



June 26, 2017

Attn: Julie Kaiser
CENAB-EN-HN
10 S. Howard Street
Baltimore, MD 21201-1715

Dear Ms Kaiser,

ERT, Inc., is pleased to present the Final Remedial Investigation Addendum #2 Report for the Fort Hancock FUDS RI Addendum through Decision Document task order, Monmouth County, NJ. This report was prepared under Contract W912QR-12-D-0011, DA01, and incorporates changes made based on final resolution of NJDEP comments on the Draft-Final version, as documented in USACE June 2017 letter (G. Goepfert) to NJDEP (R. Rodrigues).

Please do not hesitate to call me at 301-323-1442 if you need anything more.

Sincerely,

An electronic signature of Thomas J. Bachovchin, written in black ink. The signature is cursive and stylized. Below the signature, the words "ELECTRONIC SIGNATURE" are printed in a small, black, sans-serif font.

ELECTRONIC SIGNATURE

Thomas J. Bachovchin
Project Manager

DISTRIBUTION:

CENAB (Kaiser)

FINAL
MMRP REMEDIAL INVESTIGATION
ADDENDUM #2 REPORT
Remedial Investigation/Feasibility Study
Fort Hancock Formerly Used Defense Site
Monmouth County, New Jersey

Prepared for:

U.S. Army Corps of Engineers
Baltimore District

Contract: W912QR-12-D-0011, Delivery Order DA01



US Army Corps
of Engineers®
BUILDING STRONG®

Prepared by:

ERT, Inc.

Laurel, Maryland 20707

(240) 554-0161

JUNE 2017

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FINAL
MMRP REMEDIAL INVESTIGATION
ADDENDUM #2 REPORT
FORT HANCOCK FORMERLY USED DEFENSE SITE
MONMOUTH COUNTY, NEW JERSEY

Prepared for:
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ELECTRONIC SIGNATURE

06/26/17

Thomas Bachovchin
Project Manager

Date



03/02/16

Jennifer Harlan
Program Manager, PMP

Date

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COMPLETION OF SENIOR TECHNICAL REVIEW

This document has been produced within the framework of the ERT, Inc. (ERT) quality management system. As such, a senior technical review has been conducted. This included review of all elements addressed within the document, proposed or utilized technologies and alternatives and their applications with respect to project objectives and framework of U.S. Army Corps of Engineers regulatory constraints under the current project, within which this work has been completed.



03/02/16

Jennifer Harlan
Senior Technical Reviewer

Date

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

This document has been produced within the framework of ERT's quality management system. As such, an independent technical review, appropriate to the level of risk and complexity inherent in the project, has been conducted. This included a review of assumptions; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the project objectives. Comments and concerns resulting from review of the document have been addressed and corrected as necessary.



02/23/16

Wanfang Zhou, Ph.D., P.G.
Independent Technical Reviewer

Date

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LIST OF ACRONYMS AND ABBREVIATIONS

AS	analytic signal
ASR	Archive Search Report
BGS	below ground surface
BIP	blow-in-place
CD	cultural debris
CENAB	U.S. Army Corps of Engineers, Baltimore District
CENAN	U.S. Army Corps of Engineers, New York District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	conceptual site model
CWM	chemical warfare materiel
DA	Department of the Army
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DMM	discarded military munitions
DoD	Department of Defense
DQO	data quality objective
ECRPP	Environmental and Cultural Resources Protection Plan
EE/CA	Engineering Evaluation/Cost Analysis
EOD	Explosive Ordnance Disposal
ESP	Explosives Site Plan
FS	Feasibility Study
ft	feet
FUDS	Formerly Used Defense Site
FUDMIS	FUDS Management Information System
GIS	Geographic Information System
GPO	geophysical prove-out
GPS	Global Positioning System
GSV	Geophysical System Verification
HFD	hazard fragmentation distance
HTW	hazardous and toxic waste
Hz	hertz
in	inch
ISO	industry standard objects
IVS	Instrument Verification Strip
m	meter
MAMMS	Multiple-Award Military Munitions Services
MC	munitions constituents

MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MEC HA	MEC Hazard Assessment
mg/kg	milligram per kilogram
mm	millimeters
MM	military munitions
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRS	Munitions Response Site
MRSP	Munitions Response Site Prioritization Protocol
NCP	National Contingency Plan
NGVD	National Geodetic Vertical Datum
NJDEP	New Jersey Department of Environmental Protection
NPS	National Park Service
nT	nanoTesla
OESS	Ordnance and Explosives Safety Specialist
PAOI	potential area of interest
QA	quality assurance
QC	quality control
RI	Remedial Investigation
RTS	robotic total station
RTK GPS	Real Time Kinematic Global Positioning System
SI	Site Inspection
SUXOS	Senior UXO Supervisor
TOI	target of interest
TPP	Technical Project Planning
TVG	G-882 transverse gradiometer
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
UXOSO	UXO Safety Officer
V	volt
VSP	Visual Sample Plan
WGS	World Geodetic System

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GLOSSARY OF TERMS

Cultural Debris – Debris found on operational ranges or munitions response sites (MRSs), which may be removed to facilitate a range clearance or munitions response, that is not related to munitions or range operations. Such debris includes, but is not limited to, rebar, household items (refrigerators, washing machines, etc.), automobile parts and automobiles that were not associated with range targets, fence posts, and fence wire. Cultural debris does not refer to items of cultural or historical significance.

Defense Site – All locations that are or were owned by, leased to, or otherwise possessed or used by the DoD. The term does not include any operational range, operating storage or manufacturing facility, or facility that is used or was permitted for the treatment or disposal of military munitions.

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 United States Code [USC] 2710(e)(2)).

Explosive Hazard – A condition where danger exists because explosives are present that may react (e.g., detonate, deflagrate) in a mishap with potential unacceptable effects (e.g., death, injury, damage) to people, property, operational capability, or the environment.

Explosive Ordnance Disposal (EOD) – The detection, identification, on-site evaluation, rendering safe, recovery, and final disposal of unexploded ordnance and of other munitions that have become an imposing danger, for example, by damage or deterioration.

Explosives Safety – A condition where operational capability and readiness, people, property, and the environment are protected from the unacceptable effects or risks of potential mishaps involving military munitions.

Material Potentially Presenting an Explosive Hazard (MPPEH) – Material potentially containing explosives or munitions (e.g., munitions containers and packaging material; munitions debris (MD) remaining after munitions use, demilitarization, or disposal; range-related debris); or material potentially containing a high enough concentration of explosives such that the material presents an explosive hazard (e.g., equipment, drainage systems, holding tanks, piping, or ventilation ducts that were associated with munitions production, demilitarization or disposal operations). Excluded from MPPEH are munitions within DoD's established munitions management system and other hazardous items that may present explosion hazards (e.g., gasoline cans, compressed gas cylinders) that are not munitions and are not intended for use as munitions.

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 DoD, the Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants; explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives, and chemical warfare agents; 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 nonnuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under the Atomic Energy Act of 1954 (42 U.S.C. 201 1 et seq.) have been completed. (10 U.S.C. 101(e)(4)(A) through (C)).

Munitions and Explosives of Concern (MEC) – This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks means (A) UXO, as defined in 10 U.S.C. 101(e)(5); (B) DMM, as defined in 10 U.S.C. 2710(e)(2); or (C) MC (e.g., Trinitrotoluene [TNT], Cyclotrimethylenetrinitramine [RDX]), as defined in 10 U.S.C. 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

Munitions Constituents (MC) – Any materials originating from UXO, DMM, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 U.S.C. 2710(e)(3)).

Munitions Debris (MD) – Remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization, or disposal.

Munitions Response – Response actions, including investigation, removal actions and remedial actions to address the explosives safety, human health, or environmental risks presented by UXO, DMM, or MC, or to support a determination that no removal or remedial action is required.

Munitions Response Area (MRA) – Any area on a defense site that is known or suspected to contain UXO, DMM, or MC. Examples include former ranges and munitions burial areas. An MRA is composed of one or more MRSs.

Munitions Response Site (MRS) – A discrete location within an MRA that is known to require a munitions response.

Unexploded Ordnance (UXO) – Military munitions that (A) have been primed, fuzed, armed, or otherwise prepared for action; (B) have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and (C) remain unexploded whether by malfunction, design, or any other cause. (10 U.S.C. 101(e)(5)(A) through (C))

Unexploded Ordnance (UXO)-Qualified Personnel – Personnel who have performed successfully in military EOD positions or are qualified to perform in the following Department of Labor, Service Contract Act, Directory of Occupations, contractor positions: UXO Technician II, UXO Technician III, UXO Safety Officer, UXO Quality Control Specialist, or Senior UXO Supervisor.

Unexploded Ordnance (UXO) Technicians – Personnel who are qualified for and filling Department of Labor, Service Contract Act, Directory of Occupations, contractor positions of UXO Technician I, UXO Technician II, and UXO Technician III.

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EXECUTIVE SUMMARY

Introduction and Scope

ERT, Inc. (ERT) performed a Remedial Investigation (RI) for the United States Army Corps of Engineers (USACE), at the Fort Hancock Formerly Used Defense Site (FUDS), located in Monmouth County, New Jersey. Those activities were documented in the *Final Remedial Investigation Report, Fort Hancock Formerly Used Defense Site, January 2014* (USACE, 2014).

Based upon the conclusions and recommendations of the 2014 RI Report, ERT performed additional RI field activities in two follow-on RI addenda phases. Addendum #1 activities were conducted in July 2014 and the results are documented in the RI Addendum #1 Report (Draft-Final, March 2016). Addendum #2 follow-on activities were contracted under Environmental and Restoration Services Contract W912QR-12-D-0011. Performed under the Military Munitions Response Program (MMRP), the work involved munitions and explosives of concern (MEC) and munitions constituents (MC) that may be present at Fort Hancock. USACE Baltimore District (CENAB) administers this work and provides technical oversight, and the USACE New York District (CENAN) is the overall life cycle manager for the project.

Fort Hancock is located on the Sandy Hook peninsula in Monmouth County, New Jersey, in the Lower Bay of the Hudson River. The peninsula, which encompasses approximately 1,700 acres, is known as the Sandy Hook Unit of the Gateway National Recreation Area and is a National Historic Landmark. It is currently managed by the Department of the Interior (NPS) and the U.S. Coast Guard, and is used for a variety of recreational purposes year-round.

The purpose of the RI was to adequately characterize the nature and extent of any potential MC contamination or MEC hazards resulting from the past U.S. military use of Fort Hancock. The 2014 RI included investigation of eight Munitions Response Sites (MRSs), seven land-based and one ocean MRS. However, based on requirements of the site manager [the National Parks Service (NPS)], there were NPS-identified environmentally sensitive "excluded areas" where USACE was limited in terms of field work activities that could be conducted. This impacted the ability of USACE to fully investigate one MRS (the Livens Discovery Area), where only 4.8 of 29 acres could be fully investigated during the 2014 RI.

Recently, more expanded access was granted by NPS and further investigation activities at the Livens Discovery Area were completed under this RI Addendum #2. Therefore, the purpose of RI Addendum #2 is to conduct additional investigation to adequately characterize the nature and extent of any potential MC contamination or MEC hazards from the past U.S. military use of Fort Hancock specific to the Livens Discovery Area.

Investigation Activities

MRS Development

The Fort Hancock MRS footprints have evolved as successive investigations have provided new characterization information. MRS boundary changes are associated with three primary investigation phases, the 2007 Site Inspection (SI), the 2014 RI, and RI Addendum #1. The RI revealed detailed information about the potential locations of MEC, and MRS boundaries have significantly changed since the SI. The MRSs were adjusted, resulting in six revised MRSs that replace those identified in the 2014 RI Report. The Livens Discovery Area, previously designated MRS-7, is now designated MRS 06.

MEC/MD

The RI Addendum #2 activities to evaluate MEC and munitions debris (MD) presence included a comprehensive statistically-based Digital Geophysical Mapping (DGM) and intrusive investigation. DGM was conducted on more than 17,000 linear feet of transects, six clusters (1.9 acres), and nine grids, and approximately 1,000 anomalies found with more than 500 of those intrusively investigated.

MRS 06 encompasses 24 acres surrounding the location of a former munitions storehouse where a fire occurred in 1927. During the 2014 RI, NPS granted access to only 4.8 acres of the original 29-acre MRS to conduct the geophysical investigation, due to the absence of sensitive vegetation in this portion. It was determined that there was a potential for MEC to remain in the rest of MRS 06, as various items, including a potentially live Stokes mortar fuze, were found during the previous 1998 Engineering Evaluation/Cost Analysis (EE/CA) investigation. Most of the munitions-related items were found in EE/CA Grid E004 (the assumed location of the 1927 storehouse fire).

The RI Addendum #2 geophysical investigation in MRS 06 took place in phases. First, the central portion of the MRS was investigated by a series of parallel “inner” transects centered over EE/CA Grid E004. All geophysical anomalies on the inner transects were excavated. Next, the outer area surrounding these inner transects was investigated using transects and grids. The outer transect data were acquired with a G-858 magnetometer and geophysical anomalies were then analyzed by geostatistical mapping of anomaly density using Visual Sample Plan (VSP) software. VSP identified six areas, or clusters, with anomaly density above a background density. Following USACE concurrence on cluster locations, a single grid (100 ft x 100 ft) was randomly placed within each cluster. In addition to these six grids, three more grids were installed outside of the clusters in order to enhance overall coverage in the MRS. DGM data in the grids were acquired with an EM61-MK2A instrument. All anomalies within grids above a certain threshold were intrusively investigated.

MC

For the 2014 RI, a random surface soil sampling approach was developed through VSP to support a statistical comparison to applicable screening standards for metals and explosives constituents. However, since significant acreage of MRS 06 was excluded by the NPS during the 2014 RI, and no geophysical investigation could be conducted, it could not be determined whether any breached munitions, posing potential MC risks, were present in MRS 06. Therefore, for this RI Addendum #2 effort, biased grab soil samples were planned for areas where there was visible evidence of energetic material, e.g., munitions items that were breached. While no evidence of energetics or significantly breached munitions were found, in the interest of complete characterization, two discrete soil samples were collected at locations where apparently intact Livens projectiles were found on the inner transects and were analyzed for explosives.

Investigation Findings

MEC/MD

Material potentially presenting an explosive hazard (MPPEH) was found primarily in the inner transects, but was also found in two of the nine grids. All MPPEH items were ultimately determined to be material documented as safe, or MDAS, not MEC. The MPPEH items included

two apparently intact Livens projectiles, a partial Livens projectile, 5 Stokes Mortar MK1 fuzes, 4 Livens burster tubes, an MK1 detonator, an M-1 smoke canister, and a brass base fuze.

MD was somewhat common in the inner transects and in the grids, consisting of unidentified munitions fragments or Livens projectile fragments. Many of the anomalies were cultural debris (CD), which was either removed or left in place.

Overall, 15 MPPEH items and 22 MD items were found in MRS 06. Some of these items were found on the surface and some were found in the subsurface. No items categorized as MEC were found in MRS 06. The primary intrusive investigation findings are summarized in Table ES-1.

Table ES-1. Intrusive Investigation Findings				
Area	MEC	MPPEH	MD	Description
Inner Transects	0	13	9	MPPEH: 2 nearly intact Livens projectiles, one damaged Livens, 3 Livens burster tubes, 5 Stokes Mortar fuzes, one MK1 detonator, one M-1 Smoke canister. Miscellaneous MD and CD
Grid 1	0	0	0	CD associated with former railroad track
Grid 2	0	0	0	CD associated with former railroad track
Grid 3	0	0	0	CD associated with former railroad track
Grid 4	0	0	4	Miscellaneous MD and CD
Grid 5	0	0	0	Miscellaneous CD
Grid 6	0	0	2	Miscellaneous MD and CD
Grid 7	0	0	2	Miscellaneous MD and CD
Grid 8	0	1*	2	MPPEH: Base fuze (brass). Miscellaneous MD and CD
Grid 9	0	1*	3	MPPEH: Livens burster tube housing. Miscellaneous MD and CD
TOTALS	0	15	22	

* Following detonation, SUXOS classified these as MDAS items based on visual inspection, even though the detonation may have consumed any potential explosives.

The results of the DGM and intrusive investigations indicate that certain areas containing a concentration of metallic anomalies (clusters) within the MRS have a higher likelihood of a human or ecological receptor encountering MEC or MD than others. Using cluster analysis, a focus area of MRS 06 was developed into MEC/MD Hazard Area 6A. The boundary of MEC/MD Hazard Area 6A was defined by the extent of the inner transects and the grids where MPPEH or MD was found. MEC/MD Hazard Area 6A is 5.0 acres, and it is considered to have a moderate to high probability of encountering MEC/MD, while all other areas within MRS 06 are considered to have a low probability of encountering MEC/MD.

The RI Addendum #2 effort provided additional information about the locations and potential locations of MEC, MPPEH, and MD within MRS 06. The area known or suspected to contain MEC or MD, developed into MEC/MD Hazard Area 6A, is now smaller. Consequently, the MRS 06 boundary has been reduced accordingly, and the acreage for MRS 06 has been revised

from 24 acres to 5.0 acres.

As described in detail in Section 1.2.1 of the 2014 RI Report, projectiles found in this area during previous investigations contained liquid fillers speculated at that time to be classified as chemical warfare materiel (CWM). However, the material was found to be titanium tetrachloride (FM smoke), which is not classified as CWM. The Addendum #2 investigation uncovered no evidence to change the determination that no CWM is associated with the Fort Hancock FUDS.

The Munitions Response Site Prioritization Protocol (MRSP) is the methodology for prioritizing sites known or suspected to contain MEC or MC for response actions, assigning a relative priority to an MRS based on various safety and environmental factors. The MRSP evaluation for the reduced 5.0 acre MRS 06 is MRS priority 2, based on an Explosive Hazard Evaluation module rating of A.

The MEC Hazard Assessment Methodology (MEC HA) assesses potential explosive hazards to human receptors under current and future conditions, given various cleanup and land use or land control alternatives. The MEC HA scores fall within one of four defined ranges or Hazard Levels, with 1 defined as the highest potential hazard conditions and 4 being low potential hazard conditions. The MEC hazard level category for MRS 06 is 2, based on a total score of 820. This level reflects high potential hazard conditions.

MC

For the 2014 RI, a total of 21 random samples were collected at depths of 0-6 inches bgs and the baseline risk assessment presented in the 2014 RI concluded that there was no unacceptable MC risk. For the RI Addendum #2 effort, biased grab soil samples were collected at two locations where apparently intact Livens projectiles were found on the inner transects. These samples were analyzed for explosives. No explosive compounds were detected in either soil sample. These non-detects support the previous MC characterization of MRS 06 presented in the 2014 RI Report, and therefore, it is concluded that there is no unacceptable MC risk at MRS 06.

Conclusions

Nature and extent of MC and MEC has been characterized for MRS 06. No unacceptable MC risk to human health or ecological receptors is present within MRS 06. An area of focus (MEC/MD Hazard Area 6A) has been delineated as having a moderate to high probability of encountering MEC/MD based on the investigation findings. Based on this newly delineated area of focus, the boundary of MRS 06 has been reduced to 5.0 acres. Table ES-2 presents these findings, summarizing the overall conclusions with regard to MC risks and MEC/MD hazards present at the site.

Table ES-2. Summary of Findings				
MRS	Focus Area	Acreage	Potential Concern	
			MC	MEC/MD ¹
MRS 06	MEC/MD Hazard Area 6A	5.0	None	Moderate to High
	All areas other than 6A	19	None	Low

¹ – Probability of encountering MEC/MD

1.0 INTRODUCTION AND BACKGROUND

ERT, Inc. (ERT) performed a Remedial Investigation (RI) for the United States Army Corps of Engineers (USACE), at the Fort Hancock Formerly Used Defense Site (FUDS), located in Monmouth County, New Jersey. Those activities were documented in the *Final Remedial Investigation Report, Fort Hancock Formerly Used Defense Site, January 2014* (USACE, 2014), hereinafter referenced as the 2014 RI Report.

Based upon the conclusions and recommendations of the 2014 RI Report, ERT performed additional RI field activities in two follow-on RI addenda phases. Addendum #1 activities were conducted in July 2014 and the results are documented in the RI Addendum #1 Report (Draft-Final, March 2016).

Addendum #2 follow-on activities were contracted under Environmental and Restoration Services Contract W912QR-12-D-0011. Performed under the Department of Defense (DoD) Military Munitions Response Program (MMRP), the work involved munitions and explosives of concern (MEC) and munitions constituents (MC) that may be present at the Livens Discovery Area at Fort Hancock. USACE Baltimore District (CENAB) administers this work and provides technical oversight, and the USACE New York District (CENAN) is the overall life cycle manager for the project.

ERT performed all work in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104 and the National Contingency Plan (NCP), Sections 300.120(d) and 300.400(e). Applicable provisions of Chapter 29 of the Code of Federal Regulations 1910.120 apply. All activities involving work in areas potentially containing MEC hazards was conducted in compliance with USACE, Department of the Army (DA), and DoD safety regulations.

The Project Team consisted of ERT, CENAB and CENAN, as well as other government and non-government agencies with specific expertise for implementation of specialized components of the field operations. For purposes of this RI Addendum Report, CENAB and CENAN are referred to jointly as "USACE", unless specific district responsibilities are discussed.

This document is Addendum #2 to the 2014 RI Report. RI Addendum #2 includes only information that has changed or is in addition to what has already been provided in the 2014 RI Report or the RI Addendum #1 Report.

1.1 Purpose and Scope

The overall purpose of the 2014 RI was to adequately characterize the nature and extent of any potential MC contamination or MEC hazards resulting from the past U.S. military use of Fort Hancock. The 2014 RI included investigation of eight Munitions Response Sites (MRSs), seven land-based and one ocean MRS. Project objectives were met, nature and extent of MC and MEC was characterized and human health and ecological risks were assessed. However, based on requirements of the site manager [the National Parks Service (NPS)], there were NPS-identified environmentally sensitive "excluded areas" where USACE was limited in terms of field work activities that could be conducted. This impacted the ability of USACE to fully investigate one MRS (the Livens Discovery Area), where NPS excluded areas accounted for 24.2 of 29 acres, i.e., only 4.8 acres could be fully investigated during the 2014 RI.

However, more expanded access was ultimately granted by NPS and further investigation activities at the Livens Discovery Area were completed under RI Addendum #2. Therefore, the purpose of RI Addendum #2 is to conduct additional investigation to adequately characterize the nature and extent of any potential MC contamination or MEC hazards from the past U.S. military use of Fort Hancock specific to the Livens Discovery Area.

1.2 Property Description and Problem Identification

Fort Hancock is located on the Sandy Hook peninsula in Monmouth County, New Jersey, in the Lower Bay of the Hudson River. Raritan Bay is north of Fort Hancock, Sandy Hook Bay borders the site on the west, and the Atlantic Ocean is east of the peninsula. The peninsula, which encompasses approximately 1,700 acres, is known as the Sandy Hook Unit of the Gateway National Recreation Area and is a National Historic Landmark. It is currently managed by the Department of the Interior (NPS) and the U.S. Coast Guard, and is used for a variety of recreational purposes year-round. An active U.S. Coast Guard Station is positioned on the northwest corner of the peninsula (approximately 68 acres). The closest city is Highlands, located on the mainland of New Jersey, south of the peninsula. Figure A-1 presents the project location with MRSs shown (all figures are presented in Appendix A).

The discussions below provide the detail of how the MRS footprints have evolved as successive investigations have provided new characterization information. MRS boundary changes, as associated with three primary investigation phases, the 2007 Site Inspection (SI), the 2014 RI, and RI Addendum #1, are described below in Sections 1.3.2.1, 1.3.3.1, and 1.3.4.1, respectively. The RI revealed detailed information about the potential locations of MEC, and MRS boundaries have significantly changed since the SI. The MRSs were adjusted, resulting in the six current MRSs shown in Figure A-1. These MRSs replace those identified in the 2014 RI Report. The Livens Discovery Area, previously designated MRS-7, is now designated MRS 06.

1.3 Previous Investigations

Multiple investigations have taken place at Fort Hancock. The following are summaries of those investigations that were key to characterizing nature and extent of contamination for the Fort Hancock FUDS.

1.3.1 Engineering Evaluation/Cost Analysis

In 1998, USACE conducted an Engineering Evaluation/Cost Analysis (EE/CA) (*Draft Final Former Fort Hancock EE/CA, December 1998*) to more thoroughly investigate ordnance at the Fort Hancock FUDS. Ten areas of concern were established for investigation, based on the 1993 USACE Archives Search Report (ASR) and an analysis of historical aerial photographs conducted by the U.S. Army Topographic Engineering Center. These included:

- Area A: Historic Fort Hancock;
- Area B: Former Proving Ground;
- Area C: Potential Ordnance Depositional Area;
- Area D: Battery Arrowsmith;
- Area E: Livens Discovery Area/Location of Underground Magazines;
- Area F: South Beach Ordnance Discovery Area;
- Area G: Wooden Barrels Discovery Area;

- Area H: Critical Zone/Location of Underground Magazines;
- Area I: Small Arms Range/Area of Foreign Ordnance Finds; and
- Area J: Plum Island.

A total of 3,904 anomalies were identified during the geophysical investigations; of these, 1,710 were intrusively investigated. One of the ten areas of concern was Area E, or the Livens Discovery Area, where Livens projectiles containing FM smoke were discovered by NPS personnel in 1981. Currently designated MRS 06, various munitions related items were found during the EE/CA. Radiographic testing in the field indicated that the filler was likely FM smoke (these conclusions were confirmed at a later point in time [USACE, 1998]). An explosive risk assessment was conducted as part of the EE/CA, and the Livens Discovery Area was recommended for MEC clearance to depth. Although the removal actions were never undertaken, NPS maintained a protocol for public education through information sheets/signage.

1.3.2 Site Inspection

In 2007, USACE completed an SI as part of a DoD-wide effort to evaluate the inventoried MRSs for further action. The SI served to inspect each of the MRSs (as defined in the Archive Search Report supplement) for MEC on the surface and to collect environmental samples to determine if there may have been a release of MC. The SI recommended that an RI be conducted.

1.3.2.1 *SI MRS Delineations*

The 2007 SI was conducted on six MRSs that are based on the 1993 ASR and 2004 ASR Supplement. The acreages are those that were approved for further investigation; however, upon further evaluation and research for scoping of the 2014 RI, it became apparent that many of the MRSs did not accurately reflect areas suspected of containing MEC. As a result, the MRSs were significantly revised for purposes of conducting the 2014 RI. As investigated in the 2007 SI, the MRSs were:

- MRS 1, Southern Dredging Disposal Area. 31 acres on southern portion of property where beach replenishment operations were said to have resulted in munitions and debris being deposited on the beach.
- MRS 2, Livens Projectile Disposal Area. 24 acres in central portion where Livens projectiles were found in 1981 and a disposal area for chemical warfare materiel (CWM) was suspected, as the projectiles contained liquid filler.
- MRS 3, Northern Disposal Area. Presumed 1-acre off-shore area where fragmentation grenades were said to have been dumped.
- MRS 4, CWM Research and Development Laboratory. Presumed CWM testing lab based on historical report identifying Building 109 as a chemical lab and record that phosgene gas was stored at the property.
- MRS 5, Northern Battery Complex. 356 acres on land and 130,580 acres off-shore, consisting of overlapping range fans associated with 13 gun batteries on northern portion of property. Includes the “Northern Proving Ground” (boundaries estimated).
- MRS 6, Hand Grenade Court. Zero-acre area (because location is unknown), to represent potential hand grenade training area. Based on an assumption that grenade training took place.

For purposes of scoping the 2014 RI, USACE researched the six MRSs to determine which should be included in the study. During follow-up discussions with NPS, it was discovered that some the MRSs were based on anecdotal information obtained during the ASR interviews. The assumption of a grenade training area on Plum Island (MRS 6) was apparently based on the recollection of one WWII veteran, who was probably wrong because no historical records of the area and no MEC items of any kind were found there. In a separate conversation, an employee said he could not recall the existence of MRS 3, Northern Disposal Area, and that it might have been based on items that had washed up on the northwestern shore of the peninsula. Consequently, the presence of these two MRSs was considered speculative, and they were therefore excluded from the 2014 RI.

1.3.3 2014 Remedial Investigation

ERT completed the 2014 RI that characterized the nature and extent of MEC, munitions debris (MD) and MC in six of the seven land-based MRSs. The scope included digital geophysical mapping (DGM), intrusive investigations to identify location, density, and types of MEC, and environmental sampling to determine the distribution and concentrations of metals and explosives in soil, sediment, surface water, and groundwater.

1.3.3.1 2014 RI MRS Delineations

To better define areas where MEC and MC may remain from historical military operations on the Fort Hancock property, MRSs were developed that differed from those investigated for the SI. ERT reviewed historical reports regarding proving ground operations, including NPS historic resource studies, and discovered a summary report containing a map of the locations of six impact areas associated with the historic proving ground. This key document identifies the location of proof firing targets and indicates that guns were fired from north to south along the beach (NPS undated report). No other testing, training, or disposal areas potentially containing MEC were found in the NPS documents reviewed.

The impact areas are the basis for most of the MRSs investigated during the 2014 RI. Buffer zones equal to the radius of the targets were added on all sides of the circular target areas, allowing for under- and over-shoots. A revised boundary was drawn for the Livens area, based on newly-discovered documentation of a 1927 fire in a storage bunker. A report was found verifying that the source of the projectiles was kick-out from the fire or explosion (CWS, 1927). An in-water MRS, parallel to the proving ground and target areas, was established to address areas on the beach where munitions have been found, portions of the former proving ground that may have eroded into the ocean, and off-shore areas to a depth at which recreational users or NPS employees may come into contact with MEC, if present.

The re-configuration of MRSs was discussed during technical project planning (TPP) meetings and presented in the RI Work Plan, which was reviewed by the New Jersey Department of Environmental Protection (NJDEP) and NPS. The MRSs are described below. A crosswalk between the 2007 SI MRSs and the 2014 RI MRSs is provided in Table 1-1 (at the end of this Section).

- MRS-1, 1,000-Yard Impact Area. 99 acres, covers the northernmost part of the proving ground from the southern border of the impact area to and including the firing points.

- Includes an area referred to as the B003 Area, a 100x100 foot investigation grid in which MEC was found during the 1998 EE/CA conducted by USACE (discussed in 1.4.4)
- MRS-2, 2,000-Yard Impact Area. 151 acres, covers the area between the 1,000 and 2,000-yard impact areas.
- MRS-3, 2,500-Yard Impact Area. 89 acres, covers the area between the 2,000 and 2,500-yard impact areas.
- MRS-4, 3,000-Yard Impact Area. 73 acres, covers the area between the 2,500 and 3,000-yard impact areas.
- MRS-5, 3-Mile Impact Area. 205 acres (exclusive of MRS 7), covers the area between the 3,000-yard and 3-mile impact areas.
- MRS-6, 3.75-Mile Impact Area. 90 acres, covers the area between the 3 and 3.5-mile impact areas.
- MRS-7, Livens Discovery Area. 29 acres, lies mostly within boundary of MRS-5. The center of the MRS is the location of the former storehouse that contained the Livens projectiles and caught fire in 1927.
- MRS-8, Water MRS. 154 acres along the eastern shore of the property, parallel to the former proving ground and impact locations. The MRS extends eastward into the ocean approximately 100 yards, reflecting a 6-foot depth contour (at mean lower low water). Six feet was used to reflect a conservative maximum depth for human receptors to potentially encounter MEC through fishing, wading or swimming activities.

In addition to the eight MRSs described above, in response to concerns from the New Jersey Department of the Environment (NJDEP), two Potential Areas of Interest (PAOIs) were also investigated (the 9-Gun Battery area and the Kingman and Mills Battery area).

The 2014 RI concluded that nature and extent of MC and MEC at Fort Hancock had been characterized, including assessment of human health and ecological risks. It was recommended that additional soil sampling be conducted to determine the extent and source of metals contamination posed by MC found in the B003 Area soil, which was addressed in Addendum #1.

Areas of focus (MEC/MD Hazard Areas) were delineated based on MEC/MD densities. With regard to the portion of the Livens Discovery Area that was excluded by NPS and could not be fully investigated, it was recommended that the NPS excluded portion (24.2 of 29 acres) be further investigated using DGM and anomaly excavations to determine the nature and extent of MEC/MD, and to identify possible MEC/MD Hazard Areas.

1.3.4 RI Addendum #1

ERT conducted additional RI field activities in July 2014 as a result of recommendations from the 2014 RI Report. The 2014 RI Report concluded that in the B003 Area (within the former MRS 01), arsenic and lead in soil could potentially pose a threat to human health, and that antimony, arsenic, copper, lead, selenium, and thallium could pose a threat to ecological receptors. RI Addendum #1 was completed to further characterize this area; based on additional soil sampling, the human health and ecological risk assessments were updated and it was concluded that the nature and extent of MC contamination at the B003 Area had been characterized and no unacceptable risk to human health or the environment was present.

1.3.4.1 RI Addendum #1 MRS Delineations

The results of the RI were used to delineate six new MRSs, which replace those identified in the 2007 SI report and the 2014 RI Report. These adjustments resulted in the six current MRSs shown in Figure A-1.

As presented in more detail in RI Addendum #1, two smaller MRSs were defined based on the MEC/MD Hazard Areas defined in the 2014 RI Report. The Livens Discovery Area was retained for future investigation, and a fourth, larger MRS was defined for all remaining land areas. Lastly, an MRS was defined for the off-shore range fans emanating from the firing batteries. These adjustments resulted in the six current MRSs shown in Figure A-1. The MRS designations correspond to newly-created FUDS project numbers; the MRSs are described below:

- MRS 03, Northern Portion Proving Ground: This MRS encompasses 30.2 acres and includes the MEC/MD Hazard Area 1A (29 acres) and PAOI 9-Gun Battery (1.2 acres).
- MRS 05, Southern Portion Proving Ground: This MRS encompasses 51 acres and includes the following seven MEC/MD Hazard Areas (as defined in the 2014 RI Report): 1B, 2A, 3A, 3B, 4A, 5A, and 5B.
- MRS 06, Livens Discovery Area: This MRS encompasses 24 acres of the area where the 1927 munitions storehouse fire occurred. NPS prevented access to the 24 acres during the 2014 RI field work. The original Livens Discovery Area footprint was 28.8 acres (rounded up to 29 acres in the 2014 RI discussions), of which NPS granted access to 4.8 acres; those 4.8 acres were included in MRS 07 (see below) as the 2014 RI determined that no MEC is suspected in this area.
- MRS 07, Remaining Land Areas: At 952 acres, this MRS encompasses all remaining land on the eastern side of the Sandy Hook peninsula, where there is a potential MEC hazard from munitions that may wash onto the shore during storm events in the Atlantic Ocean. The MRS extends to the northernmost extent of the Sandy Hook peninsula and to the southernmost boundary of the recreation area. The MRS also includes the 4.8 acres of the Livens Discovery Area investigated during the 2014 RI and not included in MRS 05.
- MRS 08, NPS Excluded Area: This MRS is 140 acres and encompasses portions of the former proving ground to which NPS has indefinitely excluded access for geophysical investigation. Right-of-entry refusal is based on concerns about potential impacts to plant communities (i.e., maritime holly forest) due to vegetation clearance required for running transects and placing grids. No determination has been made about the presence, absence, or extent of potential MEC or MC contamination in this MRS.
- MRS 09, Water Ranges: This MRS is 129,611 acres and encompasses the off-shore portions of the coastal battery range fans. A large portion of the range fans overlaps those of Fort Tilden, another FUDS in New York, and have been excluded (the overlapping acres are accounted for in the Fort Tilden MMRP project). The MRS encompasses the in-water segment of the SI MRS called the Northern Battery Complex. It also encompasses the 154 acre area paralleling the eastern shore, which was identified in the 2014 RI Report as MRS 08. Investigation of the 154-acre area consisted of

underwater geophysics to a water depth of 6 feet, and no MEC or MD was found. No distinct MEC source areas have been or can feasibly be identified in the off-shore areas, and deep water in portions of the 129,611 acres is considered a partial barrier to MEC that is potentially present. No MC samples have been collected off-shore, nor is MC suspected to pose a risk to receptors because of the high dilution factor of the Atlantic Ocean.

A crosswalk between the 2014 RI MRSs and the new RI Addendum #1 MRSs is provided in Table 1-2 (at the end of this Section).

1.3.5 RI Addendum #2

This document, RI Addendum #2, presents the results of the investigation of the approximately 24 acre MRS 06 (Livens Discovery Area).

1.3.5.1 MRS 06 Background

MRS 06 encompasses 24 acres surrounding the location of a former munitions storehouse where a fire occurred in 1927. Figure A-2 shows the MRS 06 site layout. During the 2014 RI, NPS granted access to 4.8 acres of the originally 29-acre MRS 06 to conduct the geophysical investigation, due to the absence of sensitive vegetation in this portion. In addition, NPS granted access to the entire 29 acres for the collection of soil samples. The results of those activities are described in detail in the 2014 RI Report.

It was determined that there was a potential for MEC to remain in the rest of MRS 06, as MD items and a potentially live Stokes mortar fuze were found during the 1998 EE/CA investigation. Most of the munitions-related items were found in EE/CA investigation Grid E004 (the assumed location of the 1927 storehouse fire). The EE/CA recommended a UXO clearance to depth for Grid E004 and vicinity, but it was never conducted.

For the 2014 RI, the Grid E004 location was used to define the MRS by drawing a 600-foot radius circle around it using the hazard fragmentation distance for a Livens plus an investigation buffer. The conceptual site model (CSM) developed during the 2014 RI indicated that the source of the munitions-related items was kick-out from the fire or explosion. However, while MRS 06 was defined by the storehouse fire, MEC, as UXO or from low order detonations, could exist on or under the ground surface from historical proving ground operations, as MRS 06 also lies within the overshot/undershot of the 3,000 yard and 3-mile target impact areas, respectively. Further, while it was considered possible that MRS 06 represents a disposal area (because there is no documentation of cleanup activities), intact ordnance was not expected to be present due to the intensity of the storehouse fire.

Note that while Figure A-2 shows the pre-RI Addendum #2 footprint for MRS 06, the further characterization completed for RI Addendum #2 resulted in a reduced footprint as described in Section 5; the current reduced MRS 06 footprint can be found in Figure A-6.

Table 1-1. Crosswalk of 2007 SI and 2014 RI MRS Designations		
2014 RI MRS	2007 SI MRS	Notes
MRS-1 1,000-Yard Impact Area (99 acres)	MRS 5 Northern Battery Complex (portion) – (total 356 acres)	<p>RI MRS-1 is the northern portion of the proving ground, covering both the “old” and “new” proof battery firing points, down to the 1,000-yard target (impact) area as well as estimated buffer areas. It encompasses the EE/CA Grid B003 Area as well as an area to the east where historical aerial photographs show ground disturbance (a potential sign of munitions impact craters). The park’s northern parking lot and beach plaza (shower house) are included in this area, as well as portions of North and Gunnison Beaches.</p> <p>SI MRS 5 partially overlaps RI MRS-1 and covers a small portion of the historic proving ground. The “Northern Battery Complex” mostly consists of the large, overlapping range fans emanating from 13 of the firing batteries to presumed off-shore target locations at the maximum distance the guns could fire. The majority of this acreage was excluded from the RI, as (1) limited firing of the guns is likely to have occurred, since they were installed between 1890 and 1933, during which time harbor defense was not necessary when the guns were in place, (2) no disposal operations are documented to have occurred near the batteries, (3) there are limited reports of munitions finds on the northern beaches, (4) much of the northern tip of the peninsula is sand that has accreted since firing operations ceased, likely burying any munitions that may have been in near-shore or on-shore areas, and (5) the off-shore targets would have been in deep water thousands of feet from shore.</p>
MRS-2 2,000-Yard Impact Area (151 acres)	MRS 5 Northern Battery Complex (portion) – (total 356 acres)	MRS-2 encompasses the second target area, moving from north to south from the proving ground firing area. A small portion of SI MRS 5 is covered by this area.
MRS-3 2,500-Yard Impact Area (89 acres)	MRS 5 Northern Battery Complex (portion) (total 356 acres)	MRS-3 encompasses the third target area, moving from north to south from the proving ground firing area. A small portion of SI MRS 5 is covered by this area.

Table 1-1. Crosswalk of 2007 SI and 2014 RI MRS Designations		
2014 RI MRS	2007 SI MRS	Notes
MRS-4 3,000-Yard Impact Area (73 acres)	NA	MRS-4 encompasses the fourth target area, moving from north to south from the proving ground firing area. The SI covered no portion of this MRS.
MRS-5 3-Mile Impact Area (205 acres)	NA	MRS-5 encompasses the fifth target area, moving from north to south from the proving ground firing area. The SI covered no portion of this MRS.
MRS-6 3.75-Mile Impact Area (90 acres)	MRS 1 Southern Dredging Disposal Area (31 acres)	MRS-6 encompasses the sixth target area, moving from north to south from the proving ground firing area. This MRS covers the SI MRS 1 in its entirety, the area where beach replenishment occurred, as well as the former small arms range.
MRS-7 Livens Discovery Area (29 acres)	MRS 2 Livens Projectile Disposal Area (24 acres)	MRS-7 covers the area where the 1927 storehouse explosion took place and spread Livens projectiles into an area not discovered until 1981. To draw the MRS boundary, a blast radius for the Livens projectiles, plus a buffer area, was measured from the storehouse location. The Livens found in 1981 contained FM smoke. In the SI report and ASR Supplement, the location of the Livens area was incorrectly identified (too far to the north). Although this area was called an underground storage magazine in the 1998 EE/CA report, there is no documentation or visual evidence to date that the magazines in the ordnance depot were underground.
MRS-8 Water MRS (154 acres)	MRS 5 Northern Battery Complex (offshore portion) – (total 130,580 acres)	154 acres along the eastern shore of the property, parallel to the former proving ground and impact locations. The MRS extends eastward into the ocean approximately 100 yards, reflecting a 6-foot depth contour (at mean lower low water). Six feet was used to reflect a conservative maximum depth for human receptors to potentially encounter MEC through fishing, wading or swimming activities.

Table 1-1. Crosswalk of 2007 SI and 2014 RI MRS Designations		
2014 RI MRS	2007 SI MRS	Notes
NA	MRS 3 Northern Disposal Area (1 acre)	This was presumed to be the area off the north end of the peninsula, as described in an ASR interview, where fragmentation grenades were dumped. However, there is no map or description to document the dump or its location. The interview subsequently stated that items may possibly have washed up on-shore in this area, but the location of the dump is entirely unknown. The interviewee subsequently did not recall this area and stated that he may have been referring to items that washed up on shore in the general vicinity.
NA	MRS 4 CWM Research and Development Laboratory (0.06 acres)	No CWM is documented to have been used or developed at Fort Hancock, and the name of this building in the ASR is a misnomer. The correct name was "School/Chemical Laboratory." The building was used for chemistry tests associated with conventional ordnance fired at the proving ground.
NA	MRS 6 Plum Island/Hand Grenade Court (0 acres-unlocated)	The ASR provides no documentation of the location of a grenade court, only a statement by an NPS employee that grenade training took place. The interviewee subsequently explained that the presence of a training range was conjecture and is not thought to be accurate. The found item was thought to have washed up from an off-shore area. (Note that none of the anomalies found on the island during the EE/CA were MEC-related.)

Table 1-2. Crosswalk of 2014 RI and RI Addendum #1 MRS Designations	
Addendum #1 Revised MRS Designation	MRS Designation - 2014 RI Report
MRS 03, Northern Portion Proving Ground	MRS-1: MEC/MD Hazard Area 1A
MRS 05, Southern Portion Proving Ground	MRS-1 through 5: MEC/MD Hazard Areas 1B , 2A , 3A/3B , 4A, and 5A/5B
MRS 06, Livens Discovery Area	MRS-7 where NPS excluded RI activities (24 acres)
MRS 07, Remaining Land Areas	Remaining acreage of MRSs-1 through 7
MRS 08, NPS Excluded Area	Portions of MRSs-1 through 6 where NPS denied right of entry for RI activities
MRS 09, Water Ranges	MRS 08

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2.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The following discussions, summarized from the 2014 RI Report, are provided for context.

2.1 Overall Site Description

2.1.1 Surface Features

Sandy Hook is a coastal spit, or peninsula, that projects northward, more than 5 miles into the Atlantic Ocean. Beach and dune sands make up all of the Sandy Hook spit. Most of the MRSs have similar surface features, with relatively flat beach areas on the eastern side and densely vegetated areas on the western side. MRS 06 is densely vegetated acreage with no beach areas.

2.1.2 Meteorology

Monmouth County's climate generally is moderate, with warm summers, mild winters, and evenly distributed average monthly rainfall. February is usually the month with minimum precipitation (2.89 inches (in.) average at Sandy Hook) and June is normally the month of maximum rainfall (4.45 in. average). Summer temperatures are warm, but seldom extreme due to the effect of the Atlantic sea breezes. Highest monthly temperatures occur in July (74-75 degrees Fahrenheit (°F) average). The lowest monthly average temperature occurs in January (33-34 °F). With the ocean influence, winds may blow across Sandy Hook from any direction; however, wind data are not recorded on Sandy Hook.

2.1.3 Surface Water Hydrology

There are no significant surface streams on the peninsula, and only a few marshy areas noted on the topographic maps. Except during intense rainfall events, infiltration is high and surface runoff minimal due to the sandy soils. Mean tide ranges from approximately -1.6 feet to 3 feet National Geodetic Vertical Datum (NGVD), while spring tides range from -2.1 feet to 3.5 feet NGVD. Flooding occurs only as a result of storm surges or hurricanes.

Surface water does not supply drinking water on or around Fort Hancock given the proximity to the ocean; all surface water is non-potable. There are three ponds on Sandy Hook. While recreational fishing occurs along the beaches at Sandy Hook, it does not occur at any of the ponds.

2.1.4 Geology

Fort Hancock is situated on the New Jersey Coastal Plain, a seaward-dipping wedge of unconsolidated sediments ranging in age from Cretaceous to Recent. These sediments are clay, silt, sand, and gravel, and represent continental, coastal, or marine deposition. The Coastal Plain deposits thicken seaward at the Fall Line to more than 6,500 ft at the southern tip of Cape May County (USACE, 1993). Sandy Hook is an example of an active compound recurved spit (i.e., the end of the sand bar turns landward), which has lengthened about 1,000 ft in the past quarter century. Dunal topography is present on parts of the spit. Some of the recent growth of the spit is at the expense of the spit elsewhere. A large seawall along the barrier bar and southern part of the spit have been constructed to curtail the loss of sand from the open ocean side of Sandy Hook.

2.1.5 Soils

Beach and dune sands make up all of the Sandy Hook Unit spit. The beach sand is composed principally of quartz from underlying and nearby formations. Grain size ranges from clay to small pebbles, but the sand is mainly medium to coarse. The sand is fairly clean and loose and shifts about readily. The dunes are partly stabilized and fairly well covered by bushes and grass. A small area on the western side of the spit contains tidal marsh deposits.

2.1.6 Hydrogeology

Two major aquifer systems are associated with Fort Hancock and the surrounding peninsula. Groundwater is primarily found in the Northern Atlantic Coastal Plain aquifer system, with a typical yield of 250 to 300 gallons per minute of groundwater in high-capacity wells. Groundwater beneath the northern portion of the peninsula is associated with the Englishtown aquifer. These features, and the coastal topography of the site, will affect the general flow of groundwater. Drinking water for the entire Sandy Hook peninsula is supplied by one well approximately 880 feet deep, completed in a confined aquifer. Surrounding boroughs receive drinking water from other public community supply wells.

2.1.7 Demography and Land Use

The Sandy Hook peninsula currently is part of the Gateway National Recreation Area and is used for a variety of purposes year-round. Public attractions include access to a 5-mile multi-use pathway, the Sandy Hook Visitor Center, the Fort Hancock Museum, the Sandy Hook Light House, and the Sandy Hook Bird Observatory. Recreational activities include hiking, wind surfing, swimming, and beach fishing. There are full-time and seasonal residents on Sandy Hook as well as an office of the National Oceanographic and Atmospheric Administration, the Marine Academy of Science and Technology, field offices of other non-profit environmental advocacy groups and a child care center. Many of the former Fort Hancock military buildings still exist, including housing, batteries, and silos. The U.S. Coast Guard Station is in use on Sandy Hook on the north end of the site with a functioning, on-line weather station. Many of the Coast Guard family members reside in homes on the 68 acre Coast Guard property (totaling approximately 200 residents). The NPS employs 55 permanent staff and 94 temporary (summer) employees (NPS, 2006). NPS has stated that Sandy Hook will remain part of the Gateway National Recreation Area in the future and that no changes to the current land use are projected.

2.1.8 Ecology

The Sandy Hook peninsula is characterized by a wide variety of habitats including forest, wetland, dune shrubland, dune grassland, beach, and adjacent benthic habitats (NPS, 2008a; NPS, 2008b). The peninsula serves as a valuable migratory flyway, stopover site, breeding site, and wintering site for many bird species of concern. Threatened, endangered, and special concern species within or near Fort Hancock are primarily associated with beach and dune habitats.

Sensitive ecological communities at Fort Hancock include a globally-rare 231-acre Maritime Holly forest, which is not open to the public (NPS, 2008a; 2008b). Because of the sensitive ecological communities, NPS imposed vegetation removal or cutting restrictions on specific 'excluded areas'. The Maritime Holly forest and other sensitive plants of concern in the MRSs

were not cut to minimize disturbance, including Beach Wormwood (*Artemisia campestris caudata*), American Holly (*Ilex opaca*), Eastern Red Cedar (*Juniperus virginiana*), Northern Bayberry (*Myrica pensylvanica*), Beach Plum (*Prunus maritima*), Common Hackberry (*Celtis occidentalis*), Serviceberry (*Amelanchier arborea*), and experimental vegetation research plots consisting of Asiatic Sand Sedge (*Carex kobomugi*) and American Beachgrass (*Ammophila breviligulata*), the federally-threatened and state-endangered Seabeach Amaranth (*Amaranthus pumilis*), the Sea-beach Knotweed (*Polygonum glaucum*), and Coast Flat Sedge (*Cyperus polystachyos*).

Procedures for conducting the field activities were documented in the Environmental and Cultural Resources Protection Plan (ECRPP) section of the RI Work Plan (USACE, 2010) and addenda to the ECRPP (USACE, 2011, and the RI Addendum #2 Work Plan, 2015). Formal agency consultations and ongoing communication with stakeholders ensured that field activities did not jeopardize any federally-listed and/or state-listed species or critical habitats in the investigation area.

Overall environmental impacts within MRS 06 were minimized by limiting the geophysical transect width and spacing, limiting the extent of cut vegetation, and preserving undisturbed buffer zones. NPS biologists accompanied field teams when possible to ensure that plant species of concern were properly identified and avoided. Field protocols minimized risks of spreading invasive species. No adverse effects to vegetation or the surrounding media occurred during collection of environmental soil samples. No restoration or replanting activities were required, as all holes were properly backfilled and brush cut vegetation was allowed to re-establish naturally. Few wildlife species were encountered during RI Addendum #2 activities due to the investigation time frame (December).

Any recovered archaeological artifacts, including MD items, deemed to be archaeologically significant were fully documented by USACE and NPS archaeological professionals.

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3.0 REMEDIAL INVESTIGATION OBJECTIVES AND PRELIMINARY CONCEPTUAL SITE MODEL

3.1 RI Objectives and Conceptual Site Model

The objective of RI Addendum #2 is to adequately characterize the nature and extent of any MEC hazards or MC risk resulting from the past military use of MRS 06. MC contamination was addressed in the 2014 RI. In order to complete an RI that achieves these objectives, a preliminary Conceptual Site Model (CSM) was developed in the RI Work Plan (USACE, 2010). A CSM is used to communicate and describe the current state of knowledge and assumptions about risks at a project site. The CSM presents the exposure pathway analysis by integrating information on the MEC and MC source, receptors, and receptor/MEC interaction.

The CSM for MRS 06, developed during the 2014 RI, indicated that the source of the munitions-related items was kick-out (munitions spread beyond the immediate vicinity by the detonation) from the 1927 storehouse fire or explosion. However, while MRS 06 was defined by the storehouse fire, MEC, as UXO or from low order detonations, could exist on or under the ground surface from historical proving ground operations as MRS 06 also lies within the overshot/undershot of the 3,000 yard and 3-mile target impact areas, respectively. Further, while it was considered possible that MRS 06 represents a disposal area (because there is no documentation of cleanup activities), intact ordnance was not expected to be present due to the intensity of the storehouse fire.

Table 3-1 presents a detailed preliminary CSM for MRS 06, including facility and physical profiles (setting, layout, structures, terrain, vegetation, significant features, security), land use and exposure profiles (receptors), ecological (habitat, species) and munition release profiles (types, transport mechanisms, migration routes, pathway analysis).

Impacts to this preliminary CSM, based on the RI Addendum #2 findings, are discussed in Section 5.4, where an updated CSM is presented.

Table 3-1. Preliminary Conceptual Site Model for MRS 06

Profile Type	Site Characterization
Facility Profile	Location and Area: <ul style="list-style-type: none"> MRS 06, the Livens Discovery Area, is approximately 24 acres and located approximately in the middle of original MRS-5. Most of MRS 06 lies east of Hartshorne Drive, with small portions of the MRS located to the west of Hartshorne Drive and north of the Fishing Beach access road. Most of the MRS 06 acreage was NPS excluded area during the 2014 RI.
	Structures: <ul style="list-style-type: none"> MRS 06 contains no structures. Historically, the MRS contained munitions storehouses.
	Boundaries: <ul style="list-style-type: none"> MRS 06 is a 600 foot radius circle centered on the location of the former munitions storehouse, with the boundary based on the hazard fragmentation distance of a Livens projectile plus an investigation buffer.

Table 3-1. Preliminary Conceptual Site Model for MRS 06

Profile Type	Site Characterization
	<p>Security:</p> <ul style="list-style-type: none"> The MRS is mostly covered by dense vegetation (woody and herbaceous), which naturally limits access to parts of the MRS. <p>Utilities:</p> <ul style="list-style-type: none"> Along Hartshorne Drive, overhead electric, telephone and cable lines, and buried pipes associated with beach replenishment activities.
Physical Profile	<p>Topography:</p> <ul style="list-style-type: none"> Elevation is approximately 0-15 ft amsl. Dunal topography is present on parts of the MRS. <p>Vegetation:</p> <ul style="list-style-type: none"> Flora is predominantly characterized by evergreen and mixed maritime forests, with deciduous forests (both maritime and non-maritime) existing on most of the site. <p>Wetlands:</p> <ul style="list-style-type: none"> There are wetlands in the eastern, northwest and southwest portions of the MRS. <p>Soil:</p> <ul style="list-style-type: none"> Beach and dune sands make up all of the Sandy Hook Unit spit. The dune sand is chiefly medium grained and better sorted than the beach sand. The dunes are partly stabilized and fairly well covered by bushes and grass. <p>Hydrology:</p> <ul style="list-style-type: none"> The closest surface water bodies are the Nike Missile pond and the Atlantic Ocean. Except during intense rainfall events, groundwater infiltration is high and surface runoff minimal due to the sandy soils. Therefore, surface water changes are mainly due to tidal action, including daily fluctuations and storm surges. <p>Hydrogeology/Geology:</p> <ul style="list-style-type: none"> New Jersey Coastal Plain, a seaward-dipping wedge of unconsolidated sediments ranging in age from Cretaceous to Recent. These sediments are clay, silt, sand, and gravel, and represent continental, coastal, or marine deposition.
Land Use and Exposure Profile	<p>Current Land Use:</p> <ul style="list-style-type: none"> NPS and associated recreational uses. Hiking, bird watching, picnicking, bike riding. <p>Cultural, Archaeological and Historical Resources:</p> <ul style="list-style-type: none"> Based on previous archaeological investigations, may include archaeological artifacts, features and sites that are associated with the former military use of Fort Hancock. <p>Current Potential Human Receptors:</p> <ul style="list-style-type: none"> Residents, employees, construction workers, and visitors. Because there are no residences currently in MRS 06, residents of Sandy Hook peninsula would be potential recreational visitors for this site. <p>Potential Future Land Use:</p> <ul style="list-style-type: none"> NPS has stated that Sandy Hook will remain part of the Gateway National Recreation Area in the future and that no changes to the current land use are projected. <p>Potential Future Human Receptors:</p> <ul style="list-style-type: none"> No changes are anticipated to the current human receptors.

Table 3-1. Preliminary Conceptual Site Model for MRS 06

Profile Type	Site Characterization
Ecological Profile	Degree of Disturbance: <ul style="list-style-type: none"> Primarily undisturbed with minimal trafficked areas due to natural barriers.
	Habitat Types: <ul style="list-style-type: none"> Rare Ecological Communities include: Maritime Holly Forest, Heathland, Primary Dune System, Coastal Dune Woodland. Other types present are evergreen, mixed maritime, and deciduous forests; wetland, dune shrubland, dune grassland.
	Current Potential Ecological Receptors: <ul style="list-style-type: none"> See detail provided in Section 2.1.8.
Munitions Release Profile	Munitions Types: <ul style="list-style-type: none"> Table 1-1 of the 2014 RI lists munitions historically used at Fort Hancock; it is possible that any of these could be present in MRS 06.
	Release Mechanisms: <ul style="list-style-type: none"> MEC, as UXO or from low order detonations could exist on or under the ground surface from historical proving ground or training operations (overshot/undershot of the 3,000 yard and 3-mile target impact areas, respectively). DMM may exist from the disposal of discarded munitions (i.e., burial pits). Natural processes such as erosion, wave action or shifting of sand could expose MEC, if present. MC could be present in environmental media from the release of filler materials at low order detonations or from the corrosion of munitions projectiles (casings). Kick-out from the 1927 storehouse fire or explosion.
	MEC Density: <ul style="list-style-type: none"> MEC density is expected to be scattered throughout the MRS based on kick-out from the explosion of the former storehouse.
	Munitions Debris: <ul style="list-style-type: none"> Munitions debris may be scattered across the MRS.
	Associated Munitions Constituents: <ul style="list-style-type: none"> Explosives compounds, and these selected metals: antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, thallium, titanium, vanadium, and zinc.
	Transport Mechanisms/Migration Routes: <ul style="list-style-type: none"> MEC/MD: <ul style="list-style-type: none"> moving a potential item by a person(s) disturbance of MEC/MD through construction activities natural processes such as wave action and beach erosion MC: <ul style="list-style-type: none"> natural processes such as wave action due to storm surge physical/chemical processes such as infiltration, adsorption, and/or dispersion
	Pathway Analysis: <ul style="list-style-type: none"> MEC/MD: <ul style="list-style-type: none"> MEC/MD may be present on the surface and in the subsurface; receptors are present and the pathway is considered potentially complete. MC: <ul style="list-style-type: none"> MC may be present in the surface and subsurface soil above background concentrations. Receptors are present and these pathways are considered potentially complete.

3.2 Data Needs and Data Quality Objectives

3.2.1 Data Needs

Data were needed to achieve the site characterization goal of assessing the nature and extent of MEC and MC contamination at MRS 06 and to recommend whether further CERCLA actions are warranted. Data obtained included DGM surveys, intrusive investigations to identify location, density, and types of MEC, and environmental sampling to determine the distribution and concentrations of MC in soil. These data were used to quantify risks to human health and the environment and assess MEC hazards.

3.2.2 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality and level of data required to support the decision-making processes for a project. The *Data Quality Objectives Process for Hazardous Waste Site Investigations (QA/G-4HW)* (US Environmental Protection Agency, 2000a) provides general, non-mandatory guidance on developing DQOs for environmental data collection operations in support of hazardous waste site investigations. USACE’s TPP process (USACE EM 200-1-2) closely mirrors EPA’s 7-step DQO process, and the DQOs for MRS 06 were refined through TPP meetings.

Table 3-2 presents the overall DQOs for the DGM and intrusive investigation, the primary means of identifying the nature and extent of MEC contamination. Table 3-3 presents the DQOs for soil sampling activities, the primary means for identifying the nature and extent of MC contamination. All DQOs were discussed in the TPP meetings and any comments received from stakeholders were addressed; final versions of all DQOs were outlined in the RI Addendum #2 Work Plan (USACE, 2015). Visual Sample Plan (VSP) was used to help design the investigation.

All DQOs for MRS 06 were met unless specifically discussed in Section 5.0.

DQO Element	Site-Specific DQO Statement
Project Objective(s) Satisfied	To determine if further actions are required to support the continued use of MRS 06 for recreational activities.
Data User Perspective(s)	To obtain data that satisfy compliance, risk, and if needed, remedy requirements.
Contaminant or Characteristic of Interest	To characterize the nature and extent of MEC.
Media of Interest	MEC in Soil
Required Sampling Locations or Areas and Depths	A. Use VSP in Target Search Mode to design transect placement (random parallel transect sampling). Based on identified targets, transect design ensures 100% chance of detecting a target (this approach is discussed in the RI Work Plan and no changes are proposed from the 82.5 ft spacing).

Table 3-2. Data Quality Objectives – Digital Geophysical Mapping/Intrusive Investigation	
DQO Element	Site-Specific DQO Statement
	<p>B. Perform the DGM of transects. Pick anomalies.</p> <p>C. Use VSP to “Locate and mark target areas based on elevated anomaly density.” Select “Flag areas with density significantly > background.” The background of 40 anomalies/acre was used in the 2014 RI for the area to the southwest of the center of MRS 06. Use 95% confidence value and a window diameter equivalent to the transect spacing of 82.5 ft.</p> <p>D. Organize MRS 06 into the flagged areas (anomaly clusters).</p>
Number of Samples Required	<p>E. Test each anomaly cluster using VSP. The area of each anomaly cluster will be entered, along with a sampling unit (grid) size of 100 ft x 100 ft, and a confidence of 95% that the MEC density will be no more than 5 items/acre, with the additional assumption that there is no prior knowledge about the likelihood of finding MEC. VSP will output a minimum number of grids needed to accomplish this statistical goal for the anomaly cluster.</p> <p>F. Use VSP to randomly locate the grids inside the cluster.</p> <p>G. Perform DGM of the grids and <u>dig all anomalies</u>. Note that depth is whatever the associated munition depth is to a practical maximum of 4 ft bgs based on hand digging (no powered digging equipment permitted) and a shallow water table. Also note that if a cluster is identified in an area of dense excluded vegetation and no grid can be installed, at a minimum anomalies along the transects within the cluster will be dug.</p> <p>H. Statistical analysis of actual DGM coverage and number of MEC or MD finds within each cluster will show the MEC or MD density at 95% confidence.</p> <p><i>Note: as an additional conservative approach, the area of the MRS outside the central kickout area was also assessed as a larger kickout area. To ensure a statistically supported equivalent coverage (acreage), VSP was used to estimate minimum coverage assuming different densities (i.e., targets of interest/acre) at a 95% confidence level. At the 1.0-1.5 TOI/acre range, 1.6-2.5 acres (or 7-11 grids) coverage would be required. Therefore, the mid-point of 9 grids of equivalent coverage will be completed for MRS 06 as a minimum. That is, if cluster analysis only requires 6 or 7 grids, that coverage will conservatively be increased to a minimum of 9 grids.</i></p>
Reference Concentration of Interest or Other Performance Criteria	DGM coverage objective (number of grids) will be determined based on the statistical goal of obtaining 95% confidence that less than 5 MEC/acre are present within each anomaly cluster. Objective may not be met due to presence of vegetation that is not permitted to be cut by NPS.
Sampling Method	VSP software tool for designing statistically based geophysical and intrusive investigations.
Analytical Method	NA

Table 3-3. Data Quality Objectives – Soil Sampling	
DQO Element	Site-Specific DQO Statement
Project Objective(s) Satisfied	To determine if further actions are required to support the continued use of MRS 06 for recreational activities.
Data User Perspective(s)	To obtain data that satisfy compliance, risk, and if needed, remedy requirements.
Contaminant or Characteristic of Interest	To characterize the nature and extent of MC contamination.
Media of Interest	Soil
Required Sampling Locations or Areas and Depths	Soil samples will only be collected in areas where there is visible evidence of energetic material, e.g., munitions items which are breached. Also, in areas of significant MD, where at least 50% of the munition could be identified by UXO Techs, such that an assumption of MC in the vicinity could be tested by taking a sample. Depth is whatever the associated munition depth is to a practical maximum of 4 feet bgs based on hand digging (no powered digging equipment permitted). However, identified MC contamination greater than 4 feet will be characterized.
Number of Samples Required	A sufficient number of samples to characterize nature and extent of MC soil contamination at MRS 06 was completed for the 2014 RI; additional samples based on MEC/MD finds as described above, may be collected.
Reference Concentration of Interest or Other Performance Criteria	Human Health: USEPA Regional Screening Levels and NJ Soil Remediation Standards. Ecological Risk: USEPA’s Eco-Soil Screening Levels and NJDEP’s Ecological Screening Criteria table.
Sampling Method	Obtain discrete surface or sub-surface soil using hand trowels or hand auger depending on depth.
Analytical Method	Preparatory methods for metals collected as grab samples by SW-846 3050B/7471A and analytical methods by SW-846 6010B/7471A; and explosives preparatory method by SW-846 8330B Appendix A and analytical method by SW-846 8330B.

4.0 CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN AND MUNITIONS CONSTITUENTS

This section describes the RI Addendum #2 field activities performed. The results of these activities are presented in Section 5.0. All activities were performed in accordance with the RI Addendum #2 Work Plan (USACE, 2015) or, where still applicable, the original RI Work Plan (USACE, 2010).

4.1 Munitions and Explosives of Concern Characterization

4.1.1 General Approach

4.1.1.1 *Equipment*

Geophysical and navigational equipment used to identify locations for intrusive investigation both on land and in the water are listed below.

- G-858 Gradiometer: The G-858 is a split-beam cesium vapor (non-radioactive) magnetometer that produces a measurement of the ambient magnetic field in units of nanoTeslas (nT). Measurements of the total magnetic field are collected using two sensors spaced 1.0-m apart in the vertical orientation, with the lower sensor kept 6 inches above the ground surface. In this way the total field and the vertical magnetic gradient are recorded concurrently. The instrument was set to collect data at a maximum rate of 10 readings per second. The G-858 was integrated with a HiperGa Real Time Kinematic Global Positioning System (RTK GPS, described below).
- Geonics EM61-MK2A: This is a time-domain electromagnetic (TDEM) device consisting of a computer, data logger (Juniper Systems Allegro CX), and cart assembly towed on wheels. This instrument measures the response of the immediate area to a primary pulsed electromagnetic (EM) field, generated in the lower copper coil. The EM61-MK2A is able to discriminate between surface and subsurface conductive materials more efficiently than most other metal detection devices. The device was integrated with the HiperGa RTK GPS, or operated in line and fiducial mode, for navigation. When two EM61 units were needed at the site, one was used for mapping and another was used for reacquisition and anomaly resolution.
- Schonstedt GA-52 Cx: The GA-52 Cx Magnetic Locator (Schonstedt) is a hand-held gradiometer that detects the magnetic field of a ferromagnetic object. It responds to the difference in the magnetic field between two sensors spaced about 0.51 m apart. The instrument provides audio detection signals that peak in frequency when the locator's tip is held directly over a ferrous object. The Schonstedt was used by qualified UXO personnel for anomaly avoidance, anomaly reacquisition, and for intrusive location clearance.
- Topcon HiperGa RTK GPS: The Topcon HiperGa model of RTK GPS was used at the site, and controlled with an Allegro CX field computer running Carlson SurvCE software. The base station was set up only on survey nails installed by the licensed surveyor. When integrated with the G-858, the rover was mounted on a backpack worn by the operator. When integrated with the EM61-MK2A, the rover was mounted on a tripod directly above the coils. NMEA 0183 data sentences were transmitted from the rover at a frequency of 1 Hz. For the transect survey, GGA sentences were transmitted

to the G-858 console. For the grid surveys, both GGA and GSA sentences were transmitted by serial cable to the Allegro CX on the EM61-MK2A.

- Trimble GeoXH Global Positioning System: The GeoXH is a hand-held global positioning system (GPS) of sub-meter accuracy. It was used by the UXO team to lay out transects using waypoints.

4.1.1.2 Geophysical Investigation Process

The RI Addendum #2 geophysical investigation in MRS 06 took place in phases. First, the central portion of the MRS was investigated by a series of parallel transects spaced 30 feet apart (Figure A-3 shows these “inner transects”). Data were collected with the G-858 integrated with RTK GPS and by fiducial flags where tree canopy prevented the GPS from obtaining accurate positioning. The area was centered over EE/CA Grid E004, the location of the former storehouse. The transects were designed to determine the extent of MEC contamination in this area, since nature of contamination had previously been defined based on the EE/CA findings. As described in the RI Addendum #2 Work Plan, using the procedures followed for the similar B003 area in the 2014 RI, all anomalies on the inner transects were excavated.

Next, the outer area surrounding these inner transects was investigated using transects and grids. Spaced at approximately 82.5 feet, the actual transect locations are shown in Figure A-3, while the contoured transect data are shown in Appendix B-1. Outer transect data were acquired with the G-858 integrated with RTK GPS.

Geophysical anomalies on the outer transects were then analyzed by geostatistical mapping of anomaly density using VSP software. VSP identifies areas, or clusters, with anomaly density above a background density, as determined by a spatial histogram (see Section 4.1.3.3 for a more detailed explanation). After USACE concurrence on cluster locations, grids were randomly placed within the clusters. All grids were nominally 100 ft x 100 ft in size. Figure A-3 shows the six cluster locations with grids (G1 through G6) placed within.

In addition to these six grids placed within the clusters, per the RI Addendum #2 Work Plan, ERT installed three more grids (G7, G8, G9) outside of the clusters in order to enhance overall coverage in the MRS. These grids were placed in areas where coverage could more readily be obtained (open sand, sparse underbrush, etc.). DGM data in the grids were acquired with the EM61-MK2A integrated with RTK GPS (in open areas) or with line and fiducial navigation (under tree canopy), with a line spacing of 2.5 feet (100% coverage). However, the grids often contained vegetation that could not be cut per NPS restrictions, as described in Section 2.1.2, and consequently DGM coverage within the proposed grid boundary was often less than 100%. In some cases (G1, G2, G3) a minor expansion into nearby open areas beyond the grid boundaries was done to increase coverage (see Appendix B-1 figures). All anomalies within grids above a certain threshold (as discussed in Section 4.1.3.1) were intrusively investigated.

4.1.1.3 Intrusive Investigation Process

Anomalies determined using the G-858 on the inner transects or with the EM61-MK2A in grids, were documented on dig sheets, presented in Appendix C-2. For grids with little or no canopy, coordinates were uploaded to RTK GPS and flagged using non-metallic pin flags by field geophysicists (anomaly selection is discussed in Section 4.1.3.1). For grids with significant canopy, anomalies were flagged using taped distances from the surveyed grid corners. For the process of reacquisition of anomalies, the G-858 or EM61-MK2A was used by field

geophysicists to reacquire each anomaly and to refine its location by searching for peaks and troughs, following procedures outlined in the RI Addendum #2 Work Plan. New vertical gradient values or mV values and offset distances and directions were documented on the dig sheet for each anomaly. Occasionally anomalies were merged, or the signal could not be reacquired (i.e., ‘no finds’ potentially caused by an erroneous original signal that may have been the result of noise); these were documented on the dig sheets.

UXO teams supervised by a UXO Technician III completed all excavations using shovels. Depth to contact, contact type, and other notes were recorded on the dig sheet. The UXO team excavated until the anomaly was encountered, or continued digging a minimum hole dimension of 18 inches in radius around the anomaly and 24 inches below ground surface (bgs) if nothing was encountered. Section 5.1 described items that required demolition. MD was removed and stored in a secure location on site until proper disposal as MDAS at the end of the project. Cultural debris (CD) was either removed or left in place.

After intrusive work was completed in a grid, field geophysicists returned to each grid to complete anomaly resolution, or to check up to 12 anomalies (as required by the Performance Work Statement) that were excavated, to ensure that the vertical gradient signal dropped by 80% or more.

4.1.2 Geophysical Quality Control

4.1.2.1 Geophysical System Verification

Geophysical Quality Control for the 2014 RI was partially accomplished by a Geophysical Prove-out (GPO) Plan and GPO Report. However, for this field effort, the process that was followed for geophysical QC was geophysical system verification (GSV), as described in *Geophysical System Verification (GSV): A Physics-Based Alternative to Geophysical Prove-Outs for Munitions Response* (Environmental Security Technology Certification Program [ESTCP], 2009). GSV is composed of daily surveys of an Instrument Verification Strip (IVS) and the use of a blind seed program, where metallic pipes (“seeds”) are placed in the subsurface within the MRS at locations unknown to the geophysical data collectors. The objective of the IVS is to confirm the geophysical survey instrument selection, verify that the targets of interest will be detectable to the depth of interest, validate predetermined anomaly selection methods, and provide a daily verification of proper operation of the geophysical sensor system (sensor plus location system plus data recording approach).

The IVS was installed in the Nike Missile Radar Site (the same location as the GPO used during the 2014 RI) in November 2015 prior to the RI Addendum #2 field effort. The IVS installation was documented in a memorandum (Appendix B-3) approved by USACE on November 30, 2015.

The blind seed program was implemented in the production survey areas. The seeds (small industry standard objects [ISOs], or 1 inch diameter pipe nipples) were used to verify that the DQOs concerning geolocation and sensor performance requirements were met. Seed placement occurred during stakeout of each area of investigation, and was performed by the civil surveyor with a UXO escort. The UXO Safety Officer (UXOSO) followed anomaly avoidance procedures and excavated a shallow (less than 1 ft) hole to bury a seed in a clear area. The civil surveyor then captured the location and depth of the seed prior to the UXO technician backfilling the hole.

Blind seeds were installed in each grid and along the inner transects. The civil surveyor provided the blind seed coordinates to the Project Geophysicist after data processing and target selection.

4.1.2.2 Daily Quality Control Tests

Quality control tests were conducted twice daily for the G-858 and both EM61-MK2A units at the IVS, prior to (“AM”) and immediately following (“PM”) data collection. The G-858 was set up, turned on, and allowed to warm up for approximately 5 minutes, with the two sensors in the vertical orientation and the lower one approximately 6 inches above the ground. The EM61-MK2A was set in a fixed position on the ground also. A “static background” test was conducted where each instrument recorded data for 3 minutes. A “cable shake” test was conducted where the instrument recorded data for one minute while the various cables were moved around to ensure proper connections. A “static spike” test was conducted where the instrument recorded data for 3 minutes, but with a steel rebar next to the lower sensor of the G-858 or within the coil of the EM61-MK2A. The rebar caused the gradient to be in the 100 to 1000 nT/m range, and Channel 2 of the EM61-MK2A to be in the 300 to 500 mV range. Results of daily AM and PM Quality Control Tests are presented in Appendix B-2.

4.1.2.3 Navigational Accuracy

RTK GPS was the primary means of navigation site wide. The base station was set up daily on a point next to the IVS and at the top of an old former magazine on Fishing Beach Road. The rover was always checked on a nearby point to ensure the coordinates were correct and that the signal was “fixed” at the highest accuracy. All points were installed by the licensed surveyor. Geophysical technicians monitored the GPS state on the G-858 console or the EM61’s Allegro during data collection, and paused or stopped work if the signal deviated from fix.

Along parts of the inner transects where GPS fix could not be sustained with a moving G-858 due to tree canopy, flags were placed in relatively open spaces where a static fix could be obtained, and the transects were cut from flag to flag. The G-858 was then used to collect short, straight segments of data between flags. The data processor then stretched and rotated the segments to start and end on the appropriate flags. Along parts of the inner transects where tree canopy was minimal, the RTK GPS was integrated with the G-858 successfully. Fixed GPS data were not required for the outer transects because there was no need to return to specific anomalies. “Float” and occasionally “autonomous” GPS data were usable for the analysis of the outer transect data in VSP.

For grids where the EM61-MK2A could not be integrated with GPS due to tree canopy, line and fiducial methods were used. Grid corners were placed by licensed surveyors, and tapes and ropes were used to record the position of the EM61 data, which was set to run in “wheel” mode (with an odometer) to collect one data point every 0.62 feet along each line, with a line spacing of 2.5 feet.

Handheld GPS units were used to navigate along transects. Because the exact position of the transects was determined more by existing vegetation that could not be cut than by evenly-spaced transects that would have been cut, the GPS quality did not need to be better than sub-meter accuracy.

4.1.3 Geophysical Data Analysis

4.1.3.1 Processing and Anomaly Selection

G-858 Gradiometer Data

G-858 data were processed according to the RI Addendum #2 Work Plan. G-858 magnetic data were downloaded from the instrument using Geometrics *MagMap2000*® software. Heading corrections caused by the offset of the sensor (in front of the operator) and the GPS rover antenna (worn on the operator's back) were made with this software. Dropouts (zero readings) are removed using the dropout filter. The data were then exported to Geosoft .xyz format.

G-858 data were then imported to Geosoft Oasis Montaj® and processed using the following procedures:

- The data were converted from WGS84 Universal Transverse Mercator (UTM)18N, meter coordinates to NAD83, New Jersey State Plane coordinates in US survey feet;
- Latency corrections were performed based on instrument latency determined from the IVS test using the UCELATENCY application. Verification of proper latency corrections were made by reviewing maps for “chevron effects”;
- Data were reviewed for completeness, across-track sampling, and velocity;
- The vertical magnetic gradient data and the analytic signal (AS) of the vertical gradient were gridded using the minimum curvature algorithm with a cell size of 0.5 feet;
- A series of color maps were produced from the gridded data; and
- Line paths were posted over the mapped data, and reviewed for coverage completeness.

The following procedures were followed for magnetic anomaly selection:

- The anomaly threshold value was 7.5 nT/m based on the IVS memorandum. Anomalies along transects were automatically selected and added to a database for analysis or intrusive investigation based on the AS, using the Blakely method within UX-Process®;
- The anomaly locations were reviewed and manually adjusted during QC using both the vertical magnetic gradient and calculated AS data; and
- USACE reviewed data and approved the anomalies selected for intrusive investigation by ERT using this process.

EM61-MK2A Data

EM61-MK2A data were processed according to the RI Addendum #2 Work Plan. EM61-MK2A data were downloaded from the instrument and pre-processed using DAT61 software. In the case of data integrated with GPS data, this included conversion from latitude/longitude to UTM Zone 18 coordinates in meters. In the case of line and fiducial data, all position corrections to local grid coordinates were made. The data were then exported to Geosoft .xyz format.

EM61-MK2A data were then imported to Geosoft Oasis Montaj® and processed using the same procedures described for the G-858 above.

The following procedures were followed for anomaly selection:

- The anomaly threshold value was 5 mV based on the IVS memorandum. Anomalies in grids were automatically selected and added to a database for analysis or intrusive investigation, using the Blakely method within UX-Process®; and
- USACE reviewed data and approved the anomalies selected for intrusive investigation by ERT using this process.

4.1.3.2 Transects

Transect data were collected with the G-858 gradiometer. As described in previous sections, there were closely spaced inner transects and more widely spaced outer transects (see Figure A-3). The DQOs for the inner and outer transects were different. The goal of the inner transect investigation was to determine the extent MEC contamination in the area around the EE/CA Grid E004, and therefore, all anomalies on the transects were intrusively investigated. This required high navigational accuracy (fixed GPS or equivalent with fiducial flags). The goal of the outer transects was to map variations in anomaly density across the remainder of the MRS to identify grid locations; since no anomalies on the outer transect were to be reacquired, a lower navigational accuracy was acceptable. Transect data are summarized in Table 4-1.

Table 4-1: Transect Summary			
Transects	Transect Length (ft)	Geophysical Coverage (acres)	G-858 Anomalies
Inner	1,583	0.119	55*
Outer	15,569	1.172	344
Total	17,152	1.292	399

* This reflects ‘picked’ anomalies, and does not account for subsequent merging during reacquisition or the discovery of multiple objects corresponding to a single anomaly.

4.1.3.3 Cluster Analysis and Grid Placement

The objective of cluster analysis is to focus the investigation on areas of high anomaly density on the outer transects, assuming these represent areas of elevated MEC or MD contamination, possibly representing impact areas. Cluster analysis was accomplished using VSP software, under the following menu:

- Sampling Goal > Find Target Areas and Analyze Survey Results (UXO) > Locate and mark target areas based on elevated anomaly density.

For MRS 06, coordinates of geophysical anomalies and the outer transect locations were loaded into VSP. Elevated anomaly density was considered to be anything above the background density of 100 anomalies/acre. The background density was determined by examining a spatial histogram of the data and identifying the lowest density at which there was a significant drop in frequency from the lowest values. Based on this, “Target Markers” (the centers of possible impact areas based on elevated anomaly density) were created by flagging areas significantly above the background anomaly density (100 anomalies/acre), the required confidence of 95% that the “window” (circle moved along each transect in which anomalies are counted at a discrete interval) density is above the background density, and a window diameter equivalent to the nominal transect spacing of 82.5 feet. Delineation of areas with high anomaly density (clusters) was automatically generated from Target Markers assuming a “block” (square drawn around a

target marker) width equivalent to the nominal transect spacing. Overlapping blocks defined the perimeters of clusters.

The VSP file with the above information and six identified clusters was submitted to USACE for review on December 9, 2015, and was approved the following day. A single 100 ft x 100 ft grid was placed in each of the relatively small clusters. In addition, three more grids were placed outside of the clusters to fulfill minimum coverage requirements as described in the RI Addendum #2 Work Plan. These grids were placed in areas where coverage could more readily be obtained (Figure A-3).

4.1.3.4 Grids

Grid corners were staked out by licensed surveyors. Grid locations were approved by USACE by email. As previously noted, due to NPS restrictions on vegetation removal, achieving DGM coverage goals within grids was challenging. The minimum geophysical coverage was approximately 81%, but many grids had geophysical coverage greater than 90%. As a means of increasing coverage, data collection was expanded beyond the grid boundary into adjacent open areas in three of the nine grids.

Summary information for each grid is presented in Table 4-2.

Grid	Type	Geophysical Coverage (acres)	Geophysical Coverage (percent)	EM61-MK2 Anomalies*
G1	Cluster	0.215	94%	153
G2	Cluster	0.189	82%	123
G3	Cluster	0.210	92%	187
G4	Cluster	0.203	88%	12
G5	Cluster	0.237	103%	6
G6	Cluster	0.208	91%	10
G7	Biased	0.185	81%	10
G8	Biased	0.225	98%	5
G9	Biased	0.231	100%	17
Total		1.903		523

* This reflects 'picked' anomalies, and does not account for subsequent merging during reacquisition or the discovery of multiple objects corresponding to a single anomaly.

4.2 Munitions Constituents Characterization

For the 2014 RI, based on concerns expressed by NJDEP and to ensure that MRS 06 was thoroughly characterized, a random surface soil sampling approach (discrete grab samples) was developed through VSP to support a statistical comparison to applicable screening standards for the analytes (metals and explosives). A total of 21 random samples were collected at depths of 0-6 inches bgs and analyzed for metals and explosives by SW-846 Method 6010B/7470A and SW-846 Method 8330B, respectively. The baseline risk assessment presented in the 2014 RI concluded that there was no unacceptable MC risk.

However, since significant acreage of MRS 06 was excluded by the NPS during the 2014 RI, and no geophysical investigation could be conducted, it could not be determined whether any breached or damaged munitions, posing potential MC risks, were present in MRS 06. Therefore, in accordance with the soil sampling DQO presented in Table 3-3, for the RI Addendum #2 effort, biased grab soil samples were planned for areas where there was visible evidence of energetic material, e.g., munitions items that were breached.

During the RI Addendum #2 investigation, no evidence of energetics or significantly breached munitions were found. However, in the interest of complete characterization, two discrete soil samples were collected at locations where apparently intact Livens projectiles were found on the inner transects, and were analyzed for explosives.

5.0 REMEDIAL INVESTIGATION RESULTS

Section 5.0 presents the results of the RI Addendum #2 field activities. Section 5.1 addresses the MEC/MD intrusive investigation findings and 5.2 provides the analysis of those findings. Section 5.3 presents the MC sampling findings. An updated/revised CSM is presented in Section 5.4 and a discussion of uncertainties associated with DGM and MEC/MD findings is presented in Section 5.5.

5.1 MEC Intrusive Investigation Findings

More than 500 geophysical anomalies were intrusively investigated at MRS 06. The primary intrusive investigation findings are summarized in Table 5-1. Figure A-4 shows the location of key findings from the transects and grids and Appendix B-1 provides maps of the geophysical data of the transects and grids.

A total of 55 anomalies were excavated on the inner transects and a total of 523 anomalies were excavated in the nine grids. During the reacquisition and digging process, some anomalies were merged. The dig sheets of these grids and transects, showing specific findings at each anomaly, are provided in Appendix C-2.

As discussed previously, all anomalies in the inner transects were intrusively investigated. In the digs completed in the inner transects, material potentially presenting an explosive hazard (MPPEH) was found as described in the following discussions (note that ultimately, all MPPEH items were determined to be material documented as safe, or MDAS, not MEC).

Two apparently intact Livens projectiles were found at anomaly #25 and anomaly #36 (Figure A-4). Based on the site history, a Livens would most likely be filled with FM smoke. However, while in the judgment of the Senior UXO Supervisor (SUXOS), neither item was filled with any chemical, this could not be confirmed in the field.

In addition to these, a partial Livens projectile was found at anomaly #8, but the shell was damaged and no chemicals or smoke were present. The burster tube within Livens projectiles typically has a small amount of TNT and so all three Livens projectiles were classified as MPPEH.

At anomaly #13, multiple items were found, including 5 Stokes Mortar MK1 fuzes, 3 Livens burster tubes, and one MK1 detonator. In addition, one M-1 smoke canister was found at anomaly #14. Because of the potential for some of these items to contain FM smoke, the OESS and the SUXOS determined that the items should be addressed offsite. Therefore, all of these items (anomalies #25, 36, 8, 13, and 14) were taken by the EOD team of Naval Weapons Station (NWS) Earle on 9 December 2015 for detonation on their range. EOD confirmed that none of the Livens projectiles contained FM smoke or other chemical fillers. Disposition documentation is contained in Appendix C-3.

MPPEH was also found within Grids 8 and 9. A brass base fuze was found at anomaly #4 in Grid 8. An intact Livens burster tube was found at anomaly #6 in Grid 9. Both of these MPPEH items were blown-in-place by ERT on 19 December 2015. Following detonation, these items were determined to be MDAS.

Table 5-1 indicates 15 separate MPPEH items uncovered from the 7 anomalies described in the above paragraphs and shown on Figure A-4. All MPPEH items were ultimately determined to be MDAS, not MEC. MPPEH items are documented in the photographic log in Appendix G.

MD was somewhat common (22 MD items found) in the inner transects and in Grids 4, 6, 7, 8, and 9. MD mostly consisted of unidentified munitions fragments or Livens projectile fragments. One MD item of note was a "gas check" associated with the propelling charge can for the Livens Projector system (inner transect, anomaly #40).

Many of the anomalies were cultural debris (CD), which was either removed or left in place. Grids #1, #2, and #3 were located in the wide median of Hartshorne Drive on the west side of MRS 06. Site history, including aerial photographs, indicates that this was the previous location of railroad tracks used to transport material throughout the former Fort Hancock. Consequently, these grids were very cluttered, with the vast majority of items excavated in these grids being railroad debris, unassociated with munitions. Much of this CD was left in place following identification. In addition, overhead power lines and active subsurface electric lines produced a significant amount of electromagnetic noise, leading to many false-positive anomalies and "no contacts", where nothing was found during the intrusive work. No munitions related material was found in any of these grids.

Table 5-1: Intrusive Investigation Summary

Area	Cultural Debris*	No Contacts	MD	MPPEH	MPPEH Description	Disposition
Inner Transects	26	12	9	13 (from 5 anomalies)	2 nearly intact Livens projectiles, one damaged Livens, 3 Livens burster tubes, 5 Stokes Mortar fuzes, one MK1 detonator, one M-1 Smoke canister	Taken offsite by EOD unit from NWS Earle and detonated at their range
Grid 1	127	19**	0	0		Some MD and CD were given to NPS archaeologist and remainder taken to scrap metal recycler
Grid 2	105	9**	0	0		
Grid 3	121	60**	0	0		
Grid 4	3	4	4	0		
Grid 5	5	0	0	0		
Grid 6	8	0	2	0		
Grid 7	6	2	2	0		
Grid 8	2	0	2	1	Base fuze (brass)***	Blown on site in consolidated shot by ERT
Grid 9	12	0	3	1	Livens burster tube housing***	
Total	415	106	22	15		

* Includes "hot rocks" and blind seeds.

** Grids 1, 2, and 3 were affected by overhead and subsurface electric lines producing electromagnetic noise.

***Following detonation, SUXOS classified these as MDAS items based on visual inspection, even though the detonation may have consumed any potential explosives.

5.2 Analysis of MEC Intrusive Investigation Findings

In the 2014 RI, UXO Estimator software (v2.2) was used to analyze the results of the intrusive work. However, the more up-to-date version 7.0 of VSP performs the identical calculations to UXO Estimator and it was used for analysis of the RI Addendum #2 findings.

Clusters were evaluated separately in the 2014 RI. However, for RI Addendum #2, all of the clusters were small with only one grid in each, and it is not particularly meaningful to report the MEC or MD density for each cluster. Rather, VSP was used to evaluate any area within MRS 06 where DGM and intrusive investigations have taken place.

5.2.1 Derivation of MEC/MD Hazard Area

Section 5.2.2 of the 2014 RI Report describes the procedure used for identification of MEC/MD Hazard Areas. Using that process, MEC/MD Hazard Area 6A was developed for MRS 06 based on the presence of MPPEH and MD in the grids and the inner transects (Figure A-5). The boundary of MEC/MD Hazard Area 6A is defined by the extent of the inner transects and the grids where MPPEH or MD has been found (Grids #4, 6, 7, 8, and 9). It is important to note that while the footprint of MEC/MD Hazard Area 6A was not developed based on the old EE/CA findings, it incidentally encloses the two EE/CA grids, E004 and E007 (slightly southeast of E004), where MPPEH and MD were found in 1998. In particular, Grid E004 included an FM Smoke filled Livens projectile, several “possibly live” Stokes mortar fuzes, and two M-1 Smoke canisters, and E007 contained portions of Livens projectiles.

Note that the 2014 RI Report used the term MEC/MD Hazard Area even for some areas where only MD (no MEC) was found. Accordingly, RI Addendum #2 uses this term even though only MPPEH and MD (no MEC) were found in the newly defined MEC/MD Hazard Area 6A.

The area of MEC/MD Hazard Area 6A is 5.0 acres, and the total DGM coverage within the area is 1.17 acres. These parameters were input into VSP’s Remedial Investigation (UXO) and Post Survey Analysis of the “Target of Interest (TOI) Estimation/Comparison” module. The results of the analysis are shown in Table 5-2.

TOI Type	Number of TOI	Average density (TOI/acre)	Density at 95% confidence (TOI/acre)
MPPEH	15	12.8	18.7
MPPEH+MD	37	31.6	40.3

Different classifications of TOI represent varying levels of conservatism regarding the risk present at the site. The inclusion of MPPEH plus MD is presented for comparison with results in the 2014 RI, where the sum of MEC and MD in each MEC/MD Hazard Area was presented.

As defined in the 2014 RI Report, MEC/MD Hazard Areas are considered to have a moderate to high probability of encountering MEC. These probability designations are based on USACE pamphlet Engineering Pamphlet 75-1-2, which prescribes avoidance and safety support procedures required for project sites potentially containing MEC. That document states that a moderate to high probability of encountering MEC means that current or previous land use leads to a determination that MEC was employed or disposed of in the area of concern, while “low

probability of encountering MEC” means that current or previous land use leads to an initial determination that MEC may be present.

For the 2014 RI Report, these designations included MEC/MD. Accordingly, MEC/MD Hazard Area 6A is considered to have a moderate to high probability of encountering MEC/MD while all other areas within MRS 06 are considered to have a low probability of encountering MEC/MD.

5.2.2 MRS 06 Footprint Reduction

The RI Addendum #2 effort provided additional information about the locations and potential locations of MEC, MPPEH, and MD within MRS 06, and areas known or suspected to contain MEC or MD are now smaller. Consequently, the MRS 06 boundary has been reduced accordingly. The revised MRS footprint for MRS 06 is based on the MEC/MD Hazard Area 6A boundary as shown in Figure A-6. The new acreage for the revised MRS 06 is 5.0 acres.

In order to account for FUDSMIS acreages properly, the 19 acres removed from MRS 06 became part of MRS 07 (Remaining Land Areas), such that MRS 07 is now 971 acres. Figure A-7 shows the current MRS footprints, reflecting the acreage changes.

5.3 MRSPP

DoD developed the Munitions Response Site Prioritization Protocol (MRSP) as the methodology for prioritizing sites known or suspected to contain MEC or MC for response actions. The MRSP consists of three modules to evaluate the unique characteristics of each hazard type at an MRS:

- a. The Explosive Hazard Evaluation (EHE) Module addresses explosive hazards posed by MEC and MC in high enough concentrations to pose an explosive hazard;
- b. The Chemical Warfare Materiel (CWM) Hazard Evaluation (CHE) Module addresses hazards associated with the effects of CWM; and
- c. The Health Hazard Evaluation (HHE) Module addresses chronic health and environmental hazards posed by MC and incidental non-munitions-related contaminants.

Each of the modules is assigned a rating from “G” (lowest) to “A” (highest), with alternative ratings of Evaluation Pending (insufficient information available), No Known or Suspected Hazard (NKSH), or No Longer Required (cleanup is complete). The highest of the three module ratings is used to assign an MRS priority ranking, ranging from 1 to 8, with Priority 1 having the highest relative priority and Priority 8 having the lowest.

The MRSP evaluation for reduced 5.0 acre MRS 06 is presented in Appendix D and summarized below.

- **MRS 06, Livens Discovery Area:** The MRS priority is 2, based on an EHE module rating of A. The explosive hazard conditions are based on the 1998 EE/CA findings (one 3-inch and one 4.7-inch projectile, one full Livens projectile containing FM smoke, and a potentially live Stokes mortar fuze). Site accessibility is also partial, and population density high near the site with several occupied buildings and land uses. The CHE and HHE modules are both NKSH, based on the lack of CWM and MC above background attributable to the MRS.

5.4 MEC HA

The MEC Hazard Assessment Methodology (MEC HA) assesses potential explosive hazards to human receptors under current and future conditions, given various cleanup and land use or land control alternatives.

The MEC HA is structured around three components: severity, accessibility, and sensitivity. Severity addresses the energetic material type and location of human receptors. Accessibility addresses site access, total contact hours, amount of MEC, minimum MEC depth/maximum intrusive depth, and migration potential. Sensitivity addresses MEC classification and size. The scores fall within one of four defined ranges or Hazard Levels, with 1 defined as the highest potential hazard conditions and 4 being low potential hazard conditions. The MEC HA score for MRS 06 is presented in Appendix E and summarized below.

- **MRS 06, Livens Discovery Area:** The MEC hazard level category for MRS 06 is 2, based on a total score of 820. This level reflects high potential hazard conditions.

It should be noted that no removal or remedial alternatives were evaluated, so there are no comparison scores for different cleanup scenarios. MEC HA scores will be generated for remedial response alternatives after the Feasibility Study is conducted.

5.5 Munitions Constituents Findings

Section 4.2 describes how MC sampling was completed for the 2014 RI, and that the baseline risk assessment presented in the 2014 RI Report concluded that there was no unacceptable MC risk for MRS 06. However, in accordance with the soil sampling DQO presented in Table 3-3, for the RI Addendum #2 effort, biased grab soil samples were planned for areas where there was visible evidence of energetic material, e.g., munitions items that were breached.

While no evidence of energetics or significantly breached munitions were found during the RI Addendum #2 investigation, in the interest of complete characterization, two discrete soil samples were collected at locations (anomaly #25 and anomaly #36, Figure A-4) where apparently intact Livens projectiles were found on the inner transects. These samples were analyzed for explosives (SW-846, Method 8330B).

5.5.1 MC Soil Sample Results

No explosive compounds were detected in either soil sample. These non-detects for all explosive compounds support the previous MC characterization of MRS 06 presented in the 2014 RI Report, and therefore, it is concluded that there is no unacceptable MC risk at MRS 06.

The data summary table for these two samples is presented in Appendix F.

5.5.2 MC Data Quality

The analysis was performed by Accutest Laboratories, Inc., in accordance with the original RI Work Plan (USACE, 2010), as amended by the RI Addendum #2 Work Plan (USACE, 2015). These data were validated to evaluate the data quality indicators of precision, accuracy, reproducibility, comparability, completeness, and sensitivity (PARCCS) with respect to the project DQOs. Overall, the data were considered to be of an acceptable quality to be used in this RI Addendum #2 report.

5.6 Updated Conceptual Site Model

Section 3.0 presented the initial preliminary CSM for MRS 06. This section presents an updated CSM based on the findings of RI Addendum #2.

For MRS 06, Table 5-3 indicates that MPPEH and MD have been found on the surface and in the subsurface, receptors are present, and the pathway is considered potentially complete. For MC, the table shows that while receptors are present, no MC was found at levels of concern. The baseline risk assessment conclusion of no unacceptable MC risks at MRS 06 from the 2014 RI Report was not changed based on the findings of the RI Addendum #2 investigation.

Table 5-3. Updated Conceptual Site Model for MRS 06	
Profile Type	Site Characterization
Facility Profile	Location, structures, boundaries, security, and utilities: <ul style="list-style-type: none"> No change from Table 3-1.
Physical Profile	Topography, vegetation, wetlands, soil, hydrology, and geology/hydrogeology: <ul style="list-style-type: none"> No change from Table 3-1.
Land Use and Exposure Profile	Current and potential future land use, cultural, archaeological and historical resource, current and potential future human receptors : <ul style="list-style-type: none"> No change from Table 3-1.
Ecological Profile	Degree of disturbance, habitat types, current potential ecological receptors: <ul style="list-style-type: none"> No change from Table 3-1.
Munitions Release Profile	Munitions Types: <ul style="list-style-type: none"> Historically, munition items including Livens projectiles, Livens burster tubes, Stokes Mortar fuzes, and M-1 Smoke canisters have been found in MRS 06.
	Release Mechanisms: <ul style="list-style-type: none"> As described in Table 3-1, release could be from kick-out from the 1927 storehouse fire or explosion, or as UXO or from low order detonations from historical proving ground operations (overshot/undershot of 3,000 yard and 3-mile target impact areas). Based on the investigation findings, it is still possible, but unlikely, that DMM (i.e., burial pits) is present, as no such areas were found on the closely spaced inner transects centered around the storehouse. Based on the investigation findings, MC from low order detonations or from corrosion of munitions is not present in environmental media.
	MEC and MD Density: <ul style="list-style-type: none"> No MEC was found in MRS 06 during the RI Addendum #2 field work. However, multiple MPPEH and MD items were found, including Livens projectiles, Livens burster tubes, Stokes Mortar fuzes, and an M-1 Smoke canister. The MPPEH plus MD average density was 34.2 TOI/acre.

	<p>Associated Munitions Constituents:</p> <ul style="list-style-type: none"> • In the 2014 RI Report, the baseline risk assessment concluded that there is no unacceptable MC risk at MRS 06. • No breached MEC items or concentrated MD were found during RI Addendum #2, but two soil samples were collected and analyzed for explosives; none were detected. Based on this, MC risk is not present at MRS 06.
	<p>Transport Mechanisms/Migration Routes:</p> <ul style="list-style-type: none"> • No change from Table 3-1.
	<p>Pathway Analysis:</p> <ul style="list-style-type: none"> • MPPEH and MD have been found on the surface and in the subsurface; receptors are present and the pathway is considered potentially complete. • MC receptors are potentially present; however, no MC was found and the baseline risk assessment concluded there is no unacceptable MC risk at MRS 06.

5.7 MEC or DGM Uncertainty

There is uncertainty in the detection of MEC or MD due to the limitations of the geophysical detectors used. The G-858, used for the inner and outer transects, can detect ferrous objects to various depths depending on size. For example, a 37mm round can be detected at a depth of approximately 0.4 m or less, or a 155 mm round can be detected at a depth of approximately 1.7m or less, meaning that small items at depth are more likely to be left in the ground. Similarly, the EM61-MK2A, used for the grids, can detect both ferrous and non-ferrous objects, but its maximum detection depth is somewhat more limited than the G-858.

There is uncertainty in the detection capability due to the transect spacing design. The transects are designed to detect impact areas of one half the diameter of the impact areas that defined the extent of each MRS, as explained in the 2014 RI Report. For MRS 06, the impact area of MRS-5 (2014 RI designation) was used to size the transect spacing.

There is uncertainty in the results of MEC or MD density as calculated with VSP software. The calculated average density and density at 95% confidence are inversely and exponentially related to the area investigated. DGM coverage was good relative to certain other areas investigated during the 2014 RI, and so a higher confidence in results was obtained, but it is possible that the areas sampled are not representative of the level of MEC or MD contamination present at the site.

There is uncertainty associated with incomplete historical records of military operations. It is not known with complete certainty exactly what munitions were fired or where they were fired to. There were many anecdotal descriptions based on recollections of various NPS employees; however, in many cases this information could not be confirmed.

Finally, no conclusions can be made about the presence or absence of MEC and MD in any areas excluded from investigation by NPS, i.e., a particularly large area of restricted vegetation could have masked a MEC or MD item even though DGM coverage goals were met for that area.

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6.0 SUMMARY AND CONCLUSIONS

6.1 Summary

This section summarizes the key findings from Sections 5.0.

6.1.1 Nature and Extent of Contamination

6.1.1.1 MEC/MD

A comprehensive statistically based DGM and intrusive investigation of MRS 06 was conducted at Fort Hancock, including more than 17,000 linear feet of transects, six clusters (1.9 acres), nine grids, and approximately 1,000 anomalies found with more than 500 of those intrusively investigated.

Fifteen MPPEH items and 22 MD items were found on the surface and in the subsurface of MRS 06. All MPPEH items were ultimately determined to be MD; no MEC items were found in MRS 06. Table 6-1 summarizes the MEC and MD finds per area of investigation. These are also shown in Figure A-4.

Area	MEC	MPPEH	MD	Description
Inner Transects	0	13	9	MPPEH: 2 nearly intact Livens projectiles, one damaged Livens, 3 Livens burster tubes, 5 Stokes Mortar fuzes, one MK1 detonator, one M-1 Smoke canister. Miscellaneous MD and CD
Grid 1	0	0	0	CD associated with former railroad track
Grid 2	0	0	0	CD associated with former railroad track
Grid 3	0	0	0	CD associated with former railroad track
Grid 4	0	0	4	Miscellaneous MD and CD
Grid 5	0	0	0	Miscellaneous CD
Grid 6	0	0	2	Miscellaneous MD and CD
Grid 7	0	0	2	Miscellaneous MD and CD
Grid 8	0	1*	2	MPPEH: Base fuze (brass). Miscellaneous MD and CD
Grid 9	0	1*	3	MPPEH: Livens burster tube housing. Miscellaneous MD and CD
TOTALS	0	15	22	

* Following detonation, the SUXOS classified these as MDAS items based on visual inspection, even though the detonation may have consumed any potential explosives.

The results of the DGM and intrusive investigations indicate that certain areas containing a concentration of metallic anomalies (clusters) within the MRS have a higher likelihood of a human or ecological receptor encountering MEC or MD than others. Using cluster analysis, a focus area of MRS 06 was developed into MEC/MD Hazard Area 6A.

The boundary of MEC/MD Hazard Area 6A was defined by the extent of the inner transects and the grids (Grids #4, 6, 7, 8, and 9) where MPPEH or MD was found. The MEC/MD Hazard Area 6A footprint (see Figure A-5) incidentally includes the two EE/CA grids where MPPEH and MD were found in 1998. The area of MEC/MD Hazard Area 6A is 5.0 acres, and it is considered to have a moderate to high probability of encountering MEC/MD, while all other areas within MRS 06 are considered to have a low probability of encountering MEC/MD.

The RI Addendum #2 effort provided additional information about the locations and potential locations of MEC, MPPEH, and MD within MRS 06. The area known or suspected to contain MEC or MD, developed into MEC/MD Hazard Area 6A, is now smaller. Consequently, the MRS 06 boundary has been reduced accordingly, and the acreage for MRS 06 has been revised from 24 acres to 5.0 acres. The revised MRS 06 boundary is shown in Figure A-6. The 19 acres removed from MRS 06 are now part of MRS 07, and MRS 07 is now 971 acres (see Figure A-7).

The MRSP evaluation for the reduced 5.0 acre MRS 06 is presented in Appendix D. The MRS priority is 2, based on an Explosive Hazard Evaluation module rating of A. The MEC HA score for MRS 06 is presented in Appendix E. The MEC hazard level category for MRS 06 is 2, based on a total score of 820. This level reflects high potential hazard conditions.

6.1.1.2 MC

For the 2014 RI, based on concerns expressed by NJDEP and to ensure that MRS 06 was thoroughly characterized, a random surface soil sampling approach (discrete grab samples) was developed through VSP to support a statistical comparison to applicable screening standards for the analytes (metals and explosives). A total of 21 random samples were collected at depths of 0-6 inches bgs and analyzed for metals and explosives by SW-846 Method 6010B/7470A and SW-846 Method 8330B, respectively. The baseline risk assessment presented in the 2014 RI concluded that there was no unacceptable MC risk.

However, since significant acreage of MRS 06 was excluded by the NPS during the 2014 RI, and no geophysical investigation could be conducted, it could not be determined whether any breached or damaged munitions, posing potential MC risks, were present in MRS 06. Therefore, in accordance with the soil sampling DQO presented in Table 3-3, for the RI Addendum #2 effort, biased grab soil samples were planned for areas where there was visible evidence of energetic material, e.g., munitions items that were breached.

While no evidence of energetics or significantly breached munitions was found during the RI Addendum #2 effort, two discrete soil samples were collected at locations where apparently intact Livens projectiles were found on the inner transects. These samples were analyzed for explosives (SW-846, Method 8330B). No explosive compounds were detected in either soil sample. These non-detects for all explosive compounds support the previous MC characterization of MRS 06 presented in the 2014 RI Report, and therefore, it is concluded that there is no unacceptable MC risk at MRS 06.

6.2 Conclusions

Nature and extent of MC and MEC has been characterized for MRS 06 as described above. No unacceptable MC risk to human health or ecological receptors is present within MRS 06. An area of focus (MEC/MD Hazard Area 6A) has been delineated as having a moderate to high probability of encountering MEC/MD based on the investigation findings. Based on this newly delineated area of focus, the boundary of MRS 06 has been reduced to 5.0 acres; the remaining 19 acres were added to MRS 07.

Table 6-2 presents these findings in a single table, summarizing the overall conclusions with regard to MC risks and MEC/MD hazards present at the site.

Table 6-2. Summary of Findings				
MRS	Focus Area	Acreage	Potential Concern	
			MC	MEC/MD¹
MRS 06	MEC/MD Hazard Area 6A	5.0	None	Moderate to High
	All areas other than 6A	19	None	Low

¹ – Probability of encountering MEC/MD

7.0 REFERENCES

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Appendix A: Figures

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