APPENDIX O

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

This page intentionally left blank

Human Health Risk Assessment

for the

Former Camp Croft
Spartanburg, South Carolina

Prepared under:
Contract No. W912DY-10-D-0028
Task Order No. 0005
Black & Veatch Project No. 042306.05.00

Prepared for:
Zapata, Incorporated
6302 Fairview Road, Suite 600
Charlotte, NC 28210

Prepared by:
Black & Veatch Special Projects Corp.
1120 Sanctuary Parkway, Suite 200
Alpharetta, Georgia 30009

Revision 3
August 2014

This page intentionally left blank.

Contents

Page No.:

Acronyms and Abbreviations AA-1
1.0 Introduction 1-1
2.0 Identification of Chemicals of Potential Concern 2-1
3.0 Exposure Assessment 3-1
3.1 Characterization of the Exposure Setting 3-1
3.2 Exposure Pathways and Analysis 3-2
3.2.1 Sources, Mechanisms of Chemical Release and Transport 3-2
3.2.2 Exposure Pathway Analysis 3-2
3.3 Exposure Summary 3-4
4.0 References 4-1

Tables

Table 2 Occurrence, Distribution and Selection of Chemicals of Potential Concern in Surface Soil

Attachments

Attachment A IEUBK Output

Acronyms and Abbreviations

COPC	Chemicals of Potential Concern
dL	deciliter
DNR	Department of Natural Resources
EPA	Environmental Protection Agency
FUDS	Formerly Used Defense Site
HHRA	human health risk assessment
IEUBK	Integrated Exposure Uptake Biokinetic
µg	microgram
MC	munitions constituents
mg/kg	milligrams per kilogram
PETN	pentaerythritol tetranitrate
RI/FS	Remedial Investigation/Feasibility Study
RSL	Regional Screening Level
USACE	United States Army Corps of Engineers

1.0 Introduction

The purpose of this baseline human health risk assessment (HHRA) is to evaluate the potential current and future health effects in a baseline condition caused by the releases of munitions constituents (MC), i.e., hazardous substances, from the site, in the event that no action is taken to remove contaminants or stop contaminant migration. The HHRA is intended to support a Remedial Investigation/Feasibility Study (RI/FS) for the Former Camp Croft Formerly Used Defense Site (FUDS).

In 2012 and 2013, soil samples were collected as part of the RI that focused on the possible risk to human health from munitions response sites at the Former Camp Croft FUDS. This HHRA evaluates the 2012 and 2013 data to determine if there are any chemicals of potential concern (COPCs) that may require further assessment of exposure and risks.

The principal guidance documents used in conducting this human health risk assessment include:

- *Munitions and Explosives of Concern Hazard Assessment Methodology, Interim, October 2008* (U.S. Environmental Protection Agency [EPA], 2008).
- *Risk Assessment Guidance for Superfund (RAGS) (Parts A through F)* (EPA, 1989, 1991a, 1991b, 2001, 2004, and 2009) and U.S. Army Corps of Engineers [USACE] guidance, *EM 200-1-4, Volume I, Human Health Evaluation* (USACE, 1999).

This page intentionally left blank.

2.0 Identification of Chemicals of Potential Concern

The first step in the risk assessment process is to identify those hazardous substances that may pose a threat to human health. The selection of COPCs includes an evaluation of the analytical data, a careful analysis of the sources of MC contamination and affected areas, and a review of site characteristics.

For this risk assessment, 132 surface soil samples were screened for the presence zinc and explosives plus nitroglycerin and pentaerythritol tetranitrate (PETN). An additional eight samples, or a total of 140 samples, were screened for the presence of antimony and copper. An additional nine samples, or 141 total, were screened for the presence of lead. The full data set is presented in Chapter 5 of the RI report.

Samples were collected from the region designated as the Land Range Complex (MRS 3). The Range Complex is a 12,102-acre area composed of 15 ranges and two lakes. Documented munitions used within this complex included small arms, rifle grenades, 2.36-inch rockets, and 60 mm and 81mm mortars. Numerous other munitions have been discovered within the range complex; those items include the 37 mm, 57 mm, 105 mm and 155 mm.

Per risk assessment guidance, RAGS Part D Table 2 lists all chemicals that have been analyzed for in at least one sampling location. Sampling locations are presented in Exhibits 5-6 through 5-10 of the RI report. Table 2 also contains statistical information about the chemicals, the detection limits of chemicals analyzed, risk-based screening values for COPC selection, and rational for the selected or deletion of the chemical as COPCs. The following screening criteria were used to select or eliminate each chemical:

- Surface soil analytical results were compared against the EPA Regional Screening Levels (RSLs) for Residential Soil (dated November 2012).
- Analytical results were also compared to site-specific background levels.

The maximum concentration for each constituent was compared to the applicable screening criterion. If a duplicate sample was collected, the average of the parent and duplicate sample was used if the constituent was detected in both samples and the detection was used if only one of the sample results detected the constituent. If the concentration used for screening for a constituent exceeded the conservative risk-based screening level, then the chemical was retained as a COPC and evaluated further in the risk assessment. Site-specific background levels were only used to eliminate a chemical as a COPC if the maximum detected concentration exceeded the RSL but was less than the background level. If the maximum detected concentration exceeded the background level, that chemical could only be selected as a COPC if the RSL was also exceeded. Since background levels were only available for the inorganics and the maximum detected concentrations of these constituents all exceeded their background levels, background could not be used to eliminate any chemical as a COPC. Results of the surface soil screening (Table 2) indicate that lead is the only COPC.

3.0 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude of potential human exposure to the COPCs at the site. The results of the exposure assessment are then combined with chemical-specific toxicity information to estimate the potential human health risks associated with chemical exposure.

3.1 Characterization of the Exposure Setting

The physical characteristics of the site area are described in detail in Section 2.2 of the RI report. The project site is located in the upstate of South Carolina, less than 10 miles southeast of downtown Spartanburg, SC. The site is roughly bound to the north SC Highway 295, to the east by US Highway 176, to the south by SC Highway 150 and to the west by SC Highway 56. The site can be accessed by taking US Highway 176 south at Exit 72 along US Interstate 85.

The surrounding landscape is consistent with the Piedmont physiographic province, with rolling hills, many tributary channels, and iron-rich clay overburden soils. The FUDS property occupies approximately 19,044 acres, the majority of which includes Croft State Natural Area. Much of the land surface is wooded. The highest elevation is approximately 800 ft above mean sea level. Topography varies only by several hundred feet. There are two man-made lakes within Croft State Natural Area: Lake Johnson and Lake Craig.

During the development of the Comprehensive Plan, Spartanburg County categorized land uses by major type, i.e., residential, commercial, industrial, agricultural, woodland, etc. As of the late 1990s, over one-half of the county was in woodlands of various ownerships. Approximately one-quarter of the county was in farmland, and nearly one-quarter in urban/built up land. The South Carolina Department of Natural Resources (DNR) prepared in 1992 a digital land cover map of the state, including Spartanburg County. Land cover in Spartanburg County generally is divided on the map into four broad categories; those include Agricultural/Cropland, Urban/Built up land, Mixed Forest (woodland), and Deciduous Forest (woodland). From an aerial perspective, these four land use groups present a physical form. The urban/built up land form represents a continually changing land mass, running into agricultural, grasslands and forested areas, continually altering its boundaries in response to changes wrought by growth and development (Spartanburg County, 1998).

Croft State Natural Area occupies 7,054 acres of the 19,044-acre FUDS property. The majority of the park is open to the public although access is controlled by maintaining various roads and trails and restricting off-trail activities. The primary activities conducted at the park include hiking, mountain biking, fishing, boating, and equestrian. The park hosts a horse shows on the third Saturday of each month between February and November. Bow hunting is allowed during three two-day sessions between September and November. It is not anticipated that site usage at Croft State Natural Area would change unless RI/FS findings indicated an immediate need to do so. Land used for the remainder of the FUDS property (approximately 11,990 acres) is composed of industrial, agricultural, commercial, residential and private ownership. It is likely those types of land use will continue in the future.

3.2 Exposure Pathways and Analysis

An exposure pathway is the mechanism through which a receptor comes in contact with contaminated media. Potential exposure pathways typically include incidental ingestion and dermal contact with soil. Refer to Tables 3-1 through 3-3 of the Remedial Investigation Report for the Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC) Revised Conceptual Site Model and Generalized MEC and MC Conceptual Site Exposure Models.

3.2.1 Sources, Mechanisms of Chemical Release and Transport

Munitions constituents expected at the study area include antimony, copper, lead, zinc, and explosives plus nitroglycerin and PETN. Based on the screening described above, lead is the only COPC in surface soil.

3.2.2 Exposure Pathway Analysis

Lead was detected in surface soil samples at concentrations ranging from 2.3 to 2,320 milligrams per kilogram (mg/kg). It was chosen as a COPC based on the fact that its maximum concentration exceeded the EPA RSL of 400 mg/kg.

Lead contamination is limited to two distinct areas: MRS3-A and -B, and Grid A4718. MRS3-A and -B are represented by six grab samples collected approximately 20 feet apart (see Exhibit 5-12 of the Remedial Investigation Report). They are designated CC-MRS3-ZSB-29, CC-MRS3-ZSB-30, CC-MRS3-ZSB-PB01, CC-MRS3-ZSB-PB02, CC-MRS3-ZSB-PB03, and CC-MRS3-ZSB-PB04. Lead was discovered at concentrations ranging from 95.3 to 1,080 mg/kg. The average concentration at MRS3-A and -B is 428 mg/kg.

The area of lead contamination associated with Grid A4718 is represented by a quadrilateral defined by sample points PB06, PB07, PB10 and PB09 (see Exhibit 5-13 of the Remedial Investigation Report). Five additional sample locations within this area define this exposure unit. They are samples CC-MRS3-ZSB-101, CC-MRS3-ZSB-102 and its duplicate, CC-MRS3-ZSB-103, CC-MRS3-ZSB-104, and CC-MRS3-ZSB-105. Lead was discovered at concentrations ranging from 154 to 2,320 mg/kg within this area. The average concentration in the Grid A4718 exposure unit is 534 mg/kg.

There are no traditional toxicity constants available for lead. Instead, blood-lead concentrations have been accepted as the best measure of exposure to lead. Because young children (especially those under the age of 7 years) are the most vulnerable to lead toxicity, EPA developed an Integrated Exposure Uptake Biokinetic (IEUBK) model for lead in children to predict blood-lead levels from chronic exposures of children to lead. When this model is used with site concentration data, and the predicted blood-lead levels in young children (the most vulnerable group in the population) are shown to be acceptable, it is not necessary to also address adult exposure.

Per the IEUBK model guidance, the arithmetic average concentration of lead in surface soil at MRS A and B (428 mg/kg) and Grid A4718 (534 mg/kg) were input into the latest version of the IEUBK model (EPA, 2010). Default lead concentrations were used for the remaining parameters. The printouts from the model are provided in Attachment A.

EPA uses a level of 10 micrograms (μg) lead per deciliter (dL) blood as the benchmark to evaluate individual and population-level lead exposure. EPA’s target is for a typical child or group of children exposed to have an estimated risk of no more than 5% of exceeding a blood-lead level of 10 μg/dL. Assuming lead concentrations of 534 and 428 mg/kg lead in soil, the projected blood lead levels for 100 percent of the population are below the 10 μg/dL benchmark. These results indicate that lead is not a MC of concern in surface soil.

Uncertainty associated with the health effects of lead is quite low. Some of the uncertainties associated with the IEUBK model are default assumptions related to soil and dust ingestion values and air intake; however, they are designed to be conservative. In addition, the model is not designed for short-term exposures (i.e., less than 3 months) and is related to residential risk, which is unlikely to be a future scenario within the Camp Croft Natural Area.

3.3 Exposure Summary

Maximum and average exposure concentrations of the COPCs were used to compare to conservative residential screening levels. Except for lead, the maximum exposure concentrations were below residential screening levels. Since the dominant exposure scenario would be recreational, potential risks are considered negligible and are not quantified further in the risk assessment process.

Lead occurs above its screening level at two locations within the MRS. Based on the output from EPA's IEUBK model for lead in children that assumes residential exposure assumptions, lead is not a concern at these concentrations.

In conclusion, there are no threats from concentrations of MC to human health at the MRS 3 at the Former Camp Croft FUDS.

4.0 References

U.S. Army Corps of Engineers (USACE). 1999. *Human Health Evaluation, Vol. 1*. EM 200-1-4.

U.S. Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part A), Interim Final*, Office of Emergency and Remedial Response, Washington, DC, EPA/540/1-89/002, 1989.

U.S. Environmental Protection Agency (EPA). 1991a. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part B, Development of Preliminary Remediation Goals)*, Office of Emergency and Remedial Response, Washington, DC, EPA/540/ R-92/003, 1991.

U.S. Environmental Protection Agency (EPA). 1991b. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives),* Office of Emergency and Remedial Response, Washington, DC, 9285.7-01.

This page intentionally left blank.

Table

This page intentionally left blank.

TABLE 2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SURFACE SOIL

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration (1)	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	2x Background Value (2)	Screening Toxicity Value (n/c) (3)	Potential ARAR/TBC Value (3)	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Inorganics (Metals)															
Surface Soil	7440-36-0	Antimony	0.028 J	5.4	mg/kg	CC-MRS3-ZSB-PB08	126 / 140	0.018 - 0.39	5.4	0.3	31 n	NA	NA	N	Max < SL
	7440-50-8	Copper	2	787 J	mg/kg	CC-MRS3-POSTZSB-10	140 / 140	NA - NA	787	33.7	3,100 n	NA	NA	N	Max < SL
	7439-92-1	Lead	2.3	2,320	mg/kg	CC-MRS3-ZSB-PB08	141 / 141	NA - NA	2,320	79.0	400 n	NA	NA	Y	>SL
	7440-66-6	Zinc	9	1,680	mg/kg	CC-MRS3-ZSB-63	132 / 132	NA - NA	1,680	157.3	23,000 n	NA	NA	N	Max < SL
Explosives															
	99-35-4	1,3,5-Trinitrobenzene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	2,200,000 n	NA	NA	N	Max < SL
	99-65-0	1,3-Dinitrobenzene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	6,100 n	NA	NA	N	Max < SL
	118-96-7	2,4,6-Trinitrotoluene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	19,000 c	NA	NA	N	Max < SL
	121-14-2	2,4-Dinitrotoluene	ND	ND	ug/kg	NA	0 / 132	61 - 170	ND	NA	1,600 c	NA	NA	N	Max < SL
	606-20-2	2,6-Dinitrotoluene	ND	ND	ug/kg	NA	0 / 132	61 - 170	ND	NA	61,000 n	NA	NA	N	Max < SL
	35572-78-2	2-Amino-4.6-dinitrotoluene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	150,000 n	NA	NA	N	Max < SL
	88-72-2	2-Nitrotoluene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	2,900 c	NA	NA	N	Max < SL
	99-08-1	3-Nitrotoluene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	6,100 n	NA	NA	N	Max < SL
	19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	150,000 n	NA	NA	N	Max < SL
	99-99-0	4-Nitrotoluene	ND	ND	ug/kg	NA	0 / 132	61 - 170	ND	NA	30,000 c	NA	NA	N	Max < SL
	121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	117 J	117 J	ug/kg	CC-12A-POSTZSB-2	1 / 132	58 - 170	117	NA	5,600 c	NA	NA	N	Max < SL
	479-45-8	Methyl-2,4,6-trinitrophenylnitroamine (Tetryl)	ND	ND	ug/kg	NA	0 / 132	58 - 170	ND	NA	240,000 n	NA	NA	N	Max < SL
	98-95-3	Nitrobenzene	ND	ND	ug/kg	NA	0 / 132	61 - 170	ND	NA	4,800 c	NA	NA	N	Max < SL
	55-63-0	Nitroglycerine	ND	ND	ug/kg	NA	0 / 132	360 - 1,700	ND	NA	6,100 n	NA	NA	N	Max < SL
	2691-41-0	Octahydro-tetranitro-1,3,5,7-tetrazocine (HMX)	ND	ND	ug/kg	NA	0 / 132	58 - 200	ND	NA	3,800,000 n	NA	NA	N	Max < SL
	78-11-5	Pentaerythritol tetranitrate (PETN)	1,240 J	1,240 J	ug/kg	CC-MRS3-ZSB-18	1 / 132	360 - 1,700	1,240	NA	120,000 c	NA	NA	N	Max < SL

(1) The data set evaluated includes surface soil samples collected in March, April, August, September and October 2012. For duplicates, the average of the parent and duplicate sample was used to represent the sample location.
(2) Background consists of samples CC-BKGD-ZSB-1 and its duplicate through CC-BKGD-ZSB-10.
(3) Screened against EPA Regional Screening Levels for Residential Soil (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm, Nov 2012). EPA RSLs are based on incidental ingestion, inhalation of vapors or dust, and dermal absorption.
(4) Rationale for Selection or Deletion
Max < SL = Maximum Concentration is less than the RSL
Max > SL = Maximum Concentration is greater than the RSL

Definitions :
NA = Not applicable
n = Screening Toxcity Value is based on noncancer effects
c = Screening Toxicity Value is based on cancer effects
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Concentration
J+ = Estimated high
J- = Estimated low

Attachment A
IEUBK Output

This page intentionally left blank.

LEAD MODEL FOR WINDOWS Version 1.1

==
Model Version: 1.1 Build11
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==

******** Air ********

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m³/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m³)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

******** Diet ********

Age	Diet Intake(µg/day)
.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

******** Drinking Water ********

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 µg Pb/L

******** Soil & Dust ********

Multiple Source Analysis Used
Average multiple source concentration: 293.500 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
.5-1	405.000	293.500
1-2	405.000	293.500
2-3	405.000	293.500
3-4	405.000	293.500
4-5	405.000	293.500
5-6	405.000	293.500
6-7	405.000	293.500

****** Alternate Intake ******

Age	Alternate (µg Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 1.000 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
.5-1	0.021	1.016	0.000	0.360
1-2	0.034	0.865	0.000	0.883
2-3	0.062	0.956	0.000	0.933
3-4	0.067	0.929	0.000	0.965
4-5	0.067	0.915	0.000	1.032
5-6	0.093	0.972	0.000	1.100
6-7	0.093	1.059	0.000	1.126

Year	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
.5-1	7.879	9.276	5.0
1-2	12.288	14.071	5.8
2-3	12.492	14.443	5.4
3-4	12.678	14.639	5.1
4-5	9.672	11.685	4.2
5-6	8.801	10.966	3.5
6-7	8.361	10.639	3.1

LEAD MODEL FOR WINDOWS Version 1.1

==
Model Version: 1.1 Build11
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(µg/day)
.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 µg Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 473.400 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
.5-1	662.000	473.400
1-2	662.000	473.400
2-3	662.000	473.400
3-4	662.000	473.400
4-5	662.000	473.400
5-6	662.000	473.400
6-7	662.000	473.400

******** Alternate Intake ********

Age	Alternate (µg Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 1.000 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
.5-1	0.021	0.966	0.000	0.342
1-2	0.034	0.816	0.000	0.832
2-3	0.062	0.908	0.000	0.886
3-4	0.067	0.888	0.000	0.922
4-5	0.067	0.887	0.000	1.001
5-6	0.093	0.948	0.000	1.073
6-7	0.093	1.036	0.000	1.101

Year	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
.5-1	12.175	13.505	7.2
1-2	18.818	20.500	8.4
2-3	19.267	21.123	7.8
3-4	19.676	21.553	7.5
4-5	15.234	17.188	6.1
5-6	13.940	16.054	5.1
6-7	13.285	15.515	4.5

Screening-Level Ecological Risk Assessment

for the

Former Camp Croft
Spartanburg, South Carolina

Prepared under:
Contract No. W912DY-10-D-0028
Task Order No. 0005
Black & Veatch Project No. 042306.05.00

Prepared for:
Zapata, Incorporated
6302 Fairview Road, Suite 600
Charlotte, NC 28210

Prepared by:
Black & Veatch Special Projects Corp.
1120 Sanctuary Parkway, Suite 200
Alpharetta, Georgia 30009

Revision 2
May 2014

This page intentionally left blank.

Contents

Page No.:
Acronyms and Abbreviations AA-1
1.0 Introduction 1-1
2.0 Screening-Level Problem Formulation and Ecological Effects Characterization 2-1
2.1 Environmental Setting 2-1
2.2 Contaminant Fate and Transport Mechanisms 2-2
2.3 Likely Receptors and Mechanisms of Toxicity 2-2
2.4 Identification of Complete Exposure Pathways 2-2
2.5 Screening-Level Assessment and Measurement Endpoints 2-3
3.0 Screening-Level Exposure Estimate and Risk Calculation 3-1
3.1 Screening-Level Exposure Estimates 3-1
3.2 Screening-Level Risk Calculation 3-1
3.3 Screening Level Refinement and Potential Ecological Risks 3-2
3.3.1 Exposure to Antimony 3-2
3.3.2 Exposure to Copper 3-3
3.3.3 Exposure to Lead 3-3
3.3.4 Exposure to Zinc 3-3
3.4 Uncertainty 3-4
4.0 Conclusion 4-1
5.0 References 5-1

Tables

Table 2-1 Ecological Screening Levels
Table 3-1 Occurrence, Distribution and Selection of Chemicals of Potential Concern in Soil
Table 3-2 Soil Data Results
Table 3-3 Screening Level Refinement - Comparison of Upper Bound Site COPC Concentrations with Screening Values for Receptors

Acronyms and Abbreviations

BIP	blow-in-place
COPC	Chemicals of Potential Concern
EPA	Environmental Protection Agency
ESV	ecological screening value
FUDS	Formerly Used Defense Site
HQ	hazard quotient
MC	munitions constituents
mg/kg	milligrams per kilogram
NOAEL	No-Observed-Adverse-Effect Level
RI/FS	Remedial Investigation/Feasibility Study
SLERA	screening-level ecological risk assessment
USACE	United States Army Corps of Engineers
UXO	Unexploded ordnance

1.0 Introduction

The purpose of the screening-level ecological risk assessment (SLERA) is to evaluate the potential effects to ecological receptors caused by the releases of munitions constituents (MC), i.e., hazardous substances from the site. This SLERA is developed within the framework of a Remedial Investigation/Feasibility Study (RI/FS) for the former Camp Croft property and is consistent with *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (Environmental Protection Agency [EPA], 1997) and EM 200-1-4, Volume II Environmental Evaluation (United States Army Corps of Engineers [USACE], 2010).

The SLERA constitutes steps 1 and 2 of the 8-step ecological risk assessment process (EPA, 1997) and is comprised of a screening-level problem formulation and a screening-level exposure estimate and risk calculation. The outcome of the SLERA will determine if:

- ecological risks are negligible;
- the ecological risk assessment process should continue to determine whether a risk exists (i.e., continue to Step 3);
- there is a potential for adverse ecological effects and a more detailed assessment incorporating more site-specific information is needed.

This SLERA evaluates the data collected as part of the RI to determine if there any MC of concern that may require further assessment of ecological risks.

This page intentionally left blank.

2.0 Screening-Level Problem Formulation and Ecological Effects Characterization

This section covers Step 1 of the EPA risk assessment process and provides a general discussion of the following issues:

- environmental setting;
- contaminant fate and transport mechanisms that may exist on the site;
- categories of likely receptors and mechanisms of ecotoxicity;
- identification of complete exposure pathways; and
- screening-level assessment and measurement endpoints.

2.1 Environmental Setting

The physical characteristics of the site area are described in detail in Section 2.2 of the RI report.

The Site lies within the Southern Outer Piedmont ecoregion, with low rounded hills and ridges and iron-rich clay overburden soils. Streams within the Site area have low to moderate gradients with a mix of cobble, gravel, and sandy substrates. The Formerly Used Defense Site (FUDS) property occupies approximately 19,044 acres, the majority of which includes Croft State Natural Area. Much of the land surface is wooded and dominated by a mixed oak forest. The highest elevation is approximately 800 ft above mean sea level. Topography varies only by several hundred feet. There are two reservoir lakes within Croft State Natural Area: Lake Johnson and Lake Craig.

Croft State Natural Area occupies 7,054 acres of the 19,044-acre FUDS property. The diverse park covers nearly 12 miles of rolling, wooded terrain that also provides habitat for a wide variety of flora and fauna. Terrestrial habitats at the site include open fields, shrub/scrub, as well as both upland and lowland forests. In the northern portion of the FUDS boundary, numerous small wetland and riparian areas ranging from 0.1 to 5 acres in size have been identified, such as a 4.8-acre Freshwater Forested/Shrub located near the north boundary of MRS-3. The southern portion of the Site area contains larger wetland areas, primarily the Freshwater Forested/Shrub type, along Fairforest Creek and in an area located southwest of Lake Craig.

Flora species include a diverse variety of grasses, shrubs and trees. Many of the private lands around the natural Area have been planted with loblolly pine or are in cultivation. Wildlife species in the area include soil and aquatic invertebrates, fish, amphibians, reptiles, small mammals, and birds. The site is widely used for hunting and game species such as turkey and deer are common.

Only one species is listed by the U.S. Fish and Wildlife Service and that is the Dwarf-flowered Heartleaf (*Hexastylis naniflora*) which is classified as federally threatened. This plant may occur in very small colonies on rolling hillsides and in ravine areas. There are no State threatened or endangered species.

2.2 Contaminant Fate and Transport Mechanisms

Munitions constituents (MC) are the potential contaminants associated with the former military site. These include explosives, antimony, copper, lead, and zinc in the firing range and target areas. The metals are generally found as munitions fragments with a low potential for weathering and leaching. Unexploded ordnance (UXO) may also be found. Explosives in soil and sediment are generally degraded over time by biotic transformations by bacteria, fungi, and other soil microbes. Degradation of explosives also occurs through abiotic transformations such as alkaline hydrolysis, photolysis, and reduction by iron. There is a slight potential that explosives could be leached into shallow groundwater. However, given that several decades have passed since military operations ceased, it is expected that detections of explosives would be rare. Please refer to Tables 3-1 through 3-3 of the Remedial Investigation Report for the Munitions and Explosives of Concern (MEC) and MC Conceptual Site Model (CSM) and MEC and MC Conceptual Site Exposure Models (CSEM).

2.3 Likely Receptors and Mechanisms of Toxicity

Soil organisms, plants, and ground-dwelling small mammals (e.g., rodents) and ground birds (e.g., quail and wild turkey) are likely to be most exposed to soil contamination. In the aquatic environment of the creeks, sediment-dwelling organisms and those that prey on them are considered most exposed. The toxic mechanisms of MC include direct toxicity by contact and some bioaccumulation through the food chain.

2.4 Identification of Complete Exposure Pathways

Soils within the former firing range and target areas are identified as being potentially contaminated with MC, either by direct contamination from past military training activities or through localized transport via erosion. No surface water or sediment samples were collected because these media were not considered to be of concern at this Site (see Tables 3-1 through 3-3 of the Remedial Investigation Report).

Surface soils and riparian zones support terrestrial receptors across several trophic levels (e.g., primary producers, primary consumers, secondary and tertiary consumers) and feeding guilds (e.g., herbivores, omnivores, and carnivores). The primary exposure routes to these ecological receptors may include the following:

- Uptake by vegetation through roots or leaves;
- Direct contact and inadvertent ingestion of contaminated media; and
- Indirect exposure of predatory wildlife to bioaccumulative contaminants in prey items.

2.5 Screening-Level Assessment and Measurement Endpoints

Screening-level assessment endpoints include populations of plants and animals, communities, habitats, and sensitive environments. Various EPA and other federal soil screening values were used as ecological screening values (ESVs). In addition, ten soil samples representative of background conditions of Camp Croft area were collected. If the conservative ESVs from the literature were less than twice the average background concentration, then the background level was used as the ESV. Table 2-1 provides a list of available ecological screening values and their associated references. Some of the explosives compounds do not have any screening values for particular media.

This page intentionally left blank.

3.0 Screening-Level Exposure Estimate and Risk Calculation

This section provides a summary of the screening-level assessment (considered Step 2 of the 1997 EPA guidance), which includes an initial estimate of exposure to receptors and calculates preliminary risks by comparing the maximum documented exposure concentrations in soil with the ESVs.

3.1 Screening-Level Exposure Estimates

For this ecological risk assessment, 132 surface soil samples (0-2 inches depth) were screened for the presence of zinc and explosives plus nitroglycerin and pentaerythritol tetranitrate (PETN) to identify Chemicals of Potential Concern (COPCs). An additional eight samples, or a total of 140 samples, were screened for the presence of antimony and copper. An additional nine samples, or 141 total, were screened for the presence of lead. Twelve of these samples were considered post blow-in-place (BIP) samples, and ten soil samples were collected to be representative of background conditions. The full data set is presented in Chapter 5 of the RI report. The maximum detected soil concentration of each chemical was used as the exposure estimate.

3.2 Screening-Level Risk Calculation

Screening-level risks to ecological receptors were evaluated by calculating a maximum hazard quotient (HQ) for each detected chemical in each medium. The HQ in this case is the ratio of the site maximum detected concentration (exposure concentration) to the ecological screening value. A HQ less than one indicates that the chemical alone is unlikely to cause adverse effects to ecological receptors. A HQ greater than one indicates a potential for ecological impact from exposure to that chemical and becomes designated as a COPC. The screening-level risk calculation is a very conservative estimate to ensure that potential risk to ecological receptors is not underestimated. The results of this screening calculation serve only to determine whether a chemical presents negligible risk or whether additional site-specific information is warranted.

Table 3-1 presents the results of the screening assessment by identifying the soil COPCs and the frequency of exceedances. For example, zinc only had two out of 132 samples that exceeded the ESV.

All of the explosive compounds were either not detected or were below their respective ESVs, therefore no explosives were identified as COPCs.

Each of the four metals analyzed were above their respective ESVs, and are retained for further evaluation. Table 3-2 shows all the samples that exceeded the initial screening values.

3.3 Screening Level Refinement and Potential Ecological Risks

The initial screening levels were based on the most conservative ecological receptor that is assumed to be exposed 100 percent of the time with 100 percent bioavailability. In addition the ESVs were based on No-Observed-Adverse-Effect Levels (NOAELs). For the four metal COPCs, a more detailed refinement of the initial ESVs is warranted. Table 3-3 presents the range of soil concentrations considered protective of a variety of receptors based on EPA's ecological soil screening levels (EPA, 2010). These concentrations also assume 100 percent exposure and bioavailability. In general, herbivorous and carnivorous birds and mammals are less sensitive receptors than insectivorous fauna. Most of the toxicity studies with plants are based on laboratory cultivated crops such as lettuce, grains, and corn. Thus, the ESVs likely overestimate potential risks to indigenous plants at Camp Croft that is dominated by a forest community.

The soil samples were collected in those areas with the highest known densities of munitions debris based on the mag and dig effort and the geophysics data. This biased sampling results in near worst-case exposure concentrations to ecological receptors in highly localized areas (generally less than 0.1 acre at each grid or hub location). The frequency of exceeding the ESVs ranged from 2 percent for zinc to 26 percent for copper indicating that widespread elevated levels of COPCs do not occur.

3.3.1 Exposure to Antimony

The highest level of antimony was at Hub Location A4718 (CC-MRS3-ZSB-PB-08) with a maximum antimony HQ of 17. The average antimony concentration at this Hub location was 1.4 which resulted in an average HQ of 4.3. This location was also high in copper and had the highest concentration of lead. The second highest antimony concentrations were at Hub Location MRS-3A where the average HQ was 4.2. This location also contained elevated copper and lead. Other locations, such as MRS3-10450, 1A-212, and 12A-205 had elevated antimony and other COPCs (see Table 3-2). The HQs for these areas ranged from 1.7 to 2.4 suggesting low exposure hazards. Given widely scattered locations and very small affected areas (< 0.1 acre), risk to insectivorous mammals is considered negligible. There are no risks to other mammals or soil invertebrates (Table 3-3).

3.3.2 Exposure to Copper

The highest concentrations of copper were associated with the post-BIP samples at location 12A-1 and MRS3-1 through 7 (Table 3-2). These samples are highly localized (< 0.1 acre) and likely reflect shell casing fragments in the soils that are not readily bioavailable. Other areas of elevated copper include 12A-187, 12A-205, A4718, and MRS3-A. The hazard quotients for these locations range from 1.1 to 7.6, suggesting relatively low hazards to insectivorous birds and mammals. MRS3-A appears to have some of the highest levels of copper, antimony and lead. Nevertheless, the relatively low HQs, small affected areas, and scattered/isolated pockets of copper suggest that adverse risks to ecological receptors would be low to negligible.

3.3.3 Exposure to Lead

Elevated lead concentrations are often associated with elevated copper and antimony (e.g., A-4718, MRS3-A, 12A-205, 1A-212, and the post-BIP samples as shown in Table 3-2). Hazard quotients for the most sensitive insectivorous birds and mammals range from 1.1 to 29. Again, these very localized elevated levels are not expected to adversely affect resident populations. The initial subsamples collected at locations MRS3-A and A4718 were elevated which prompted additional characterization with further samples that increased the size of the affected areas to about 0.5 acres each. The average HQs at MRS3-A and A4718 were 5.4 and 6.8, respectively. In general, rodents and ground birds do not directly ingest metal fragments, so risks are considered to be overestimated relative to soluble and bioavailable forms. Risks to ground birds and rodents in these specific areas may be likely but are not expected to significantly affect the local population.

3.3.4 Exposure to Zinc

The maximum concentration of zinc (1,680 milligrams per kilogram [mg/kg]) was found at station CC-MRS3-ZSB-63. This appears somewhat of an anomaly because the zinc concentration was not associated with elevated levels of the other COPCs, and the adjacent quadrant sampling results were not elevated. Therefore, potential localized risk could occur to insectivorous birds and mammals, some plants, and soil invertebrates. However, this potential risk is not considered to be significant to local populations of these receptors.

The only other exceedance of the initial screening level was at CC-MRS3-ZSB-63 (164 mg/kg) which was just slightly above background (157 mg/kg). This is not expected to result in significant risk to insectivorous birds and mammals.

3.4 Uncertainty

Sources of uncertainty include the literature-based screening levels selected and the use of local background soil levels. Each of the four metals described above were elevated relative to background which is represented by a small set of samples covering thousands of acres. However, conservative exposure assumptions such as 100 percent bioavailability and 100 percent exposure within an organism's home range are designed to ensure that risks are not underestimated. Confidence in the ecological screening levels for several of the explosive compounds is relatively low due to limited toxicological studies on various ecological receptors. However, the two detected explosives (RDX and PETN) were well below their respective screening levels.

This page intentionally left blank.

4.0 Conclusion

At a few locations, most notably at A4718, MRS3-A, 12A-196, and the post-BIP samples, the metal COPC concentrations exceed conservative screening levels protective of insectivorous birds and mammals with hazard quotients generally less than 6.0. Exposure to metal fragments that are not readily bioavailable suggests an overestimation of potential risks. In addition, these small affected areas comprise only a tiny fraction of overall habitat and home ranges of the receptors. Given the existing data, it is not anticipated that significant adverse risks would occur to local populations of wildlife. There is adequate information to conclude that ecological risks are insignificant and therefore no need for remediation on the basis of ecological risk.

This page intentionally left blank.

5.0 References

U.S. Army Corps of Engineers (USACE). 2010. Environmental Evaluation, Vol. 2. EM 200-1-4, December 31, 2010.

U.S. Environmental Protection Agency (EPA). 2010. Ecological Soil Screening Level Guidance Documents. http://www.epa.gov/ecotox/ecossl/

U.S. Environmental Protection Agency (EPA). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final, EPA/540-R97-006, Environmental Response Team, Edison, NJ, June, 1997.

This page intentionally left blank.

Tables

This page intentionally left blank.

Table 2-1
Ecological Screening Levels
Former Camp Croft

Analyte	*ESV Soil mg/kg*	*Source*
Metals		
Antimony	0.32	A
Copper	33.7	A
Lead	79	A
Zinc	157	A
Explosives		
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	5.8	B
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	43	B
2,4,6-Trinitrotoluene (TNT)	8	B
1,3,5-Trinitrobenzene	0.38	B
1,3-Dinitrobenzene	0.66	C
2,4-Dinitrotoluene	1.28	C
2,6-Dinitrotoluene	0.3	B
2-Amino-4,6-dinitrotoluene	5.3	B
2-Nitrotoluene	4.1	B
3-Nitrotoluene	5.3	B
4-Amino-2,6-dinitrotoluene	NA	--
4-Nitrotoluene	9.4	B
Nitrobenzene	40	C
Nitroglycerin	150	B
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	2	B
Pentaerythritol Tetranitrate (PETN)	21,000	B

NA - Not Available
A - Twice local background (ambient)
B - Los Alamos National Laboratory ECORISK Database (LANL, 2005)
C - EPA Region 5 Ecological Quality Levels (EPA, 2005)

This Page Intentionally Left Blank

TABLE 3-1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL

Screening Level Ecological Risk Assessment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration (1)	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	2x Background Value (2)	Ecological Screening Value (ESV) (3)	Maximum Hazard Quotient	Frequency Exceeding ESV	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Inorganics (Metals)															
	7440-36-0	Antimony	0.028 J	5.4 J-	mg/kg	CC-MRS3-ZSB-PB-08	126 / 140	0.018 - 0.39	5.4	0.32	0.32	16.9	17/132	Y	Max > ESV
Soil	7440-50-8	Copper	2	787 J	mg/kg	CC-MRS3-POSTZSB-10	140 / 140	NA - NA	787	33.7	33.7	23.4	34/132	Y	Max > ESV
	7439-92-1	Lead	2.3	2,320 J-	mg/kg	CC-MRS3-ZSB-PB-08	141 / 141	NA - NA	2,320	79.0	79	29.4	16/132	Y	Max > ESV
	7440-66-6	Zinc	9	1,680	mg/kg	CC-MRS3-ZSB-63	132 / 132	NA - NA	1,680	157	157	10.7	2/132	Y	Max > ESV
Explosives															
	99-35-4	1,3,5-Trinitrobenzene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	2,200,000	NA	NA	N	Max < ESV
Soil	99-65-0	1,3-Dinitrobenzene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	6,100	NA	NA	N	Max < ESV
	118-96-7	2,4,6-Trinitrotoluene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	19,000	NA	NA	N	Max < ESV
	121-14-2	2,4-Dinitrotoluene	ND	ND	µg/kg	NA	0 / 132	61 - 170	ND	NA	1,600	NA	NA	N	Max < ESV
	606-20-2	2,6-Dinitrotoluene	ND	ND	µg/kg	NA	0 / 132	61 - 170	ND	NA	61,000	NA	NA	N	Max < ESV
	35572-78-2	2-Amino-4.6-dinitrotoluene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	150,000	NA	NA	N	Max < ESV
	88-72-2	2-Nitrotoluene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	2,900	NA	NA	N	Max < ESV
	99-08-1	3-Nitrotoluene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	6,100	NA	NA	N	Max < ESV
	19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	150,000	NA	NA	N	Max < ESV
	99-99-0	4-Nitrotoluene	ND	ND	µg/kg	NA	0 / 132	61 - 170	ND	NA	30,000	NA	NA	N	Max < ESV
	121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	117 J	117 J	µg/kg	CC-12A-POSTZSB-2	1 / 132	58 - 170	117	NA	5,600	0.02	NA	N	Max < ESV
	479-45-8	Methyl-2,4,6-trinitrophenylnitroamine (Tetryl)	ND	ND	µg/kg	NA	0 / 132	58 - 170	ND	NA	240,000	NA	NA	N	Max < ESV
	98-95-3	Nitrobenzene	ND	ND	µg/kg	NA	0 / 132	61 - 170	ND	NA	4,800	NA	NA	N	Max < ESV
	55-63-0	Nitroglycerine	ND	ND	µg/kg	NA	0 / 132	360 - 1,700	ND	NA	6,100	NA	NA	N	Max < ESV
	2691-41-0	Octahydro-tetranitro-1,3,5,7-tetrazocine (HMX)	ND	ND	µg/kg	NA	0 / 132	58 - 200	ND	NA	3,800,000	NA	NA	N	Max < ESV
	78-11-5	Pentaerythritol tetranitrate (PETN)	1,240 J	1,240 J	µg/kg	CC-MRS3-ZSB-18	1 / 132	360 - 1,700	1,240	NA	120,000	0.01	NA	N	Max < ESV

(1) The data set evaluated includes surface soil samples collected in March, April, August, September and October 2012. For duplicates, the average of the parent and duplicate sample was used to represent the sample location.

(2) Background consists of samples CC-BKGD-ZSB-1 (and its duplicate) through CC-BKGD-ZSB-10.

(3) See Table 2-1 for sources of ESVs.

(4) Rationale for Selection or Deletion

Max < SL = Maximum Concentration is less than the ESV

Max > SL = Maximum Concentration is greater than the ESV

Definitions :

NA = Not applicable

COPC = Chemical of Potential Concern

J = Estimated Concentration

J- = Estimated low

This Page Intentionally Left Blank

Table 3-2
Soil Data Results
Former Camp Croft

Hub Location	Sample Identification	Grid Quadrant	Antimony		Copper	Lead	Zinc
			mg/kg		mg/kg	mg/kg	mg/kg
Ecological Screening Value (ESV)			0.32		33.7	79	157
12A-187	CC-MRS3-ZSB-16	SW	0.11	J	13.2	8.2	17.9
12A-187	CC-MRS3-ZSB-17	NW	0.062	J	61.6	7.0	14.9
12A-187	CC-MRS3-ZSB-18	NE	0.13	J	87.3	14.7	27.2
12A-187	CC-MRS3-ZSB-19	SE	0.059	J	32.2	7.6	17.6
12A-187	CC-MRS3-ZSB-20	Center	0.18	J	3.4	2.3	13.4
12A-196	CC-MRS3-ZSB-1	SW	0.082	J	5.4	15.4	11.6
12A-196	CC-MRS3-ZSB-2	NW	0.077	J	4.5	11.2	10.4
12A-196	CC-MRS3-ZSB-3	NE	0.058	J	5	13.3	12
12A-196	CC-MRS3-DUP-1	NE	0.068	J	5.8	13.9	13.4
12A-196	CC-MRS3-ZSB-4	SE	0.071	J	4	12.5	10.5
12A-196	CC-MRS3-ZSB-5	Center	0.07	J	4.1	10.1	9.4
12A-205	CC-MRS3-ZSB-10	Center	0.16	J	40.6	33.5	86.5
12A-205	CC-MRS3-ZSB-6	SW	0.24	J	34.3	27.1	72.2
12A-205	CC-MRS3-ZSB-7	NW	0.33		128	92.0	164
12A-205	CC-MRS3-DUP-2	NW	0.45		129	93.9	179
12A-205	CC-MRS3-ZSB-8	NE	0.75		86.9	63	117
12A-205	CC-MRS3-ZSB-9	SE	0.66		29.1	26.6	118
10A-110	CC-MRS3-ZSB-81	SW	0.051	J	4.7	7.3	31
10A-110	CC-MRS3-ZSB-82	NW	0.13	J	32.6	21.3	26.6
10A-110	CC-MRS3-DUP-12	NW	0.14	J	30.8	22.9	23.4
10A-110	CC-MRS3-ZSB-83	NE	0.058	J	9.7	10.3	13.5
10A-110	CC-MRS3-ZSB-84	SE	0.13	J	18.9	20.8	38.6
10A-110	CC-MRS3-ZSB-85	Center	0.057	J	6.9	12.2	10.5
1A-212	CC-MRS3-ZSB-106	SW	0.079	J	7.2	44.1	24.5
1A-212	CC-MRS3-ZSB-107	NW	0.21	J	8.8	70.1	30.8
1A-212	CC-MRS3-ZSB-108	NE	0.8		46.2	276	62.6
1A-212	CC-MRS3-ZSB-109	SE	0.52		18.2	129	28
1A-212	CC-MRS3-ZSB-110	Center	0.058	J	8.6	9.6	18.1
1A-212	CC-MRS3-DUP-15	Center	0.075	J	10.9	14.9	23.9
1A-249	CC-MRS3-ZSB-111	SW	0.21	J	23.9	13.0	24.6
1A-249	CC-MRS3-ZSB-112	NW	0.06	J	34.6	10.6	32.2
1A-249	CC-MRS3-ZSB-113	NE	0.17	J	137	32.0	62
1A-249	CC-MRS3-ZSB-114	SE	0.081	J	35.6	17.1	32.5
1A-249	CC-MRS3-ZSB-115	Center	0.14	J	18.4	10.8	26.9
1A-368	CC-MRS3-ZSB-116	SW	0.33		19.8	10.3	32.9
1A-368	CC-MRS3-ZSB-117	NW	0.14	J	26.6	12.6	64.3
1A-368	CC-MRS3-ZSB-118	NE	0.077	J	12.2	15.4	35.2
1A-368	CC-MRS3-ZSB-119	SE	0.083	J	28.8	14.8	74.5
1A-368	CC-MRS3-ZSB-120	Center	0.036	J	18.4	7.9	44.5
1A-572	CC-MRS3-ZSB-100	Center	0.067	J	8	8.9	13.4

Table 3-2
Soil Data Results
Former Camp Croft

Hub Location	Sample Identification	Grid Quadrant	Antimony		Copper	Lead	Zinc
			mg/kg		mg/kg	mg/kg	mg/kg
Ecological Screening Value (ESV)			0.32		33.7	79	157
1A-572	CC-MRS3-ZSB-96	SW	0.14	J	23.9	13.4	30.3
1A-572	CC-MRS3-ZSB-97	NW	0.28	J	14.8	12.0	21.1
1A-572	CC-MRS3-ZSB-98	NE	0.058	J	16.3	12.3	23.2
1A-572	CC-MRS3-ZSB-99	SE	0.028	J	5.5	4.3	32.1
1A-653	CC-MRS3-ZSB-91	SW	0.066	J	9.5	30.5	14.8
1A-653	CC-MRS3-ZSB-92	NW	0.057	J	13.3	16.6	22.3
1A-653	CC-MRS3-ZSB-93	NE	0.15	J	22.9	22.9	24.4
1A-653	CC-MRS3-ZSB-94	SE	0.31		8.2	14.3	19.7
1A-653	CC-MRS3-ZSB-95	Center	0.031	J	10.7	8.1	20
1A-949	CC-MRS3-ZSB-86	SW	0.16	J	18.8	23.1	31.2
1A-949	CC-MRS3-DUP-13	SW	0.11	J	14.9	11.7	22.3
1A-949	CC-MRS3-ZSB-87	NW	0.1	J	41.1	26.0	45.9
1A-949	CC-MRS3-ZSB-88	NE	0.14	J	43.6	34.1	61.9
1A-949	CC-MRS3-ZSB-89	SE	0.067	J	9.9	6.3	27.3
1A-949	CC-MRS3-ZSB-90	Center	0.11	J	37.3	21.1	54.3
A4718	CC-MRS3-ZSB-101	SW	0.94		43.3	430	68.5
A4718	CC-MRS3-ZSB-102	NW	1.1		48.7	675	92
A4718	CC-MRS3-DUP-14	NW	1.1		47.3	504	87.2
A4718	CC-MRS3-ZSB-103	NE	1.1		44.5	327	65.1
A4718	CC-MRS3-ZSB-104	SE	1		45.6	382	98.2
A4718	CC-MRS3-ZSB-105	Center	1		37.9	296	63
MRS3-10085	CC-MRS3-ZSB-31	SW	0.019	U	3	8.7	22.4
MRS3-10085	CC-MRS3-ZSB-32	NW	0.089	J	5.9	14.9	42.5
MRS3-10085	CC-MRS3-ZSB-33	NE	0.059	J	3.5	11.7	23.5
MRS3-10085	CC-MRS3-ZSB-34	SE	0.19	J	35.4	48.7	46.4
MRS3-10085	CC-MRS3-ZSB-35	Center	0.12	J	255	21.7	26.3
MRS3-10085	CC-MRS3-DUP-7	Center	0.12	J	4.5	11.0	35.5
MRS3-10216	CC-MRS3-ZSB-66	SW	0.15	J	22.8	14.0	35.4
MRS3-10216	CC-MRS3-ZSB-67	NW	0.12	J	22.5	14.6	39.1
MRS3-10216	CC-MRS3-ZSB-68	NE	0.24	J	10.1	14.5	14.3
MRS3-10216	CC-MRS3-ZSB-69	SE	0.27	J	28.7	18.3	37.6
MRS3-10216	CC-MRS3-ZSB-70	Center	0.14	J	11.3	16.3	21
MRS3-10292	CC-MRS3-ZSB-61	SW	0.084	J	15.7	17.2	31.1
MRS3-10292	CC-MRS3-ZSB-62	NW	0.089	J	11.1	11.2	22.9
MRS3-10292	CC-MRS3-ZSB-63	NE	0.2	J	30.7	13.6	1680
MRS3-10292	CC-MRS3-ZSB-64	SE	0.059	J	15.6	11.9	19.9
MRS3-10292	CC-MRS3-ZSB-65	Center	0.093	J	15.6	16.2	24.5
MRS3-10304	CC-MRS3-ZSB-56	SW	0.19	J	49	13.5	69.3
MRS3-10304	CC-MRS3-ZSB-57	NW	0.15	J	28.5	14.2	35.7
MRS3-10304	CC-MRS3-DUP-10	NW	0.12	J	24.7	12.7	42.6

Table 3-2
Soil Data Results
Former Camp Croft

Hub Location	Sample Identification	Grid Quadrant	Antimony		Copper	Lead	Zinc
			mg/kg		mg/kg	mg/kg	mg/kg
Ecological Screening Value (ESV)			0.32		33.7	79	157
MRS3-10304	CC-MRS3-ZSB-58	NE	0.051	J	5.2	11.2	42.4
MRS3-10304	CC-MRS3-ZSB-59	SE	0.19	J	34.7	20.8	55.4
MRS3-10304	CC-MRS3-ZSB-60	Center	0.13	J	21.6	20.7	44.9
MRS3-10450	CC-MRS3-ZSB-26	SW	0.72		28.3	76.1	30.4
MRS3-10450	CC-MRS3-ZSB-27	NW	1.2		30.2	119	36.1
MRS3-10450	CC-MRS3-ZSB-28	NE	0.4		10.4	46.8	23.9
MRS3-10762	CC-MRS3-ZSB-51	SW	0.19	J	18.5	27.4	25.7
MRS3-10762	CC-MRS3-DUP-9	SW	0.33		22.9	32.5	26.2
MRS3-10762	CC-MRS3-ZSB-52	NW	0.17	J	18.8	23.4	47.2
MRS3-10762	CC-MRS3-ZSB-53	NE	0.094	J	10.5	27.1	51.6
MRS3-10762	CC-MRS3-ZSB-54	SE	0.07	J	7.7	13.0	10.6
MRS3-10762	CC-MRS3-ZSB-55	Center	0.18	J	18.2	27.6	20.9
MRS3-11369	CC-MRS3-ZSB-11	SW	0.12	J	3.9	20.1	23.5
MRS3-11369	CC-MRS3-ZSB-12	NW	0.097	J	1.9	11.6	11.1
MRS3-11369	CC-MRS3-DUP-3	NW	0.091	J	2.1	14.6	11.5
MRS3-11369	CC-MRS3-ZSB-13	NE	0.099	J	6.8	12.8	17.1
MRS3-11369	CC-MRS3-ZSB-14	SE	0.069	J	2.7	12.8	12
MRS3-11369	CC-MRS3-ZSB-15	Center	0.074	J	2.9	11.7	13.3
MRS3-8662	CC-MRS3-ZSB-46	SW	0.084	J	9.3	15.3	29.5
MRS3-8662	CC-MRS3-DUP-8	SW	0.05	J	6.5	12.6	24.8
MRS3-8662	CC-MRS3-ZSB-47	NW	0.051	J	8.7	16.2	26.5
MRS3-8662	CC-MRS3-ZSB-48	NE	0.038	J	11.1	12.4	30.6
MRS3-8662	CC-MRS3-ZSB-49	SE	0.068	J	15.6	24.9	39.4
MRS3-8662	CC-MRS3-ZSB-50	Center	0.063	J	11.5	15.8	33.1
MRS3-8944	CC-MRS3-ZSB-21	SW	0.11	J	3.5	14.1	15.3
MRS3-8944	CC-MRS3-ZSB-22	NW	0.13	J	7.6	15.1	29.5
MRS3-8944	CC-MRS3-ZSB-23	NE	0.098	J	13.4	24.0	38.4
MRS3-8944	CC-MRS3-ZSB-24	SE	0.07	J	5.2	13.9	18.1
MRS3-8944	CC-MRS3-ZSB-25	Center	0.069	J	7.9	15.0	26.9
MRS3-9120	CC-MRS3-ZSB-41	SW	0.077	J	8.5	20.4	57.9
MRS3-9120	CC-MRS3-ZSB-42	NW	0.27	J	23.6	30.8	33.6
MRS3-9120	CC-MRS3-ZSB-43	NE	0.22	J	35.4	48.2	54.8
MRS3-9120	CC-MRS3-ZSB-44	SE	0.18	J	21.6	13.5	41.2
MRS3-9120	CC-MRS3-ZSB-45	Center	0.18	J	31.7	31.8	70.6
MRS3-9345	CC-MRS3-ZSB-36	SW	0.086	J	7.8	24.3	41.1
MRS3-9345	CC-MRS3-ZSB-37	NW	0.14	J	10.6	36.6	43.9
MRS3-9345	CC-MRS3-ZSB-38	NE	0.086	J	8.2	20.7	42.4
MRS3-9345	CC-MRS3-ZSB-39	SE	0.12	J	8.8	26.9	50.9
MRS3-9345	CC-MRS3-ZSB-40	Center	0.07	J	20.8	21.7	25.2
MRS3-9848	CC-MRS3-ZSB-76	SW	0.12	J	8.9	38.6	9.5

Table 3-2
Soil Data Results
Former Camp Croft

Hub Location	Sample Identification	Grid Quadrant	Antimony		Copper	Lead	Zinc
			mg/kg		mg/kg	mg/kg	mg/kg
Ecological Screening Value (ESV)			0.32		33.7	79	157
MRS3-9848	CC-MRS3-ZSB-77	NW	0.13	J	6.1	15.6	14.6
MRS3-9848	CC-MRS3-ZSB-78	NE	0.018	U	3	8.4	7.9
MRS3-9848	CC-MRS3-DUP-11	NE	0.11	J	4.3	16.3	10.7
MRS3-9848	CC-MRS3-ZSB-79	SE	0.018	U	3.4	14.5	9
MRS3-9848	CC-MRS3-ZSB-80	Center	0.12	J	5.3	32.9	13.9
MRS3-9928	CC-MRS3-ZSB-71	SW	0.094	J	22.2	46.2	14.2
MRS3-9928	CC-MRS3-ZSB-72	NW	0.068	J	4.1	10.7	10.7
MRS3-9928	CC-MRS3-ZSB-73	NE	0.06	J	5	8.3	15.5
MRS3-9928	CC-MRS3-ZSB-74	SE	0.12	J	6	23.5	14
MRS3-9928	CC-MRS3-ZSB-75	Center	0.15	J	14.8	15.7	21.4
MRS3-A	CC-MRS3-ZSB-29	Center	3		255	1080	53.8
MRS3-A	CC-MRS3-ZSB-30	Center	0.98		100	244	47

Hub Location	Sample Identification	Grid Quadrant	Antimony		Copper	Lead	Zinc
			mg/kg		mg/kg	mg/kg	mg/kg
Ecological Screening Value (ESV)			0.32		33.7	79	157
12A-1	CC-12A-POSTZSB-1	N/A	0.25	J	735	174	30.5
12A-2	CC-12A-POSTZSB-2	N/A	0.15	J	38.5	28.0	20.1
12A-3	CC-12A-POSTZSB-3	N/A	0.21	J	70.1	126	97.6
12A-3	CC-12A-POSTZSB-4	N/A	0.1	J	84.4	25.4	14.4
12A-3	CC-12A-POSTZSB-5	N/A	0.097	J	53.9	26.5	20.5
BKGD-1	CC-BKGD-ZSB-1	N/A	0.036	J	11.5	7.9	12
BKGD-1	CC-BKGD-DUP-ZSB-1	N/A	0.085	J	16	25.6	42.6
BKGD-2	CC-BKGD-ZSB-2	N/A	0.028	J	9.5	16.6	30.7
BKGD-3	CC-BKGD-ZSB-3	N/A	0.038	J	6.6	21.5	24.8
BKGD-4	CC-BKGD-ZSB-4	N/A	0.25	J	17.5	56.8	123
BKGD-5	CC-BKGD-ZSB-5	N/A	0.083	J	16.1	26.5	40.5
BKGD-6	CC-BKGD-ZSB-6	N/A	0.57		27.8	43.4	127
BKGD-7	CC-BKGD-ZSB-7	N/A	0.064	J	11.5	40.0	56.9
BKGD-8	CC-BKGD-ZSB-8	N/A	0.098	J	17.3	125	92.2
BKGD-9	CC-BKGD-ZSB-9	N/A	0.023	U	22.5	21.2	105
BKGD-10	CC-BKGD-ZSB-10	N/A	0.4		25.7	27.0	159
MRS3-1	CC-MRS3-POSTZSB-1	N/A	0.32		20.8	15.9	27.9
MRS3-2	CC-MRS3-POSTZSB-2	N/A	0.31	J	58.2	25.9	26.5
MRS3-3	CC-MRS3-POSTZSB-3	N/A	0.28	J	349	99.0	25.8
MRS3-4	CC-MRS3-POSTZSB-7	N/A	0.2	J	486	198	21.6
MRS3-5	CC-MRS3-POSTZSB-8	N/A	0.065	J	110	22.9	14.5
MRS3-6	CC-MRS3-POSTZSB-9	N/A	0.075	J	15.3	14.3	22.4
MRS3-7	CC-MRS3-POSTZSB-10	N/A	0.18	J	787	163	20

4 of 4

Table 3-3
Screening Level Refinement - Comparison of Upper Bound Site COPC Concentrations with Screening Values for Receptors [a]

COPC	Maximum Concentration (Qualifier)	Avian Insectivore (Woodcock)	Avian Herbivore (Dove)	Avain Carnivore (Hawk)	Mammalian Insectivore (Shrew)	Mammalian Herbivore (Vole)	Mammalian Carnivore (Weasel)	Plants	Soil Invertebrates
Antimony	3 J-	--	--	--	0.27 - 2.7	10 - 100	4.9 - 49	--	78
Copper	787 J	28 - 84	76 - 225	1,600 - 4,750	49 - 81	1,100 - 1,800	560 - 930	70	80
Lead	1080 J-	11 - 22	46 - 92	510 - 1,020	56 - 105	1,200 - 2,250	460 - 870	120	1,700
Zinc	1680	46 - 120	950 - 2,450	30,000 - 77,000	79 - 310	6,800 - 26,500	10,000 - 39,000	160	157

[a] - Based on EPA Eco-SSLs (EPA, 2010)
J = Estimated Concentration
J- = Estimated low

This Page Intentionally Left Blank