FINAL

FEASIBILITY STUDY REPORT ADDENDUM
FORMER SPENCER ARTILLERY RANGE
SPENCER/VAN BUREN COUNTY, TENNESSEE

prepared for

U.S. ARMY ENGINEERING AND SUPPORT CENTER, HUNTSVILLE

and

U.S. ARMY CORPS OF ENGINEERS MOBILE DISTRICT

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LIST OF ACRONYMS AND ABBREVIATIONS

AGC	advanced geophysical classification
AP	armor piercing
ARAR	applicable or relevant and appropriate requirements
BIP	blown-in-place or blow-in-place
BKIA	Bald Knob Impact Area
BUD	Berkley UXO detector
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DoD	Department of Defense
DMM	discarded military munitions
EE/CA	Engineering Evaluation and Cost Analysis
EM	electromagnetic
ESTCP	Environmental Security Technology Certification Program
ESQD	explosive safety quantity distance
FS	Feasibility Study
FUDS	Formerly Used Defense Site
GPS	Global Positioning System
HA	hazard assessment
HE	high explosive
IC	institutional control
INPR	Inventory Project Report
JMIA	Jake's Mountain Impact Area
MC	munitions constituents
MD	munitions debris
MEC	munitions and explosives of concern
mm	millimeter
MMRP	Military Munitions Response Program
MPV	Man Portable Vector
MRS	Munitions Response Site
MSL	mean sea level
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
RAO	Remedial Action Objectives
RI	Remedial Investigation
ROE	right-of-entry
SARA	Superfund Amendments and Reauthorization Act
T&E	threatened and endangered
TBC	to be considered
TPP	technical project planning
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
UU/UE	unlimited use / unrestricted exposure
UXO	unexploded ordnance

GLOSSARY

This glossary is intended to provide the general public with an understanding of the terms used in this report.

Advanced Geophysical Classification

Fits physics-based models to the observed sensor responses to determine physical characteristics such as geometry and wall thickness. The physical properties are compared to a library of known MEC items to classify them based on the closest match. The library forms the basis for determining if anomalies are potentially MEC or other metallic debris. (USACE, 2017)

Anomaly

Any item that appears as a subsurface irregularity after geophysical investigation. This irregularity should deviate from the expected subsurface ferrous and nonferrous material at a site (e.g., pipes, power lines, etc.).

Applicable or Relevant and Appropriate Requirements (ARARs)

Applicable Requirements - Those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Relevant and Appropriate Requirements - Those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to the hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

Archives Search Report

A detailed investigation of past munitions and explosives of concern (MEC) activities conducted on an installation. The principal purpose of the archives search is to assemble historical records and available field data, assess potential ordnance presence, and recommend follow-up actions at a Defense Environmental Restoration Program Formerly Used Defense Site (FUDS). There are four general steps in an archives search: records search, site safety and health plan, site survey, and archives search report (including risk assessment).

Blown-in-Place (BIP)

The term used to describe detonating an ordnance item that is deemed unsafe to move from the location where it is discovered.

GLOSSARY (Continued)

Comprehensive Environmental Response, Compensation, and Liability Act of 1980

Authorizes federal action to respond to the release or threatened release of hazardous substances into the environment or a release or threat of release of a pollutant or contaminant into the environment that may present an imminent or substantial danger to public health or welfare. Also known as Superfund. Amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). [42 U.S. Code (USC) 9601 et seq.].

Defense Environmental Restoration Program

Established in 1984, Defense Environmental Restoration Program promotes and coordinates efforts for the environmental restoration at facilities under the jurisdiction of the Secretary of Defense. The program shall be carried subject to, and a manner consisted with, Section 120 of CERCLA [10 USC 2701].

Digital Geophysical Mapping

The collection of data intended to locate metal objects at various depths in media. Typical instruments include metal detectors.

Discarded Military Munitions (DMM)

Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. [10 USC 2710(e)(2)].

Electromagnetic Method

A method of geophysical exploration that uses an active source to induce varying magnetic fields in the subsurface. The two primary techniques applied during ordnance and explosives investigations are the time-domain electromagnetic method and the frequency-domain electromagnetic method. Both methods use manmade sources. Time-domain electromagnetic instruments work by pulsing an electrical signal in the transmitter coils, which produces a primary magnetic field that induces an eddy current in the ground. The transmitting coil is turned off and the secondary magnetic field produced from the resulting eddy current decay is then measured over predefined time intervals. Frequency-domain electromagnetic instruments work by transmitting a sinusoidally varying electromagnetic signal at one or more frequencies through a transmitter coil. A separate receiver coil measures a signal that is a function of the primary signal and the induced currents in the subsurface (USACE, 2015).

GLOSSARY (Continued)

Endangered Species Act [USC Title 16 Chapter 35§1536 (a)(2)]

Each federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or results in destruction or adverse modification of habitat or such species.

Exclusion Zone

A safety zone established around a work area. Only authorized project personnel are allowed within the exclusion zone. Examples of exclusion zones are safety zones around MEC intrusive activities and safety zones where MEC is intentionally detonated.

Explosive Ordnance Disposal

The detection, identification, field evaluation, rendering safe, recovery, and final disposal of unexploded ordnance or munitions.

Formerly Used Defense Site

A facility or site (property) that was under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination by hazardous substances. By the Defense Environmental Restoration Program policy, the FUDS program is limited to those real properties that were transferred from the Department of Defense (DoD) control prior to 17 October 1986. FUDS properties can be within the 50 states, the District of Columbia, territories, commonwealths, and possessions of the United States.

Fragmentation Distance

The maximum distance that fragments of an ordnance item will travel when that ordnance item is detonated without the use of engineering controls.

Geophysical Techniques

Techniques used for the detection and measurement of buried anomalies (e.g., ferromagnetic indicators and ground penetrating radar) to investigate the presence of munitions.

Military Munitions

All ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the DoD, the United States (U.S.) Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants; explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical agents; chemical munitions, rockets, guided and

GLOSSARY (Continued)

ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. The term does not include wholly inert items; improvised explosive devices; and nuclear weapons, nuclear devices, and nuclear components other than non-nuclear components of nuclear devices, managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under the Atomic Energy

Act of 1954 (42 USC 2011 et Seq.) have been completed. [10 USC 101(e)(4)(A) through (C)].

Munitions and Explosives of Concern

This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means (1) unexploded ordnance (UXO) as defined in 10 USC 101(e)(5)(A) through (C), (2) DMM as defined in 10 USC 2710(e)(2), or (3) munitions constituents (e.g., 2,4,6-trinitrotoluene, hexahydro-1,3,5-trinitro-1,3,5-triazine) as defined in 10 USC 2710(e)(3) present in high enough concentrations to pose an explosive hazard.

National Oil and Hazardous Substance Pollution Contingency Plan (NCP)

Revised in 1990, the NCP provides the regulatory framework for responses under CERCLA. The NCP designates the DoD as the removal response authority for ordnance and explosives hazards. (40 Code of Federal Regulations [CFR] 300).

Superfund Amendments and Reauthorization Act

Superfund Amendments and Reauthorization Act of 1986 (see CERCLA).

Stakeholder

Community organizations, property owners, and others having a personal interest or involvement or having a monetary or commercial involvement in the real property that is to undergo a munitions response action.

Unexploded Ordnance (UXO)

Military munitions that (1) have been primed, fuzed, armed, or otherwise prepared for action, (2) have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material, and (3) remain unexploded either by malfunction, design, or any other cause [10 USC 101(e)(5)(A) through (C)].

CHAPTER 1
EXECUTIVE SUMMARY

This Feasibility Study (FS) addendum is an update/revision to the Final FS issued for Spencer Artillery Range in October 2011 (Parsons, 2011b). Following issuance of the Final FS, it was determined that financial settlement agreements had been reached between the government and two property owners within the historic boundaries of Spencer Artillery Range. On January 22, 1965, the Court of Claims recommended that Congress award the Rock River Company and Macy Land Corporation the amount of $88,729.60 for diminution of 3,059 acres (U.S. Army Corps of Engineers [USACE], 1985). The properties that accepted settlement agreements are not eligible for remedial action under the Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP). This FS Addendum regroups the 16 Munition Response Sites (MRSs) previously proposed in the Remedial Investigation (RI) into nine MMRP Project Areas in accordance with the approved Defense Environmental Restoration Program-FUDS (DERP-FUDS) Revised Inventory Project Report (INPR) memorandum (USACE, 2014). The delineated Project Areas will allow the proposed response actions to be prioritized and sequenced appropriately according to defined hazards and predicted remediation costs.

The Project Areas, corresponding RI recommended MRSs, and associated acreages are presented in Table 1.1. Project Area 02 incorporates the settlement agreement properties and has been removed from further assessment and consideration. Figure 1.1 depicts the Project Areas and associated MRSs identified in the RI.

In addition, this FS Addendum incorporates advanced geophysical classification (AGC) as part of one of the response alternatives. AGC has been fully developed since the 2011 FS and is evaluated as an alternative for managing risk associated with potential MEC. This FS Addendum also updates the estimated costs associated with each of the response alternatives.

Table 1.1
Summary of Project Areas and Munitions Response Sites
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

Project Areas	Classification	RI recommended MRSs	Area: (acres)
Project Area 01	RI LTM Areas	MRS-01 (partial), 02,11, 12, 14, 15 (partial)	4,120
Project Area 02	Settlement Area [1]	MRS-01, 04, 05, 06, 07, 08, 15, 16 (partial), MRS-09,10	3,059
Project Area 03	Covenant Farms- 5 Acre Lots	MRS-03	262
Project Area 04	Covenant Farms- Large Lots	MRS-04	60
Project Area 05	Recreation/Cabins	MRS-05	646
Project Area 06	Sequoia Subdivision	MRS-06	241
Project Area 07	Indian Trails Development	MRS-07 (partial), 08 (partial)	352
Project Area 08	Rocky River Road - Residential	MRS -13	260
Project Area 09	Remaining Lands	MRS-16 [2]	9,561
		TOTAL	**18,561**

[1] Settlement Area is not eligible for remedial action under the FUDS MMRP.
[2] Due to a low probability for explosive hazard, the RI did not recommend an FS for Project Area 09 (MRS-16). It is included on Table 1.1 for completeness, but Project Area 09 is not included in the FS addendum for assessment of response action alternatives.

1.0 BACKGROUND

1.0.1 On January 1, 1940, USACE began securing leases in rural Tennessee to construct an artillery range. Construction began in February 1941, and it was likely in operation shortly thereafter (USACE, 2001). The Spencer Artillery Range, located approximately 10 miles southeast of McMinnville, and 12 miles south of Spencer, Tennessee, encompassed 30,618 acres in Van Buren, Warren, Sequatchie, and Bledsoe Counties. A December 1941 report describes two impact ranges constructed at Spencer Artillery Range. By September 1944, Army ground forces had either departed or were under orders to depart, and arrangements were made for Dyersburg Army Air Field to use the Spencer Artillery Range as an air-to-ground gunnery range. The land reverted to the 25 original landowners in the summer of 1946. Several surface decontamination sweeps were completed on portions of the former range in the 1950s. Since then, numerous tracts of land have been sold and/or subdivided, significantly increasing the number of property owners from the original 25 to several hundred landowners today. The land within the former Spencer Artillery Range is entirely privately owned.

1.0.2 Fifteen MRSs were identified in the RI and recommended for further action in the FS. MRSs were delineated primarily based on historic use (e.g., impacts from munitions), as well as current and projected future land use. As discussed, these 15 MRSs

have been grouped into nine MMRP Project Areas (Table 1.1 and Figure 1.1). Project Area 02 is not included in the FS since these properties accepted settlement agreements and are not eligible for remedial action. Project Area 09 is not included in the FS due to a low probability of explosive hazard. The remaining seven Project Areas (Project Area 01, Project Area 03, Project Area 04, Project Area 05, Project Area 06, Project Area 07, and Project Area 08) have been recommended for an FS to assess response action alternatives for managing risk associated with potential human interaction with MEC. The results and discussion of FSs conducted for the seven Project Areas are included in this stand-alone FS document. The remainder of this FS will reference MMRP Project Area Numbers and not the MRSs carried forward from the RI. Further information on MRSs recommended for an FS at Spencer Artillery Range is summarized below in Section 1.1 or can be viewed in the RI Report. (Parsons, 2011a). The purpose of the FS is to provide decision makers with the data necessary to select the final remedy for the Project Areas; however, a specific remedy is not selected during the FS process.

1.1 REMEDIAL INVESTIGATION

1.1.1 Much of the land within the FUDS is undeveloped, wooded land. Portions of the site, however, have been heavily subdivided for residential development, and several of these developments could result in future residential development (e.g., Sequoia, Whispering Pines, and Indian Trails). In some cases, roads and utility infrastructure have been installed; actual housing construction, however, has not yet been initiated in most subdivisions. Logging has been conducted on the site since before the artillery range was constructed and is ongoing within portions of the former range. Historically, land use within the site has also included coal strip mining operations, particularly in the eastern portion of the site. Numerous drill programs have also been conducted in this area to delineate potential coal resources. Several of the strip-mined areas have been reclaimed.

1.1.2 The Archives Search Report Supplement defined 17,260 acres of the total former range (30,618 acres) as the MRS boundary for Range Complex No. 1 (USACE, 2001). This complex contained four sub-ranges: the Moving Target Range, Artillery Range, Anti-Tank Range, and Air-to-Ground Gunnery Range. The RI report for the former Spencer Artillery Range (Parsons, 2011a) focused on the area of the single MRS, but recommended that the one 17,260-acre MRS be divided into 16 separate MRSs (now regrouped into nine Project Areas) based on land use, historic munitions use, risk, etc. Figure 1.1 shows the locations of the 16 recommended MRSs and corresponding Project Areas. Based on the presence of MEC and areas containing elevated geophysical anomaly densities (indicative of concentrated munitions use), and due to changes in current and future land use, 15 MRSs were recommended in the RI Report for an FS (Parsons 2011a). No unacceptable risk was identified for MRS-16 (Project Area 09); therefore, the RI did not recommend MRS-16 (Project Area 09) be included in the subsequent FS. Each MRS, including MRS-16 (Project Area 09) and the Settlement Areas (Project Area 02), will be addressed in the Proposed Plan and Decision Document, which will be submitted following the approval FS.

1.1.3 An RI was conducted in 2010 to determine whether MEC or munitions constituents (MC) present sufficient hazards or risks to warrant further remedial action,

and to adequately characterize the nature and extent of detected contamination, if any. The characterization used information from previous investigations (plus RI data results) to assess risk associated with potentially complete exposure pathways. Based on MC sampling results, unacceptable risks associated with MC contamination are not expected at the site; therefore, MC is not addressed within this FS report. Tasks performed during the RI and previous investigations have included reconnaissance, brush cutting, geophysical surveys, surface removal, intrusive anomaly investigation, and soil and groundwater sampling.

1.1.4 Complete MEC exposure pathways are possible when there is a source (e.g., MEC), receptor (e.g., resident, hunter, etc.), and interaction between the receptor and MEC (e.g., striking or handling the munition). Based on the confirmed presence of MEC and/or munitions debris (MD) on the surface and subsurface, historic land use as an artillery training range, and/or high anomaly density within the recommended MRSs, there is the potential for residual MEC within the MRSs. In addition, receptors are present, the MRSs are generally accessible, and interaction is possible based on current and anticipated future land use.

1.1.5 Using information from investigations completed at the site, a qualitative MEC Hazard Assessment (HA) was conducted for each MRS evaluated during the RI , with the exception of MRS-16. The MEC HA provides the baseline for assessment of response alternatives. Because MEC HA scores were previously calculated for MRSs, the conservative value was selected for each criterion to develop Project Area MEC HA scores. Anticipated hours spent within each corresponding MRS were summed per Project Area to determine the appropriate number of total contact hours. Additional information for MRS MEC HA scores is provided in Appendix A.

1.2 FEASIBILITY STUDY

1.2.1 Based on the results and recommendations of the RI, an FS was conducted for Project Area 01 and Project Areas 03 through 08 (Table 1.1). The remedial action objectives (RAOs) for the FS Project Areas are presented in Chapter 3. This FS develops and screens several response alternatives for managing risk associated with potential MEC. Four of the five alternatives were identified as appropriate for detailed analysis (Alternatives 1-4). These alternatives include the following:

- Alternative 1—No Further Action Alternative: no further action is conducted under this alternative and is included as a baseline for comparison purposes (i.e., hazards remain at current levels).

- Alternative 2—Educational Awareness: Development of a site-specific educational awareness program consisting of educational tools and materials (e.g., brochures, fact sheets).

- Alternative 3—Surface Removal with Educational Awareness: This alternative would involve visual inspection of the Project Areas and removal of surface

MEC. Educational awareness would be implemented as described in Alternative 2.

- Alternative 4—Geophysical Investigation and MEC Removal with Educational Awareness: Vegetation will be trimmed or removed to provide access to geophysical equipment used to collect data in each project site. This alternative includes the use of AGC. Advanced geophysical sensors can differentiate between MEC and other non-hazardous metallic debris. Removal efforts are focused on surface and subsurface items that are suspected to be an explosive hazard (other metallic debris is left in the ground). The AGC targets of interest (e.g., MEC) would be investigated to the depth of the detected anomaly and MEC would be disposed of. Educational awareness would also be implemented.

- Alternative 5— Excavation and Sifting: Following extensive vegetation removal, the soil would be excavated and then sifted to remove MEC. The site would then need to be backfilled and seeded/revegetated. No long term educational awareness component or (long term costs) would be required as this alternative meets all remedial goals without them.

1.2.2 A detailed analysis was completed for each alternative using nine evaluation criteria defined by CERCLA. The detailed analysis evaluates and compares the identified remedial action alternatives, then presents a Proposed Plan for regulatory agencies and public review. Alternative 1 (No Further Action Alternative) serves as the baseline for the remaining alternatives; however, the detailed analysis of this alternative identifies no long-term solution and no reduction in current risk. Conversely, Alternative 4 (MEC Removal), of the alternatives considered provides the most extensive removal of the risk source and offers the greatest permanence, but the implementation cost of this alternative is excessive at several Project Areas. Although Alternative 5 is mentioned, it was screened out due to the implementability and cost criteria. Table 1.2 presents an overview of the alternative evaluation for the FS Project Areas.

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Table 1.2
Overview of Evaluated Alternatives for Each Project Area

Project Area	Land Use	Total Area	Evaluated Alternatives	Cost (over 30 years)	MEC HA Hazard Level/Score		Rational
Project Area 01	Wooded/ Hunting/ Logging/Residential/Commercial/Ranching	4,120	1- No Further Action	$0	2	805	No reduction of high potential explosive hazard conditions.
			2 -Education	$643,368	2	805	Reduce hazard by providing information to landowners and the public. Signage, fact sheets, and website will provide hazard recognition to reduce chance of exposure.
			3- Surface Removal	$19,883,406	3	650	Sensitive archeological/cultural resources at the Trail of Tears would make it difficult to conduct a surface clearance. Clearance would reduce risk for potential surface hazards.
			4- Geo/MEC Removal	$55,784,785	4	480	Limited intrusive activity anticipated for current land use. Excessive cost.
Project Area 03	Active Development/Residential	262	1- No Further Action	$0	3	590	No reduction of moderate potential explosive hazard conditions.
			2 -Education	$480,968	3	590	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities.
			4- Geo/MEC Removal	$4,361,093	4	410	High level of effectiveness. Large reduction in MEC HA score with implementation of alternative.
Project Area 04	Active Development/Residential	60	1- No Further Action	$0	3	715	No reduction of moderate potential explosive hazard conditions.
			2 -Education	$480,968	3	715	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities.
			4- Geo/MEC Removal	$1,990,872	4	430	High level of effectiveness for future residential development. Large reduction in MEC HA score with implementation of alternative.
Project Area 05	Recreation/ Cabins	646	1- No Further Action	$0	2	830	No reduction of high potential explosive hazard conditions.
			2 -Education	$480,968	2	830	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$4,609,910	3	660	Reduce hazards for potential receptors whose activities primarily involve surface use. Reduction in MEC HA hazard level determination; low potential hazard.
			4- Geo/MEC Removal	$13,045,666	4	435	High level of effectiveness for future development. Large reduction in MEC HA score with implementation of alternative.
Project Area 06	Undeveloped Subdivision	241	1- No Further Action	$0	1	860	No reduction of highest potential explosive hazard conditions.
			2 -Education	$480,968	1	860	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$2,318,481	3	690	Property owners may still encounter subsurface MEC while conducting intrusive activities (i.e., gardening, fence installation).
			4- Geo/MEC Removal	$8,456,656	4	515	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.
Project Area 07	Undeveloped Subdivision	352	1- No Further Action	$0	2	770	No reduction of high potential explosive hazard conditions.
			2 -Education	$480,968	2	770	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities.
			4- Geo/MEC Removal	$6,644,187	4	515	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.
Project Area 08	Active Development/Residential	260	1- No Further Action	$0	2	830	No reduction of high potential explosive hazard conditions.
			2 -Education	$480,968	2	830	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$1,337,333	3	660	Reduce risk for onsite construction that may occur for residential development. Property owners may still encounter MEC while conducting intrusive activities (i.e., gardening, fence installation).
			4- Geo/MEC Removal	$5,263,405	4	505	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.

The scores of the MEC HA method were developed by the Technical Working Group for Hazard Assessment. Scores are presented in multiples of five, with a total maximum score for all factors of 1,000 and a minimum possible score of 125. The MEC HA method describes associated hazard levels for these scores, which range from 1 (highest) to 4 (lowest). A summary of the hazard levels and their related MEC HA scores are presented in Chapter 2 and Appendix A.

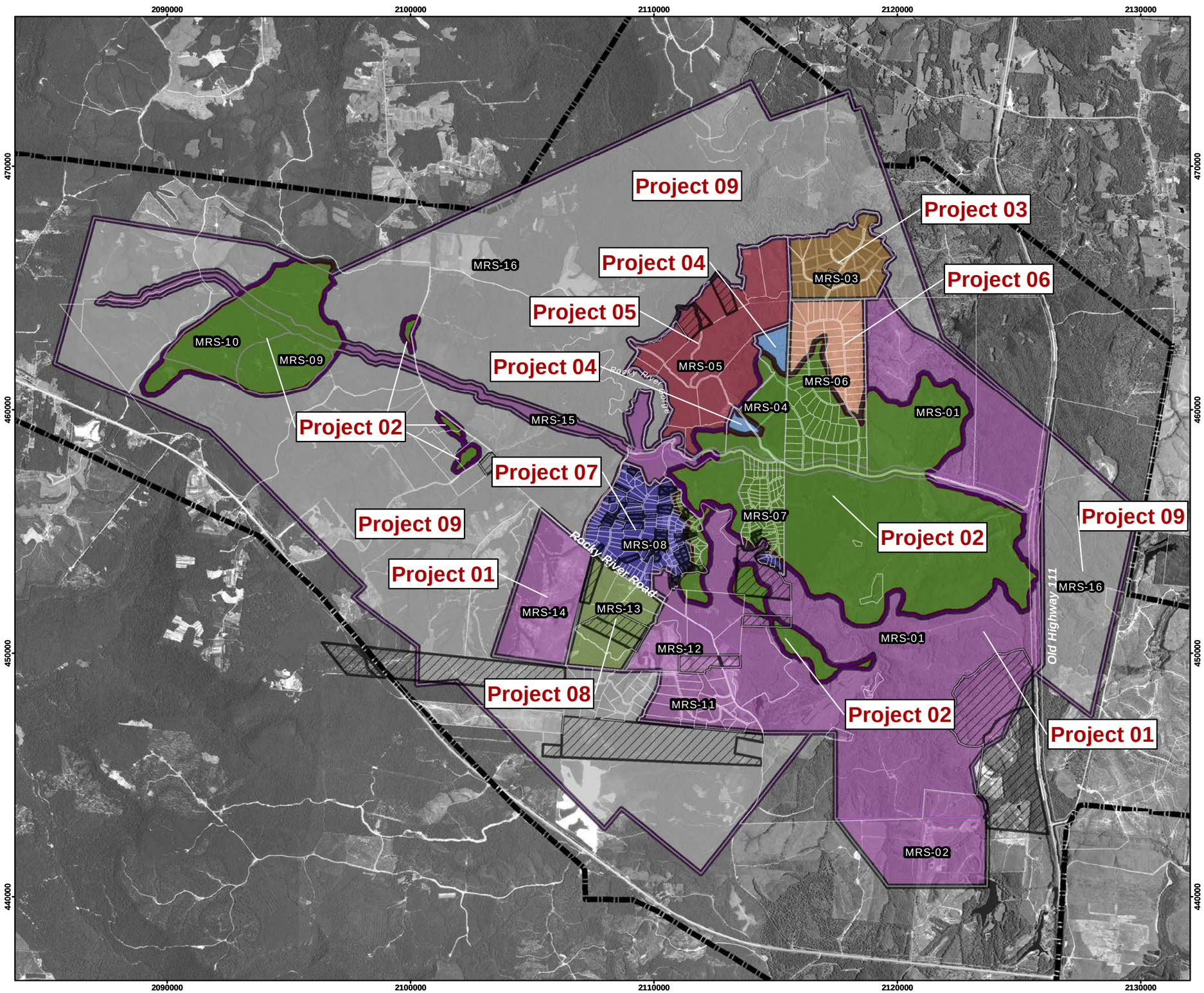

Figure 1.1

Project Areas
Formerly Used Defense Site
Spencer Artillery Range
FUDS Project # G04TN017801
Spencer, Tennessee

Legend

MRS Boundaries

Project Name

- Project Area 01
- Project Area 02
- Project Area 03
- Project Area 04
- Project Area 05
- Project Area 06
- Project Area 07
- Project Area 08
- Project Area 09
- FUDS Boundary

Right of Entry

- No Access/No Response

Refer to RI Report (Parsons, 2011) for additional information.

No concentrated munitions use and very low probability of explosive hazard was noted for Project Area 09; therefore, Project Area 09 was not recommended for an FS.

Project Area 02 is not eligible for remedial action under the Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP).

N

Image Source: 1943 Image TEC
Projection: Tennessee State Plane, NAD83, Feet

4,000 2,000 0 4,000 Feet

PARSONS	U.S. ARMY ENGINEERING & SUPPORT CENTER HUNTSVILLE, ALABAMA
DESIGNED BY: CR	Former Spencer Artillery Range
DRAWN BY: CAtB	
CHECKED BY: CR	SCALE: As Shown — PROJECT NUMBER: 746862
SUBMITTED BY: CAtB	DATE: 3/12/2018 — PAGE NUMBER:
	FILE: S:\ES\shared\Spencer Artillery Range\GIS\FS_Report\MRS_Boundaries.mxd

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CHAPTER 2
INTRODUCTION

2.0 INTRODUCTION

The RI completed at the former Spencer Artillery Range in 2010 focused on identifying munitions impact areas and delineating areas with high geophysical anomaly density. Based on the pre-RI conceptual site model, these represent the areas with the greatest likelihood of containing MEC. As presented in the RI Report (Parsons 2011a), it was recommended that the original 17,260-acre Range Complex No. 1 be divided into 16 separate MRSs. These MRSs have been grouped into nine MMRP Project Areas in accordance with the approved DERP-FUDS-INPR memorandum (USACE, 2014). However, due to no concentrated munitions use and very low probability of explosive hazard, Project Area 09 (MRS 16) was not recommended for an FS and will not be evaluated further in this FS. Following issuance of the Final FS, it was determined that financial settlement agreements had been reached between the government and two property owners within the historic boundaries of Spencer Artillery Range. The properties that accepted settlement agreements are not eligible for remedial action under the FUDS MMRP. This FS Addendum removes the settlement agreement properties (Project Area 02) from further assessment. The remaining seven Project Areas are included in this FS Addendum to assess response action alternatives for managing risk associated with potential human interaction with MEC at Spencer Artillery Range:

- **Project Area 01**: RI Long Term Monitoring (LTM) Areas
- **Project Area 03**: Covenant Farms - 5 Acre Lots
- **Project Area 04**: Covenant Farms - Large Lots
- **Project Area 05**: Recreation/Cabins
- **Project Area 06**: Sequoia Subdivision
- **Project Area 07**: Indian Trails Development
- **Project Area 08**: Rocky River Road - Residential

2.1 PURPOSE

2.1.1 The FS provides decision makers with the data necessary to select the final remedy for the site; however, a specific remedy is not selected during the FS process. Specifically, the FS process is designed to:

- Develop an appropriate range of potential alternatives to manage hazards and risks;
- Analyze the alternatives against the nine NCP criteria defined below; and
- Compare the alternatives against each other.

2.1.2 CERCLA contains several statutory provisions with which all remedies must comply. These include protection of human health and the environment, compliance with applicable or relevant and appropriate requirements (ARARs), cost effectiveness to the extent practicable, and a preference for permanence and for treatment that reduces toxicity, mobility, or volume. To satisfy these CERCLA requirements, NCP Section 300.430 identifies nine criteria against which potential remedies are judged, as summarized in Table 2.1.

Table 2.1
Nine Criteria for Detailed Analysis of Remedial Alternatives
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

Threshold Criteria	1. Overall protection of human health and the environment 2. Compliance with ARARs, unless a specific ARAR is waived
Primary Balancing Criteria	3. Long-term effectiveness and permanence 4. Reduction of toxicity, mobility, or volume through treatment 5. Short-term effectiveness 6. Implementability 7. Cost
Modifying Criteria	8. State acceptance 9. Community acceptance

2.2 SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

2.2.1 The following text briefly summarizes the key findings in the Final RI Report (Parsons 2011a) that are relevant to the development of the RAOs and the development and analysis of alternatives. The RI was conducted to determine whether MEC or MC present sufficient hazards or risks to warrant further remedial action and to adequately characterize the nature and extent of detected contamination, if any. The characterization used information from previous investigations (plus RI data results) to further assess risk associated with potentially complete exposure pathways. Tasks performed during this RI and previous investigations have included reconnaissance, brush cutting, geophysical surveys, surface removal, intrusive anomaly investigation and soil and groundwater sampling.

2.2.2 On 1 January 1940, the USACE began securing leases in rural Tennessee to construct an artillery range. Construction began in February 1941, and the range was probably in operation shortly thereafter (USACE, 2001). A December 1941 report describes two impact ranges constructed at Spencer Artillery Range. By September 1944, Army Ground Forces had either departed or were under orders to depart, and arrangements were made for Dyersburg Army Air Field to use the Spencer Artillery Range as an air-to-ground gunnery range. The land reverted to the 25 original landowners in the summer of 1946. Several surface decontamination sweeps were completed on portions of the former range in the 1950s. Financial settlement agreements were reached between the government and two property owners within the historic boundaries of Spencer Artillery Range. On January 22, 1965, the Court of Claims recommended that Congress award the Rock River Company and Macy Land Corporation the amount of $88,729.60 for diminution of 3,059 acres (USACE, 1985).

The properties that accepted settlement agreements are not eligible for remedial action under the FUDS MMRP. After reversion to the 25 original landowners in 1946, numerous tracts of land have been sold and/or subdivided, significantly increasing the number of property owners from the original 25 to several hundred landowners today.

2.2.3 The former Spencer Artillery Range encompassed 30,618 acres in Van Buren, Warren, Sequatchie, and Bledsoe Counties, approximately 10 miles southeast of McMinnville, Tennessee, and 12 miles south of Spencer, Tennessee. Land within the former Spencer Artillery Range is entirely privately owned. Portions of the site have been heavily subdivided for residential development. Although several of these developments are shown as residential (e.g., Sequoia, Whispering Pines, Indian Trails), and in some cases roads and utility infrastructure have been installed, actual construction of houses has not been initiated. Housing development/construction is known to be ongoing within the Covenant Farms subdivision. Much of the land within the FUDS is undeveloped, wooded land. Logging has been conducted on the site since before the artillery range was constructed and is ongoing within portions of the former range. Historically, land use within the site has also included coal strip mining operations, particularly in the eastern portion of the site. Numerous drill programs have also been conducted in this area to delineate potential coal resources. Several of the strip-mined areas have been reclaimed.

2.2.4 During the 2011 review up to the present day, land use is changing within the FUDS, with continued and future development of zoned residential areas planned and anticipated. Currently, land usage within undeveloped lands includes recreational activities such as hunting, camping, and all-terrain vehicle use. Cattle ranching is also conducted across various areas of the site, as are commercial operations, including tree farms and the storage of explosives. A chemical storage facility is present within Project Area 03; however, it should be noted that the explosives storage company does not store (or handle or use) 37 mm projectiles. DMM was not anticipated because the area is not a known firing point.

2.2.5 The site is on the Cumberland Plateau in east central Tennessee. The topography at former Spencer Artillery Range is typically flat with numerous undulations formed by streams running across and off the plateau. Elevation of the site is generally 1,900 feet above mean sea level (MSL). Numerous streams occur in narrow valleys and draws. At the north end of the site, the Rocky River has carved deeply into the Cumberland Plateau, and a 500-foot drop is observed along the Rocky River Gorge (from 1,800 feet above MSL at the edge of the plateau to 1,300 feet at the bottom of the gorge). In the southeastern corner of the site, Jakes Mountain rises above the plateau to an elevation of 2,400 feet above MSL. Bedrock is observed at the surface in some areas of the site. Where covered with soil, depth to bedrock across the site generally ranges from approximately 2 feet to 6 feet below ground surface (USACE, 2001).

2.2.6 Multiple parcels at Spencer Artillery Range could not be investigated during the RI because signed rights of entry (ROEs) were not obtained either due to official ROE refusal by the property owners or because the owners did not respond to the ROE request. Although characterization of these properties could not be conducted during the RI, the

MRS was adequately characterized, and therefore the recommendations for the MRS can be applied to the non-ROE parcels. Recommendations for these areas will be based on information known about surrounding parcels regarding potential MEC presence. While every effort will be made to gather ROE access from property owners across Spencer Artillery Range, ROE refusals are anticipated to exist. Parcels where ROE is not granted will likely be scattered intermittently across the project areas; therefore, these parcels will be combined as one additional project area and alternative 2 will be implemented. ROE for the remedial action will be evaluated during the development of the remedial action work plan.

2.2.7 Instrument-aided reconnaissance was conducted within six areas of the site covering 21 miles over 7.6 acres. During this effort, 850 observations were made; no MEC or MD was identified. Digital geophysical mapping (DGM) data was also collected in transects totaling approximately 59.41 acres. Approximately 160 miles of brush cutting was completed in advance of DGM transect data collection. DGM grids totaling 5.17 acres were also located and collected based on the results of the transect anomaly density. Within the DGM transect and grid data, 8,474 anomalies were identified, 1,503 of which were intrusively investigated. During the RI, 1,503 anomalies were intrusively investigated and nine MEC items were identified. In addition, three MEC items were found by field teams while traversing the site. A total of eight UXO items and four fuzed DMM were recovered during the RI.

2.2.8 Due to the presence of MEC, elevated geophysical anomaly areas, and changes in current and future land use (identified in the preliminary conceptual site model and Work Plan), 15 MRSs were recommended in the RI Report for an FS (Parsons 2011a). As described in Section 2.0, 13 of the 15 MRSs were grouped into seven MMRP Project Areas in accordance with the approved DERP-FUDS-INPR memorandum (USACE, 2014) for evaluation in this FS. Table 2.2 presents detailed information for the recommended Project Areas, including land use, average anomaly density, and MEC/MD identified during previous investigations. Figure 2.1 presents the locations and boundaries for the recommended Project Areas in conjunction with the geophysical anomaly density (using both Engineering Evaluation and Cost Analysis [EE/CA] and RI DGM data).

2.2.9 The existence of potentially complete MEC exposure pathways at the surface and in the subsurface is assumed based on the confirmed presence of MEC and/or MD, historic land use, and/or high anomaly density within the recommended MRSs, as well as the overall level of site accessibility. This assumption was confirmed in 2001 when a child was maimed in his home after dropping a 37-millimeter (mm) MKII projectile high explosive (HE) had discovered while riding an ATV across the range in 1999.

2.2.10 A qualitative MEC HA was conducted for each MRS during the RI using information from investigations completed at the site. The MEC HAs provide the baseline for assessment of response alternatives. Table 2.3 presents the MEC HA scores (total maximum score of 1,000 and minimum possible score of 125) and MEC HA hazard levels, which range from 1 (highest hazard) to 4 (lowest hazard). Because MEC HA scores were previously calculated for MRSs, the conservative value was selected for each

criterion to develop Project Area MEC HA scores. Anticipated hours spent within each corresponding MRS were summed per Project Area to determine the appropriate number of total contact hours. Additional information for MRS MEC HA scores is provided in Appendix A.

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Table 2.2
Summary of Findings for Recommended FS Project Areas
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

FS Project Areas	Current/Future Land Use	Project Area (Acres)	Past DoD Use	1956 Surface Removal (count of items)	RI and EE/CA MEC (Depth)	Average anomaly density for RI DGM area (anomalies/acre)	Estimated Total Anomaly Count	RI and EE/CA Munitions Debris (Count)	Rationale for MRS Delineation
Project Area 01	Wooded/Hunting/ Logging/Commercial/Undeveloped Sub-division/Hunting/Ranching /Trail of Tears	4,120	Jakes Mountain Artillery Impact Area, Bald Knob 37mm impact area possible firing point, timber, impact craters present	155mm (1) 105mm (1) 37mm (4) 20mm (2) unknown munitions (6)	4 each 37mm, MkII (0.25”, 4”, 9”, 10”) 2 each 37mm, BaseFuze HE (2”,5”)	79	48,822	155mm frag (1) [3”] 105mm frag (4) [30”] 75mm frag (12) [3”-10”] 37mm armor piercing (AP)/HV (2) [2” – 6”] 37mm frag (98) [0.5” – 18”] 76 AP (9) [1” – 37”] unknown frag (186) [0” – 36”] fuze (11) [0.5” – 36”] small arms ammunition (45) [0” – 7”]	MEC found, former impact area, high anomaly density, possible firing point, commercial land use, future residential development, active ranching, portions within high-density areas, National Parks Service recognizes the Trail of Tears as a National Historic Trail.
Project Area 03	Active Development/Residential (Covenant Farms – 5-acre lots)	262	Northern edge of known impact area	Not Applicable	None	92	24,104	155mm frag (9) [1” – 5”] 37mm AP (1) [0”] 37mm frag (1) [4”] unknown frag (2) [4” – 5”]	Residential area, proximity to known impact area, MD found
Project Area 04	Active Development/ Residential (Covenant Farms – large lots)	60	Jakes Mountain Artillery Impact Area	Not Applicable	None	354	21,948	155mm frag (9) [1-8”]	Residential development, known impact area, high anomaly density
Project Area 05	Recreation/Cabins	646	Jakes Mountain Artillery Impact Area	Not Applicable	None	259	167,314	155 frag (68) [0” – 22”] 105mm frag (1) [3”] 37mm frag (3) [3” – 4”] unknown frag (86) [4” – 36”] small arms ammunition (5) [4” – 9”] M-51 Fuze (1) [0”]	Former impact area, high anomaly density, camping and recreational land use
Project Area 06	Undeveloped Subdivision (Sequoia Subdivision)	241	Jakes Mountain Artillery Impact Area	17-50 CAL (1)	None	688	165,808	155 frag (12) [0-3”] 37mm frag (4) [4” – 6”] unknown frag (5) [3” – 18”] small arms ammunition (13) [4” – 6”] M-51 Fuze, 0.50 Cal Link (1) [0’]	Future residential development, former impact area, high anomaly density
Project Area 07	Undeveloped Subdivision (Indian Trails Phase I, II, III)	352	Jakes Mountain Artillery Impact Area	75mm (1)	None	188	66,176	37mm frag (3) [2”-6”] 37mm AP (1) [16”] 75mm frag (1) [3”] 76 mm AP (3) [14” – 19”] unknown frag (2) [1”] small arms (4) [3” – 6”]	Future residential development, former impact area, high anomaly density
Project Area 08	Active Development/ Residential	260	Unknown. Timber cleared, evidence of impact craters	Not included as part of 1956 surface removal	None	197	51,220	155mm frag (10) [1” – 6”] 37mm AP (1) [7”] 76 AP (4) [4” – 32”] fuze (1) [2”] 37mm frag (11) [1” – 8”] 60mm mortar frag (3) [3” – 4”] unknown frag (31) [0” – 10”] small arms (44) [0” – 6”]	Residential development, high anomaly density

[a] Some 37mm projectiles recovered in Project Area 01 were not fired and could represent DMM.

Table 2.3
Summary of MEC Hazard Assessment Results
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

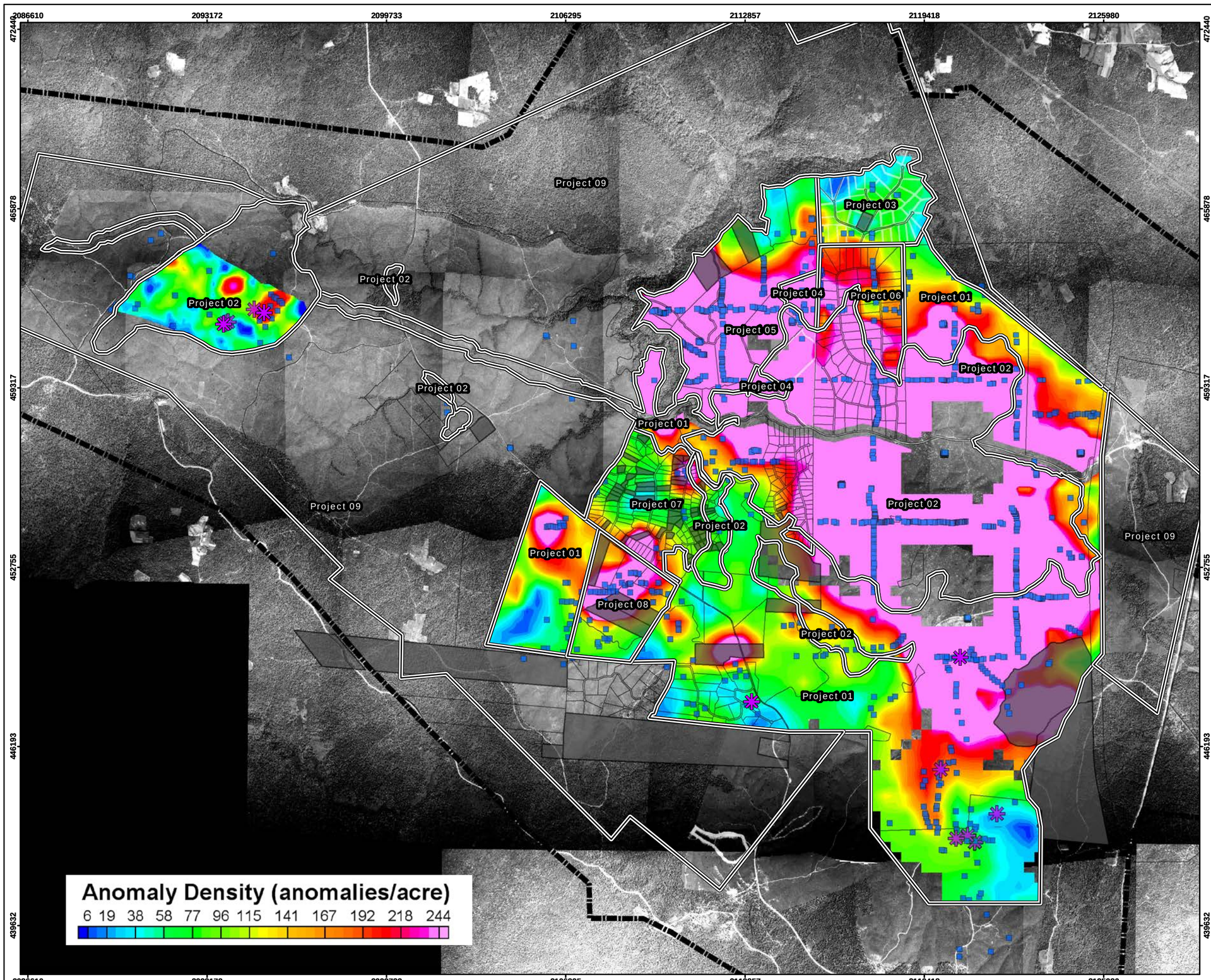
FS Project Areas	Energetic Material Type	Location of Additional Human Receptors (1) (Current/Future)	Site Accessibility	Total Contact Hours (1) (Current/Future)	Amount of MEC	Minimum MEC Depth vs. Maximum Intrusive Depth (1) (Current/ Future)	Migration Potential	MEC Classification	MEC Size	Total MEC HA Score (1) (Current/Future)	MEC HA Hazard Level (1) (Current/Future)
Maximum Possible MEC HA Score	*100*	*30*	*80*	*120*	*180*	*240*	*30*	*180*	*40*	***1,000***	***1***
Project Area 01 Private Property/ Commercial/ Whispering Pines/Rocky River Road/Greenfield Road/ Trail of Tears	100 *HE or fragmenting rounds*	30/30 *30 =Inside Project or inside explosive safety quantity distance (ESQD) arc around Project*	80 *Full accessibility*	115/120 *115 = Many hours* 120=	180 *Target area*	240/240 *MEC on surface and in subsurface*	10 *Unlikely*	110 *UXO*	40 *Small*	**805/805**	**2/2**
Project Area 03 (Covenant Farms – 5-acre lots)	100 *HE or fragmenting rounds*	30/30 *30=Inside Project or inside ESQD arc around Project*	80 *Full accessibility*	40/40 *40=Few hours*	30 *Safety buffer area*	150/150 *MEC only in subsurface; intrusive depth overlaps minimum MEC depth*	10 *Unlikely*	110 *UXO*	40 *Small*	**590/590**	**3/3**
Project Area 04 (Covenant Farms – large lots)	100 *HE or fragmenting rounds*	30/30 *30=Inside Project or inside ESQD arc around Project*	80 *Full accessibility*	40/15 *15=Very few hours* *40=Few hours*	180 *Target area*	150/150 *MEC only in subsurface; intrusive depth overlaps minimum MEC depth*	10 *Unlikely*	110 *UXO*	40 *Small*	**740/715**	**2/3**
Project Area 05 Recreation/Cabins	100 *HE or fragmenting rounds*	30/30 *30=Inside Project or inside ESQD arc around Project*	80 *Full accessibility*	40/40 *40=Few hours*	180 *Target area*	240/240 *MEC on surface and in subsurface*	10 *Unlikely*	110 *UXO*	40 *Small*	**830/830**	**2/2**
Project Area 06 Sequoia Subdivision	*100* *HE or fragmenting rounds*	0/30 *0= Outside EQSD arc* *30=Inside MRS or inside ESQD arc around Project*	80 *Full accessibility*	15/70 *15=Very few hours* *70=Some hours*	180 *Target area*	240/240 *MEC on surface and in subsurface*	10 *Unlikely*	110 *UXO*	40 *Small*	**775/860**	**2/1**
Project Area 07 Indian Trails Phase III	100 *HE or fragmenting rounds*	0/30 *0= Outside EQSD arc* *30=Inside Project or inside ESQD arc around Project*	80 *Full accessibility*	30/120 *30= few hours* *120=Many hours*	180 *Target area*	50/150 *MEC only in subsurface;* *50=does not overlap* *150=intrusive depth overlaps minimum MEC depth*	10 *Unlikely*	110 *UXO*	40 *Small*	**585/770**	**3/2**
Project Area 08 Rocky River Road - Residential	100 *HE or fragmenting rounds*	30/30 *Inside Project or inside ESQD arc around Project*	80 *Full accessibility*	40/40 *Few hours*	180 *Target area*	240/240 *MEC on surface and in subsurface*	10 *Unlikely*	110 *UXO*	40 *Small*	**830/830**	**2/2**

(1) Where two MEC HA scores or hazard levels are shown, the first number shown is based on the current site conditions and the second is based on future site conditions; where a single MEC HA score or hazard level is shown, the number is the same for both current and future site conditions.

(2) MEC HA scores were previously calculated for MRSs, the conservative value was selected for each criterion to develop MEC HA scores for Project Areas. Anticipated hours spent within each corresponding MRS were summed per Project Area to determine the appropriate number of total contact hours.

Figure 2.1

Recommended Project Areas
Anomaly Density
Formerly Used Defense Site
Spencer Artillery Range
FUDS Project # G04TN017801
Spencer, Tennessee



Legend

- Project Boundary
- MEC
- MD
- FUDS Boundary

Right of Entry

- No Access/No Response

MEC: Munitions and Explosives of Concern
MD: Munitions Debris

Note:
Anomaly density clipped to the extent of each Project Area included in the FS. Combined data from prior investigations used to calculate anomaly density.

Refer to RI Report (Parsons, 2011) for additional information regarding data collected and data results.

Project 2 is not eligible for remedial action under the Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP).

Image Source: 1943 Aerial
Projection: Tennessee State Plane, NAD83, Feet

0 1,750 3,500 7,000 Feet

N

PARSONS	U.S. ARMY ENGINEERING & SUPPORT CENTER HUNTSVILLE, ALABAMA
DESIGNED BY: CR	Former Spencer Artillery Range
DRAWN BY: CAtB	
CHECKED BY: JC	SCALE: As Shown; PROJECT NUMBER: 746862
SUBMITTED BY: CAtB	DATE: 3/12/2018; PAGE NUMBER:
	FILE: S:\ES\shared\Spencer Artillery Range\GIS\RI_Report\Assessment_Areas_rev1.mxd

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CHAPTER 3
IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The process used for developing and screening technologies included establishing RAOs and developing general response objectives. The following sections provide details regarding the RAOs, general response objectives, and remedial technologies.

3.1 REMEDIAL ACTION OBJECTIVES

The following overall goal for the project was developed by the technical project planning (TPP) team:

"Management of risk and protection of populations from residual MEC hazards"

RAOs address specific goals for reducing the explosives safety hazards for individual Project Areas to ensure protection of human health, safety and the environment. The RAOs are intended to be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Due to variations among the seven Project Areas regarding MEC risk, site conditions, and current/future use, specific RAOs have been developed for each Project individually. Detailed information is provided in the following sections.

3.1.1 Applicable or Relevant and Appropriate Requirements

3.1.1.1 Response actions at FUDS must identify and attain or formally waive ARARs based on federal and state laws (USACE, 2004). ARARs are promulgated statutory and regulatory requirements that are substantive in nature. The response actions must comply with these ARARs.

3.1.1.2 Chemical-specific ARARs are promulgated, health-based or risk-based, numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged into, the ambient environment. Risk-based screening levels (e.g., DoD perchlorate release management policy) are not considered chemical-specific ARARs because they are not promulgated. No chemical-specific ARARs have been identified for Spencer Artillery Range.

3.1.1.3 Action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to remedial/removal

actions, or requirements to conduct certain actions to address particular circumstances at a site. One action-specific ARAR has been identified for Spencer Artillery Range.

3.1.1.4 Location-specific ARARs generally are restrictions placed on the concentration of a hazardous substance or the conduct of activities solely because they are in special locations. An action in these special locations may cause irreparable harm, loss, or destruction of ecological resources, artifacts, or historic landmarks. Table 3.1 presents the ARARs identified for the project and whether they were retained.

Table 3.1
Summary of ARARs
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

Location-Specific ARAR	Description
Endangered Species Act USC Title 16 Chapter 35§1536 (a)(2)	Not Retained. No threatened and endangered (T&E) species were encountered during the RI field activities or are reported to be at these sites.
Executive Order 11990 for Protection of Wetlands and 40 Code of Federal Regulations (CFR) Part 6	Not Retained. Executive Order 11990 is not promulgated law and 40 CFR Part 6 is not substantive.
Action-Specific ARAR	**Description**
40 CFR 264.601 (Subpart X)	Retained. Regulate open detonation of consolidated MEC.

3.1.1.5 The lead agency may as appropriate, identify other advisories, criteria, or guidance to be considered (TBC) for a particular release. No TBCs were used in the development of remedial alternatives.

3.1.2 Project Area 01

3.1.2.1 Project Area 01 spans 4,120 acres and includes portions of Jake's Mountain Impact Area (JMIA), Bald Knob Impact Area (BKIA), residential Whispering Pines area, a large stretch of Greenfield road, a commercial industrial area (an explosives storage facility and tree farming business), the Trail of Tears, and undeveloped wooded areas identified in Figure 1.1. JMIA and BKIA were both historically used for artillery training. DMM have been found in the subsurface near JMIA at a minimum depth of 0.25 inch and maximum depth of 5 inches; therefore, it is assumed that additional DMM or UXO could be found at this depth as well. Current land use at Project Area 01 varies and includes: commercial, recreational (e.g. hiking and hunting), logging, private, ranching, residential, and undeveloped. Potential receptors include: recreational users (e.g. hikers and hunters), industry workers (commercial or ranch), current/future residents, site visitors, and construction workers.

3.1.2.2 Locked access gates are present for certain areas of Project Area 01; however, the gates do not constitute an effective barrier to access. Some activities

performed at Project Area 01 do not involve disturbance of the subsurface such as commercial land use and recreational use (hiking and hunting); however, home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 01 varies from heavily wooded to cleared and developed; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.2.3 A decontamination sweep conducted by DoD in the 1950s removed 20 MEC items (Table 2.2) from the subsurface. MD has been found in the surface and subsurface at a maximum depth of 37 inches. Thirty-seven inches has been identified as the maximum depth of any item recovered during the EE/CA and RI. Recovered MD included: 155mm, 105mm fragments, 76mm AP projectiles, 75mm fragments, 37mm, and HE fragments. MEC items (four 37mm MK II HE rounds, and two 37mm, BaseFuze HE) were found in the subsurface during RI field activities and during the previous EE/CA.

3.1.2.4 The RAO at Project Area 01 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated. RAOs at FS Project Areas can be viewed from Table 3.2.

3.1.3 Project Area 03

3.1.3.1 Project Area 03 is on the northern edge of JMIA. A decontamination sweep conducted by the DoD in the 1950s within Project Area 03 discovered no MEC items (Table 2.2). The EE/CA and RI, however, found 37mm fragments and unknown fragments. Project Area 03 is currently zoned for the development of 47 five-acre residential parcels. Potential receptors include residents, construction workers, and site visitors.

3.1.3.2 The land within Project Area 03 is privately owned, and locked access gates are present; however, the gates do not constitute an effective barrier to access. Most residential activities do not involve disturbance of the subsurface; however, home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 03 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.3.3 Although no MEC was found within Project Area 03, MD has been found in the subsurface at a maximum depth of 5 inches; therefore, it is assumed that MEC could potentially be found at this depth as well. A chemical storage facility is present within Project Area 03; however, it should be noted that the explosives storage company does not store (or handle or use) 37mm projectiles. DMM was not anticipated because the area is not a known firing point.

3.1.3.4 The RAO at Project Area 03 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.1.4 Project Area 04

3.1.4.1 Project Area 04 is within JMIA. A decontamination sweep conducted by the DoD in the 1950s within Project Area 04 discovered no MEC items (Table 2.2). Project Area 04 is currently zoned for the development of 4 large (50 – 100 acres) residential parcels. Two residents currently occupy the Project area. Potential receptors include; residents, construction workers, site visitors and recreational users (e.g. hikers and hunters).

3.1.4.2 The land within Project Area 04 is privately owned by two landowners and locked access gates are present; however, the gates do not constitute an effective barrier to access. Most residential activities do not involve disturbance of the subsurface; however, future home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 04 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees. The heavy vegetation stabilizes the soil and minimizes the potential for erosion and frost heave.

3.1.4.3 Although no MEC was found within Project Area 04 during the EE/CA and RI, nine items of MD (155mm frag) were found in the subsurface at a maximum depth of 8 inches; therefore, it is assumed that MEC could potentially be found at this depth as well.

3.1.4.4 The RAO for the remedial action area at Project Area 04 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.1.5 Project Area 05

3.1.5.1 Project Area 05 is located on the northwestern edge of JMIA. A decontamination sweep was conducted by the DoD in the 1950s within Project Area 05 discovered no MEC items (Table 2.2). Large quantities of MD were recovered during the EE/CA and RI, including fragments from 37mm and 155mm HE projectiles. The land use within Project Area 05 is recreational (e.g., hiking, and camping), and the recreational users may occasionally include Boy Scout troops. Five cabins (not permanent residences) are present within the Project Area.

3.1.5.2 The land within Project Area 05 is privately owned, and locked access gates are present; however, the gates do not constitute an effective barrier to access. Most activities do not involve disturbance of the subsurface (hiking); however, activities related to camping could result in intrusive activities in the shallow subsurface (up to 1 foot). The landscape at Project Area 05 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.5.3 MD was found in the subsurface at Project Area 05 at a maximum depth of 36 inches.

3.1.5.4 The RAO for the remedial action area at Project Area 05 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.1.6 Project Area 06

3.1.6.1 Project Area 06 is a proposed residential development area within JMIA. A decontamination sweep conducted by the DoD in the 1950s within Project Area 06 removed one MEC item (Table 2.2). Since the 1950s surface sweep, no documented MEC has been recovered from within Project Area 06. The EE/CA and RI, however, found a variety of MD, including fragmentation from 37mm HE projectiles. Project Area 06 is currently zoned for the development of five-acre residential parcels. Current potential receptors include recreational users (e.g. hikers and hunters), while future potential receptors also include residents, construction workers, and site visitors.

3.1.6.2 The land within Project Area 06 is privately owned, and locked access gates are present; however, the gates do not constitute an effective barrier to access. Most residential activities do not involve disturbance of the subsurface; however, home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 06 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.6.3 Although no MEC was found within Project Area 06 during the EE/CA and RI, MD has been found in the subsurface at Project Area 06 at a maximum depth of 18 inches; therefore, it is assumed that MEC could potentially be found in the surface and subsurface within the MRS.

3.1.6.4 The RAO for the remedial action area at Project Area 06 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.1.7 Project Area 07

3.1.7.1 Project Area 07 is a proposed residential development area within JMIA, previously used for artillery training. A decontamination sweep conducted by the DoD in the 1950s within Project Area 07 removed one MEC item (Table 2.2) from the surface. Since the 1950s surface sweep, no documented MEC has been recovered from within Project Area 07. The EE/CA and RI found a variety of MD including 37mm and 75mm fragments, and 37mm and 76mm AP projectiles. Project Area 07 is currently zoned for the development of five-acre residential parcels (Indian Trails Phase I, II, and III), and improvements such as gravel roads accessing the planned community have been completed. Development of the property is not anticipated in the near future because the developer is involved in litigation over its assets. Current potential receptors include recreational users (e.g. hikers and hunters), while future potential receptors include residents, construction workers, and site visitors.

3.1.7.2 The land within Project Area 07 is privately owned by either individual private owners or a commercial developer, and no barriers are present to prevent access. Most residential activities do not involve disturbance of the subsurface; however, home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 07 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.7.3 Although no MEC was found within Project Area 07 during the EE/CA and RI, MD has been found in the subsurface at a minimum depth of 1 inch and a maximum depth of 19 inches; therefore, it is assumed that MEC could potentially be found at this depth as well.

3.1.7.4 The RAO for the remedial action area at Project Area 07 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.1.8 Project Area 08

3.1.8.1 Prior military use of Project Area 08 is unknown, and the area was not included in the 1950s surface removal. However, the EE/CA and RI found 37mm and 76mm AP projectiles, and fragments from other projectiles. Project Area 08 is currently zoned for the development of ten 26-acre residential parcels. The land use is active development/residential. Potential receptors include residents, ranch workers (e.g. cattle handlers), and construction workers.

3.1.8.2 The land within Project Area 08 is privately owned, and locked access gates are present; however, the gates do not constitute an effective barrier to access. Most residential activities do not involve disturbance of the subsurface; however, home construction could result in intrusive activities to depths of 5 feet or more. The landscape at Project Area 08 is heavily wooded; the predominant vegetation in the area comprises forests of coniferous and deciduous trees.

3.1.8.3 Although no MEC was found within Project Area 08, MD has been found in the surface and subsurface at a maximum depth of 32 inches; therefore, it is assumed that MEC could potentially be found on the surface and subsurface.

3.1.8.4 The RAO at Project Area 08 is to reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.

3.2 GENERAL RESPONSE ACTIONS

3.2.1 General response actions are those actions that will achieve the RAOs and may include treatment, containment, excavation, extraction, disposal, land use control, or combinations of these. The selected general response actions to satisfy the RAOs for the Project Areas include the following:

- Educational Awareness Program;
- Surface Removal; and
- MEC Removal.

3.2.2 The general response actions identified above may be combined in developing remedial action alternatives. Project Area 03, for example, exhibits a greater exposure risk due to development/residential land usage and may require a different remedy than Project Area 01.

3.2.3 The sequencing of the response actions are ultimately related to the hazards associated with the Project Areas and the availability of funding. Project Areas have been delineated based on the approved DERP-FUDS-INPR memorandum (USACE, 2014). The delineated Project Areas will allow the proposed response actions to be prioritized and sequenced appropriately according to defined hazards and predicted remediation costs.

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Table 3.2
Remedial Action Objectives
Spencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

FS Project Areas	Contaminant	Exposure Pathways (minimum depth – max depth)[1]	Potential Receptors	ARARs and TBCs	Remediation Goal
Project Area 01 (Private Property, Commercial, Whispering Pines, Mason Property, Road/Trail of Tears) (4,120 Acres)	Projectiles (20mm, 37mm, 75mm, 105mm, and 155mm), Armor Piercing Projectiles (37mm and 76mm)	Potential surface and subsurface *(0" - 37")*	Loggers, construction workers, site visitors, recreational users (e.g. hikers and hunters), commercial workers (explosives storage and tree farming), future residents, and ranch workers (e.g. cattle handlers)	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 03 (Covenant Farms – 5-acre lots) (262 Acres)	Projectiles (37mm)	Potential subsurface *(0" - 5")*	Residents, construction workers	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 04 (Covenant Farms – large lots) (60 Acres)	Projectiles (155mm)	Potential subsurface (1"-8")	Residents, construction workers, site visitors, and recreational users (e.g. hikers and hunters)	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 05 (Leborne, others) (646 Acres)	Projectiles (37mm, 105mm, and 155mm)	Potential surface and subsurface *(0" - 36")*	Part-time residents, site visitors, and recreational users (e.g. hikers, boy scouts and hunters)	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 06 (Sequoia Subdivision) (241 Acres)	Projectiles (37mm and 155mm)	Potential surface and subsurface *(0" - 18")*	Future residents, construction workers, site visitors, and recreational users (e.g. hikers and hunters)	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 07 (Indian Trails Phase I, II, III) (352 Acres)	Projectiles (37mm, 75mm, and 76mm,)	Potential subsurface *(1" - 19")*	Future residents, construction workers, site visitors, and recreational users (e.g. hikers and hunters)	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*
Project Area 08 (Active Development/ Residential) (260 Acres)	Armor Piercing Projectiles (37mm and 76mm)	Potential surface and subsurface *(0" - 32")*	Residents, ranch workers (e.g. cattle handlers), and construction workers	40 CFR 264.601 (Subpart X)	Reduce risk of exposure to explosive hazards for land users such that a determination of negligible risk can be supported. All explosive hazards detected will be remediated.*

Note: [1)] Maximum depth shown is based on previous investigations at Spencer AR.

*Data will be collected during implementation of the selected remedial action and will be used to verify completeness in achieving the RAO. Subsequent to remedy implementation, if explosive hazards are encountered, or if the RAO is not achieved, additional remedial response will be assessed.

3.3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The U.S. Environmental Protection Agency (USEPA) has established guidelines for the types of remedial alternatives that should be developed during the detailed analysis stage; they are listed in the NCP (40 CFR 300.430[a][1]) and are summarized as follows:

- Use treatment to address the threats posed by a site, wherever practicable.
- Use engineering controls for low, long-term threats or where treatment is impracticable.
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment.
- Use institutional controls (ICs) to supplement engineering controls to prevent or limit exposure to hazardous substances, pollutants, or contaminants. The use of ICs shall not substitute for active response measures as the sole remedy unless such active measures are determined not to be practicable.
- Consider using innovative technologies.
- Return usable groundwater to their beneficial uses wherever practicable.

NCP guidance further states that "the development and evaluation of alternatives shall reflect the scope and complexity of the remedial action under consideration" (40 CFR 300.430[e]). Land use is also a consideration in developing alternatives. Due to these factors, only a limited number of alternatives are considered for this FS. In addition to no further action and institutional actions (education), remedial technologies associated with MEC include detection, recovery, and disposal.

DERP requires that the FS considers the No Action Alternative, as well as an alternative the remediated the site to a condition that allows unlimited use/unrestricted exposure (UU/UE) condition, and action to remediate the site to a protective condition that requires land use restriction. The following sections discuss available and applicable processes for detection, recovery, and disposal of MEC.

3.3.1 Detection Technologies

3.3.1.1 MEC detection methods consist primarily of ground-based surveys conducted using geophysical instruments such as metal detectors and magnetometers. As shown during prior investigations at the site (EE/CA and RI), munitions are readily detected at the site using geophysical techniques; furthermore, the techniques implemented at the site during the RI are considered the most effective means for locating MEC in these areas Time-domain electromagnetic (EM) induction metal detectors (i.e., Geonics EM61-MK2) were successfully used during the RI to conduct DGM surveys and detect and dig. The detect and dig method (real-time responses for detection) was used in areas where vegetation was blocking the view of satellites from the Global Positioning System (GPS) sensor, reducing the accuracy of the recorded positions and making reacquisition of detected anomalies infeasible. This approach used the EM61-MK2 sensor to detect

objects, which were then marked with pin flags and intrusively investigated. "DERP policy states the administrative record shall include: data gathered to characterize an MRS (including geophysical sensor data that is digitally recorded and geo-referenced) accompanied by a clear audit trail of pertinent analyses and resulting decisions. Where collecting digitally recorded, geo-referenced, geophysical sensor data is impractical or unwarranted, the installation shall forward a memorandum documenting the determination to the DoD Component Secretariat; the memorandum shall be included in the administrative record and the information repository." The detection performance of geophysical instruments (probability of detection, or Pd) varies depending on the technology used. DOD studies at blind field sites were conducted to determine Pd for common geophysical instruments. In all cases where site conditions were favorable to the sensor's capabilities, the Pd performance for analog instruments (e.g., Schoenstadt magnetometers, Minelab EM) is 50-72%, 28-95% for EM-61 instruments, and 100% for AGC systems.

3.3.1.2 Over 95% of the MEC and MD recovered at the site during the EE/CA and RI was discovered within the upper 12 inches of the subsurface (Parsons 2011a); therefore, a high degree of confidence should be expected for successful detection using the available geophysical instruments at Spencer Artillery Range. However, there are limitations to their detection capabilities, such as the depth of detection and interference from utilities, structures, and other metal in the vicinity. Table 3.3 presents munitions anticipated at Spencer Range and their detectable depth utilizing the presented thresholds.

Table 3.3
Depth Detection
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

Munitions Type	Depth of Detection (inches)[1]		Sum Channel (mV)[2]
	Most Favorable Orientation	Least Favorable Orientation	
155mm projectile	64	59	16.5
105mm projectile	53	45	16.3
75mm projectile	39	32	16.3
37mm projectile	24	12	16.4

Note:
[1] Values obtained from EM61-MK2 response calculator (NRL, 2008). EM61-MK2 coil height of 42cm
[2] Sum channel is sum of EM61-MK2 channels 1, 2 and 3

3.3.1.3 As expected, larger munitions produce larger responses and can therefore be more easily detected at deeper depths. If MEC items are located within the depth of detection range, then MEC can reliably be detected. Conversely, if MEC items are located at depths greater than the maximum depth of detection for that item, then the MEC item may not be detected.

3.3.1.4 Although these geophysical instruments can successfully find MEC, only a small percentage of the anomalies identified result in actual MEC. Based on the data collected during the RI, approximately 0.6% of the anomaly locations investigated were MEC. Project Area 01 accounted for the highest percentage of identified MEC per anomaly at 7.9%.

3.3.1.5 Several advanced digital geophysical sensors have been developed since the RI was conducted. By measuring multiple components of the EM field, these sensors acquire data which can more effectively differentiate between MEC items and other debris. The MetalMapper, TEMTADS, and Berkley UXO Detector (BUD) are some of these advanced sensors. The advanced sensors were used at the Spencer Artillery Range as part of an Environmental Security Technology Certification Program (ESTCP) demonstration project to classify detected anomalies as targets of interest or clutter. The results of this demonstration project (and several other demonstration projects at other sites) have been very successful.

3.3.1.6 Advanced sensors could be used at Spencer Artillery Range to evaluate geophysical anomalies and reduce the required number of intrusive investigations. Effective use of these sensors could eliminate a significant number of excavations and reduce the cost of remediating the Project Areas. The advanced EM instruments show significant potential to make subsurface removal more cost effective; therefore, their use will be evaluated as part of a geophysical survey remedial alternative in this FS

3.3.2 Removal Technologies

3.3.2.1 Removal technologies include hand excavation and mass excavation and sifting (using heavy equipment). On privately owned land, the use of heavy equipment for mass excavation and sifting may not be considered viable due to its extensive disturbance of the land.

3.3.2.2 Hand excavation is considered the industry standard for MEC recovery and can be done very thoroughly. Hand excavation was conducted during the EE/CA and RI, but site conditions such as heavy vegetation, heat, cold, and frequent rain/snow created difficulties for the field teams.

3.3.3 Disposal Technologies

Explosive disposal technologies for MEC include blow-in-place (BIP) and consolidate-and-blow demolition procedures. The BIP procedure is used to destroy, at the point where they are uncovered/located, those individual munitions considered unsafe to move. The consolidate-and-blow procedure, however, can be used to consolidate-and-destroy multiple munitions deemed acceptable to move at a convenient and/or safe site away from the point of detection. BIP and consolidated shot demo operations may require exclusions zones and temporary access restrictions. During the RI, the consolidate-and-blow procedure was used for the majority of MEC located, as most were determined to be acceptable to move. Detected munitions that were not considered acceptable to move (such as the 37mm, APCHE, MKII) were destroyed using the BIP

method. Following the destruction of the MEC item(s), the resulting MD was shipped away to be shredded or melted to prevent the MD from being encountered again as suspected MEC.

CHAPTER 4
DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

4.0 DEVELOPMENT OF ALTERNATIVES

4.0.1 Based on the RAOs for the FS Project Areas (Table 3.2), the general response actions, USEPA and USACE guidance, and available detection, removal, and disposal technologies for MEC, the following alternatives were developed for consideration:

- Alternative 1: No Further Action
- Alternative 2: Educational Awareness
- Alternative 3: Surface Removal with Educational Awareness
- Alternative 4: Geophysical Investigation and MEC Removal with Educational Awareness
- Alternative 5: Excavation and Sifting

4.0.2 Although five alternatives were developed for initial screening; not all were assessed for implementation at each Project Area because the characteristics of each Project Area vary due to factors such as MEC density, presence of MEC, and land use. Table 4.1 summarizes those alternatives, which alternatives were considered for initial screening at each Project Area, and a brief rationale for the alternative(s) considered. Detailed explanations of each alternative, and rationales for consideration for each Project Area, are summarized in the following sections.

4.1 ALTERNATIVE DESCRIPTIONS

4.1.1 Alternative 1: No Further Action

The no further action alternative denotes that no remedy will be implemented to reduce the potential safety risk posed by MEC. This alternative, if selected, would involve continued use of the site in its current condition. This alternative is included based on the NCP and DoD requirements, and will be evaluated for each Project Area to provide a baseline for comparing other alternatives.

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Table 4.1
Summary of Alternatives Considered for Initial Screening for FS Project Areas
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

FS Project Areas	Alternative 1 No Further Action	Alternative 2 Educational Awareness	Alternative 3 Surface Removal and Educational Awareness	Alternative 4 MEC Removal and Educational Awareness	Alternative 5 Excavation and Sifting
Project Area 01 Wooded/Hunting/Logging (Dixson Property), Commercial, Undeveloped Subdivision, Residential/Hunting/Ranching, Road/Trail of Tears	**Retained**	**Retained**	**Retained** (1)	**Retained** (1)	**Retained**
Project Area 03 Active Development/Residential (Covenant Farms – 5-acre lots)	**Retained**	**Retained**	**Not Retained**	**Retained**	**Retained**
Project Area 04 Active Development/Residential (Covenant Farms – large lots)	**Retained**	**Retained**	**Not Retained**	**Retained**	**Retained**
Project Area 05 Recreation/Cabins (Leborne, others)	**Retained**	**Retained**	**Retained**	**Retained**	**Retained**
Project Area 06 Undeveloped Subdivision (Sequoia Subdivision)	**Retained**	**Retained**	**Retained**	**Retained**	**Retained**
Project Area 07 Undeveloped Subdivision (Indian Trails Phase I, II, and III)	**Retained**	**Retained**	**Not Retained**	**Retained**	**Retained**
Project Area 08 Active Development/Residential	**Retained**	**Retained**	**Retained**	**Retained**	**Retained**

Note: "Not retained" correlates to the ineffectiveness of the alternative. The alternative is implementable (and costs would be incurred), but there would be no risk reduction because surface MEC are not anticipated in the identified "not retained" areas.
1) Surface or MEC removal of 700 acres within Project Area 01 is not necessary because MEC has not been identified on the surface. See recommendations for MRS 02, 11, and 12 in the RI report. (Parsons, 2011a)

4.1.2 Alternative 2: Educational Awareness

4.1.2.1 This alternative includes an educational awareness program coupled with annual evaluations and was considered for initial screening at each Project Area. Educational awareness is considered by DoD to be a type of Land Use Control. USACE conducted a public outreach campaign during the EE/CA and RI projects; public awareness of existing hazards within the former Spencer Artillery Range can be facilitated and maintained through continued use of these proven methods used during the public outreach campaign. An educational awareness program would focus on making known those areas containing MEC hazards and providing information regarding the appropriate response if MEC is encountered. Van Buren County has limited administrative resources; therefore, handouts through Van Buren County administrative resources (e.g., permitting offices, recorder of deeds, etc.) are not anticipated as part of the educational awareness program. Direct mailing of fact sheets to property owners, and distribution of fact sheets in public locations (e.g., libraries, stores, etc.) is considered as part of the alternative. Although warning signs may be considered appropriate in many cases to inform potential visitors of site risks, signs previously posted in the area were destroyed due to vandalism on multiple occasions. Therefore, warning signs were only considered for the Trail of Tears located within Project Area 01. Future development of the Trail of Tears may include designated trailhead parking areas. Installation of signs regarding the historic use of the site and appropriate response if MEC is encountered is included as part of the Alternative 2 response for Project Area 01. As shown in Table 4.1, Alternative 2 will be evaluated for implementation in each Project Area based on the relative ease of implementation through the existing public outreach program.

4.1.2.2 The educational awareness program would include the development of educational fact sheets aimed at modifying behavior to reduce the risk of exposure. The fact sheets would be sent to landowners of parcels in areas identified during the RI as containing MEC hazards. The fact sheet would encourage property owners to educate users of their land (e.g., hunters, loggers, and construction workers) regarding historic use of the property and proper response if a suspect item is found. A website containing educational information would also be maintained, however, there is no way to verify that the target audience will use or access the website.

4.1.3 Alternative 3: Surface Removal with Educational

For areas where surface MEC is expected to be encountered, a surface removal would be conducted by UXO technicians who would perform an instrument-aided visual surface inspection for potential MEC. It is anticipated that this alternative would include brush clearing of dense vegetation within selected Project Areas. Brush cutting will facilitate access to the remedial action area and to free space for sweeping with handheld metal detection equipment (e.g., Schonstedt) used to help locate items that may be partially buried or otherwise obscured from view by vegetation, etc. Personnel would follow predefined paths across the Project Areas and identified or suspected MEC would be removed and disposed of using BIP or consolidate-and-blow procedures. MEC may not be recovered in areas inaccessible to survey instruments and those areas with no ROE.

Upon completion of the surface removal, an educational awareness program would be implemented as described under Alternative 2. Educational awareness is considered by DoD to be a type of Land Use Control. As shown in Table 4.1, Alternative 3 is not considered appropriate in Project Areas where no MEC or MD items have been detected on the surface during the EE/CA and RI; therefore, this alternative will not be evaluated for Project Area 03, Project Area 04 and Project Area 07, and portions (approximately 700 acres) of Project Area 01. For Projects in which subsurface MEC was found, Alternative 4 is considered since it addressed subsurface MEC.

4.1.4 Alternative 4: Geophysical Survey/MEC Removal with Educational Awareness

4.1.4.1 This alternative uses a combination of activities to reduce the MEC hazards and minimize receptor interaction. The activities consist of MEC identification and removal with educational awareness. Trained UXO technicians will identify and remove MEC on the ground surface prior to brush clearing operations. Alternative 4 is evaluated for each Project area and involves four primary components:

- Brush removal (as needed to provide sufficient access);
- Performing a geophysical survey using advanced classification across the Project area;
- Performing subsurface MEC removal for items identified as targets of interest based on advanced sensors; and
- Educational awareness (to include developing and distributing educational materials).

4.1.4.2 The sensors will help to evaluate the geophysical anomalies and reduce the required number of intrusive investigations. It is anticipated that using the advanced sensors would reduce the number of intrusive investigations by 85%. Overall, the use of these sensors could eliminate a significant number of excavations and reduce the cost of remediating the Project Areas.

4.1.4.3 MEC removal would be conducted by trained UXO technicians and geophysical personnel within each Project Area to identify and remove MEC on the ground surface and in the subsurface. Geophysical data would be collected over the accessible area of each Project Area, and selected anomalies would be identified within the data and located for intrusive excavation. Engineering controls and/or evacuations may be required when working close to residences. If MEC is encountered, it is anticipated that the munition(s) would be destroyed using BIP procedures. However, munitions deemed acceptable to move could be transported to a nearby designated area for demolition.

4.1.4.4 MEC removal would not be conducted under existing roads, streams, and structures. Most of the site is currently undeveloped, so vegetation would need to be cleared to allow access for the geophysical instruments. Extensive vegetation removal is expected to be required across large areas of several of the Project Areas. Handheld

metal detectors would be used instead of geophysical instruments in areas where GPS coverage is limited by heavy canopy cover.

4.1.4.5 The completion of MEC removal would significantly reduce MEC hazards. Data collected in the remedial action will be reviewed after completion. Though not expected, based on this review, the individual Project Areas may be safe for UU/UE. If so, there would be no need for additional remedies including land use controls, and no further action will be needed in areas so designated. However, this is not expected and human safety will require the need for educational awareness using fact sheets and limited signage (like those described under Alternative 2) which would provide additional protection by making information concerning possible residual MEC hazards at the site available to the public. Reports, fact sheets, and other information would also be posted to a project website maintained by USACE.

4.1.5 Alternative 5: Excavation and Sifting

DERP guidance (Department of the Army, 2004) identifies inclusion of at least one alternative that can provide UU/UE upon completion of the remedial action. As part of the excavation and sifting alternative the following primary tasks would be implemented:

- Brush removal (as needed to provide access),
- Excavation of soils to the depth identified for explosive hazard exposure,
- Performing sifting of the soil to remove MEC, and
- Backfilling soil and seeding/revegetation (as needed).

No educational awareness would be needed for this alternative due to the removal of subsurface MEC.

4.1.6 Five-Year Reviews

All alternatives were evaluated over a 30-year period. The actual length of remediation is unknown, except for Alternative 5, and thus the USEPA option of comparing alternatives using a 30-year estimation period was used. Whenever 30 years or length of alternative is discussed, this is what is being referred to. While not a specific component of the remedy, five-year reviews would also be required for any alternative under which hazardous substances, pollutants or contaminants remain at a Project Area above levels that allow unlimited use and unrestricted exposure following remedy implementation. These reviews, as outlined in Section 121(c) of CERCLA, as amended by SARA, and 40 CFR 300.430(f)(4)(ii) of the NCP, are conducted to determine if the response action continues to minimize explosive hazard risks and continues to be protective of human health, safety and the environment. Reviews will be conducted every five years or less. For cost estimating, six five-year reviews, covering a period of 30 years, are included. Five-year reviews would be required for Alternatives 2 through 4. The five-year review process will follow applicable DoD, USACE, and USEPA guidance in the execution of the five-year review.

4.2 APPLICATION OF SCREENING CRITERIA BY ALTERNATIVE

4.2.1 This section discusses the performance of the five response action alternatives described in Section 4.1 relative to identified screening criteria. The screening criteria include the following:

- **Effectiveness**: the degree to which an alternative reduces the toxicity, mobility, or volume through treatment; minimizes residual risks; and affords long-term protection.
- **Implementability**: the technical and administrative feasibility of implementing the alternative.
- **Cost**: the costs of implementation and long-term costs to operate and maintain.

4.2.2 The screening criteria presented above were used to screen each of the five alternatives and to identify those alternatives that should be retained for further evaluation in Section 5. Table 4.1 summarizes which alternative is being considered at the FS Project Areas.

4.2.3 **No Further Action (Alternative 1)** does not provide long-term protection of human health and environment because it does not reduce risk or afford long-term protection. This alternative does not meet the effectiveness screening criterion for the Project Areas. The screening criteria for implementability and cost would be met by this alternative since there would be no further action and no cost. Although this alternative does not meet the effectiveness screening requirements, it was retained for consideration, per the NCP, for comparative purposes.

4.2.4 **Educational Awareness (Alternative 2)** will provide a framework to reduce potential risks to human health and environment. Implementation of this alternative will provide effectiveness through educational outreach. However, there would be no reduction of the toxicity, mobility, or volume of potential MEC through treatment. This alternative can readily be implemented. Chapter 5 presents the costs for implementing the educational awareness alternative. Based on the attainability of the effectiveness, implementability, and cost screening requirements, Alternative 2 was retained for further evaluation.

4.2.5 **Surface Removal with Educational Awareness (Alternative 3)** would meet the effectiveness criterion for residual surface MEC. It is considered unlikely, however, that MEC is on the surface in most of the Project Areas due to surface removals conducted during the 1950s at numerous Project Areas (Table 2.2). Also, heavy vegetation across the site, which stabilizes the soil, minimizes the potential for a buried item to be exposed due to erosion and frost heave. Chapter 5 presents the costs for implementing a surface removal based on the costs associated with the RI reconnaissance and brush removal activities. Implementation of this alternative would provide long-term effectiveness through educational awareness; therefore, Alternative 3 was retained for further evaluation at appropriate Project Areas.

4.2.6 **Geophysical Survey/MEC Removal and Educational Awareness (Alternative 4)** would meet the effectiveness criterion for residual MEC. If MEC are discovered as a result of the removal action, there would be a reduction in toxicity, mobility, and volume of MEC through their removal. Implementation of MEC removal with an educational awareness program is technically and administratively feasible; however, it requires expert personnel trained in classification. The use of AGC could eliminate a significant number of excavations and reduce the cost of remediating the Project Areas. The detailed cost for implementing a subsurface removal is presented in Chapter 5. Implementation may not be possible in some areas where sensitive habitats are present or access is limited (e.g., wetlands). Geophysical surveys and MEC Removal along with Educational Awareness provides long-term effectiveness; therefore, Alternative 4 was retained for further evaluation.

4.2.7 **Excavation and Sifting (Alternative 5)** would meet the effectiveness criterion for residual MEC. No long-term educational awareness component or (long-term costs) would be required as this alternative would result in UU/UE. Although UU/UE would result through implementation of the excavation and sifting alternative, this alternative is screened out due to the implementability and cost criterion. Excavation and sifting at Spencer Artillery Range is not considered cost effective. The cost to implement this alternative is presented in Table 4.2 for each Project Area. As noted in USEPA guidance, an alternative that eliminates the need for long-term management may not be reasonable given site conditions, the limitations of technologies, and extreme costs that may be involved (USEPA, 1999). The costs for excavation and sifting at Spencer Artillery Range would be extreme and unreasonable; therefore, Alternative 5 was not be retained for further evaluation. In addition, implementation would result in ecological destruction and likely would not be acceptable to private land owners.

Table 4.2
Estimated Excavation and Sifting Costs per Project Area
Spencer Artillery Range Feasibility Study, Van Buren County, Tennessee

Project Area	Total Cost over 30 years
Project Area 01	**$436,832,000**
Project Area 03	**$28,251,000**
Project Area 04	**$6,928,000**
Project Area 05	**$68,960,000**
Project Area 06	**$26,144,000**
Project Area 07	**$37,919,000**
Project Area 08	**$28,100,000**

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CHAPTER 5
DETAILED ANALYSIS OF ALTERNATIVES

5.0 INTRODUCTION

5.0.1 This detailed analysis evaluates and compares the identified alternatives and aids the development of a proposed plan for regulatory agencies and public review. The alternatives retained for the detailed analysis include the following:

- Alternative 1: No Further Action
- Alternative 2: Educational Awareness
- Alternative 3: Surface Removal with Educational Awareness
- Alternative 4: Geophysical Survey/MEC Removal with Educational Awareness

5.0.2 The alternatives are compared and evaluated with respect to seven evaluation criteria developed to address the statutory requirements and preferences of CERCLA:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

5.0.3 Two additional criteria, state acceptance and community acceptance of the remedy, can each play a role in deciding between remedies that are cost effective and also meet other criteria. The TPP process and other public involvement actions help provide an understanding of these factors before the Proposed Plan has been issued.

5.0.4 The community and state acceptance criteria are based on the degree of assumed acceptance from the local public and from state agencies regarding the implementation of alternatives. These criteria cannot be fully evaluated and assessed until comments on the FS and the Proposed Plan are received from the public and the state.

5.0.5 Each of the four alternatives retained for the Spencer Artillery Range was analyzed against the criteria listed above. The alternatives were then compared to one another to determine their relative strengths and weaknesses and to identify key trade-offs

in terms of efficacy, cost, etc. The following sections describe the evaluation criteria and the process used for performing the analysis of the four alternatives evaluated.

5.1 EVALUATION CRITERIA

Alternatives are compared to and evaluated with the NCP criteria, including threshold factors, balancing factors, and modifying factors. The following sections describe the threshold factors and each of the NCP criteria. Table 5.1 summarizes the estimated costs per alternative for each Project Area. Tables 5.2 through 5.9 summarize the evaluation of response alternatives for each Project Area.

5.1.1 Threshold Factors

Threshold factors (i.e., protectiveness and compliance with ARARs) are requirements that each alternative must meet to be eligible for selection.

5.1.1.1 Overall Protection of Human Health and the Environment

5.1.1.1.1 The selected remedial alternative must adequately protect human health and the environment from unacceptable risks posed by MEC in the area(s) where the alternative is implemented. In addition, selected remedial alternatives must achieve the RAO where implemented.

5.1.1.1.2 The overall protectiveness to human health and the environment was evaluated based on the effect each alternative has on the MEC exposure hazard and environment. Exposure involves three components: the MEC source characteristics, the receptor, and interaction between them. All three components are required for a safety threat from MEC to exist. The protectiveness factor also considers the environmental impact that implementation of an alternative has on the existing environmental/ecological factors at the Project Areas.

5.1.1.2 Compliance with ARARs

5.1.1.2.1 The NCP requires that project sites either meet ARARs or that an ARAR waiver be obtained for those that do not. The action-specific ARAR identified for the Project Areas are regarding the open detonation of consolidated MEC (40 CFR 264.601 [Subpart X]).

5.1.1.2.2 Discreet areas of the site could be considered sensitive environments due to the existence of the Trail of Tears National Historic Trail, the possible presence of T&E species (i.e., barking tree frog and white fringeless orchid), and identified wetlands; however, no ARARs were retained for these features. The ability of an alternative to meet an identified ARAR is evaluated for each Project Area.

5.1.2 Balancing Factors

Primary balancing criteria (i.e., long-term effectiveness, reduction of toxicity, mobility, and/or volume through treatment, short-term effectiveness, implementability, and cost) form the basis for comparison among alternatives that meet the threshold criteria. CERCLA requires that alternatives be developed for treating threats at the project site through reductions in toxicity, mobility, or volume. In addition, remedies must be permanent (e.g., removal of MEC) to the maximum extent practicable and must be cost effective. The five balancing factors described below are weighed against each other to determine which remedies are both cost effective and "permanent" to the maximum extent practicable. The NCP explains that, in general, preferential weight is given to alternatives that offer advantages in terms of the reduction of toxicity, mobility, or volume through treatment and that also achieve long-term effectiveness and permanence. However, the NCP also recognizes that treatment options and permanent remedies may not be suitable for some contamination problems. The balancing process takes these preferences into account and weighs the proportionality of costs to effectiveness to select one or more cost-effective remedies. Thus, the final risk management decision contained in the Decision Document represents a cost-effective remedy that offers a suitable balance of factors and achieves permanence to the maximum extent practicable.

5.1.2.1 Long-term Effectiveness and Permanence

The permanence criterion is used to evaluate the degree to which an alternative permanently reduces or eliminates hazards created by the potential for exposure to MEC. This criterion is also used to evaluate the magnitude of residual risk at each Project Area with the alternative in place and to measure the effectiveness of controls that may be used to manage the residual risk.

5.1.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

5.1.2.2.1 This criterion addresses the statutory preference for selecting remedies that employ treatment technologies used to permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. This preference is satisfied when treatment is used to reduce the threats at a site through the destruction of toxic contaminants, an irreversible reduction in contaminant mobility, or a reduction of total volume of contaminated media. Non-removal alternatives have negligible impact in reducing sources or associated exposure hazards. The MEC HA hazard level determination (Appendix A) is used as a baseline for this evaluation.

5.1.2.2.2 The MEC HA hazard level determination was developed following the MEC HA method, which assesses the acute explosive hazards associated with remaining MEC within an MRS by analyzing site-specific conditions and human issues that affect the likelihood that MEC accidents will occur. The process for conducting the MEC HA uses input data based on historical documentation, field observations made during the RI, previous studies and removal actions, and the results of the intrusive investigations

conducted as part of the RI in conjunction with the estimated number of receptor-hours per year at each MRS to determine a qualitative hazard score, which is used to help determine a hazard level ranking for each MRS (Parsons 2011a). The hazard scoring system ranges in multiples of 5 from a minimum score of 125 (least hazardous) to a maximum of 1,000 (most hazardous), while the hazard level scale ranges from 1 (most hazardous) to 4 (least hazardous); both scales were used to evaluate each MRS in Tables 5.2 through 5.9. MRSs were grouped into Project Areas based on boundary realignment guidance received from USACE (2014). To support the MEC HA, scores were adjusted based on conservative values provided by the MEC HA for MRSs within each Project Area. Contact hours were summed to best represent the number of hours a possible receptor would be present within a Project Area.

5.1.2.3 Short-term Effectiveness

The short-term effectiveness criterion addresses the potential consequences and risks of an alternative during the implementation phase. Alternatives were evaluated for their effects on human health and the environment prior to the remedy being completed. Short-term risk evaluation addresses potential adverse impacts to the workers and community during the construction and implementation phases of the remedy.

5.1.2.4 Technical and Administrative Implementability

The technical and administrative implementability criterion evaluates the relative difficulty of implementing a specific cleanup action alternative. The evaluation considers whether the alternative is technically possible by determining the availability of necessary onsite and offsite facilities, services, and materials. The administrative implementability of each alternative is also evaluated by assessing the feasibility of meeting all administrative and regulatory requirements as well as all monitoring requirements.

5.1.2.5 Cost

The cost criterion evaluates the financial cost to implement the alternative. This includes direct, indirect, and long-term (30-year) operational and maintenance costs. The 30-year timeframe is used to estimate costs and is not the time duration of the implemented alternative. Direct costs are those costs associated with the implementation of the alternative, while indirect costs are those costs associated with administration, oversight, and contingencies. Cost estimates presented are order-of-magnitude level estimates based on a variety of information, including productivity estimates (based on site conditions), cost estimating guides, and prior experience at the Spencer Artillery Range. The actual costs will depend on true labor rates, actual weather conditions, final project scope, and other variable factors.

5.1.3 Modifying Factors

Community and state acceptance of the remedy can play a role in weighing the balance between remedies that are cost effective and meet other criteria. The TPP process and other public involvement (e.g., public meeting) help to provide an understanding of these factors before the Proposed Plan has been issued.

5.1.3.1 Community and State Acceptance

The community and state acceptance criteria are based on the degree of assumed acceptance by the local public and state agencies of the proposed implementation of alternatives. These criteria cannot be fully evaluated and assessed until comments on the FS and the proposed plan are received.

5.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

5.2.1 Alternative 1 – No Further Action

5.2.1.1 Description

The No Further Action alternative does not implement a response or remedy. The No Further Action alternative also provides a baseline for comparing other alternatives. Because no remedial activities would be implemented with this alternative, explosive hazards would essentially be the same as those identified in the MEC HA (Table 2.3).

5.2.1.2 Assessment

Threshold Factors

5.2.1.2.1 Alternative 1 provides no reduction in risk to MEC exposure hazards. Project Areas with significant MEC hazards would not be provided protectiveness for human health. Existing and future exposure pathways would be unchanged. The RAO would not be met for the Project Areas.

5.2.1.2.2 There are no ARARs associated with Alternative 1 that would restrict or modify its implementation.

Balancing Factors

5.2.1.2.3 The No Further Action alternative includes no controls for exposure and no long-term management measures. All current and potential future risks would continue under this alternative.

5.2.1.2.4 This alternative provides no reduction in toxicity, mobility, or volume of MEC through treatment.

5.2.1.2.5 There would be no additional risks posed to workers as a result of this alternative being implemented, since no further action would be taken. No ARARs are associated with this alternative.

5.2.1.2.6 There are no implementability concerns posed by this remedy, since no further action would be taken.

5.2.1.2.7 The present worth cost and capital cost of Alternative 1 are estimated to be $0, since there would be no further action.

5.2.1.3 Summary

Alternative 1 does not reduce potential current and future exposure hazard. There would be no additional protection to human health in the Project Areas as Alternative 1 does not implement a remedy to reduce potential future MEC exposure. In addition, there would be no reduction in toxicity, mobility, or volume. Uncertainty exists about the long-term effectiveness of this approach for risk management. No costs are associated with this alternative.

5.2.2 Alternative 2 – Educational Awareness

5.2.2.1 Description

This alternative includes an educational awareness program implemented by the USACE that would educate the public about potential residual explosive hazards within remedial action Project Areas at Spencer Artillery Range. An educational awareness program would focus on providing information on the areas containing the MEC hazards and the appropriate response if MEC is encountered. Letters and fact sheets would be sent to landowners and residents. Information could also be maintained on the USACE project website. Educational awareness is considered by DoD to be a type of Land Use Control.

5.2.2.2 Assessment

Threshold Factors

5.2.2.2.1 Alternative 2 would achieve the overall protection of human health and the environment by increasing the public's awareness of potential MEC hazards using warning signs and informational pamphlets. These measures would serve to limit human interaction with surface and subsurface UXO at the Project Areas by making it more likely they would avoid or retreat from the item(s). Under this alternative, risk would be managed through controls used to reduce the potential for completion of the exposure pathway (i.e., by inhibiting interaction with MEC) rather than source removal.

5.2.3.2.2 Educational awareness may address the appropriate response to finding MEC; however, Alternative 2 may not influence the behavior of each individual who may

be potential receptors. There is also residual, long-term risk associated with the possibility that an individual may encounter MEC who has not been exposed to the educational awareness program.

5.2.2.2.3 There are no ARARs associated with Alternative 2 that would restrict or modify its implementation.

Balancing Factors

5.2.2.2.4 Controls for exposure would include long-term management measures such as reassessment of the effectiveness of controls during five-year reviews.

5.2.2.2.5 This alternative provides no reduction in toxicity, mobility, or volume of MEC through treatment.

5.2.2.2.6 There would be no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented.

5.2.2.2.7 There are no implementability concerns posed by this remedy; educational awareness is readily implemented and maintained through the existing public outreach program and by updating the program as necessary.

5.2.2.2.8 The total 30-year present worth cost of this alternative is presented in Table 5.1. The costs were developed assuming Alternative 2 would be implemented for each Project Area separately because the timing of implementation for each Project Area is unknown. However, the overall cost could be reduced substantially if Alternative 2 was implemented for multiple Project Areas concurrently.

5.2.2.3 Summary

Implementation of Alternative 2 can provide overall protection of human health. No ARARs are associated with this alternative; therefore, Alternative 2 meets this threshold factor. Educational awareness may help influence behavior to reduce the risk of exposure and interaction will potential MEC. Landowners and potential land users would both receive information regarding the risks associated with land use provided through educational awareness efforts. Specifically, a person who has seen a fact sheet is more likely to respond appropriately if a suspect item is found (versus a person who has not seen a fact sheet). Long-term effectiveness will be monitored through five-year reviews. There is no source reduction of potential MEC associated with this alternative. The cost associated with implementing this alternative is relatively low compared to the other alternatives.

5.2.3 Alternative 3 – Surface Removal with Educational Awareness

5.2.3.1 Description

5.2.3.1.1 To identify and remove MEC on the ground surface, a surface removal would be conducted by trained UXO technicians over remedial action Project Areas where MEC or MD were found on the surface. Subsurface MEC is not addressed as part of Alternative 3. It is anticipated that the field team would be comprised of five persons (two UXO technician IIIs, two UXO technician IIs, and one senior UXO supervisor). Each person would walk 5-foot-wide transects across the Project Area using a handheld magnetic locator (e.g. Schonstedt or White's metal detector) to aid in the detection of metallic items on the surface obscured by vegetation or other debris. Brush cutting, which may be extensive in many densely vegetated areas of the Project Areas, is anticipated for the surface removal. While a team may be able to make its way through some of the wooded areas without brush clearing, it is unlikely that an effective sweep of the surface would be conducted without the removal of widespread and often dense underbrush across the Project Areas. Also, as determined during the RI, the terrain across the Project Areas can be treacherous for brush clearing operations; inclement weather is also a potential hindrance. Together, site conditions and weather may make adequate brush clearing a time-consuming process and may result in areas remaining unswept due to accessibility issues (streams, flooded areas, etc.); therefore, the time, costs, and total area swept associated with implementing this alternative may be difficult to quantify prior to implementation.

5.2.3.1.2 During the surface sweep, each team member would follow predetermined transect paths. Transect paths would be recorded with GPS to document that the remedial action area of the Project Area was inspected for surface MEC. However, in areas where tree canopy prevents a GPS from receiving a signal, it may become necessary to interpolate between accurate GPS data points to estimate the surface coverage of the sweep teams. Based on brush cutting and RI reconnaissance productivity, it is assumed that the teams would cover 1.5 acres each day. It is estimated that surface removal in each Project Area, except Project Area 01, would take less than two years to complete. Surface removal within Project Area 01 would encompasses 3,420 acres (no surface clearance for 700 acres), surface removal of the entire area would take approximately 6.6 years to complete. Durations are based on total time for all tasks assuming multiple teams, however, durations could be reduced by adding additional teams and conducting brush clearing concurrently.

5.2.3.1.3 If surface MEC is encountered during the surface sweep, it is anticipated that the item would be destroyed using BIP procedures. Explosives for demolition would be provided by an on-call explosives provider. Educational awareness, as described under Alternative 2, would provide additional protection by developing a fact sheet containing information about the history of the site, MEC discovery, and most importantly, appropriate responses if MEC is encountered.

5.2.3.1.4 In addition to educational awareness (as described under Alternative 2), five-year reviews would be required under Alternative 3 to monitor and review the effectiveness of the alternative.

5.2.3.2 Assessment

Threshold Factors

5.2.3.2.1 MEC or MD was found on the surface at two of the seven Project Areas during RI activities; therefore, performing a surface removal would be beneficial in these areas. The RAO and overall protectiveness to human health can be achieved for short-term exposure to surface MEC, especially since the potential for subsurface MEC to be exposed by erosion is minimal in most areas. Educational awareness is used to address long-term effectiveness of the alternative.

5.2.3.2.2 This alternative may increase the level of effectiveness for recreational users (e.g., hikers, campers, and hunters) in Project Area 01 and Project Area 05; however, MEC may remain in the subsurface of these Project Areas after completion of the surface removal.

5.2.3.2.3 Alternative 3 would not increase the level of protectiveness for the future residential users at Project Area 06 and Project Area 08. The exposure risk in these Project Areas would remain, since property owners may encounter MEC in the subsurface while conducting intrusive activities (e.g., construction, gardening, fence installation).

Balancing Factors

5.2.3.2.4 Alternative 3 would meet the long-term effectiveness criterion only for surface MEC in the Project Areas. The risk associated with potential subsurface MEC is not addressed in this alternative. This risk would be mitigated through an educational awareness program.

5.2.3.2.5 There would be some reduction of toxicity, mobility, or volume of MEC through surface removal, especially in Project Areas where no intrusive activities are anticipated.

5.2.3.2.6 Similar to the tasks undertaken in support of the RI field activities, there would be some additional risks posed to the field crew by implementing this alternative. Surface removal may potentially include exposure/handling of MEC and would involve difficult working conditions that may include exposure to heat, cold, ticks, snakes and other biological hazards, and hazards (slips, falls, etc.) associated with thick vegetation and/or wet, muddy, or icy ground conditions.

5.2.3.2.7 Alternative 3 would be readily implemented from a technical perspective. Qualified UXO technicians are generally available to perform this type of work. However, the potentially extensive brush clearing operations necessary to ensure complete surface removal would require a large time commitment and would potentially

become extremely costly. There is also the potential for some portion of the site to remain unswept due to accessibility issues associated with natural features (rivers, steep terrain, etc.) as well as ROE denials. The total 30-year present worth cost of this alternative is Project Area-specific and is presented in Table 5.1 for each relevant Project Area.

Summary

5.2.3.2.8 Alternative 3 provides protectiveness for recreational users (e.g., hikers, campers, and hunters) through surface removal. Alternative 3 would reduce the MEC risk for future residents, but it would not eliminate risk since MEC would only be removed from the surface and only in areas accessible during brush removal and surface sweep operations and within areas where ROE has been granted. There would still be risk in Project Areas associated with residential land use, since property owners may encounter MEC while conducting intrusive activities (i.e., construction, gardening, fence installation). There would be some reduction of toxicity, mobility, or volume through removal of MEC on the surface. Educational awareness would be implemented to reduce the risk of exposure and monitor long-term effectiveness.

5.2.3.2.9 This alternative is readily implementable, but there would be some additional risks posed to the field crew. The cost associated with implementing this alternative is relatively low when compared to Alternative 4 (MEC Removal).

5.2.4 Alternative 4 – Geophysical Survey and MEC Removal with Educational Awareness

5.2.4.1 Description

5.2.4.1.1 MEC removal would be conducted by trained UXO technicians. This alternative was evaluated for each Project Area. The objective of the MEC removal is to identify and remove MEC on the ground surface and in the subsurface.

5.2.4.1.2 Vegetation would be removed as needed to enable the teams to traverse a given area without interference. While 100% vegetation removal is not anticipated across the entire site, as experienced during the RI, the removal process may prove to be extensive and time consuming within portions of the Project Areas, as thick undergrowth is widespread and presents an obstacle to the data collection teams. Also, any trees removed would need to be cut down to near ground-surface so that geophysical equipment could pass over the remaining stump. It is assumed that trees larger than 6 inches in diameter would be left in place, but final decisions regarding vegetation removal would be determined by each landowner. Therefore, the extent of vegetation removal and equipment access may vary from property to property within each project remedial action area. Brush-cut areas would be surface swept by UXO personnel prior to cutting. Based on brush cutting productivity collected during the RI, it is expected that each team would remove vegetation over 1.5 acres per day. It is anticipated that two field teams would be composed of three persons (one UXO technician III, one UXO Technician II, and one senior UXO supervisor).

5.2.4.1.3 DGM would be collected across the Project Area with a single EM61-MK2 and at times an RTK or handheld GPS, similar to techniques used during the RI. Based on previous experience at the site, it is assumed that a consistent GPS signal will not be available within large portions of the Project Areas. In these areas, it may be necessary to collect geophysical grids in fiducial mode (wherein instrument data points are positioned between physical markers with known locations) and/or to interpolate geophysical data between accurate GPS positions. Complete DGM coverage of the site would be limited to those areas which are accessible to the EM61-MK2. Accessibility may be limited by ROE denial, large trees (greater than 6 inches in diameter), and/or the unwillingness of a landowner to allow removal of vegetation that may pose an obstacle to the instrument. Based on DGM data collection productivity from the RI, it is expected that each team would collect 1.5 acres of data per day. It is anticipated that two field teams would be on site, each composed of four persons: one UXO technician III, two UXO technician IIs, and one project geophysicist. A site manager and safety manager would also be on site. Following collection of DGM data, follow-on AGC could be conducted by collecting additional data at selected anomalies using advanced sensors. Approximately 250 anomalies could be cued each day by a two-person team using advanced sensors. This data would be processed to identify targets of interest (identified as anomalies that are suspected to be associated with MEC). AGC can be deployed in dynamic mode which usually results in fewer anomalies needing to be cured. Man portable vector (MPV) platforms can access areas inaccessible to DGM. The AGC process can reduce the total number of anomalies identified during the initial DGM survey by 85%. This reduction saves costs by reducing the number of anomaly locations requiring investigation and excavation. Non-hazardous metallic debris is left in the ground.

5.2.4.1.4 During the intrusive investigation, geophysical anomalies would be investigated by hand excavation. During the RI and EE/CA, the source of 95% of all anomalies dug were found within 12 inches of the surface; therefore, it is assumed that the depth of most detected anomalies would be less than 12 inches. MEC removal is anticipated to extend to the depth of the detected anomaly.

5.2.4.1.5 During the development of the RI, an approximate anomaly count was calculated for each MRS (Table 2.1); this value was used to estimate the number of anomalies that would need to be cued during AGC. Anomaly counts for Project Areas were determined by taking the sum of MRS anomalies located within each Project. Based on intrusive productivity data from the RI, it is anticipated that each intrusive team would remove 90 anomalies per day.

5.2.4.1.6 If MEC is encountered, it is anticipated that the item would be destroyed using BIP procedures. Explosives for demolition would be provided by an on-call explosives provider. Educational awareness, as described under Alternative 2, would provide additional protection by developing a fact sheet containing information about the history of the site, MEC discovery, and most importantly, appropriate response if MEC is encountered.

5.2.4.1.7 In addition to educational awareness, a five-year review (as described under Alternative 2) would be required under Alternative 4 to monitor and review the effectiveness of the alternative.

5.2.4.1.8 The time to complete the MEC removal is based on acreage for brush cutting and the initial DGM investigation, while time to complete the AGC and intrusive investigation is based on the estimated anomaly count for the Project remedial action area. Utilizing anomaly count information collected during the RI provides a representative time and cost estimate for each Project Area. However, it does result in some smaller areas with higher anomaly counts requiring more resources than larger areas with much lower anomaly densities. It is estimated that MEC removal in each Project Area except Project Area 01 would generally take approximately three years or less to complete. Since Project Area 01 has a remedial area that encompasses 3,420 acres and has an estimated total anomaly count (consisting of MEC, nonhazardous MD, and scrap) of 456,766. MEC removal would take approximately 13 years to complete. Durations are based on total time for tasks assuming multiple teams, however, durations could be reduced by adding additional teams and conducting some tasks concurrently.

5.2.4.2 Assessment

Threshold Factors

5.2.4.2.1 Overall protectiveness of human health and the environment would be achieved in each Project Areas remedial action area with Alternative 4 through source removal of MEC. MEC removal would be conducted over the Project Area remedial action area to identify and remove MEC on the ground surface and in the subsurface. Alternative 4 would eliminate or reduce the MEC risk, depending on site constraints such as vegetation, lack of GPS coverage, or ROE restrictions. In areas where site conditions require the use of analog detectors MEC risk will remain. This alternative would be most appropriate for Project Areas with future residential land use (Project 03, Project Area 04, Project Area 06, Project Area 07, and Project Area 08) to protect the potential receptors in future residential neighborhoods as well as onsite workers and trespassers associated with these areas.

5.2.4.2.2 Munitions moved as part of Alternatives 3 and 4 for consolidation purposes will require compliance with RCRA Subpart X.

Balancing Factors

5.2.4.2.3 Alternative 4 would eliminate or reduce the MEC risk, depending on site constraints such as vegetation, lack of GPS coverage, or ROE restrictions. In areas where site conditions require the use of analog detectors MEC risk will remain. The residual risk associated with potential subsurface MEC not located during the removal action would be addressed through the educational awareness program.

5.2.4.2.4 There would be significant reduction of toxicity, mobility, or volume through removal of source material; however, due to technological limitations, some

MEC may be missed, and MEC under existing structures, roads, and streams would not be cleared. Based on the MEC HA (Appendix A), the implementation of Alternative 4 for all applicable Project Areas would result in a decrease in the hazard level determination.

5.2.4.2.5 Similar to the tasks undertaken in support of the RI field activities, there would be some additional risks posed to the field crew by implementing this alternative. The removal would be performed by qualified UXO technicians; however, there is potential to cause an accidental detonation as part of the remedy. These hazards would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, practicing anomaly avoidance), which would also minimize potential associated hazards to other surrounding receptors. The implementation of AGC in Alternative 4 would reduce the duration of the field activities; thus, reducing the hazards posed to the field crew. In addition, AGC allows workers to have a better understanding of what they are digging; ensuring they have implemented necessary precautions.

5.2.4.2.6 Alternative 4 would be readily implemented from a technical perspective. AGC has been successfully demonstrated on this project (and several other demonstration projects at other sites). Implementation of MEC removal with AGC is technically and administratively feasible; however, Alternative 4 requires expert personnel trained to operate and analyze the data collected from the advanced sensors. The use of the AGC could eliminate a significant number of excavations and reduce the cost of remediating the Project Areas. However, as in Alternative 3, the extensive brush cutting may prove extremely costly and time consuming relative to the time and effort required to perform the subsurface removal itself.

5.2.4.2.7 The total 30-year present worth cost of this alternative is Project Area-specific and is presented in Table 5.1 for each Project Area. The information used to develop the cost assumptions is provided in Appendix B.

5.2.4.3 Summary

The RAO is achieved through implementation of this alternative, and this alternative provides overall protection of human health and the environment. The balancing factors of long-term effectiveness, permanence, and reduction of toxicity, mobility, or volume would only be achieved through MEC removal. Alternative 4 would be readily implemented from a technical perspective; however, the logistics associated with extensive brush removal may prove time consuming and extremely costly. There would also be some risks posed to the field crew by implementing this alternative.

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

In the following analysis, the alternatives are evaluated in relation to one another for each of the evaluation criteria to identify the relative advantages and disadvantages of each alternative in terms of the threshold and balancing criteria. Table 5.1 summarizes the costs, and Tables 5.2 through 5.9 summarizes the evaluation of alternatives for each

Project Area. Details regarding the comparative analysis are provided in the following sections.

5.3.1 Overall Protection of Human Health and the Environment

5.3.1.1 The protectiveness criterion was evaluated in terms of possible future human and ecological interaction with MEC. Although the MRSs have limited MEC-related risk, none of the alternatives can totally eliminate the risk of MEC exposure entirely. However, Alternatives 2, 3, and 4 do provide Overall Protectiveness, and Alternative 1 does not.

5.3.1.1 Environmental protectiveness was assessed for the possible detrimental impacts an alternative would have on the existing environment and ecology. Implementation of Alternatives 1 and 2 would have no detrimental effect on the environment. Alternatives 3 and 4 may have a negative effect on the environment due to the intrusive nature and possible disturbance of ecological habitat. However, even though much of the underbrush would be disturbed, overall protectiveness is still achieved for all alternatives except Alternative 1.

5.3.2 Compliance with ARARs and Issues to Be Considered

The evaluation of the ability of the alternatives to comply with ARARs included a review of the ARARs pertinent to this remediation. Alternatives 1 and 2 have no ARARs associated with them. Implementation of Alternatives 3 and 4 would comply with RCRA Subpart X when moving munitions.

5.3.3 Long-term Effectiveness and Permanence

5.3.3.1 The permanence criterion evaluates the degree to which an alternative permanently reduces or eliminates the potential for MEC exposure hazard. Alternative 4 was determined to provide the best long-term effectiveness and permanence based on the ability to significantly reduce the risk due to possible MEC.

5.3.3.2 Alternative 3 may remove MEC currently on the surface but also relies on educational awareness for long-term effectiveness. Although Alternative 2 can deter inappropriate interaction with MEC, it cannot prevent it.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

5.3.4.1 Alternatives 1 and 2 would offer no reduction in toxicity, mobility, or volume of contaminants. Alternative 3 would provide some reduction of risk from MEC remaining on the surface, assuming any can still be found within the Project Areas. Alternative 4 would provide the greatest reduction of toxicity, mobility, or volume through treatment as a result of subsurface MEC removal. Implementation of Alternative 4 would remove the source (MEC) to the depth of MEC recovered during the RI.

5.3.4.2 Alternative 4 (and to a much lesser extent Alternative 3) relies on removal actions to reduce the MEC source hazard. However, none of these alternatives would completely remove all MEC at the site. Alternatives 1 and 2 would provide no reduction of MEC source.

5.3.5 Short-term Effectiveness

Alternatives 3 and 4 are determined to have the greatest risk and least short-term effectiveness due to the risk to workers conducting removal. Due to the increased likelihood of MEC detonation during implementation of Alternatives 3 and 4, trained technicians must perform the work. Alternatives 1 and 2 would present no short-term impacts or adverse impacts on workers and the community.

5.3.6 Implementability

Alternative 1 and Alternative 2 were determined to be the easiest to implement. Alternative 1 is both technically and administratively feasible, and no services or materials are necessary for implementation. Alternative 2 is also both technically and administratively feasible, with fact sheets and website(s) readily available. Alternatives 3 and 4 are both technically and administratively feasible but require specialized personnel and equipment to implement. Alternatives 3 and 4 would also require the development of detailed work plans.

5.3.7 Cost

5.3.7.1 The cost criterion evaluates the financial cost to implement the alternative. The cost criterion includes direct, indirect, and long-term operation and maintenance costs. Direct costs are those costs associated with the implementation of the alternative. Indirect costs are those costs associated with administration, oversight, and contingencies. These costs were adapted from costs associated with similar activities on the Spencer Artillery Range site and cost estimates prepared for other sites.

5.3.7.2 The actual costs will depend on true labor rates, actual site conditions, final project scope, and other variable factors. The alternative with the lowest cost to implement would be Alternative 1, which requires no further action; therefore, no costs are incurred. Alternative 2 requires relatively low costs compared to Alternatives 3 and 4, which are the costliest to implement.

5.3.7.3 Costs are Project Area-specific and presented in Table 5.1. Overall, costs range from $0 (Alternative 1) to over $50 million (Alternative 4). Alternative 4 has the highest cost because of the costs incurred during the brush cutting, DGM/AGC, and intrusive investigation. Table 5.1 summarizes costs for all alternatives for applicable Project Areas, and Appendix B provides additional cost information.

5.3.8 State Acceptance

State acceptance cannot be fully evaluated and assessed until comments on the FS and the proposed plan are received. Modifying criteria (i.e., state and community acceptance), however, are considered in remedy selection.

5.3.9 Community Acceptance

Community acceptance cannot be fully evaluated and assessed until comments on the Proposed Plan are received.

5.3.10 Summary of Comparative Analysis

The four alternatives were evaluated in terms of seven criteria. Tables 5.2 through 5.9 summarize the evaluation for each Project Area. Table 5.9 presents an overview of the evaluation and identifies the most practicable solution for reducing the potential MEC exposure hazard at each Project Area.

Table 5.1
Estimated Costs Per Alternative for each Project Area

Alternative	Task	Applies to Project:	Capital Cost	Annual O&M Costs	Net Present Value at 3%	Total Cost over 30 years
Alt 2	Education	Project 03-08	$12,238	$16,585	$326,805	**$480,968**
Alt 2	Education	Project 01	$17,838	$22,185	$439,813	**$643,368**
Alt 3	Surface Removal and Education	Project 01	$19,528,504	$16,585	$19,843,071	**$19,883,406**
Alt 3	Surface Removal and Education	Project 05	$4,128,942	$16,585	$4,443,509	**$4,609,910**
Alt 3	Surface Removal and Education	Project 06	$1,837,513	$16,585	$2,152,080	**$2,318,481**
Alt 3	Surface Removal and Education	Project 08	$856,365	$16,585	$1,203,346	**$1,337,333**
Alt 4	Geophysics, MEC Removal, and Education	Project 01	$55,303,817	$16,585	$55,618,384	**$55,784,785**
Alt 4	Geophysics, MEC Removal, and Education	Project 03	$3,880,125	$16,585	$4,194,692	**$4,361,093**
Alt 4	Geophysics, MEC Removal, and Education	Project 04	$1,509,904	$16,585	$1,824,471	**$1,990,872**
Alt 4	Geophysics, MEC Removal, and Education	Project 05	$12,564,698	$16,585	$12,879,265	**$13,045,666**
Alt 4	Geophysics, MEC Removal, and Education	Project 06	$7,975,688	$16,585	$8,290,255	**$8,456,656**
Alt 4	Geophysics, MEC Removal, and Education	Project 07	$6,163,219	$16,585	$6,477,786	**$6,644,187**
Alt 4	Geophysics, MEC Removal, and Education	Project 08	$4,782,437	$16,585	$5,097,004	**$5,263,405**

Note: Appendix B provides detailed cost information.

Table 5-2
Evaluation of Response Alternatives for Project Area 01

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response for MEC encounters. Requires self-implementation by USACE.		Very effective for surface users/interaction. Limited effectiveness for intrusive exposure because subsurface MEC remains. Relies on Educational Awareness.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	2	805	2	805	3	650	4	480
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to effected behavior.		Some treatment, especially because no intrusive activities are anticipated in MRS.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Risk associated with possible interaction with MEC during removal. Some brush clearance required.		Risk associated with possible interaction with MEC during removal. Significant brush removal required at some areas.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Requires qualified technicians (but readily available). Requires work plans. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans, coordination with property owner, and avoidance of sensitive environments. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$643,368		$19,883,406		$55,784,785	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Costs considered unreasonable, due to the size of the MRS and the protectiveness provided to receptors.		High cost associated with this alternative due to the size of the remedial aciton area (4,120 acres).	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.

Table 5-3
Evaluation of Response Alternatives for Project Area 03

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	3	590	3	590	3	590	4	410
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to influencing behavior.		Some treatment (No surface MEC identified). Decrease in receptor hours due to influencing behavior.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Some brush removal required.		Risk associated with possible interaction with MEC during removal. Significant brush removal required.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Information readily available and easily developed. Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$480,968		-		$4,361,093	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Not Considered (no surface MEC identified).		Costs considered somewhat reasonable. High level of protectiveness for future residential development.	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-4
Evaluation of Response Alternatives for Project Area 04

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	3	715	3	715	3	715	4	430
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to influencing behavior.		Some treatment (No surface MEC identified). Decrease in receptor hours due to influencing behavior.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Some brush removal required.		Risk associated with possible interaction with MEC during removal. Significant brush removal required.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Information readily available and easily developed. Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$480,968		-		$1,990,872	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Not Considered (no surface MEC identified).		Costs considered somewhat reasonable. High level of protectiveness for future residential development.	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-5
Evaluation of Response Alternatives for Project Area 05

Criteria	No Further Action	Educational Awareness	Surface Removal with Educational Awareness	Geophysical Investigation and MEC Removal with Educational Awareness
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Protectiveness	Not Protective	Protective	Protective	Protective
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.	No ARARs associated with the alternative.	Alternative will be implemented in compliance with ARARs.	Alternative will be implemented in compliance with ARARs.
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.	No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.	Very effective for surface users/interaction. Limited effectiveness for intrusive exposure because subsurface MEC remains. Relies on Educational Awareness.	Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.
MEC HA Hazard Level/Score	2 830	2 830	3 660	4 435
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment	No treatment. Decrease in receptor hours due to effected behavior.	Some treatment, especially because no intrusive activities are anticipated in MRS.	Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.
Short-term Effectiveness	No short-term impacts on workers or community.	No short-term impacts on workers or community.	Risk associated with possible interaction with MEC during removal. Some brush clearance required.	Risk associated with possible interaction with MEC during removal. Significant brush removal required.
Implementability	Readily implemented. No action required.	Information readily available and easily developed.	Requires qualified technicians with specialized (but readily available) equipment. Requires work plans. Requires ROE access	Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access
Cost (Evaluated over 30 years)	$0	$480,968	$4,609,910	$13,045,666
	No cost.	Comparatively little cost associated with development of fact sheet and maintenance of website.	Costs considered somewhat reasonable, and the protectiveness provided to receptors.	High cost associated with this alternative due to the size of the remedial action area (646 acres).

Note: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-6
Evaluation of Response Alternatives for Project Area 06

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		Very effective for surface users/interaction. Limited effectiveness for intrusive exposure because subsurface MEC remains. Relies on Educational Awareness.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	1	860	1	860	3	690	4	515
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to effected behavior.		Some treatment. Intrusive activities are anticipated.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Risk associated with possible interaction with MEC during removal. Some brush clearance required.		Risk associated with possible interaction with MEC during removal. Significant brush removal required.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Requires qualified technicians with specialized (but readily available) equipment. Requires work plans. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$480,968		$2,318,481		$8,456,656	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Not considered reasonable; Limited protection to residential receptors.		High cost. High level of protectiveness for future residential development.	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-7
Evaluation of Response Alternatives for Project Area 07

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	2	770	2	770	2	770	4	515
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to influencing behavior.		Some treatment (No surface MEC identified). Decrease in receptor hours due to influencing behavior.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Some brush removal required.		Risk associated with possible interaction with MEC during removal. Significant brush removal required.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Information readily available and easily developed. Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owner. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owners. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$480,968		-		$6,644,187	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Not Considered (no surface MEC identified).		Costs considered somewhat reasonable. High level of protectiveness for future residential development.	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-8
Evaluation of Response Alternatives for Project Area 08

Criteria	No Further Action		Educational Awareness		Surface Removal with Educational Awareness		Geophysical Investigation and MEC Removal with Educational Awareness	
	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Protectiveness	Not Protective		Protective		Protective		Protective	
Applicable or relevant and appropriate requirements (ARARs) compliance	No ARARs associated with the alternative.		No ARARs associated with the alternative.		Alternative will be implemented in compliance with ARARs.		Alternative will be implemented in compliance with ARARs.	
Effectiveness and Permanence	No hazard reduction and no long-term effectiveness.		No reduction of MEC, but can be effective at influencing behavior resulting in an appropriate response. Requires self-implementation by USACE.		Limited effectiveness because subsurface MEC remains. Relies on Educational Awareness.		Very effective at removing MEC. Proven approach/technology. Source removal provides greatest permanence.	
MEC HA Hazard Level/Score	2	830	2	830	3	660	4	505
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment		No treatment. Decrease in receptor hours due to effected behavior.		Some treatment. Intrusive activities are anticipated in MRS.		Greatest level of treatment proposed for MEC within remedial action area. Residual MEC possible due to technological limitations.	
Short-term Effectiveness	No short-term impacts on workers or community.		No short-term impacts on workers or community.		Risk associated with possible interaction with MEC.		Risk associated with possible interaction with MEC during removal. Significant brush removal required.	
Implementability	Readily implemented. No action required.		Information readily available and easily developed.		Requires qualified technicians with specialized (but readily available) equipment. Requires work plans. Requires ROE access		Requires qualified technicians with specialized equipment. Requires work plans and coordination with property owners. Requires ROE access	
Cost (Evaluated over 30 years)	$0		$480,968		$1,337,333		$5,263,405	
	No cost.		Comparatively little cost associated with development of fact sheet and maintenance of website.		Not considered reasonable. Limited protection to residential receptors.		Costs considered somewhat reasonable. High level of protectiveness for future residential development.	

Notes: MEC HA Hazard Level and score are provided for each alternative in the Reduction of Toxicity, Mobility, or Volume Row. For more detail see Appendix A.
Alternative 2 will be implemented for ROE refusals.

Table 5-9
Overview of Evaluated Alternatives for Each Project Area

Project Area	Land Use	Total Area	Evaluated Alternatives	Cost (over 30 years)	MEC HA Hazard Level/Score		Rational
Project Area 01	Wooded/ Hunting/ Logging/Residential/Commercial/Ranching	4,120	1- No Further Action	$0	2	805	No reduction of high potential explosive hazard conditions
			2 -Education	$643,368	2	805	Reduce hazard by providing information to landowners and the public. Signage, fact sheets, and website will provide hazard recognition to reduce chance of exposure.
			3- Surface Removal	$19,883,406	3	650	Sensitive archeological/cultural resources at the Trail of Tears would make it difficult to conduct a surface clearance. Clearance would reduce risk for potential surface hazards.
			4- Geo/MEC Removal	$55,784,785	4	480	Limited intrusive activity anticipated for current land use. Excessive cost
Project Area 03	Active Development/Residential	262	1- No Further Action	$0	3	590	No reduction of moderate potential explosive hazard conditions
			2 -Education	$480,968	3	590	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities
			4- Geo/MEC Removal	$4,361,093	4	410	High level of effectiveness. Large reduction in MEC HA score with implementation of alternative.
Project Area 04	Active Development/Residential	60	1- No Further Action	$0	3	715	No reduction of moderate potential explosive hazard conditions
			2 -Education	$480,968	3	715	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities
			4- Geo/MEC Removal	$1,990,872	4	430	High level of effectiveness for future residential development. Large reduction in MEC HA score with implementation of alternative.
Project Area 05	Recreation/Cabins	646	1- No Further Action	$0	2	830	No reduction of high potential explosive hazard conditions
			2 -Education	$480,968	2	830	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$4,609,910	3	660	Reduce hazards for potential receptors whose activities primarily involve surface use. Reduction in MEC HA hazard level determination; low potential hazard.
			4- Geo/MEC Removal	$13,045,666	4	435	High level of effectiveness for future development. Large reduction in MEC HA score with implementation of alternative.
Project Area 06	Undeveloped Subdivision	241	1- No Further Action	$0	1	860	No reduction of highest potential explosive hazard conditions
			2 -Education	$480,968	1	860	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$2,318,481	3	690	Property owners may still encounter subsurface MEC while conducting intrusive activities (i.e., gardening, fence installation).
			4- Geo/MEC Removal	$8,456,656	4	515	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.
Project Area 07	Undeveloped Subdivision	352	1- No Further Action	$0	2	770	No reduction of high potential explosive hazard conditions
			2 -Education	$480,968	2	770	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	--			Not considered based on lack of MEC/MD found on the surface during the EE/CA and RI activities
			4- Geo/MEC Removal	$6,644,187	4	515	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.
Project Area 08	Active Development/Residential	260	1- No Further Action	$0	2	830	No reduction of high potential explosive hazard conditions
			2 -Education	$480,968	2	830	Hazards reduced by providing information to land owners and public. Fact sheets and website will provide explosive hazard recognition to reduce exposure.
			3- Surface Removal	$1,337,333	3	660	Reduce risk for onsite construction that may occur for residential development. Property owners may still encounter MEC while conducting intrusive activities (i.e., gardening, fence installation).
			4- Geo/MEC Removal	$5,263,405	4	505	High level of effectiveness for future residential development. Large reduction in MEC HA hazard level determination; low potential explosive hazard.

The scores of the MEC HA method were developed by the Technical Working Group for Hazard Assessment. Scores are presented in multiples of five, with a total maximum score for all factors of 1,000 and a minimum possible score of 125. The MEC HA method describes associated hazard levels for these scores, which range from 1 (highest) to 4 (lowest). A summary of the hazard levels and their related MEC HA scores are presented in Chapter 2 and Appendix A.

CHAPTER 6
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