

## **FINAL**

# **REMEDIAL INVESTIGATION** FORMER SPENCER ARTILLERY RANGE SPENCER/VAN BUREN COUNTY, TENNESSEE

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and

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# LIST OF ACRONYMS AND ABBREVIATIONS

ADR	automated data review
AIDS	Acquired Immune Deficiency Syndrome
ARAR	applicable or relevant and appropriate requirements
ASAP	as soon as possible
ASR	Archives Search Report
BIP	blown-in-place or blow-in-place
BKIA	Bald Knob Impact Area
CADD	computer aided design and drafting
CCV	continuing calibration verification
CD	compact disk
CERCLA	Comprehensive Environmental Response, Compensation, and Liability
	Act
CESAM	U.S. Army Corps of Engineers, Mobile District
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	Chemical of potential concern
CLP	contract laboratory program
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DGM	Digital Geophysical Mapping
DID	Data Item Description
DoD	Department of Defense
DOT	Department of Transportation
DQCR	Daily Quality Control Report
DQI	Data Quality Indicator
DQO	data quality objective
DTL	Demolition Team Leader
DVD	digital versatile disc
EDD	electronic data delivery
EE/CA	Engineering Evaluation/ Cost Analysis
EM	Engineer Manual
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
EP	Engineering pamphlet
EPC	exposure point concentration
EPP	Environmental Protection Plan
ER	Engineer Regulation
ERCP	Emergency Response & Contingency Plan
ESAP	Environmental Sampling and Analysis Plan
ESAT	explosives storage and transportation
ESP	Explosives Siting Plan
ESV	ecological screening value

ESRI	Environmental Systems Research Institute
EZ	exclusion zone
°F	degrees Fahrenheit
F-B	flash-to-bang
FD	field duplicate
FFP	firm fixed price
FP	false positives
FS	Feasibility Study
FSP	Field Sampling Plan
Ft	feet
FTP	file transfer protocol
FUDS	Formerly Used Defense Site
GIS	geographical information systems
GPO	geophysical prove-out
GPS	global positioning system
GW	groundwater
HA	hazard assessment
H&S	health and safety
HPP	Tennessee Historic Preservation Program
IAW	in accordance with
ICV	initial calibration verification
IC/MS	ion chromatographic / mass spectrometry
IDLH	immediately dangerous to life or health
IDW	investigative-derived waste
IGD	Interim Guidance Document
INPR	Inventory Project Report
JMIA	Jake's Mountain Impact Area
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LQL	lower quantitation limit
MB	method blank
MC	munitions constituents
MD	munitions debris
MDL	method detection limit
MEC	munitions and explosives of concern
MGFD	munition with the greatest fragmentation distance
MM CX	Military Munitions Center of Expertise
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MQO	Measurement Quality Objectives
MRS	Munitions Response Site
MS/MSD	matrix spikes/matrix spike duplicates
MSD	Minimum Separation Distance

MSL	mean sea level
mV	millivolt
NAD 83	North American Datum 1983
NCP	National Contingency Plan
NCR	nonconformance report
NDAI	No Department of Defense Action Indicated
NELAC	National Environmental Laboratory Accreditation Conference
NEW	net explosive weight
NHA	National Heritage Areas
NHL	National Historic Landmarks
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRHD	National Register of Historic District
NRHP	National Register of Historic Places
NRIS	National Register Information System
NWI	National Wetlands Inventory
NWRS	National Wildlife Refuge System
Oasis	Geosoft Oasis Montaj <sup>TM</sup>
OE	Ordnance and Explosives
OER	Ordnance and Explosives Remediation, Inc
OEW	Ordnance and Explosive Waste
PAOI	Potential Areas of Interest
PAO	Public Affairs Office
PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCL	protective concentration level
PDA	personal digital assistant
PDT	Project Delivery Team
PLS	professional land surveyor
PM	Project Manager
PQL	practical quantitation limit
PSHO	Project Safety and Health Officer
PSR	Project Status Report
PWS	Performance Work Statement
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCP	Quality Control Plan

QSM	Quality System Manual
RAC	Risk Assessment Code
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
ROE	Right-of-Entry
RPD	relative percent difference
RSD	relative standard deviation
RSL	regional screening levels
RTK	real-time kinematic
SAP	Sampling and Analysis Plan
SBAS	Space Base Augmentation System
SDSFIE	Spatial data standards for facilities, infrastructure, and environment
SHPO	State Historic Preservation Office
SLERA	screening level ecological risk assessment
SM	Site Manager
SOP	standard operating procedure
SOW	statement of work
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SUXOS	Senior Unexploded Ordnance Supervisor
SZ	support zone
T&E	threatened and endangered
TBC	to be considered
TBD	to be determined
TCLP	toxicity characteristic leaching procedure
TCRA	Time-Critical Removal Action
TDEQ	Tennessee Department of Environmental Quality
TDEC	Tennessee Department of Environment and Conservation
TDOR	Division of Remediation
TEC	U.S. Army Topographic Engineering Center
TESS	Threatened and Endangered Species System
TMP	Technical Management Plan
TPP	Technical Project Planning
μg/L	milligrams per litter
U.S.	United States
USACE	U. S. Army Corps of Engineers
USAESCH	U. S. Army Engineering and Support Center, Huntsville
USDA	U. S. Department of Agriculture
USEPA	U. S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

USGS	U. S. Geological Survey
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
VSP	Visual Sample Plan

# **GLOSSARY OF TERMS**

Anomaly	Any item that is seen as a subsurface irregularity after geophysical investigation. This irregularity should deviate from the expected subsurface ferrous and non-ferrous material at a site (i.e., pipes, power lines, etc.).
Blow-in-Place (BIP)	The term used to describe the detonation of an ordnance item that is deemed unsafe to move from the location where it is discovered.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	CERCLA 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.
Chemical of concern (COC)	COCs are defined as the COPCs that are present at sufficient concentrations to pose a risk to human health or the environment.
Chemical of potential concern (COPC)	For purposes of this RI, COPCs are defined as any munitions- constituents that are present at concentrations above applicable preliminary screening values. "Preliminary" COPCs are those chemical contaminants that were considered to be potentially present at an MRS, and so have been selected for analysis, but have not yet been analyzed and evaluated.
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 UXO, 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)).
Exclusion Zone (EZ)	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.
Geophysical Techniques	Methods used to explore subsurface conditions using quantitative physical properties. Typical properties measured include seismic wave travel time and waveform changes, electrical potential differences, magnetic and gravitational field strength, temperature, etc. For MEC investigations, electromagnetic and magnetic methods are most frequently used.

Military Munitions	Military munitions means 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 Department of Defense, the 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 CAs; chemical munitions, rockets, guided and 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 Constituents (MC)	Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 U.S.C. $2710(e)(4)$ )
Munitions and Explosives of Concern (MEC)	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) discarded military munitions (DMM) as defined in 10 U.S.C. 2710(e)(2), or (3) munitions constituents (e.g., TNT, RDX) 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 Department of Defense as the removal response authority for ordnance and explosives hazards.
Preliminary Screening Values	This term refers to the screening values used to determine whether or not MC contamination is present at a site. For this project, the preliminary screening values are based on site-specific background concentrations and applicable risk screening values. Any MC detected at concentrations above their respective preliminary screening values are considered to be COPCs.
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

1.1 Spencer Artillery Range served as the main artillery range for Camp Forrest in Tullahoma, Tennessee, 45 miles to the southwest. Historic documentation identifies land clearance for development of two impact areas in 1941: "Jakes Mountain cleared impact area (5060 acres), Range 10,000 yards" and "Bald Knob cleared (2090 acres), Range 4,000 yards" (USACE, 2001a). Training was conducted at Spencer Artillery Range, and small arms, 37-mm anti-aircraft guns, field and heavy artillery, mortars, anti-tank rockets, and target rockets are known to have been used (USACE, 2004). After closure in 1946, several surface clearances were conducted between the Bald Knob and Jakes Mountain impact areas.

1.2 Much of the land within the formerly used defense site (FUDS) is undeveloped, wooded land. Logging has been conducted on the plateau since before the artillery range was constructed and is ongoing within portions of the former range. Historically, land use included coal strip mining, 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. Land within the former Spencer Artillery Range is entirely privately owned. Portions of the site have been heavily subdivided for residential development, although, actual construction of houses has not been initiated. Based on the findings of an Engineering Evaluation and Cost Analysis (EE/CA) conducted between 2003 and 2007, and documented encounters with munitions remaining on site, a remedial investigation was authorized by U.S. Army Corps of Engineers (USACE).

1.3 Between February 16, 2010 to June 23, 2010, Parsons and its subcontractors performed remedial investigation (RI) field activities at eleven investigation areas located within the FUDS referred to herein as "Spencer Artillery Range", Spencer, Tennessee. The RI was conducted in general accordance with the approved work plan (Parsons 2010). The investigation areas that are the subject of this RI include the following:

- Bald Knob Impact Area (BKIA)
- Jake's Mountain Impact Area (JMIA)
- Potential Areas of Interest (PAOI) 1 through 7
- Residential Areas
- Trail of Tears

1.4 Figure 1.1 presents the investigation areas within the Spencer Artillery Range. The objective and purpose of the RI at the Spencer Artillery Range is to confirm whether or not

munitions and explosives of concern (MEC) contamination is present within the investigation areas and, if they are, to characterize their nature and extent. The results of the RI are used to determine the need for future actions at Spencer Artillery Range and, if necessary, provide the baseline characterization for a subsequent feasibility study (FS) that will recommend the actions to be taken. The site closeout statement developed and approved by the Technical Project Planning (TPP) Team is "To manage the MEC risk through a combination of remedial action, administrative controls, and/or public education; thereby rendering the site as safe as reasonably possible to humans and the environment and conducive to the anticipated development." The objective of this RI will be considered accomplished when a MEC investigation has been safely completed sufficient to characterize the areas of interest (determination of absence or presence of MEC) for development and evaluation of remedial alternatives. This RI is one step in a process with the overall goal of obtaining stakeholder concurrence on a decision document for Spencer Artillery Range.

1.5 In support of these goals, instrument-aided reconnaissance, digital geophysical data collection, and intrusive investigations were conducted within the areas of interest. In addition, groundwater samples were collected and analyzed for perchlorate. The field investigation was conducted under a work plan reviewed and approved by the TPP Team, which includes representatives from the U.S. Army Engineering and Support Center, Huntsville (USAESCH), USACE Mobile District (CESAM), the Tennessee Department of Environment & Conservation, Division of Remediation (TDOR), and Parsons. Deviations from the approved work plan are discussed within this report and summarized in Subchapter 4.4.

1.6 To complete the characterization of MEC at Spencer Artillery Range, 8,980 acres of the 30,618 acre site boundary were investigated. Over 20 miles (7.63 acres) of instrument aided reconnaissance were completed and 163.37 miles (59.41 acres) of digital geophysical mapping (DGM) were conducted along multiple transects throughout the areas of interest using brush cutting, as required, to clear the transect paths.

1.7 The objectives of the transect-based DGM were to determine the relative density of DGM anomalies across the investigation areas, to locate areas for grid-based DGM, and to identify the types of MEC found in each investigation area through intrusive investigation of selected anomalies. The goals of the grid-based DGM were to determine local densities of anomalies and MEC items, to select anomalies for intrusive investigation in order to characterize the type of MEC present at the investigation areas, and to determine the vertical extent of MEC contamination. Grid-based DGM surveys were also used to document the level of effort required, in terms of time and costs, to clear a grid of vegetation, conduct DGM, and intrusively investigate anomalies to support FS objectives. DGM transects and grids identified a total of 8,474 anomalies, 1,503 of which were intrusively investigated. The data quality objectives (DQOs) for the MEC investigation were achieved for the areas investigated during the RI.

1.8 Twelve MEC items and over 1,000 MD items were recovered during the intrusive investigation. Recovered MEC items included one 3" AP, Mk29 with an MkII Mod 9 Fuze, and eleven 37mm MKII. Both of these types of munitions are high explosive rounds. The five 37mm MK II projectiles recovered in BKIA and six in JMIA were not a "surprise" because the

37mm projectile was the most common non-small arms munition found at the site. Historic use of 37mm projectiles at the former Spencer Artillery Range was well documented and both BKIA and JMIA were known impact areas. The one 3-inch AP MK29 was unusual because it was the only 3-inch round found at the site. Additionally, the Mk II Mod 9 fuze with the 3-inch round was not typical. The 3-inch AP, MK29 was recovered in PAOI5 which had not been previously identified as an impact area.

1.9 The MEC items were safely detonated on site in accordance with the approved work plan. Munitions debris (MD) items included remnants of various projectiles (155mm, 75mm, and 37mm), expended fuzes, and hundreds of pieces of unidentifiable munitions fragmentation. Over a thousand items of MD were recovered during the intrusive investigation conducted during the RI. MD discovered during the investigation or generated by MEC disposal activities was collected, certified, stored securely, and ultimately disposed of in accordance with the approved work plan.

1.10 For the RI, eleven separate investigation areas were identified. Based on data results presented within this RI Report, MEC contamination is not anticipated within PAOI-1, PAOI-2, PAOI-3, PAOI-4, PAOI-6, and PAOI-7. MEC was found within BKIA, PAOI-5, and JMIA and elevated geophysical anomaly densities and MD was found in these three investigation areas (as well as the residential investigation area). Due to the presence of MEC, elevated geophysical anomaly areas, and changes in current and future land use (identified since the preliminary CSM and the work plan) throughout the investigation areas, 15 MRSs are recommended for a Feasibility Study. In addition, no further action (NFA) is identified for one MRS (MRS-16, Remaining Lands). No concentrated munitions use and very low probability of explosive hazard was noted for MRS-16. The location of each of the 16 MRSs and geophysical anomaly density are shown on Figure 1.2. An overview of the MRSs including, current and future land use, historic military use, MEC and MD findings, and rationale associated with the MRS recommendation are provided in Table 1.1.

1.11 Using the RI data and information gathered during previously completed historical investigations, a qualitative MEC hazard assessment (HA) was conducted for the 15 of the 16 recommended MRSs where potential MEC hazards were determined to exist. However, the MEC-related characteristics of discrete areas within an MRS may differ with regard to the ordnance types and quantities, land uses, receptors, and other factors. MRS-16 includes the remaining lands of the single, 17,260 acre MRS originally identified for the site. It was agreed by the TPP team that only portions of this MRS be investigated as part of the RI based on historical records, analysis of aerial photography, previous field investigations, and future land use. This area is not deemed to have been impacted by concentrated munitions use and is considered to be "uncontaminated by MEC." This MRS only presents explosive hazards at very low probability of occurrence; therefore, a MEC HA was not conducted for this area and a Feasibility Study is not recommended.

1.12 Based on the current and likely future land use, there is a potential for human receptors to come into contact with surface or subsurface MEC in MRSs 1 through 15. The results of these 15 MEC HAs are presented in this RI report and will provide the baseline for ssessment of response alternatives to be conducted during the subsequent FS. MEC HAs were not

conducted for PAOI 1, 2, 3, 4, 6 and 7, where no MEC or MD were identified during the RI. Based on this evidence, no complete MEC exposure pathways are expected to exist for the receptors anticipated to be present and, therefore, no significant MEC hazards are anticipated to be present at these PAOI.

1.13 Multiple parcels within the Jake's Mountain Impact Area and PAOI-5 at Spencer Artillery Range could not be investigated during the RI because signed ROEs were not obtained (see Subchapter 4.2.3.1 and Figure 4.1), due to official ROE refusal by the property owners or because the owners did not respond to the ROE request. Although full characterization of these properties could not be conducted during the RI, the MRS as a whole was adequately characterized, and therefore, the recommendations for the MRS (e.g., Feasibility Study) are applied to the non-ROE parcels. Recommendations for further action in these areas will be based on information known about surrounding parcels with regard to potential MEC presence.

1.14 To complete characterization of perchlorate at Spencer Artillery Range, groundwater samples were planned for collection. The primary purpose of collecting these samples was to determine the presence of perchlorate contamination. During the RI field work at Spencer Artillery Range, eleven groundwater samples (including quality control (QC) samples) were collected. Perchlorate was not detected in any of the groundwater samples.

1.15 Based on the results of the prior historical investigations and this RI, and the assessments of MEC hazards, potential MEC hazards remain at Spencer Artillery Range. Based on the potential MEC hazards identified during this RI, an FS is recommended for 15 of the 16 MRSs to assess possible response action alternatives for MEC within Spencer Artillery Range (Table 1.2). This FS does not need to address risks related to MC contamination, which the EE/CA determined was not present at the site based on the samples collected and risk assessments conducted.

1.16 The data collected during this RI and the associated characterization described above is considered sufficient to characterize the investigation areas at Spencer Artillery Range, to identify and quantify any associated potential MEC hazards risks at the areas of interest, and to support the recommended FS. Therefore, the objectives of this RI have been met.

MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	UXO (Depth)	High anomaly density Acreage (> 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-01	Wooded/Hunting/Logging Redacted-Privacy Act	4,521	Jakes Mountain Artillery Impact Area	240mm (4) 155mm (6) 105mm (11) 75mm (3) 37mm (57) 20mm (3) unknown munitions (108)	4 each 37mm, MkII (surface, 5", 9", 10") 1each 75mm AP (1") 1each 155mm w/m1907 powder train time fuze (30")	3,427 acres (75% of total area)	131	240mm frag (44) 155mm frag (381) 105mm frag (10) 81mm mortor frag (1) 75mm frag (39) 60mm mortor frag (1) 37mm frag (50) 8" projectile (4) unknown frag (573) fuze (12) Base plate (1) small arms (8)	UXO found, former impact area, high anomaly density
MRS-02	Commercial (explosives storage, tree farming)	331	South of known impact area. Timber cleared area, no evidence impact craters. Possible firing point.	Not included as part of 1956 Surface Clearance	4 each 37mm, MkII <sup>a)</sup> (0.25", 2", 4", 5")	2 acres (0.4% of total area)	38	75mm frag (2) 37mm frag (13) unknown frag (5) fuze (2) small arms (7)	UXO found, proximity to known impact area, possible firing point, commercial land use
MRS-03	Active Development/Residential (Covenant Farms – 5acre lots)	262	Northern edge of known impact area	None	None	21 acres (8% of total area)	92	155mm frag (9) 37mm AP (1) 37mm frag (1) unknown frag (2)	Residential area, proximity to known impact area, MD found
MRS-04	Active Development/Residential (Covenant Farms – large lots)	192	Jakes Mountain Artillery Impact Area	155mm (3) 37mm (2) unknown munitions (3)	None	185 acres (96% of total area)	354	155mm frag (26) small arms (2)	Residential development, known impact area, high anomaly density
MRS-05	Recreation/Cabins Redacted-Privacy Act others)	684	Jakes Mountain Artillery Impact Area	155mm (2) 75mm (2)	1each 155mm HE w/M- 51 Fuze (14")	526 acres (77% of total area)	259	155 frag (73) 105mm debris (2) 37mm frag (2) fuze (2) unknown frag (221) small arms (21)	UXO found, former impact area, high anomaly density, camping and recreational land use

Table 1.1Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

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				Spencer in uner	j mange menneanar mye	sugation, van Daren Sounty, re	intessee		
MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	UXO (Depth)	High anomaly density Acreage ( <u>&gt;</u> 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-06	Undeveloped Subdivision (Sequoia Subdivision)	497	Jakes Mountain Artillery Impact Area	37mm (3) 20mm (3) small arms (17) unknown munitions (3)	None	462 acres (93% of total area)	688	155mm frag (62) 105mm frag (2) 76 mm AP (2) 75mm frag (1) fuze (3) 37mm frag (4) unknown frag (111) small arms (66)	Future residential development, former impact area, high anomaly density
MRS-07	Undeveloped Subdivision (Indian Trails Phase III)	145	Jakes Mountain Artillery Impact Area	155mm (1) 37mm (1) unknown munitions (13)	None	134 acres (93% of total area)	124	155mm frag (2) 37mm frag (15) 37mm AP (1) unknown frag (22)	Future residential development, former impact area, high anomaly density
MRS-08	Undeveloped Subdivision (Indian Trails Phase I and II)	379	Western edge of known impact area	105mm (1) 75mm (1) 37mm (1)	None	117 acres (31% of total area)	64	155mm frag (2) 37mm frag (1) 37mm AP (1) 75mm frag (1) 76 mm AP (2) unknown frag (2) small arms (8)	Future residential development, proximity to known impact area
MRS-09	Wooded/Hunting/Future Residential (Bald Knob east)	165	Bald Knob 37mm impact area	37mm (9)	5 each 37mm, MkII (3 on surface, 7", 21")	29 acres (18% of total area)	83	37mm frag (2) unknown frag (5) small arms (1)	UXO found, former impact area, future residential area
MRS-10	Wooded/Hunting (Bald Knob west)	193	Bald Knob 37mm impact area	37mm (6)	None	13 acres (6.7% of total area)	88	155mm frag (1) 37mm frag (30) unknown frag (1) small arms (2)	Former impact area
MRS-11	Undeveloped Subdivision (Whispering Pines) (some historic strip mining ~18 acres)	196	Unknown. Partially cleared, no impact craters.	Not included as part of 1956 Surface Clearance	1 each 3" AP, Mk29 with an MkII Mod 9 Fuze (12")	11 acres (3% of total area)	36	37mm AP (1) 76 AP (5) fuze (2) unknown frag (11) small arms (6)	UXO found, future residential development
MRS-12	Residential/Hunting/ Ranching (some historic strip mining ~13 acres)	173	Unknown. Timber cleared, evidence of impact craters	Not included as part of 1956 Surface Clearance	None	82 acres (47% of total area)	109	76mm AP (4) small arms (3)	High anomaly density (partial), land use

Table 1.1Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

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MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	UXO (Depth)	High anomaly density Acreage (≥ 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-13	Active Development/Residential	260	Unknown. Timber cleared, evidence of impact craters	Not included as part of 1956 Surface Clearance	None	176 acres (68% of total area)	197	155mm frag (10) 37mm AP (1) 76 AP (4) fuze (1) 37mm frag (11) 60mm mortor frag (3) unknown frag (31) small arms (44)	Residential development, high anomaly density
MRS-14	Wooded/Hunting/Ranching East half is open grassland currently used to graze cattle/horses Redacted-Privacy Act	353	Unknown. Timber cleared, evidence of impact craters in NE quadrant	Not included as part of 1956 Surface Clearance	None	154 acres (44% of total area)	82	155mm frag (2) 37mm frag (3) fuze (4) unknown frag (18) small arms (55)	High anomaly density (partial, North end), active ranching
MRS-15	Road/Trail of Tears	404 200 ft buffer from centerline	Traverses FUDS - Jakes Mountain Artillery Impact Area & Bald Knob 37mm impact area	37mm (6)	None. No intrusive investigations conducted due to archeological/cultural sensitivity.	172 acres (43% of total area)	Varies based on adjacent MRSs.	None. No intrusive investigations conducted due to archeological/cultural sensitivity.	Portions of MRS within high density areas. National Parks Service recognizes the Trail of Tears as a National Historic Trail.
MRS-16	Wooded/Hunting/Logging (Remaining Lands)	9,800	Unknown. Possible troop maneuver area. Little/no evidence of concentrated munitions use.	155mm (1) 75mm (1) 40mm (2) 37mm (15)	None	Not Assessed	Not Assessed	155mm frag (13) 37mm frag (4) 75mm AP (1) M-51 fuze (1) 60mm Mortar (1) unknown frag (8) small arms (10)	Although scattered MD found, little/no evidence of concentrated munitions use. MRS required under FUDS program to account for "original" MRS acreage.

# Table 1.1Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

<sup>a)</sup> 37mm projectiles recovered in MRS-2 were not fired and could represent discarded military munitions (DMM).

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Table 1.2Summary of Results and RecommendationsSpencer Artillery Range Remedial Investigation, Spencer/Van Buren County, Tennessee

Munitions Response Site	Potential MEC Hazards	MEC HA Level <sup>1)</sup> (Current/Future)	MC Risks	Recommendation	Comments
MRS-01 Redacted-Privacy Act	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-02 Commercial	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-03 (Covenant Farms – 5acre lots)	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-04 (Covenant Farms – large lots)	Yes	2/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-05 Recreation/Cabins	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-06 Sequoia Subdivision	Yes	2/1	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-07 Indian Trails Phase III	Yes	3/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-08 Indian Trails Phase I and II	Yes	4/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-09 Bald Knob east	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-10 Bald Knob west	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-11 Whispering Pines	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-12 Rocky River Road	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.

 Table 1.2

 Summary of Results and Recommendations

 Spencer Artillery Range Remedial Investigation, Spencer/Van Buren County, Tennessee

Munitions Response Site	Potential MEC Hazards	MEC HA Level <sup>1)</sup> (Current/Future)	MC Risks	Recommendation	Comments
MRS-13 Rocky River Road - Residential	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-14 Redacted-Privacy Ac	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-15 Greenfield Road/Trail of Tears	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-16 Remaining Lands	Unlikely	Not Assessed	No	No Department of Defense Action Indicated	Explosives safety hazard is not anticipated.

1) The MEC HA Level is a qualitative risk evaluation, additional information regarding the MEC HA Level is provided in Chapter 7 and Appendix J.



# Figure 1.1

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

Legend

FUDS Boundary **Investigation Area** Bald Knob Investigation Area Jake's Mountain Investigation Area **Residential Investigation Areas** Trail of Tears Potential Area of Interest Image Source: 1943 Image TEC Projection: Tennessee State Plane, NAD83, Feet Feet 6,000 3,000 6,000 0

U.S. ARMY ENGINEERING PARSONS & SUPPORT CENTER HUNTSVILLE, ALABAMA DESIGNED BY: Former Spencer Artillery Range AWN BY: CAtB PROJECT NUMBER CHECKED BY: SCALE: As Shown 746862 CR PAGE NUMBER: DATE: October 2010 ĬĦĬ JBMITTED BY: FILE: S:\ES\shared\Spencer Artillery Range \GIS\RI\_Report\Spencer\_RI\_Areas.mxc CAtB

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#### CHAPTER 2 INTRODUCTION

#### 2.1 PURPOSE

2.1.1 An RI was completed at the Spencer Artillery Range FUDS near Spencer, Tennessee to characterize the property (i.e., determine the nature and extent of contamination) to allow development of effective remedial alternatives. This RI Report presents the results from the RI and provides information to assess potential risks to human health, safety, and the environment. Specifically, this RI Report identifies the nature and extent of potential MEC and MC contamination. The RI was conducted under contract W912DY-04-D-0005 with USAESCH as Delivery Order No. 0026. The overall goal of the delivery order is to obtain acceptance of a decision document that summarizes the planned response to address identified contamination.

2.1.2 As noted herein, the data collected in support of the RI includes instrument-aided reconnaissance, digital geophysical mapping, and intrusive investigation of anomalies. The RI fills previously identified data gaps and meets the data quality objectives established in the *Final RI/FS Work Plan* (Parsons, 2010). The Spencer Artillery Range FUDS RI was characterized as "successful" in determining the nature and extent of hazards associated with MEC and MC contamination.

#### 2.2 PROPERTY DESCRIPTION AND PROBLEM IDENTIFICATION

#### 2.2.1 Project Location and Property Description

2.2.1.1 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. Figure 2.1 shows the location of Spencer Artillery Range.

2.2.1.2 On 1 January 1940, the USACE began securing leases in rural Tennessee to construct an artillery range. Construction began in February 1941, and it was probably in operation shortly thereafter (USACE, 2001a). 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 back to the 25 original leaseholders 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.

#### 2.2.2 Topography

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 on the site is generally 1,900 feet above mean sea level (MSL). Numerous streams occur in narrow valleys and draws. Figure 2.2 shows the topography of Spencer Artillery Range. 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.

#### 2.2.3 Climate

The site is part of the Southeast region of the United States and is characterized by a humid climate. Temperatures often reach 90 degrees Fahrenheit (°F) during the months of July and August. Winters span from November to March, with temperatures down to 25°F. The average annual rainfall is approximately 50 inches, and snowfall totals 10 inches per year. The area averages 100 clear days, with 120 days per year of recordable precipitation.

#### 2.2.4 Vegetation

The vegetation across the site consists of forests of predominately coniferous and deciduous trees, largely the result of grow-back after surface and clear-cutting activities, and undergrowth is pervasive. Revegetation efforts on site involve the planting of loblolly pines in uniform rows (EODT, 2007).

#### 2.2.5 Geology and Soil

The former Spencer Artillery Range is underlain by Pennsylvanian era sandstone, shale, siltstone, and conglomerate. The rocks in this area consist of Pennsylvanian marine deposits of sandstone, shale, coal, and limestone. Bedrock is observed at the surface in some areas of the site. Where covered with soil, depth to bedrock generally ranges from approximately 2 feet to 6 feet below ground surface (bgs) (USACE, 2001a). The soil types on site include the Gilpin silt loam, Hartsells loam, Lonewood silt loam, and Udorthents-Mine Pits complex. The Mine Pits complex consists of areas that have been strip mined for coal. The mine pits are 6 feet to more than 30 feet deep. Between the mine pits are high heaps of material excavated from the mines; the excavated material varies considerably. The upper part is largely low-grade coal and shaly material. This material was excavated last and was spread unevenly over material that was largely sandstone and shale fragments mixed with variable amounts of fine-earth material. Common features of the excavated material are the large amount of fragments (more than 50 percent), the relatively small amount of fine-earth material, and the extreme acidity. Individual areas vary in size from 2 acres to more than 200 acres. Some areas have had pine trees planted, but their survival rate is low. Some pits contain several feet of water (EODT, 2007).

#### 2.2.6 Hydrology and Shallow Groundwater Conditions

Surface water flow for the majority of the site is to the north-northwest. The Rocky River, which is the water supply for the City of Spencer, has its source in the many tributaries within the boundaries of Spencer Artillery Range (Figure 2.2). Existing drinking water sources are tapping aquifers at depths from 50 to 260 feet.

#### 2.2.7 Sensitive Environmental Resources within the Project Site

2.2.7.1 The site is not within a national wildlife refuge; national forest; or state, county, or city park. Although parcels within the FUDS boundary are privately owned, the National Park Service recognizes the Trail of Tears as a National Historic Trail (National Park Service, 2009). The Trail of Tears refers to the forced relocation of the Cherokee Nation in the 1830s from the southeastern United States to present-day Oklahoma. Research regarding Trail of Tears events and routes is ongoing, but two different routes are believed to cross the project site (Figure 2.2).

2.2.7.2 The site includes farm areas, agricultural land, and residential properties. Habitats of particular concern in the sandstone layers on top of the Cumberland Plateau are acidic seeps, streamheads, and open barrens habitats such as roadsides, maintained power line easements, and field edges (TDEC, 2009). Caves, sinkholes, and other karst features typically encountered with limestone along the edges of the plateau were not assessed as part of the RI because historic military activities typically occurred on the plateau.

2.2.7.3 Using the criteria in the Army Checklist for Important Ecological Places, the Spencer Artillery Range site is classified as an important ecological place due to the wetlands within the site (see Section 2.2.9).

#### 2.2.8 Threatened or Endangered Species

The State of Tennessee actively tracks 1,100 rare and endangered plant and animal species. According to an environmental review conducted by the State Natural Heritage Program, two endangered species, the barking tree frog (*Hyla gratiosa*) and white fringeless orchid (*Platanthera integrilabia*) have been documented within the RI area. Table 2.2 shows the barking tree frog and white fringeless orchid, including their federal and state status. The barking tree frog and white fringeless orchid were not encountered during RI field activities.

#### 2.2.9 Wetlands

2.2.9.1 The U.S. Fish and Wildlife Service (USFWS) Wetlands Online Mapper through the National Wetlands Inventory (NWI) was used to identify the wetlands within the Spencer Artillery Range FUDS boundary. Wetlands are land areas that are transitional between terrestrial and deep-water habitats in which the water table usually is at or near the surface or in which the land is covered by shallow water. Digital wetland data provided through NWI is presented on Figure 2.2. The majority of the wetlands consist of freshwater forested/shrub wetlands, which are only temporarily flooded and are described as a forested swamp or wetland shrub bog.

Common Name	Scientific Name	Federal Status	State Status	Habitat
Barking Tree Frog	Hyla gratiosa		Deemed in Need of Management	Low wet woods and swamps especially with ephemeral ponds.
White Fringeless Orchid	Platanthera integrilabia	Candidate Species	Endangered	Acidic Seeps and Stream Heads

 Table 2.2

 State and Federally Listed Species Within Investigation Areas

Freshwater emergent wetlands also exist within the site; these wetlands are seasonally/semipermanently flooded areas, described as herbaceous marsh, fen, swale, and wet meadow.

2.2.9.2 Both wetland classifications found at the site are "Palustrine" which was developed to group vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie throughout the United States. It also includes small, shallow, permanent or intermittent water bodies (creeks or ponds). The erosive forces of wind and water are of minor importance except during severe floods.

#### 2.2.10 Cultural and Archaeological Resources

Professional archaeological investigations in the former Spencer Artillery Range began in the early 1970s. These investigations confirmed that a portion of the Trail of Tears crosses the project site. Also in the middle 1970s, archeological sites were discovered within or immediately adjacent to the Spencer Artillery Range project boundaries. The majority of the sites recorded within the site are lithic scatters, or isolated lithic artifact finds, lacking diagnostic artifacts. Sites with known cultural components (based on presence of diagnostic lithics) include four Early Archaic, one Middle Archaic, three Late Archaic, three Early Woodland, five Middle Woodland, and one Late Woodland. The majority of these sites are on ridge tops or sides, while the remaining sites are in stream bottoms (USACE, 2005).

#### 2.2.11 Demographics

Spencer Artillery Range is approximately 90 miles from Nashville and 60 miles from Chattanooga, Tennessee (Figure 2.1). Eighty percent of the range is within Van Buren County, which has a population of 5,480 and a population density less than one person per square mile (U.S. Census Bureau, 2010). The population of Van Buren County decreased one-half percent between 2000 and 2008.

#### 2.2.12 Current and Projected Land Use

2.2.12.1 Land within the former Spencer Artillery Range is entirely privately owned. Figure 2.3 presents current land use within the FUDS boundary. 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. Currently, the only known ongoing housing development/construction is within Covenant Farms (Figure 2.3). Much of the land within the FUDS is undeveloped, wooded land. Logging has been conducted on the plateau since before the artillery range was constructed and is ongoing within portions of the former range. Historically, land use included coal strip mining, particularly in the eastern portion of the site. Figure 2.2 presents the locations of the historic coal mining areas. Numerous drill programs have also been conducted in this area to delineate potential coal resources. Several of the strip mined areas have been reclaimed.

2.2.12.2 Land use within undeveloped lands also includes recreational activities such as hunting, camping, and riding all-terrain vehicles. Cattle ranching is also conducted in various areas of the site. Commercial operations include tree farms and explosives storage. Land use is changing quickly within the FUDS, with continued and future development of zoned residential areas anticipated.

#### 2.3 HISTORICAL INFORMATION

2.3.1 Spencer Artillery Range served as the main artillery range for Camp Forrest in Tullahoma, Tennessee, 45 miles to the southwest. Historic documentation identifies land clearance for development of two impact areas: "Jakes Mountain cleared impact area (5060 acres), Range 10,000 yards" and "Bald Knob cleared (2090 acres), Range 4,000 yards" (USACE, 2001a). The document also notes that areas were cleared for observation points on Jakes Mountain and Hillis Mountain. Rocky River Road was developed for access to the impact areas, and a bivouac area was developed east of Old Highway 111. Training was conducted at Spencer Artillery Range, and small arms, 37-mm anti-aircraft guns, field and heavy artillery, mortars, anti-tank rockets, and target rockets are known to have been used (USACE, 2004).

2.3.2 In 1942, a request was made for clearance of an additional 10,000 acres between the Bald Knob and Jakes Mountain impact areas to provide maneuver space with the existing impact areas. In addition, funds were requested for an anti-tank range suitable for 75mm and 105mm projectiles in the Bald Knob area. By September 22, 1944, Spencer Artillery Range was no longer needed for artillery training and it was reportedly used by Dyerburg Army Air Field as an air-to-ground gunnery range. All leases for lands associated with Spencer Artillery Range were cancelled by August 13, 1946. The DoD conducted decontamination sweeps in 1950, 1952, 1955, and 1956 on various sections of the former range, and certificates of clearance were issued for those areas. The 1956 certificate, superseding previous certificates of clearance, noted that 3,059 acres were restricted to surface use only. This restriction violated the terms of the lease, and the two primary landowners within the impact areas were compensated for value diminution of their land.

2.3.3 In 1984, the Military Department of Tennessee announced its intentions to use the former Spencer Range for a new camp. The Tennessee National Guard, however, never acquired the site. There have been incidents and injuries resulting from unexploded ordnance at the former Spencer Artillery Range. Additional information associated with previous investigations at the site is provided in the following section.

#### 2.4 PREVIOUS INVESTIGATIONS

Several prior MEC-related investigations and removal actions have been conducted by USACE at the former Spencer Artillery Range over the past 15 years. The results of these investigations have been used during the development of the technical approach for this RI and were also used to supplement the data gathered concerning the presence of MEC at the project site. Brief descriptions of these investigations are provided below.

#### 2.4.1 1994 Inventory Project Report

An inventory project report (INPR) was prepared for Spencer Artillery Range by the USACE, Nashville District in November 1994 (USACE, 1994). The INPR concluded that land previously occupied by the Spencer Artillery Range was formerly used by the DoD, that there was the potential for MEC to be present, and that the 30,618-acre site was eligible under the FUDS program. The initial INPR and the amended INPR (dated 2001) state that the land is primarily used for farming, timber, and strip mining operations.

#### 2.4.2 2001 Archives Search Report

2.4.2.1 An Archive Search Report (ASR) for the Spencer Artillery Range was completed by the USACE, Rock Island District in November 2001 (USACE, 2001a). The ASR documented the results of a site visit that took place during October 2001, as well as a historical records search. The ASR divided the former Spencer Artillery Range into two areas, Area A (Impact Area) and Area B (Remaining Lands). The ASR considered that ordnance was confirmed to be present in Area A but not in Area B.

2.4.2.2 The ASR described four decontamination actions performed in 1950, 1952, 1955, and 1956. The certificate of clearance issued after the 1956 investigation restricted 3,059 acres to surface use only based on the MEC items found during a visual surface clearance. The location of the surface clearance is shown on Figure 2.4. The ASR noted that an 8-inch high explosive round was found in 1998 while a crew was clearing a logging road. In addition, in 2001, a boy was maimed in his home by dropping a 37mm MKII projectile he had recovered from the range in 1999.

#### 2.4.3 2004 ASR Supplement

The ASR Supplement defined 17,260 acres of the FUDS as Range Complex No. 1 and subdivided it into four overlapping sub-ranges: the Moving Target Range, Artillery Range, Anti-Tank Range, and Air-to-Ground Gunnery Range. Range Complex No. 1 and the four sub-ranges are shown on Figure 2.4. The 17,260 acre Range Complex No. 1 represents the one munitions response site (MRS) currently identified for the site.

#### 2.4.4 2004 GIS-Base Historical Photographic Analysis

The Topographic Engineering Center (TEC) analyzed historic air photos and maps to "determine if there are features on these photos that could be indicative of possible ordnance impact areas, burial areas, and/or areas of general ground disturbance." The TEC photo analysis identified numerous impact craters and potential ground scars shown on Figure 2.4.

#### 2.4.5 2007 Engineering Evaluation / Cost Analysis Report

2.4.5.1 A contractor for USACE performed an Engineering Evaluation / Cost Analysis (EE/CA) between 2003 and 2007 to evaluate response alternatives for the former Spencer Artillery Range. The EE/CA included reconnaissance, DGM, and intrusive investigation of anomalies. The objective of the EE/CA was to

- 1) Delineate ordnance and explosives within the project area,
- 2) Determine current and future land uses,
- 3) Determine if the boundary between the ASR-identified Area A (impact area) and Area B (remaining lands) should be revised, and
- 4) Conduct a risk assessment.

2.4.5.2 Ground reconnaissance was performed in Area B, and evidence of a possible mortar firing point was found west of the impact areas. Digital geophysical data was also collected with an EM61-MK2, and anomalies were intrusively investigated. The EE/CA results, including discovered munitions, are presented in Figure 2.5. The EE/CA identified no MEC and very little munitions debris (MD) within the Bald Knob impact area (in the western portion of Area A). As shown on Figure 2.5, five MEC items and hundreds of MD/fragments were found within the former Jake's Mountain impact area (eastern portion of Area A).

2.4.5.3 The EE/CA noted that MEC was found outside the range fans noted in the ASR and concluded that the ASR designations of Area A (impact area) and Area B (remaining land) did not adequately depict the distribution of MEC across the site. The EE/CA also concluded that artillery fired at the former Spencer Artillery Range has the potential to land anywhere within the range. In addition to reconnaissance, DGM, and intrusive investigation, soil samples were collected to assess potential MC contamination. Based on the sampling results of the EE/CA, unacceptable risks associated with MC contamination are not expected at the site.



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17	Pri	mary Road	S						
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47 0000	Historic Ranges and Photographic Analysis Features Formerly Used Defense Site Spencer Artillery Range FUDS Project # G04TN017801 Spencer, Tennessee					
	Legend					
	FUDS E	Boundary				
	Range	Complex No	. 1 Munitions			
	Respon	ise Site (17,2	260 acres)(%)			
	Sub Are	ea Range Fa	INS <sup>(2)</sup>			
0000	1956 Se	earched Are	а			
4	1956 "Surface Use Only" Restriction					
	1943 Features <sup>(b)</sup>					
	Ground S	car				
	Impact Cr	ater				
	1956 Projectiles					
	240mm (5)		37mm (110)			
	155mm (16	6) 2	20mm (9)			
•	105mm (12	2)	Small Arms (17)			
12 000	75mm (8)	L l	Jnknown Muniti	ons		
•	40mm (2)					
	Note: (a) Range Complex No. 1 MRS (17,260 acres) was identified in the Supplemental ASR. FUDSMIS identified this as the only MRS for this FUDS. (b) Features and range fans identified by Topographic Engineering Center during GIS-based photographic analysis					
	Image Source: 1943 Image TEC					
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# Figure 2.5

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

#### Legend

- FUDS Boundary
  - Area A (Impact Area) Boundary <sup>(a)</sup>
  - Range Complex No.1 MRS <sup>(b)</sup>
  - Reconnaissance Transect
  - Geophysical Survey Transects
- Munitions Debris 18 items
- Fragment 906 items
- Small Arms 40 items
- Other (trash, hot rock, no contact) 1723 items
- Not Intrusively Investigated 3777 items<sup>(c)</sup>

#### **Unexploded Ordnance**

- 37mm 2 items
- **.**
- 75mm 1 item
- 155mm 2 items

#### Notes:

(a) Area A (13,995 acres) was identified in the 2001 Archives Search Report and was "considered to have confirmed ordnance presence". Area B remaining lands (located outside Area A and within the FUDS boundary) was "considered to have no ordnance presence".

have no ordnance presence".
(b) Range Complex No. 1 MRS (17,260 acres) was identified in the Supplemental ASR. FUDSMIS identifies this as the only MRS for this FUDS.

(c) Anomaly identified but not included in intrusive investigation

Image Source: 2010 Orthophotos Projection: Tennessee State Plane, NAD83, Feet				
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#### CHAPTER 3 PROJECT REMEDIAL RESPONSE OBJECTIVES

This RI was conducted in accordance with the PWS, dated March 24, 2009, and the objectives and goals presented and accepted by the TPP Team during the TPP process and as summarized in the TPP Memorandum (Appendix I, Parsons, 2009). The TPP Team for this RI includes representatives from USAESCH, CESAM, TDOR, and Parsons. The primary objective and purpose of the RI is to characterize MEC and MC contamination present in the identified investigation areas at Spencer Artillery Range and to assess potential risks to human health or the environment that might result from that contamination. The overall goal of this process is to obtain stakeholder concurrence on a decision document that summarizes the planned response to address any identified contamination.

#### 3.1 CONCEPTUAL SITE MODEL AND PROJECT APPROACH

#### 3.1.1 Preliminary Conceptual Site Model

3.1.1.1 The conceptual site model (CSM) depicts and evaluates the MEC and MC migration/exposure pathways and the possible human and/or ecological receptors for those pathways, based on site-specific conditions. It is necessary to evaluate site-specific conditions and land use to evaluate risks posed to potential receptors under current and future land use scenarios.

3.1.1.2 The CSM summarizes which potential receptor exposure pathways are (or may be) complete and which are (and are likely to remain) incomplete. An exposure pathway is considered incomplete unless all four of the following elements (in italics) are present (USEPA, 1989). An example regarding a hypothetical groundwater exposure pathway for MC is included.

- *A source of contamination* (for example, a site has known MEC from which MC have leached and contaminated surface soil).
- An environmental transport and/or exposure medium (in the example, the MC in soil are mobile and can contaminate groundwater).
- A point of exposure at which the contaminant can interact with a receptor (a drinking water well drawing from the contaminated aquifer is at the site).
- A receptor and a likely route of exposure at the exposure point (an onsite resident uses groundwater as a source of drinking water).

3.1.1.3 In the hypothetical example, each of the four factors is present, and therefore the groundwater exposure pathway is complete. If any single factor was not present (e.g., MC was

not present in groundwater, or the resident used drinking water from another source), the pathway would be incomplete. An incomplete exposure pathway indicates that there are no current means by which a receptor (human or ecological) can come into contact with MEC or MC; therefore, no risks from exposure to MEC or MC would be expected.

3.1.1.4 A CSM is dynamic and represents the current understanding of the site. The CSM is evaluated and revised each time new information is received. As part of the TPP process for the RI at Spencer Artillery Range, a preliminary MEC CSM was developed in accordance with EM 1110-1-1200. The process included review of historic data, including the ASR, TEC photographic analysis, and EE/CA, to identify data gaps and areas in which to focus RI activities. Table 3.1 summarizes the key information from the preliminary CSM for the Spencer Artillery Range, including identification of investigation areas, potential receptors, current land use, and potentially complete exposure pathways for MEC and MC. More detailed CSMs developed prior to the RI for each investigation area are included in Appendix E (Table E1-1 and E1-2).

3.1.1.5 Prior investigations at Spencer Artillery Range confirmed the use of numerous different munitions at the site, including small arms ammunition up to .50 caliber and high explosive projectiles from 37mm to 155mm. Expended small arms ammunition is MD and poses no explosive hazard. Unexpended small arms ammunition is considered MEC, but it is not considered to pose a significant explosive hazard (Department of the Army, 2005). However, unexpended projectiles, if present at the surface or in the subsurface, would provide a source of MEC for an exposure pathway (subsurface MEC are those MEC items that are not visible above the soil surface [i.e., they are fully covered by soil]). The investigation areas identified in the preliminary CSM summary (Table 3.1) were developed based on review of historic documentation and MEC/MD findings from prior investigations. The locations of the investigation areas are shown on Figure 3.1.

3.1.1.6 The preliminary CSM noted that current land use at Spencer Artillery Range is mainly undeveloped, wooded land, but scattered residences across the site and portions of the site have been subdivided for residential development. Additional residential development is anticipated in the future. Based on the land uses, the primary human receptors at Spencer Artillery Range are anticipated to be residents, construction workers, commercial/industrial workers (e.g., ranchers, loggers, utility workers, etc.) and site visitors and recreational users (hikers and hunters). Typical intrusive activities (construction, logging, etc.) could be up to 2 feet, meaning that receptors could be exposed to subsurface MEC. Parcels are privately-owned, and the site is accessible to authorized receptors, so there is the potential for human receptors to come into contact with surface or subsurface MEC if a source is present within the site. Therefore, the preliminary CSM identified potentially complete MEC exposure pathways at the surface and in the subsurface at the Spencer Artillery Range.

3.1.1.7 No MC contamination was identified during the EE/CA (EODT, 2007); therefore, it was determined during the TPP process that additional sampling for explosives and munitions-related metals was not necessary. Although the exposure pathway for explosives and metals was determined to be incomplete, perchlorate was subsequently identified as a possible munitions-related constituent. Groundwater was not evaluated in the EE/CA for the presence

of perchlorate. The possible presence of this preliminary chemical of potential concern (COPC) at the site provides a potential source of MC for complete groundwater exposure pathways. The TPP team agreed to collect groundwater samples from existing wells to determine if there is an unacceptable risk posed to human health and the environment due to perchlorate in groundwater (Parsons, 2009).

3.1.1.9 The primary groundwater receptors at the site are anticipated to be current and future residents, construction workers, commercial/industrial workers (e.g., agricultural workers, foresters, etc.) and site visitors and recreational users (e.g., hikers and hunters). Based on the potential for perchlorate in groundwater and possible receptors, the preliminary CSM identified a potentially complete MC exposure pathway (for perchlorate in groundwater only). These pathways are summarized in Table 3.1. Ecological receptors are also potentially present at the site, but they are not typically exposed to groundwater, so the groundwater exposure pathways are incomplete for ecological receptors.

#### **3.1.2 Project Approach**

3.1.2.1 The technical approach for this RI is based on the findings of the previously conducted investigations and other available historic information (see Subchapter 2.4), and was designed to evaluate potentially complete MEC and MC exposure pathways as identified in the preliminary CSMs (Subchapter 3.1.1) and to determine the potential presence of MEC or MC contamination. Furthermore, where such contamination is identified, the approach was planned to adequately characterize the nature and extent of the contamination so that possible remedial alternatives could be developed and assessed. The general methods used for this approach included instrument-aided reconnaissance, DGM, intrusive investigation of identified geophysical anomalies, and perchlorate groundwater sampling.

3.1.2.2 Based on the information currently available (Subchapter 2.4), the munitions known or expected to be present at Spencer Artillery Range include small arms ammunition up to .50 caliber and high explosive projectiles from 37mm to 155mm, all of which date back to the World War II era. The specific approach for the MEC investigation at Spencer Artillery Range was to characterize the nature and extent of MEC contamination within 11 investigation areas inside the FUDS using a combination of instrument-aided reconnaissance, DGM, and intrusive investigations. A project approach was developed for each investigation area:

- **Bald Knob** is a known impact area where several decontamination surface sweeps were historically performed in the 1950s. The EE/CA did not find MEC or a substantial amount of MD in the area. The project approach for Bald Knob was designed to confirm the EE/CA results (e.g., a lack of contamination) and achieve a higher confidence level that no significant target area exists within the Bald Knob impact area.
- **Potential Area of Interest (PAOI) 5** was not clearly defined as an impact area; however, MD was identified in the area during the EE/CA. The project approach

Table 3.1 Summary of Preliminary Conceptual Site Models and Potentially Complete Exposure Pathways Spencer Artillery Range, Spencer, Tennessee

			Munitions and Explosives of Concern	Munitions Constituents	
Investigation Area	Potential Receptors	Current Land Use <sup>(2)</sup>	Potential for Complete Pathway	Preliminary Chemicals of Potential Concern <sup>(3)</sup>	Potentially Complete MC Exposure Pathways
JMIA	Commercial/industrial workers (e.g. agricultural and forestry workers), site visitors and recreational users (e.g. hikers and hunters)	Hunters/Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
BKIA	Commercial/industrial workers (e.g. agricultural and forestry workers)	Hunters/Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
Residential Areas	Residents, construction workers	Residential	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
Trail of Tears	Residents, construction workers, commercial/industrial workers (e.g. agricultural and forestry workers and archaeologists), site visitors and recreational users (e.g. hikers)	Access Road/Hunting	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-1	Residents, commercial/industrial workers (e.g. agricultural and forestry workers), site visitors (e.g. hikers and hunters)	Agricultural/Forestry Residential	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-2	Commercial/industrial workers (e.g. agricultural and forestry workers), site visitors and recreational users (e.g. hikers and hunters)	Agricultural/Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-3	Commercial/industrial workers (e.g. forestry workers), site visitors and recreational users (e.g. hikers and hunters)	Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-4	Commercial/industrial workers (e.g. agricultural workers)	Agricultural	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-5	Commercial/industrial workers (e.g. forestry workers), construction workers, site visitors and recreational users (e.g. hikers and hunters)	Forestry Residential	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-6	Commercial/industrial workers (e.g. forestry workers), site visitors and recreational users (e.g. hikers and hunters)	Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact
PAOI-7	Commercial/industrial workers (e.g. forestry workers), site visitors and recreational users (e.g. hikers and hunters)	Forestry	Yes	Perchlorate	Groundwater: ingestion as drinking water, incidental ingestion, dermal contact

(1) More detailed information on the land uses, potential receptors, and munitions known or expected to be present at each investigation area based on historical information is provided in Table E2.1 in Appendix E of this RI report.

(2) (3) (4) Based on EE/CA GIS Geodatabase land use data

Munitions associated with perchlorate potentially present at Spencer Artillery Range (Parsons, 2010) JMIA = Jakes Mountain Impact Area, BKIA = Bald knob Impact Area, PAOI = Potential Area of Interest

### FINAL

for PAOI-5 was designed to determine if the MD items found during the EE/CA were related to a significant target area or concentrated munitions use.

- Jakes Mountain Impact Area and the Residential Area are within a known impact area where MEC was identified during the EE/CA. The project approach for JMAI/Residential Area was designed to define the extent of the impact area (i.e., achieve a 95% confidence level that contaminated and non-contaminated areas have been identified).
- **PAOI 1, 2, 3, 4, 6 & 7** were identified as low-probability areas based on EE/CA results and historic documentation. Limited MD was historically found within these areas, and the project approach was designed to characterize these areas using reconnaissance to determine if there was evidence of concentrated munitions use and if further investigation activities were warranted.
- **Trail of Tears** was avoided due to archeological/cultural/historic significance. Similar munitions are expected within the Trail of Tears as in adjacent areas, so no investigations were proposed.

3.1.2.3 The TPP team agreed to assess perchlorate in groundwater on a site-wide basis due to the presence of munitions associated with perchlorate at the site.

#### 3.2 PRELIMINARY REMEDIATION GOALS

3.2.1 Preliminary remediation goals are both site- and contaminant-specific and define the conditions considered by stakeholders to be protective of human health and the environment. There may be preliminary remediation goals for MEC at each area evaluated during an RI. As with the CSMs, preliminary remediation goals are reevaluated and refined throughout the remedial investigation and feasibility study (RI/FS) process as new information becomes available. The site closeout statement agreed on by the TPP Team for the Spencer Artillery Range was "To manage the MEC risk through a combination of remedial action, administrative controls, and/or public education; thereby rendering the site as safe as reasonably possible to humans and the environment and conducive to the anticipated development."

3.2.2 The preliminary remediation goal for MEC is based on limiting interaction between residual MEC and receptors accessing the FUDS. Based on the site closeout statement for Spencer Artillery Range, the preliminary remediation goals are either to remove MEC present to a depth at which they no longer present a hazard to the anticipated human receptors, or to implement land use controls that will minimize the possibility of receptors coming into contact with MEC at the site.

3.2.3 The preliminary remediation goal for perchlorate is based on the Department of Defense (DOD) Perchlorate Release Management Policy, April 22, 2009, for managing perchlorate (15 micrograms per liter [ $\mu$ g/L]) (DOD, 2009b). The preliminary remediation goal is to ensure that perchlorate detected in groundwater at the site in excess of this screening value is addressed to minimize or mitigate risks to human health or the environment.

#### 3.3 PRELIMINARY IDENTIFICATION OF APPLICABLE, RELEVANT, AND APPROPRIATE REQUIREMENTS AND "TO BE CONSIDERED" INFORMATION

3.3.1 Response actions under FUDS must identify and attain or formally waive applicable or relevant and appropriate requirements (ARAR) under federal and state laws (ER 200-3-1). ARARs include promulgated statutory and regulatory requirements that are substantive in nature. ARARs must be complied with to the extent practicable. Although the RI is not considered a response action, preliminary identification of chemical-specific and location-specific ARARs is conducted during RI site characterization. ARARs are used as a starting point to determine the protectiveness of a site remedy.

3.3.2 As the RI/FS process continues, the list of ARARs will be updated, particularly as guidance is issued by state and federal agencies. ARARs will be used as a guide to establish the appropriate extent of site cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative. As part of the feasibility study (FS), primary consideration should be given to remedial alternatives that attain or exceed the requirements of the identified ARARs. Throughout the RI/FS, ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the site;
- Chemical analysis performed or scheduled to be performed;
- Types of media (air, soil, groundwater, surface water, and sediment);
- Geology and other site characteristics;
- Use of site resources and media;
- Potential contaminant transport mechanisms;
- Purpose and application of potential ARARs; and
- Remedial alternatives considered for site cleanup.

3.3.3 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 to, 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.

3.3.4 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. No action-specific ARARs have been identified for Spencer Artillery Range.

3.3.5 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. Some examples of special locations include flood plains, wetlands, historic places, and sensitive ecosystems or habitats. Although the Spencer Artillery Range is privately owned by numerous land owners, as noted in Section 2.2 of this report, select areas of the site could be considered a special location due to the existence of the Trail of Tears National Historic Trail, the possible presence of threatened and endangered species (i.e., barking tree frog and white fringeless orchid), and identified wetlands. Table 3.2 presents the preliminary ARARs identified for the project. Further refinement of the ARARs will be accomplished in the FS as part of the analysis of response alternatives.

# Table 3.2 Summary of ARARs Spencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

Location-Specific ARAR	Description
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.
National Trails System {16 USC. 1242)	Regarding protection of historic routes and its historic remnants and artifacts;
Executive Order 11990 for Protection of Wetlands and 40 CFR Part 6	Federal actions that involve potential impacts to, or take place within, wetlands.

3.3.6 When ARARs do not exist for a particular chemical or remedial activity, other criteria, advisories, and guidance referred to as To Be Considered (TBC) are useful in designing and selecting a remedial alternative. The TBC information identified for this site is presented in Table 3.3.

# Table 3.3 To Be Considered Information Spencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

TBC Information	Description
USACE EM CX Interim Guidance Document 06-04	This USACE guidance document transmits a draft revised version of EP 1110-1-18 that specifies how to conduct an RI for the MMRP and how to write the RI report.
USEPA MEC Hazard Assessment Methodology. Interim. EPA 505B08001. October 2008 (USEPA 2008)	This USEPA guidance document describes the method of how to conduct a MEC hazard assessment (HA) to qualitatively characterize the MEC hazards at a site.
USACE ER 200-1-4, Risk Assessment Handbook Volumes I and II	This USACE guidance document describes the methods of how to conduct human health (Volume I) and ecological (Volume II) risk assessments to characterize risks of chemical contaminants at a site.
DoD preliminary remediation goal established for managing perchlorate	Used to establish preliminary screening value used to determine whether contamination is present in groundwater and surface water, and also to provide comparison value for risk assessment.

#### 3.4 SUMMARY OF INSTITUTIONAL ANALYSIS

3.4.1 Institutional analyses are prepared to support the development of institutional control strategies and plans of action as a munitions response alternative. These strategies rely on existing powers and authorities of government agencies to protect the public at large from potential MEC hazards and risks.

3.4.2 The objectives of the institutional analysis are to illustrate the opportunities that exist to implement an institutional control program at the site; identify government agencies having jurisdiction over MEC contaminated lands; and assess the appropriateness, capability and willingness of government agencies to assert their control over MEC contaminated lands. The typical strategies for addressing the presence of MEC on a site are physical removals and institutional controls. Although physical removals are conducted to reduce the amount of MEC at a site, current technologies are not adequate to provide for the detection and removal of all ordnance. Therefore, institutional controls are implemented to manage residual risk remaining at a MEC site. Institutional controls are also sometimes put into place without a physical removal, as a stand-alone response.

3.4.3 State, local, and/or tribal governments/authorities are critical to the development and selection of site-specific institutional controls in concert with USACE. The federal government does not have the authority to enforce local initiatives; however, it can encourage the local community and pledge its support to provide leadership, expertise, resources and a continuing long-term review of the implemented institutional control program. Managing the residual risk

by encouraging local initiatives is the essence of institutional control planning. The local community is encouraged to become actively involved in developing local initiatives to implement institutional controls. Local initiatives are institutional controls for which the local authorities agree to support and provide long-term enforcement.

3.4.4 Landowners provide critical input into the development of a viable institutional control program for their property. If an institutional control program is selected for their property, the property owner will maintain compliance with the provisions of the institutional control and notify the USACE and the appropriate, state, local, and/or tribal government with any proposed land use changes for the site that may impact the effectiveness of the institutional control.

3.4.5 A review of government institutions and private entities that exercise jurisdiction and ownership of the investigation areas indicated that all of Spencer Artillery Range is under the control of private landowners. Although the Trail of Tears has been designated a historic trail by National Parks Service it remains privately owned; therefore, government agencies do not have jurisdiction. The entire investigation area within Spencer Artillery Range is privately owned, with numerous land owners living out of state, and zoning and permitting is generally not enforced, there are very limited local institutions that have jurisdiction, authority, a mission, capability, or desire to participate. Van Buren County has limited resources and there are no county zoning or building commissions.

3.4.6 The institutional analysis identified six entities with the willingness and capability to implement, enforce, or maintain an institutional control program at the Spencer Artillery Range: CESAM, USAESCH, TDOR, the Van Buren County Sheriff's Office, the Van Buren County Planning Commission, and the Van Buren County Register of Deeds. The institutional analysis and Institutional Analysis Report are provided as Appendix C to this RI report.

#### 3.5 DATA NEEDS AND DATA QUALITY OBJECTIVES

#### 3.5.1 Data Needs

MEC was found at various locations across the site during the prior investigations, and an RI/FS was recommended to further characterize MEC contamination, and gather information for the completion of MRSPP scores. The data needs for this project were reviewed by the TPP Team and include collecting adequate data to assess MEC contamination and perchlorate in groundwater at Spencer Artillery Range. The DQOs associated with the data to be collected during the RI were developed by the TPP Team and included in the final work plan (Parsons, 2009).

#### 3.5.2 Data Quality Objectives

DQOs are qualitative and quantitative criteria used to guide sample collection and analysis activities. The DQOs for this RI/FS project were developed prior to conducting the investigation to ensure that the data generated during the execution of the analytical program are of appropriate quality to support the anticipated end use of the data. DQOs are intended to

ensure that the adequate type, amount, and quality of data are collected to accomplish the objectives of the project. The major site-wide DQOs for each element of the RI are summarized in the following subchapters

#### 3.5.2.1 Reconnaissance Data Quality Objective

The DQOs for field reconnaissance presented in Table 3.4 were met during the RI field activities.

<b>RI</b> - Data Quality Objectives - Instrument-Aided Reconnaissance			
Data Quality Objective	Project Specific Action		
1. State the Problem	Previous investigations found munitions debris or evidence of military use. It is unknown if these are isolated instances or		
	possible areas with elevated MEC concentrations (e.g., impact areas). If still present, MEC may pose a risk to human health and the environment		
2. Identify the Decision	Is MEC present or is there evidence an impact area within the		
	area of interest?		
3. Identify Inputs to the Decision	Visual reconnaissance will determine the location and concentration of surface MEC/MD. Identification of subsurface magnetic anomalies with handheld instruments could indicate subsurface MEC/MD.		
4. Define the Boundaries of the Study	Instrument-aided reconnaissance will focus on six potential areas of interest (based on prior investigation results). Approximate 200-foot transect spacing within the six PAOIs (1-4, and 6-7) for which right-of-entry have been obtained. Within the six PAOIs, a total of 6.67 acres of transects will be investigated. Visual and subsurface (magnetometer) reconnaissance will identify areas with high concentrations of MEC and MD and/or anomalies.		
5. Develop a Decision Rule	If MEC found or elevated subsurface anomaly counts are consistent with a possible impact area, then evaluate area for inclusion of transect and/or grid-based DGM. Otherwise, if MEC is not found and area does not contain elevated subsurface anomaly counts, no additional investigation.		
6. Specify Limits on Decision Errors	A UXO-qualified technician will evaluate debris on the surface to determine if it is related to munitions. Subsurface anomaly counts recorded along transects using handheld magnetometer. Transect spacing not greater than 400-feet.		
7. Optimize the Design	Reconnaissance paths selected based on historical records, analysis of aerial photography, previous field investigations, and permitted right-of-entry.		

 Table 3.4

 RI - Data Quality Objectives - Instrument-Aided Reconnaissan

#### 3.5.2.2 Digital Geophysical Mapping Data Quality Objective

The DQOs for DGM presented in Table 3.5 were met during the RI field activities.

KI - Data Quanty Objectives - Digital Geophysical Mapping			
Data Quality Objective	Project Specific Action		
1. State the Problem	Previous investigations conducted at the former Spencer Artillery Range have identified artillery impact areas. If still present, MEC in these areas may pose a risk to human health and the environment.		
2. Identify the Decision	Is MEC present within the area? If present, what is the nature and extent of MEC?		
3. Identify Inputs to the Decision	A geophysical investigation will identify anomalies some of which may be attributed to munitions. Visual observations, geophysical reacquisition, and intrusive investigations will be used to confirm the presence or absence of MEC and MD.		
4. Define the Boundaries of the Study	The DGM will be focused on Bald Knob, PAOI-5, Jakes Mountain, and residential areas. Within these focused areas, a total of 43.6 acres of 3-foot wide transects and 5 acres of geophysical grids will be mapped. This approach was designed using Visual Sample Plan software to identify contaminated and uncontaminated areas with a 95% confidence level assuming: target area size = $300$ ft radius, target area anomaly density = $200$ anomalies per acre, background anomaly density = $50$ anomalies per acre. 1500 anomalies which may be attributed to potential munitions will be intrusively investigated.		
5. Develop a Decision Rule	<ul> <li>The DGM will be considered complete when the following criteria have been met.</li> <li>1. Selected DGM anomalies have been investigated.</li> <li>2. A sufficient portion of each site has been surveyed to delineate the boundaries of MEC/MD contamination and estimate anomaly densities and adequately characterize the nature of MEC through intrusive investigations.</li> <li>3. Sufficient data are collected for the feasibility study.</li> <li>4. Pacovared waste has been properly disposed of off site</li> </ul>		
6. Specify Limits on	A UXO-qualified technician will evaluate debris removed from		
Decision Errors	excavations to determine if it is related to munitions.		
7. Optimize the Design	DGM transect results will be used to select DGM grid locations to most effectively estimate anomaly densities and identify anomalies for intrusive investigation.		

Table 3.5RI - Data Quality Objectives- Digital Geophysical Mapping

### 3.5.2.3 Groundwater Sampling Data Quality Objective

The DQOs for groundwater sampling presented in Table 3.6 were met during the RI field activities.

Ki - Data Quanty Objectives - Groundwater Sampling			
Data Quality Objective	Project Specific Action		
1. State the Problem	Previous investigations conducted at the former Spencer		
	Artillery Range have identified the site as a former munitions		
	impact area. Perchlorate is a component of some munitions. If		
	present, perchlorate in groundwater may pose a risk to human		
	health and the environment.		
2. Identify the Decision	Is there an unacceptable risk posed to human health and		
	environment due to perchlorate in groundwater?		
3. Identify Inputs to the	Laboratory analysis will be used to determine the concentration		
Decision	of perchlorate in groundwater.		
4. Define the	A total of 10 groundwater samples will be collected from		
Boundaries of the	existing water wells. Accessible water wells within known		
Study	impact areas will be prioritized for sampling. Upgradient and		
	downgradient wells will be sampled (if available) for		
	comparison purposes.		
5. Develop a Decision	Maximum perchlorate results will be compared to three times		
Rule	maximum ambient concentrations and the Department of		
	Defense Human Health Screening Criteria for perchlorate of 15		
	micrograms per liter (µg/L) (DoD, 2009b).		
6. Specify Limits on	Data will be validated in accordance with the Sampling and		
Decision Errors	Analysis Plan (Appendix E of the Work Plan).		
7. Optimize the Design	Accessible water wells within known impact areas will be		
	prioritized for sampling. Upgradient and downgradient wells		
	will be sampled (if available) for comparison purposes.		

Table 3.6			
RI - Data Quality Objectives -	<b>Groundwater Sampling</b>		



# Figure 3.1

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

# Legend

FUDS Boundary

Potential Area of Interest

## **Investigation Area**

Bald Knob Investigation Area

Jake's Mountain Investigation Area

**Residential Investigation Areas** 

Trail of Tears

1956 "Surface Use Only" Restriction

## 1943 Features <sup>(a)</sup>

Ground Scar



Impact Crater

Note: (a) Features identified by Topographic Engineering Center during GIS-based photographic analysis

Image Source: 2010 Orthophotos Projection: Tennessee State Plane, NAD83, Feet

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	U.S. ARMY ENGINEERING
	& SUPPORT CENTER
	HUNTSVILLE, ALABAMA
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#### CHAPTER 4 CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN AND MUNITIONS CONSTITUENTS

#### 4.1 INTRODUCTION

The RI is being performed in a manner consistent with CERCLA, Section 104, and the NCP, Sections 300.120(d)-300.400(e). Therefore, no federal, state, or local permits are required for any action taken on the site. The RI adheres to the relevant U.S. Army regulations and guidance for the MMRP.

#### 4.2 MEC CHARACTERIZATION

#### 4.2.1 General

4.2.1.1 This section provides details of the approach, methods, and operational procedures used for the instrument-aided reconnaissance, geophysical data acquisition and associated data processing, and intrusive investigation activities conducted for the characterization of MEC within the Investigation Areas at Spencer Artillery Range. In general, the work flow for each area was initiated by first conducting a review of historical records (reports, aerial photography, and prior investigations). Based on the historical review a technical approach was developed and the field work was carried out to collect data. Data was obtained to fill data gaps and meet DQOs.

4.2.1.2 Infrastructure for support of the MEC investigation included two office trailers, which were used as the field office and the command post during the intrusive investigation activities. Support equipment included a storage container near the office, two portable toilet facilities, four wheel drive utility vehicles that could be transported around the sites, and pickup trucks capable of hauling equipment necessary to complete the field investigation.

#### 4.2.2 Identification of Investigation Areas

The areas recommended for the RI encompass 8,980 acres of the FUDS and were identified based on historical records, analysis of aerial photography, previous field investigations, and future land use. The rationale for inclusion of each investigation area is provided as follows:

#### Jake's Mountain Impact Area

The JMIA covers approximately 5,907 acres in the eastern portion of the site. Historical records document that the area was used for artillery training between 1941 and 1944 and as an air-to-ground gunnery range for a few months in 1944. The 1956 surface clearance covered almost the entire area and removed 20mm, 37mm, 75mm, 105mm, 155mm, 240mm, and 8-inch

projectiles, and anti-tank mines. Aerial photograph analysis identified many possible craters within the area on the 1943 images. The EE/CA investigation confirmed the presence of MEC, including 37mm, 75mm, and 155mm projectiles. In addition, MD related to 37mm, 75mm, 105mm, 155mm, 240mm, and 8-inch projectiles, 60mm and 81mm mortars, and associated fuzes were found during the EECA. The boundaries of the JMIA are based on these previous investigations. Based on the results of these investigations, it was concluded that the central part of the MRS is likely contaminated with MEC. Additional geophysical data collection at the apparent edge of the contaminated area to more precisely delineate the extent of contamination was conducted as part of the RI. DGM data collected along transects were used to select locations for grids to determine if anomalies are caused by MEC-related items and to calculate the anomaly density. Additional grids and transects were collected within the central part of the area to better estimate the anomaly density.

#### **Bald Knob Impact Area**

The BKIA covers approximately 444 acres in the western portion of the site. Historical records document that the area was used for artillery training between 1941 and 1944 and as an air-to-ground gunnery range for a few months in 1944. The 1956 surface clearance covered the entire area and removed 37mm projectiles, leading to a recommendation for limits on subsurface activities. Aerial photograph analysis identified possible craters within the area on the 1943 images. The EE/CA investigation discovered only one piece of MD, a fragment of a 155mm projectile. The RI boundaries of the BKIA are based on the 1956 surface clearance recommended restrictions. Portions surrounding the BKIA with little other evidence of contamination found during the EE/CA were designated as PAOIs.

Based on the results of prior investigations, it was concluded that 37mm projectiles used at the site may not have penetrated the subsurface, allowing the 1956 surface removal to effectively clear the majority of MEC from the site. The data collected during the EE/CA investigation suggest that this area does not contain significant contamination. Additional geophysical data collection along a denser pattern of transects was completed as part of the RI to confirm the EE/CA results and achieve a higher confidence level that no significant target area exists within the area. The DGM data collected along those transects were used to select locations for grids to determine if anomalies are caused by MEC-related items and to calculate the anomaly density.

#### **Residential Areas**

The Residential Areas identified in the RI work plan cover approximately 370 acres in two sections in the central-eastern portion of the site. The boundaries of these areas were based on the land use database included in the EE/CA geographical information system (GIS) geodatabase (it is noted that residential land use in/near JMIA has changed since the EE/CA). These sections are within and adjacent to the JMIA, and their histories are similar to the JMIA. However, none of the limited number of EE/CA intrusive investigations conducted within these residential areas found MEC or MD.

Additional geophysical data collection along a denser pattern of transects was conducted during the RI. This approach was developed to confirm the EE/CA results and achieve a higher

confidence level that no significant target area exists within the defined residential areas. The DGM data collected along those transects were used to select locations for grids to determine if anomalies are caused by MEC-related items and to calculate the anomaly density.

#### Potential Area of Interest 1: Possible Mortar Firing Points

PAOI-1 is in the western portion of the FUDS. The 2004 photo analysis performed by TEC noted a line of ground scars in the 1943 air photos. A reconnaissance team visited the site during the 2007 EE/CA field work and observed depressions that could be related to mortar firing points. During the RI, a reconnaissance team revisited the area to further investigate the possible mortar firing points.

#### Potential Area of Interest 2: Possible Rifle Grenades

PAOI-2 is southwest of the BKIA. It was part of the area recommended for subsurface restrictions after the 1956 surface clearance due to the discovery of a rifle grenade. The 2007 EE/CA investigation did not visit this area recommended for restricted subsurface activities. During the RI, a reconnaissance team visited the area to search for evidence of MEC-related activities.

#### Potential Area of Interest 3: Possible Rifle Grenades/Mines

PAOI-3 is in the central part of the former Spencer Artillery Range between BKIA and JMIA. Part of PAOI-3 was recommended for subsurface restrictions after the 1956 surface clearance due to the discovery of a rifle grenade and anti-tank mines. That area was expanded to include locations where craters and ground features were observed during the 2004 air photo analysis. The 2007 EE/CA investigation included several transects through PAOI-3 and the discovery of 60mm mortar and 155mm projectile fragments at two locations. During the RI, a reconnaissance team visited the area to search for evidence of MEC-related activities.

#### Potential Area of Interest 4: Possible 37mm Projectiles

PAOI-4 is northeast of the BKIA. It was part of the area recommended for subsurface restrictions after the 1956 surface clearance due to the discovery of multiple 37mm projectiles. The 2007 EE/CA investigation included two transects through PAOI-4, but discovered no MEC-related items. During the RI, a reconnaissance team visited the area to search for evidence of MEC-related activities.

#### Potential Area of Interest 5: Various MD Items

PAOI-5 is in the south-central part of the former Spencer Artillery Range. The 1956 surface clearance did not include PAOI-5. The 2007 EE/CA investigation included two transects through PAOI-5. Intrusive investigation resulted in the discovery of MD items at 28 of the anomalies detected along those transects, including fragments of 37mm, 75mm, and 155mm projectiles and 60mm mortars. During the RI, DGM transects were collected spaced approximately 340 feet apart across the site to determine if the MD items are related to a significant target area.

#### Potential Area of Interest 6: Possible 155mm Projectiles

PAOI-6 covers 81.2 acres west of the BKIA. This area was searched as part of the 1956 surface clearance, but no munitions were found here and it was not part of the area recommended for subsurface restrictions. The 2007 EE/CA investigation included two transects and a grid in PAOI-6, and discovered three unidentified fragments, two pieces of 155mm projectile fragments, and one M51 fuze. During the RI a reconnaissance team visited the area to search for evidence of MEC-related activities.

#### Potential Area of Interest 7: Possible 37mm Projectiles

PAOI-7 is 54.6 acres east of the BKIA. This area was searched as part of the 1956 surface clearance, but no munitions were found here, and it was not part of the area recommended for subsurface restrictions. The 2007 EE/CA investigation included one transect through PAOI-7 and discovered a half shell of a 37mm projectile. During the RI, a reconnaissance team visited the area to search for evidence of MEC-related activities.

#### 4.2.3 Remedial Investigation MEC Characterization Tasks

The tasks involved with the MEC characterization effort at the various investigation areas during this RI included obtaining ROEs, location surveying, brush clearance, instrument-aided reconnaissance, DGM, and intrusive anomaly investigation. The methods used for the MEC characterization performed at Spencer Artillery Range are described in the following subchapters.

#### 4.2.3.1 Obtaining Rights-of Entry

4.2.3.1.1 Based on County appraisal district data for Van Buren, Warren, and Sequatchie Counties, over 500 parcels were identified within the investigation areas. Parcels are owned by over 150 different persons/entities owning one or more parcels each. A letter approved for use by the project team requesting ROE was sent to land owners along with an RI/FS Fact Sheet in September 2009. Although parcel owner address information was obtained from the most recent county databases, numerous ROE requests were returned from the postal service as undeliverable. More research was done to update contact addresses, and ROE requests were reissued. Obtaining landowner contact information often involved a time-consuming Internet search to obtain information on the current land owner. Calls were made at various times of the day and on weekends to make contact with owners. During February 2010, a public meeting was also held to allow landowners to meet with USACE representatives to ask questions regarding ROE.

4.2.3.1.2 Approximately 90 percent of the investigation areas were accessible to the RI field teams. Of the 150 landowners contacted, 117 granted ROE and five refused ROE. Twenty-six landowners either did not respond to mailed information, or contact information was incorrect. Of the 117 that granted ROE, some had conditions or restrictions affecting access or activities that would be allowed (e.g., no brush cutting allowed). The majority of resident landowners wanted specific information when work would be done on their property.

4.2.3.1.3 A spreadsheet of parcel and landowner information was created and stored in the GIS from information obtained from Van Buren County in August 2009. ROE status per parcel is presented in Figure 4.1. The database established during the ROE collection efforts was also used for sending notifications to residents of upcoming fieldwork. It was updated continuously as new information was obtained.

#### 4.2.3.2 Location Survey

4.2.3.2.1 Land surveying was conducted by Vick's Surveying, a professional land surveyor (PLS) licensed in the State of Tennessee. Site control was established using a semi-permanent monument set by the PLS.

Northing	Easting	Coordinate System
462938.79	2090327.3	TN State Plane Feet NAD 83

**Semi-Permanent Survey Monument Location** 

4.2.3.2.2 Temporary locations used to position the base station during real-time kinematic (RTK) global positioning system (GPS) surveys were acquired by the field crews using the RTK system. The positional accuracy of temporary base station locations were checked against the monument set by the PLS.

#### 4.2.3.3 Brush Cutting

4.2.3.3.1 Where necessary, vegetation was cleared to enhance DGM and intrusive investigation activities without disturbing or destroying plant root structures. A UXO escort was present during brush cutting operations. MEC avoidance was practiced using a handheld magnetic locator to scan in the vicinity of vegetation to be cleared. Brush cutting completed in preparation for RI work is presented on Figure 4.2.

4.2.3.3.2 Approximately 159.6 miles of 5-foot wide transects and 3.82 acres of grids were cleared by mechanical means. Brush cutting was accomplished using Bobcat-type tractors that cleared vegetation to 6 inches from the ground surface. Residents were contacted ahead of time to identify brush cutting restrictions and concerns.

4.2.3.3.3 Brush cutting transects started February 23 and continued until May 25, 2010, for a total of 71 brush cutting crew days (one crew is an UXO escort and one equipment operator). Production for the Spencer Artillery Range RI averaged 2.25 miles of brush cutting per crew day. Extensive rains and soft ground encountered on the plateau often caused the brush cutter's equipment to get stuck. Several times, the situation required the second brush cutter to mobilize to assist in dislodging from the muck (thus decreasing productivity). Rugged terrain across the site was extremely hard on equipment and resulted in dislodged tracks and damage to equipment. At times, this required shutting down brush cutting operations for repair work. The site conditions as well as the damaged equipment resulted in mobilizing an additional crew to maintain the proposed schedule.

#### 4.2.3.4 Instrument-Aided Reconnaissance

4.2.3.4.1 Instrument-aided reconnaissance was conducted in accordance with the procedures identified in the work plan (Parsons, 2010b). Brush cutting was not performed in support of reconnaissance efforts. To meet the DQOs, reconnaissance was conducted in six PAOIs. The reconnaissance traversed 110,750 feet and included 850 observations points, resulting in an average distance between observation points of 130 feet. The exact distance between observation points varied in the field due to subsurface anomaly counts and vegetation. The completed instrument-aided reconnaissance transects and observation locations are shown on Figure 4.3. Table 4.1 summarizes the reconnaissance coverage over the six PAOIs.

Former Spencer Artillery Range Remedial Investigation/Feasibility Study			
Investigation Area	Size (Acres)	<b>Reconnaissance</b> (Acres)	
PAOI - 1	22*	0.37	
PAOI - 2	30	0.68	
PAOI - 3	102	1.99	
PAOI - 4	96	1.77	
PAOI – 6	81.2	1.56	
PAOI - 7	54.6	1.25	
Total	386	7.63	

Table 4.1Summary of Reconnaissance CoverageFormer Spencer Artillery Range Remedial Investigation/Feasibility Study

\*Right of Entry was only granted for 5 acres within PAOI-1.

4.2.3.4.2 In addition to instrument-aided reconnaissance conducted within the six PAOIs identified in the work plan, instrument-aided reconnaissance was also conducted within the former airfield located in the southeast corner of the site. Reconnaissance was completed in the former airfield due to concerns raised by TDOR during a site meeting held May 13, 2010. The airfield reconnaissance survey traversed 1,300 meters and, due to the lack of subsurface anomalies and lack of surface military-related debris, only six observations points were recorded. The location of the instrument-aided reconnaissance transects and observation waypoints for the airfield are shown on Figure 4.4.

#### 4.2.3.5 Geophysical Investigation

This section provides details of the approach, methods, and operational procedures for the geophysical surveying and associated data processing for the Former Spencer Artillery Range RI. The geophysical investigation included the collection of data along transects and within grids of varying sizes across the site.

#### 4.2.3.5.1 Geophysical Prove-Out Plan and Report

4.2.3.5.1.1 A geophysical prove-out (GPO) was undertaken over a pre-existing prove-out grid originally established in 2003 in preparation for the EE/CA. The GPO was conducted in accordance with the work plan procedures to confirm the responses and limitations of the geophysical instrument determined during the EE/CA investigation. Several advanced

processing methods were also evaluated on the GPO data to focus intrusive investigations on anomalies most likely to be MEC, as determined by the GPO results.

4.2.3.5.1.2 The 100-foot by 100-foot GPO grid contains 28 buried, inert ordnance items and simulated MEC items. The GPO location is shown on Figure 4.1. The 28 seed items were buried at various depths and orientations. Seed item coordinates, depths, and orientations can be found within the Final GPO Letter Report (Appendix G). The GPO Plan and subsequent Letter Report comply with DID MR-005-005.01. The GPO grid was left in place for subsequent geophysical efforts at the Former Spencer Artillery Range.

4.2.3.5.1.3 Included in the GPO Letter Report were a description of field procedures and the results from the surveys of the GPO grid. Five datasets were collected over the GPO grid and along two transects created within the GPO grid. Two datasets were collected over the entire grid at a 2.5-foot line spacing using fiducial and RTK GPS positioning methods. Additionally, three datasets were collected over the GPO transects using fiducial, RTK GPS, and Rino GPS positioning methods.

4.2.3.5.1.4 The project geophysicist analyzed the results of DGM data collected during the GPO to confirm that the geophysical systems met the project detection requirements. The GPO data were also used to create an anomaly prioritization scheme based on instrument response and advanced parameters to aid selection of anomalies most likely to represent MEC-related items for intrusive investigation. In this prioritization scheme, a priority 1 anomaly was assumed most likely representative of MEC-related items, while priority 3 anomalies are assumed least likely to represent MEC-related items. Anomaly prioritization criteria are summarized in Table 4.2. The anomaly selection criteria, prioritization scheme, and measurement quality objectives (MQOs) that were developed based on the GPO results were also presented in the GPO Letter Report. The GPO Letter Report (Appendix G) was submitted to USAESCH as a draft on April 15, 2010, and then as final on May 17, 2010.

Former Spencer Artillery Range Remedial Investigation/Feasibility Study			
Priority	Instrument Response (mV)	Ch1-Ch3 Decay Constant (microseconds)	
1	Greater than 12	400 to 600	
2	Greater than 6	295 to 705*	
-	4 to 6	400 to 600	
_	Greater than 4	Less than 295 or greater than 705	
3	4 to 6	Less than 400 or greater than 600	

Table 4.2
DGM Anomaly Prioritization Criteria
Former Spencer Artillerv Range Remedial Investigation/Feasibility Study

\*Assuming the anomaly has not been categorized as Priority 1.

#### 4.2.3.5.2 DGM Investigation Areas

4.2.3.5.2.1 Geophysical data were collected over representative portions of four investigation areas (BKIA, PAOI-5, Residential Area, and JMIA) using a combination of transect- and grid-based surveys. A geophysical grid-base survey was also conducted in PAOI-1 and PAOI-6 due to results of reconnaissance. The objectives of the transect-based DGM were to determine the relative density of DGM anomalies across the investigation areas, to locate areas for grid-based DGM, and to identify the types of MEC found in each investigation area through intrusive investigation of selected anomalies. The goals of the grid-based DGM were to determine local densities of anomalies and MEC items, to select anomalies for intrusive investigation in order to characterize the type of MEC present at the investigation areas, and to determine the vertical extent of MEC contamination. Grid-based DGM surveys were also used to document the level of effort required, in terms of time and costs, to clear a grid of vegetation, conduct DGM, and intrusively investigate anomalies to support FS objectives.

4.2.3.5.2.2 Geophysical data were collected along transects spaced at approximately 200foot intervals across the investigation areas using a hand-towed EM61-MK2 sensor. The DGM transects are shown on Figure 4.5. Table 4.3 summarizes the DGM transects within the investigation areas and, as shown, 163.35 linear miles or 59.41 acres of DGM transect data were collected, which met the MQO for coverage across the Site first noted in the Work Plan and included in the GPO Letter Report in Appendix G. Following the selection of anomalies from the processed DGM transect data, the transect paths and anomaly locations were imported into a statistical modeling software package, Visual Sample Plan (VSP). VSP was used to calculate anomaly densities per investigation area based on the area characterized by the transect data and on the number and position of anomalies detected in the investigation area. The calculated anomaly densities (discussed in Chapter 5) were then used to locate grids for additional DGM within each investigation area. Proposed grid locations were presented to USACE for concurrence prior to final placement, and conference calls were held frequently to discuss proposed grid locations and anomaly selections. Table 4.4 summarizes DGM grids data, and as shown, DGM grids were collected totaling 5.23 acres.

Former Spencer Arunery Kange Remedial Investigation/Feasibility Study				
	Digital Geophysical Mapping			
Investigation Area	Transect Length (miles)	Transect Area (acres) <sup>(1)</sup>	Transect Spacing (feet)	
JMIA	101.2	36.8	200	
BKIA	12.04	4.38	200	
Residential Area	13.64	4.96	200	
PAOI-5	36.49	13.27	200	
Total	163.37	59.41		

Table 4.3Summary of Digital Geophysical Mapping: TransectsFormer Spencer Artillery Range Remedial Investigation/Feasibility Study

<sup>(1)</sup> Acreage calculated using the transect length shown and an assumed path width of 3 feet.

4.2.3.5.2.3 As shown in Table 4.4, 45 grids were located within the four DGM investigation areas. Grid locations were selected during the RI/FS by the project geophysicist to further refine the characterization of MEC hazard by determining densities, vertical extent, and types of MEC. The size of each grid depended roughly on the associated anomaly density. Smaller grids (50 feet by 50 feet) were placed in higher-density areas, and larger grids (100 feet by 100 feet) were placed in lower-density areas. Figure 4.6 shows the location and lists the size of each DGM grid. Grids were also used to document the work force required to clear the grid of vegetation, conduct geophysical surveys, and investigate anomalies to help support feasibility study objectives. In addition, based on the instrument-aided reconnaissance results (discussed in detail in Section 5.2.1) one DGM grid each was located in PAOI-1 and one in PAOI-6. Geophysical data were collected in the grids by towing the EM61-MK2 sensor by hand in the same manner described in the GPO Letter Report (Appendix G).

Table 4.4Summary of Digital Geophysical Mapping: GridsFormer Spencer Artillery Range Remedial Investigation/Feasibility Study

	Digital Geophysical Mapping <sup>(1) (2)(3)</sup>		
Investigation Area	Grid Area (acres)	Number of Grids	
JMIA	2.78	21	
BKIA	0.61	7	
Residential Area	0.49	5	
PAOI-5	1.29	12	
Total	5.17	45	

<sup>(1)</sup> Grid locations were based on evaluation of anomaly density results from the DGM transect data.

<sup>(2)</sup> Does not include single grid (PAOI1\_G01) investigated using detect and dig method

<sup>(3)</sup> Includes four DGM grids which were collected, but which not intrusively investigated due to ROE issues.

#### 4.2.3.5.3 RTK GPS DGM Survey

4.2.3.5.3.1 DGM data were collected using a hand-towed EM61-MK2 time-domain electromagnetic sensor. Positioning was accomplished using RTK GPS where a consistent GPS signal was available. The EM61-MK2 consists of two 0.5-meter by 1-meter coils, separated vertically by a distance of 30 centimeters, set on a pair of wheels. The EM61-MK2 generates an electromagnetic pulse that triggers eddy currents in the subsurface. The decay of an eddy current produces a secondary magnetic field that is monitored by the receiving coil or coils within the EM61-MK2. These secondary magnetic fields are received as data and are stored in a data logger or field computer before being downloaded to a personal computer for interpretation. The EM61-MK2 data logger collects data at automatic time intervals determined by the user to about 10 times per second. The logger can be set to record data received from either the top coil and three different time gates from the bottom coil (Mode D), or from four different time gates from the bottom coil (Mode 4). For this project, the EM61-MK2 sensors were set to Mode 4, and the top coil was not used.

4.2.3.5.3.2 During the grid-based surveys, the operator walked parallel lines at various line spacings up to 2.5 feet. Grid locations and associated line spacings are shown in Figure 4.6. In all grids the operator between two survey tapes stretched along the two end lines of the grid until the entire grid was covered. Cones were moved along these tapes to assist the operator in maintaining a straight path from one end of the grid to the other. Collected data were positioned using RTK GPS equipment where a GPS signal could be received.

#### 4.2.3.5.4 Fiducial DGM Survey

In grids where a consistent GPS signal was not available, fiducial-based positioning described in the GPO Letter Report (Appendix G) was used to locate the data and to select and locate anomalies. In these grids, from one to three fiducial lines were strung at regular intervals across the grid and parallel to the two end lines. During data collection, the operator created individual lines for each pass across the grid and manually inserted an electronic marker in the data stream as the EM61-MK2 crossed each fiducial line using a button and cable attached to the data logger. The spacing and relative location of the fiducials were then used to constrain the data collected between each fiducial line during data processing.

#### 4.2.3.5.5 Detect and Dig DGM Survey

The intrusive team used a detect and dig method that involved an equipment operator walking the EM61-MK2 along the center of the selected transects and across the entire surface of grid PAOI1\_G01. The equipment operator monitored the data logger screen while pulling or pushing the instrument along the transect, and anomalies greater than the target selection threshold (4mV on channel 2) were marked with pin flags. To best mimic the RTK GPS DGM transect data collection method, no effort was made to find the anomaly peak, which may have been off of the transect path, during the flagging effort. A fieldwork variance memorandum describing the detect and dig method in detail was submitted by the project geophysicist and was approved by USACE; it is included as Appendix G. Four transects totaling approximately 6,500 linear feet and one 50- by 50-foot grid were collected using detect and dig DGM survey technique. The locations of the detect and dig transects are shown in Figure 4.5.

#### 4.2.3.5.6 Digital Geophysical Data Processing

4.2.3.5.6.1 No data processing was conducted for detect and dig DGM surveys. Raw geophysical data files for the RTK GPS and fiducial DGM were transferred from the data logger to a laptop computer and were pre-processed using Geomars' TrackMaker61MK2 and Geonics' DAT61MK2 software. During pre-processing, the locations of EM61-MK2 data are interpolated between RTK GPS coordinates or fiducial positions. The data are then exported to Geosoft .XYZ format, which includes position data (including the quality of the GPS signal), data from each of the four EM61-MK2 channels (four bottom coil time gates), other equipment status information, and the data acquisition time stamp.

4.2.3.5.6.2 The Geosoft .XYZ data files were imported into the Geosoft Oasis montaj<sup>™</sup> geophysical data processing environment. Once in Oasis, the coordinates for the data were converted to the project coordinate system and units (Tennessee State Plane, U.S. Survey Feet),

the four channels were leveled using a median statistics filter, and the four leveled bottom coil channels were summed to produce a total channel.

4.2.3.5.6.3 The rolling terrain and dense vegetation of certain areas occasionally interfered with radio signal and satellite coverage, resulting in lower quality RTK GPS. If the quality of RTK GPS data did not meet accuracy requirements, the positions of EM61-MK2 data were corrected by interpolation in Oasis between higher-quality positions. These interpolated-position datasets were not used for the selection of anomalies for intrusive investigation, but were retained for anomaly density estimates.

4.2.3.5.6.4 The QC data for each survey were evaluated by the QC geophysicist for compliance with requirements specified in the GPO Letter Report (Appendix G). The site geophysicist further evaluated the results of the daily latency tests and applied these latency values per team day to transect datasets. Latency values were determined per grid dataset by visual inspection and correction of anomalies within the gridded data. Latency values ranged between 0.2 and 0.4 seconds.

4.2.3.5.6.5 The site geophysicist then evaluated the results of the daily latency tests to determine an instrument latency correction necessary for transect data, or evaluated gridded anomalies to determine a latency correction necessary for grids. This process corrects the delays between the electronics of the EM61-MK2 and the processing of the data on the data logger. A latency correction value was determined per gridded dataset by visual inspection of anomalies when the sensor travels over it in opposite directions. Typically, this value was between 0.2 and 0.4 seconds.

4.2.3.5.6.6 After a latency value had been applied to a dataset, the geophysicist gridded the leveled Channel 2 data within Oasis. The gridded leveled Channel 2 data were then displayed on a map with an appropriate color scale to present the range of response (typically -4mV to 10mV). Gridded data and maps were evaluated to determine if they were consistent with the known site conditions and whether the data met MQOs.

#### 4.2.3.5.7 Digital Geophysical Anomaly Selection

4.2.3.5.7.1 The anomaly selection process for RTK GPS and fiducial-based DGM data was established using data gathered during the GPO (Subchapter 4.2.3.5.1) with input from the USAESCH project geophysicist. For transect data, the processor used a Geosoft UX-Detect<sup>TM</sup> algorithm to automatically select anomalies with leveled Channel 2 amplitudes of 4mV or greater. Transect anomalies were then prioritized as described in Subchapter 4.2.3.5.1.4 and in the GPO Letter Report (Appendix G) using additional advanced processing anomaly parameters (decay constant and size) described in the GPO Letter Report (Appendix G) and in Table 4.2. For grid data, the processor selected targets using the Geosoft UX-Detect<sup>TM</sup> Blakely algorithm with a threshold of 4 mV on leveled Channel 2. Additional DGM anomalies meeting target selection criteria but not selected automatically by the algorithms were hand-selected by the site geophysicist.

4.2.3.5.7.2 Some anomalies selected in grid datasets were merged so that closely spaced anomaly selections (peaks that appear to be caused by the same source item) were consolidated to a single pick. For large single anomalies selected (apparent diameter >6 feet) in grid data, several anomalies may have been picked within the anomalous area to ensure that the entire anomaly was excavated during intrusive investigation. Anomalies known to be caused by cultural features (e.g., fences) were removed from target lists. Parsons geophysicists evaluated selected anomalies and added or deleted anomalies as necessary to ensure that only those anomalies meeting selection criteria were intrusively investigated.

4.2.3.5.7.3 Anomalies selected from each investigation area were prioritized based on instrument response and calculated decay constant, as summarized in Table 4.2 and described in Appendix G. Random transects throughout the investigation areas were selected for intrusive investigation. Along transects selected for intrusive investigation, 100% of priority 1, 25% of priority 2, and 10% of priority 3 anomalies along the transect were investigated intrusively. Each identified anomaly within the grids was investigated intrusively. A summary of the number and priority of anomalies identified per investigation area is included in Table 4.5. Figure 4.7 displays the location of geophysical anomalies identified during the RI.

Total Minimules Selected from Down Transeet Data by Elocation and Thorney				
Former Spencer Artillery Range Remedial Investigation/Feasibility Study				
Investigation Area	Priority 1	Priority 2	Priority 3	Total <sup>(1)</sup>
JMIA	1,171	3,811	1,614	6,596
BKIA	69	146	154	369
Residential Area	93	358	146	597
PAOI-5	111	521	280	912
Total	1,474	4,806	2,194	8,474

 Table 4.5

 Total Anomalies Selected from DGM Transect Data by Location and Priority

 Former Spencer Artillery Range Remedial Investigation/Feasibility Study

(1) Total represents the number of anomalies selected regardless of GPS quality.

#### 4.2.3.6 Quality Control

#### 4.2.3.6.1 Instrument/Equipment Testing

4.2.3.6.1.1 To assure the quality of the geophysical data, a variety of QC tests were performed daily with the geophysical instruments. These tests, the objective of each test, and the acceptance criteria for each test are described below. The complete records of the DGM QC tests are presented in Appendix E.

4.2.3.6.1.2 A static repeatability test was conducted during the GPO and during the morning and evening of each work day. This test involved collecting background data with the instrument in a static (stationary) mode for three minutes, collecting data with a standard test item for one minute, and removing the test item and collecting data for one minute. The respective Channel 2 responses at the beginning and end of each work day were compared to ensure that the response was repeatable within 20% each day. Background and response data

were also analyzed for high noise levels and/or data spikes, which may indicate malfunctioning equipment.

4.2.3.6.1.3 A dynamic test of the RTK GPS with the EM61-MK2 was conducted each morning over an item at a known location. Instruments were pulled over the item in perpendicular directions, and the coordinates of the crossing point were compared to the known coordinates to ensure that the crossing point was within 3 feet.

4.2.3.6.1.4 Dynamic detection repeatability and positioning repeatability tests were conducted at the beginning of the project and at least once daily with each EM61-MK2 and GPS unit used. During the test, DGM data were collected as the instrument passed over a test item twice in opposing directions. The peak instrument response over the test item, selected from the leveled Channel 2 data, was compared with the original response collected during the GPO to confirm that it was at least 75% of the original response value. Also, the position of the test item, as selected either from data positioned using RTK GPS or from fiducially positioned data, was compared to the actual known position of the test item. The position of the peak selected from the data was ensured to be within 3 feet of the known location of the test item. Repeat collection of 2% of the transect data collected each day was not performed; it was determined, and approval was granted by the Army Corps of Engineers geophysicist, that the dynamic repeatability test would demonstrate repeatability.

4.2.3.6.1.5 Dynamic detection repeatability and positioning repeatability tests were also conducted in each grid collected during the RI. A standard seed item (4-inch bolt) was placed inside each grid prior to DGM data collection, and the location of the seed item was surveyed using an RTK GPS unit. In the case of a grid collected fiducially, local coordinates were measured in decimal feet using measuring tapes. During data processing, the leveled Channel 2 response and the decay constant (Channel 1 to Channel 3) for the Blakely-selected target nearest the known location of the seed item were compared to those values recorded over the test item during the GPO. Leveled Channel 2 response had to be greater than 9.2mV (75% of the minimum GPO-determined response), and the decay constant had to be between 400 microseconds (µs) and 600µs for the grid to pass the dynamic detection repeatability test.

#### 4.2.3.6.2 Measurement Quality Objectives

4.2.3.6.2.1 The MQOs for DGM proposed in the work plan were confirmed or refined based on the GPO results. The final GPO Letter Report (Appendix G), issued May 17, 2010, includes the final project-specific MQOs. With the exceptions and conditions listed in subchapters 4.2.3.7.2.2 through 4.2.3.7.2.4, all geophysical MQOs were met during the RI field activities.

4.2.3.6.2.2 In areas of poor GPS quality, calculated data densities and acquisition speeds were artificially skewed due to variations in consecutive data positions created by the inaccurate GPS data. To obtain a relatively accurate representation of the data quality, data positions were interpolated manually, as described in subchapter 4.2.3.5.4.3. The sampling density and data acquisition speed were then calculated from the interpolated data and compared against the MQOs described. Approval of the manual interpolation method was

requested by the QC geophysicist and was granted by the USACE project geophysicist. Anomalies selected from interpolated data positions or data positions having poor GPS quality were not selected for intrusive investigation but were retained for anomaly density estimates.

4.2.3.6.2.3 Two datasets collected with a single EM61-MK2 on March 22, 2010, in the Area of Interest 5 investigation area failed the background noise MQO. A large number of negative spikes and low amplitude anomalies were detected in the DGM data. The high noise levels were found to be a result of water infiltrating the coil through several cracks in the plastic coating during the adverse weather conditions (rain and snow) encountered that day. The instrument was subsequently replaced and the data in question were recollected. No spikes or excessively noisy data were observed in the recollected data, and the new instrument passed each of the daily QC tests. A root cause analysis written by the site geophysicist and approved by the USACE project geophysicist is included as Appendix G.

4.2.3.6.2.4 The dynamic positioning repeatability MQO for a single grid (G03\_JM) was not met. In this case, the seed item was not selected by the Blakely test during target selection. When the known location of the seed item was plotted on the gridded and positioned DGM data, it was found to have been placed within a large area of anomalous readings. The automated Blakely test was unable to distinguish the seed item from the surrounding anomalous area and therefore did not select the seed item as a discreet target. This issue was discussed with the USACE project geophysicist, who determined that the grid would not need to be recollected. The field team was instructed in subsequent grids to ensure that seed items were placed in locations free of anomalous EM61-MKII readings. The dynamic positioning MQO was met in all other grids.

#### 4.2.3.7 Anomaly Reacquisition

Anomalies identified for intrusive investigation were reacquired consistent with the methods identified in the final work plan. Reacquisition was conducted using the Geonics EM61-MK2 metal detector equipped with a handheld computer capable of displaying real-time mV readings. The highest mV reading within the search radius was flagged for investigation. Anomaly locations were marked with pin flags labeled with the appropriate anomaly identification number. Pertinent information recorded during the reacquisition included the reacquisition time, date, and the geophysical instrument response. Reacquisition data are included in the project intrusive results database as Appendix H.

#### 4.2.3.8 Excavation Methods

Consistent with work plan procedures, intrusive operations at anomaly locations identified for investigation were initiated by hand digging (i.e., using hand tools, not mechanical methods). Exclusion zones established in the RI work plan to protect the public and nonessential personnel from both intentional and unintentional detonations were enforced throughout the intrusive operations. The intrusive team excavated at the location of the highest mV reading within the 3-foot search radius until the source of the anomaly was found or a nocontact was determined. If no single point within the search radius was determined to be an anomaly location (i.e., all readings remained constant), the center point of the radius was dug until the source of the anomaly was found or a no-contact was determined. A location was considered a no-contact when no specific metallic items were encountered after excavating 2 feet in depth, and no definite anomalous signal remained in the excavation. If present, the signal was pursued until a metallic item was found.

#### 4.2.4 Munitions Management

#### 4.2.4.1 Munitions and Explosives of Concern Identification and Removal

Intrusive investigation activities were conducted by teams consisting of either a three-man team consisting of one UXO technician III (team leader), and two UXO technician IIs or a five-man team of one UXO technician III and four UXO technician IIs. Excavation procedures at each anomaly location were conducted in accordance with the work plan (Parsons, 2010).

#### 4.2.4.2 Intrusive Investigation Quality Control

Selected anomalies were intrusively investigated and characterized by the downrange intrusive team. The downrange team leader documented the source of the anomaly and verified that the anomaly had been adequately characterized. A final reading was taken with the EM61-MK2 at the anomaly location to confirm that the area had been cleared. Any remaining response at an anomaly location was investigated unless the source of the response could be attributed to an anomaly greater than 3 feet from the original peak. In addition to the post-intrusive checks by the dig teams, the site geophysicist reviewed the dig results and compared what was found by the intrusive teams with the geophysical anomalies selected from the DGM data.

#### 4.2.4.3 MEC/MD Accountability

4.2.4.3.1 In accordance with the approved Work Plan (Parsons, 2010b), an account of recovered MPPEH, MEC, or MD items, including photographs, was maintained during the RI. The size, type, and model/mark number were recorded in the project database for each MEC item. If possible, similar information was recorded for MD as well (although many times, the specific munition could not be determined from MD fragments). The depth to the top of each recovered items was recorded as well. The demolition date for MEC items that were blown-in-place (BIP) was also recorded in the database.

#### 4.2.4.4 Inspection of Material Potentially Presenting an Explosive Hazard

4.2.4.4.1 In accordance with the approved work plan (Parsons, 2010b), MPPEH items observed during intrusive operations were evaluated by the SUXOS and the UXOSO. Items confirmed or suspected to be MEC were either BIP or, if they were determined to be acceptable-to-move and with the concurrence of both the UXOSO and the USACE safety specialist, the items were consolidated with other MEC items for detonation.

4.2.4.4.2 Once demolition operations were complete, the SUXOS certified that the explosively vented items and remaining MPPEH were free of explosive hazards. This condition was verified by the unexploded ordnance quality control specialist (UXOQCS). Once the MPPEH was determined to be free of explosive hazards, the SUXOS certified and

signed, and the SSHO/UXOQCS verified and signed, the DD Form 1348-1A to certify the material as MD (Appendix A). After inspection and certification, the recovered MD items were drummed, and the drummed MD was stored in the secure storage area until appropriate disposition was arranged.

#### 4.3 PERCHLORATE CONTAMINATION CHARACTERIZATION

#### 4.3.1 Purpose of Perchlorate Groundwater Sampling Activities

4.3.1.1 Based on the findings of previous investigations, it was determined that this investigation would focus on the potential presence of perchlorate in groundwater. Therefore, the objective of the RI with regard to MC was to determine if a release of perchlorate from munitions activities at the former Spencer Artillery Range site has occurred to the groundwater and to determine the nature and extent of the release, if applicable. The intent of this characterization is to determine if there is a need for remedial response due to MC and, if so, to provide the required information for the development and evaluation of any necessary response alternatives.

4.3.1.2 For this RI, preliminary COPCs are those chemical contaminants considered to be potentially present, and so were initially selected for analysis but have not yet been analyzed and evaluated. COPCs are defined as chemical contaminants resulting from munitions-related activities that are present at concentrations above applicable preliminary screening values (see Subchapter 4.3.4). Chemicals of concern (COCs) are defined as the COPCs that are present at sufficient concentrations to pose a risk to human health or the environment.

4.3.1.3 The only preliminary COPC identified for the RI is perchlorate (Appendix I, Parsons, 2010b). As stated in the sampling and analysis plan (SAP) (Parsons, 2010b), if perchlorate is detected in groundwater and complete exposure pathways are identified, analytical results will be incorporated into a phased human health risk assessment. First, analytical perchlorate results will be compared to ambient groundwater concentrations. Ambient concentrations of perchlorate in groundwater will be based on two upgradient ambient samples collected from areas with no prior known munitions impact, as specified in Section E.6.2 of the SAP. Concentrations of perchlorate greater than three times the maximum ambient concentration will be compared to the DOD preliminary remediation goal (Perchlorate Release Management Policy, April 22, 2009) of 15 micrograms per liter ( $\mu$ g/L) (DoD, 2009b) for managing perchlorate. Concentrations present below the criteria are not expected to pose an unacceptable risk and will not be considered further in the risk assessment. Concentrations of perchlorate for further consideration in a quantitative deterministic risk assessment.

4.3.1.4 To achieve these objectives, groundwater samples were collected across the site based on agreements reached by the TPP team during the TPP process for this RI (Appendix I, Parsons, 2010a). Samples were collected in accordance with the approved project SAP (Parsons 2010b).

#### 4.3.2 Field Sampling Activities Summary

#### 4.3.2.1 Characterization of Chemicals of Potential Concern

The work plan (Parsons, 2010b) identified proposed groundwater sampling locations; however, research identified additional wells. These groundwater sampling locations within the Cumberland Plateau aquifer system were presented and approved by the TPP team. The sample locations for Spencer Artillery Range are presented on Figure 4.8. Sampling was conducted to evaluate the presence of perchlorate in groundwater due to munitions activities at the site.

#### 4.3.3 Analytical Laboratory and Analyses

4.3.3.1 Samples were shipped to Agriculture and Priority Pollutants Laboratory, Inc. (APPL), in Clovis, California, and one QA sample was sent to ALS Laboratory Group, in Salt Lake City, Utah, for analysis. Groundwater samples were analyzed for perchlorate (Method SW6850). Analytical data were verified prior to being released by APPL using both editorial and technical reviews. Laboratory extraction, analysis methods, and target analytes were conducted in accordance with the RI/FS work plan (Parsons, 2010b).

4.3.3.2 Once finalized by the laboratories, analytical data generated during the sampling effort were validated by the Parsons data validator in accordance with the requirements identified in the SAP. The validation included requirements in DoD Quality System Manual (QSM) Version 4.1; DoD Perchlorate Handbook, August 2007, Revision 1, Change 1; and USEPA SW 846 methods. Data validation reports were generated by the project chemist for data packages and are provided in Appendix B. The validation reports note that all data are usable.

#### 4.3.4 Preliminary Screening Values

For this RI, the DOD preliminary remediation goal (Perchlorate Release Management Policy, April 22, 2009) for managing perchlorate (15  $\mu$ g/L) is used to determine whether perchlorate contamination is present.

#### 4.4 DEPARTURES FROM PLANNING DOCUMENTS

4.4.1 The RI at Spencer Artillery Range was conducted in accordance with the final RI/FS work plan (Parsons, 2010b) with the following deviations:

• Rights of entry were negotiated prior to completion of the final work plan and approximately 90% of the planned investigation areas were accessible to the field team. Access to one parcel in the southeast portion of Jakes Mountain was denied after DGM had been conducted on the parcel. Therefore, no intrusive work was conducted on this parcel. Although access to some parcels was not granted, access was permitted to 90% of the investigation area and the goals and objectives of the RI were met.

- Reconnaissance of the former airfield south of the site was supplementary to the scope of the project because of concerns that TDOR expressed of possible MEC/MD contamination.
- Due to heavy canopy cover in many areas and signal interference from rugged terrain, procedures for positional acquisition/reacquisition of transect anomalies were altered. Four transects and one grid were collected using the detect and dig method of anomaly acquisition, which involved detecting the anomaly and digging the same day.
- During the field activities, the team reviewed the DGM data for JMIA and discussed the possibility of collecting an additional 7 acres of DGM transects (previously funded for the project but not included in the work plan). The team agreed that the Sequoia Subdivision should be further investigated due to its future residential land use.
- Based on the intrusive investigation data results, it was agreed that the southern perimeter of JMIA be extended to further delineate the area.

4.4.2 All changes were fully discussed with the TPP team prior to initiation. No other departures from the planning documents occurred for the RI performed at Spencer Artillery Range.

#### 4.5 STATUS OF DATA QUALITY OBJECTIVES

#### 4.5.1 Data Quality Objectives for Munitions and Explosives of Concern Investigation

The MEC DQO was achieved for the investigation areas within Spencer Artillery Range by meeting or exceeding the goals for acreages of instrument-aided reconnaissance and DGM and by exceeding the required number of anomalies to be investigated in areas where ROEs were obtained. A total of 7.63 acres of instrument-aided reconnaissance (within six designated PAOIs) was performed during the RI (21 miles at a path width of 3 feet with approximate 200-foot line spacing), which exceeded the DQO of 6.67 acres agreed to by the TPP Team. Furthermore, the total acreage of geophysical data collected included 59.4 acres of transects (137.5 miles at a path width of 3 feet) and 5.17 acres of grids, which met the agreed DQOs of 57 acres of transects (7 acres were added to the originally planned 50 acres during field activities) and 5 acres of grids, respectively. A total of 8,474 anomalies were identified, of which 1,503 were intrusively investigated. This exceeded the established DQO of 1,500. The geophysical MQOs for the RI project were also achieved. Table 4.6 summarizes the status of the MEC DQOs for the Spencer Artillery Range RI.

Table 4.6Munitions Response Site-Specific MEC Data Quality ObjectivesSpencer Artillery Range, Van Buren County, Tennessee

	Instrument Aided	Digital Geophysical Mapping		Anomaly Investigation		
Recon (a	(acres)	Transects <sup>(1)</sup> (acres)	Grids (acres)	Total Anomalies	Transects	Grids
DQO	6.67	57 <sup>(3)</sup>	5	1500 <sup>(2)</sup>	-	-
RI Actual Total	7.63	59.4	5.17	1503	781	722
DQO Met?	Yes	Yes	Yes	Yes	-	-

(1) Transect acreage based on 3-foot-wide path.

(2) A DQO of 1,500 intrusive anomalies was established for the site without specification by transect or grid.

(3) 7 acres of DGM transects were added during the field investigation (not included in the work plan)

#### 4.5.2 Data Quality Objectives for Perchlorate Groundwater Sampling

The perchlorate groundwater sampling DQO for the RI at Spencer Artillery Range is to establish if there is an unacceptable risk to human health and the environment. The groundwater sampling DQO was achieved for Spencer Artillery Range by the collection and analysis of groundwater samples from 10 existing water wells (Figure 4.8). Each well sample was analyzed for perchlorate.






## Figure 4.3

Reconnaissance Transects and Observation Points Formerly Used Defense Site Spencer Artillery Range FUDS Project # G04TN017801 Spencer, Tennessee

## Legend









HUNTSVILLE, ALABAMA Former Spencer Artillery Range

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## Legend

Reconnaissance Transect Former Airfield Location FUDS Boundary

**Observation Point** 

500 250 0 500

Image Source: 2010 Orthophotos Projection: Tennessee State Plane, NAD83, Feet

## Figure 4.4

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







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

### Legend



Bald Knob Investigation Area

Jake's Mountain Investigation Area

**Residential Investigation Areas** 

Trail of Tears<sup>(a)</sup>

PAOI-6

PAOI-5

PAOI-1

Yes

FUDS Boundary

## **Right of Entry**

No Access/No Response

Notes:

(a) No brush cutting or intrusive investigation within identified Trail of Tears location.
(b) Grid JM-G08 collected within grass area along Trail of Tears, but not intrusively investigated.

> Image Source: 2010 Orthophotos Projection: Tennessee State Plane, NAD83, Feet

Ν

0 2	2,250	4,5	Feet 9,000				
PARSONS U.S. ARMY ENGI BARSONS & SUPPORT CI HUNTSVILLE, AI					INEERING CENTER ALABAMA		
designed by: CR	Former Spencer Artillery Ran				Range		
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## Figure 4.8

Groundwater Sampling Locations Formerly Used Defense Site Spencer Artillery Range FUDS Project # G04TN017801 Spencer, Tennessee

## Legend





3,000 1,500 0

3,000

#### PARSONS

#### U.S. ARMY ENGINEERING & SUPPORT CENTER HUNTSVILLE, ALABAMA

⊐ Feet

6,000

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#### CHAPTER 5 REMEDIAL INVESTIGATION RESULTS AND REVISED CONCEPTUAL SITE MODEL

#### 5.1 INTRODUCTION

RI activities were conducted at Spencer Artillery Range between February 16, 2010, and June 23, 2010. This chapter describes the results of the RI, the estimated extent of contamination at the site, and how these results affect the CSM.

#### 5.2 REMEDIAL INVESTIGATION RESULTS

As described in Chapter 4, the tasks involved with the MEC and MC characterization during this RI included instrument-aided reconnaissance, DGM, intrusive anomaly investigation, and perchlorate groundwater sampling. This subchapter details the results of the activities and investigations conducted at the Spencer Artillery Range.

#### 5.2.1 Instrument-Aided Reconnaissance Results

5.2.1.1 No surface MD or MEC was observed during the reconnaissance. In addition, observations associated with past munitions use or historic military activity/training was limited to one location. One observation recorded within PAOI-1 during reconnaissance identified eight large depressions in the ground surface. Each depression was approximately the same size (4.5 feet deep, 8 feet wide) and, similar to the findings noted in the EE/CA for this area, could have been associated with historic mortar firing positions. Only one subsurface anomaly was recorded in and around the eight depressions, a significant (i.e., large) subsurface anomaly at the bottom of one depression. No subsurface anomalies were detected in the other depressions noted in PAOI-1.

5.2.1.2 In general, low subsurface anomaly counts were recorded throughout each reconnaissance area. As shown on Table 5.1, 83% of the observations (704 out of 850 observations) recorded zero subsurface anomalies. None of the observations recorded a subsurface anomaly count greater than 9 (i.e., the number of anomalies counted while traversing from one waypoint to the next; on average a distance of 130 feet). The subsurface anomaly density was calculated for each of the six reconnaissance PAOIs. Figure 5.1 presents the calculated subsurface anomaly density. The eastern portion of PAOI-4 contained the highest concentration of subsurface anomalies; however, this area coincides with a former timber camp that can be seen in the 1943 image.

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<b>Recorded Number of</b> <b>Subsurface Anomalies</b> <sup>(1)</sup>	Number of Recon Observations (waypoints)	Percent of Total						
Zero	704	82.8%						
1	88	10.3%						
2-5	54	6.4%						
6-9	4	0.5%						
Total	850	100						

 Table 5.1

 Summary of Subsurface Anomaly Counts

 Remedial Investigation, Spencer Artillery Range, Van Buren County, Tennessee

(1) The number of anomalies counted while traversing from one waypoint to the next; on average a distance of 130 feet.

5.2.1.3 The complete results of the instrument-aided reconnaissance conducted at Spencer Artillery Range are presented in the Final Reconnaissance Summary Report in Appendix K. The Reconnaissance Report, dated June 9, 2010, was developed following completion of reconnaissance data collection and was approved by the USACE. The report recommended a 50-foot by 50-foot DGM grid centered on the depression with the subsurface anomaly at PAOI-1. The location could have been a mortar firing position and was therefore recommended for additional investigation. The Reconnaissance Report also recommended a 50-foot by 50-foot DGM grid in the high-density subsurface anomaly area within the western portion of PAOI-6. Although this location was relatively small and relatively low subsurface anomaly density, it represented the "most probable" target impact area based on reconnaissance results. Figure 5.1 shows the locations of the DGM grids identified based on reconnaissance results.

5.2.1.4 Upon completion of DGM data collection and data processing, no anomalies were identified in the grid placed within PAOI-6; therefore, no intrusive activities were warranted. No brush cutting (landowner refusal) was allowed in or around the DGM grid for the investigation of the grid within PAOI-1; therefore, the detect and dig method was implemented. Thirteen cultural debris items (e.g., wire) were found within the grid and no MEC or MD.

5.2.1.5 As indicated in Chapter 4, additional surface reconnaissance activities were conducted in the airfield in the southern portion of the site at the request of TDOR. No surface MD or MEC was observed during the reconnaissance, resulting in no indication of MEC/MD remains. Photographs taken at each observation point are provided in Appendix K.

5.2.1.6 The decision rule for the reconnaissance effort was to determine "if MEC or elevated subsurface anomaly counts are consistent with a possible impact area, then evaluate area for inclusion for transect and/or grid-based DGM. Otherwise, if MEC is not found and the area does not contain elevated subsurface anomaly counts, no additional investigation." Based on reconnaissance results, no MEC was identified. One area within PAOI-6, however, was identified as a possible small impact area. This area within PAOI-6 and a location in PAOI-1 (possible firing position) were recommended for additional investigation. The additional investigations completed at PAOI-1 and PAOI-6 identified no MEC/MD. Based on the identified decision rule and the results of the additional investigations, PAOI-1 through PAOI-4, PAOI-6, and PAOI-7 are not considered contaminated with MEC, and additional investigation is not warranted.

#### 5.2.2 Intrusive Investigation Results

#### 5.2.2.1 General

Twelve MEC items and over 1,000 MD items were recovered during the intrusive investigation. Small arms ammunition (i.e., .50-caliber) was identified throughout most of the site. Other non-munitions-related items were identified as cultural debris (e.g., wire, nails, hand tools, horse shoes, etc.). Table 5.2 summarizes the results, and a complete listing of intrusive results is provided on the dig sheets in Appendix H. Figure 5-2 provides an overview of the results of the intrusive investigation. Appendix A documents disposal of munitions debris removed during the RI, and Appendix D documents demolition of MEC items, including a demolition summary table.

Remedial	Remedial Investigation, Spencer Artillery Range, Van Buren County, Tennessee								
Category	Number	Percentage	Priority 1	Priority 1 %	Priority 2	Priority 2 %	Priority 3	Priority 3 %	
MEC	12	0.8%	5	83%	1	17%	0	0%	
MD	1,094	72.6%	123	41%	150	51%	24	8%	
Trash/Cultural	225	15%	65	38%	77	45%	28	17%	
No Contact	150	10%	0	0%	14	29%	34	71%	
Other <sup>(1)</sup>	69	4.5%	9	23.5%	14	37%	15	39.5%	
Duplicate Anomalies	25	1.6%	3	50%	3	50%	0	0%	
Total	1,	<b>506</b> <sup>(2)</sup>							

 Table 5.2

 Remedial Investigation – Intrusive Results

 Demodial Investigation Spancer Artillery Pange Van Puren County Tennessee

(1) "Other" refers to anomalies which were reacquired during intrusive investigation, but which no source for the signal was identified.

<sup>(2)</sup> Three MEC items were found on the surface between anomaly locations; 1,503 anomaly locations were intrusively investigated.

#### 5.2.2.2 Munitions and Explosives of Concern

5.2.2.2.1 Recovered MEC items included one each 3-inch AP, Mk29 with an MkII Mod 9 fuze, and 11 each 37mm MKII. Both types of munitions are high explosive rounds; additional information regarding these munitions, including size and explosive component, are in Appendix F. Table 5.3 summarizes MEC and MD items recovered in each investigation area during the RI.

5.2.2.2 The 11 37mm MK II projectiles recovered in BKIA (five) and JMIA (six) were not unexpected because the 37mm projectile was the most common non-small arms munition found at the site. Historic use of 37mm projectiles at the former Spencer Artillery Range was well documented, and both BKIA and JMIA were known impact areas. Figure 5.2 shows the locations of the 37mm MK II projectiles found within BKIA. Three of the MEC items in BKIA were found on the surface, while the remaining two items were found at depths of 7 inches and

Table 5.3 Summary of Recovered Munitions and Explosives of Concern and Munitions Debris Remedial Investigation, Spencer Artillery Range, Van Buren County, Tennessee

Investigation Area	Munitions and Explosives of Concern <sup>(1)</sup>	Munitions Debris
Bald Knob	5 – 37mm, MkII	<ul> <li>35 – 37mm projectile pieces</li> <li>7 – Fragmentation, unidentifiable</li> <li>4 – Small arms ammunition (.50 cal)</li> </ul>
Potential Area of Interest 5	1 – 3" AP, Mk29 with an MkII Mod 9 Fuze	<ul> <li>14 – 76mm, AP, M79</li> <li>2 – 37mm, AP, M80</li> <li>6 – 37mm projectile pieces</li> <li>7 – Fuze pieces</li> <li>1 – Balistic Cap</li> <li>58 – Fragmentation, unidentifiable</li> <li>112 – Small arms ammunition (.50 cal)</li> </ul>
Residential	None	<ul> <li>3 - 155mm,</li> <li>3 - 76mm, AP, M79</li> <li>1 - 75mm projectile remains</li> <li>2 - 37mm, AP, M80</li> <li>17 - 37mm projectile pieces</li> <li>65 - Fragmentation, unidentifiable</li> <li>8 - Small arms ammunition (.50 cal)</li> </ul>
Jakes Mountain Impact Area	6 – 37mm, MkII	<ul> <li>3 - 155mm,</li> <li>3 - 155mm, shrapnel</li> <li>1 - 105mm</li> <li>3 - 76mm, AP, M79</li> <li>3 - 75mm, shrapnel</li> <li>1 - 75mm projectile remains</li> <li>100 - 37mm projectile pieces</li> <li>9 - Fuze pieces</li> <li>568 - Fragmentation, unidentifiable</li> <li>1 - 105 Cartridge case &amp; link</li> <li>2 - Lead ball pieces</li> <li>1 - Powder Train Time Fuse</li> <li>1 - T Bar fuze (M48) and shrapnel balls</li> <li>1 - T-bar/Champ</li> <li>106 shell piece</li> <li>Bullet Casing</li> <li>1 - Shotgun primer base</li> <li>116 - Small arms ammunition (.50 cal)</li> </ul>

21 inches bgs. Surface MEC within BKIA was not anticipated due to several decontamination surface sweeps conducted in the 1950s.

5.2.2.3 Figure 5.2 also shows the locations of the six 37mm MK II projectiles found in JMIA. As shown, the rounds were found close to each other in the very southern portion of the Jakes Mountain investigation area. Five of the MEC items were outside the remedial investigation boundary identified in the work plan. Based on the preliminary CSM, MEC was

not anticipated outside the Jakes Mountain boundary identified in the work plan. Historic evidence of past use and MEC/MD impacts to this area had not previously been identified. The six 37mm MK II projectiles were found at depths ranging from 0.25 to 10 inches bgs.

5.2.2.4 The one 3-inch AP MK29 recovered in PAOI-5 was unusual because it was the only 3-inch round found at the site (including EE/CA results). Additionally, the Mk II Mod 9 fuze with the 3-inch round was not typical. The 3-inch AP, MK29 was recovered in PAOI-5, which had not been previously identified as an impact area. Figure 5.2 shows the location of the MEC item found in the southeast corner of PAOI-5. The 3-inch AP MK29 was found at a depth of 12 inches bgs.

#### 5.2.2.3 Munitions Debris

MD items generally included remnants of various projectiles (37mm, 75mm, 76mm, 105mm, and 155mm), expended fuzes, small arms ammunition (.50 caliber), and hundreds of pieces of unidentifiable munitions fragmentation. The MD findings were consistent with the findings of the EE/CA. The most readily identifiable non-small arms MD included 37mm projectiles (162 items), 76mm projectiles (20 items), 155mm projectiles (nine items), 75mm projectiles (five items), and 105mm projectiles (two items). When fragments were found in dense clusters, the anomaly was characterized as a fragmentation pit. At some areas, fragments were so dense that it was uncertain if the pieces were derived from just one munition. Representative photographs of MD items found during the RI are in the Photo Documentation Log in Appendix K. After sorting to separate out cultural debris and inspection of the debris, the MD were transferred to 55-gallon steel drums, secured with serialized seals, and stored in the secure MD storage area pending proper disposal. The recovered MD was transferred on June 23, 2010, to personnel from DeMil Metals for disposal. The disposal documentation for MD found at Spencer Artillery Range during this RI is included in Appendix A.

#### 5.2.2.4 False Positive Rate

A performance goal for this RI (described in section 3.5.2.2 of the work plan) was to achieve a false positive rate of less than 15 percent. A false positive designation was given to each anomaly selected from the DGM data for which no signal was identified upon reacquisition and intrusive investigation of the anomaly. Intrusive investigation of 1,503 anomalies selected within the Spencer Artillery Range from transects, grids, and via the detect and dig method resulted in 69 false positives, or a false positive rate of approximately 4.5 percent (Table 5.2). This false positive rate meets the performance goal set for the RI/FS at the Spencer Artillery Range.

#### 5.2.2.5 Geophysical Anomaly Density

5.2.2.5.1 Geophysical anomaly density values across the FUDS were calculated using VSP software. VSP calculates anomaly density for transect and grid acreage within multiple, circular, user-defined areas (or "windows") along the length of each transect. For each window, an anomaly density is assigned to the center point, equal to the number of anomalies within the window divided by the total grid and transect area within each window. The density

calculations for each window are combined and statistically analyzed by VSP, which produces an overall color-shaded density data map for the area investigated (Figure 5.3).

5.2.2.5.2 The northwest area of JMIA appears not to be bounded on Figure 5.3; this is a result of a deep gorge crossing the edge of the area (Figure 2.2). The terrain in the gorge would not allow DGM and ROE was not permitted. Also, the EE/CA investigations found only cultural debris on the west side of the gorge with no evidence of MEC (refer to Figure 2.5) and the conceptual site model does not identify the gorge as a possible impact area. For these reasons, the northwest area of JMIA is bounded by the gorge.

5.2.2.5.3 The geophysical anomaly density was calculated to meet the data quality objective of identifying an impact area with a 95% confidence level assuming: target area size = 300ft radius, target area anomaly density = 200 anomalies per acre, background anomaly density = 50anomalies per acre. The TPP Team defined these anomaly density parameters to delineate impact areas and MRS boundaries (boundaries based on MEC/MD associated with defined geophysical anomaly density). As noted in Table 5.2, there is a strong correlation between geophysical anomalies and MEC/MD; 73.4% of the investigated geophysical anomalies were MEC or MD. Therefore, it is reasonable to assume that the high-density geophysical anomaly areas also contain the highest concentrations of MEC/MD. At several locations, however, as shown on Figure 5.3, MEC was found in areas with relatively low geophysical anomaly density. Specifically, MEC was found in the low-density areas within the southern portion of JMIA, the southeast portion of PAOI-5, and the southwestern portion of BKIA. Although it can be stated with a 95% confidence level that areas above 200 anomalies per acre (shown as reddish-pink on Figure 5.3) were identified, in areas where DGM data could not be collected (e.g., ROE refusal or inaccessible terrain), the confidence level is less than 95%. The DOOs established in the work plan were met; however, the proposed definition of "contamination" requires revision based on the actual RI results (e.g., MEC found in areas with an anomaly density less than 200 anomalies per acre). Recommendations for revised MRSs based on the RI results are discussed in Subchapter 5.3.1.1.

#### 5.2.3 Munitions Constituents Sampling and Results

5.2.3.1 The groundwater sample locations and laboratory analytical results for perchlorate are presented on Figure 5.4 and in Appendix B. Twelve groundwater samples (including two QC samples) were collected from existing wells at Spencer Artillery Range. Wells selected for sampling were existing domestic wells and groundwater monitoring wells. As shown on Figure 5.4, one sample was collected from location JMIA-GW-008 and sent to the QA lab (ALS Laboratory Group) for analysis. QA sample results were sent directly to the USAESCH project manager.

5.2.3.2 Perchlorate was not detected in the groundwater samples collected during the RI. A detection of perchlorate exceeding the PRG (Subchapter 4.3.4) and attributable to historic munitions-related activities conducted at Spencer Artillery Range would be considered a COPC. Based on the analysis of the samples collected, however, there is no evidence of COPCs in the groundwater at Spencer Artillery Range, and further evaluation of this MC in the Chapter 7 risk assessment is unnecessary.

#### 5.3 EXTENT OF MUNITIONS AND EXPLOSIVES OF CONCERN AND MUNITIONS CONSTITUENTS CONTAMINATION

#### 5.3.1 Extent of Munitions and Explosives of Concern Contamination

As described in Subchapter 5.2, the instrument-aided reconnaissance, DGM surveys, and subsequent intrusive investigation conducted at Spencer Artillery Range during this RI, along with the results of the previously conducted investigations, have confirmed the presence of MEC and/or MD on the surface and in the subsurface.

MEC and MD recovered during the EE/CA and RI are summarized in Table 5.4

MEC Items		
Item	Model	Туре
37mm Projectile	M74	Armor Piercing
	MKII	High Explosive
75mm Projectile	M61	Armor Piercing Capped
3" Projectile	Mk 29	Armor Piercing
155mm Projectile	M101,M101B1	High Explosive
155mm Projectile	MK1	Shrapnel
Munitions Debris and Poten	tial Items <sup>(1)</sup>	
Item	Model	Туре
37mm Projectile	MKII	High Explosive
	MK1	Shrapnel
75mm Projectile	M48	High Explosive
	M71	Armor Piercing Shot
76mm Projectile	M79	Armor Piercing
105mm Projectile	M1	High Explosive
	MKI, MKIAI, M102	High Explosive
155mm Projectile	M107	High Explosive
155mm Flojectile	M102, M102B1	High Explosive
	MKIII, MKIIIA1	High Explosive
8" Projectile	MKIA1	High Explosive
240mm Projectile	M114	High Explosive
60mm Mortar	M49A2	High Explosive
81mm Mortar	M43A1	High Explosive

# Table 5.4Munitions Found During the EE/CA and RISpencer Artillery Range, Van Buren County, Tennessee

<sup>(1)</sup> Unidentifiable fragments/debris found during the EECA/and RI are characterized as potential items and indicates that fragments from this general type of ordnance were potentially found during the investigation.

The RI focused on identifying possible impact areas and delineating areas with high geophysical anomaly density, as these represent the areas with the greatest likelihood of

containing MEC. Based on the EE/CA and RI results, sixteen (16) MRSs are recommended. An MRS is defined as a discrete location known to require a munitions response. Although the RI was successful in meeting the objectives of assessing potential impact areas based on anomaly density (i.e., DQOs were met), it should be noted that, similar to conclusions identified in the EE/CA, artillery has the potential to land anywhere within the former Spencer Artillery Range. The recommended MRSs within the FUDS are discussed below.

#### 5.3.1.1 Recommended Munitions Response Sites

5.3.1.1.1 For the RI, 11 separate investigation areas were identified. Based on data results presented within this RI Report, MEC contamination is not anticipated within PAOI-1, PAOI-2, PAOI-3, PAOI-4, PAOI-6, and PAOI-7. MEC was found within BKIA, PAOI-5, and JMIA, and elevated geophysical anomaly densities and MD were also found in these three investigation areas (as well as the residential investigation area). Due to the presence of MEC, elevated geophysical anomaly areas, and changes in current and future land use (identified since the preliminary CSM and the work plan), the 15 MRSs identified on Table 5.5 are recommended.

5.3.1.1.2 In addition, MRS-16 includes the remaining lands of the original 17,260 acre MRS. It was agreed by the TPP team that only portions of this MRS be investigated as part of the RI based on historical records, analysis of aerial photography, previous field investigations, and future land use. This area is not deemed to have been impacted by concentrated munitions use and is considered to be "uncontaminated by MEC." This MRS only presents explosive hazards at very low probability of occurrence; therefore, a MEC HA will not be conducted for this area and a Feasibility Study is not recommended. Figure 5.5 presents the locations and boundaries for the recommended MRSs in conjunction with the geophysical anomaly density (using both EE/CA and RI DGM data).

5.3.1.1.3 The proposed MRSs were created based on historical data, the results of the intrusive investigation, and site land uses. Predominantly, the MRS boundaries are based on the general levels of MEC hazards present at the site, which largely depend on the type and amount of MEC and the numbers of potential receptors (i.e., population) present. Although several of the proposed MRSs did not contain MEC, they are included based on historic use (e.g., artillery impact area), the presence of MD, current or future land use, and/or relative geophysical anomaly density.

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MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	MEC (Depth)	High anomaly density Acreage (≥ 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Total Anomaly Count	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-01	Wooded/Hunting/Logging Redacted-Privacy Act	4,521	Jakes Mountain Artillery Impact Area	240mm (4) 155mm (6) 105mm (11) 75mm (3) 37mm (57) 20mm (3) unknown munitions (108)	4 each 37mm, MkII (surface, 5", 9", 10") 1each 75mm AP (1") 1each 155mm w/m1907 powder train time fuze (30")	3,427 acres (75% of total area)	131	592,251	240mm frag (44) 155mm frag (381) 105mm frag (10) 81mm mortor frag (1) 75mm frag (39) 60mm mortor frag (1) 37mm frag (50) 8" projectile (4) unknown frag (573) fuze (12) Base plate (1) small arms (8)	MEC found, former impact area, high anomaly density
MRS-02	Commercial (explosives storage, tree farming)	331	South of known impact area. Timber cleared area, no evidence impact craters. Possible firing point.	Not included as part of 1956 Surface Clearance	4 each 37mm, MkII <sup>a)</sup> (0.25", 2", 4", 5")	2 acres (0.4% of total area)	38	12,578	75mm frag (2) 37mm frag (13) unknown frag (5) fuze (2) small arms (7)	MEC found, proximity to known impact area, possible firing point, commercial land use
MRS-03	Active Development/Residential (Covenant Farms – 5acre lots)	262	Northern edge of known impact area	None	None	21 acres (8% of total area)	92	24,104	155mm frag (9) 37mm AP (1) 37mm frag (1) unknown frag (2)	Residential area, proximity to known impact area, MD found
MRS-04	Active Development/Residential (Covenant Farms – large lots)	192	Jakes Mountain Artillery Impact Area	155mm (3) 37mm (2) unknown munitions (3)	None	185 acres (96% of total area)	354	67,968	155mm frag (26) small arms (2)	Residential development, known impact area, high anomaly density
MRS-05	Recreation/Cabins Redacted-Privacy Act others)	684	Jakes Mountain Artillery Impact Area	155mm (2) 75mm (2)	1each 155mm HE w/M- 51 Fuze (14")	526 acres (77% of total area)	259	177,156	155 frag (73) 105mm debris (2) 37mm frag (2) fuze (2) unknown frag (221) small arms (21)	MEC found, former impact area, high anomaly density, camping and recreational land use

Table 5.5Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

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MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	MEC (Depth)	High anomaly density Acreage (≥ 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Total Anomaly Count	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-06	Undeveloped Subdivision (Sequoia Subdivision)	497	Jakes Mountain Artillery Impact Area	37mm (3) 20mm (3) small arms (17) unknown munitions (3)	None	462 acres (93% of total area)	688	341,936	155mm frag (62) 105mm frag (2) 76 mm AP (2) 75mm frag (1) fuze (3) 37mm frag (4) unknown frag (111) small arms (66)	Future residential development, former impact area, high anomaly density
MRS-07	Undeveloped Subdivision (Indian Trails Phase III)	145	Jakes Mountain Artillery Impact Area	155mm (1) 37mm (1) unknown munitions (13)	None	134 acres (93% of total area)	124	17,980	155mm frag (2) 37mm frag (15) 37mm AP (1) unknown frag (22)	Future residential development, former impact area, high anomaly density
MRS-08	Undeveloped Subdivision (Indian Trails Phase I and II)	379	Western edge of known impact area	105mm (1) 75mm (1) 37mm (1)	None	117 acres (31% of total area)	64	24,256	155mm frag (2) 37mm frag (1) 37mm AP (1) 75mm frag (1) 76 mm AP (2) unknown frag (2) small arms (8)	Future residential development, proximity to known impact area
MRS-09	Wooded/Hunting/Future Residential (Bald Knob east)	165	Bald Knob 37mm impact area	37mm (9)	5 each 37mm, MkII (3 on surface, 7", 21")	29 acres (18% of total area)	83	13,695	37mm frag (2) unknown frag (5) small arms (1)	MEC found, former impact area, future residential area
MRS-10	Wooded/Hunting (Bald Knob west)	193	Bald Knob 37mm impact area	37mm (6)	None	13 acres (6.7% of total area)	88	16,984	155mm frag (1) 37mm frag (30) unknown frag (1) small arms (2)	Former impact area
MRS-11	Undeveloped Subdivision (Whispering Pines) (some historic strip mining ~18 acres)	196	Unknown. Partially cleared, no impact craters.	Not included as part of 1956 Surface Clearance	1 each 3" AP, Mk29 with an MkII Mod 9 Fuze (12")	11 acres (3% of total area)	36	7,056	37mm AP (1) 76 AP (5) fuze (2) unknown frag (11) small arms (6)	MEC found, future residential development
MRS-12	Residential/Hunting/ Ranching (some historic strip mining ~13 acres)	173	Unknown. Timber cleared, evidence of impact craters	Not included as part of 1956 Surface Clearance	None	82 acres (47% of total area)	109	18,857	76mm AP (4) small arms (3)	High anomaly density (partial), land use

Table 5.5Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

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MRS	Current/Future Land Use	Acreage	Past DoD Use	1956 Surface Clearance (count of items)	MEC (Depth)	High anomaly density Acreage (≥ 120 anomalies/acre)	Average anomaly density for RI DGM area (anomalies/acre)	Total Anomaly Count	Munitions Debris (Count)	Rationale for MRS Delineation
MRS-13	Active Development/Residential	260	Unknown. Timber cleared, evidence of impact craters	Not included as part of 1956 Surface Clearance	None	176 acres (68% of total area)	197	51,220	155mm frag (10) 37mm AP (1) 76 AP (4) fuze (1) 37mm frag (11) 60mm mortor frag (3) unknown frag (31) small arms (44)	Residential development, high anomaly density
MRS-14	Wooded/Hunting/Ranching East half is open grassland currently used to graze cattle/horses Redacted-Privacy Act	353	Unknown. Timber cleared, evidence of impact craters in NE quadrant	Not included as part of 1956 Surface Clearance	None	154 acres (44% of total area)	82	28,946	155mm frag (2) 37mm frag (3) fuze (4) unknown frag (18) small arms (55)	High anomaly density (partial, North end), active ranching
MRS-15	Road/Trail of Tears	404 200 ft buffer from centerline	Traverses FUDS - Jakes Mountain Artillery Impact Area & Bald Knob 37mm impact area	37mm (6)	None. No intrusive investigations conducted due to archeological/cultural sensitivity.	172 acres (43% of total area)	Varies based on adjacent MRSs.	Varies based on adjacent MRSs.	None. No intrusive investigations conducted due to archeological/cultural sensitivity.	Portions of MRS within high density areas. National Parks Service recognizes the Trail of Tears as a National Historic Trail.
MRS-16	Wooded/Hunting/Logging (Remaining Lands)	9,800	Unknown. Possible troop maneuver area. Little/no evidence of concentrated munitions use	155mm (1) 75mm (1) 40mm (2) 37mm (15)	None	Not Assessed	Not Assessed	Not Assessed	155mm frag (13) 37mm frag (4) 75mm AP (1) M-51 fuze (1) 60mm Mortar (1) unknown frag (8) small arms (10)	Although scattered MD found, little/no evidence of concentrated munitions use. MRS required under FUDS program to account for "original" MRS acreage.

Table 5.5Munitions Response SitesSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

<sup>a)</sup> 37mm projectiles recovered in MRS-2 were not fired and could represent DMM.

#### 5.3.1.2 MEC/MD Density

5.3.1.2.1 The preliminary CSM associated MEC with high anomaly density areas and this is supported by recovery of MEC from within the high density area of Jakes Mountain Impact Area during the EE/CA. As noted previously, however, Figure 5.3 shows several MEC items found during the RI within relative low geophysical anomaly density areas. MEC at relatively high concentrations outside high-density geophysical anomaly areas does not agree with the preliminary CSM or the definition of "contaminated" developed for the site. Some possible explanations for MEC recovery during the RI within low anomaly density areas include the following:

- Although not identified as a firing point location, the 37mm projectiles found in the very southern portion of Jakes Mountain during the RI (MRS-02) were not fired and could represent discarded military munitions (DMM) associated with a firing point. These munitions were abandoned without proper disposal and; therefore, were not associated with an impact area with high anomaly density.
- Three 37mm projectiles found within Bald Knob (MRS-09) were found within a low anomaly density area that had been included in several surface removal actions in the 1950s. While it is unclear why some of the recovered items were found on the surface, the surface sweeps performed in the 1950s may have removed much of the metallic debris that would result in a high anomaly density area such as typically observed within an impact area.
- One 3" armor piercing projectile was found in an area without documentation as to past military use (MRS-11). Although the area was cleared of timber in the early 1940s (presumably for training), the DGM data results did not identify a high density anomaly area typically associated with an impact area. The recovered round was an armor piercing munition, so it is possible that it was fired at a temporary target. It is also possible that the area was grossly disturbed during coal strip mining activities (conducted after Spencer Artillery Range was closed) that took place in the vicinity. Strip mining activities may have disturbed the area such that high anomaly density areas are not present.

5.3.1.2.2 The revised CSM still identifies areas with high anomaly density as potentially associated with MEC. But additional areas that are "exceptions to the rule" are also considered (as noted above) when delineating munitions response sites.

#### 5.3.1.3 Depth of Recovered MEC/MD and Geophysical Investigation Depth Limitations

5.3.1.3.1 Chart 5.1 presents the depths associated with recovered MEC/MD during the EE/CA and RI. The data excludes small arms ammunition and, as indicated, over 95% of the recovered items were within the upper 12-inches.



Chart 5.1 Depths Associated with MEC/MD Recovered During EE/CA and RI Spencer Artillery Range, Van Buren County, Tennessee

5.3.1.3.2 As noted in the RI work plan, there are limitations to the DGM depth of detection regarding MEC. As expected, larger munitions produce larger responses and can therefore be more easily detected at deeper depths. If MEC items are limited in depth to the range where the geophysical sensors are capable of reliably detecting them then the vertical extent of MEC contamination can be accurately be determined. Conversely, if MEC items are located at depths greater than the maximum depth of detection for that item, then the geophysical method may not establish the maximum depths. Based on the results of the EE/CA and RI, over 95% of the MEC and MD recovered at the site has been found within the upper 12-inches (Chart 5.1). Although capable of detecting items at depths greater than 12-inches, it appears that the distribution of most items is within the upper 12-inches.

5.3.1.3.3 The smallest MEC item identified during the RI was a 37mm projectile with the depths of recovery ranging from the surface to 21-inches below ground surface. Chart 5.2 presents the number of 37mm projectiles and the depth of recovery. As noted in the work plan, 37mm projectiles have an anticipated depth of detection at 4mv of 13.4 inches when oriented in the "worst" position and a maximum detection depth of 25.3 inches when in the "best" position (Parsons 2010). Based on the depth of detection of the instrumentation and the recovered depth of 37mm, it appears that the vertical extent was determined.





#### 5.3.2 Extent of Munitions Constituents Contamination

5.3.2.1 Previous sampling of the Spencer Artillery Range collected in support of the EE/CA did not identify release of MC in the surface soil. As described in Subchapter 5.2.3 and shown on Figure 5.8, analysis of the groundwater samples collected from existing wells did not contain detectable concentrations of the COPC (perchlorate). Therefore, no contamination is attributable to the historical munitions-related activities that were conducted at Spencer Artillery Range.

#### 5.4 REVISED CONCEPTUAL SITE MODEL

Based on the results of the MEC and MC characterizations conducted at Spencer Artillery Range, the preliminary CSMs (described in Subchapter 3.1) were revised to reflect new information obtained during the RI. Table 5.6 summarizes the key information from the revised CSMs for each of the recommended MRSs at Spencer Artillery Range, including the potential receptors, the known or expected munitions and any confirmed COPCs, and the potentially complete exposure pathways for MEC and MC. Graphical depictions and summary tables for these revised CSMs are also included in Appendix E-2 of this RI report. The MEC and MC exposure pathways shown on this revised CSM are discussed further in the following subchapters.

#### 5.4.1 Munitions and Explosives of Concern Exposure Pathways

5.4.1.1 A potentially complete MEC exposure pathway is present any time a receptor can come near or into contact with a source of MEC and interact with it in a manner that might result in its detonation. As discussed in Subchapter 3.1.1, complete exposure pathways commonly require the presence of four critical elements (USEPA 1989); however, for MEC exposure pathways these are simplified to three critical elements: a *source* of MEC (i.e., an explosively hazardous item); a *receptor* (i.e., a person); and the *potential for interaction between the MEC source and the receptor* (i.e., the possibility that the item might be touched, moved, or otherwise disturbed by the receptor). All these elements must be present for a potentially complete MEC exposure pathway to exist; the MEC exposure pathway is incomplete if any one of these three elements is absent. The following paragraphs discuss the anticipated exposure pathways for MEC at Spencer Artillery Range based on the results of this RI, previous investigations, and historical information.

5.4.1.2 The preliminary CSMs for Spencer Artillery Range (Subchapter 3.1.1, Table 3.1, and Appendix E) indicated potentially complete MEC exposure pathways at each of the eleven investigation areas. Through the RI, however, no MEC source was identified for 6 of the investigation areas including PAOI-1, PAOI-2, PAOI-3, PAOI-4, PAOI-6, and PAOI-7; therefore, a complete exposure pathway for these areas is not anticipated. The other investigations areas confirmed the presence of MEC and/or MD on the surface and/or subsurface and the boundaries have been revised based on RI results. The areas with MEC/MD presence that have been revised and are recommended MRSs are identified in Table 5.5.

5.4.1.3 Based on the confirmed presence of MEC and/or MD, historic use, and/or high anomaly density within the recommended MRSs and the general level of site accessibility, the existence of potentially complete MEC exposure pathways at the surface and in the subsurface is confirmed for all MRSs, except MRS-16 as discussed in Section 5.3.1.1. This area is not deemed to have been impacted by concentrated munitions use and is considered to be "uncontaminated by MEC"; therefore, there is no MEC exposure pathway for MRS-16. These MEC exposure pathways are summarized in Table 5.6 and are depicted graphically on the revised CSMs included in Appendix E.

5.4.1.4 The CSMs and exposure pathways for MEC described above should be reviewed and possibly revised if new information concerning MEC presence, potential receptors, or site accessibility becomes available. The related characterization of MEC hazards for the fifteen identified MRSs at Spencer Artillery Range is described in Section 7.2 and Appendix J.

#### Table 5.6 Summary of Revised Conceptual Site Models and Potentially Complete Exposure Pathways Former Spencer Artillery Range Remedial Investigation

		Munitions and Explosives of Concern		Munitions Constituents	
Munitions Posnonso Sito	Potential Pecentors (1)	Known or Expected	Potentially Complete MEC	Chemicals of	Potentially Complete
Multitions Response Site	I otential Receptors	General Munitions Types <sup>(1)</sup>	Exposure Pathways	Potential Concern <sup>(2)</sup>	MC Exposure Pathways
MRS-01 Jakes Mountain Artillery Impact Area Redacted-Privacy Act	Future residents, loggers, construction workers, site visitors, and recreational users (e.g. hikers and hunters)	Projectiles (37mm, 75mm, 105mm, 155mm, 240mm, and 8")	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-02 Southern Jakes Mountain	Commercial workers (explosives storage and tree farming)	Projectiles (37mm and 75mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-03 Covenant Farms Subdivision	Residents, construction workers	Projectiles (37mm and 155mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-04 Covenant Farms (large lots)	Residents, construction workers, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (155mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-05 Recreation/Cabins <sup>Redacted-Privacy Act</sup>	Part-time residents, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm, 105mm, and 155mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-06 Sequoia Subdivision	Future residents, construction workers, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm, 75mm, 76mm, and 155mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-07 Indian Trail Phase III	Future residents, construction workers, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm and 155mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-08 Indian Trail Phase I and II	Future residents, construction workers, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm, 75mm, 76mm, 105mm and 155mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-09 Bald Knob East	Future residents, construction workers, site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-10 Bald Knob west	Site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-11 Whispering Pines	Future residents, ranch workers (e.g. cattle handlers), construction workers, site visitors, and recreational users (e.g. hikers and hunters)	3" AP, MK 29 and Armor Piercing Projectiles (37mm and 76mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-12	Residents, hunters, ranch workers (e.g. cattle handlers),	Armor Piercing Projectiles (76mm)	Potential subsurface	N/A <sup>(3)</sup>	None
MRS-13	Residents, ranch workers (e.g. cattle handlers), construction workers	Projectiles (37mm, 76mm, and 155mm); Mortar (60mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-14 Redacted-Privacy Act	Hunters and ranch workers (e.g. cattle handlers)	Projectiles (37mm and d155mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-15 Trail of Tears	Site visitors and recreational users (e.g. hikers and hunters)	Projectiles (37mm, 75mm, 76mm, 105mm and 155mm)	Potential surface and subsurface	N/A <sup>(3)</sup>	None
MRS-16 Remaining Lands	Residents, site visitors and recreational users (e.g. hikers and hunters)	N/A - uncontaminated by MEC	None	N/A <sup>(3)</sup>	None

More detailed information on the land uses, potential receptors, and munitions known or expected to be present at each MRS is provided in Figure E-1 through E-15 in Appendix E of this RI report.
 The individual CSM diagrams for each MRS, indicating the status of specific exposure pathways is provided in Figures E2-1 through E2-18 in Appendix E of this RI report.
 COPCs were not identified during the EECA, and perchlotate was not detected in groundwater during the RI.

#### 5.4.2 Munitions Constituents Exposure Pathways

#### 5.4.2.1 Known Contamination Areas and Source Media

As described in Subchapter 5.2.3, analysis of the groundwater samples collected from existing wells at the site did not identify the COPC (i.e., perchlorate). Therefore, there are no known areas of contamination that are attributable to the historical munitions-related activities that were conducted at Spencer Artillery Range.

#### 5.4.2.2 Potential Receptors

As discussed in Subchapter 3.1.1, the primary receptors, based on the current and anticipated future land uses at the site, are anticipated to be current and future residents, construction workers, commercial/industrial workers (e.g., agricultural and forestry workers, etc.) and site visitors and recreational users (e.g. hikers, hunters, etc.) While ecological receptors are also potentially present in at the site, they are not typically exposed to groundwater. Therefore, the groundwater exposure pathways are incomplete for ecological receptors.

#### 5.4.2.3 Groundwater Exposure Pathways

The presence of MC contamination is a necessary element for a complete exposure pathway. As described above, no COPCs were identified at Spencer Artillery Range. Because no MC contamination has been identified in the soil or groundwater that is attributable to the historical munitions-related activities that were conducted at Spencer Artillery Range, all potential migration and exposure pathways are incomplete for human and ecological receptors. The MC exposure pathways discussed above are summarized in Table 5.5 and are depicted graphically on the revised CSMs included in Appendix E.







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Grid ID	Munitions Debris	Grid ID	Munitions Debris
BK01	1 – Fragmentation, unidentifiable		1 – Fuze pieces
BK02	1 – 37mm projectile pieces	JM_G18	44–Fragmentation, unidentifiable
BK03	6 – 37mm projectile pieces	JM_G19	30–Fragmentation, unidentifiable
BK04	1 – Fragmentation, unidentifiable	JM_G20	No MD
BK05	1 – 37mm, MkII (MEC)		1 – 37mm projectile pieces
	1 – 37mm, MkII (MEC)	JM_G21	12 – Fragmentation, unidentifiable
BK06	8–37mm projectile pieces	JM_G22	3–Fragmentation, unidentifiable
	2 – T Bar fuze (M48)	PAOI1G01	No MD (shown on Figure 4.6)
JM_G01	69 – Fragmentation, unidentifiable	PAOI5G01	2 – Fragmentation, unidentifiable
JM_G02	1–Fragmentation, unidentifiable	PAOI5G02	No MD
	2 – 37mm projectile pieces	PAOI5G03	3–Fragmentation, unidentifiable
JM_G03	35 – Fragmentation, unidentifiable	PAOI5G04	8–Fragmentation, unidentifiable
JM_G04	Not Intrusively Investigated		1 – 37mm projectile pieces
	1 – 37mm projectile pieces		1 – 76mm, AP, M79
JM_G05	29 – Fragmentation, unidentifiable	PAOI5G05	8–Fragmentation, unidentifiable
JM_G06	19–Fragmentation, unidentifiable		1 – 37mm projectile pieces
JM_G07	15–Fragmentation, unidentifiable	PAOI5G06	3–Fragmentation, unidentifiable
JM_G08	Not Intrusively Investigated	PAOI5G07	No MD
JM_G10	46–Fragmentation, unidentifiable	PAOI5G08	1–Fragmentation, unidentifiable
	1 – 37mm projectile pieces	PAOI5G09	No MD
JM_G11	1 – Fragmentation, unidentifiable	PAOI5G10	No MD
	1 – Fuze pieces	PAOI5G11	1 – 76mm, AP, M79
JM_G12	46–Fragmentation, unidentifiable		1–3" AP, Mk29 with an MkII Mod 9 Fuze (ME
	69 – 37mm projectile pieces		2–Fragmentation, unidentifiable
JM_G13	1 – 75mm, projectile remains		1 – Fuze pieces
	1 –76mm, AP	PAOI5G12	1 – Balistic Cap
JM_G14	9 – Fragmentation, unidentifiable	RA_G01	1–Fragmentation, unidentifiable
JM_G15	No MD (60 - small arms)	RA_G02	No MD (1 - small arm)
	1–155mm	RA_G03	7–Fragmentation, unidentifiable
	2 – 155mm , shrapnel		2 – 37mm projectile pieces
	1 – Fuze pieces	RA_G04	7 – Fragmentation, unidentifiable
JM_G16	30–Fragmentation, unidentifiable		10 – 37mm projectile pieces
JM_G17	16–Fragmentation, unidentifiable	RA_G05	1 – Fragmentation, unidentifiable

Grid Munition Debris Results

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Figure 5.2			
Remedial Investigation Transect & Grid Intrusive Results Formerly Used Defense Site Spencer Artillery Range FUDS Project # G04TN017801 Spencer, Tennessee			
Legend			
₩ MEC			
37mm Projectile Pieces			
<ul> <li>Miscellaneous MD*</li> </ul>			
Fragmentation, Unidentifiable			
<ul> <li>Small Arms</li> </ul>			
• Other (CD, DUP, NC)			
DGM Transects			
Bald Knob Investigation Area			
Jake's Mountain Investigation Area			
Residential Investigation Areas			
Trail of Tears			
Potential Area of Interest 5			
FUDS Boundary			
Grid Results**			
Grid Containing MEC (3)			
Grid Containing 20-71 MD items (9)			
Grid Containing 10-20 MD items (6)			
Grid Containing 1-10 MD items (17)			
Grid Containing No MD (8)			
Grid not intrusively investigated (2)			
Right of Entry			
Notes: CD - Cultural Debris (eg. trash) DGM - Digital Geophysical Mapping DUP - Duplicate MEC - Munitions and Explosives of Concern MD - Munitions Debris			
NC - No Contact *Miscellaneous MD includes 75 mm, 76mm, 105mm, 155mm, Fuzes and other various items. (see Chapter 5 - Table 5.3 for further detail) ** Small arms not included as MD for grid results Grids not to scale			
Figure 4.7 shows location of all identified anomalies			
N Image Source: 2010 Orthophotos Projection: Tennessee State Plane, NAD83, Feet			
Miles			
U.S. ARMY ENGINEERING			
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#### CHAPTER 6 CONTAMINANT FATE AND TRANSPORT FOR MUNITIONS AND EXPLOSIVES OF CONCERN AND FOR MUNITIONS CONSTITUENTS

#### 6.1 INTRODUCTION

6.1.1 Understanding the fate of the various MEC and MC contaminants present in or released to the environment is important for evaluating the potential hazards or risks posed by those contaminants to human health and/or the environment. For example, MEC may be on the ground surface or be buried in the subsurface; however, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, thereby increasing the chance of subsequent exposure by human receptors. Furthermore, MC may remain inside intact munitions, or chemicals may have been released to the environment during training activities.

6.1.2 As described in Chapter 5, MEC and MD were found over a large portion of the site during the RI at Spencer Artillery Range. The following paragraphs discuss potential migration processes for, the persistence of, and the potential migration routes of MEC present at the site. No COPCs were identified at the Spencer Artillery Range; therefore, fate and transport of MC are not discussed below.

## 6.2 FATE AND TRANSPORT PROCESSES FOR MUNITIONS AND EXPLOSIVES OF CONCERN

#### 6.2.1 Natural Processes

6.2.1.1 Two primary natural processes can result in the migration or exposure of MEC items that might be present at a site: erosion and frost heave. Natural erosion over time of soil by the wind or by water (surface water or precipitation) can expose buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient, this process can also result in the movement of MEC from its original position to another location (typically downstream of the wash). In general, surface topography at Spencer Artillery Range is heavily wooded. Vegetation of the area includes forests of predominantly coniferous and deciduous trees. The heavy vegetation stabilizes the soil, minimizing the potential for erosion.

6.2.2.2 In addition to erosion, buried objects have been known to migrate toward the surface during freezing and thawing cycles. This occurs when cold penetrates into the ground and water below the buried objects freezes and expands, gradually pushing the items upwards. This phenomenon is often referred to as frost heave and is most likely to affect items buried above the frost line. The frost line for the Tennessee plateau is at 13 inches bgs (City of Jackson, 2010). Due to the heavy vegetation in the area, frost heave is not anticipated.

#### 6.2.2 Human Activities

The primary human activities that can result in the relocation of MEC items that might be present at Spencer Artillery Range include construction, land clearing, and farming. These human activities can expose buried MEC by the removal of the overlying soil. The ASR documented two instances of historical contaminant migration of MEC within Spencer Artillery Range. In November 1999, an 8-inch high explosive projectile was reported by a crew cutting logging roads. In 1999, a 37-mm projectile was removed from the Spencer Artillery Range and stored at a resident's home 30 miles north of the range (USACE, 2001a).

#### CHAPTER 7

#### BASELINE RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS AND HAZARD ASSESSMENT FOR MUNITIONS AND EXPLOSIVES OF CONCERN

#### 7.1 INTRODUCTION

7.1.1 An evaluation of the need for cleanup action alternatives is demonstrated through either quantitative or qualitative hazard or risk assessments. The purpose of a baseline hazard or risk assessment is to evaluate the potential current and future adverse health effects caused by hazards or hazardous substance releases from a site in the absence of any actions to control or mitigate these releases. In addition, the hazard/risk assessments evaluate the magnitude of the potential hazard/risk at the site and the primary causes of those potential hazards or risks. The results of the hazard/risk assessments aid in the development, evaluation, and selection of appropriate response alternatives.

7.1.2 Hazard/risk assessments are site-specific evaluations and may vary in both detail and extent to which qualitative and quantitative inputs are used. Generally, hazard/risk assessments follow a phased approach, starting with generic assumptions and moving toward a more complex, site-specific evaluation as necessary. The characteristics of the hazard/risk assessment depend on the complexity and particular circumstances of the site as well as the availability of ARARs and other guidance. The hazard/risk assessments also consider the potential hazards/risks associated with current land use and activities, as well as reasonably anticipated future land use.

7.1.3 Detailed descriptions of the methods used to assess MEC hazards and risks at Spencer Artillery Range are provided in Appendix J of this RI Report, while the method and the results are summarized in this subchapter.

#### 7.2 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT

#### 7.2.1 Background

7.2.1.1 A qualitative hazard assessment was conducted to assess potential explosive hazards to human receptors associated with complete MEC exposure pathways at the fifteen of the sixteen recommended MRSs at Spencer Artillery Range (see Subchapter 5.4.1). The purpose of these hazard assessments was to qualitatively characterize the potential hazards from MEC and the primary causes of those potential hazards at each of the three MRSs.

7.2.1.2 An explosive hazard exists at a site if there is a potentially complete MEC exposure pathway. As explained in Subchapter 5.4.1, a potentially complete MEC exposure pathway is present any time a receptor can come near or into contact with MEC and interact with the MEC

in a manner that might result in its detonation. The three elements of a potentially complete MEC exposure pathway — a source of MEC, a receptor, and the potential for interaction between the MEC source and the receptor — are explained in Subchapter 5.4.1; all three elements must be present for a potentially complete MEC exposure pathway to exist.

7.2.1.3 The qualitative hazard assessment technique presented here follows the MEC hazard assessment (MEC HA) method, which assesses the acute explosive hazards associated with remaining MEC at an MRS by analyzing site-specific conditions and human issues that affect the likelihood that a MEC accident will occur. The MEC HA method focuses on hazards to human receptors and does not directly address environmental or ecological concerns that might be associated with MEC. The process for conducting the MEC HA is described in the MEC HA interim guidance document (USEPA, 2008b) and uses input data based on historical documentation, field observations made during this RI and previous studies, and results of the intrusive investigations conducted as part of EE/CA and this RI (see Chapter 5). The MEC HA interim guidance was developed by the Technical Working Group for Hazard Assessment, which included representatives from the DoD, the U.S. Department of the Interior, the USEPA, and various states and tribes. The DoD has encouraged use of this method on a trial basis (DoD, 2009a).

7.2.1.4 The MEC HA method reflects the basic difference between assessing acute hazards from exposure to MEC and assessing chronic environmental risks from exposure to potential contaminants, such as MC. An explosive hazard can result in immediate injury or death, and therefore, risks from explosive hazards are evaluated either as present or not present. If the potential for an encounter with MEC exists, then the potential that the encounter may result in injury or death also exists. Conversely, if the potential presence of MEC at an MRS can be ruled out as a result of RI activities or an earlier investigation such as a site inspection (SI), then no explosive hazards are present and no MEC HA is necessary.

7.2.1.5 The MEC HAs presented in this RI Report were conducted to characterize the baseline conditions for the Spencer Artillery Range recommended MRSs with regard to explosive hazards. These baseline characterizations may be referenced in the subsequent FS, where they may be used to provide the basis for the evaluation and implementation of effective management response alternatives. Appendix J of this RI Report describes the MEC HA method used and the associated results for each MRS addressed in this RI, while this subchapter provides a brief overview of the method and the results.

#### 7.2.2 Defining the Areas to be Assessed

The MEC HA focuses on each of the fifteen recommended MRSs. However, the MECrelated characteristics of discrete areas within an MRS may differ with regard to the ordnance types and quantities, land uses, receptors, and other factors. Figure 7.1 shows the locations and boundaries of each recommended MRS. The MRSs were developed to address the variability of land use, receptor, munitions type, etc. If these factors vary significantly, it is likely that the qualitative MEC hazards will also differ. Different MEC hazards may make different response alternatives appropriate. A determination regarding response alternatives will be made during the FS for each MRS that is subject to the MEC HA.

#### 7.2.3 Overview of MEC HA Input Factors

7.2.3.1 Under the MEC HA method, the potential hazards posed by MEC are characterized qualitatively for each MRS or assessment area by evaluating three primary factors. These primary factors are related to the three critical elements of a potentially complete MEC exposure pathway that were described previously:

- *Severity*: the potential consequences of the effect on a human receptor should MEC detonate;
- *Accessibility*: the likelihood that a human receptor will be able to come into contact with MEC; and
- Sensitivity: the likelihood that MEC will detonate if a human receptor interacts with it.

7.2.3.2 To complete the baseline MEC HA for each assessment area, the various input factors are reviewed and suitable categories are selected based on historical documentation and field observations made during the RI and previous studies. These input factors include such details as energetic material type, site accessibility, potential receptor contact hours, amount of MEC, MEC classification, and MEC size, each of which has two or more possible categories. Each category for each of the MEC HA input factors has an assigned score that relates to the relative contributions of the different input factors to the overall MEC hazard. Scores for the categories are in multiples of five, with a total maximum possible score for all factors of 1,000 and a minimum possible score of 125. These MEC HA scores are *qualitative references only* and should *not* be interpreted as quantitative measures of explosive hazard. The various input factors for the MEC HA method are explained in detail in the MEC HA interim guidance document (USEPA, 2008b) and are summarized in Appendix J of this report.

#### 7.2.4 Overview of MEC HA Output Factors

Once the categories and scores for input factors have been determined for each MRS at the site, the related scores for each category are totaled to calculate an overall MEC HA score for each MRS. The total maximum possible MEC HA score for an MRS is 1,000, while the minimum possible score is 125. The MEC HA method describes associated hazard levels for these scores, which range from 1 (highest) to 4 (lowest). The basis for these hazard levels is provided in the MEC HA interim guidance document (USEPA, 2008b). Again, the total MEC HA scores and associated hazard levels are *qualitative references only* and should *not* be interpreted as quantitative measures of explosive hazard.

#### 7.2.5 Right-of-Entry Refusal

As discussed in Subchapter 5.2 of this RI report, multiple parcels within the Jake's Mountain Impact Area and PAOI-5 at Spencer Artillery Range could not be investigated during the RI because signed ROEs were not obtained (see Subchapter 4.2.3.1 and Figure 4.1), due to official ROE refusal by the property owners or because the owners did not respond to the ROE request. Although full characterization of these properties could not be conducted during the RI, the MRS as a whole was adequately characterized, and therefore, the recommendations for the MRS (e.g., Feasibility Study) are applied to the non-ROE parcels. Recommendations for further action in these areas will be based on information known about surrounding parcels with regard to potential MEC presence.

#### 7.2.6 MEC HA Characterization for Munitions Response Sites with Confirmed Potential MEC Hazards

7.2.6.1 Qualitative baseline characterizations of the potential hazards posed by MEC were developed for the MRSs at Spencer Artillery Range where MEC hazards were confirmed or suspected. The qualitative baseline characterizations of potential MEC hazards were conducted for the 15 recommended MRSs at Spencer Artillery Range by reviewing each of the MEC HA input factors summarized in Subchapter 7.2.3. The data collected during this field investigation, and the historical data available from prior studies and removal actions, were used to determine the appropriate categories for each MEC HA input factor.

7.2.6.2 A detailed description of the MEC HAs conducted for the assessment areas at Spencer Artillery Range is in Appendix J. This description includes background on each of the assessment areas assessed and the rationale for the selection of the various input factors.

#### 7.2.7 Summary of Baseline MEC HA Characterizations for Spencer Artillery Range

7.2.7.1 For areas at Spencer Artillery Range where potential MEC hazards were determined to be present, hazards were characterized using the MEC HA method (USEPA, 2008b). The recommended MRSs, were characterized using the MEC HA method based on the results of the RI and the historical information available from prior studies and removal actions.

7.2.7.2 Table 7.1 summarizes the results of these MEC HAs for current and future land use. This information will provide the baseline for assessment of response alternatives to be conducted. Based on the MEC HA characterization, the MRSs have total MEC HA scores between 435 and 860, with corresponding hazard levels ranging from 4 up to 1. Note that these total MEC HA scores and the associated hazard levels are *qualitative references only* and should *not* be interpreted as quantitative measures of explosive hazard.

#### 7.3 MUNITIONS CONSTITUENTS RISK ASSESSMENT

Based on the MC sampling results of the EE/CA, unacceptable risks associated with MC contamination in soil are not expected at the site. Perchlorate was assessed in groundwater due to the potential use of munitions associated with perchlorate at the site. Perchlorate was not detected in groundwater samples collected during the RI. Therefore, further evaluation of

perchlorate in this risk assessment is unnecessary. Due to the absence of COPCs, complete groundwater exposure pathways were not identified for the Spencer Artillery Range. Therefore, potential risks from exposure of receptors to MC are not anticipated at the site.
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Munitions Response Site	Energetic Material Type	Location of Additional Human Receptors <sup>(1)</sup> (Current/Future)	Site Accessibility	Total Contact Hours <sup>(1)</sup> (Current/Future)	Amount of MEC	Minimum MEC Depth vs. Maximum Intrusive Depth <sup>(1)</sup> (Current/ Future)	Migration Potential	MEC Classification	MEC Size	Total MEC HA Score <sup>(1)</sup> (Current/ Future)	MEC HA Hazard Level <sup>(1)</sup> (Current/Future)
Maximum Possible MEC HA Score	100	30	80	120	180	240	30	180	40	1,000	1
MRS-01 Redacted-Privacy Act	100 HE or fragmenting rounds	0/0 0= Outside EQSD arc	80 Full accessibility	40/40 $40 = Few hours$	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	800/800	2/2
MRS-02 Commercial	100 HE or fragmenting rounds	30/30 30 =Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/15 15=Very few hours	75 Firing points	150/150 MEC located only in subsurface; intrusive depth overlaps minimum MEC depth	10 Unlikely	55 Fuzed DMM	40 Small	555/555	3/3
MRS-03 (Covenant Farms – 5acre lots)	100 HE or fragmenting rounds	30/30 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	40/40 40=Few hours	30 Safety buffer area	150/150 MEC located only in subsurface; intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	590/590	3/3
MRS-04 (Covenant Farms – large lots)	100 HE or fragmenting rounds	30/30 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	40/15 15=Very few hours 40=Few hours	180 Target area	150/150 MEC located only in subsurface; intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	740/715	2/3
MRS-05 Recreation/Cabins	100 HE or fragmenting rounds	30/30 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	40/40 40=Few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	830/830	2/2
MRS-06 Sequoia Subdivision	100 HE or fragmenting rounds	0/30 0= Outside EQSD arc 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/70 15=Very few hours 70=Some hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	775/860	2/1
MRS-07 Indian Trails Phase III	100 HE or fragmenting rounds	0/30 0= Outside EQSD arc 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/70 15=Very few hours 70=Some hours	180 Target area	50/150 MEC located only in subsurface; 50=does not overlap 150=intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	585/770	3/2
MRS-08 Indian Trails Phase I and II	100 HE or fragmenting rounds	0/30 0= Outside EQSD arc 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/70 15=Very few hours 70=Some hours	30 Safety buffer area	50/150 MEC located only in subsurface; 50=does not overlap 150=intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	435/620	4/3

Table 7.1Summary of MEC Hazard Assessment ResultsSpencer Artillery Range Remedial Investigation, Van Buren County, Tennessee

# FINAL

Munitions Response Site	Energetic Material Type	Location of Additional Human Receptors <sup>(1)</sup> (Current/Future)	Site Accessibility	Total Contact Hours <sup>(1)</sup> (Current/Future)	Amount of MEC	Minimum MEC Depth vs. Maximum Intrusive Depth <sup>(1)</sup> (Current/ Future)	Migration Potential	MEC Classification	MEC Size	Total MEC HA Score <sup>(1)</sup> (Current/ Future)	MEC HA Hazard Level <sup>(1)</sup> (Current/Future)
MRS-09 Bald Knob east	100 HE or fragmenting rounds	0/30 0= Outside EQSD arc 30=Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/40 15=Very few hours 40=Few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	775/830	2/2
MRS-10 Bald Knob west	100 HE or fragmenting rounds	0/0 Outside of ESQD arc	80 Full accessibility	15/15 Very few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 <i>UXO</i>	40 Small	775/775	2/2
MRS-11 Whispering Pines	100 HE or fragmenting rounds	30/30 Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/40 15=Very few hours 40=Few hours	30 Safety Buffer	150/150 MEC located only in subsurface; intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	565/590	3/3
MRS-12 Rocky River Road	100 HE or fragmenting rounds	30/30 Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/15 Very few hours	30 Safety Buffer	150/150 MEC located only in subsurface; intrusive depth overlaps minimum MEC depth	10 Unlikely	110 UXO	40 Small	565/565	3/3
MRS-13 Rocky River Road - Residential	100 HE or fragmenting rounds	30/30 Inside MRS or inside ESQD arc around MRS	80 Full accessibility	40/40 Few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 <i>UXO</i>	40 Small	830/830	2/2
MRS-14 Redacted-Privacy Act	100 HE or fragmenting rounds	30/30 Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/15 Very few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	805/805	2/2
MRS-15 Greenfield Road/Trail of Tears	100 HE or fragmenting rounds	30/30 Inside MRS or inside ESQD arc around MRS	80 Full accessibility	15/15 Very few hours	180 Target area	240/240 MEC located on surface and in subsurface	10 Unlikely	110 UXO	40 Small	805/805	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.

# FINAL



### CHAPTER 8 SUMMARY OF REMEDIAL INVESTIGATION RESULTS

#### 8.0 INTRODUCTION

8.1 During February 2010 through June 2010, Parsons conducted an RI at the former Spencer Artillery Range in Spencer/Van Buren County, Tennessee. The RI was conducted to determine whether MEC or MC present sufficient hazards or risks to warrant further action and, if so, to adequately define the nature and extent of those MEC and/or MC. The characterization tasks performed during this RI included reconnaissance, brush cutting, geophysical surveys, intrusive anomaly investigation, and groundwater sampling and analysis. The results of these MEC and MC characterization activities are described in the following paragraphs.

8.2 To complete the characterization of MEC at the former Spencer Artillery Range 11 areas were investigated. All of the land within the former Spencer Artillery Range is privately owned and land use is changing. Several areas of the site are owned by development companies and the land has been subdivided for residential development. In some instances, roads and utility lines have been placed. Rights of entry were obtained and access was granted to over 90% of the privately owned parcels within the investigation areas.

8.3 Instrument-aided reconnaissance was conducted within 6 areas covering 21 miles (7.6 acres) and included 850 observations. No MEC or MD was identified and relatively low subsurface anomaly counts were recorded during the instrument aided reconnaissance. Approximately, 160 miles of brush cutting was completed in advance of DGM transect data collection. The DGM transects met the objectives of the RI and the transect data results were used to map the anomaly density at the site. DGM grids were placed based on the results of the transect anomaly density. DGM identified a total of 8,474 anomalies, 1,503 of which were intrusively investigated (three additional MEC items were identified on the ground surface while traversing to intrusive locations). The DQOs for the MEC investigation were achieved during the RI.

8.3 A total of twelve MEC items were found within BKIA (5 each 37mm MK II), PAOI-5 (one each 3-inch AP MKII), and JMIA (6 each 37mm MK II). These MEC items were all safely detonated on site in accordance with the approved work plan. Over 1,000 MD items were found and included remnants of various projectiles (155mm, 105mm, 76mm, 75mm, and 37mm), mortars (81mm and 60mm), expended fuzes, and hundreds of pieces of unidentifiable munitions fragmentation. MD discovered during the investigation or generated by MEC disposal activities was collected, certified, stored securely, and ultimately disposed of in accordance with the approved work plan.

8.4 Using the data acquired during the RI and information gathered during previously completed investigations (e.g., EE/CA), 15 MRSs are recommended and a qualitative MEC HA was conducted for each MRS. The results of these MEC HAs are presented in this RI report and will provide the baseline for assessment of response alternatives to be conducted during subsequent FS. MEC HAs were not conducted for investigation areas PAOI-1, PAOI-2, PAOI-3, PAOI-4, PAOI-6, and PAOI-7, where no MEC or MD were located during the RI. Based on this evidence, no complete MEC exposure pathways are expected to exist for the receptors anticipated to be present and, therefore, no significant MEC hazards are anticipated to be present at these PAOIs.

8.5 No MC contamination was identified during the EE/CA; therefore, it was determined during the TPP process that additional sampling for explosives and munitions-related metals was not necessary. Perchlorate, however, was subsequently identified as a possible munitions-related constituent. To complete characterization of MC at Spencer Artillery Range groundwater samples were collected for perchlorate analysis. Twelve groundwater samples (including two QC samples) were collected from existing wells at Spencer Artillery Range. Wells selected for sampling were existing domestic wells and groundwater monitoring wells. Perchlorate was not detected in the groundwater samples collected during the RI. With no source identified, there was no potentially complete exposure pathway; therefore, no risk assessment was performed.

8.9 Based on the results of the prior historical investigations and this RI, and the assessments of MEC hazards and MC summarized above, potential MEC hazards remain at 15 of the 16 recommended MRSs. An FS is recommended to assess possible response action alternatives for MEC at the 15 identified MRSs. These recommendations and their rationales are summarized in Table 8.1.

8.10 The data collected during this RI and the associated characterization described above is considered sufficient to characterize the investigation areas at the former Spencer Artillery Range. In addition, the characterization was sufficient to identify and quantify associated potential MEC hazards or MC risks, and to support the recommended FS. Therefore, the objectives of this RI have been met.

Table 8.1Summary of Results and RecommendationsSpencer Artillery Range Remedial Investigation, Spencer/Van Buren County, Tennessee

Munitions Response Site	Potential MEC Hazards	MEC HA Level <sup>1)</sup> (Current/Future)	MC Risks	Recommendation	Comments
MRS-01 Redacted-Privacy Ac	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-02 Commercial	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-03 (Covenant Farms – 5acre lots)	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-04 (Covenant Farms – large lots)	Yes	2/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-05 Recreation/Cabins	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-06 Sequoia Subdivision	Yes	2/1	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-07 Indian Trails Phase III	Yes	3/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-08 Indian Trails Phase I and II	Yes	4/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-09 Bald Knob east	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-10 Bald Knob west	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-11 Whispering Pines	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-12 Rocky River Road	Yes	3/3	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.

Table 8.1Summary of Results and RecommendationsSpencer Artillery Range Remedial Investigation, Spencer/Van Buren County, Tennessee

Munitions Response Site	Potential MEC Hazards	MEC HA Level <sup>1)</sup> (Current/Future)	MC Risks	Recommendation	Comments
MRS-13 Rocky River Road - Residential	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-14 Redacted-Privacy Act	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-15 Greenfield Road/Trail of Tears	Yes	2/2	No	Feasibility Study	Potential MEC hazards present; no further action required for MC.
MRS-16 Remaining Lands	Unlikely	Not Assessed	No	No Department of Defense Action Indicated	Explosives safety hazard is not anticipated.

1) The MEC HA Level is a qualitative risk evaluation, additional information regarding the MEC HA Level is provided in Chapter 7 and Appendix J.

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