/5/98	1605	☑	☐	☐	2-4	1605	☐	☐	☐
SB10	2/5/98	1625	☐	☐	☑	4-6	1630	☐	☐	☐
SB11	2/5/98	1640	☐	☐	☐	6-8	1645	☐	☐	☐
SB12	2/5/98	1700	☐	☑	☐	8-10	1710	☐	☐	☐
SB13	2/3/98	1330	☑	☐	☑	6-8	1335	☐	☐	☐
SB14	2/3/98	0850	☐	☐	☐	4-6	0855	☐	☐	☐
SB15	2/3/98	0825	☐	☑	☐	8-10	0835	☐	☑	☐
SB16	2/3/98	0800	☐	☐	☐	6-8	0805	☐	☐	☐
SB17	2/3/98	1450	☐	☐	☐	8-10	1500	☐	☐	☑

**Samples that were inadvertently discarded.*

[illegible]g #	N1 Date	N1 Time	N1 MS/MSD	N1 Duplicate	N1 Rinsate	N2 Depth	N2 Time	N2 MS/MSD	N2 Duplicate	N2 Rinsate
SB18	2/3/98	1435	☐	☐	☐	6-8	1440	☐	☐	☐
SB19	2/3/98	1420	☐	☐	☐	4-6	1425	☐	☐	☐
SB20	2/3/98	1400	☐	☐	☐	6-8	1405	☐	☐	☐
SB21	2/3/98	1525	☐	☐	☐	6-8	1530	☐	☐	☑
SB22	2/3/98	1545	☐	☐	☐	2-4	1545	☐	☐	☐
SB23	2/3/98	1600	☐	☐	☐	4-6	1605	☐	☐	☐
SB24	2/3/98	1620	☐	☑	☐	8-10	1630	☐	☐	☐
SB25	2/2/98	1455	☐	☐	☐	4-6	1500	☐	☐	☐
SB26	2/2/98	1505	☐	☑	☐	8-10	1515	☐	☑	☐
SB27	2/2/98	1540	☐	☐	☐	4-6	1545	☑	☐	☐
SB28	2/2/98	1600	☑	☐	☐	2-4	1600	☐	☐	☐
SB29	2/5/98	0835	☐	☑	☐	2-4	0835	☐	☐	☐
SB30	2/5/98	0810	☐	☐	☐	4-6	0815	☐	☐	☐
SB31	2/5/98	0900	☐	☐	☐	6-8	0905	☐	☐	☐
SB32	2/5/98	0920	☐	☐	☑	8-10	0930	☐	☐	☐
SB33	2/4/98	1535	☐	☐	☐	4-6 *	1540	☐	☐	☐
SB34	2/4/98	1610	☐	☐	☐	2-4 *	1610	☐	☐	☐
SB35	2/4/98	1630	☐	☐	☐	8-10	1640	☐	☐	☐
SB36	2/4/98	1545	☐	☐	☐	6-8 *	1550	☐	☐	☐
SB37	2/5/98	1200	☑	☐	☐	4-6	1205	☐	☑	☐

***Samples that were inadvertently discarded.**

Boring #	N1 Date	N1 Time	N1 MS/MSD	N1 Duplicate	N1 Rinsate	N2 Depth	N2 Time	N2 MS/MSD	N2 Duplicate	N2 Rinsate
SB38	2/5/98	1215	☐	☐	☐	8-10	1225	☐	☐	☑
SB39	2/5/98	1235	☐	☐	☐	4-6	1240	☐	☐	☐
SB40	2/5/98	1250	☐	☐	☐	6-8	1255	☐	☐	☐
SB41	2/4/98	1135	☐	☑	☐	4-6 *	1140	☐	☐	☐
SB42	2/4/98	1115	☐	☐	☐	6-8	1120	☑	☑	☐
SB43	2/4/98	1050	☐	☐	☐	2-4 *	1050	☐	☐	☐
SB44	2/4/98	1010	☐	☐	☐	4-6	1015	☑	☑	☐
SB45	1/30/98	0800	☐	☐	☐	6-8	0805	☐	☐	☐
SB46	1/30/98	0830	☐	☐	☐	4-6	0835	☐	☐	☐
SB47	1/30/98	0850	☐	☐	☐	4-6	0900	☐	☐	☐
SB48	1/30/98	0945	☐	☐	☐	8-10	1000	☐	☐	☐
SB49	2/4/98	1455	☐	☐	☐	2-4	1455	☐	☐	☐
SB50	2/4/98	1435	☐	☐	☐	4-6 *	1440	☐	☐	☐
SB51	2/4/98	1225	☐	☐	☐	6-8 *	1230	☐	☐	☐
SB52	2/4/98	1330	☐	☐	☐	8-10	1340	☐	☐	☑
SB53	2/5/98	1105	☐	☐	☐	2-4	1105	☐	☐	☐
SB54	2/5/98	0950	☐	☐	☐	4-6	0955	☐	☐	☐
SB55	2/5/98	1015	☐	☐	☐	6-8	1020	☐	☐	☐
SB56	2/5/98	1035	☐	☐	☐	8-10	1045	☐	☐	☐
SB57	2/2/98	1225	☐	☐	☐	2-4	1225	☐	☐	☐

***Samples that were inadvertently discarded.**

Boring #	N1 Date	N1 Time	N1 MS/MSD	N1 Duplicate	N1 Rinsate	N2 Depth	N2 Time	N2 MS/MSD	N2 Duplicate	N2 Rinsate
SB58	2/2/98	1130	☐	☐	☐	6-8	1135	☐	☑	☐
SB59	2/2/98	1155	☐	☐	☐	4-6	1200	☑	☐	☐
SB60	2/2/98	1025	☐	☐	☐	8-10	1115	☐	☐	☐
SB61	2/2/98	1000	☐	☐	☐	4-6	1005	☐	☐	☐
SB62	2/2/98	0935	☐	☐	☐	6-8	0940	☐	☐	☐
SB63	2/2/98	0910	☐	☐	☐	2-4	0910	☐	☐	☐
SB64	2/2/98	0835	☐	☐	☐	8-10	0845	☐	☑	☐

*Samples that were inadvertently discarded.

Table 3.2-2
Background Study
Second Interval
Sample Dispersement
Fort Polk, LA

	SB01	SB02	SB03	SB04	SB05	SB06	SB07	SB08	SB09	SB10	SB11	SB12
2' - 4'	SM	ns	CL	CL	ML	ML	SC	CL	[illegible]	CL	CL	CH
4' - 6'	CL	CL	CL	CL	CL/SM	SM	SC	CL	CL	[illegible]	CH	CL
6' - 8'	CL	CL	CL	CL	SM	SM	SC	CL	CL	CH	[illegible]	CL
8' - 10'	CL	CL	CL	CH	SM	ns	SC	[illegible]	CH	CH	CH	SC

	SB13	SB14	SB15	SB16	SB17	SB18	SB19	SB20	SB21	SB22	SB23	SB24
2' - 4'	ML	ML	CL	CL	CL	CL	SM	SC	CL/CH	CL	ML	CL/SM
4' - 6'	ML	ML	CL	CL	CL	CL	SC	CL/CH	CH	CL	ML	SM/CL
6' - 8'	SC	ML	CL/SC	CL	ns	CL	SC/CH	CH	CH	CL	ML/CL	CL
8' - 10'	SC	ML	SC	CL	CH	CH	CL	CH	CH	CL	CL	SM

	SB25	SB26	SB27	SB28	SB29	SB30	SB31	SB32	SB33	SB34	SB35	SB36
2' - 4'	CL/SM	CL	CL	ML	[illegible]	CH	CH	CL	CL	[illegible]	CL	CL
4' - 6'	SM/SC	CL/ML	CH	ML	CH	CH	CH	CL	[illegible]	CL	CL	CL
6' - 8'	SC	CL	CL	ML/SM	CH	CH	CH	CL	CH	CL	CL	[illegible]
8' - 10'	SM/CH	SC	CL	SM/CH	CH	CH	CH	CL	CL	CL	CH	CL

	SB37	SB38	SB39	SB40	SB41	SB42	SB43	SB44	SB45	SB46	SB47	SB48
2' - 4'	SM	SC	SM	SM	CL	CH	[illegible]	CH	ns	ns	CL	ns
4' - 6'	SP	SC	SM	SM	[illegible]	CL	CH	SC	CH	CH	CH	CH
6' - 8'	ns	SC	SM	SP	CH	ML	CH	SC	SM	CH	CH	CH
8' - 10'	SP/SC	SC	SM	SC	CH	CL	CH	SM	CH	CH	CH	CH

	SB49	SB50	SB51	SB52	SB53	SB54	SB55	SB56	SB57	SB58	SB59	SB60
2' - 4'	CL	CL	CL	CL	CL	CL	CH	CL	CH	CL	CL	CL
4' - 6'	CL	[illegible]	CL	CL	CL	CH	CH	CL	CH	CL	CL	CL
6' - 8'	CL	CL	[illegible]	CL	CL	CH	CH	CH	CH	CL	CL	CL
8' - 10'	CL	CL	CL	CL	CH	CH	CH	CH	CH	CL	CL	CL

	SB61	SB62	SB63	SB64
2' - 4'	CL	CL	SM	CL
4' - 6'	CL	CL/ML	CL	CL
6' - 8'	CL	ML	CL	CL
8' - 10'	CL	ML	CL	[illegible]

CH - High plastic clay
CL - low plastic clay
SM - silty sand
SC - clayey sand
ML - Silt or fine sand

SP - clean, poorly graded sand
ns - no sample
- If interval contains different soil types, then the predominant type is listed followed by a "/" and then the subordinate type (e.g., CH/CL).

* These samples were collected, but inadvertantly discarded prior to shipment, therefore were not analyzed.

Field QC samples were collected and consisted of seven duplicate samples (10% of samples), four equipment blanks (5% of samples), five matrix spike/matrix spike duplicate (MS/MSD)(5% of samples) samples from the surface, and four QC samples from the greater than two feet bgs depth (subsurface samples). A total of seventeen soil duplicate, eight equipment blank, and nine MS/MSD samples were submitted for analysis. Soil sample duplicates were collected using the same methods as the original samples. Equipment blanks were collected by pouring Type II Reagent Grade Water over the sampling devices (i.e. shovels, spoons, bowls, and sample barrels) and transferring the water to a sample bottle. Field QC samples were sent to the Radian laboratory in the same container as the shipment for the normal field samples.

4.0 *Background Study Evaluation*

The statistical methodology followed in this background investigation was laid out in the Fort Polk Background Study Evaluation Framework and follows standard EPA guidance for Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) activities. The statistical approach for this site specific background characterization consisted of two primary activities:

Initial Data Review

- Comparison of background concentrations to blank concentrations.
- Comparison of normal field samples to their corresponding field duplicates.
- Outlier evaluation of background data.

Statistical evaluation of background data

- Comparison of concentrations among soil granularities and depths
- Calculation of upper tolerance limits (UTLs) and summary statistics.

Background sample results were compared with the results of blank sample results to determine whether naturally occurring concentrations could be resolved, given the field and analytical system noise. Both the blank data and the background data were evaluated for outliers.

Background data were evaluated to determine whether significant differences could be resolved among sample depths or soil granularities. The appropriate 95%/95% UTL and summary statistics, including the sample size, mean, median, minimum, maximum, and a one sided 95% upper confidence interval on the mean, were then calculated.

4.1 Summary of Available Data

The objective of the background sampling was to determine the concentrations of naturally occurring metals, organic herbicides and organochlorine pesticides in soils at Fort Polk. This data may be used during subsequent investigations to distinguish between elevated concentrations attributable to potential releases and typical local concentrations. This section presents a summary of the available data used in the background investigation.

The soil types were classified into two classes of granularity. SP, SM and SC were classified as coarse-grained, CH, CL, and ML were classified as fine-grained. If two soil types are indicated in

Table 4.1-1 (e.g., ML/CL), this indicates that the soil sample was of a combination of the two soil types. The predominant soil type is listed first. Thus, ML/CL exhibits more characteristics of ML type soil than CL type soil. These mixed soil types granularity were classified according to the predominant soil type of the sample. An attempt was made to collect samples representative of all of the soil types encountered at Fort Polk. All normal data available for the background investigation is shown in Appendix B.

4.2 Initial Data Review

The following activities were performed as part of the initial data review and are described in the following sub-sections:

Review blank results for outliers;

- Compare background concentrations and blank concentrations;
- Review duplicate data; and
- Review background concentrations for outliers.

4.2.1 Evaluation of Blanks Data

Blanks are artificial samples designed to detect the introduction of contamination or other artifacts into the sampling and analytical process. This is an especially important role in measurement programs involving trace-level analyses. Method blanks are processed through the entire preparation and analytical measurement techniques in the same manner as investigative field samples, and provide an indication of systematic contamination whose root cause may be preparation or measurement systems. When evidence of contamination is indicated by blank values above pre-established levels, corrective action is initiated to identify and eliminate the source of contamination.

Equipment blank samples are collected by pouring reagent grade water over decontaminated field equipment. There are no acceptance criteria for equipment blank results. Equipment blanks provide information regarding both field and laboratory contamination, but are not used to "control" either the sampling or the analytical processes. Rather, results from equipment blanks are compared to field concentrations to identify interpretation issues.

Table 4.1-1
Background Study
Soil Types
(Continued)

Soil Boring Number	First Interval Depth	First Interval Soil Type	Second Interval Depth	Second Interval Soil Type
SB-01	0' - 2'	SM	2' - 4'	SM
SB-02	0' - 2'	SM	4' - 6'	CL
SB-03	0' - 2'	SM	6' - 8'	CL
SB-04	0' - 2'	SM	8' - 10'	CH
SB-05	0' - 2'	ML	2' - 4'	ML
SB-06	0' - 2'	ML	4' - 6'	SM
SB-07	0' - 2'	SM	2' - 4'	SC
SB-08	0' - 2'	SM/SC	*8' – 10'*	*CL*
SB-09	0' - 2'	CL	2' - 4'	CL
SB-10	0' - 2'	CL	4' - 6'	CH
SB-11	0' - 2'	CL	6' - 8'	CH
SB-12	0' - 2'	CL	8' - 10'	SC
SB-13	0' - 2'	ML	6' - 8'	SC
SB-14	0' - 2'	ML	4' - 6'	ML
SB-15	0' - 2'	CL	8' - 10'	SC
SB-16	0' - 2'	CL	6' - 8'	CL
SB-17	0' - 2'	ML	8' - 10'	CH
SB-18	0' - 2'	ML/CL	6' - 8'	CL
SB-19	0' - 2'	SM	4' - 6'	SC
SB-20	0' - 2'	CL	6' - 8'	CH
SB-21	0' - 2'	CL	6' - 8	CH
SB-22	0' - 2'	CL	2' - 4'	CL
SB-23	0' - 2'	CL	4' - 6'	ML
SB-24	0' - 2'	ML/CL	8' - 10'	SM
SB-25	0' - 2'	SM/CL	4' - 6'	SM/SC
SB-26	0' - 2'	CL	8' - 10'	SC
SB-27	0' - 2'	CL	4' - 6'	CL
SB-28	0' - 2'	ML	2' - 4'	ML
SB-29	0' - 2'	CL	2' - 4'	CL
SB-30	0' - 2'	CH	4' - 6'	CH
SB-31	0' - 2'	CL	6' - 8'	CH
SB-32	0' - 2'	CL	8' - 10'	CL
SB-33	0' - 2'	ML/CL	*4' – 6'*	*CH*
SB-34	0' - 2'	ML/CL	*2' – 4'*	*CL*

Table 4.1-1
Background Study
Soil Types
(Continued)

Soil Boring Number	First Interval Depth	First Interval Soil Type	Second Interval Depth	Second Interval Soil Type
SB-35	0' - 2'	CL	8' - 10'	CH
SB-36	0' - 2'	SM	***6' – 8'***	***CL***
SB-37	0' - 2'	SM	4' - 6'	SP
SB-38	0' - 2'	SM	8' – 10'	SC
SB-39	0' - 2'	CL/SM	4' - 6'	SM
SB-40	0' - 2'	SM	6' - 8'	SP
SB-41	0' - 2'	CL	***4' – 6'***	***CH***
SB-42	0' - 2'	CH	6' - 8'	ML
SB-43	0' - 2'	CH	***2' – 4'***	***CH***
SB-44	0' - 2'	CL	4' - 6'	SC
SB-45	0' - 2'	ML/CL	6' - 8'	CH
SB-46	0' - 2'	ML	4' - 6'	CH
SB-47	0' - 2'	CL	4' - 6'	CH
SB-48	0' - 2'	SM/CL	8' - 10'	CH
SB-49	0' - 2'	CL	2' - 4'	CL
SB-50	0' - 2'	ML/CL	***4' – 6'***	***CL***
SB-51	0' - 2'	ML/CL	***6' – 8'***	***CL***
SB-52	0' - 2'	CL	8' - 10'	CL
SB-53	0' - 2'	CL	2' - 4'	CL
SB-54	0' - 2'	ML/CL	4' - 6'	CH
SB-55	0' - 2'	CL	6' - 8'	CH
SB-56	0' - 2'	CL	8' - 10'	CH
SB-57	0' - 2'	ML	2' - 4'	CH
SB-58	0' - 2'	ML/CL	6' - 8'	CL
SB-59	0' - 2'	ML	4' - 6'	CL
SB-60	0' - 2'	ML/CL	8' - 10'	CL
SB-61	0' - 2'	ML	4' - 6'	CL
SB-62	0' - 2'	CL	6' - 8'	ML
SB-63	0' - 2'	ML	2' - 4'	ML
SB-64	0' - 2'	CL	8' - 10'	CL

*Note: Those in bold, italics were samples that were inadvertently discarded.

The blank data for this project were evaluated using statistical analyses to better understand the random and systematic "noise" in the sampling and analytical systems. The population of method blank results provides an estimate of the noise of the measurement process. Noise of the measurement process includes low-level contaminants from sample preparation and analysis as well as random noise from electronic signals from the instrumentation. In a normal distribution of blank data, a significant number of blank measurements will produce values greater than zero (and at times greater than the method detection limit). As a result, populations of method blank results can be used to establish a range of low-level values that represent measurement of noise. The upper tolerance limit (UTL) of this range can be statistically generated and used as a "limit" for the amount of noise expected from the analytical system. It is also used to determine whether sample results are significantly different from the noise represented by the blank results. Similarly, combined equipment and method blank UTLs can be calculated. By comparing the combined UTL and the method blank UTL, it can be determined if the sampling effort contributed to the overall sampling and analytical system noise; and if the results of samples from the site are significantly different from field and analytical noise. For this report, equipment blank results were compared to method blank UTLs.

Prior to computing blank UTLs, graphical displays of blank data were studied and an outlier evaluation was performed. The outlier evaluation method is consistent with that applied to the background data and is described in Section 3.3 below.

There were three equipment blank samples that showed particularly high concentrations of all metals. These samples are identified by file ids 61E20210-29, 61E20210-30, and 61E20210-31. These points indicate that there may be high variability in the blank data, indicating a high level of "noise" in the sampling and analytical process. This high variability may make it more difficult to distinguish background concentrations from noise. The effect on the background analysis is a potentially elevated blank UTL. As a result, some inorganic analytes may be indistinguishable from "noise", due primarily to the three anomalous results.

Influence of these points for particular analytes are discussed below. Other than these three points, method and equipment blanks were similar. The blank data were combined for statistical analysis, but due to the three elevated equipment blank results, separate UTLs and summary statistics were also prepared for method blanks alone. Summary statistics and upper tolerance limits for blank data (combined equipment and method blanks) are given in Appendix C, Table 1. Summary statistics for method blanks data only are available in Appendix C, Table 2.

4.2.2 Comparison of Background Results and Blank Results

Background sample results were compared to both the combined blank UTLs and to the method blank UTLs to determine which sample results, if any, are statistically indistinguishable from the population of method and equipment blanks. Sample results that are statistically different from blank populations (i.e., greater than the blank UTL) are considered to be representative of actual site conditions; sample results that are statistically indistinguishable from the blank population are considered indistinguishable from sampling and analytical noise. If an analyte showed no results greater than the combined blank UTL, the results for that analyte were compared to the method blank UTL to characterize any effect of the three high equipment blank results. The combined blank UTLs overlaid on boxplots of the data are shown in Appendix D, and provide a graphical indication of how the background samples compare to the "noise" in the system. For analytes where no samples are greater than the blank UTL, their presence in background samples cannot be demonstrated statistically. Background concentrations for these analytes are within the range of sampling and analytical noise.

Based on the graphical and statistical analysis of the background and blank data, the following conclusions were drawn for background surface and subsurface soils.

Surface Soils Results

Coarse Granularity

- The following inorganics had concentrations indistinguishable from combined blank concentrations indicating that these naturally occurring concentrations cannot be resolved with the analytical methods that are specified. These are antimony, beryllium, molybdenum, silver, and sodium. The fact that these analytes are indistinguishable from the noise in the system could be due to elevated combined blank UTLs for inorganics due to three anomalous results (see discussion above). Antimony, silver and sodium are indistinguishable from the method blank concentrations as well as the combined blank concentrations indicating that these three analytes are truly indistinguishable from sampling and analytical "noise". However, beryllium and molybdenum can be distinguished from the method blank concentrations, but not from combined blank concentrations, indicating that the three anomalous results may have elevated the combined blank UTL.

- The following organics had concentrations indistinguishable from combined blank concentrations, indicating that ubiquitous concentrations cannot be resolved with the analytical methods that are specified. These are: 2,4,5-T, 2,4,5-TP (Silvex), Aldrin, Dalapon, 4,4'-DDD, 4,4'-DDT, 2,4-D, Dicamba, Dichloroprop, Dieldren, Dinoseb, Endosulfan I, Endrin Ketone, MCPA, MCPP, delta-BHC, and gamma-BHC.

Fine Granularity

- Fine-grained concentrations were greater than combined blank UTLs for all inorganic constituents. Thus, naturally occurring metals concentrations in background surface soils could be resolved with the analytical methods specified.

- The following organics had concentrations indistinguishable from combined blank concentrations, indicating ubiquitous concentrations cannot be resolved with the analytical methods that are specified. These are: 2,4,5-T, 2,4,5-TP (Silvex), Aldrin, Chlordane, Dalapon, 4,4'-DDD, 4,4'-DDT, 2,4-D, Dicamba, Dichloroprop, Dieldren, Dinoseb, Endosulfan I, Endosulfan II, Endrin Aldehyde, Heptachlor, Heptachlor epoxide, MCPA, MCPP, Mirex, Toxaphene, alpha-BHC,gamma-BHC, alpha-Chlordane, and gamma-BHC.

Subsurface Soils Results

Coarse Granularity

- Coarse-grained concentrations were greater than combined blank concentrations. Thus, naturally occurring concentrations in background subsurface soils could be resolved with the analytical methods specified.

- Beryllium, molybdenum, silver and sodium have background concentrations that are indistinguishable from combined blank concentrations indicating that naturally occurring concentrations cannot be resolved with the analytical methods that are specified for these inorganic constituents. The fact that these analytes are indistinguishable from the noise in the system could be due to elevated combined blank UTLs for inorganics due to three anomalous results. Silver and sodium are indistinguishable from the method blank concentrations as well as the combined blank concentrations, indicating that these two analytes are truly indistinguishable from sampling and analytical "noise". However, beryllium and molybdenum can be distinguished from the method blank concentrations, but not from combined blank concentrations, indicating that the three anomalous results may have elevated the combined blank UTL.

Fine Granularity

- Fine-grained concentrations were greater than combined blank concentrations for all analytes but silver. Thus, naturally occurring concentrations in background subsurface soils could be resolved with the analytical methods specified.

- Silver was the only analyte to have background concentrations indistinguishable from combined blank concentrations indicating naturally occurring concentrations cannot be resolved with the analytical methods that are specified. The fact that these analytes are indistinguishable from the noise in the system could be due to elevated combined blank UTLs for inorganics due to three anomalous results. However, silver was indistinguishable from the method blank concentrations as well as the combined blank concentrations indicating that this analyte is truly indistinguishable from sampling and analytical "noise".

4.2.3 Evaluation of Duplicates

Duplicate samples are designed to provide estimates of precision. Precision is a measure of agreement among individual measurements of the same property made under prescribed similar conditions. Duplicate field samples are used as indicators of overall measurement data precision. The analysis of duplicate samples involves replicating sample collection (and the associated sample handling activities), as well as the sample preparation and analysis. Precision estimates based on duplicate sample results incorporate both sampling and analytical variability.

From graphical evaluation of field duplicate data versus its normal field result several soil boring locations were identified as unusual. Soil Boring 15 (SB15) shows the field duplicate result much larger than the normal result for several analytes: arsenic cadmium, chromium, iron, molybdenum, and lead. Endrin shows one location, SB3, where the normal result is much bigger than the field duplicate. Lead and sodium show field duplicate results much greater than the normal for SB41 and SB26 respectively. **The presence of such large discrepancies does not imply that the background data are incorrect. Rather they suggest a large amount of measurement imprecision.** In general, the data used for the background study (the normal data) were lower than the field duplicate results. This means that the estimates of background data will be, if anything, more conservative (i.e., lower). The differences between some field duplicates and normal samples indicate that measurement error for individual samples may be high. This imprecision will be reflected in the variability of the data, and may result in real differences in the data being obscured.

4.2.4 Outlier Testing and Graphical Data Review

Boxplots of the raw background data were prepared and used to conduct outlier tests to identify anomalous results. Box plots are useful graphical tools for displaying the central tendency and variability of data distributions. The boxplots shown in Appendix D were used to identify potential outliers and to characterize the variability of the data. In these boxplots, data points further than 1.5 times the inter-quartile range distance from either the first or third quartiles are shown as asterisks. Data points that were further than three times the inter-quartile range from either the first or third quartiles were labeled as potentially extreme outliers. An outlier test (U. S. EPA, 1989) was performed on those potentially extreme outliers to determine if they were statistically different from the rest of the background sample population. The outlier test used creates a test statistic where $\overline{X}$ and s are the mean and standard deviation of all observations, and X_n is the suspected outlier, the nth observation when observations are ordered smallest to largest.

$$T_n = (X_n - \overline{X}) / S$$

The test statistic, T_n was compared to tabled values found in Table 8 of the "Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities", (U.S. EPA 1989). If the test statistic was greater than the tabled value at the 0.05 level of significance, it was labeled as significant. Each potential outlier that was significantly different from the rest of the background population according to the outlier test was reviewed to determine whether causes could be identified that would support removing the outlier from the background data set. Outliers were also reviewed by sample number to determine if any location(s) produced multiple outliers, making it a questionable background location.

Two locations showed an unusually high number of statistical outliers (i.e., multiple analytes had outliers for these two locations). Subsurface results at SB-44 and Surface results at SB-36 all showed a high number of outliers (11 and 16 respectively). However, none of the samples identified as outliers by the test described above could be removed for an assignable cause. Therefore the validated analytical results for all the normal soil samples collected were retained for further statistical analysis.

4.3 Statistical Analysis

Statistical analysis of the background sample results consisted of the following steps:

- Evaluate the effects of soil granularity on soil concentrations and evaluate statistical differences between surface and subsurface soil concentrations.

- Determine the statistical distribution of background constituent concentrations for each constituent in surface and subsurface soil.

- Calculate 95% upper tolerance limits (UTLs) and additional summary statistics (e.g., means and 95% upper confidence limits for the means) to be used for determining presence/absence and nature and extent of contamination for future studies.

- Each of these steps in the data analysis process is described in the following sub-sections along with a discussion of the data reporting used for this study.

4.3.1 Data Reporting

As required by the Background Study Evaluation Framework, an uncensored reporting convention was used for all background study analytical results. Uncensored data include all instrument response values. Numerical results are never censored at a pre-established value (e.g., instrument detection limit, project-required reporting limit, etc.). For some analytical procedures (e.g., inorganic methods) there is always an instrument response and sometimes the instrument response is negative. A negative uncensored value does not indicate a negative concentration. For practical application, negative analytical results (and calculated statistics, including UTLs) can be interpreted as results that are at, or very near, a concentration of zero.

Because of differences in methodology and instrumentation, negative values are not reported for organic analytical procedures. Data from these procedures are reported as ND, meaning there is no measurable instrument response. A proxy concentration will be calculated for ND results using random uniform numbers between zero and the method detection limit (MDL) or the lowest (below MDL) result reported.

The use of negative results for inorganic constituents in statistical calculations contribute to more accurate characterization of background conditions than the use of proxy concentrations such as one-half of the detection limit, a random number between zero and the detection limit. Calculations that are made using censored data bias the mean and the standard error of the data set because information about variability is distorted (see ASTM D-4210-89 for further discussion on this topic). Based on these considerations, uncensored data were selected as the most appropriate reporting convention for use in the statistical evaluation of background concentrations.

When using the summary statistics and UTLs contained in this report for future applications, two major factors must be accounted for to avoid potentially making erroneous conclusions. First, data to be compared to the background values must be from corresponding environmental media and acquired using comparable sampling and analytical methods. Second, data to be compared to the background values should also be reported in the same uncensored convention.

4.3.2 Statistical Evaluation

A statistical analysis was performed to evaluate whether physical sample characteristics have a significant effect on metals concentrations in background surface and subsurface soil. Surface and subsurface soil was evaluated on the basis of six different soil types [i.e., clay (CH), silty or sandy clay (CL), clayey silt (ML), clayey sand (SC), silty sand (SM), and gravelly sand (SP)] classified into two granularities [fine (CH, CL, ML) and coarse (SC, SM, SP)].

Statistical analysis of variances (ANOVAs) were performed for each analyte to test for statistically significant effects of soil granularities within each depth (surface and subsurface). ANOVAs were also performed to determine differences between surface soil and subsurface soil concentrations. ANOVAs were performed for each analyte separately. The analyses were performed in the following manner.

- ANOVAs were performed on the raw results, natural log transformed results, and the ranked results.
- Residuals from these ANOVAS were evaluated using the Shapiro-Wilks W test of normality
  - If the raw residuals were normal, the original data were used in analyses.
  - If the log-transformed residuals were normal, the log-transformed data were used in analyses.
  - If the ranked data were normal, the ranked data were used in analyses.

A characteristic (e.g., soil granularity) is said to have a statistically significant effect if the ANOVA p-value is less than or equal to 0.05 (an alpha level of 0.05 is equivalent to a 95% confidence level). The p-value is the probability of getting a result as extreme as the one obtained just by chance.

While an ANOVA indicates whether or not a group of characteristics are significantly different, it does not indicate *which* characteristic(s) are different from one another (i.e., how the characteristics should be grouped or ranked). For example, the ANOVA may indicate that there is a statistically significant difference between the soil granularities for a particular analyte, but it will not indicate which granularity is higher or lower. Therefore, when the ANOVA results indicated that granularity for a given analyte and medium was statistically significant, boxplots of the coarse and fine samples were compared to evaluate which granularity had higher concentrations. These boxplots are shown in Appendix D. Patterns identified in the boxplots among all or most analytes within a medium provide a means of dividing analyte concentrations into natural groupings. These groupings are used to report all summary statistics.

The results of the ANOVAs and discussion of groupings suggested by evaluation of the boxplots in Appendix D are given in the two sub-sections below.

Comparison of Soil Granularity Concentrations

A statistical analysis was performed to evaluate whether physical sample characteristics (e.g., soil granularity) have a significant effect on the analyte concentrations in soil. The six surface soil types and their granularity classification (Unified Soil Classification System) from which background samples were collected are:

- clay (CH) Fine
- silty clay or sandy clay (CL) Fine
- clayey silt (ML) Fine
- clayey sand (SC) Coarse
- silty sand or fine sand (SM) Coarse
- gravelly sand (SP) Coarse

An analysis of variance (ANOVA) was performed to test for granularity effects for each analyte separately. The analyses showed 17 of the 24 metals in subsurface soils had statistically significant differences among soil granularities: aluminum, arsenic, barium, beryllium, cadmium, chromium (total), copper, iron, lead, magnesium, nickel, potassium, selenium, sodium, thallium, vanadium and zinc. For these 17 analytes, the boxplots in Appendix D indicate that coarse-grained soil is consistently lower than fine-grained soil.

For surface soils, 13 of the 24 metals had statistically significant differences between granularities. The boxplots in Appendix D again show coarse-grained soil consistently lower than fine-grained soil for: aluminum, arsenic, cadmium, calcium, chromium (total), copper, iron, lead, magnesium, nickel, potassium, vanadium and zinc. None of the pesticides or herbicides analyzed in surface soils show significant differences between granularities. However, the number of detects was in general low for these analytes.

Comparison of Surface and Subsurface Soil Concentrations

ANOVAs were also performed to test for effects of soil depths (i.e., surface and subsurface) for each analyte separately. The analyses showed that, in general, there were no differences between surface soil sample concentrations and subsurface soil sample concentrations. Of the 24 analytes evaluated, only the following four analytes showed statistically significant differences between surface and subsurface soil concentrations: manganese, mercury, selenium, and silver.

Results of Comparisons

Since analytes did show a significant difference between surface soil and subsurface soil concentrations in previous background studies done at Fort Polk and the exposure pathways are different for surface and subsurface soil contamination, summary statistics are presented for each depth classification separately.

Since many analytes showed a significant difference between coarse and fine-grained soil concentrations, coarse and fine-grained soils were also segregated for this background study. It is recommended that they be segregated for future investigations. However, because information will not always be available about the granularity of the samples, UTLs and other summary statistics are provided for the combined granularities as well. Combining granularities reduces the ability of the study to determine true differences between potential releases and background, but may be necessary in some cases. The process of deriving the combined UTLs and summary statistics was the same as that for the segregated data.

Summary statistics are presented for each granularity and depth classification separately in Appendix C, Table 3. Summary statistics for combined coarse and fine granularities for each depth are presented in Appendix C, Table 4.

4.3.3 Statistical Distribution of Background Concentrations

Normality tests were performed on the background surface soil and subsurface soil data for each analyte and granularity and also for granularities combined. The assumption of normality is a fundamental tenet of statistical tests involving parametric methods. Therefore, the extent to which the data support this assumption determined the direction of subsequent analyses in which summary statistics were calculated.

Several statistics were evaluated in determining the distribution of the background data. These include the mean, median, skewness and kurtosis. The final determination of the data distribution, however, was based on the results of the Shapiro-Wilk's W-test (Shapiro and Wilk, 1965) for normality. The Shapiro-Wilk W-test was performed first on the raw results to test for normality of the data. A p-value greater than 0.05 indicates that the hypothesis of normality cannot be rejected. If the data are not normally distributed then the Shapiro-Wilk W-test was performed on the natural logarithms of the data to test for lognormality. A p-value greater than 0.05 for the lognormal Shapiro-Wilk W-test indicates that the hypothesis of lognormality cannot be rejected. If the data are neither normally nor lognormally distributed, then the data were said to be nonparametrically distributed (i.e., no distribution type). Appendix C Table 5 presents the results of the Shapiro-Wilk W-test for analytes in surface and subsurface soils by granularity. Appendix C Table 6 presents the results of the Shapiro-Wilk W-test for analytes in surface and subsurface soils across granularity

The other summary statistics presented in Appendix C Table 5 and Table 6 (i.e., the mean, median, skewness, and kurtosis) were evaluated to better understand why the data are or are not normally distributed. For data sets that are normally distributed, the mean and median tend to be close together. As the data set becomes further skewed to the right the mean becomes increasingly larger than the median. Skewness and kurtosis describe further departures from normality. Skewness is characterized by a lack of symmetry in the data distribution. The skewness is close to zero for normal populations. The skewness will be positive for populations in which the upper tail is the extended one, and the skewness will be negative for populations in which the lower tail is the extended one. Kurtosis is a measure of the heaviness of the tail of a distribution. Normal populations generally have a kurtosis close to zero, long-tailed distributions show a positive kurtosis and flat-topped distributions show a negative kurtosis.