REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
26-08-2014

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
May - August 2011

4. TITLE AND SUBTITLE
Remedial Investigation Report for RVAAP-033-R-01 Firestone Test Facility MRS, Version 1.0

5a. CONTRACT NUMBER
W912DR-09-D-0005

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Laura O'Donnell, David Crispo, P.E.

5d. PROJECT NUMBER
136147

5e. TASK NUMBER
0800320

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
North Atlantic Baltimore District
10 S. Howard Street, Room 7000
Baltimore, MD 21201

10. SPONSOR/MONITOR'S ACRONYM(S)
NAB

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
Reference distribution page.

13. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless designated by other documentation.

14. ABSTRACT
This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at the RVAAP-033-R-01 Firestone Test Facility Munitions Response Site (MRS) between May and August 2011 at the Ravenna Army Ammunition Plant. The purpose of the RI is to determine whether the Firestone Test Facility MRS warrants further response action pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the National Oil and Hazardous Substances Pollution Control Plan. More specifically, the RI is intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the likely hazards and risks posed to human and environmental receptors by MEC and MC. This RI Report also presents additional data to support the identification and evaluation of alternatives in the Feasibility Study (FS), if required. This RI Report was prepared in accordance with the Army's Final Military Munitions Response Program Munitions Response RI/FS Guidance dated November 2009.

15. SUBJECT TERMS
Firestone Test Facility, Remedial Investigation, Military Munitions Response Program

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	UU	560	David Crispo
					19b. TELEPHONE NUMBER *(Include area code)* 781.821.3513

Reset

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CB&I Federal Services LLC has completed the *Final Remedial Investigation Report for RVAAP-033-R-01 Firestone Test Facility MRS* at the former Ravenna Army Ammunition Plant in Portage and Trumbull Counties, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy, principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets customer's needs consistent with law and existing United States Army Corps of Engineers policy.

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Final Remedial Investigation Report for
RVAAP-033-R-01 Firestone Test Facility MRS
Version 1.0

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912DR-09-D-0005
Delivery Order 0002

Prepared for:

US Army Corps
of Engineers®

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Canton, Massachusetts 02021

August 26, 2014

DOCUMENT DISTRIBUTION

Name/Organization	Number of Printed Copies	Number of Electronic Copies
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ARNG—Army National Guard
CB&I—CB&I Federal Services LLC
Ohio EPA—Ohio Environmental Protection Agency
RVAAP—former Ravenna Army Ammunition Plant
USACE—U.S. Army Corps of Engineers

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AEDB-R	Army Environmental Data Base Restoration
AMEC	AMEC Earth and Environmental, Inc.
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ARNG	Army National Guard
ASR	*Final Archives Search Report*
ASTM	American Society of Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	baseline ecological risk assessment
bgs	below ground surface
bss	below sediment surface
BSV	background screening value
bws	below water surface
CAS	Chemical Abstracts Service
CB&I	CB&I Federal Services LLC
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
Cr^{+3}	trivalent chromium
Cr^{+6}	hexavalent chromium
CRJMTC	Camp Ravenna Joint Military Training Center
CSM	conceptual site model
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DQO	data quality objective
e^2M	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESL	ecological screening level
ESV	ecological screening value
EU	exposure unit
FS	Feasibility Study

Acronyms and Abbreviations (continued)

FWSAP	*Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP*
FWCUG	facility-wide cleanup goal
gpm	gallons per minute
GPS	global positioning system
HA	hazard assessment
HHRA	human health risk assessment
HHRAM	Human Health Risk Assessor Manual
HI	hazard index
HQ	hazard quotient
HRR	*Final Historical Records Review*
IDW	investigation-derived waste
INRMP	*Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site*
IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip
LANL	Los Alamos National Laboratory
LCS	laboratory control sample
LOD	limit of detection
MC	munitions constituents
MD	munitions debris
MDL	method detection limit
MEC	munitions and explosives of concern
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MKM	MKM Engineers, Inc.
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRL	method reporting limit
MRS	munitions response site
MRSPP	*Munitions Response Site Prioritization Protocol*
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt(s)
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NGT	National Guard Trainee
NOAEL	no observed adverse effect level
ODNR	Ohio Department of Natural Resources
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
ORNL	Oak Ridge National Laboratory

Acronyms and Abbreviations (continued)

PBA	Performance-Based Acquisition
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
R(A)	Resident Receptor (Adult)
R(C)	Resident Receptor (Child)
RCRA	*Resource Conservation and Recovery Act*
RDX	research department explosive
RME	reasonable maximum exposure
RI	Remedial Investigation
RSL	Regional Screening Level
RPD	relative percent difference
RTK	real time kinematic
RTS	robotic total station
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	*Final Sampling and Analysis Plan and Quality Assurance Project Plan*
SDG	sample delivery group
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	site inspection
SLERA	screening-level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
SRC	site-related chemical
SVOC	semivolatile organic compound
TBC	to be considered
TOC	total organic carbon
TOW	tube-launched, optically-tracked, wire-guided
TRV	toxicity reference value
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USP&FO	U.S. Property and Fiscal Officer
UXO	unexploded ordnance
VOC	volatile organic compound
VQ	validation qualifier
Work Plan	*Final Work Plan for MMRP for Remedial Investigation Environmental Services*

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EXECUTIVE SUMMARY

This *Remedial Investigation (RI) Report* documents the findings and conclusions of the RI field activities for the Firestone Test Facility (RVAAP-033-R-01) Munitions Response Site (MRS) located at the former Ravenna Army Ammunition Plant (RVAAP) in Portage and Trumbull Counties, Ohio. This RI Report was prepared by CB&I Federal Services LLC under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the facility under the *Multiple Award Military Munitions Services Performance-Based Acquisition* Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

The purpose of the RI was to determine whether the Firestone Test Facility MRS warranted further response action pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) of 1980 and the *National Oil and Hazardous Substances Contingency Plan*. More specifically, the RI was intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the potential hazards and risks posed to human health and the environment by MEC and MC.

ES.1 MRS Description

Whenever possible, existing information and data were incorporated into this RI Report. Background information related to the MRS was taken from the *Final Archives Search Report* (USACE, 2004) and the *Final MMRP Historical Records Review* documents included in the *Final Site Inspection Report* (engineering-environmental Management, Inc. [e^2M], 2008), hereafter referred to as the SI Report. Previous data collected at the MRS under the Installation Restoration Program were also reviewed, but were not considered applicable since samples were collected at the MRS during the RI and are considered to be representative of current conditions.

The Firestone Test Facility MRS is a 0.41-acre former munitions testing area located within Load Line #6 and was used for the testing of shaped charges. When active, the MRS area consisted of a small building, a man-made pond, and the area surrounding the pond. The building contained a test chamber for shaped charges and has since been demolished. The former MRS activities included the testing of shaped charges within the building test chamber and underwater testing of the shaped charges in the pond. The MRS is currently undeveloped, vacant land with no improvements.

No MEC or munitions debris (MD) was found during the 2007 site inspection (SI) field activities; however, various subsurface anomalies were detected that were not verified during the SI. No MC was identified in a surface soil sample that was collected from a small clearing added to the SI area following the *Final MMRP Historical Records Review* (e^2M, 2007). The sample location was situated outside of the MRS boundaries identified during the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory. The SI Report (e^2M, 2008) concluded that there was a potential for MEC around the perimeter and bottom of the pond and adjacent to the former shaped charge test chamber building and recommended that these areas be further characterized to address the MEC concerns. Due to the lack of detected MC in the open area located outside of the MRS and that sampling investigations at the remaining portions of the MRS were being conducted under the Installation Restoration Program, the SI Report (e^2M, 2008) did not recommend additional characterization of MC at the MRS.

Current activities at the Firestone Test Facility MRS include maintenance activities, environmental sampling, and natural resource management activities. The Ohio Army National Guard (OHARNG) future land use for the Firestone Test Facility MRS is military training (USACE, 2005).

ES.2 Summary of Remedial Investigation Activities

The preliminary MEC and MC conceptual site models (CSMs) were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used to identify the data needs and data quality objectives (DQOs) as outlined in the *Final Work Plan for MMRP for Remedial Investigation Environmental Services* (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011), hereafter referred to as the Work Plan. The data needs and DQOs were determined at the planning stage and included characterization for MEC and MC associated with former activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and valid assumptions could be inferred from the data. The DQOs for the Firestone Test Facility MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform a geophysical investigation to identify if buried MEC or MD was present.
- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC/MD was present.
- Collect incremental and/or discrete soil samples (surface and subsurface) in areas with concentrated MEC/MD, if any, to evaluate for MC.

- Process the information to evaluate whether there are unacceptable risks to human health and the environment associated with MEC and/or MC and make a determination if further investigation was required under the CERCLA process.

Geophysical Investigation

In May 2011, Shaw performed a DGM survey to identify potential subsurface areas of MEC and/or MD at the Firestone Test Facility MRS. Additional DGM fill-in data were collected in June and July of 2011 over two small areas at the MRS in order to ensure the final DGM dataset represented the MRS characteristics as accurately as possible. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was calculated to be 0.31 acres or nearly 84 percent of the land-based portion at the MRS. No MEC or MD was identified on the ground surface during the DGM survey.

Anomaly Selection

Evaluation of the data collected during the DGM survey identified 423 individual anomalies. Approximately 60 of the anomalies are located within a high anomaly density zone in the central portion of the MRS. The geophysical data indicate that the anomaly density at the MRS is relatively high and considered “cluttered” in the region directly northeast of the pond and “saturated” in the area of the MRS that is located northwest of the pond. At the southern end of the saturated anomaly area, the field crew documented metals objects consisting of rebar and other construction debris protruding through the ground surface that are considered cultural debris.

Intrusive Investigations

Following the completion of the DGM survey in July 2011, an intrusive investigation was conducted for the locations identified as potentially containing subsurface MEC and/or MD based on an analysis of the DGM survey data. A total of 105 of 423 anomalies (25 percent) were selected for intrusive investigation based on the approved statistical sampling method that is based on the estimation required sample size for populations. No MEC or MD was identified at the 105 anomaly locations selected for investigation.

Underwater Investigation

An underwater tactile investigation was performed at the former shaped charge test pond in August 2011 to examine for potential MEC items buried within the pond sediment. The underwater investigation included 100 percent coverage of the walls and floor of the 0.04-acre pond. No MEC or MD was identified in the pond during the RI field activities.

Investigation of MC was not addressed during the SI for sediment in the pond or the soils surrounding the pond at the current MRS. Based on the identified data gaps for suspected environmental media at the MRS and since the soil sample collected during the SI was outside of the current MRS boundaries, further characterization of MC was addressed in these media at the MRS during the RI. Since no MEC or MD were found during the RI intrusive investigation or underwater tactile investigation, sampling for potential MC focused on surface soil around the edges of the test pond and in the pond sediment.

MC Sampling

Two discrete sediment samples were collected on August 8, 2011, at locations just beneath the vegetation surrounding the pond at a depth of approximately 2 feet below the pond water surface. The samples were collected at opposite ends of the pond and the sample interval was from 0 to 0.5 feet beneath the sediment surface.

On August 12, 2011, one surface soil sample was collected around the former test pond collected using the incremental sampling methodology (ISM). The purpose of the ISM surface soil sample was to characterize if former shaped charge test activities had impacted the soils immediately surrounding the pond. The ISM soil sample depth was collected at 0 to 0.5 feet below ground surface, since MC would only be expected to be found in the top several inches of soil based on the historical activities at the MRS.

Additionally, a surface water sample was collected from the former test pond on May 5, 2011, to evaluate options for investigating the test pond sediment, which included approved and controlled discharge of the pond water to the ground surface or manual diving operations. This sample is also used in the RI to evaluate for the presence of MC in the pond.

ES.3 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008a) addresses human health and safety concerns associated with potential exposure to MEC at an MRS under a variety of site conditions, including various cleanup scenarios and land use assumptions. If an explosive hazard is identified for the RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and provide a scoring summary for the current and future land use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns. No MEC or MD items were identified at the MRS during RI field activities, which indicates that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA score was not warranted for the Firestone Test Facility MRS.

ES.4 MC Risk Assessment Summary

Site-related chemicals (SRCs) for the Firestone Test Facility MRS were determined for the surface soil, sediment, and surface water samples collected during the RI field activities through the facility data screening process as presented in the *Final Facility-Wide Human Health Cleanup Goals for the RVAAP* (Science Applications International Corporation, 2010). The detected chemicals retained as SRCs included copper and cadmium in surface soil; aluminum, antimony, cadmium, copper, and lead in sediment; and chromium, copper, lead, and strontium in surface water. The identified SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions.

Human Health Risk Assessment

A human health risk assessment was conducted for the surface soil, sediment, and surface water samples collected at the Firestone Test Facility MRS to determine if the identified SRCs were chemicals of potential concern (COPCs) and/or chemicals of concern (COCs) that may pose a risk to future human receptors. The future land use for the Firestone Test Facility MRS is military training, and the Representative Receptors are the National Guard Trainee and the Engineering School Instructor. The Representative Receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA and as outlined in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Army National Guard [ARNG], 2014), modifications to the human health risk assessment specified in the technical memorandum were not required for the RI. Specifically, the RI still includes an assessment of risks to a formerly used human health receptor, the Engineering School Instructor, and does not include the Commercial Industrial Land Use using the Industrial Receptor.

Aluminum in sediment was the only SRC identified as a COPC during the first screening step. The COC evaluation of aluminum in sediment was performed and concluded that aluminum is not considered a COC and is not likely to pose risks to human receptors. In summation, none of the MC-related SRCs were determined to pose risks to likely human receptors, including the Resident Receptor (Adult and Child), in the evaluated potential exposure pathways of surface soil, sediment, and surface water; and Unrestricted Land Use was achieved for the MRS.

Ecological Risk Assessment

Several metals were identified as chemicals of potential ecological concern (COPECs) in soil, sediment, and surface water samples collected for the RI at the Firestone Test Facility

MRS. COPECs are determined in the ecological risk assessment and may differ from COPCs. Copper was present in all three media at slightly elevated concentrations. COPECs were identified in sediment only and consisted of aluminum, antimony, cadmium, and lead.

Given the conservativeness of the ecological risk assessment and the low overall concentrations detected, the potential that exposure to the COPECs identified to adversely impact populations of ecological receptors at the Firestone Test Facility MRS is considered to be very low and not pose a concern to ecological receptors. No final COPECs are identified for any media, and no further investigation (i.e., a Level III Baseline) or action is necessary at the Firestone Test Facility MRS for ecological purposes. Therefore, there are no chemicals of ecological concern that require additional investigation.

ES.5 Conceptual Site Model

The information collected during the RI field activities were used to update the MEC and MC CSMs for the Firestone Test Facility MRS as presented in the SI Report (e^2M, 2008). The purpose of a CSM is to identify all complete, potentially complete, or incomplete source–receptor interactions for reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, activity, access, and receptor.

MEC Exposure Analysis

Complete DGM coverage of accessible land-based areas was conducted at the MRS during the RI and a statistical approach was taken for the selection of anomalies for intrusive investigation. An underwater tactile investigation was performed in the former test pond area at the MRS. No MEC or MD was identified at the MRS during the land-based intrusive investigation or in sediment within the former test pond during the RI field activities; therefore, the MEC exposure pathways for surface soil, sediment, and surface water are incomplete for all receptors. Given the lack of a MEC source in surface soil at the MRS, incomplete pathways were considered for subsurface soil for all receptors as well.

MC Exposure Analysis

Sampling for MC was performed at the Firestone Test Facility MRS based upon the potential for MEC items to be buried on the ground surface around the former shaped charge test pond and within the sediment of the pond. Although a MEC source was not encountered during the RI field activities, detected chemicals were conservatively evaluated as SRCs. None of the SRCs were determined to pose risks to likely human or ecological receptors and the MC exposure pathways for surface soil, sediment, and surface water are incomplete for all receptors.

Groundwater beneath the facility is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. No MEC or MD was found during the RI field activities and the results of the detected chemicals that were conservatively evaluated as SRC were low. No groundwater samples were collected at the Firestone Test Facility MRS during the RI field activities; however, it is unlikely that groundwater has been impacted. Therefore, the MC exposure pathway for groundwater is incomplete for all receptors.

ES.6 Conclusions

This RI Report was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose risks to likely receptors. The following statements can be made for the Firestone Test Facility MRS based on the results of the RI field activities:

- Complete DGM coverage of accessible land-based areas (0.31 acres) was conducted at the MRS during the RI and 84 percent coverage of the 0.368-acre land-based portion of the MRS was achieved.
- A full coverage (100 percent) underwater tactile investigation was performed in the former test pond area (0.04 acres) at the MRS and no MEC or MD was found.
- The nature and extent of MEC or MD has been adequately defined at the MRS and no explosive safety hazard is present at the MRS.
- The SRCs that were conservatively evaluated as MC in surface soil, sediment, and surface water do not pose risks to human or ecological receptors at the MRS; therefore, no further action is required for MC at this MRS.

Based on these conclusions, it is determined that the Firestone Test Facility MRS has been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. No Further Action is recommended for the Firestone Test Facility MRS under the MMRP, and the next course of action will be to proceed to a No Further Action Proposed Plan.

Since the RI was initiated before the finalization of the U.S. Army's technical memorandum (ARNG, 2014) and No Further Action (Unrestricted Land Use) was determined for MEC and MC, evaluation for the Commercial Industrial Land Use using the Industrial Receptor was not included. The CERCLA investigations for the Installation Restoration Program (IRP) are still being completed at this time. If results in the IRP investigations do no indicate that Unrestricted Land Use has been achieved, then the evaluation for the Commercial Industrial Land Use will be incorporated along with the Unrestricted (Residential) Land Use and the Military Training Land Use under the IRP, as specified in the technical memorandum (ARNG, 2014).

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1.0 INTRODUCTION

This *Remedial Investigation (RI) Report* documents the findings and conclusions of the RI field activities for the Firestone Test Facility (RVAAP-033-R-01) Munitions Response Site (MRS) located at the former Ravenna Army Ammunition Plant (RVAAP) in Portage and Trumbull Counties, Ohio. This RI Report was prepared by CB&I Federal Services LLC (CB&I) under Delivery Order 0002 for Military Munitions Response Program (MMRP) environmental services at the facility under the *Multiple Award Military Munitions Services Performance-Based Acquisition* (PBA) Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

This RI Report presents the results of the RI field activities that were conducted at the MRS between May and September 2011. This report was developed in accordance with the *Final Work Plan for Military Munitions Response Program Remedial Investigation Environmental Services* (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011) at the former RVAAP, hereafter referred to as the Work Plan, and the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

1.1 Purpose

Environmental cleanup decision making under the MMRP follows the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) of 1980 prescribed sequence of RI, Feasibility Study (FS), Proposed Plan, and Record of Decision. The RI serves as the mechanism for collecting data to characterize MRS conditions, determining the nature and extent of the contamination, and assessing potential risks to human health and the environment from this contamination. While not all munitions and explosives of concern (MEC) or munitions constituents (MC) under the MMRP constitute CERCLA hazardous substances, pollutants or contaminants as defined in 40 Code of Federal Regulations (CFR) 302.4, the Defense Environmental Restoration Program (DERP) statute provides the U.S. Department of Defense (DoD) the authority to respond to releases of MEC/MC, and DoD policy states that such responses shall be conducted in accordance with CERCLA and the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP).

The purpose of the RI was to determine whether the Firestone Test Facility MRS warranted further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the potential hazards and risks posed to human health and the environment by MEC and MC. Also, additional data are presented in this RI Report to support the identification and evaluation of alternatives in the FS, if required.

1.2 Problem Identification

The Firestone Test Facility was used for the testing of shaped charges within a former building test chamber and underwater testing of the shaped charges in a man-made test pond. Although the tests were controlled, underwater testing activities may have resulted in releases of MEC and MC into sediment in the pond and surface soil surrounding the pond. The Firestone Test Facility MRS is collocated with the Load Line #6 Area of Concern (AOC).

The unexploded ordnance (UXO) survey activities performed during the site inspection (SI) field activities in 2007 resulted in no findings of MEC or munitions debris (MD); however, multiple, closely spaced subsurface anomalies were detected around the pond and the location of the former test chamber. At the end of the *Final Site Inspection Report* (engineering-environmental Management [e^2M], 2008), hereafter referred to as the SI Report, it was determined that the extent of buried MEC items around the perimeter of the pond and in the pond was not fully understood. Based on historical operations at the MRS, any MEC source would be expected to be found just below the ground surface and/or pond sediment.

During the SI field activities, a surface soil sample was collected using the incremental sampling methodology (ISM) at a small clearing located outside of the current MRS area. The sample area was suspected to be a former test range associated with past activities at the MRS. No MC was detected in the surface soil sample. Due to the lack of detected MC in the open area outside of the MRS and that sampling investigations at the remaining portions of the MRS were being conducted under the Installation Restoration Program (IRP) for the collocated AOC, the SI Report (e^2M, 2008) did not recommend additional characterization of MC at the MRS. However, additional surface soil sampling within the shaped charge testing area of the MRS (i.e., the vicinity of the test pond) was proposed at a minimum during development of the Work Plan (Shaw, 2011).

1.3 Physical Setting

This section presents the physical characteristics of the facility and the Firestone Test Facility MRS, which are factors in understanding fate and transport, conceptual site model (CSM), and exposure scenarios for potential human health and ecological hazards and risks. The physiographic setting, hydrology, climate, and ecological characteristics of the facility were compiled from information originally presented in the SI Report (e^2M, 2008), that included the Firestone Test Facility MRS, and the *Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site* (AMEC Earth and Environmental, Inc. [AMEC], 2008), hereafter referred to as the INRMP, that was prepared for the Ohio Army National Guard (OHARNG).

1.3.1 Location

The former RVAAP (Federal Facility ID No. OH213820736), now known as the Camp Ravenna Joint Military Training Center (Camp Ravenna), is located in northeastern Ohio within Portage and Trumbull Counties and is approximately 3 miles east-northeast of the city of Ravenna. The facility is approximately 11 miles long and 3.5 miles wide. The facility is bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad to the south; Garret, McCormick, and Berry Roads to the west; the Norfolk Southern Railroad to the north; and State Route 534 to the east. In addition, the facility is surrounded by the communities of Windham, Garrettsville, Newton Falls, Charlestown, and Wayland (**Figure 1-1**).

Administrative control of the 21,683-acre facility has been transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the OHARNG for use as a training site, Camp Ravenna. The restoration program involves cleanup of former production areas across the facility related to former operations under the former RVAAP.

The Firestone Test Facility MRS is an approximate 0.41-acre parcel located in the former Load Line #6 at the south-central portion of the facility within Portage County (**Figure 1-2**). The IRP AOC, with which the MRS is collocated, is identified as Army Environmental Database-Restoration Module (AEDB-R) number RVAAP-33. The MRS is located on federal property with administrative accountability assigned to the USP&FO for Ohio. The MRS is currently managed by the ARNG and OHARNG. **Table 1-1** summarizes the administrative description for the Firestone Test Facility MRS. The table includes the facility AEDB-R numerical designation for the MRS, the current MRS acreage, and the agencies responsible for the MRS.

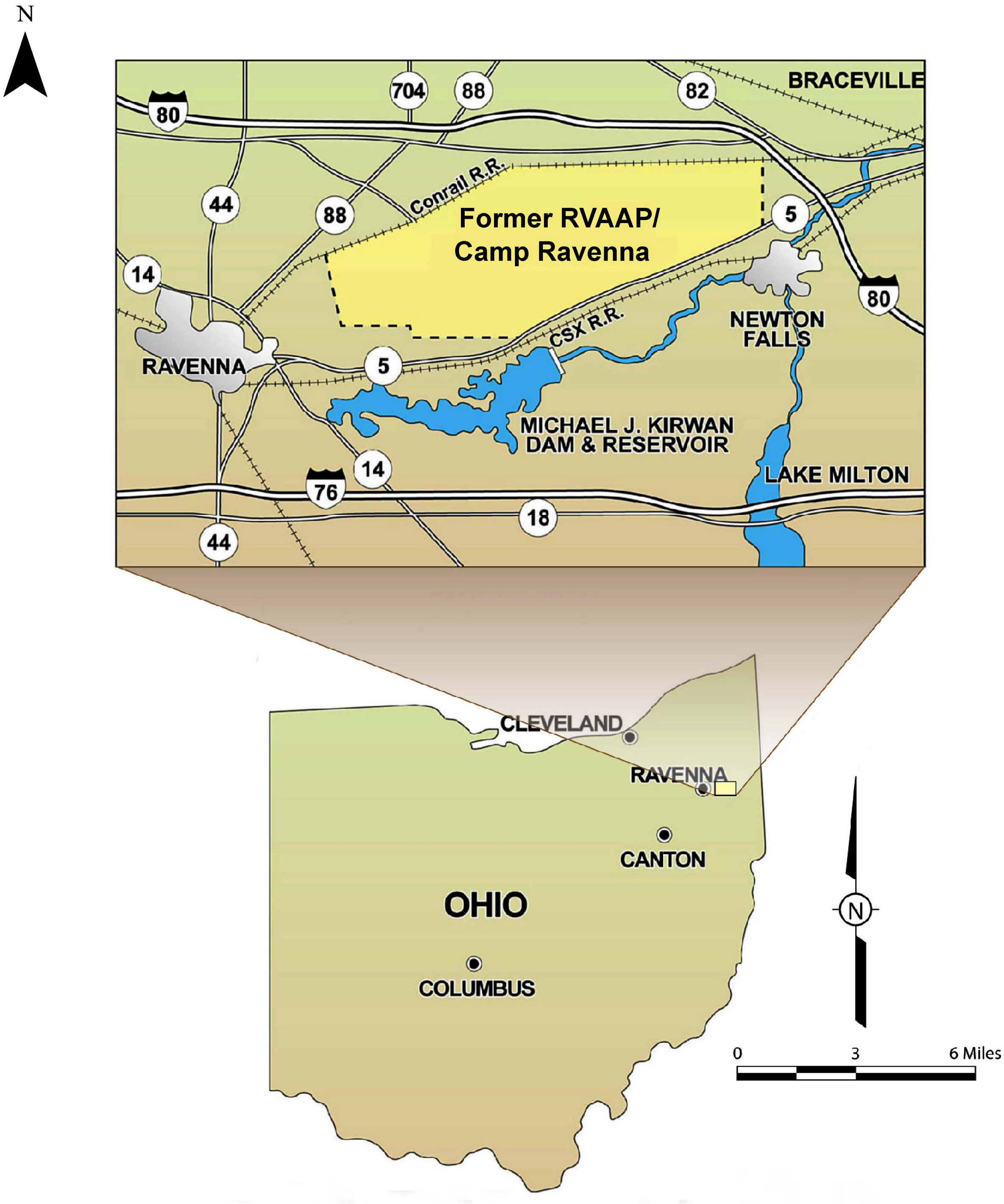
Table 1-1
RVAAP Administrative Description Summary of the Firestone Test Facility MRS

MRS Name	AEDB-R MRS Number	MRS Area (Acres)	Property Owner	MRS Management Responsibility
Firestone Test Facility	RVAAP-033-R-01	0.41	USP&FO	ARNG/OHARNG

AEDB-R denotes Army Environmental Data Base Restoration.
ARNG denotes Army National Guard.
MRS denotes munitions response site.
OHARNG denotes Ohio Army National Guard.
USP&FO denotes U.S. Property and Fiscal Officer.

1.3.2 Current and Projected Land Use

Current activities at the Firestone Test Facility MRS include maintenance activities, environmental sampling, and natural resource management activities. Potential users associated with the current activities at the MRS include facility personnel, contractors, and occasional trespassers (e^2M, 2008).



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Note:
The Scale is for the Upper Map Only
Showing the Former RVAAP/Camp Ravenna Location

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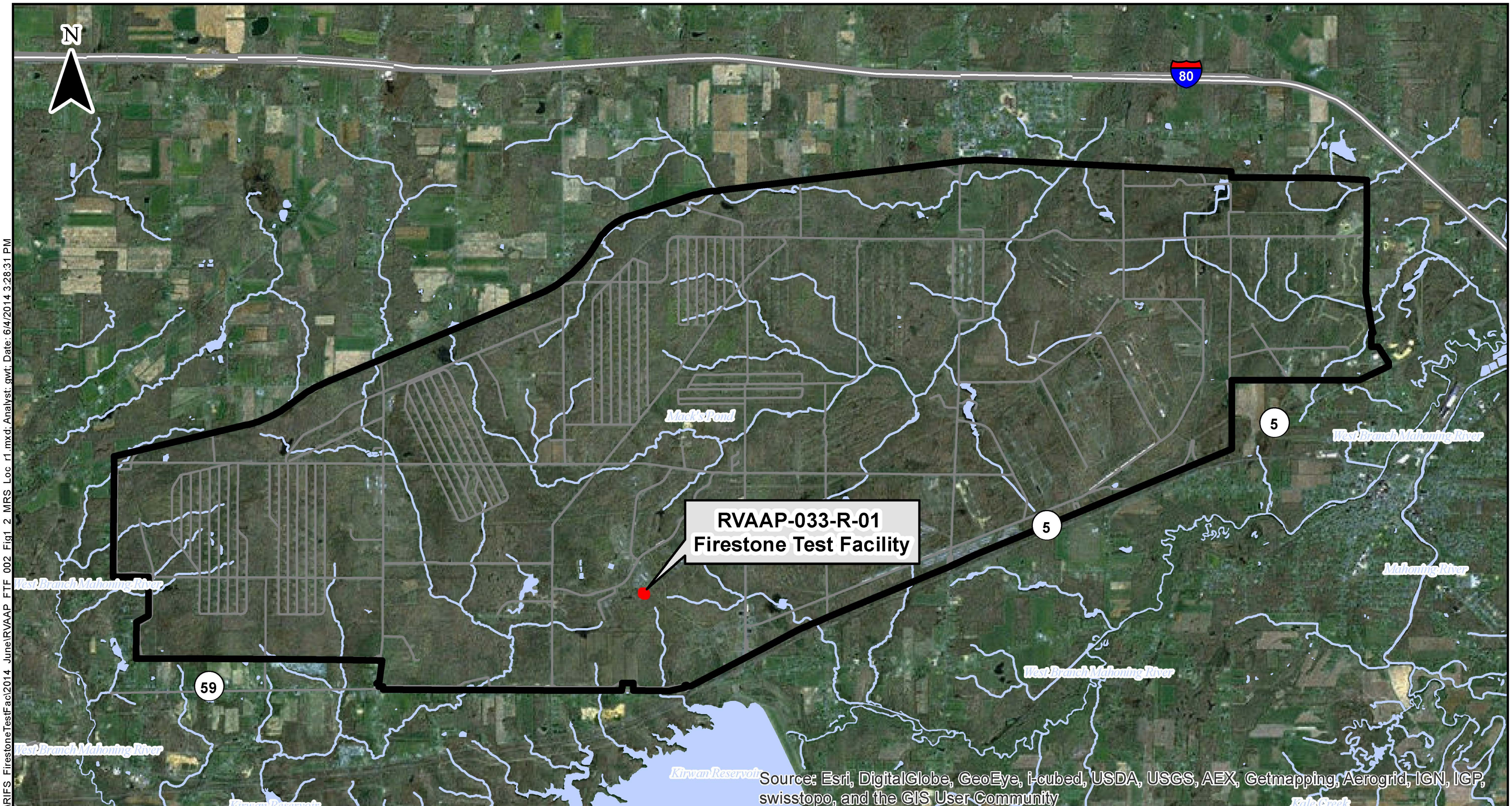
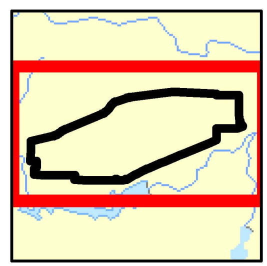
FIGURE 1-1 INSTALLATION LOCATION MAP



Facility Boundary
MRS Boundary
Stream



0 1.25 2.5 Miles

PROJECTION: NAD83 UTM Zone 17N

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FIGURE 1-2 MRS LOCATION MAP

The OHARNG future land use for the Firestone Test Facility MRS is military training. The National Guard Trainee and the Engineering School Instructor are the Representative Receptors for the future land use (USACE, 2005).

1.3.3 Climate

The climate at the facility is classified as humid continental, and the region is characterized by warm, humid summers and cold winters. The National Weather Service identified the average annual precipitation for Ravenna, Ohio as 40.23 inches, with February as the driest month and July as the wettest month. **Table 1-2** reflects the annual climate and weather normally encountered at nearby Youngstown Municipal Airport.

Table 1-2
Climatic Information, Youngstown Municipal Airport, Ohio

Temperature Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal Maximum Temperature (°F)	32.4	36.0	46.3	58.2	69.0	77.1	81.0	79.3	72.1	60.7	48.4	37.3
Normal Minimum Temperature (°F)	17.4	19.3	27.1	36.5	46.2	54.6	58.7	57.5	50.9	40.9	33.0	23.4
Mean Precipitation (inches)	2.34	2.03	3.05	3.33	3.45	3.91	4.10	3.43	3.89	2.46	3.07	2.96
Mean Snowfall (inches)	13.1	9.6	10.4	2.2	0	0	0	0	Trace	0.6	4.5	12.3

Source: National Oceanic and Atmospheric Administration Climatography of the United States No. 20 1971–2000.
°F denotes degrees Fahrenheit.

1.3.4 Topography

The facility is located within the Southern New York Section of the Appalachian Plateaus physiographic province. Rolling topography containing incised streams and dendric drainage patterns are prevalent in the province. Rounded ridges, filled major valleys, and areas covered with glacially derived unconsolidated deposits were the product of glaciation in the Southern New York Section. In addition, bogs, kettle lakes, and kames are evidence of past glacial activity in the province. Old stream drainage patterns were disturbed and wetlands were created within the province as a result of past glacial activity (e^2M, 2008).

Firestone Test Facility MRS Topography

The topography at the Firestone Test Facility MRS is relatively flat to gently sloping towards the natural drainage channel to the east and adjacent to the MRS. The ground surface elevation at the MRS is approximately 1,115 feet above mean sea level (amsl). Natural drainage at the MRS is towards the drainage ditch that runs along the eastern boundary of the

MRS or the former man-made test pond. The topographical features at the Firestone Test Facility MRS are presented in **Figure 1-3**.

1.3.5 Geology and Soils

Based on regional geology, the facility consists of Mississippian- and Pennsylvanian-age bedrock strata, which dips to the south at approximately 5 to 10 feet per mile. The bedrock is overlain by unconsolidated glacial deposits of varying thickness.

Bedrock is overlain by deposits of Wisconsin-aged Lavery Till and Hiram Till in the western and eastern portions of the facility, respectively. The thickness of the glacial deposits varies throughout the former RVAAP ranging from ground surface in parts of the eastern portion of the facility to an estimated 150 feet in the south-central portion of the facility.

Bedrock is present near the ground surface in many locations at the facility. Where glacial deposits are still present, their distribution and character are indicative of ground moraine origin. Laterally discontinuous groupings of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments are present. Glacial-age standing-water-body deposits may be present at the facility, in the form of uniform light gray silt deposits over 50 feet thick.

At approximately 200 feet below ground surface (bgs), the Mississippian Cuyahoga Group is present throughout most of the facility. In the northeastern corner of the facility, the Meadville Shale Member of the Cuyahoga Group is present close to the surface. The Meadville Shale Member of the Cuyahoga Group is blue-gray silty shale characterized by alternating thin beds of sandstone and siltstone.

The Sharon Member of the Pennsylvanian Pottsville Formation unconformably overlies the Meadville Shale Member of the Mississippian Cuyahoga Group. A relief of as much as 200 feet exists in Portage County, which can be seen in the Sharon Member thickness variations. The Sharon Member is made up of shale and a conglomerate.

The Sharon Member conglomerate unit is identified as highly porous, permeable, cross-bedded, frequently fractured and weathered quartzite sandstone, which is locally conglomeratic and has an average thickness of 100 feet. A thickness of as much as 250 feet exists in the Sharon Member conglomerate where it was deposited in a broad channel cut into Mississippian-age rocks. In marginal areas of the channel, the conglomerate unit may thin out to approximately 20 feet, or in places it may be missing owing to nondeposition on the uplands of the early Pennsylvanian-age erosional surface. Thin shale lenses occur intermittently within the upper part of the conglomerate unit.

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FIGURE 1-3 TOPOGRAPHIC MAP

The Sharon Member shale unit is identified as a light to dark-gray fissile shale, which overlies the conglomerate in some locations; however, it has been eroded throughout the majority of the facility. The Sharon Member shale unit outcrops in many locations in the eastern half of the facility.

The remaining members of the Pottsville Formation overlie the Sharon Member in the western portion of the facility. Due to erosion and because the land surface was above the level of deposition, the Pottsville Formation is not found in the eastern half of the facility.

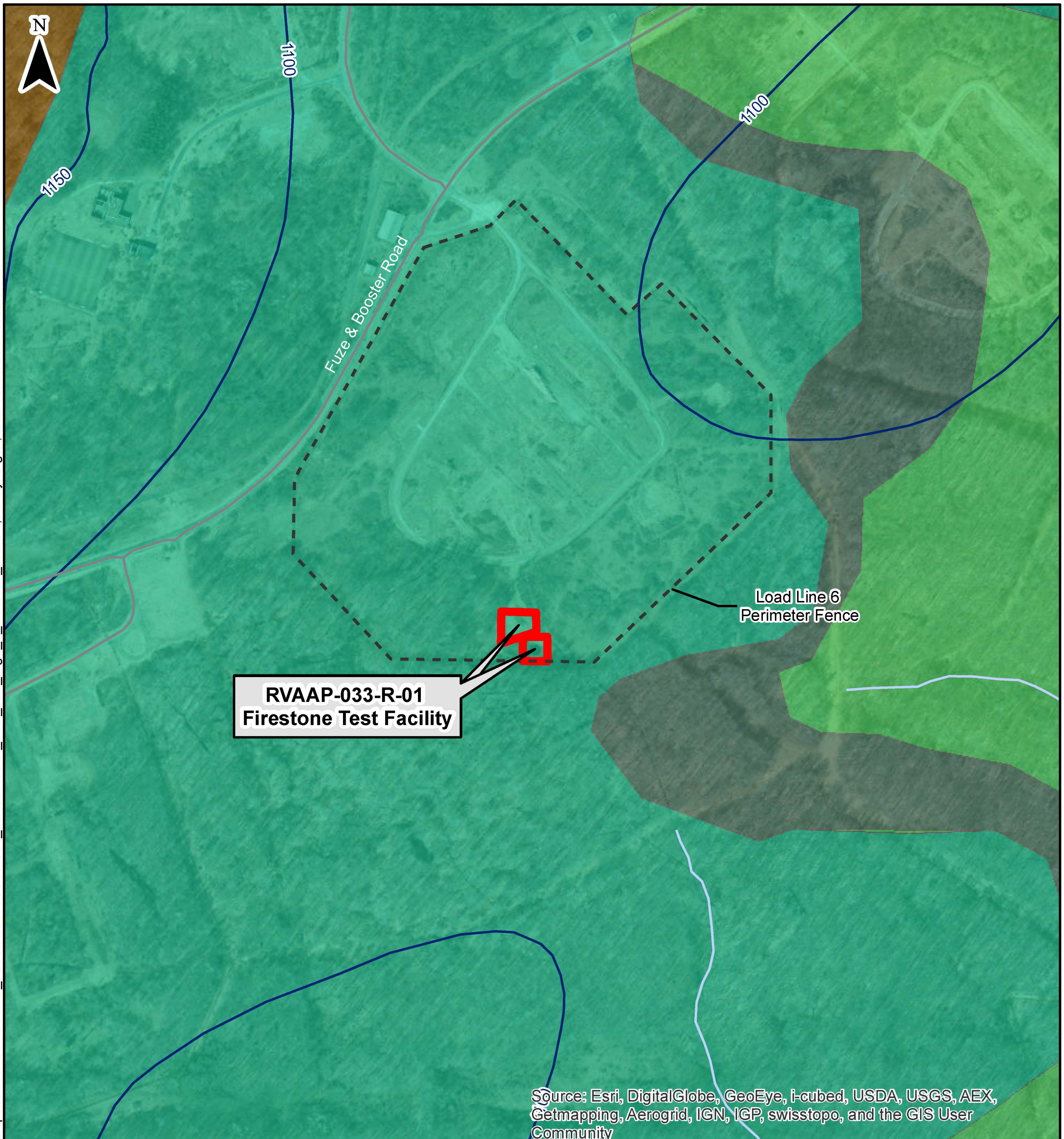
The Connoquenessing Sandstone Member, which is sporadic, relatively thin-channel sandstone comprised of gray to white, coarse-grained quartz with a higher percentage of feldspar and clay than the Sharon Member conglomerate unit, unconformably overlies the Sharon Member. The Mercer Member, which is found above the Connoquenessing Sandstone Member, consists of silty to carbonaceous shale with many thin and discontinuous lenses of sandstone in its upper part. The Homewood Sandstone Member unconformably overlies the Mercer Member and consists of the uppermost unit of the Pottsville Formation. The Homewood Sandstone Member ranges from well-sorted, coarse-grained, white quartz sandstone to a tan, poorly sorted, clay-bonded, micaceous, medium- to fine-grained sandstone. The Homewood Sandstone Member occurs as a caprock on bedrock highs in the subsurface (e^2M, 2008).

The soils identified at the facility are generally derived from the Wisconsin-age silty clay glacial till and are silt or clay loams ranging in permeability from 6.0×10^{-7} to 1.4×10^{-3} centimeters per second (U.S. Department of Agriculture [USDA] et al., 1978). Much of the native soil at the facility was disturbed during construction activities in former production and operational areas of the facility (Science Applications International Corporation [SAIC], 2011a).

Firestone Test Facility MRS Geology and Soils

The Firestone Test Facility MRS is located over the Mercer Member and the bedrock elevation is approximately 1,100 feet amsl (MKM Engineers, Inc. [MKM], 2007). The estimated depth to bedrock at the MRS is between 13 and 20 feet (SAIC, 2011a). **Figure 1-4** illustrates the bedrock formation beneath the MRS.

The soil type at the Firestone Test Facility MRS is the Mahoning silt loam with 0 to 2 percent slope (SAIC, 2011a). The Mahoning silt loam is characterized with medium to rapid runoff, severe seasonal wetness, and slow permeability. The average permeability of the Mahoning silt loam is 9.1×10^{-5} centimeters per second (USDA et al, 1978). **Figure 1-5** illustrates the soil types at the Firestone Test Facility MRS.



MRS Boundary

Geologic Formation

- Connoquennissing Sandstone Member
- Homewood Sandstone Member
- Mercer Member
- Sharon Member

Bedrock Elevation Contour

Stream

Fence Line

0 500 1,000 Feet

Projection : NAD_1983_UTM_Zone_17N

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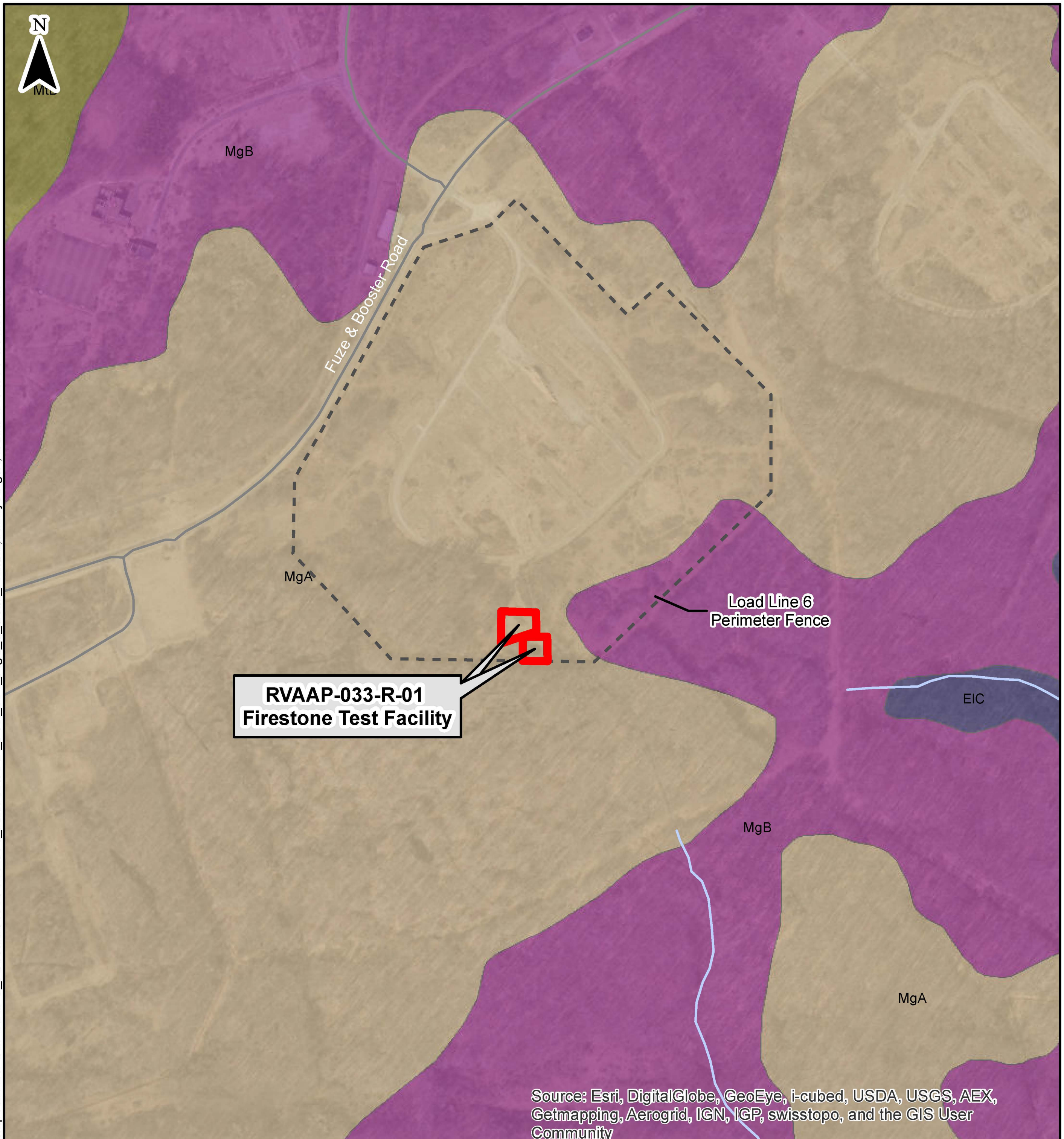
FIGURE 1-4 BEDROCK MAP



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MRS Boundary

Soil Type

- EIC - Ellsworth silt loam, 6 to 12 percent slopes
- MgA - Mahoning silt loam, 0 to 2 percent slopes
- MgB - Mahoning silt loam, 2 to 6 percent slopes
- MtB - Mitiwanga silt loam, 2 to 6 percent slopes
- Pq - Pits, quarries
- Stream
- Fence Line

0 500 1,000 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 1-5 SOILS MAP

1.3.6 Surface Water

The facility is located within the Ohio River Basin. The major surface stream at the facility is the West Branch of the Mahoning River, which flows adjacent to the western end of the facility, generally from north to south, before flowing into the Michael J. Kirwan Reservoir. After leaving the reservoir, the West Branch joins the Mahoning River east of the facility.

Surface water features within the facility include a variety of streams, lakes, ponds, floodplains, and wetlands. Numerous streams drain the facility, including approximately 19 miles of perennial streams. The total combined stream length at the facility is 212 linear miles (AMEC, 2008).

Three primary watercourses drain the facility: (1) the South Fork of Eagle Creek, (2) Sand Creek, and (3) Hinkley Creek. Eagle Creek and its tributaries, including Sand Creek, are designated as State Resource Waters. With this designation, the stream and its tributaries fall under the Ohio State Antidegradation Policy. These waters are protected from any action that would degrade the existing water quality.

Approximately 153 acres of ponds are found on the facility. Most of the ponds were created by beaver activity or small man-made dams and embankments. Some were constructed within natural drainage ways to function as settling ponds for effluent or runoff (AMEC, 2008).

A planning-level survey (i.e., desktop review of wetlands data and resources such as National Wetland Inventory maps, aerials, etc.) for wetlands was conducted for the entire facility, including the MRS. Wetland delineations have also been completed for select areas of the facility. Wetlands located within the facility include seasonally saturated wetlands, wet fields, and forested wetlands. Sand and gravel aquifers are present within the buried-valley and outwash deposits in Portage County. In general, the aquifer is too thin and localized to provide large quantities of water; however, yields are sufficient for residential water supplies. Wells located on the facility were primarily located within the sandstone facies of the Sharon Member (MKM, 2007).

Firestone Test Facility MRS Surface Water Features

Jurisdictional wetlands delineation has not been conducted at the MRS. A planning-level survey for wetlands was conducted for the facility, including the MRS, and no wetlands have been identified at the Firestone Test Facility MRS. No bogs, kettle lakes, or kames have been identified as being present within the MRS (AMEC, 2008). Perennial surface water at the Firestone Test Facility MRS is limited to the former test pond, which was formerly utilized for explosives testing.

Surface water at the northern and eastern portions of the MRS flows to the drainage ditch that runs along the eastern boundary of the MRS. Surface water at the southeast portion of the MRS enters the former man-made test pond or the drainage ditch.

Perennial surface water features exist outside the fenced MRS boundary to the southwest (within a planning-level wetland) as two small unnamed headwater streams that eventually drain to the Michael J. Kirwan Reservoir. Surface water runoff that enters the natural drainage channel east and adjacent to the MRS eventually enters the downstream perennial headwater stream to the Michael J. Kirwan reservoir. The local and regional surface water features associated with the MRS are presented in **Figure 1-6**.

1.3.7 Hydrology and Hydrogeology

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County. Generally, these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies; however, yields are sufficient for residential water supplies. Lateral continuity of these aquifers is unknown. Recharge of these units comes from surface water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge areas at the facility have not been delineated (USACE, 1998).

The thickness of the unconsolidated interval at facility ranges from thin to absent in the eastern and northeastern portion of facility to an estimated 150 feet in the south-central portion of the facility. The groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones, desiccation cracks, and partings within the soil column. Laterally, most groundwater flow likely follows topographic contours and stream-drainage patterns, with preferential flow along pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities than surrounding clay or silt-rich material (USACE, 1998).

Depending on the existence and depth of overburden, the Sharon Sandstone ranges from an unconfined to a leaky artesian aquifer. Water yields from water supply wells at the facility that were completed in the Sharon Sandstone/Conglomerate were 30 to 400 gallons per minute (gpm) (U.S. Army Toxic and Hazardous Materials Agency, 1978). Well yields of 5 to 200 gpm were reported for on-site bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer, 1982). Other local bedrock units capable of producing water include the Homewood Sandstone, which is generally thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells completed in the Connoquenessing Sandstone in Portage County have yields of 5 to 100 gpm, but are typically

FIGURE 1-6 SURFACE WATER FEATURES

less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow et al, 1966).

Firestone Test Facility MRS Hydrology and Hydrogeology

Although groundwater recharge and discharge areas have not been delineated at the facility, it is assumed that the extensive uplands areas, located at the western portion of the facility, are regional recharge zones. Sand Creek, Hinkley Creek, and Eagle Creek are presumed to be major groundwater discharge areas (e^2M, 2008). The Firestone Test Facility MRS is located at the south-central, more level portion of the facility and is not presumed to be in a ground water recharge area.

The estimated groundwater flow direction at the MRS is to the east-southeast. The depth to groundwater measurements were taken from existing monitoring wells installed at the Load Line #6 AOC under the IRP. The nearest monitoring well to the MRS is LL6-mw-007 located approximately 100 feet to the southeast. Groundwater is present at the MRS at approximately 5 feet bgs in primarily sandy silt (MKM, 2007). Potentiometric data indicate the groundwater table occurs within the unconsolidated formation throughout the AOC that is collocated with the MRS (Environmental Quality Management, Inc., 2012).

1.3.8 Vegetation

The facility has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas. Vegetation at the facility can be grouped into three categories: (1) herb dominated, (2) shrub dominated, and (3) tree dominated. Tree-dominated areas are most abundant, covering approximately 13,000 acres on the facility. Shrub vegetation covers approximately 4,200 acres. A plant species survey identified 18 vegetation communities on the facility. The facility has as total of seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Firestone Test Facility MRS Vegetation

Vegetation at the MRS has been influenced by man-made improvements associated with the former use of the MRS as a test area for shaped charges and the vegetation community present at the Firestone Test Facility MRS is categorized as “other land” (AMEC, 2008), which presumably refers to highly disturbed areas that do not support any particular plant community. Vegetation associated with aquatic and semiaquatic conditions (i.e., cattails) are present at the edges of the shaped charge test pond.

1.3.9 Endangered, Threatened, and Other Rare Species

Federal status as a candidate, threatened, or endangered species is derived from the *Endangered Species Act* (ESA; 16 U.S. Code [USC] § 1538, et seq.) and is administered by the U.S. Fish and Wildlife Service. While there are species under federal review for listing, there are currently no federally listed species or critical habitats at the facility. State-listed plant and animal species are determined by the Ohio Department of Natural Resources (ODNR). Although biological inventories have not occurred within the MRS boundary and no confirmed sightings of state-listed species have been reported, there is the potential for state listed or rare species to be within the MRS boundary. Information regarding endangered, threatened, and candidate species at the facility was obtained from the CRJMTC Rare Species List (2010). **Table 1-3** presents state-listed species that have been identified to be on the facility by biological inventories and confirmed sightings.

Table 1-3
Camp Ravenna Rare Species List

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Northern harrier	*Circus cyaneus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-winged warbler	*Vermivora chrysoptera*
Osprey	*Pandion haliaetus*
Trumpeter swan	*Cygnus buccinator*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Graceful underwing moth	*Catocala gracilis*
Tufted moisture-loving moss	*Philonotis fontana var. Caespitosa*
Bobcat	*Felis rufus*
Narrow-necked Pohl's moss	*Pohlia elongata var. Elongata*
Sandhill crane (probable nester)	*Grus canadensis*
Bald eagle (nesting pair)	*Haliaeetus leucocephalus*
State Threatened	
Barn owl	*Tyto alba*
Dark-eyed junco (migrant)	*Junco hyemalis*

Common Name	Scientific Name
Hermit thrush (migrant)	*Catharus guttatus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Caddisfly	*Psilotreta indecisa*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*
Lurking leskea	*Plagiothecium latebricola*
Pale sedge	*Carex pallescens*
State Potentially Threatened Plants	
Gray birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum var. Roseum*
Hobblebush	*Viburnum alnifolium*
Long beech fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Large St. Johnswort	*Hypericum majus*
Water avens	*Geum rivale*
Shining lady's tresses	*Spiranthes lucida*
Swamp oats	*Sphenopholis pensylvanica*
Arborvitae	*Thuja occidentalis*
American chestnut	*Castanea dentata*
State Species of Concern	
Pygmy shrew	*Sorex hoyi*
Woodland jumping mouse	*Napaeozapus insignis*
Star-nosed mole	*Condylura cristata*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*

Common Name	Scientific Name
Cerulean warbler	*Dendroica cerulea*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chloropus*
Great egret (migrant)	*Ardea alba*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*
Mayfly	*Stenonema ithaca*
Coastal plain apamea	*Apamea mixta*
Willow peasant	*Brachylomia algens*
Sedge wren	*Cistothorus platensis*
State Special Interest	
Canada warbler	*Wilsonia canadensis*
Little blue heron	*Egretta caerulea*
Magnolia warbler	*Dendroica magnolia*
Northern waterthrush	*Seiurus noveboracensis*
Winter wren	*Troglodytes troglodytes*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Mourning warbler	*Oporornis philadelphia*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Golden-crowned kinglet	*Regulus satrapa*

Common Name	Scientific Name
Blackburnian warbler	*Dendroica fusca*
Blue grosbeak	*Guiraca caerulea*
Common snipe	*Gallinago gallinago*
American wigeon	*Anas americana*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*

Source: Camp Ravenna Joint Military Training Center Rare Species List, April 27, 2010.

1.3.10 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility. Cultural and archeological resources have been identified at the facility during past surveys (AMEC, 2008). The Firestone Test Facility MRS has not been previously surveyed for cultural or archaeological resources; however, due to the disturbed nature of the ground from former activities, it is unlikely that cultural/archaeological resources exist at the MRS.

1.4 Facility History and Background

During operations as an ammunition plant, the former RVAAP was a government-owned and contractor-operated industrial facility. Industrial operations at the former RVAAP consisted of 12 munitions assembly facilities, referred to as “load lines.” Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene and Composition B into large caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the “pink water” waste water, which contained 2,4,6-trinitrotoluene and Composition B, was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers prior to use as a weapons demilitarization facility.

In 1950, the former RVAAP was placed in standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with storage of munitions. Production activities were resumed from July 1954 to October 1957 and again from May 1968 to August 1972. In addition to production missions, various demilitarization activities were conducted at facilities constructed at Load Lines 1, 2, 3, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at the former RVAAP include MRSs that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Potential contaminants at these MRS include explosives, propellants, metals, and waste oils. Other AOCs present at the facility include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities.

Firestone Test Facility MRS History and Background

The Firestone Test Facility was an approximately 1-acre area that consisted of two buildings and a pond located on the southeastern side of the Load Line #6 Fuze and Booster Area. The buildings were used as a test chamber for tube-launched, optically-tracked, wire-guided (TOW) missiles and Dragon missiles, while shaped charges were tested under water at the pond. Due to the classified nature of the research that was conducted at the Firestone Test Facility, there is little available information regarding the activities that occurred or how the tests were conducted (SAIC, 1996). The tests that were conducted were reportedly contained, which limited any release of MEC (e^2M, 2007). An additional building was located adjacent to the pond that was used for testing shaped charges. The building, which measured 10 feet high and 10 feet square, was constructed of reinforced concrete and fitted with steel plates, and was surrounded by a barricade constructed of railroad ties. All three buildings have been removed and the areas have been cleared of surface construction debris. Some buried construction debris is evident in the area around the pond due to mounded areas with rebar protruding through the ground surface. The MRS is 0.41 acres in size and is the location of the former building and area around the former test pond only. The MRS is currently undeveloped, vacant land with no improvements. The MRS layout and primary site features are presented in **Figure 1-7**.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions as it pertains to the Firestone Test Facility MRS. This information was obtained primarily from the *Final MMRP Historical Records Review* (HRR) (e^2M, 2007) and the SI Report (e^2M, 2008).

FIGURE 1-7 SITE FEATURES MAP

1.5.1 2004 USACE Archives Search Report

The USACE conducted an archives search in 2004 under the DERP as a historical records search and SI for the presence of MEC at the former RVAAP. The *Final Archives Search Report* (ASR) was prepared by the USACE in 2004 and identified 12 AOCs as well as 4 additional locations with the potential for MEC. Based on the ASR, Ramsdell Quarry Landfill, Erie Burning Grounds, Open Demolition Area #1, Load Line 12 and Dilution/Settling Pond, Building 1200 and Dilution/Settling Pond, Quarry Landfill/Former Fuze and Booster Burning Pits, 40mm Firing Range, Building 1037—Laundry Waste Water Sump, Anchor Test Area, Atlas Scrap Yard, Block D Igloo, and Tracer Burning Furnace were identified as potential MRSs containing MEC. Confirmed MEC was identified at Open Demolition Area #2, Landfill North of Winklepeck, Load Line #1 and Dilution/Settling Pond, and Load Line 3 and Dilution/Settling Pond (USACE, 2004). The Firestone Test Facility MRS was not identified as one of the original sites that contained MEC as part of the 2004 ASR.

1.5.2 2007 e^{2}M Historical Records Review

The HRR was completed by e^{2}M in January 2007. The primary objective of the HRR was to perform a limited scope records search to document historical and other known information on MRS identified at the former RVAAP, to supplement the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, and to support the technical project planning process designed to facilitate decisions on those areas where more information was needed to determine the next step(s) in the CERCLA process.

Of the 19 MMRP-eligible MRSs identified during the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, the HRR identified 18 MRSs that qualified for the MMRP due to the demolition and/or disposal activities that were conducted on the MRSs that resulted in the possible presence of MEC and/or MC and where the releases occurred prior to September 2002 (e^{2}M, 2008). These 18 MRSs identified during the HRR include the following:

- Ramsdell Quarry Landfill (RVAAP-001-R-01)
- Erie Burning Grounds (RVAAP-002-R-01)
- Open Demolition Area #2 (RVAAP-004-R-01)
- Load Line #1 (RVAAP-008-R-01)
- Load Line #12 (RVAAP-012-R-01)
- Fuze and Booster Quarry (RVAAP-016-R-01)
- Landfill North of Winklepeck (RVAAP-019-R-01)

- 40mm Firing Range (RVAAP-032-R-01)
- Firestone Test Facility (RVAAP-033-R-01)
- Sand Creek Dump (RVAAP-034-R-01)
- Building #F-15 and F-16 (RVAAP-046-R-01)
- Anchor Test Area (RVAAP-048-R-01)
- Atlas Scrap Yard (RVAAP-050-R-01)
- Block D Igloo (RVAAP-060-R-01)
- Block D Igloo-TD (RVAAP-061-R-01)
- Water Works #4 Dump (RVAAP-062-R-01)
- Areas Between Buildings 846 and 849 (RVAAP-063-R-01) (now identified as "Group 8")
- Field at the Northeast Corner of the Intersection (RVAAP-064-R-01)

Following the HRR, the Field at the Northeast Corner of the Intersection (RVAAP-064-R-01), otherwise known as the Old Hayfield MRS, was classified as an operational range. This MRS was removed from eligibility under the MMRP, reducing the number of active MRS at the former RVAAP to 17.

Information gathered during the HRR indicated that the Firestone Test Facility was a security-classified experimental test facility for munitions. Reportedly, the facility was used to construct and test shaped charges for the DoD in addition to missile testing (e^2M, 2007).

Prior to the HHR, the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory identified the MRS boundaries of the Firestone Test Facility to include only the location of the former test pond and the test chamber building located next to it. The locations of the two former TOW and Dragon missile test chamber buildings and an area suspected to be a former test range associated with the Firestone Test Facility were identified during the HRR and were added as areas for additional investigation to be conducted during the SI field work (e^2M, 2007). The areas investigated during the SI based on the HRR recommendations are presented in **Figure 1-8**.

The MEC analysis in the HRR concluded that while the release mechanism for MEC was the intentional testing of the TOW and Dragon missiles and shaped charges, the tests were contained and any release was limited. As such, the potential for MEC to be located at the areas associated with the former Firestone Test Facility was expected to be limited.

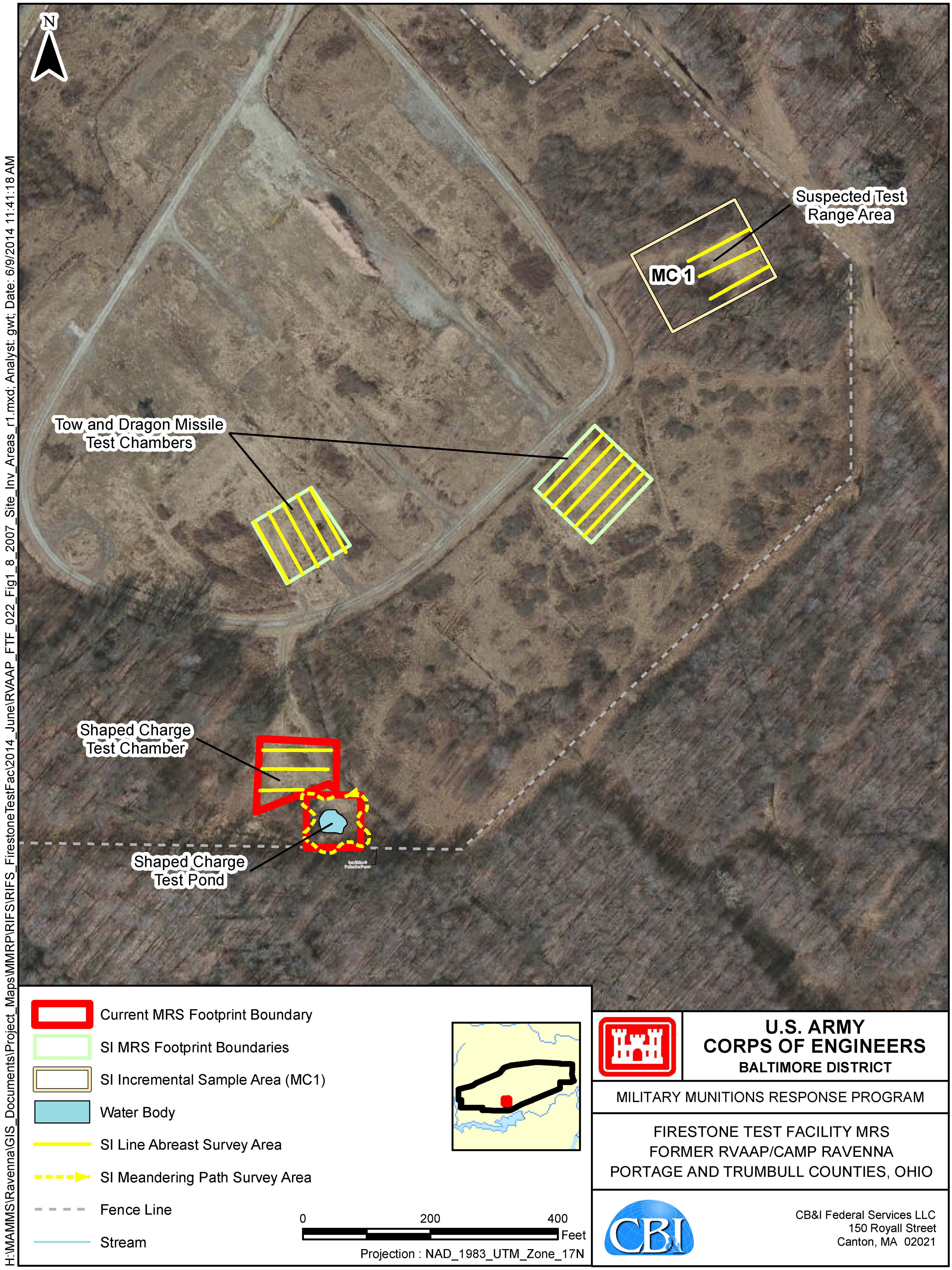

FIGURE 1-8 2007 SITE INVESTIGATION AREAS

The HRR reviewed analytical results collected in the vicinity of the MRS during the previous IRP investigations at the MRS and identified elevated concentrations of antimony, copper, and lead that exceeded the Relative Risk Site Evaluation screening criteria. Further, the Fiscal Year 2006 Installation Action Plan indicated that lead azide, trinitrotoluene, research department explosive (RDX), other explosives, and metals were chemicals of potential concern (COPCs) at the Load Line #6 AOC. Since MC was being addressed at the collocated Load Line #6 AOC under the IRP, additional sampling was not recommended as part of the SI process (e^2M, 2007).

1.5.3 2008 e^2M MMRP Site Inspection Report

In 2007, e^2M conducted a SI at each the 17 MRSs under the MMRP. The primary objectives of the SI activities were to collect the appropriate amount of information to support recommendations of "No Further Action, Immediate Response, or Further Characterization" concerning the presence of MEC and/or MC at each of the MRSs. The SI also included a review of the HRR for each of the applicable MRSs. Out of the 17 MRSs evaluated during the SI, 14 were recommended for "Further Characterization" under the MMRP that included the Firestone Test Facility MRS (RVAAP-033-R-01). A summary of the SI Report (e^2M, 2008) recommendations for the Firestone Test Facility MRS are presented in **Table 1-4** and are discussed below.

Table 1-4
Site Inspection Report Recommendations

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
Firestone Test Facility MRS (RVAAP-033-R01)	5	Further characterization of MEC at reduced MRS footprint.	MEC potentially present in pond and buried at former test chamber.	MC not a concern. No MC detected above screening criteria.

MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
MRSPP denotes Munitions Response Site Prioritization Protocol.

At the time of the SI, the area investigated as the Firestone Test Facility MRS included the areas at the two former TOW and Dragon missile test chamber buildings, the area around the former test pond, and a suspected test range area located to the northeast of the former test chambers, along the eastern fence line. The total area investigated was 0.91 acres and was based on the areas recommended in the HRR. **Figure 1-8** shows the areas investigated at the Firestone Facility MRS during the SI.

Instrument- and metal-detector-assisted UXO surveys were conducted during the SI at the Firestone Test Facility investigation areas. The UXO surveys included a line-abreast survey at the former test chamber buildings and the suspected test range areas, as well as a meandering-path survey around the former test pond. No MEC or MD was found during the survey; however, various subsurface anomalies were detected, in particular around the test pond, which was not verified during the SI (e^2M, 2008).

Surface soil samples were not collected around the former test chambers or pond, as chemical contamination in this area was being investigated under the IRP. One surface soil sample, MC1, was collected using the ISM at the suspected test range area that was added to the SI following the HRR (e^2M, 2007). The sample was analyzed for explosives, propellants, and metals.

No MC was detected in the surface soil sample above the U.S. Environmental Protection Agency (EPA) Preliminary Remediation Goals, the screening criteria used at the time of the SI. Due to the lack of detected MC in the open area outside of the MRS and that sampling investigations at the remaining portions of the MRS were being conducted under the IRP, the SI Report (e^2M, 2008) did not recommend additional characterization of MC at the MRS.

The SI Report (e^2M, 2008) concluded that there was a potential for MEC around the perimeter and bottom of the pond and adjacent to the former shaped charge test chamber building and recommended that further characterization for MEC be addressed at these areas. The area recommended for further characterization following the SI was the original 0.41-acre MRS identified during the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory.

The SI Report (e^2M, 2008) assigned the Firestone Test Facility MRS a Munitions Response Site Prioritization Protocol (MRSPP) priority of 5. The MRSPP is a funding mechanism typically performed during the preliminary assessment/SI stage to prioritize funding for MRSs on a priority scale of 1 to 8 with a Priority 1 being the highest relative priority. Based on the MRSPP score identified for the MRS in the SI Report (e^2M, 2008), the Firestone Test Facility MRS was selected for inclusion for further characterization under the MMRP.

1.6 RI Report Organization

The contents and order of presentation of this RI Report are based on the requirements of *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Specifically, this RI Report includes the following sections:

- **Section 1.0**—Introduction
- **Section 2.0**—Project Objectives
- **Section 3.0**—Characterization of MEC and MC
- **Section 4.0**—Remedial Investigation Results
- **Section 5.0**—Fate and Transport
- **Section 6.0**—MEC Hazard Assessment
- **Section 7.0**—Human Health Risk Assessment
- **Section 8.0**—Ecological Risk Assessment
- **Section 9.0**—Revised Conceptual Site Models
- **Section 10.0**—Summary and Conclusions
- **Section 11.0**—References

Appendices included at the end of this RI Report are as follows:

- **Appendix A**—Digital Geophysical Mapping Report
- **Appendix B**—Field Documentation
- **Appendix C**—Data Validation Report
- **Appendix D**—Summary of Laboratory Analytical Results
- **Appendix E**—Investigation-Derived Waste Management
- **Appendix F**—Photographic Documentation
- **Appendix G**—Intrusive Investigation Results Summary Table
- **Appendix H**—Statistical Analysis of Intrusive Findings
- **Appendix I**—Ecological Screening Values
- **Appendix J**—Munitions Response Site Prioritization Protocol Worksheets
- **Appendix K**—Ohio EPA Correspondence
- **Appendix L**—Responses to Ohio EPA Comments
- **Appendix M**—Ohio EPA Approval Letter

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2.0 PROJECT OBJECTIVES

This section presents the preliminary CSMs for MEC and MC for the Firestone Test Facility MRS based on historical information, identifies data gaps associated with the preliminary CSMs, and the data quality objectives (DQOs) necessary to achieve the project objectives.

A CSM for a MRS provides an analysis of potential exposures associated with MEC and/or MC and an evaluation of the potential transport pathways MEC and/or MC take from a source to a receptor. Each pathway includes a source, activity, access, and receptor component, with complete, potentially complete, or incomplete exposure pathways identified for each receptor. Each component of the CSM analysis is discussed below:

- **Sources—**Sources are those areas where MEC or MC have entered (or may enter) the physical system. A MEC source is the location where material potentially presenting an explosive hazard (MPPEH) or ordnance is situated or are expected to be found. A MC source is a location where MC has entered the environment.
- **Activity—**The hazard from MEC and/or MC arises from direct contact as a result of some human or ecological activity. Interactions associated with activities describe ways that receptors come into contact with a source. For MEC, movement is not typically significant, and interaction will occur only at the source area as described above, limited by access and activity. However, there can be some movement of MEC through natural processes such as frost heave, erosion, and stream conveyance. For MC, this can include physical transportation of the contaminant and transfer from one medium to another through various processes such that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. Ecological exposure can include coming into contact with MEC or MC lying on the ground surface or through disturbing buried MEC/MC while digging or performing other activities such burrowing.
- **Access—**Access is the ease in which a receptor can come into contact with a source. The presence of access controls help determine whether an exposure pathway to a receptor is complete, as fences or natural barriers can limit human access to a source area. Furthermore, the depth of MEC items in subsurface soils and associated MC may also limit access by a receptor. Ease of entry for adjacent populations (i.e., lack of fencing) can facilitate trespassing at the MRS, either intentional or accidental.

- **Receptors—**A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use and activities, as receptors are determined on that basis. If present, MEC and/or MC on the ground surface and near the surface can be accessed by facility personnel, contractors, visitors, trespassers, and biota.

A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. A pathway is considered potentially complete when a source has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. Lastly, an incomplete pathway is any case where one of the three components (source, activity, or receptors) is missing from the MRS.

In general, the CSM for each MRS is intended to assist in planning, interpreting data, and communicating MRS-specific information. The CSMs are used as a planning tool to integrate information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to evolve through an iterative process of further data collection or action. A discussion of the preliminary CSMs identified for the Firestone Test Facility MRS, as presented in the SI Report (e^2M, 2008), is presented in the following section. The data collected during the RI are incorporated into this model and is discussed in Section 9.0, "Revised Conceptual Site Models."

2.1 Preliminary CSM and Project Approach

The preliminary CSMs for the Firestone Test Facility MRS are based on MRS-specific data and general historical information including literature reviews, maps, training and technical manuals, and field observations. The preliminary MEC and MC CSMs were originally developed during the SI process based on guidance from USACE Engineer Manual (EM) 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects* (USACE, 2003a). The preliminary MEC and MC CSMs are represented by the diagrams provided as **Figure 2-1** and **Figure 2-2**, respectively. A summary of each of the factors evaluated for the preliminary MEC and MC CSMs is discussed below:

- **Sources—**Based on review of the archival records and available documentation, the potential release mechanism for MEC and MC at the Firestone Test Facility MRS was the intentional testing of shaped charges in the former building test chamber and the test pond. The tests were reportedly contained, thereby, limiting

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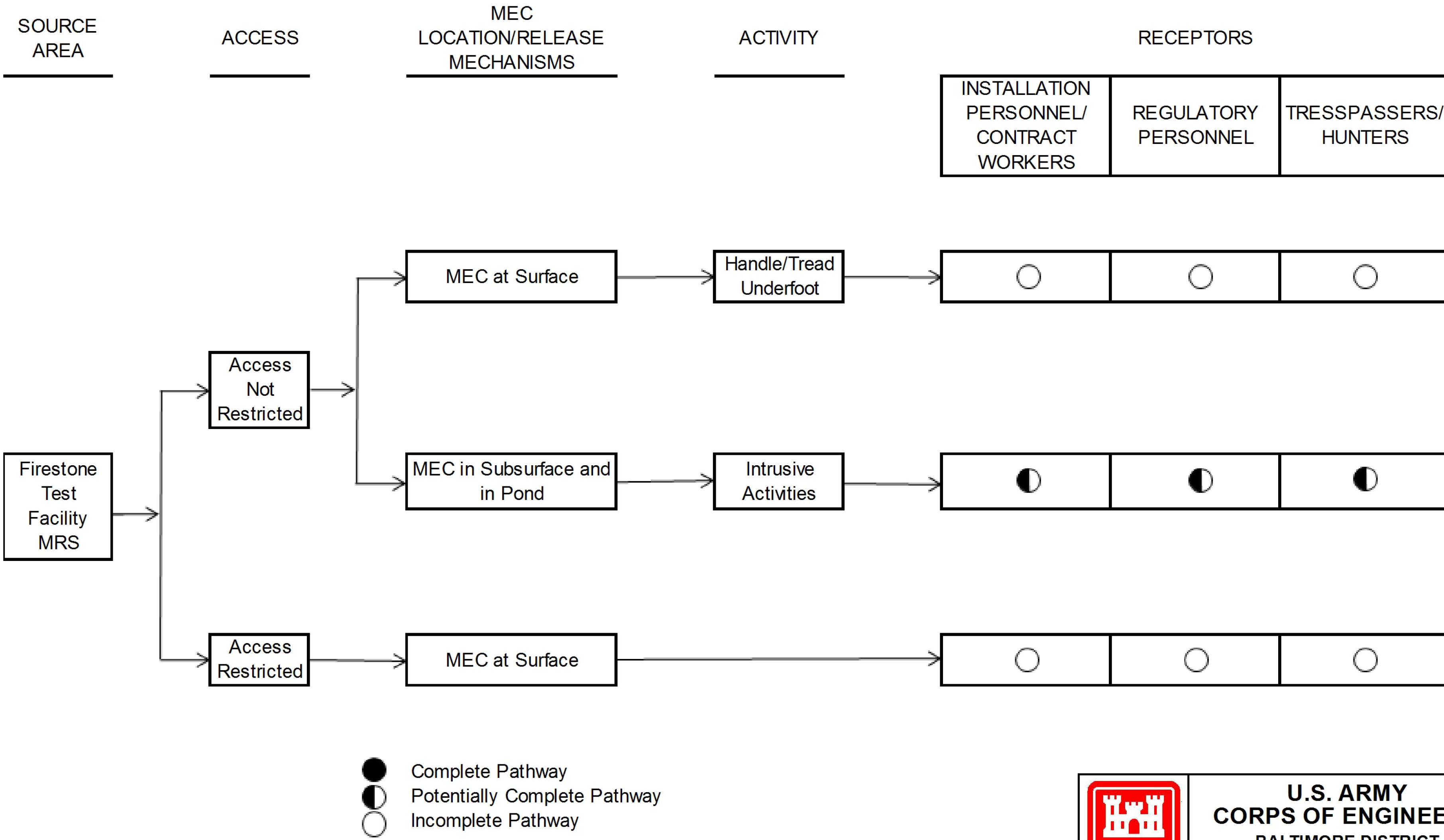


Source: Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio (e^{2}M, 2008)

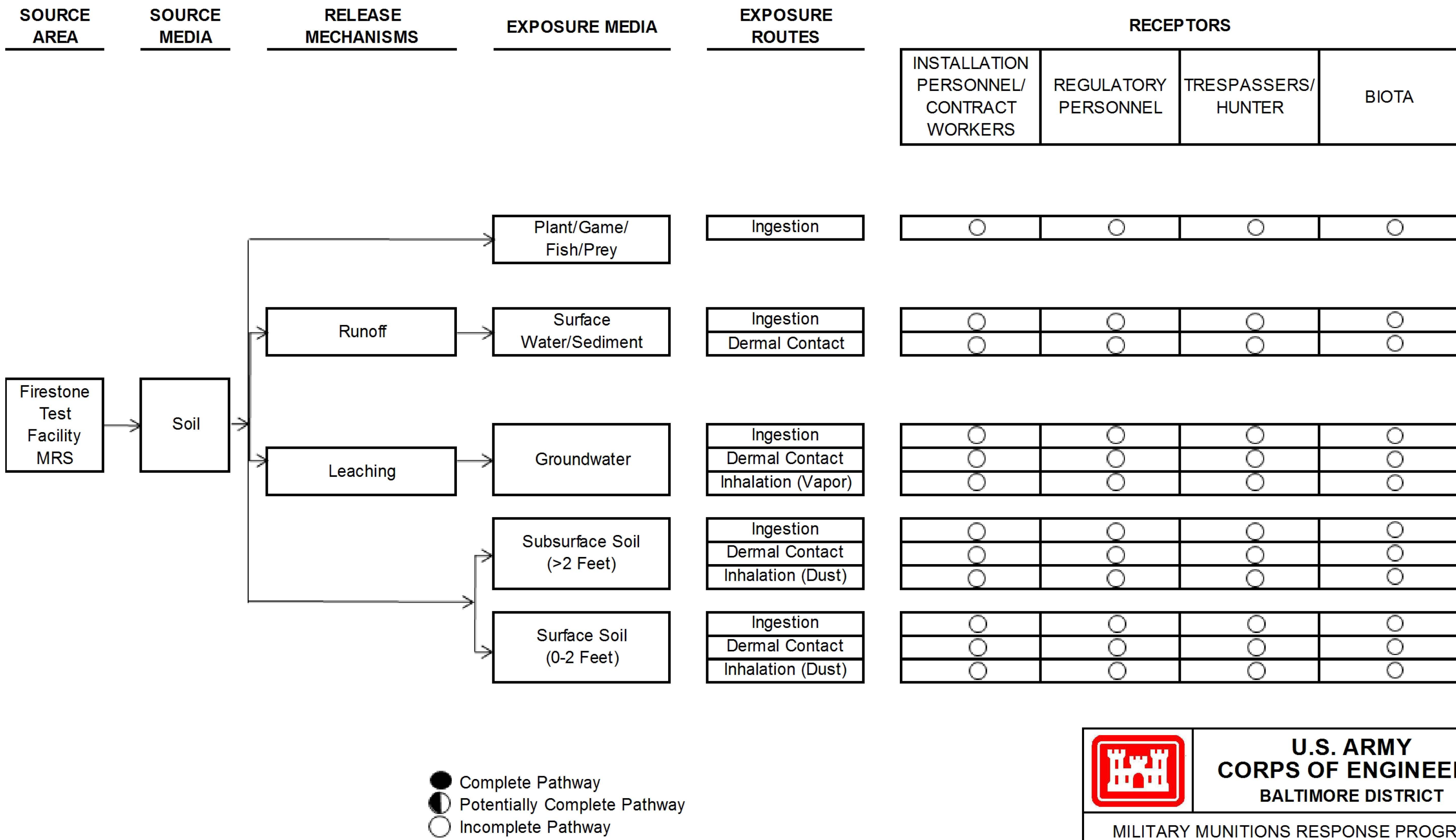
U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

FIRESTONE TEST FACILITY MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL



Source: Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio (e^{2}M, 2008)

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CBI

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Canton, MA 02021

FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL

the release of any MEC and MC and there is no historical information that would indicate that MEC had been found lying on the ground surface or buried at the MRS. However, the 2007 UXO survey did return substantial subsurface anomalies around the pond and adjacent former test chamber suggesting that MEC may be present.

- **Activity—**Human activities considered for the preliminary CSMs were the maintenance of the grounds, signs and fences, and security checks that were being performed at an infrequent basis.
- **Access—**Access to MRS at the time of the SI was controlled by a fenced perimeter and an unlocked gate. The SI Report (e^2M) identified that future plans for the MRS included removal of the perimeter fence.
- **Receptors—**At the time of the SI, current and reasonably anticipated receptors included installation personnel, soldiers, contractors (including maintenance personnel), regulatory personnel, and possibly infrequent trespassers and hunters. The ecological receptors (biota) identified in the SI Report (e^2M, 2008) were the state-listed species identified as being present at the facility and listed in **Table 1-3**. If present, MEC and/or MD and associated MC on the ground surface and near the surface could have been accessed by receptors.

No MEC was found on the ground surface during the SI field activities; therefore, the surface soil pathway for MEC was considered incomplete for all receptors. The SI results indicated that MEC was potentially present at the pond used to test shaped charges and at the location of the adjacent former test chamber. As such, the MEC exposure pathway for human receptors was considered potentially complete and included the disturbance of subsurface soils or contact with submerged munitions in the pond. Since no MC was detected in the surface soil; the MC exposure pathways for receptors were considered incomplete (e^2M, 2008). The preliminary CSMs for MEC and MC at the Firestone Test Facility MRS, as presented in the SI Report (e^2M, 2008), are shown in **Figures 2-1** and **2-2**, respectively.

2.2 Applicable or Relevant and Appropriate Requirements and “To Be Considered” Information

Applicable or relevant and appropriate requirements (ARARs) and “to be considered” (TBC) guidance for future anticipated and reasonable remedial actions at the former RVAAP under the MMRP are currently under development. The identified ARARs and TBC guidance will be included in the follow-on documents to this RI Report as required per the CERCLA process.

2.3 Data Quality Objectives and Data Needs

The DQOs and data needs were determined at the planning stage and are outlined in the Work Plan (Shaw, 2011). The data needs included characterization for MEC and MC associated with the former activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and valid assumptions could be inferred from the data.

2.3.1 Data Quality Objectives

The DQOs were developed for MEC and MC in accordance with the *Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP* (SAIC, 2011b), hereafter referred to as the FWSAP, and the EPA *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW (2000). **Table 2-1** identifies the DQO process at the Firestone Test Facility MRS as presented in the Work Plan (Shaw, 2011).

Table 2-1
Data Quality Objectives for the Firestone Test Facility MRS

Step	Data Quality Objective
1. State the problem.	The Firestone Test Facility MRS was used for the testing of shaped charges. Underwater testing of shaped charges was performed in the pond located on the MRS. One building, which has since been demolished, was used to test shaped charges. Therefore, there is a potential for MEC/MD associated with testing activities on the ground surface, pond, and shallow subsurface. In addition, there is a potential for environmental impacts from MC at the MRS.
2. Identify the decision.	The goal of the investigation at the Firestone Test Facility MRS is to identify the areas impacted with MEC/MD. In addition, MC sampling will be performed in order to further characterize the nature and extent of contamination associated with munitions activities at the MRS. The information obtained during the RI will be used to assess the risk and hazards posed to human health and the environment.
3. Identify inputs to the decision.	• Historical information • Geophysical survey • Intrusive inspection • Incremental and discrete environmental media sampling
4. Define the study boundaries.	The RI investigation will be performed in the Firestone Test Facility MRS boundaries as defined at the conclusion of the SI Report (e^2M, 2008).
5. Develop a decision rule.	Prior to the MEC investigation at the Firestone Test Facility MRS, the water in the pond will be discharged. Although no formal visual survey transects are planned at the MRS, a visual survey will be performed concurrently with the geophysical investigation. 100 percent DGM coverage will be performed within the MRS boundaries.

Table 2-1 (continued)
Data Quality Objectives for the Firestone Test Facility MRS

Step	Data Quality Objective
	Since full DGM coverage is proposed at Firestone Test Facility MRS, the number of anomalies investigated will be based on a prioritized ranking system and statistical sampling. The statistical sampling method used will be a hypergeometric statistics module based on estimating the required sample size for populations. The statistical inputs will be 95 percent confidence, 5 percent error limits, and a probability of 0.1 (10 percent) to determine the number of anomalies to investigate. ISM surface soil and discrete sediment samples within the shaped charge testing areas. In addition, discrete samples (surface and subsurface soil) will be collected in areas with concentrated MEC/MD. The final location and number of samples will be proposed at the conclusion of the MEC investigation.
6. Specify limit of decision errors.	QC procedures are in place so that all field work is performed in accordance with all applicable standards. Further details on the QC process during the RI are located in Section 4 of the Work Plan (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Firestone Test Facility MRS will be used to determine what risks or hazards, if any, are present at the MRS. Shaw will perform a MEC HA to identify the potential MEC hazards. In addition, a MRS-specific HHRA and ERA will be performed on the analytical results. If unacceptable risks or hazards to human health and the environment are determined to exist at the MRS at the conclusion of the investigation, then the MRS will be identified for further evaluation under the CERCLA process.

CERCLA denotes Comprehensive, Environmental Response, Compensation, and Liability Act of 1980.
DGM denotes digital geophysical mapping.
ERA denotes ecological risk assessment.
HA denotes hazard assessment.
HHRA denotes human health risk assessment.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
RVAAP denotes former Ravenna Army Ammunition Plant.
SI denotes Site Inspection.

2.3.2 Data Needs

For MEC, data needs include determining the types, locations, condition, and number of MEC items present at the MRS so that the potential hazard to human health can be assessed and remedial decisions can be made. The DQOs were developed in accordance with the FWSAP (SAIC, 2011b), the EPA DQO Guidance (2000), and past experience with MRSs containing MEC. These data needs for MEC were evaluated using the most applicable methods and technologies that are discussed in the following sections.

For MC, data needs include sufficient information to determine the nature and extent of MC, determine the fate and transport of MC, and characterize the risk of MC potential receptors by performing a human health risk assessment (HHRA) and an ecological risk assessment (ERA). More specifically, the data needed are concentrations of MC in environmental media at the MRS based on the results of the MEC investigation and included sample and analysis of surface soil, sediment, and surface water that potentially pose unacceptable risk to human health and ecological receptors. Data quality was assessed through the evaluation of sampling activities and field measurements associated with the chemical data in order to verify the reliability of the chemical analyses and the precision, accuracy, completeness, and sensitivity of information acquired from the laboratory. Representativeness and comparability were also evaluated with regards to the proper design of the sampling program and quality of the data set respectively. The reporting limits (a.k.a., method detection limits [MDLs] or method reporting limits [MRLs]) should be equal to or less than the screening levels to support human health and ecological evaluation whenever possible.

2.3.3 Data Incorporated into the RI

Whenever possible, existing data is incorporated into the RI. The following is a summary of existing data and how it was used:

- **Historical Records Review—**The HRR (e^2M, 2008) provides historical documentation regarding the MRS and identifies the types of activities previously conducted, the types of munitions used, and historical finds and incidents. This data was used to identify the expected baseline conditions and other hazards that may be present.
- **Installation Restoration Program Data—**Data collected under the IRP at various AOCs collocated with MRSs includes analytes considered to be MC associated with previous activities at the MRS. It should be noted that not all analytes are considered as MC. The IRP data set may be incorporated with sampling data collected during the RI in order to close data gaps. As part of the IRP, contamination was identified at Load Line #6, which is collocated with the Firestone Test Facility MRS. The IRP data was reviewed and it was determined that incorporation of the data into the RI was not necessary since the samples collected for the RI provide more coverage (i.e., ISM versus discrete samples for surface soil) and are more representative of the current MRS conditions.

- **2007 Site Inspection Data—**The SI Report (e^2M, 2008) provides subsurface geophysical information obtained from a limited UXO meandering-path survey that was used to preliminarily delineate areas where MEC and/or MD may have been deposited as a result of the shaped charge testing activities (**Figure 1-7**). The single ISM soil sample collected at the MRS during the SI field activities was not considered for inclusion in the RI since it was collected outside of the MRS area investigated for the RI.

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3.0 CHARACTERIZATION OF MEC AND MC

This section documents the approaches used to investigate MEC and MC at the Firestone Test Facility MRS in accordance with the DQOs presented in Section 2.0, "Project Objectives." The MEC and MC characterization activities were conducted in accordance with Section 3.0, "Field Investigation Plan," of the Work Plan (Shaw, 2011).

3.1 MEC Characterization

The following section summarizes the geophysical, anomaly reacquisition and subsequent intrusive investigation activities that were performed at the Firestone Test Facility MRS. Based on the testing activities associated with the MRS, it was determined in the SI reporting stage that there is a potential for buried MEC/MD around the test pond at the MRS. The initial step in evaluating for buried MEC at the Firestone Test Facility MRS consisted of performing a digital geophysical mapping (DGM) investigation throughout the MRS as presented in the Work Plan (Shaw, 2011). Visual surveys of surface conditions were performed in conjunction with the geophysical investigation. The results of the DGM survey, intrusive investigation, and underwater investigation activities are discussed in Section 4.0, "Remedial Investigation Results."

3.1.1 Geophysical Survey

In May 2011, Shaw performed a DGM survey to identify potential subsurface areas of MEC and/or MD at the Firestone Test Facility MRS. Additional DGM fill-in data were collected in June and July of 2011 over two small areas at the MRS in order to ensure the final geophysical dataset represented the MRS characteristics as accurately as possible. The *Digital Geophysical Mapping Report for the Firestone Test Facility MRS (RVAAP-033-R-01)*, hereafter referred to as the DGM Report, is presented in **Appendix A** and provides a comprehensive review of the DGM survey at the MRS with regards to data acquisition, processing and analysis, anomaly reacquire, and results of the DGM quality control (QC) program.

Instrumentation used for the DGM survey consisted of an EM61-MK2 time domain electromagnetic instrument and a Leica 1200 real-time kinematic (RTK) global positioning system (GPS) for positioning. A robotic total station (RTS) positioning system was used for minor fill-in surveys in areas obstructed by vegetation. The DGM platform consisted of a standard wheeled configuration with the lower coil 16 inches above the ground surface. The field team that performed the DGM survey consisted of two geophysicists.

The DGM system used for the Firestone Test Facility MRS investigation and other MRSs at the facility was initially validated during the start-up phase of the project at an instrument verification strip (IVS) located near Load Line 7. The results of the initial IVS effort are documented in the *Instrument Verification Strip Technical Memorandum in Support of Digital Geophysical Mapping Activities for Military Munitions Response Program Remedial Investigation Environmental Services,* which is located in the DGM Report (**Appendix A**). A localized IVS at the Firestone Test Facility MRS was used to ensure the functionality of the DGM system on a daily basis during DGM activities at the MRS.

A discussion of the MRS preparation activities for the DGM investigation, the data collection process, and summary of the DGM results are presented in the following sections.

3.1.1.1 Civil Survey

A Registered Ohio Land Surveyor established five survey monuments at the Firestone Test Facility MRS. Each monument was established with third order horizontal accuracy (residual error less than or equal to 1 part in 10,000). The survey monuments were used to provide positional data that was streamed directly to the EM61-MK2.

For QC purposes, the RTK-GPS or RTS positioning system was used to reacquire a minimum of one known, fixed location each time the system was set up on one of the five survey monuments. Per the project metrics defined in the Work Plan (Shaw, 2011), static measurements for the positioning system were required not to exceed 0.5 feet. One hundred percent of the location checks satisfied the metric. All mapping was developed in the North American Datum 1983 Universal Transverse Mercator Zone 17 North Coordinate System.

3.1.1.2 Vegetation Clearance

Much of the MRS consists of dense vegetation that includes high grasses and thick brush. Vegetation removal was required at the MRS in order to provide adequate ground clearance for the DGM equipment. Vegetation removal was performed manually using weed trimmers and was minimized to the extent possible to allow for the execution of work. No grass mowing was performed at the MRS, since the investigation activities occurred between the months of April and August and mowing between these months had the potential for disturbing grassland nesting species.

3.1.1.3 Data Collection

The DGM data were acquired over all accessible areas of the 0.41-acre MRS on transects spaced at approximately 2.5-foot intervals, which resulted in a spatial coverage of 0.312 acre or nearly 76 percent of the MRS. The remaining 0.098 acre could not be investigated due to steep, inaccessible terrain in several isolated areas (0.058 acre) and the pond (0.04 acre) located in the southern portion of the MRS. Within the areas accessible to DGM, 100 percent of the data were acquired at a line spacing of less than 3.5 feet and equates to nearly 84 percent DGM coverage of the land-based portions of the MRS and meets the metric specified in Section 3.3.6.4 of the Work Plan (Shaw, 2011).

The general DGM procedures performed for data acquisition at the Firestone Test Facility MRS consisted of the following:

- The DGM survey area was reviewed by performing a MRS walkover. Special attention was made to difficult terrain and the presence of obstacles, which created potential safety issues.
- The positioning system was set up at a documented control point of known location or a location was determined by using a minimum of two known control points (i.e., RTS). The location control was checked by at least one “checkshot” to a different control point of known location.
- DGM system instrument functional checks were performed at the start and end of each day and the results were documented.
- DGM data were collected over the area in a systematic fashion with respect to the terrain, vegetation, and obstacles present. The acquisition protocol used navigation techniques proven at the IVS.
- Field logs were used to document MRS conditions during data collection. The field logs included information and observations regarding the data collection process, weather, field conditions, data acquisition parameters, and quality checks performed. The positioning system was used to document the presence of significant MRS features related to terrain, vegetation, and cultural features so these features could be accounted for during the interpretation of the data.

At the end of each day, the field geophysicist uploaded the DGM data to a computer where the data was archived, backed up, and initially processed and analyzed. The data were also transferred to the Shaw Processing Center in Concord, California on a daily basis for processing and review by the data processor. The raw and final processed data were transferred to USACE at intervals specified in Data Item Description (DID) MMRP-09-004, *Geophysics* (USACE, 2009a).

The proposed area of DGM coverage included the entire MRS as presented in the Work Plan (Shaw, 2011) and is shown in **Figure 3-1**. The areas of the MRS that were identified as inaccessible areas during the walkover prior the DGM survey are also provided in **Figure 3-1**. A summary and discussion of the DGM data is discussed in Section 4.0.

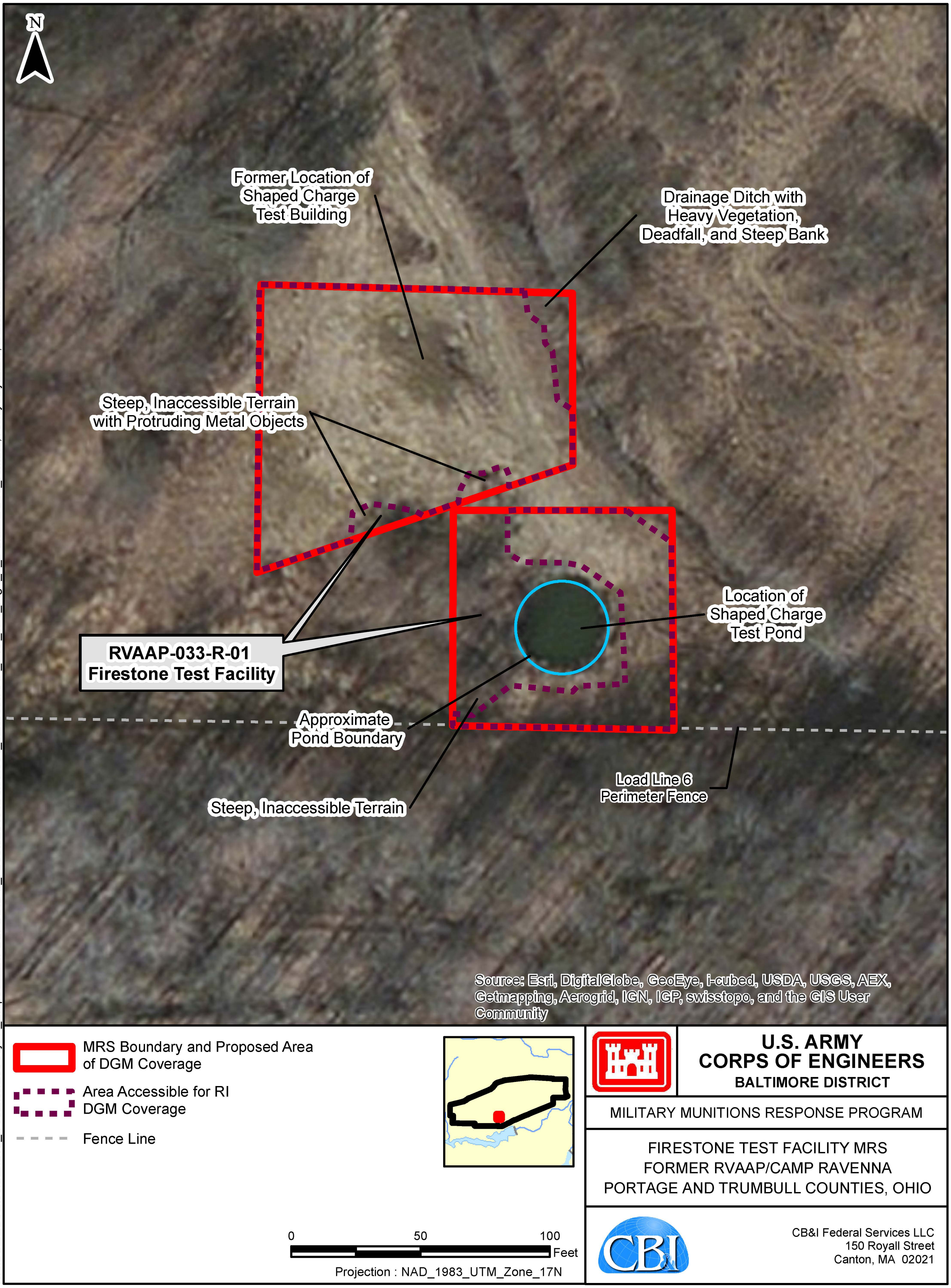

FIGURE 3-1 PROPOSED AND ACTUAL DGM INVESTIGATION AREA

3.1.1.4 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan (Shaw, 2011). A 5-millivolt (mV) threshold for Channel 2 of the EM61-MK2 was used to initially select 423 anomalies for potential investigation. The 5 mV criterion is in accordance with the approved Work Plan (Shaw, 2011). Important factors that were considered during the interpretation process included the following:

- Data acquisition methodology (full coverage as is the case for Firestone Test Facility MRS)
- Types of MEC most likely present at the MRS based on historical data
- Anomaly shape and signal intensity in relation to the spatial sample density (along track and across track)
- Anomaly time constants
- Local background conditions
- Presence of surrounding anomalies (anomaly density)
- Presence of cultural features and sources of interference
- Anomaly characteristics from the IVS items

3.1.1.5 Geophysical QC Program

The geophysical field QC procedures consisted of tests performed at the start and end of each day to ensure the geophysical sensor and positioning equipment were functioning properly and the data were of sufficient quantity and quality to meet the RI objectives in the Work Plan (Shaw, 2011). The performance metrics for the DGM system were derived from a combination of DID MMRP-09-004, *Geophysics* (USACE, 2009a) and the USACE Table *Performance Requirements for RI/FS using DGM Methods* (U.S. Army, 2009). Quality objectives and metrics associated with MRS coverage, signal quality during data acquisition, anomaly reacquire, and the intrusive investigation were also developed from the referenced documents. The DGM field team and the data processor/analyst reviewed and documented the results of the DGM QC program on a Microsoft© Excel spreadsheet that was updated on a daily basis and delivered to the client for approval. The Microsoft© Excel spreadsheet is part of the geophysics digital data deliverable in the DGM Report (**Appendix A**).

3.1.2 Anomaly Investigation Activities

Following the completion of the DGM survey in July 2011, anomaly selection, reacquisition, and an intrusive investigation was conducted to assess the potential for buried MEC and MD at the Firestone Test Facility MRS. The following sections present discussions of the target dig list development and the intrusive investigation procedures performed for the evaluation of MEC and MD at the MRS.

3.1.2.1 Target List Development

To determine what number of anomalies to sample in order to characterize the nature and extent of MEC at the Firestone Test Facility MRS, the hypergeometric method was applied. Use of such a statistical sampling method is in accordance with guidance provided in EM 1110-1-4009, *Military Munitions Response* (USACE, 2007), which states:

> "When there are, on average, more than 50 anomalies per acre then it may be necessary to statistically sample the anomalies. Statistical sampling should be applied such that the results of the sampling will meet the data needs and the DQOs of the characterization project. The method for statistically sampling the anomalies should take into the account the objectives of the characterization effort. Different sampling strategies should be employed if the objective is to confirm the presence of MEC or the number of MEC related items. Furthermore, if the statistical sampling is based on anomaly characteristics (amplitude or size) then some sampling of anomalies which don't meet the criteria should be sampled to validate the selection process."

The hypergeometric method for determining the number of anomalies to sample (n) is based on the following equation:

$$n = Nz^2pq(E^2(N-1) + z^2pq)$$

Where:

N = population size
z = confidence level
E = allowable error
p = probability
q = $1-p$

Using input parameters of 95 percent confidence (z), 10 percent probability (p), and 5 percent error limits (E), a total of 105 anomalies, which represents 25 percent of the total population of 423 anomalies (N), were selected. The 105 locations were transferred to a dig sheet and provided to the Shaw Geographical Information System Department for inclusion in the Shaw MEC data base for the facility that is used to track the investigation results. The program used to pick the actual locations of the target anomalies in order to eliminate manually biasing the process was the RANDBETWEEN function in Microsoft© Excel.

Thirteen of the 105 anomalies selected for investigation (targets 140, 145, 153, 180, 181, 204, 206, 241, 259, 260, 373, 383, and 390) were located within the high anomaly density area in the central portion of the MRS. Within the high anomaly density feature area, several of the 13 anomalies were biased in terms of their location to ensure adequate characterization of the feature. The remaining 92 anomalies were considered as individual target locations.

The Microsoft© Excel HYPERGEOM function was used as a QC measure to check the results of the approved statistics module following the intrusive investigation. A discussion of the results of the statistical analysis of the intrusive program findings is presented in further detail in Section 4.0.

3.1.2.2 Anomaly Reacquisition and Investigation Procedures

For the anomaly reacquire task, the field geophysicists used the dig sheet coordinates to guide the relocation of each of the 105 anomaly locations utilizing an RTK-GPS. The area around each anomaly was scanned with an EM61-MK2 and the optimum dig location was marked with a pin flag. The “x-y” coordinate offset for each individual anomaly were digitally recorded by the anomaly reacquire crew using a handheld personal digital assistance device and the information was uploaded to the project database at the end of each day.

To locate the ground position of the interpreted anomaly coordinates, the navigational system “Waypoint Location” mode was used for the RTK-GPS. A nonmetallic pin flag, labeled with the unique anomaly identification, was placed in the ground at the interpreted location. Reacquisition of any sampling or dig sheet locations (i.e., interpreted location) was performed to ±0.5 feet of the coordinates specified on the dig sheet.

All anomaly investigation activities were performed by UXO-qualified personnel. The UXO-qualified personnel used a Schonstedt magnetometer to investigate the 92 individual target anomalies. These personnel used hand tools to unearth an item and as the excavation progressed toward the anomaly source, the UXO technician continued to use the Schonstedt magnetometer to determine the item location both horizontally and vertically.

The remaining 13 anomalies (targets 140, 145, 153, 180, 181, 204, 206, 241, 259, 260, 373, 383, and 390) were located in high-density anomaly areas and were investigated using shallow mechanical trenching methods with a small excavator. The use of trenching in high-density areas is an intrusive procedure that is consistent with those used in the industry. During the shallow trenching activities, one UXO Technician stood in a safe area at the front of the operation and was responsible for examining the area to be advanced into and to visually observe for the presence of MEC or MD.

For both investigation methods, once an item was found it was determined if it was MEC, MD, or other metallic material. Once the item was determined not to be MEC, if it was physically able to be moved, then it was temporarily removed from the excavation hole and a

Schonstedt magnetometer was used to confirm no additional ferrous items were located beneath the first item. Once confirmed that the source had been identified and no MEC or MD was present, the item was replaced and the soil was returned back into the investigation hole in reverse order from which it was excavated. The UXO-qualified personnel were also conscious of encountering any cultural artifacts associated with historical cultural or archeological resources.

3.1.2.3 Anomaly Investigation Documentation

All anomalies identified during the reacquisition and intrusive investigation activities were logged and recorded in accordance with DID MMRP-09-004, *Geophysics* (USACE, 2009a). The ShawGeo and/or ShawMEC software was used to record any discrepancies between the dig sheet location and the actual required location and to note any anomalies that could not be investigated. The anomaly reacquisition and investigation results are further discussed in Section 4.0.

3.1.2.4 Anomaly Field QC Procedures

Ground-truth excavation data reported on anomaly-specific dig sheets was the primary basis for field QC. The dig sheets documented the item description; location; and approximate weight, shape, orientation, and depth. Dig sheets were reviewed by the field geophysicist on a daily basis to determine whether the excavation data were representative of the millivolt reading for the selected anomaly. Anomalies that were not representative of the excavation results were revisited by the field geophysicist and the UXO QC Specialist.

3.1.3 Underwater Investigation Activities

Underwater tactile investigation was performed at the former shaped charge test pond on August 4, 2011, to examine for potential MEC items buried within the pond sediment. The underwater investigation team consisted of four former U.S. Navy Explosive and Ordnance Disposal-trained divers who were familiar with the different ordnance categories/groups, and the arming and functioning of each item that was being investigated. The underwater investigation included 100 percent coverage of the walls and floor of the 0.04-acre pond.

3.1.3.1 Field Procedure Change

As stated in the Work Plan (Shaw, 2011), the original plan for investigating the former shaped charge test pond included pumping the pond to remove the water and performing visual inspection of the pond walls and floor. Due to the size of the pond (0.04 acres) and the depth (14 feet), it was determined that diving was the more logical alternative for investigation with the potential for less impact to the surrounding environment. The option for diving as an alternative to pumping the pond was included in Section 3.3.6.4, "Data

Acquisition and Survey Methodology," of the Work Plan (Shaw, 2011); therefore, a field work variance was not required.

3.1.3.2 Tactile Underwater Investigation Procedures

Due to the minimal size of the test pond, the tactile underwater investigation activities were performed by a single diver with dive and technical support situated along the shore of the pond. The general procedures performed by the diver were to swim predetermined transects along the conical walls of the test pond, investigate anomalies as they were encountered, and relay the information to the dive station with voice communications. Instrumentation used by the diver consisted of a Diver 1 underwater magnetometer.

Prior to the dive operations, jackstay lines were placed across the pond to serve as a guide for the diver. Using the metal detector to pinpoint the location of the object on the bottom (or in the mud/silt), the diver gently used his hands to assess the orientation of the item and from tactile exploration, determine if it was an ordnance item by its shape (i.e., bomb, projectile, grenade, rocket, etc.). Then, using general measurement tools (i.e., elbow to wrist = 1 foot, palm width = 4 inches, etc.) the approximate size of the item was determined. The item was then to be evaluated if it contained a fuze (point detonating, mechanical time, proximity, etc.). If a MEC item was identified, the item was not to be moved or subjected to any sudden forces during the investigation.

3.2 MC Characterization

The following section summarizes the MC characterization activities and decision making process at the Firestone Test Facility MRS. Sampling for MC was predetermined during the DQO decision making process to characterize the nature and extent of contamination associated with previous activities at the MRS. The collection of surface soil samples within the shaped charge testing area of the MRS (i.e., the vicinity of the test pond) was proposed at a minimum during development of the Work Plan (Shaw, 2011). Since no MEC or MD were found during the RI intrusive investigation or underwater tactile investigation, sampling for potential MC focused on surface soil around the edges of the test pond and in the pond sediment. A surface water sample was originally collected from the pond prior to the underwater investigation activities for the purpose of evaluating if contaminants were present at concentrations that may prevent controlled discharge of the pond water or may be hazardous to a diver. The surface water sample is also used to evaluate for the presence of MC in the pond. Additional discrete samples were proposed in areas identified with concentrated MEC/MD. Additional sampling for MC was not warranted since no MEC or MD was identified at the Firestone Test Facility MRS during the RI field activities.

All MC samples were collected in accordance with the *Final Sampling and Analysis Plan and Quality Assurance Project Plan* included in Appendix D of the Work Plan (Shaw, 2011); hereafter referred to as the SAP, with the noted exceptions discussed in this section. The results of the MC sampling activities are presented in Section 4.3, "Nature and Extent of SRCs."

3.2.1 Sampling Approach

The ISM surface soil and discrete sediment samples were collected at the Firestone Test Facility MRS to evaluate for the nature and extent of contamination associated with previous activities at the MRS and to determine whether or not there is unacceptable risk. The intent of the surface water sampling event was to evaluate options for investigating the test pond sediment, which included approved and controlled discharge to the ground surface or manual diving operations. The results of the surface water sample are used for the purposes of this RI to characterize the nature and extent of contamination of the surface water in the pond and to determine if there is any unacceptable risk associated with that medium at the MRS. The Work Plan (Shaw, 2011) stated that additional ISM and/or discrete samples may be required at locations at the MRS with concentrated areas of MEC/MD that are identified during the RI field surveys. No MEC or MD was identified at the Firestone Test Facility MRS during the investigation; therefore, only the referenced samples were collected and additional sampling for MC was not warranted. **Table 3-1** summarizes the sample locations and types of samples collected for the RI and the rationale for the sample strategy.

Table 3-1
Summary and Rationale for Munitions Constituents Sample Collection

Medium	Sample Type	Sample Depth	Number of Samples[1]	Rationale
Surface Soil	ISM	0–0.5 feet bgs	1	To characterize MC in surface soils surrounding the test pond where shaped charges were tested
Sediment	Discrete	0–0.5 feet bss (approximately 2 feet bws)	2	To characterize the potential release of MC in sediment where shaped charges were tested
Surface Water	Discrete	6–7 feet bws (approximate center depth of pond)	1	To evaluate investigation options for sediment and to characterize the potential release of MC in surface water where shaped charges were tested

[1] Number of samples does not include field duplicate or other quality control samples.
bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
ISM denotes incremental sampling methodology.
MC denotes munitions constituents.

The methods used in the collection of the surface soil, sediment, and surface water samples during the RI field activities are summarized in the following sections.

3.2.1.1 Surface Soil Sample Collection

The ISM surface soil sample (FTFSS-004(I)-0001-SS) was collected during the RI field activities on August 12, 2011. The ISM surface soil sample was collected over a 0.02-acre sampling unit surrounding the former test pond and is considered the surface soil decision unit for the Firestone Test Facility MRS. This is the location where contamination from the test activities that were conducted in the pond are expected to be the greatest in surface soil and is the land-based area of the MRS in which a decision regarding MC in surface soil will be made. The sample depth was determined to be 0.5 feet bgs, which is the maximum depth that MC from past MEC or MD on or just below the ground surface would have expected to vertically migrate in the soil column. There were no deviations from the Work Plan (Shaw, 2011) during the RI field activities for the surface soil sample collection activities.

The collection methodology for the ISM surface soil sample is presented in the SAP (Shaw, 2011) that is based upon the procedures presented in the *Interim Guidance 09-02, Implementation of Incremental Sampling of Soil for the Military Munitions Response Program* (USACE, 2009b). The ISM surface soil sample consisted of 30 increments collected around the former test pond (i.e., sampling unit) at evenly spaced distances. The three key steps for collection of each increment were: (1) subdivide the sampling unit into a uniform grid (i.e., pace out the area around the pond and divide into at least 30 grids for a 30-increment sample), (2) randomly select a single increment location in the first grid, and (3) collect increments from the same relative location within each of the other grids.

The sampling unit was established by placing pin flags around the perimeter of the sampling unit. The ISM sample was collected from the predetermined number of increment sample locations using a ⅞-inch stainless steel step probe sample collection device. The increments of soil were placed into a plastic lined bucket and combined to make a single sample weighing between 1 and 2 kilograms.

The QC samples included one field duplicate sample, one matrix spike (MS)/matrix spike duplicate (MSD) sample, and an equipment rinse sample. The collection of the field duplicate sample required similar increments of soil as the original sample. Therefore, at the ISM sampling unit, an additional ISM sample was collected from within the same sampling unit consisting of at least 30 increments of soil. The field duplicate was labeled with a different sample number (FTFSS-005(I)-0001-SS) and submitted to the laboratory for processing as a blind field duplicate. Due to sufficient soil volume, additional collection of soil for the MS/MSD was not required and the original sample (FTFSS-004(I)-0001-SS) was designated at the MS/MSD on the chain-of-custody form prior to shipment.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the ISM surface soil sample location at the MRS.

3.2.1.2 Sediment Sample Collection

Two discrete sediment samples (FTFSD-002-SD and FTFSD-003-SD) were collected from opposite sides of the former test pond sidewalls during the underwater investigation at the test pond on August 8, 2011. The sediment samples were collected along the sidewall of the pond, just beneath the vegetation surrounding the pond, at a depth of approximately 2 feet beneath the pond water surface. The sample interval was from 0 to 0.5 feet beneath the sediment surface. The locations of the sediment samples were considered as the most accessible areas where human and terrestrial ecological receptors may come into contact with the pond sediment and where semiaquatic receptors may enter and leave the pond. The locations and sample depths for the sediment within the former test pond is the exposure scenario for which a decision regarding MC in sediment will be made.

The trowel/spoon method using disposable sampling equipment was used to collect the discrete sediment samples at the Firestone Test Facility MRS. The trowel was used to manually dig into the subsurface material to the required 0.5-foot depth interval designated for the sampling location. Enough sediment was collected at that depth to fill the applicable jars for analysis.

Due to a miscommunication in the field with the UXO diver who collected the sediment samples, two discrete sediment samples were collected in place of a single discrete sediment sample plus a QC field duplicate sample, which is considered a deviation from the Work Plan (Shaw, 2011). Therefore the QC samples for sediment consisted of one MS/MSD sample. Due to sufficient soil volume, additional collection of soil for the MS/MSD was not required and one sediment sample (FTFSD-002-SD) was designated as the MS/MSD on the chain-of-custody form prior to shipment.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the sediment sample locations at the former shaped charge test pond.

3.2.1.3 Surface Water Sample Collection

A grab surface water sample (FTFSW-001-0001-SW) was collected from the former shaped charge test pond on May 5, 2011, to determine if contaminants were present in the pond at concentrations that were above the facility human health and proposed ecological screening

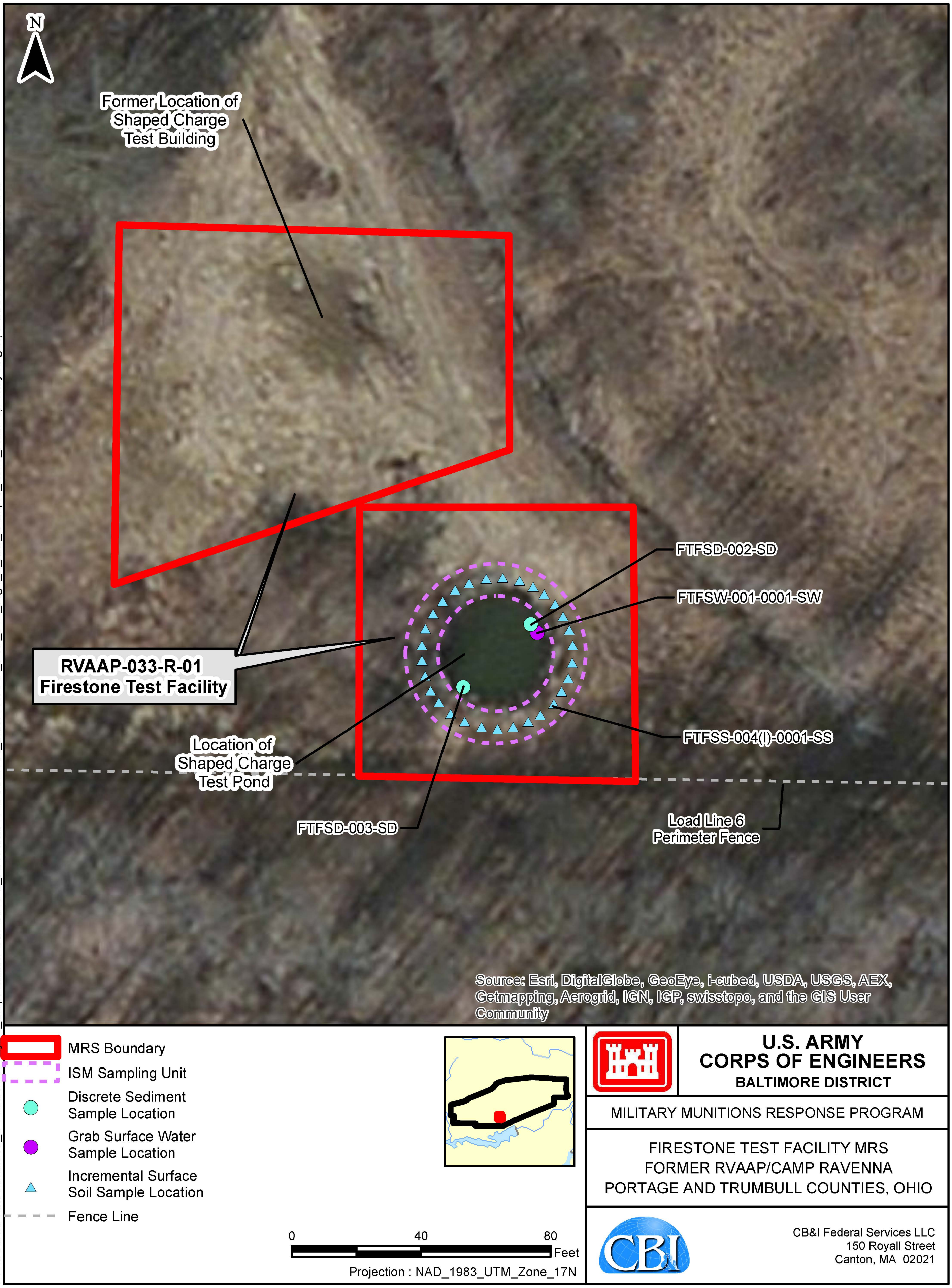

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FIGURE 3-2 SAMPLE LOCATIONS

criteria presented in the SAP (Shaw, 2011). The intent of the sampling event was to evaluate options for investigating the test pond sediment, which included approved and controlled discharge to the ground surface or manual diving operations. Although not specified in the Work Plan (Shaw, 2011), the surface water data was also considered to be useful for the purposes of the RI to evaluate for potential MC in the pond.

The pond sample was collected using the Van Doren sample method. The sample collection procedure included placing the Van Doren sampler in the pond and lowering it to the approximate midpoint depth of the pond (6 to 7 feet). Once at the designated depth, a messenger was activated to close the sampler ports and collect the sample. The sampler was filled such that a minimum of bubbling occurred and the sampler was then retrieved from the pond. The water was immediately placed into the appropriate sample containers using the lower stopper drain. Immediately following sample collection and completion of the bottle label information, each sample container was placed into a sealable plastic bag and then placed into an ice-filled cooler to ensure preservation.

The original purpose for collecting the surface water sample was to evaluate for options for investigating the pond sediment. QC field duplicate and MS/MSD samples were not required. The surface water sample was not originally intended to be used in the RI and the lack of a QC field duplicate and MS/MSD is not considered a deviation from the Work Plan (Shaw, 2011). The surface water sample was submitted for volatile organic compound (VOC) analysis, and a QC trip blank sample (FTFSW-001-0001-TB) was submitted for analysis to assess the potential for contamination of samples due to contaminant interference during sample shipment and storage.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix B**. **Figure 3-2** presents the surface water sample location at the MRS.

3.2.2 Sample Analysis

Analytical services for chemical samples were provided by CT Laboratories, Inc. (CT Laboratories) of Baraboo, Wisconsin, which is accredited through the DoD Environmental Laboratory Accreditation Program (ELAP) and the National Environmental Laboratory Accreditation Conference. The selection of chemical analyses for surface soil and sediment at the Firestone Test Facility MRS was based on the types of munitions historically identified for the MRS that consisted of shaped charges used in testing. The EPA publication SW846 entitled, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007) provides test procedures and guidance that are recommended for use in conducting the evaluations and measurements needed to comply with the *Resource*

Conservation and Recovery Act (RCRA). These methods are accepted by the EPA for obtaining data to satisfy the requirements of 40 CFR, Parts 122 through 270, promulgated under RCRA, as amended, and are commonly used on CERCLA sites for contamination evaluation. Test methods are approved procedures for measuring the presence and concentration of physical and chemical pollutants, evaluating properties such as toxic properties of chemical substances, or measure the effects of substances under various conditions. The selection of chemical analyses for surface soil and sediment at the Firestone Test Facility MRS was based on the types of munitions historically identified for the MRS, which consisted of shaped charges used in testing. Based on this information, the proposed SW846 analytical suites and methods were presented in the MC Sampling Rationale in the SAP (Shaw, 2011) and included the following:

- Metals (aluminum, antimony, barium, cadmium, total chromium, hexavalent chromium [Cr^{+6}], copper, iron, lead, strontium, mercury, and zinc)—Method EPA SW846 6010C/7471A/7196A
- Explosives—Method EPA SW846 8330B
- Nitrocellulose—Method EPA SW846 9056 Modified
- Total Organic Carbon (TOC)—Lloyd Kahn Method
- pH—Method EPA SW846 9045D (surface soil only)

In addition to the above analyses, the surface soil and sediment samples were also analyzed for geochemical parameters via EPA Method SW846 6010C in order to potentially evaluate naturally high metal concentrations and distinguish them from potential contamination. The geochemical parameters analyzed for the Firestone Test Facility MRS included calcium, magnesium, and manganese.

For the ISM surface soil sample and duplicate, each 1- to 2-kilogram sample was submitted to the contracted laboratory for processing and analysis. Processing consisted of drying out the sample and sieving the sample through a #10 sieve. Any material larger than the #10 sieve was discarded. The remaining air-dried, sieved material was then ground using a puck mill to reduce the particle size as sampling splitting and particle size reduction is necessary to reduce fundamental error. The final reduced portions of the ISM field samples were analyzed for metals, explosives, and nitrocellulose. The ISM field samples were analyzed for TOC and pH following processing of the sample and prior to grinding.

Since the original intent of the surface water sample was to characterize the pond water for potential discharge or diver entry, it was submitted for a more thorough set of analyses. The analytical suite identified for the surface water sample was as follows:

- Metals (aluminum, antimony, barium, cadmium, calcium, total chromium, copper, iron, lead, magnesium, manganese, mercury, strontium, and zinc)—Method EPA SW846 6010C/7471A
- Explosives—Method EPA SW846 8330B
- Nitrocellulose—Method EPA SW846 9056 Modified
- Polychlorinated Biphenyls (PCBs)—Method EPA SW846 8082A
- Pesticides—Method EPA SW846 8081B
- Semivolatile Organic Compounds (SVOCs)—Method EPA SW846 8270C
- VOCs—Method EPA SW846 8260B

A summary of the number and types of samples collected are presented in **Table 3-2**.

Table 3-2
Summary of Field Samples Collected and Required Analytical Parameters

Sample Name	Sample Type	Depth	Analytical Parameters	Number of Samples	Field Duplicates
Surface Soil/Sediment					
FTFSD-002-SD	D	0–0.5 feet bss	Metals[1], Explosives, Nitrocellulose, TOC, pH (soil only) Geochemical metals[2]	1	
FTFSD-003-SD				1	
FTFSS-004(I)-0001-SS	ISM	0–0.5 feet bgs		1	1
Surface Water					
FTFSW-001-0001-SW	D	6–7 feet bws (approximate depth to center of pond)	Metals[3], Explosives, Nitrocellulose, PCBs, Pesticides, SVOCs, VOCs	1	

Table 3-2 (continued)
Summary of Field Samples Collected and Required Analytical Parameters

[1] Metals includes analysis for aluminum, antimony, barium, cadmium, chromium (total and hexavalent), copper, iron, lead, strontium, mercury, and zinc.

[2] Geochemical metals include analysis for calcium, magnesium, and manganese.

[3] Metals includes analysis for aluminum, antimony, barium, cadmium, total chromium, copper, iron, lead, strontium, mercury, and zinc.

bgs denotes below ground surface.

bss denotes below sediment surface.

bws denotes below water surface.

D denotes discrete.

ISM denotes incremental sampling methodology.

PCB denotes polychlorinated biphenyl.

SVOC denotes semivolatile organic compound.

TOC denotes total organic carbon.

VOC denotes volatile organic compound.

The collected samples were packaged for shipment and dispatched to the contracted analytical laboratory, CT Laboratories in accordance with the SAP (Shaw, 2011). A separate signed custody record with sample numbers and locations listed was enclosed with each shipment. When transferring the possession of samples, the individuals relinquishing and receiving signed, dated, and noted the time on the record. All shipments were in compliance with applicable U.S. Department of Transportation regulations for environmental samples.

3.2.3 Laboratory Analysis

All samples were collected and analyzed according to the FWSAP (SAIC, 2011b) and the project-specific SAP in the Work Plan (Shaw, 2011). The FWSAP and associated addenda were prepared in accordance with USACE and EPA guidance for the DQO process (2000), and outline the organization, objectives, intended data uses, and quality assurance (QA)/QC activities to achieve the desired DQOs and to maintain the defensibility of the data. Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for the RI are consistent with EPA requirements for National Priorities List sites. The DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data.

Strict adherence to the requirements set forth in the FWSAP (SAIC, 2011b) and the SAP (Shaw, 2011) was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (2007). SW-846 chemical analytical procedures were followed for the analyses of VOCs, SVOCs, pesticides, PCBs, metals, explosives, and nitrocellulose. The contracted laboratory was required to comply with all methods as written; recommendations were considered requirements.

The QA/QC samples for this project included a QC split sample, laboratory method blanks, laboratory control samples (LCSs), laboratory duplicates, and MS/MSDs. An equipment rinsate sample was submitted for analysis along with the field duplicate sample for surface soil to provide a means to assess the quality of the data resulting from the field sampling program. A trip blank was submitted with the surface water sample that was analyzed for VOCs. **Table 3-3** presents a summary of QA/QC samples utilized during the RI field activities for the Firestone Test Facility MRS.

Table 3-3
Summary of Quality Assurance/Quality Control Samples

<table>
<tr><th>Sample Type</th><th>Rationale</th></tr>
<tr><td>Field Duplicate</td><td>Analyzed to determine sample heterogeneity and sampling methodology reproducibility</td></tr>
<tr><td>Equipment Rinse</td><td>Analyzed to assess the adequacy of the equipment decontamination processes</td></tr>
<tr><td>Laboratory Method Blanks</td><td>Analyzed to determine the accuracy and precision of the analytical method as implemented by the laboratory</td></tr>
<tr><td>Laboratory Duplicate Samples</td><td rowspan="2">Analyzed to assist in determining the analytical reproducibility and precision of the analysis for the samples of interest and provide information about the effect of the sample matrix on the measurement methodology</td></tr>
<tr><td>Matrix Spike/Matrix Spike Duplicate</td></tr>
<tr><td>Trip Blank</td><td>Analyzed to assess the potential for contamination of samples due to contaminant interference during sample shipment and storage</td></tr>
</table>

CB&I is the custodian of the project file and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms. These files will remain in a secure area under the custody of CB&I until they are transferred to USACE–Baltimore District and the ARNG. CT Laboratories retains all original raw data in a secure area under the custody of the laboratory project manager.

CT Laboratories performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing Shaw of any data that are considered “unacceptable” or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and the laboratory standard operation procedures in the SAP (Shaw, 2011). Data reduction, review, and reporting by the laboratory were conducted as follows:

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria, as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the laboratory project manager.
- The laboratory project manager completed a thorough review of all reports.
- Final reports were generated by the laboratory project manager.

Data were then delivered to Shaw for data validation. CT Laboratories prepared and retained full analytical and QC documentation for the project in electronic storage media (i.e., compact disc), as directed by the analytical methods employed. CT Laboratories provided the following information to Shaw in each analytical data package submitted:

- Cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis.
- Tabulated results of inorganic and organic compounds identified and quantified.
- Analytical results for QC sample spikes, sample duplicates, and initial and continuing calibration verifications of standards and blanks, method blanks, and LCS information.

3.2.4 Data Validation

Following receipt of the analytical data packages, Shaw performed data validation on all surface soil, sediment, and surface water samples collected at the MRS (including field duplicate and QC samples) to ensure that the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary dataset and a comparison of primary sample and field duplicate sample. This validation also attempted to minimize the potential of using false-positive or false-negative results in the decision-making process (i.e., to ensure accurate identification of detected versus nondetected compounds). This approach was consistent with the DQOs for the project and with the analytical methods, and was appropriate for determining contaminants of concern and calculating risk.

Analytical results were reported by the laboratory in electronic format and were issued to Shaw on compact disc. Data validation was performed to ensure all requested data were received and complete. Data use qualifiers were assigned to each result based on laboratory QA review and verification criteria. Results were qualified as follows:

- “U”—Analyte was not detected or reported less than the level of detection.
- “UJ”—Analyte was estimated and not detected or reported less than the level of detection.
- “J”—The reported result is an estimated value.

In addition to assigning qualifiers, the validation process also selected the appropriate result to use when reanalysis or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the validation chemist determined whether laboratory reanalysis should be used in place of an original reported result. If the laboratory results reported for both diluted and undiluted samples, diluted sample results were used for those analytes that exceeded the calibration range of the undiluted sample. A complete presentation of the validation process and results for the RI data is contained in the *Data Validation Report* in **Appendix C**.

3.2.5 Data Review and Quality Assessment

This section provides discussion of data review and the results of the data validation process and evaluates usability of data collected for this sampling event in accordance with the project QA program. QA is defined as the overall system for assuring the reliability of data produced. The system integrates the quality planning, assessment, and improvement efforts of various groups in the organization to provide the independent QA program necessary to establish and maintain an effective system for collection and analysis of environmental samples and related activities. The program also encompasses the generation of useable and complete data, as well as its review and documentation.

The QA program was designed to achieve the DQOs for the RI. Data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the SAP (Shaw, 2011), the FWSAP (SAIC, 2011b), the *DoD Quality Systems Manual for Environmental Laboratories* (DoD, 2010), and the laboratory’s QA manual. Laboratory reports included documentation verifying analytical holding time compliance. DQOs were developed concurrently with the work plan to ensure the following:

- The reliability of field sampling, chemical analyses, and physical analyses
- The sufficiency of collected data

- The applicability of data for intended use
- The validity of assumptions inferred from the data

Attainment of DQOs was assessed throughout the evaluation of all data collected using data quality indicators that are discussed in detail in this section. For this RI Report, a full data validation effort was performed to assess laboratory performance, including a review of the following:

- Completeness
- Chain-of-custody records
- Sample holding times
- QC results reported on summary forms as applicable to the analysis performed (i.e., initial and continuing calibrations; method, calibration, trip blanks, and equipment blanks; LCS/MS/MSD; performance and interference check samples and instrument tunes; surrogates; internal standards; and serial dilutions)
- Detection and reporting limits
- Other contractual items

Criteria for QC results were compared to laboratory established criteria in accordance with the method and Work Plan (Shaw, 2011) requirements. Further details and discussion are provided in the *Data Validation Report* in **Appendix C**.

Data were qualified during the validation process from predetermined criteria for QC nonconformances. The quality of data collected in support of the RI sampling activities as noted in data tables is considered acceptable with qualifications, unless qualified as rejected (and denoted with "R" qualifier) during the validation process. Results were assessed for accuracy and precision of laboratory analyses to identify the limitations and quality of data. The following data quality indicators were measured and QA reviews were performed:

- **General Review—**The EPA guidance, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, (Part A)*, Interim Final (EPA, 1989), states that the data qualified during the validation process as estimated "J" or "UJ" may be included in quantitative assessments indicating the associated numerical value is an estimated quantity, i.e., the guidance states to "use J-qualified concentrations the same way as positive data that do not have this qualifier." In review of analytical information, the sample results qualified as "J" (i.e., estimated or nondetect estimated values) during the validation process are considered usable data points (EPA, 1989), and are included in the data summary tables of this report. The majority of the "J"-qualified samples were the result of the common condition of reported values being below the certainty range of detection (i.e., either less than the MRL] and greater than the MDL, or less than three times the MDL, whichever is greater) as well as MS/MSD accuracy recoveries found outside criteria. There were no data rejections (i.e., R-flagged results) as a result from the data validation reviews.

- **Precision—**Laboratory duplicate pairs and/or laboratory spiked duplicate pairs were analyzed as per method requirements for each parameter and/or compound on a batch and matrix specific basis. Field duplicates were collected on the basis of 10 percent frequency per matrix to identify the cumulative precision of the sampling and analytical process and were sent on a blind basis to the laboratory. Field duplicates are evaluated at less than or equal to 50 percent the relative percent difference (RPD) for organic parameters and less than or equal to 25 percent RPD for inorganic parameters. Field duplicate pairs were evaluated for the surface soil sample only. Laboratory duplicate pairs and/or laboratory MSDs were evaluated for the surface soil, sediment, and surface water samples for the evaluation of precision.

  The MS/MSD pair was outside RPD criteria for target compound 4-amino-2,6-dinitrotoluene for the spiked sample FTFSD-002-SD; therefore, the associated sample was qualified estimated "J" for 4-amino-2,6-dinitrotoluene based upon this outlier. All other MSD pairs were within RPD criteria limits; therefore, did not warrant further qualification. All laboratory duplicate pairs were within RPD criteria limits; therefore, did not warrant further qualification. Blind field duplicate sample pair FTFSS-004(I)-0001-SS and FTFSS-005(I)-0001-SS was collected for explosives, metals, nitrocellulose, and TOC. Calcium, manganese, and strontium were outside criteria and qualified estimated "J" for the field duplicate pair based upon the high RPDs. All other target analytes were within criteria for the field duplicate pair.

  Although some data results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion is provided in the *Data Validation Report* in **Appendix C**.

  For sediment, a second independent sediment sample was collected instead of a field duplicate. For this event, the field precision data gaps posed no significant impacts given that the sampling bias was measured using the soil sample duplicate, which uses the same preparatory and analytical techniques as the sediment sample, as well as the other laboratory precision data quality indicators performed to measure laboratory precision for the sediment matrix. A field duplicate was not collected for the surface water sample, since the sample was originally collected to evaluate options for investigating the test pond sediment and not for evaluating risk. The precision for the surface water sample was evaluated through the laboratory MS/MSD and laboratory duplicate sample, and the indicators for precision were within the criteria for the aqueous matrix. Since the laboratory QC takes into account the analytical precision from the preparation and analysis stage, uncertainty with regard to the lack of field duplicates for sediment and surface water is minimized.

- **Accuracy—**Accuracy was evaluated for each matrix by reviewing the recovery results of the LCS, MS/MSD, and surrogate, as applicable, for each analytical method performed. The LCS, MS/MSD, and surrogate QC samples were analyzed as per method requirements for each parameter and/or compound on a batch and matrix specific basis.

  All LCS and surrogate recoveries were within criteria for all associated samples and runs. The MS/MSD recoveries were outside recovery limits for the spiked sample (in parenthesis) for antimony, cadmium, chromium, iron, manganese, zinc and hexavalent chromium (FTFSS-004(I)-0001-SS). Cadmium and antimony were not applicable because the parent sample results for these analytes were less than 50 times the limit of quantitation. The associated serial dilution and/or post-digestion spike recoveries were outside acceptable limits (spiked sample qualified estimated "J") for zinc, manganese, iron, copper, and chromium. Hexavalent chromium was qualified for the spiked sample as estimated nondetect "UJ" based upon this outlier. MS/MSD recoveries for sample FTFSD-002-SD were below the recovery limits for 1,3-dinitrobenzene, 3-nitrotoluene, 4-amino-2,6-dinitrotoluene, and RDX; therefore, the parent sample result was qualified estimated nondetect with a "UJ" flag based upon these outliers. The MS/MSD recoveries for sample FTF-006-RB were below the recovery limits for aluminum; therefore, the parent sample result was qualified estimated nondetect with a "UJ" flag based upon this outlier. All other MS/MSD recoveries were within criteria.

  Although some data results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion is presented the *Data Validation Report* in **Appendix C**.

- **Representativeness—**Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled. It is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, and actual material collected as a "sample" of the whole. Representativeness applies to both sampling and analytical evaluations and should be 100 percent. Analytical representativeness is inferred from associated documentation (i.e., data validation reports, field records, etc.) for holding times, QC blanks, accuracy, and precision, as well as from the completeness evaluations. Sampling protocols were developed to assure that samples collected are representative of the media. Field handling protocols (i.e., storage, handling in the field, and shipping) were designed to protect the representativeness of the collected samples.

For the sampling round, the sample collection was performed using Shaw standard operating procedures (SOPs) and the analytical testing was performed using the EPA methodology with the ELAP-accredited laboratory. Sampling protocols were properly followed to assure that samples collected are representative of the media including the field handling protocols (i.e., storage, handling in the field, and shipping) of the collected samples. Sample identification and integrity were maintained (i.e., chain of custody) during this sampling event as determined during data validation. Due to a miscommunication in the field with the UXO diver who collected the sediment samples, two discrete sediment samples were collected in place of a single discrete sediment sample plus a QC field duplicate sample and is considered a deviation from the Work Plan (Shaw, 2011). A field duplicate was collected for the ISM surface soil sample. In review of the analytical data, data validation reports, and field records, no significant nonconformances were noted for holding times, QC blanks, accuracy, precision, and completeness evaluations. All analytical data were deemed representative in accordance with EPA guidance (EPA, 1989), with no sample or data rejections for the compounds of concern.

A QC field inspection was conducted for field sampling activities at the facility as required by the Work Plan (Shaw, 2011). The inspection was conducted at the Group 8 MRS in February 2012. Although the inspection was not conducted at the Firestone Test Facility MRS, it is considered applicable to the representativeness of the ISM surface soil samples collected at the MRS, with the basis being that the inspection was activity-based, the same sample methods were used at both MRSs, and most of the same sample personnel were present for both sampling events. The *Quality Surveillance Summary Report* conducted at the Group 8 MRS is presented along with the field documentation in **Appendix B**.

Several nonconformances were observed during the QA field inspection by the Shaw UXO QC Specialist at the Group 8 MRS, which is also representative of the ISM surface soil field sampling activities conducted at the Firestone Test Facility MRS. The noncomformances included not having the sampling SOPs on site during the beginning of field sampling activities and the potential for cross-contaminating equipment with used sampling gloves. These noncomformances were remedied in the field and the corrective action included retrieving the sampling SOPs from the field office and ensuring that new sampling gloves were donned after handling used equipment. The primary nonconformance that had the potential to affect the data was the handling of decontaminated equipment with used gloves. However, this incidence was observed by the UXO QC Specialist prior to actual sampling activities and during the removal of the sampling equipment and materials from the vehicle. There was no contact with used gloves on the end of the step probe used to collect the ISM samples and the handle and stem of the step probe were re-cleaned prior to sample collection. Results of the rinsate blank (GR8-RB-01) for the sampling equipment step probes support the evidence that equipment was properly decontaminated during field activities.

An additional nonconformance was identified by the UXO QC Specialist, but was more of a recommendation. The recommendation was to ensure the separation of the step probes from other equipment in the vehicle. The step probes were properly protected at the time of the observance as noted in the audit and did not affect the data.

- **Completeness—**Completeness is a measure of the amount of information that must be collected during the field investigation to allow for successful achievement of the objectives of the program and valid conclusions. Completeness is defined as the percentage of measurements which are judged to be usable. The percent completeness criterion is 90 percent. In this data validation review, three categories of completeness quotients are calculated, including the overall sampling completeness, overall analytical completeness, and analytical completeness by parameter groups.

The sampling percent completeness is determined by taking the number of planned samples (including QC samples) and dividing that number by the number of samples actually collected during the current round of sampling. Two discrete sediment samples, two ISM surface soil samples (including one field duplicate sample), one discrete surface water sample, one trip blank, and one rinse equipment blank were collected and sent to the laboratory for analyses. Two discrete sediment samples (including one field duplicate sample), two ISM surface soil samples (including one field duplicate sample), one discrete surface water sample, one trip blank, and one rinse equipment blank were proposed in the SAP for this sampling event. The substitution of collecting an extra sediment sample instead of a sediment field duplicate did not affect the total number of samples collected. Excluding rinse and trip blanks, the overall sampling completeness was

100 percent (or 5 surface soil, sediment, and surface water samples collected divided by 5 planned surface soil, sediment, and surface water samples).

The overall analytical percent completeness is calculated from the number of usable data inputs divided by the number of analyzed data inputs. The evaluation of completeness for the surface soil, sediment, surface water samples, field duplicates, trip blank, and rinse blank resulted in 430 useable data points of possible 430 data points, resulting in an overall analytical completeness quotient of 100 percent for all parameter groups. The completeness statistics were computed as follows:

- 430 represents the total number of accepted analytes as usable data points (no analytes were rejected)
- 430 represents the number of analyzed inputs which is equal to the total number of analytes for all field samples.

There were no rejected data points for any of the parameters for explosives, nitrocellulose, metals, Cr^{+6}, SVOCs, VOCs, pesticides, PCBs, TOC, and pH or for this event; therefore, their analytical completeness quotients were each 100 percent. All of the overall and parameter-specific analytical completeness and soil sampling completeness quotients were above the predefined completeness goal of 90 percent. Further discussion is presented in the *Data Validation Report* in **Appendix C**.

- **Comparability—**Comparability is the confidence with which one data set can be compared to another. Comparability was controlled through the use of SOPs that have been developed to standardize the collection of measurements, samples, and approved analytical techniques with defined QC criteria. The laboratory chemical analyses were performed by ELAP-accredited laboratories in accordance with the approved SAP (Shaw, 2011) using cited EPA methodology. Where applicable, the EPA-approved methods and *DoD Quality Systems Manual* provided the QC criteria guidelines for the analytical methods and the ELAP accrediting body provided the QA oversight (DoD, 2010). The laboratory adapted its processes accordingly into an applicable working SOP specific to their laboratory capabilities (i.e., instrumentation, prep method, sample volumes, etc.) in applying the EPA methods. The SOPs were followed throughout the process by the laboratories, as reviewed by the ELAP accrediting body. Furthermore, laboratory data were validated in accordance with established SOPs, and the validation qualifiers were applied when QC nonconformances were identified (as applicable).

The consistent use of the laboratory SOPs provides confidence with which one data set could be compared to another previous data set.

Established field SOPs that were preapproved in the SAP (Shaw, 2011) for the RI program were applied to on-site work during this surface water, sediment, and soil sampling events. The field SOPs were followed, as established in the SAP (Shaw, 2011) to ensure that protocols meet project DQOs. The recorded field documentation provided verification (i.e., field calibration, etc.) that proper field procedures were followed. The consistent application of field SOPs over the course of the RI program from sampling event to sampling event lends confidence in the comparison of field data sets.

- **Sensitivity—**The sensitivities are dependent on the analytical method, the sample volumes, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, limits of detection [LODs], MRLs, etc.) and analyte detections presented in **Appendix C** were compared to the screening criteria for the each of the samples collected. The analytical laboratory updated their sensitivity reporting convention from MDLs/MRLs to MDLs/LODs/MRLs during the sampling and analysis phase for the RI. The screening criteria are presented in Table 2-2 (*Proposed Human Health and Ecological Screening Level for Ravenna AAP MRSs*) of the Work Plan (Shaw 2011). Specifically, the data was compared to the background values as presented in the *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (SAIC, 2010), hereafter referred to as the FWCUG Guidance. Upon comparing the surface water, sediment, and soil sample results to the background values project screening criteria, the method sensitivity requirements were met. All MDLs, LODs or MRLs were less than the noted project screening criteria.

- **QC Blanks—**Method blanks, calibration blanks, rinsate blanks, and trip blanks were evaluated to identify potential non-site-related contamination from sample collection through laboratory analyses. Analytical results found within the 5 times and 10 times rules were qualified "U" and considered nondetect at the LOD or level of contamination, whichever was greater. From the EPA guidance, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, Interim Final (EPA, 1989), the definitions of the 5 times and 10 times rules are as follows:
  - "If the blank contains detectable levels of one or more organic or inorganic chemicals, then consider site sample results as positive only if the concentration

of the chemical in the site sample exceeds five times the maximum amount detected in any blank for compounds that are not considered by EPA to be common laboratory contaminants. Consider 10 times the maximum amount for common laboratory contaminants acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene, and the phthalate esters. Treat samples containing less than 5 times (10 times for common laboratory contaminants) the amount in any blank as nondetects and consider the blank-related chemical concentration to be the quantitation limit for the chemical in that sample."

The rinsate blank (FTF-006-RB) applied for the surface soil samples and was analyzed for explosives, metals, hexavalent chromium, nitrocellulose and pH. All target analytes were nondetect (less than or equal to the limit of detection) for the rinse blank; therefore, no samples required further qualification.

The trip blank (FTFSW-001-0001-TB) applied for the surface water sample was analyzed for VOCs. All target analytes were nondetect (less than or equal to the limit of detection) for the trip blank; therefore, no samples required further qualification.

Aluminum was detected above the LOD in several initial calibration blanks and continuing calibration blanks (Sample Delivery Groups [SDGs] 86587 and 86495); however, the associated sample results were greater than 5 times the initial calibration blank/continuing calibration blank results and no qualification was required. Aluminum and calcium were detected above ½ of the reporting limit in the method blank (SDG 86587). The results for these elements in the associated samples were all greater than 5 times the method blank results; therefore, the data were not qualified. For all other SDGs and/or analytes, all method and calibration blank criteria were met. Further discussion is provided in the *Data Validation Report* in **Appendix C**.

The Firestone Test Facility MRS data were determined to be of sufficient quality to make informed decisions for the surface soil, sediment, and surface water samples collected. Further discussions of data qualifications are provided in the *Data Validation Report* in **Appendix C**.

3.3 Decontamination Procedures

Decontamination of dedicated sampling equipment was performed in accordance with the procedures presented in the SAP (Shaw, 2011) with the exception that the hydrochloric acid step was eliminated due to previous observations of surface corrosion on the sampling equipment when applied. The sampling equipment consisted of individual ⅞-inch diameter stainless steel step probes used to collect the ISM surface soil sample and associated field duplicate. All sampling decontamination procedures were performed at Building 1036, the facility contractors' building. In summary, the decontamination procedures consisted of the following:

- Wet the equipment with an American Society of Testing and Materials (ASTM) Type 1 water and phosphate-free detergent (Liquinox) solution to remove residual particulate matter and surface film from the equipment.
- Rinse the equipment with ASTM Type 1 water.
- Rinse the equipment with methanol.
- Rinse with ASTM Type 1 water.
- Allow equipment to air dry.

Once dry, the sampling equipment was wrapped in aluminum foil to prevent cross contamination while in storage or transport to an MRS for sampling. In order to minimize waste, the liquids used in the decontamination process were applied using hand-held spray bottles.

Following the equipment decontamination process, an equipment rinsate sample was collected by running distilled water through the sampling equipment for the identical analytical parameters as the environmental samples. The purpose of the equipment rinsate sample was to assess the adequacy of the equipment decontamination process.

The results of the equipment blank analysis did not identify any interference or anomalies in the laboratory data and supports the adequacy of the equipment decontamination process. Evaluation of the equipment rinsate sample analytical data to assess the adequacy of the equipment decontamination process is further discussed in Section 3.2.5, "Data Review and Quality Assessment." A summary of results of the equipment rinse sample is presented in **Appendix D**.

3.4 Investigation-Derived Waste

The investigation-derived waste (IDW) generated during the field activities at the Firestone Test Facility MRS consisted of solid waste that included personal protective equipment, disposable sample equipment, and equipment decontamination materials. Due to the minimal number of pieces of sampling equipment and in an effort to minimize waste generation, the decontamination liquids were applied using hand-held spray bottles and the overspray and excess liquid was collected on absorbent pads. No free liquid wastes were generated.

The disposal of IDW was performed in accordance with the procedures presented in the Work Plan (Shaw, 2011). The IDW generated was containerized in a 55-gallon steel drum along with similar materials generated from other MRSs and were staged at Building 1036 in accordance with the FWSAP (SAIC, 2011b). IDW Management that describes the waste characterization analyses performed, waste characterization screening, and IDW transport and disposal is presented in **Appendix E**.

4.0 REMEDIAL INVESTIGATION RESULTS

This section presents a discussion of the results of the RI data that were collected for MEC and MC at the Firestone Test Facility MRS in accordance with the procedures discussed in Section 3.0, "Characterization of MEC and MC." These results will be used to determine the nature and extent of MEC and associated MC and subsequently determine the potential hazards and risks posed to likely human and ecological receptors. Once the risks are determined, they will then be integrated into the preliminary CSMs developed during the SI (e^2M, 2008) that were presented in Section 2.0. Photographs of the RI activities performed at the MRS are presented in **Appendix F**.

4.1 Munitions Investigation Results

The following sections present the results of the RI field efforts for MEC that were performed to achieve the DQOs defined in Section 2.3.1, "Data Quality Objectives," and define the nature and extent of MEC and/or MD at the Firestone Test Facility MRS. These efforts included a combination of visual and DGM surveys and intrusive investigations that were conducted in accordance with the Work Plan (Shaw, 2011).

4.1.1 Visual Survey Results

While no visual survey transects were proposed for the MRS, the potential presence of MEC and/or MD on the ground surface was evaluated during the surface clearance of metal debris prior to the DGM survey. A total of 0.31 acres of full coverage DGM data, which equates to 84 percent of the 0.368-acre land-based portion of MRS, was collected during the DGM survey, and no MEC or MD was identified on the ground surface.

4.1.2 Geophysical Survey Results

A total of 0.31 acre of full coverage DGM data was collected at the Firestone Test Facility MRS. Data was acquired in all accessible areas of the MRS. The area of the pond (0.04 acres) was not included in the DGM survey since it was evaluated using underwater investigation techniques. In addition, several areas of the MRS totaling approximately 2,500 square feet (0.058 acres) were determined to be unsafe to access due to construction debris and rebar protruding through the ground surface. **Figure 3-1** illustrates the areas of actual DGM survey coverage at the MRS performed for the RI versus the coverage area proposed in the Work Plan (Shaw, 2011).

Evaluation of the data collected during the DGM survey identified a total of 423 individual anomalies. Approximately 60 of the anomalies are located within the high anomaly density zone in the central portion of the MRS. The geophysical data indicate that the anomaly density at the MRS is relatively high and considered "cluttered" in the region directly northeast of the pond and "saturated" in the area of the MRS that is located northwest of the pond. At the southern end of the saturated anomaly area, the field crew documented metal objects consisting of rebar and other construction debris protruding through the ground surface that are considered cultural debris. In general, the anomaly density decreases towards the northwest section of the MRS. **Figures 4-1** and **4-2** display the results of the EM61-MK2 survey. **Figure 4-1** provides a sensitive color-scale that highlights all anomalies above a signal threshold of 5 mV (Channel 2), while **Figure 4-2** uses a coarse color-scale to delineate the major aggregates of buried metal with increased definition.

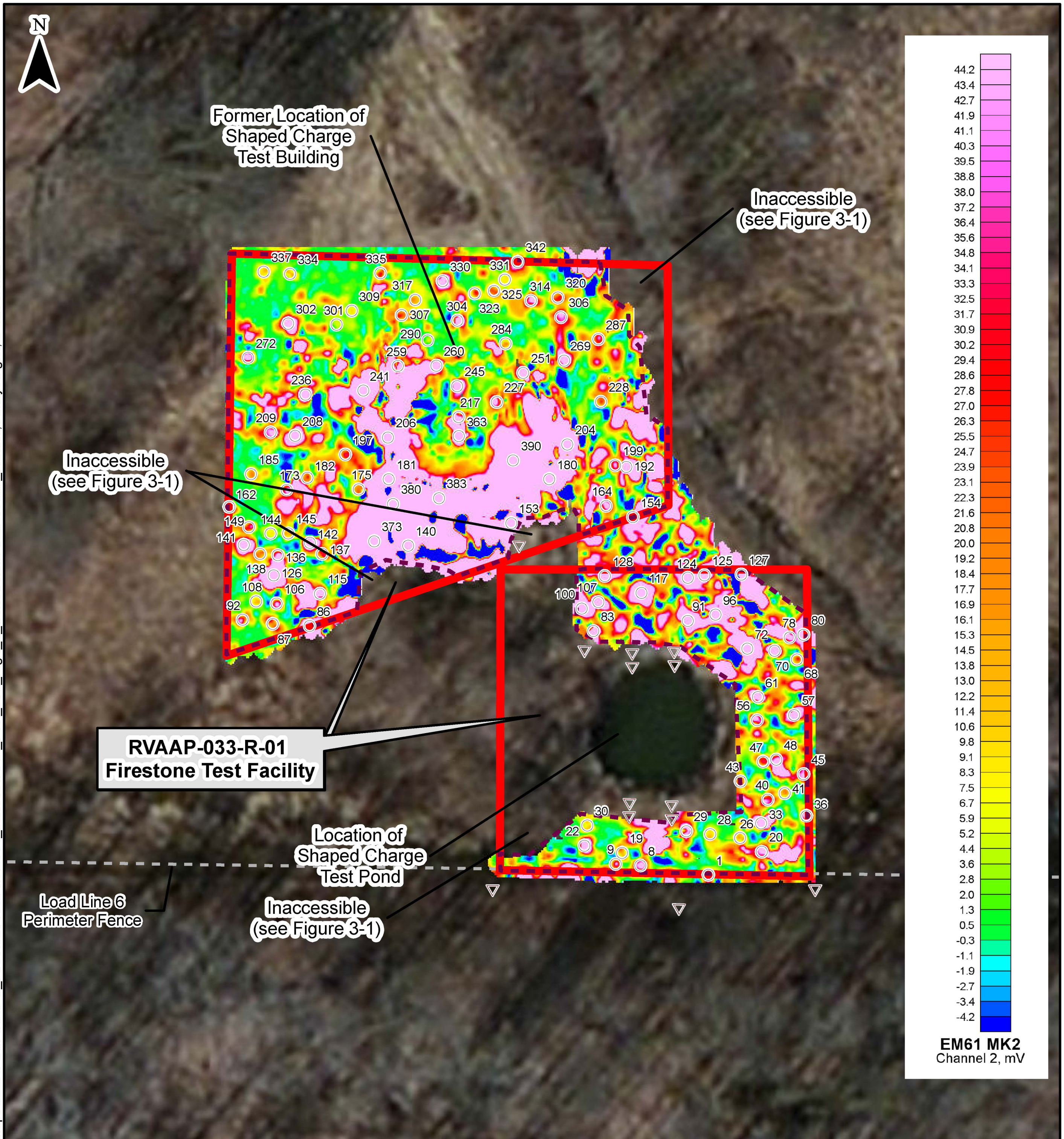
4.1.3 Geophysical QC Results

The DGM data were processed and interpreted consistent with the Work Plan (Shaw, 2011). Data was acquired in all areas void of inaccessible terrain. The DGM quality objectives and metrics were achieved for all data collected. The geophysical data files generated during the DGM activities consist of field data and QC test files. This data and the results of the DGM quality objectives and metrics are discussed and presented in further detail in the DGM Report in **Appendix A**.

4.1.4 Intrusive Investigation Results

A total of 105 of 423 anomalies, which represent 25 percent of the anomalies within the MRS, were selected for intrusive investigation based on the anomaly selection and prioritization process presented in the Work Plan (Shaw, 2011) and discussed in Section 3.1.2.1, "Target List Development." Thirteen of the 105 anomalies (targets 140, 145, 153, 180, 181, 204, 206, 241, 259, 260, 373, 383, and 390) were targeted for investigation at the high-anomaly-density zone at the central portion of the MRS by the mechanical shallow trenching method, which is an intrusive procedure consistent with those used in the industry. The remaining 92 anomalies were individual target locations that were manually investigated by hand digging. The anomalies identified by the DGM effort were selected randomly and are distributed throughout the MRS.

All 105 anomaly locations were successfully reacquired and intrusively investigated and no MEC or MD was identified. Once the item(s) was verified as not being MEC or MD, it was removed from the hole and the hole was further inspected using the Schonstedt magnetometer to verify that there were no deeper metallic items at that location. At several of the high-anomaly-density investigation areas, the nature of the debris (i.e., scrap steel, reinforced concrete, etc.) did not allow for removal and the anomaly was considered as the maximum depth for investigation at that location. The maximum depth of the intrusive investigation locations was 48 inches bgs. Approximately 9,600 pounds of "Other Debris" consisting primarily of scrap metal, rebar, and other construction debris were determined by the UXO Teams in the field.



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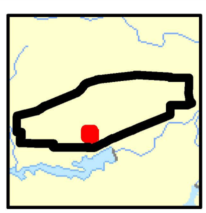
MRS Boundary

Area Accessible for RI DGM Coverage

Fence Line

Cultural Feature/Surface Metal/ Natural Site Feature

Anomaly Location Investigated (No MEC or MD Items Found)



0 20 40 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 4-1 SENSITIVE COLOR-SCALE DGM RESULTS

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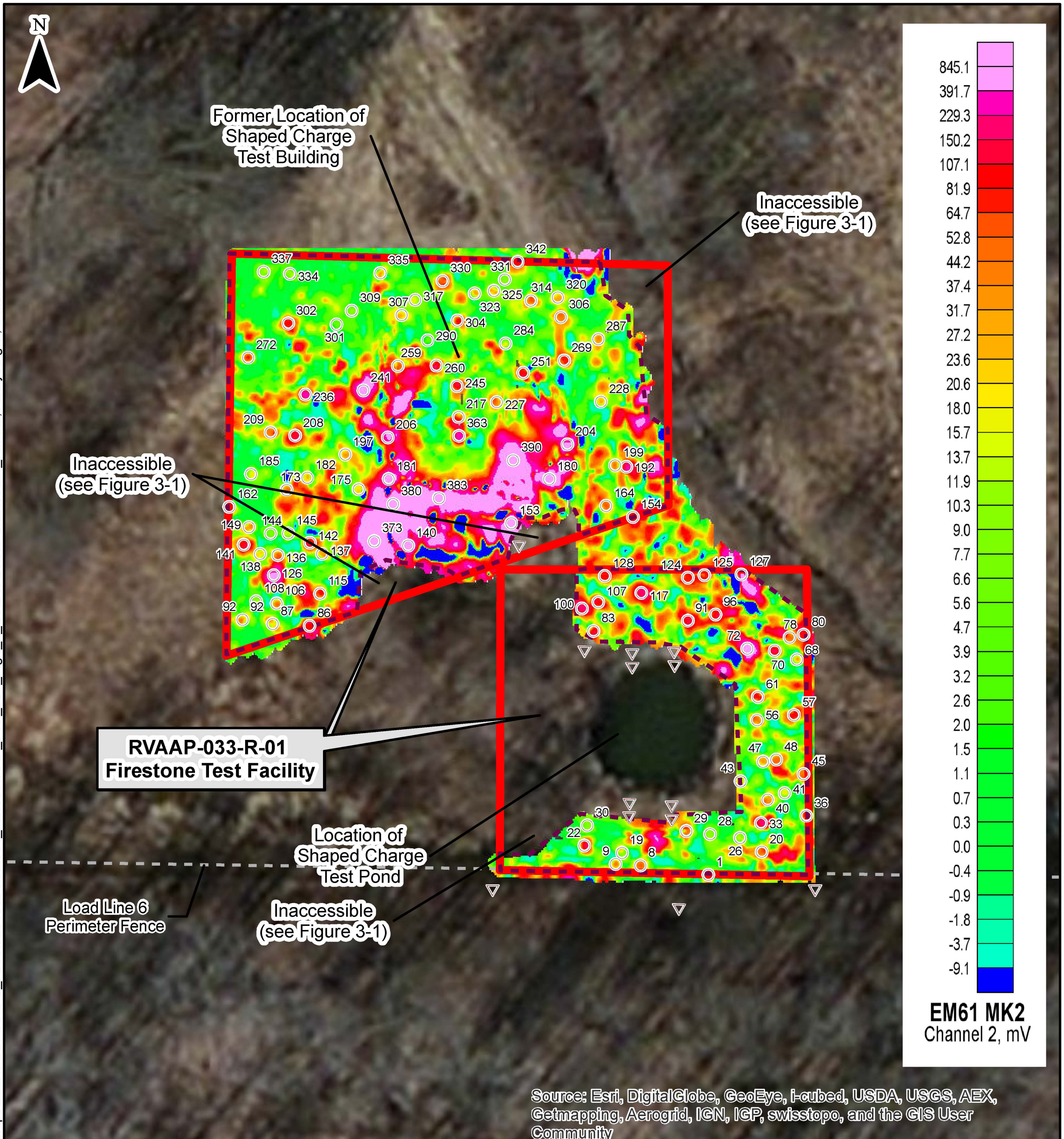


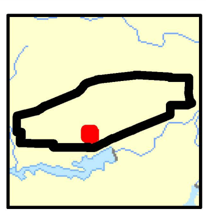
MRS Boundary

Area Accessible for RI DGM Coverage

Cultural Feature/Surface Metal/ Natural Site Feature

Anomaly Location Investigated (No MEC or MD Items Found)

Fence Line



0 40 80 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 4-2 COARSE COLOR-SCALE DGM RESULTS

The results of the anomaly investigation are shown in **Figure 4-3**. A summary of investigation data results collected for each of the anomaly and exploratory trench excavation locations is included in **Appendix G**.

4.1.5 Post-Excavation Field Quality Control

A total of 22 anomaly locations were randomly selected for post-excavation QC with the EM61-MK2 following the intrusive investigation in accordance with DID WERS-004.01, *Geophysics, Attachment D, "Table D-1 Performance Requirements for RI/FS Study Using DGM Methods"* (USACE, 2010a). The purpose of the post-excavation QC activities was to ensure that at a 90 percent confidence, less than 5 percent of the remaining anomalies are "unresolved" (i.e., there is a low probability that a significant item related to MEC is present within the dig locations that were not checked post excavation).

At 18 of the locations, the residual signal from the sensor was less than 5 mV (Channel 2). At 100 percent of the post-excavation QC locations, the Channel 2 response was less than 8 mV. For the four target locations between the 5 and 8 mV responses, two anomalies (targets 1 and 144) were cultural features that were left in place. Target 1 is located on the edge of the MRS boundary and the response at this target was likely influenced by other anomalies located outside of the MRS. Target 144 resulted in small pieces of aluminum during intrusive operations and there is likely additional small piece(s) of aluminum near the post-excavation QC location. The source of nonferrous metal at this location is also supported by the low decay constant. Based on the results of the post-excavation QC, no additional excavation locations were required to be investigated.

4.1.6 Statistical Analysis of Intrusive Findings

A statistical approach was then used to quantify the intrusive findings of the RI. Since no MEC or MD was found during the intrusive investigation and based on the statistical approach used to select the number of anomalies to investigate; there is a 99 percent probability that there is no MEC present at the remaining 318 anomaly locations that were not investigated during the RI field activities. These results achieved the DQOs established in the Work Plan (Shaw, 2011). A summary of the statistical analysis of the intrusive findings is presented in **Appendix H**.

4.1.7 Underwater Investigation Results

On August 4, 2011, Shaw performed an underwater investigation at the Firestone Test Facility MRS former shaped charge test pond. The goal of the underwater investigation was to identify potential MEC items within the pond and the investigation included complete coverage of the pond area. The underwater tactile investigation revealed that the pond is conical shaped with approximate 50 to 60 degree side slopes. The maximum depth of the

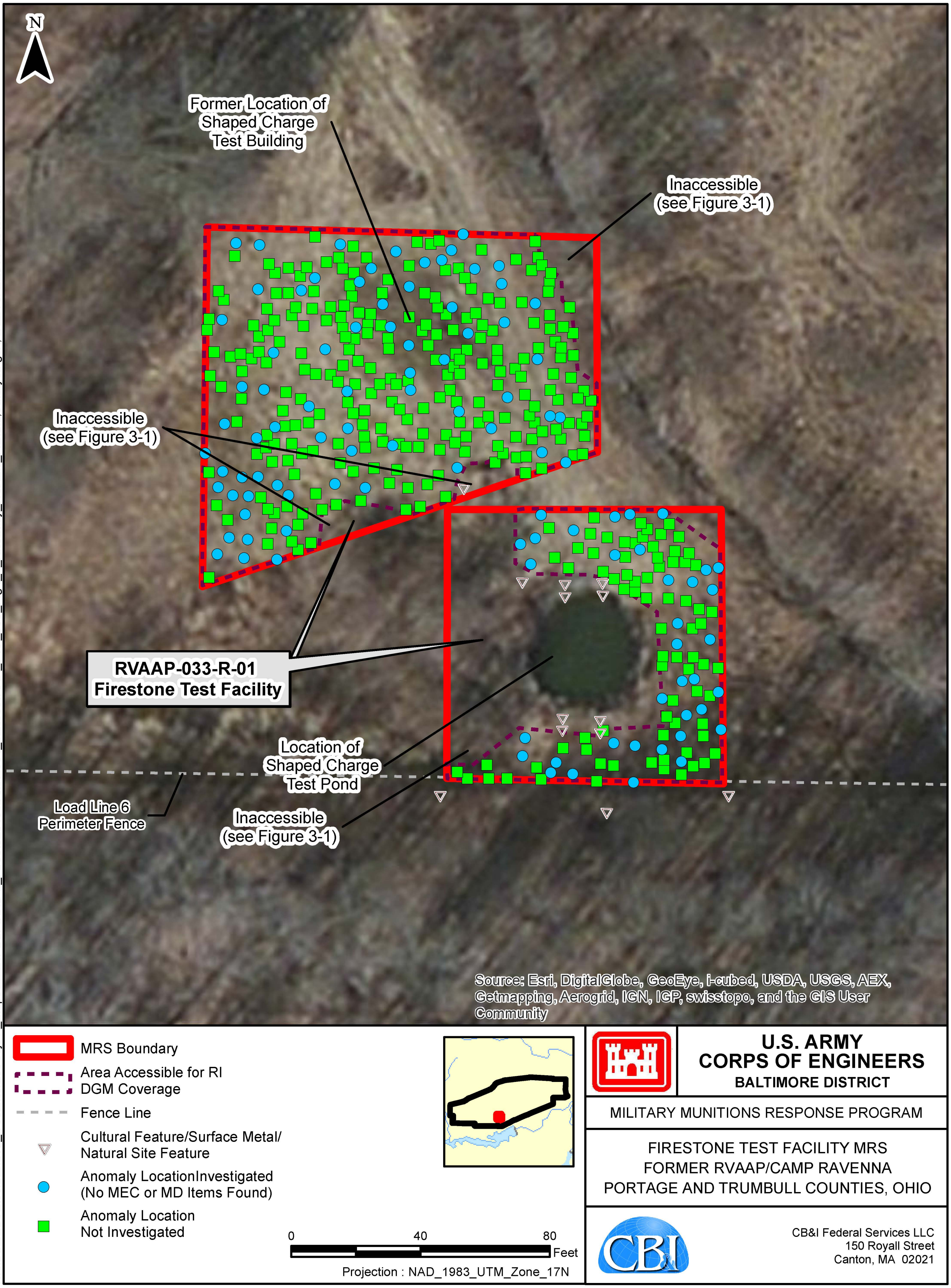

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FIGURE 4-3 ANOMALY INVESTIGATION RESULTS

pond is approximately 14 feet bgs. There were no findings of MEC or MD in the pond sediment.

4.2 MC Data Evaluation

This section presents the results of the RI data screening process for MC that may be indicative of impacts from historical munitions events, which have occurred at the Firestone Test Facility MRS, and to evaluate the occurrence and distribution of the MC in surface soil, sediment, and surface water. The data evaluated in this section is inclusive of the results of the RI sampling event only. Analytical data from previous samples collected during the 2007 SI field activities and under the IRP were not included in this evaluation since comparison of these samples to the RI data were either not considered relevant or the RI data is considered to be more representative of current conditions at the MRS as summarized in Section 2.3.3, "Data Incorporated into the RI."

The data reduction and screening process presented herein describes the statistical methods and facility-wide background screening criteria used to distinguish constituents present at ambient concentrations from those present at concentrations that indicate potential impacts related to historical operations within the MRS. The nature and extent of identified MC within the sampled environmental media (surface soil, sediment, and surface water) established for this RI Report are also presented below. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.2.1 Data Evaluation Methods

Data evaluation methods for the Firestone Test Facility MRS are consistent with those established in the FWCUG Guidance (SAIC, 2010). These methods consist of three general steps: (1) define data aggregates; (2) data validation, reduction, and screening; and (3) data presentation.

4.2.1.1 Definition of Aggregates

Samples were grouped (aggregated) at the Firestone Test Facility MRS based on the type of environmental medium sampled and consistency in sample type, area, and depth. The data aggregates identified for the MRS included the following:

- **Surface Soil (0 to 0.5 feet)—**This data aggregate consists of one surface soil sample collected using ISM at a 0.2-acre sampling unit surrounding the former test pond. The sampling unit consists of 30 increments collected at sample depths of 0 to 0.5 feet each. The 0- to 0.5-foot interval is the maximum depth that MC associated with MEC on or just below the ground surface would be expected to vertically migrate in the soil column. The sampling unit is the decision unit for the land-based portion of the MRS and the data results for this area are considered suitable for comparison against established screening values for the evaluation of the nature and extent of contamination associated with previous activities at the MRS.

- **Sediment (0 to 0.5 feet)—**This data aggregate consists of two discrete sediment samples with a sample depth of 0 to 0.5 feet beneath the sediment surface. The maximum depth of the discrete sediment samples to 0.5 feet is consistent with the guidance established for wet sediment at the facility (USACE, 2005; SAIC, 2010). The locations and sample depths for the sediment within the former test pond represent the most likely exposure scenario for receptors, and the data results for the sediment samples are considered suitable for comparison against established screening values for the evaluation of the nature and extent of contamination associated with previous activities at the MRS.
- **Surface Water—**This data aggregate consists of one surface water sample collected at the approximate center depth of the former test pond between 6 to 7 feet below the water surface. The data results for the surface water sample are considered suitable for comparison against established screening values for the evaluation of the nature and extent of contamination associated with previous activities at the MRS.

For risk assessment purposes and consideration of MC exposure analysis, the surface soil, sediment, and surface water aggregates encompass only areas of probable anticipated use by receptors and are the defined exposure units (EUs) for evaluation in the human health and ecological risk exposure assessments for the RI as discussed in Section 7.0, “Human Health Risk Assessment” and Section 8.0, “Ecological Risk Assessment.”

4.2.1.2 Data Validation

Data validation was performed on all samples collected at the Firestone Test Facility MRS (including the field duplicate and QC samples) during the RI field activities to ensure the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary dataset as discussed in Section 3.2.4, “Data Validation.”

4.2.1.3 Data Reduction and Screening

The data reduction process implemented to identify site-related chemicals (SRCs) involves identifying frequency of detection summary statistics, comparison to RVAAP facility-wide background screening values (BSVs) for metals only, and evaluation of essential nutrients. QC and field duplicates were excluded from the screening data sets. All analytes having at least one detected value was included in the data reduction process. Summary statistics calculated for each data aggregate included the minimum, maximum and average (mean) detected values and the proportion of detected results to the number of samples collected. For calculation of mean detected values, nondetected results were included by using one half of the reported detection limit as a surrogate value during calculation of the mean result for each compound. Following data reduction, the data was screened to identify chemicals as SRCs using the processes outlined in the following sections. **Figure 4-4** shows the facility data screening process to identify SRCs as COPCs and perform selection for chemicals of concern (COCs) as necessary. The determination of COPCs and COCs is for human health evaluation only.

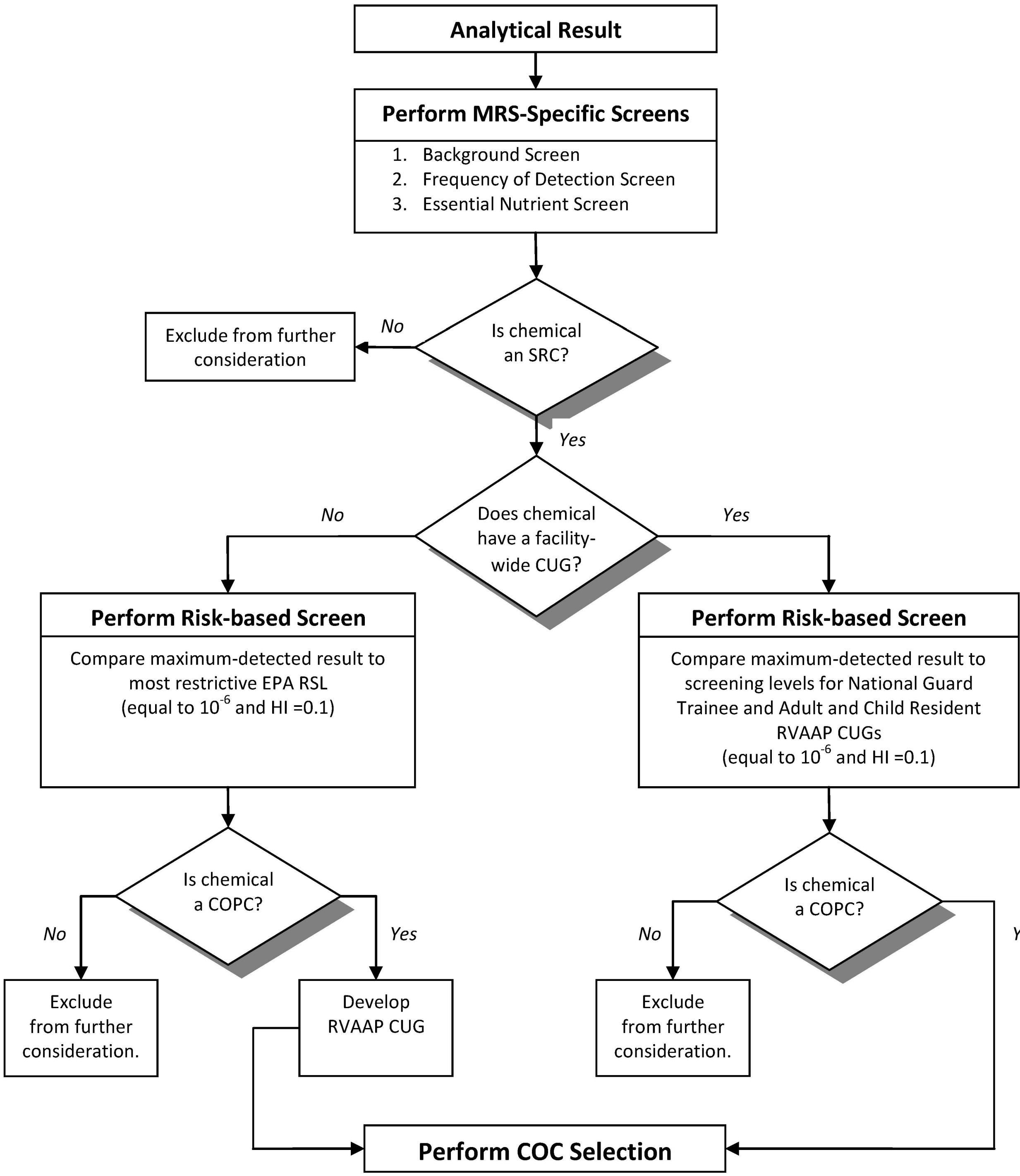
Frequency of Detection

Chemicals that are detected infrequently, except explosives and propellants, may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to the munitions related activities. For sample aggregations, except for explosives and propellants, with at least 20 samples and frequency of detection of less than 5 percent, a weight of evidence approach may be used to determine if the chemical is MRS-related. Since the total number of samples collected at the Firestone Test Facility MRS was less than 20 (1 ISM surface soil, 2 discrete sediment, and 1 surface water), frequency of detection was not utilized to support a weight of evidence approach for the Firestone Test Facility MRS dataset.

Facility-Wide Background Screen

For inorganic constituents, if the maximum detected concentration exceeded its respective BSV, it was considered to be a SRC. Not all inorganic compounds analyzed as part of the RI sampling event have established screening levels or BSVs. Therefore, in the event an inorganic constituent was not detected in the background data set, the BSV was set to zero, and any detected result for that constituent was considered above background. This conservative process ensures that detected constituents are not eliminated as SRCs simply because they are not detected in the background data set. All detected organic compounds were considered to be above background because these classes of compounds do not occur naturally.

For the RI field efforts across the facility MRSs being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical analysis. Aluminum was analyzed for geochemical purposes at certain MRSs where it is not considered an MC related to munitions; however, aluminum is considered to be an MC associated with the Firestone Test Facility MRS and was not analyzed as a geochemical metal for this MRS. Geochemical analysis is typically used when metals are found to be only slightly elevated above background levels and risk assessment identifies potential risk to receptors due to metals. A geochemical analysis is then used to determine if MEC metals are background related or actually elevated due to site history. Use of



COC = Chemical of Concern
COPC = Chemical of Potential Concern
CUG = Cleanup Goal
EPA = Environmental Protection Agency
HI = Hazard Index
MRS = Munitions Response Site
RSL = Regional Screening Level
SRC = Site Related Chemical

Note: The determination of COCs and COPCs is for human health evaluation only.

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FIGURE 4-4 RVAAP DATA SCREENING PROCESS

geochemical evaluation in this manner requires approval from the USACE and the Ohio Environmental Protection Agency (Ohio EPA) prior to implementing the results as a comparison tool for background results. A geochemical evaluation was not required for the Firestone Test Facility MRS based on the evaluation of the metal results in Section 4.0 and the HHRA and ERA conclusions in Section 7.0 and Section 8.0, respectively.

Essential Nutrient Screen

Chemicals that are considered to be essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the food supply and are often added to foods as supplements. The EPA recommends that these chemicals not be evaluated as COPCs as long as they are present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and toxic at very high doses (i.e., much higher than those that could be associated with contact at the MRS). Recommended daily allowance and recommended daily intake values are available for most of the metals identified as essential nutrients (USACE, 2005).

For the RI field effort, analyses were conducted for calcium and magnesium to be used for geochemical analysis should one have been considered necessary. These two constituents were eliminated as SRCs in the environmental media since they are not considered MC associated with the Firestone Test Facility MRS. Iron is identified as an MC associated with the shaped charge historically tested at the MRS and; therefore, is not eliminated as an essential nutrient.

4.2.1.4 Data Presentation

Data use summary statistics and screening results for SRCs in the surface soil, sediment, and surface water samples collected at the Firestone Test Facility MRS are presented in the following sections. Designation of the intended use of the samples for evaluation of fate and transport, human health risk, and ecological risk are presented in **Table 4-1**. A summary of the laboratory analytical results and identification of SRCs following the facility screening process for the surface soil, sediment, and surface water results are presented in **Table 4-2** through **Table 4-7**. The SRCs identified for Firestone Test Facility MRS are presented by sample location in **Figure 4-5**. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.2.1.5 Data Use Evaluation

Available sample data were evaluated to determine suitability for use in the various key RI data screens that include evaluation of nature and extent of SRCs, fate and transport, and human and ecological risk assessments. Evaluation of data suitability for use in this RI Report involved two primary considerations: (1) representativeness with respect to current MRS conditions, and (2) sample collection methods (i.e., discrete and ISM). A summary of

Table 4-1
Data Use Summary and Collection Rationale

Sample Location ID	Sample Date	Depth	Sample Type	Data Use Type	Rationale
Surface Soil					
FTFSS-004(I)-0001-SS	8/12/11	0–0.5 feet bgs	ISM	N&E, F&T, R	Collected to characterize for MC in surface soil area surrounding the pond where kick-out from testing activities may have occurred
Sediment					
FTFSD-002-SD	8/8/11	0–0.5 feet bss	D	N&E, F&T, R	Collected to characterize for MC in sediment at the northeast side of the pond that may have been impacted from testing activities
FTFSD-003-SD	8/8/11	0–0.5 feet bss	D	N&E, F&T, R	Collected to characterize for MC in sediment at the southwest side of the pond that may have been impacted from testing activities
Surface Water					
FTFSW-001-0001-SW	5/5/11	6–7 feet bws	D	N&E, F&T, R	• Initially collected to characterize the surface water for potential discharge to ground surface and evaluate health risk to divers if diving considered most appropriate option • Used to characterize for MC in surface water that may have been impacted from testing activities

bgs denotes below ground surface.

bss denotes below sediment surface.

bws denotes below water surface.

D denotes discrete.

F&T denotes fate and transport evaluation.

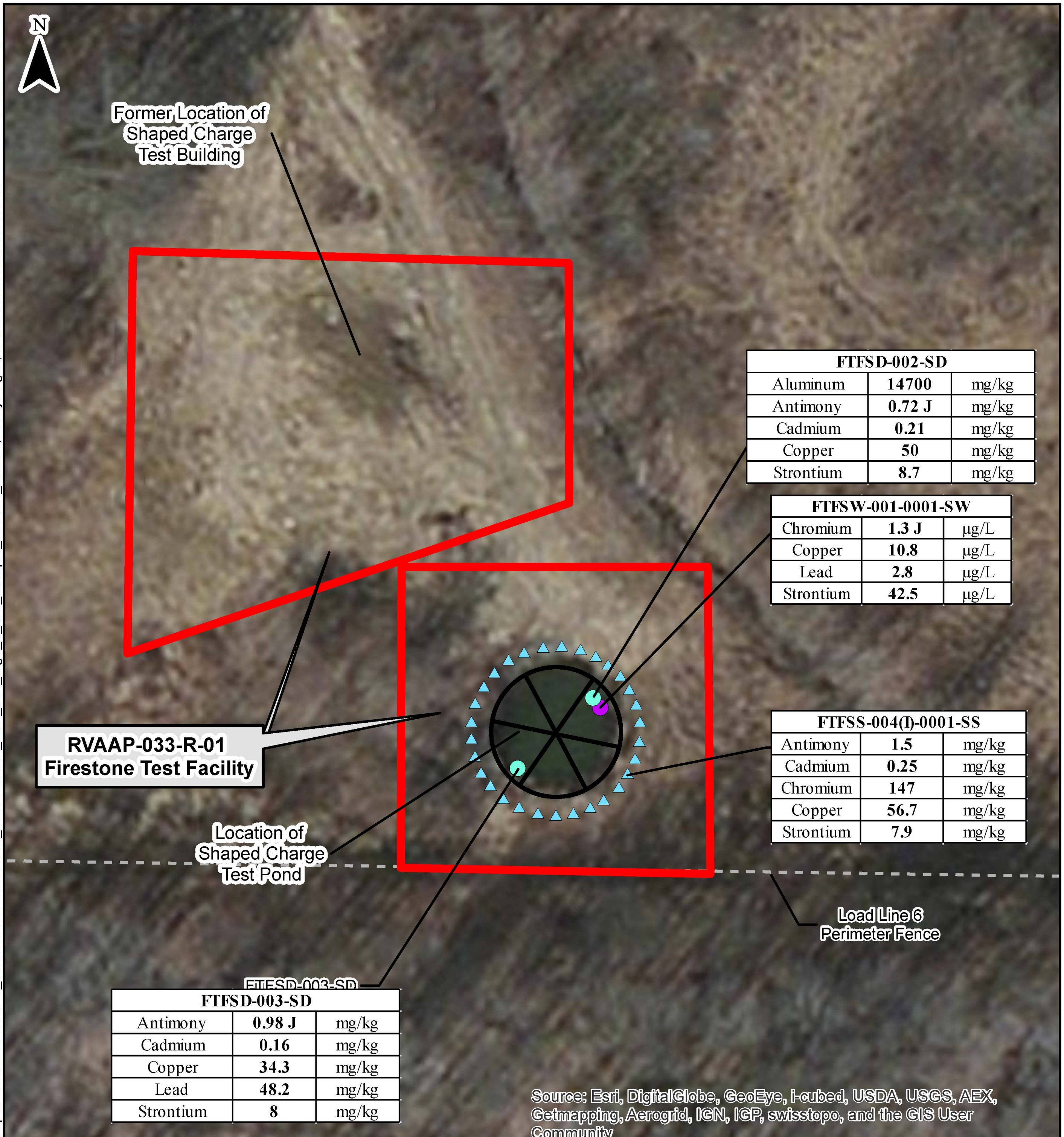
ID denotes identification.

ISM denotes incremental sampling methodology.

MC denotes munitions constituents.

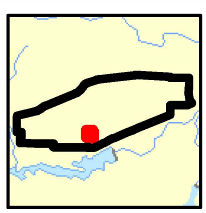
N&E denotes nature and extent evaluation.

R denotes risk assessment evaluation.



MRS Boundary
Dive Grid
Fence Line
Discrete Sediment Sample Location
Grab Surface Water Sample Location
Incremental Surface Soil Sample Location

Notes:
1) mg/kg denotes milligrams per kilogram
2) µg/L denotes micrograms per liter
3) "J" value denotes estimated concentration



0 40 80 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 4-5 SRC SAMPLE RESULTS

the samples collected at the Firestone Test Facility MRS and the intended use of the data sets is presented in **Table 4-1**.

4.3 Nature and Extent of SRCs

This section presents the nature and extent of SRCs within the data aggregates (surface soil, sediment, and surface water) evaluated for this RI Report.

4.3.1 Surface Soil

Data from the RI surface soil sample was screened to identify SRCs representing current conditions at the Firestone Test Facility MRS. The SRC screening data for surface soil (not including the field duplicate or QC samples) consisted of sample FTFSS-004(I)-0001-SS where increments for the ISM sample were collected at 0 to 0.5 feet bgs. The ISM sample was collected in the surface soil surrounding the former shaped charge test pond where MC may have been distributed as a result of historical detonations in the pond.

The ISM surface soil sample was submitted for laboratory analysis for explosives, nitrocellulose, metals, TOC, and pH. Metals analysis consists of the inorganic MCs that are attributed to the shaped charge munitions historically used at the MRS. For the Firestone Test Facility MRS, metals identified as MC consist of aluminum, antimony, barium, cadmium, chromium (total and Cr^{+6}), copper, iron, lead, strontium, mercury, and zinc.

The surface soil samples were also submitted for geochemical parameters that included calcium, magnesium and manganese for the rationale discussed in Section 4.2.1.3, “Data Reduction and Screening.” However, since a geochemical analysis was not performed for the MRS, the geochemical parameters are not evaluated further.

Table 4-2 presents a summary of the ISM surface soil results. **Table 4-3** presents the results of the SRC screening for the ISM surface soil sample results. **Figure 4-5** presents the distribution of SRCs in the ISM surface soil sample location at the Firestone Test Facility MRS. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.3.1.1 Explosives and Propellants

No concentrations of explosives or propellants were detected in the ISM surface sample collected around the former shaped charge test pond at the Firestone Test Facility MRS.

4.3.1.2 Metals

Eleven of the 12 metals considered as MC associated with the shaped charges were detected at the ISM surface soil sample collected around the former test pond. Antimony, chromium and copper were the only metals that exceeded the BSVs. Since the analysis results for Cr^{+6}

Table 4-2
Summary of Surface Soil Results

Detected Analyte	Units	Location ID:	FTFSS-004	
		Sample ID:	FTFSS-004(I)-0001-SS	
		Sample Date:	8/12/11	
		Depth (feet bgs):	0–0.5	
		BSV[1]	Result	VQ
Explosives				
1,3,5-Trinitrobenzene	mg/kg	*NA*	<0.25	U
1,3-Dinitrobenzene	mg/kg	*NA*	<0.2	U
2,4,6-Trinitrotoluene	mg/kg	*NA*	<0.2	U
2,4-Dinitrotoluene	mg/kg	*NA*	<0.25	U
2,6-Dinitrotoluene	mg/kg	*NA*	<0.25	U
2-Amino-4,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U
3,5-Dinitroaniline	mg/kg	*NA*	<0.2	U
4-Amino-2,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U
HMX	mg/kg	*NA*	<0.2	U
m-Nitrotoluene	mg/kg	*NA*	<0.2	U
Nitrobenzene	mg/kg	*NA*	<0.2	U
Nitroglycerin	mg/kg	*NA*	<1	U
Nitroguanidine	mg/kg	*NA*	<0.125	U
o-Nitrotoluene	mg/kg	*NA*	<0.25	U
PETN	mg/kg	*NA*	<1	U
p-Nitrotoluene	mg/kg	*NA*	<0.2	U
RDX	mg/kg	*NA*	<0.25	U
Tetryl	mg/kg	*NA*	<0.2	U
Metals				
Aluminum	mg/kg	*17,700*	9,630	
Antimony	mg/kg	*0.96*	**1.5**	
Barium	mg/kg	*88.4*	87.6	
Cadmium	mg/kg	*0*	**0.25**	
Calcium	mg/kg	*15,800*	1,860	
Chromium (as Cr^{+3})	mg/kg	*17.4*	**147**	**J**
Copper	mg/kg	*10.4*	**56.7**	**J**

Table 4-2 (continued)
Summary of Surface Soil Results

Detected Analyte	Units	Location ID:	FTFSS-004	
		Sample ID:	**FTFSS-004(I)-0001-SS**	
		Sample Date:	**8/12/11**	
		Depth (feet bgs):	**0–0.5**	
		BSV[1]	**Result**	**VQ**
Iron	mg/kg	*23,100*	17,900	J
Lead	mg/kg	*26.1*	20.4	
Magnesium	mg/kg	*3,030*	1,680	
Manganese	mg/kg	*1,450*	1,300	J
Mercury	mg/kg	*0.036*	0.033	
Strontium	mg/kg	*0*	**7.9**	
Zinc	mg/kg	*61.8*	50.4	J
General Chemistry				
Nitrocellulose	mg/kg	*NA*	<50	U
Hexavalent Chromium	mg/kg	*NA*	<5.0	U
Total Organic Carbon	mg/kg	*NA*	19,000	
pH	pH Units	*NA*	6.43	

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

For metals, bold numbering indicates concentration is greater than the RVAAP background value. For organics, bold numbering indicates a detected value.

< denotes less than.

bgs denotes below ground surface.

BSV denotes background screening value.

ID denotes identification.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes that a BSV is not available.

U denotes result is not detected or the concentration is below the detection limit.

UJ denotes not detected. The detection limits and quantitation limits are approximate.

VQ denotes validation qualifier.

Table 4-3
SRC Screening Summary for Surface Soil

Detected Analyte	CAS Number	BSV[1]	Result (mg/kg)	VQ	SRC?	SRC Justification
		Location ID:	FTFSS-004			
		Sample ID:	FTFSS-004(I)-0001-SS			
		Sample Date:	8/11/11			
		Depth (feet bgs):	0–0.5			
Metals						
Aluminum	7429-90-5	*17,700*	9,630		No	Below BSV
Antimony	7440-36-0	*0.96*	1.5		Yes	Above BSV
Barium	7440-39-3	*88.4*	87.6		No	Below BSV
Cadmium	7440-43-9	*0*	0.25		Yes	No BSV
Chromium (as Cr^{+3})	7440-47-3	*17.4*	147	J	Yes	Above BSV
Copper	7440-50-6	*17.7*	56.7	J	Yes	Above BSV
Iron	7439-89-6	*23,100*	17,900	J	No	Below BSV
Lead	7439-92-1	*26.1*	20.4		No	Below BSV
Mercury	7439-97-6	*0.036*	0.033		No	Below BSV
Strontium	7440-24-6	*0*	7.9		Yes	No BSV
Zinc	7440-36-0	*61.8*	50.4	J	No	Below BSV

[1] Background values taken from the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

bgs denotes below ground surface.

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

Cr^{+3} denotes trivalent chromium.

ID denotes identification.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

were not detected, the chromium results in surface soil are assumed to consist nearly entirely in its trivalent (Cr^{+3}) form and is compared to the trivalent screening values in the FWCUG Guidance (SAIC, 2010). Cadmium and strontium were detected and were retained as SRCs, since no facility BSV is available for either metal.

4.3.2 Sediment

Data from the RI sediment samples were screened to identify SRCs representing current conditions at the Firestone Test Facility MRS. The SRC screening data for sediment included evaluation of the samples FTFSD-002-SD and FTFSD-003-SD that were collected at 0 to 0.5 feet at discrete sample locations beneath the sediment surface.

The sediment samples collected during the RI sampling event were submitted for laboratory analysis for explosives, nitrocellulose, metals, and TOC. Metals analysis consists of the inorganic MCs that are attributed to the shaped charge munitions historically used at the MRS. For the Firestone Test Facility MRS, the metals identified as SRCs consist of aluminum, antimony, barium, cadmium, chromium (total and Cr^{+6}), copper, iron, lead, strontium, mercury, and zinc.

The sediment samples were also submitted for geochemical parameters that included calcium, magnesium, and manganese for the rationale discussed in Section 4.2.1.3. However, since a geochemical analysis was not performed for the MRS, the geochemical parameters are not evaluated further.

Table 4-4 presents a summary of the discrete sediment sample results. **Table 4-5** presents the results of the SRC screening for the discrete sediment sample results. **Figure 4-5** presents the distribution of SRCs in the sediment sample locations at the Firestone Test Facility MRS. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.3.2.1 Explosives and Propellants

No concentrations of explosives or propellants were detected in the sediment samples collected from the former shaped charge test pond at the Firestone Test Facility MRS.

4.3.2.2 Metals

Eleven of the 12 metals considered as MC associated with shaped charges were detected in each of the two sediment samples collected from the former test pond. Aluminum and copper exceeded the BSVs in sediment sample FTFSD-002-SD and copper and lead exceeded the BSV in sediment sample FTFSD-003-SD. Antimony, cadmium, and strontium were retained as SRCs in both samples, since there are no sediment BSVs available for these metals.

Table 4-4
Summary of Sediment Results

Detected Analyte	Units	Location ID:	FTFSD-002		FTFSD-003	
		Sample ID:	FTFSD-002-SD		FTFSD-003-SD	
		Sample Date:	8/8/2011		8/8/2011	
		Depth (feet bss):	0–0.5		0–0.5	
		BSV[1]	Result	VQ	Result	VQ
Explosives						
1,3,5-Trinitrobenzene	mg/kg	NA	<0.25	U	<0.25	U
1,3-Dinitrobenzene	mg/kg	NA	<0.2	UJ	<0.2	U
2,4,6-Trinitrotoluene	mg/kg	NA	<0.2	U	<0.2	U
2,4-Dinitrotoluene	mg/kg	NA	<0.25	U	<0.25	U
2,6-Dinitrotoluene	mg/kg	NA	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	mg/kg	NA	<0.2	U	<0.2	U
3,5-Dinitroaniline	mg/kg	NA	<0.2	U	<0.2	U
4-Amino-2,6-Dinitrotoluene	mg/kg	NA	<0.2	UJ	<0.2	U
HMX	mg/kg	NA	<0.2	U	<0.2	U
m-Nitrotoluene	mg/kg	NA	<0.2	UJ	<0.2	U
Nitrobenzene	mg/kg	NA	<0.2	U	<0.2	U
Nitroglycerin	mg/kg	NA	<1	U	<1	U
Nitroguanidine	mg/kg	NA	<0.125	U	<0.125	U
o-Nitrotoluene	mg/kg	NA	<0.25	U	<0.25	U
PETN	mg/kg	NA	<1	U	<1	U
p-Nitrotoluene	mg/kg	NA	<0.2	U	<0.2	U
RDX	mg/kg	NA	<0.25	UJ	<0.25	U
Tetryl	mg/kg	NA	<0.2	U	<0.2	U
Metals						
Aluminum	mg/kg	13,900	**14,700**		12,600	
Antimony	mg/kg	0	**0.72**	**J**	**0.98**	**J**
Barium	mg/kg	123	65.6		60.9	
Cadmium	mg/kg	0	**0.21**		**0.16**	
Calcium	mg/kg	*5,510*	1,620		1,750	
Chromium (as Cr^{+3})	mg/kg	18.1	18		15.2	
Copper	mg/kg	27.6	**50**		**34.3**	
Iron	mg/kg	28,200	23,700		18,100	
Lead	mg/kg	27.4	24.3		**48.2**	

Table 4-4 (continued)
Summary of Sediment Results

Detected Analyte	Units	Location ID:	FTFSD-002		FTFSD-003	
		Sample ID:	FTFSD-002-SD		FTFSD-003-SD	
		Sample Date:	8/8/2011		8/8/2011	
		Depth (feet bss):	0–0.5		0–0.5	
		BSV[1]	Result	VQ	Result	VQ
Magnesium	mg/kg	*2,760*	2,720		2,160	
Manganese	mg/kg	*1,950*	232		217	
Mercury	mg/kg	0.059	0.033		0.029	
Strontium	mg/kg	0	**8.7**		**8.0**	
Zinc	mg/kg	532	47.2		39.8	
General Chemistry						
Nitrocellulose	mg/kg	NA	<50	U	<50	U
Hexavalent Chromium	mg/kg	NA	<7.2	U	<7	U
Total Organic Carbon	mg/kg	NA	2,100		6,100	

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

For metals, bold numbering indicates concentration is greater than the facility background value. For organics, bold numbering indicates a detected value.

< denotes less than.

bgs denotes below ground surface.

bss denotes below sediment surface.

BSV denotes background screening value.

Cr^{+3} denotes trivalent chromium.

ID denotes identification.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes that a BSV is not available.

U denotes result is not detected or the concentration is below the detection limit.

UJ denotes not detected. The detection limits and quantitation limits are approximate.

VQ denotes validation qualifier.

Table 4-5
SRC Screening Summary for Sediment

Analyte	CAS Number	Frequency of Detection	Minimum Detect Result (mg/kg)	Minimum Detect VQ	Maximum Detect Result (mg/kg)	Maximum Detect VQ	Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
Metals										
Aluminum	7429-90-5	2/2	12,600		14,700		13,650	13,900	Yes	Above BSV
Antimony	7440-36-0	2/2	0.72	J	0.98	J	0.85	0	Yes	No BSV
Barium	7440-39-3	2/2	60.9		65.6		63.25	123	No	Below BSV
Cadmium	7440-43-9	2/2	0.16		0.21		0.185	0	Yes	No BSV
Chromium (as Cr^{+3})	7440-47-3	2/2	15.2		18		16.6	18.1	No	Below BSV
Copper	7440-50-6	2/2	34.3		50		42.15	27.6	Yes	Above BSV
Iron	7439-89-6	2/2	18,100		23,700		20,900	28,200	No	Below BSV
Lead	7439-92-1	2/2	24.3		48.2		36.25	27.4	Yes	Above BSV
Mercury	7439-97-6	2/2	0.029		0.033		0.031	0.059	No	Below BSV
Strontium	7440-24-6	2/2	8.0		8.7		8.35	0	Yes	No BSV
Zinc	7440-36-0	2/2	39.8		47.2		43.5	532	No	Below BSV

[1] Background values taken from the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

Cr+3 denotes trivalent chromium.

J denotes that the result is reported as an estimated value.

mg/kg denotes milligrams per kilogram.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

4.3.3 Surface Water

Data from the RI surface water sample were screened to identify SRCs representing current conditions at the former test pond at the Firestone Test Facility MRS. The SRC screening data for surface water included sample FTFSW-001-0001-SW that was collected at 6 to 7 feet below the water surface; the approximate center depth of the pond.

The surface water sample was collected on the northeast side of the former test pond and was submitted for laboratory analysis for explosives, nitrocellulose, metals, PCBs, pesticides, SVOCs, and VOCs. Metals analysis consisted of aluminum, cadmium, copper, total chromium, iron, lead, zinc, antimony, barium, and mercury that are considered MC attributed to the shaped charges historically used at the MRS.

Table 4-6 presents a summary of the surface water results. **Table 4-7** presents the results of the SRC screening for the surface water results. **Figure 4-5** presents the distribution of SRCs in the former test pond at the Firestone Test Facility MRS. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix D**.

4.3.3.1 Explosives and Propellants

No concentrations of explosives or propellants were detected in the surface water sample collected from the former shaped charge test pond at the Firestone Test Facility MRS.

4.3.3.2 Metals

The detected concentrations for aluminum, barium, calcium, iron, magnesium, manganese, and zinc were all below their respective BSVs and were not evaluated further. No BSVs are available for chromium, lead and strontium; therefore, these metals were automatically retained as SRCs. The surface water sample was not analyzed for Cr^{+6}; therefore, the result for chromium in the surface water sample is considered to be a total concentration for the Cr^{+3} and Cr^{+6} forms. The copper result exceeded the BSV and was retained as an SRC.

4.3.3.3 Pesticides and PCBs

One pesticide (4,4'-DDT) was detected in the surface water sample. Pesticides are not considered to be MC associated with historical munitions activities at this MRS and; therefore, the detected pesticide concentration was not retained as an SRC requiring further consideration under the MMRP. No concentrations of PCBs or other pesticides were detected in the surface water sample.

Table 4-6
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	Result	VQ
Explosives				
1,3,5-Trinitrobenzene	µg/L	*NA*	<1	U
1,3-Dinitrobenzene	µg/L	*NA*	<0.4	U
2,4,6-Trinitrotoluene	µg/L	*NA*	<0.5	U
2,4-Dinitrotoluene	µg/L	*NA*	<1	U
2,6-Dinitrotoluene	µg/L	*NA*	<0.5	U
2-Amino-4,6-Dinitrotoluene	µg/L	*NA*	<0.5	U
3,5-Dinitroaniline	µg/L	*NA*	<0.5	U
4-Amino-2,6-Dinitrotoluene	µg/L	*NA*	<0.5	U
HMX	µg/L	*NA*	<0.5	U
m-Nitrotoluene	µg/L	*NA*	<0.4	U
Nitrobenzene	µg/L	*NA*	<0.4	U
Nitroglycerin	µg/L	*NA*	<4	U
Nitroguanidine	µg/L	*NA*	<50	U
o-Nitrotoluene	µg/L	*NA*	<0.5	U
PETN	µg/L	*NA*	<6	U
p-Nitrotoluene	µg/L	*NA*	<0.5	U
RDX	µg/L	*NA*	<0.4	U
Tetryl	µg/L	*NA*	<.5	U
Metals				
Aluminum	µg/L	*3,370*	639	
Antimony	µg/L	*0*	<16	U
Barium	µg/L	*47.5*	15.5	
Cadmium	µg/L	*0*	0.8	U
Calcium	µg/L	*41,400*	22,700	
Chromium	µg/L	*0*	**1.3**	**J**
Copper	µg/L	*7.9*	**10.8**	
Iron	µg/L	*2,560*	1,670	
Lead	µg/L	*0*	**2.8**	**J**
Magnesium	µg/L	*10,800*	3,710	

Table 4-6 (continued)
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	Result	VQ
Manganese	μg/L	*391*	312	
Mercury	μg/L	*0*	<0.06	U
Strontium	μg/L	*0*	**42.5**	
Zinc	μg/L	*42*	6.2	J
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	μg/L	*NA*	<0.5	U
1,2-Dichlorobenzene	μg/L	*NA*	<0.5	U
1,3-Dichlorobenzene	μg/L	*NA*	<0.5	U
1,4-Dichlorobenzene	μg/L	*NA*	<0.5	U
2,4,5-Trichlorophenol	μg/L	*NA*	<2.6	U
2,4,6-Trichlorophenol	μg/L	*NA*	<2.6	U
2,4-Dichlorophenol	μg/L	*NA*	<2.6	U
2,4-Dimethylphenol	μg/L	*NA*	<2.6	U
2,4-Dinitrophenol	μg/L	*NA*	<2.6	U
2-Chloronaphthalene	μg/L	*NA*	<0.5	U
2-Chlorophenol	μg/L	*NA*	<2.6	U
2-Methylnaphthalene	μg/L	*NA*	<0.5	U
2-Nitroaniline	μg/L	*NA*	<0.5	U
2-Nitrophenol	μg/L	*NA*	<2.6	U
3,3'-Dichlorobenzidine	μg/L	*NA*	<1.6	U
3-Nitroaniline	μg/L	*NA*	<0.5	U
4,6-Dinitro-2-Methylphenol	μg/L	*NA*	<3.1	U
4-Bromophenyl Phenyl Ether	μg/L	*NA*	<0.5	U
4-Chloro-3-Methylphenol	μg/L	*NA*	<2.6	U
4-Chloroaniline	μg/L	*NA*	<0.5	U
4-Chlorophenyl Phenyl Ether	μg/L	*NA*	<0.5	U
4-Nitrobenzenamine	μg/L	*NA*	<0.5	U
4-Nitrophenol	μg/L	*NA*	<2.6	U
Acenaphthene	μg/L	*NA*	<0.5	U
Acenaphthylene	μg/L	*NA*	<0.5	U

Table 4-6 (continued)
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	**Result**	**VQ**
Anthracene	µg/L	*NA*	<0.5	U
Benzo(a)anthracene	µg/L	*NA*	<0.5	U
Benzo(a)pyrene	µg/L	*NA*	<0.5	U
Benzo(b)fluoranthene	µg/L	*NA*	<0.5	U
Benzo(ghi)perylene	µg/L	*NA*	<0.5	U
Benzo(k)fluoranthene	µg/L	*NA*	<0.5	U
Benzoic Acid	µg/L	*NA*	<26	U
Benzyl Alcohol	µg/L	*NA*	<1.55	U
Bis(2-Chloroethoxy)methane	µg/L	*NA*	<0.5	U
Bis(2-Chloroethyl)ether	µg/L	*NA*	<0.5	U
Bis(2-Chloroisopropyl)ether	µg/L	*NA*	<0.5	U
Bis(2-Ethylhexyl)phthalate	µg/L	*NA*	<1.55	U
Butyl Benzyl Phthalate	µg/L	*NA*	<1.55	U
Carbazole	µg/L	*NA*	<0.5	U
Chrysene	µg/L	*NA*	<0.5	U
Cresols (Total)	µg/L	*NA*	<4.65	U
Dibenzo(a,h)anthracene	µg/L	*NA*	<0.5	U
Dibenzofuran	µg/L	*NA*	<0.5	U
Diethyl Phthalate	µg/L	*NA*	<1.55	U
Dimethyl Phthalate	µg/L	*NA*	<1.55	U
Di-n-Butyl Phthalate	µg/L	*NA*	**0.75**	**J**
Di-n-Octyl Phthalate	µg/L	*NA*	<1.55	U
Fluoranthene	µg/L	*NA*	<0.5	U
Fluorene	µg/L	*NA*	<0.5	U
Hexachlorobenzene	µg/L	*NA*	<0.5	U
Hexachlorobutadiene	µg/L	*NA*	<0.5	U
Hexachlorocyclopentadiene	µg/L	*NA*	<0.5	U
Hexachloroethane	µg/L	*NA*	<0.5	U
Indeno(1,2,3-cd)pyrene	µg/L	*NA*	<0.5	U
Isophorone	µg/L	*NA*	<0.5	U

Table 4-6 (continued)
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	Result	VQ
Naphthalene	µg/L	*NA*	<0.5	U
N-Nitroso-di-n-Propylamine	µg/L	*NA*	<0.5	U
N-Nitrosodiphenylamine	µg/L	*NA*	<1.05	U
o-Cresol	µg/L	*NA*	<2.6	U
Phenanthrene	µg/L	*NA*	<0.5	U
Pyrene	µg/L	*NA*	<0.5	U
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	µg/L	*NA*	<0.5	U
1,1,1-Trichloroethane	µg/L	*NA*	<0.5	U
1,1,2,2-Tetrachloroethane	µg/L	*NA*	<0.5	U
1,1,2-Trichloroethane	µg/L	*NA*	<0.5	U
1,1-Dichloroethane	µg/L	*NA*	<0.5	U
1,1-Dichloroethene	µg/L	*NA*	<0.5	U
1,1-Dichloropropene	µg/L	*NA*	<0.5	U
1,2,3-Trichlorobenzene	µg/L	*NA*	<0.5	U
1,2,3-Trichloropropane	µg/L	*NA*	<0.5	U
1,2,4-Trichlorobenzene	µg/L	*NA*	<0.5	U
1,2,4-Trimethylbenzene	µg/L	*NA*	<0.5	U
1,2-Dibromo-3-chloropropane	µg/L	*NA*	<0.5	U
1,2-Dibromoethane	µg/L	*NA*	<0.5	U
1,2-Dichlorobenzene	µg/L	*NA*	<0.5	U
1,2-Dichloroethane	µg/L	*NA*	<0.5	U
1,2-Dichloropropane	µg/L	*NA*	<0.5	U
1,3,5-Trimethylbenzene	µg/L	*NA*	<0.5	U
1,3-Dichlorobenzene	µg/L	*NA*	<0.5	U
1,3-Dichloropropane	µg/L	*NA*	<0.5	U
1,4-Dichlorobenzene	µg/L	*NA*	0.5	U
2,2-Dichloropropane	µg/L	*NA*	<0.5	U
2-Butanone	µg/L	*NA*	<5	U
2-Chlorotoluene	µg/L	*NA*	<0.5	U

Table 4-6 (continued)
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	Result	VQ
2-Hexanone	µg/L	*NA*	<5	U
4-Chlorotoluene	µg/L	*NA*	<0.5	U
4-Methyl-2-pentanone	µg/L	*NA*	<5	U
Acetone	µg/L	*NA*	<5	U
Benzene	µg/L	*NA*	<0.5	U
Bromobenzene	µg/L	*NA*	<0.5	U
Bromochloromethane	µg/L	*NA*	<0.5	U
Bromodichloromethane	µg/L	*NA*	<0.5	U
Bromoform	µg/L	*NA*	<0.5	U
Bromomethane	µg/L	*NA*	<0.5	U
Carbon disulfide	µg/L	*NA*	<0.5	U
Carbon tetrachloride	µg/L	*NA*	<0.5	U
Chlorobenzene	µg/L	*NA*	<0.5	U
Chloroethane	µg/L	*NA*	<0.5	U
Chloroform	µg/L	*NA*	<0.5	U
Chloromethane	µg/L	*NA*	<1	U
cis-1,2-Dichloroethene	µg/L	*NA*	<0.5	U
cis-1,3-Dichloropropene	µg/L	*NA*	<0.5	U
Dibromochloromethane	µg/L	*NA*	<0.5	U
Dibromomethane	µg/L	*NA*	<0.5	U
Dichlorodifluoromethane	µg/L	*NA*	<0.5	U
Ethylbenzene	µg/L	*NA*	<0.5	U
Freon 113	µg/L	*NA*	<1	U
Hexachlorobutadiene	µg/L	*NA*	<0.5	U
Iodomethane	µg/L	*NA*	<0.5	U
Isopropylbenzene	µg/L	*NA*	<0.4	U
m,p-Xylenes	µg/L	*NA*	<1	U
Methylene chloride	µg/L	*NA*	<0.5	U
Naphthalene	µg/L	*NA*	<0.5	U
n-Butylbenzene	µg/L	*NA*	<0.5	U

Table 4-6 (continued)
Summary of Surface Water Results

		Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
Detected Analyte	**Units**	**BSV[1]**	**Result**	**VQ**
n-Propylbenzene	µg/L	*NA*	<0.5	U
o-Xylene	µg/L	*NA*	<0.5	U
p-Isopropyltoluene	µg/L	*NA*	<0.5	U
sec-Butylbenzene	µg/L	*NA*	<0.5	U
Styrene	µg/L	*NA*	<0.5	U
tert-Butylbenzene	µg/L	*NA*	<0.5	U
Tetrachloroethene	µg/L	*NA*	<0.5	U
Toluene	µg/L	*NA*	<0.5	U
trans-1,2-Dichloroethene	µg/L	*NA*	<0.5	U
trans-1,3-Dichloropropene	µg/L	*NA*	<0.5	U
Trichloroethene	µg/L	*NA*	<0.5	U
Trichlorofluoromethane	µg/L	*NA*	<0.5	U
Vinyl chloride	µg/L	*NA*	<0.5	U
Pesticides				
4,4'-DDD	µg/L	*NA*	<0.0125	U
4,4'-DDE	µg/L	*NA*	<0.0125	U
4,4'-DDT	µg/L	*NA*	**0.018**	**J**
Aldrin	µg/L	*NA*	<0.0125	U
alpha-BHC	µg/L	*NA*	<0.0125	U
alpha-Chlordane	µg/L	*NA*	<0.021	U
beta-BHC	µg/L	*NA*	<0.021	U
Chlordane	µg/L	*NA*	<0.315	U
delta-BHC	µg/L	*NA*	<0.0125	U
Dieldrin	µg/L	*NA*	<0.0125	U
Endosulfan I	µg/L	*NA*	<0.021	U
Endosulfan II	µg/L	*NA*	<0.0125	U
Endosulfan sulfate	µg/L	*NA*	<0.0125	U
Endrin	µg/L	*NA*	<0.0125	U
Endrin aldehyde	µg/L	*NA*	<0.021	U
Endrin ketone	µg/L	*NA*	<0.0125	U

Table 4-6 (continued)
Summary of Surface Water Results

Detected Analyte	Units	Location ID:	FTFSW-001	
		Sample ID:	FTFSW-001-0001-SW	
		Sample Date:	5/5/2011	
		BSV[1]	Result	VQ
gamma-Chlordane	µg/L	*NA*	<0.0125	U
Heptachlor	µg/L	*NA*	<0.0125	U
Heptachlor epoxide	µg/L	*NA*	<0.0125	U
Lindane	µg/L	*NA*	<0.0125	U
Methoxychlor	µg/L	*NA*	<0.021	U
Toxaphene	µg/L	*NA*	<0.315	U
Polychlorinated Biphenyls				
Aroclor 1221	µg/L	*NA*	<0.5	U
Aroclor 1248	µg/L	*NA*	<0.5	U
Aroclor 1254	µg/L	*NA*	<0.5	U
Aroclor 1242	µg/L	*NA*	<0.5	U
Aroclor 1260	µg/L	*NA*	<0.5	U
Aroclor 1016	µg/L	*NA*	<0.5	U
Aroclor 1232	µg/L	*NA*	<0.5	U
General Chemistry				
Nitrocellulose	mg/L	*NA*	<1.6	U

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

For metals, bold numbering indicates concentration is greater than the facility background value. For organics, bold numbering indicates a detected value.

< denotes less than.

µg/L denotes micrograms per liter.

BSV denotes background screening value.

ID denotes identification.

J denotes that the result is reported as an estimated value.

mg/L denotes milligrams per liters.

NA denotes that a BSV is not available.

U denotes result is not detected or the concentration is below the detection limit.

VQ denotes validation qualifier.

Table 4-7
SRC Screening Summary for Surface Water

		Location ID:	FTFSW-001			
		Sample ID:	FTFSW-001-0001-SW			
		Sample Date:	5/5/2011			
Detected Analyte	**CAS Number**	**BSV[1]**	**Result (µg/L)**	**VQ**	**SRC?**	**SRC Justification**
Metals						
Aluminum	7429-90-5	3,370	639		No	Below BSV
Barium	7440-39-3	47.5	15.5		No	Below BSV
Chromium (total)	7440-47-3	0	**1.3**	**J**	Yes	No BSV
Copper	7440-50-6	7.9	**10.8**		Yes	Above BSV
Iron	7439-89-6	2,560	1,670		No	Below BSV
Lead	7439-92-1	0	**2.8**	**J**	Yes	No BSV
Strontium	7440-24-6	0	**42.5**		Yes	No BSV
Zinc	7440-36-0	42	6.2	J	No	Below BSV
Pesticides						
4,4'-DDT	50-29-3	NA	**0.018**	**J**	No	Not an MC
Semivolatile Organic Compounds						
Di-n-butyl phthalate	84-74-2	NA	**0.75**	**J**	No	Not an MC

[1] Background values taken from the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).

Bold numbering indicates concentration is greater than the facility background value for metals.

µg/L denotes micrograms per liter.

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

ID denotes identification.

J denotes that the result is reported as an estimated value.

MC denotes munitions constituents.

NA denotes not applicable.

SRC denotes site-related chemical.

VQ denotes validation qualifier.

4.3.3.4 VOCs and SVOCs

One SVOC (di-n-butyl phthalate) was detected in the surface water sample. SVOCs are not considered to be MC associated with historical munitions activities at this MRS and; therefore, the detected SVOC concentration was not retained as an SRC requiring further consideration under the MMRP. No concentrations of VOCs or other SVOCs were detected in the surface water sample.

4.3.4 Summary of Nature and Extent of SRCs

This section presents a summary and nature and extent of the SRCs identified in the surface soil, sediment, and surface water media at the Firestone Test Facility MRS following the facility data screening process. The SRCs identified in any of the environmental media samples collected during the RI field activities at the MRS consisted of elevated concentrations of metals only, in particular lead, copper, and strontium, which were identified as SRCs in all three of the media. The specific SRCs in each of the environmental media are presented in the following sections.

4.3.4.1 Surface Soil

The SRCs identified in the ISM surface soil sample collected around the former test pond consist of metals only. The metals identified through the facility data screening process were antimony, chromium, copper, cadmium, and strontium. Since the analysis results for Cr^{+6} were not detected, the chromium results in surface soil are assumed to consist nearly entirely in its Cr^{+3} form.

4.3.4.2 Sediment

The SRCs identified in the two discrete sediment samples collected from within the former test pond consist of metals only. The metals identified through the facility data screening process were aluminum, antimony, cadmium, copper, lead, and strontium.

4.3.4.3 Surface Water

The SRCs identified in the surface water sample collected at the former test pond consist of metals only. The metals identified through the facility data screening process were chromium, copper, lead, and strontium. The surface water sample was not analyzed for Cr^{+6}; therefore, the results for chromium in the surface water sample are considered to be a total chromium concentration that combines the Cr^{+3} and Cr^{+6} forms.

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5.0 FATE AND TRANSPORT

This section describes the fate of contaminants in the environment and potential transport mechanisms. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to migration mechanisms away from the source area. Section 5.1 and Section 5.2 discuss fate and transport associated with MEC and MC at the MRS, respectively.

5.1 Fate and Transport of MEC

Transport of MEC at a MRS is dependent on many factors, including precipitation, soil erosion and freeze/thaw events. These natural processes, in addition to human activity, may result in some movement (primarily vertical movement) of MEC if present at the MRS. The result of these mechanisms and processes is a potentially different distribution of MEC than the one that may have existed at the time of original release. In addition, MEC items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment. No MEC or MD was found at the MRS during the SI and/or RI field activities; therefore, an explosive safety hazard is not present at the MRS. A discussion on the fate and transport of MEC at the MRS is determined to be unwarranted for the MRS.

5.2 Fate and Transport of MC

An ISM surface soil sample was collected during the RI at the Firestone Test Facility MRS for potential MC at a location determined in the field to be the most likely release area as a result of previous activities at the MRS. Discrete sediment samples were collected from the sidewalls of the former test pond to characterize the absence or presence of MC associated with the previous testing activities in the pond. A surface water sample was collected to evaluate if the pond water could be discharged to ground surface or was acceptable for manual diving operations but was also used to evaluate for the presence of MC in the pond. Although a MEC source was not identified at the Firestone Test Facility MRS during the RI field activities, the detected analytes are conservatively evaluated as SRCs associated with historical shaped charge testing activities at the MRS and a discussion of the fate and transport and potential transport mechanisms is presented herein.

The release of MC is a process unique to the military. The sources and magnitude are distinctly different from the release of chemicals from industrial processes typically investigated under the IRP (Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program, 2012). Once an MC released from MEC enters an environmental medium, the fate and transport of MC are dependent on a wide variety of factors. Migration pathways often include air, water, soil, and the interfaces between the phases of the contaminant (i.e., solid, liquid, or gas). The fate and transport of MC occurs in all three environments: (1) terrestrial, (2) aquatic, and (3) atmospheric. Terrestrial environments are comprised of soil and groundwater, aquatic environments are comprised of surface water and sediment, and air is the only component of the atmospheric environment.

The fate and transport of MC at the Firestone Test Facility MRS are strongly influenced by physical and chemical properties, as well as by environmental factors such as soil characteristics and groundwater flow. Depending upon the specific contaminant and soil conditions, MC may migrate from surface soil to subsurface soil, stream/wetland sediments or surface water. MC may also migrate from each of the aforementioned media to the air. The propensity for MC to attain equilibrium conditions in the environment and migrate from one medium to another is an important factor in determining the mobility of MC.

In the terrestrial environment, if the MC is released to soil, it may volatilize, adhere to the soil by sorption, leach into the surface water bodies or groundwater, or degrade because of chemical (abiotic) or biological (biotic) processes. If the MC is volatilized, the compound may be released to the atmosphere. MCs that are dissolved eventually may be transported to an aquatic environment.

Once an MC is released to the aquatic environment, it can either volatilize or remain in the aquatic environment. In the aquatic environment, MC may be dissolved in the surface water or sorbed to the sediment. The MC may move between dissolved and sorbed states depending on a variety of physical and chemical factors.

In the atmospheric environment, MC may exist as vapors or as particulate matter. The transport of MC relies mostly on wind currents and continues until the MC is returned to the earth by wet or dry deposition. Degradation of organic compounds in the atmosphere can occur due to direct photolysis, reaction with other chemicals, or reaction with photochemically generated hydroxyl radicals (Hemond and Fechner-Levy, 1999).

5.2.1 SRC Sources

This section presents a discussion of each of the SRCs in the environmental media at the Firestone Test Facility MRS. A summary of the SRCs identified in the data aggregates at the Firestone Test Facility MRS is as follows:

- **Surface Soil (0 to 0.5 feet bgs)—**antimony, cadmium, chromium, copper, and strontium
- **Sediment (0 to 0.5 feet below sediment surface [bss])—**aluminum, antimony, cadmium, copper, lead, and strontium

- **Surface Water—**chromium, copper, lead, and strontium

The metals analyzed for the MRS were agreed upon on in the Work Plan (Shaw, 2011) and were considered as MC associated with the shaped charge munitions. The physical and chemical properties and potential release mechanisms and routes of migration for each of the SRCs are discussed below.

- **Aluminum** is the most abundant metal in the earth's crust. It can also be released as a result to soil from mining wastes as well as solid wastes from coal combustion, aluminum reduction, and other metal processing operations (U.S. Department of the Interior [DOI], 1983; 1984). The fate and transport of aluminum is largely affected by the following factors: pH, salinity, and the presence of various species with which it may form complexes. In general, the monomeric forms of aluminum tend to increase in mobility as pH decreases. In addition, aluminum tends to absorb onto clay surfaces. Aluminum does not bioaccumulate to a significant extent (Agency for Toxic Substances and Disease Registry [ATSDR], 2008).

- **Antimony** has the ability to bind to soil and depends on the nature of the soil and the form of antimony. Some studies suggest that antimony is fairly mobile under diverse environmental conditions (Rai et al., 1984), while others suggest that it is strongly adsorbed to soil (Ainsworth, 1988; Foster, 1989; King, 1988). In aerobic surface soils, oxidation generally occurs (ATSDR, 1992). In water, antimony has the capability to undergo photochemical reactions. However, these reactions do not appear to have a significant effect on its aquatic fate (Callahan et al., 1979).

- **Cadmium** is naturally occurring in the earth's crust and the mobility of cadmium is strongly influenced by the soil pH and amount of organic matter. In general, cadmium tends to bind strongly to organic matter and can be taken up by plants. However, cadmium may leach into water under acidic conditions (Elinder, 1985; EPA, 1979). Cadmium is considered more mobile than other heavy metals in aquatic environments. Under varying ambient conditions of pH, salinity, and oxidation/reduction potential, cadmium may re-dissolve from sediments (Department of the Interior, 1985; EPA, 1979; Feijtel et al., 1988; Muntau and Baudo, 1992). In addition, cadmium does not tend to form volatile compounds in the aquatic environment; therefore, partitioning from water into the atmosphere doesn't occur (EPA, 1979).

- **Chromium** exists in two valence states in the environment: Cr^{+3} or Cr^{+6}. Cr^{+3} is the most prevalent form of chromium in surface soil and is relatively insoluble. Typically, Cr^{+3} in an aqueous environment would be associated with particles, while Cr^{+6} would remain in solution. The valence state of chromium is dependent on the pH. Adsorption of Cr^{+3} will occur at slightly acidic pHs. Mobility of chromium is further inhibited and adsorption increased by soil with high clay content (EPA, 1998).

- **Copper** is strongly sorbed by soil particles (i.e., clays, metal oxides, and organic matter). Copper binds to soil much more strongly than other divalent cations, and the distribution of copper in the soil solution is less affected by pH than other metals (Gerritse and van Driel, 1984). The adsorption of copper generally increases with increasing pH. Like other heavy metals, the movement of copper in soil is also influenced by the permeability of the soil and the amount of clay, lime, and hydrous iron oxides present. These factors tend to attenuate the mobility of copper through adsorption and cation exchange. Volatilization of copper happens to a slight degree, but is insignificant relative to other processes that aid in the reduction of copper concentrations. It sorbs significantly to suspended organic materials and bed sediments, thus reducing its mobility. Much of copper discharged to waterways is in particulate matter and settles out, precipitates out, or adsorbs to organic matter, hydrous iron and manganese oxides, and clay in sediment or in the water column. A significant fraction of the copper is adsorbed within the first hour, and in most cases, equilibrium is obtained with 24 hours (Harrison and Bishop, 1984).

- **Lead** is a naturally occurring metal found in small amounts in the earth's crust and lead alloy is a primary component used in the manufacture of munitions. The most common form of lead found in nature is Pb^{+2}, although lead also exists to a lesser extent as Pb^{+4} and in the organic form with up to four lead-carbon bonds. Most lead deposited on surface soil is retained and eventually becomes mixed into the surface layer. The migration of lead in the subsurface environment is controlled by the solubility of lead complexes and adsorption to aquifer materials. Adsorption to soil greatly limits the mobility of lead in the environment. Lead may be immobilized by ion exchange with hydrous oxides or clays or by chelation with humic or fulvic acids in the soil (EPA, 1997). Adsorption of lead increases with increasing pH with most lead precipitating out at a pH greater than 6. Adsorption of lead also increases as the amount of total organic carbon in the soil increases, thereby decreasing its mobility (EPA, 1990).

- **Strontium** is a soft silver-white or yellowish metallic element that is highly reactive chemically and is found in great abundance in mineral compounds all over the earth. Strontium in its elemental form occurs naturally in many compartments of the environment, including rocks, soil, water, and air. Strontium compounds can move through the environment fairly easily, because many of the compounds are water soluble. Strontium is always present in air as dust, up to a certain level. Strontium concentrations in air are increased by human activities, such as coal and oil combustion. All strontium will eventually end up in soils or bottoms of surface waters, where they mix with strontium that is already present. Strontium can end up in water through soils and through weathering of rocks. Most of the strontium in water is dissolved, but some of it is suspended. Strontium in soil dissolves in water, so that it is likely to move deeper into the ground and enter the groundwater. A part of the strontium that is introduced by humans will not move into groundwater and can stay within the soil for decades (ATSDR, 2011).

5.2.2 Summary of Fate and Transport

The SRCs detected in the surface soil, sediment, and surface water media collected during the RI field activities are not associated with a current source, since no MEC or MD has been found to date at the MRS. However, since metals don't typically degrade over time, the SRCs may be associated with historical shaped charged testing activities performed at the MRS. The current soil conditions at the facility consist primarily of silty clay loam with low permeability and moderate pH of approximately 6.43. It is expected that the inorganic SRCs detected in soil around the pond at the Firestone Test Facility MRS would tend to bind to the soil and are considered relatively immobile.

Like most inorganics, aluminum, antimony, cadmium, copper, lead, and strontium in soil and sediment increase in mobility with a decrease in pH. The pH of the water in the test pond is 8.34 (SAIC, 2011a) and the pH of the soil surrounding the pond is 6.43. Analysis for pH was not performed for the RI sediment samples; however, it is assumed that the pH for sediment is similar to the surrounding soil and less than the surface water pH and is not considered acidic. Therefore, any detected metals in sediment would be expected to be in the top several inches where they were deposited. Although not analyzed for the dissolved fractions, the RI surface water results for metals indicate that elevated levels are not being leached from the surrounding soil or sediment in the pond.

Two of the potential migration pathways at the Firestone Test Facility MRS are infiltration through the unsaturated soil to groundwater and infiltration of surface water to groundwater. The depth to groundwater at the MRS is approximately 5 feet bgs (MKM, 2007). Precipitation that does not leave the MRS as surface runoff infiltrates into the subsurface or enters the former test pond. Some of the infiltrating water is lost to the atmosphere as evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological conditions throughout the MRS. Based on the aforementioned soil conditions and that inorganic SRCs are expected to remain in the top several inches of soil where they were deposited, subsurface soils or groundwater conditions have most likely not be impacted.

6.0 MEC HAZARD ASSESSMENT

In accordance with the Work Plan (Shaw, 2011), an evaluation of the MEC hazard at the Firestone Test Facility MRS was to be prepared in accordance with the *Interim Munitions of Concern Hazard Assessment Methodology* (EPA, 2008a), hereafter referred to as the MEC HA. The MEC HA process was developed to evaluate the potential explosive safety hazard associated with conventional MEC present at a MRS under a variety of MRS-specific conditions, including various cleanup scenarios and land use assumptions. The MEC HA addresses human health and safety concerns associated with potential exposure to MEC at a MRS. No MEC or MD items were identified at the MRS during the RI field activities, and an explosive hazard is not present at the MRS. Therefore, calculation of a MEC HA score was not warranted.

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7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of this HHRA is to document whether SRCs present at the Firestone Test Facility MRS pose a risk to current or future human receptors, and to identify which, if any MRS conditions need to be addressed further under the CERCLA process. This HHRA has been prepared in accordance with the Work Plan (Shaw, 2011) using the streamlined approach to risk decision-making, as described in the FWCUG Guidance (SAIC, 2010). In particular, the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals* (USACE, 2012); hereafter referred to as the Position Paper, describes the applicability and use of the final FWCUGs in the following steps:

- Identify COPCs at the 1×10^{-6} (one in a million) excess cancer risk level or noncarcinogenic hazard quotient (HQ) risk value of 0.1 for the MRS by comparing concentrations of SRCs to the final FWCUGs.
- Identify COCs at the 1×10^{-5} (one in one hundred thousand) excess cancer risk level or noncarcinogenic HQ risk value of 1 by comparing concentrations to specific final FWCUGs, and using a “sum of ratios” approach to account for cumulative effects. This method sums the ratios of the SRC concentrations to the final FWCUG for all COPCs. A sum of ratios greater than 1 represents an unacceptable risk, and cancer and noncancer effects are considered separately.

This HHRA was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014); therefore, evaluation for the Commercial Industrial Land Use using the Industrial Regional Screening Levels (RSLs) for industrial exposure (EPA, 2012) was not included. The CERCLA investigations for the IRP are still being completed at this time. If results in the IRP investigations do no indicate that Unrestricted Land Use has been achieved, then the evaluation for the Commercial Industrial Land Use will be incorporated along with the Unrestricted (Residential) Land Use and the Military Training Land Use under the IRP, as specified in the technical memorandum.

The following sections discuss the HHRA approach, data used in the HHRA, receptors to be evaluated in the HHRA, and the COPC and COC evaluation for the samples collected at the Firestone Test Facility MRS during the RI field activities.

7.1 Data Used in the HHRA

The MC investigation consisted of the collection of one ISM surface soil sample and two discrete sediment samples. A surface water sample was initially collected to evaluate options for investigating the test pond sediment, which included approved and controlled discharge to the ground surface or manual diving operations. The surface water sample is used to characterize the nature and extent of SRCs in the pond as well. The available data used in this HHRA are presented in **Table 7-1**.

Table 7-1
Summary of Data Used in the Human Health Risk Assessment

Sample Location ID	Sample Date	Depth	Sample Type	Analysis
Surface Soil				
FTFSS-004(I)-0001-SS	8/12/11	0–0.5 feet bgs	ISM	Metals[1], Explosives, Nitrocellulose, TOC, pH
Sediment				
FTFSD-002-SD	8/8/11	0–0.5 feet bss	D	Metals[1], Explosives, Nitrocellulose, TOC
FTFSD-003-SD	8/8/11	0–0.5 feet bss	D	
Surface Water				
FTFSW-001-0001-SW	5/5/11	6–7 feet bws	D	Metals[2], Explosives, Nitrocellulose

[1] Metals analysis for surface soil and sediment includes aluminum, cadmium, copper, chromium (total and hexavalent), iron, lead, zinc, antimony, strontium, barium, and mercury.

[2] Metals analysis for surface water includes aluminum, antimony, barium, cadmium, total chromium, copper, iron, lead, strontium, mercury, and zinc.

bgs denotes below ground surface.

bss denotes below sediment surface.

bws denotes below water surface.

D denotes discrete.

ID denotes identification.

ISM denotes incremental sampling methodology.

TOC denotes total organic carbon.

7.2 Human Receptors

The future land use for the Firestone Test Facility MRS is military training, and the likely receptors are the National Guard Trainee and the Engineering School Instructor. The receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005), which is hereafter referred to as the HHRAM.

Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not required to be included. Additionally, other modifications to the risk assessment process, such as designated Representative Receptors that are required in the technical memorandum, are not required for the RI.

The facility has defined exposure scenarios for the identified receptors and presented them in the HHRAM (USACE, 2005); however the defined exposure depths may not necessarily relate to the actual sample depths collected at the MRS during the RI field activities. Sampling for MC under the MMRP is selective in general to evaluate identified munitions-related source areas and the potential that MC may have been released from the source areas. The data used in the HHRA is used to evaluate for the receptors at the depths that the samples were collected; however, the data is not intended to evaluate for predefined exposure depth scenarios, as is typically performed under the IRP. The standard approach for investigating sites under the MMRP, to a certain degree, is adapted to address MEC; however, the HHRA is valuable in identifying potential releases of MC from the source areas and if the MC poses risks to likely human receptors (U.S. Army, 2009).

A discussion of the medium sampled during the RI field activities and how the actual sample depths relate to the facility-defined exposure depths for the human receptors is presented below.

7.2.1 Surface Soil

At the facility, surface soil for the Resident Receptor (Adult and Child) is defined as 0 to 1 foot bgs, and surface soil for the National Guard Trainee and the Engineering School Instructor (to better estimate these receptors' exposure) is evaluated from 0 to 4 feet bgs (SAIC, 2010). For the RI field activities, the ISM surface soil sample was collected at one sampling unit around the former test pond at 0 to 0.5 feet bgs that is the surface soil decision unit. The surface soil decision unit is the portion of the MRS in which a decision regarding MC at the land-based portions of the MRS will be made and is the EU for the evaluation of the human receptors in surface soil at the MRS as well. The sample data for the surface soil EU is considered suitable for comparison against the established facility HHRA screening criteria (SAIC, 2010).

The facility-defined surface soil exposure scenarios for the human receptors are deeper than the actual ISM surface soil sample collected at the MRS (0 to 0.5 feet bgs). The 0.5-foot sample depth across the surface soil EU is the focus of the HHRA, since it is the maximum depth that MC associated with any MEC on or just below the ground surface would be expected to vertically migrate in the soil column. This sampling methodology is consistent with the sample depth intervals recommended in the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Therefore, the surface soil exposure depths for the Resident Receptor (Adult and Child) and the OHARNG receptors are evaluated as 0 to 0.5 feet bgs for the HHRA, the depth at which the ISM surface soil sample was collected.

7.2.2 Sediment

The sediment samples were collected along the sidewalls of the conical shaped pond beneath the wetland vegetation at depths of 2 feet below the water surface. The sediment sample intervals were 0 to 0.5 feet below the sediment surface and are considered to be representative of the sediment conditions within the entire pond that is the EU for sediment. The facility-defined wet sediment exposure depth for the human receptors is 0 to 0.5 feet (6 inches) and is consistent with the sample depth of the sediment samples that were collected during the RI field activities (SAIC, 2010). The sample data for the sediment EU is considered suitable for comparison against the established facility HHRA screening criteria.

7.2.3 Surface Water

The surface water sample was a grab sample collected at the approximate center of the pond depth at approximately 6 to 7 feet below the water surface. It is expected that the extent of SRCs in the pond are ubiquitous and the entire surface water body is considered as the surface water EU. The sample data for the surface water EU is considered suitable for comparison against the established facility-wide HHRA screening criteria.

7.3 COPC Identification

The section presents the evaluation of the MRS data and the identification of COPCs for the intended receptors based on future land use. The data for this RI Report was evaluated in accordance with the initial evaluation step presented in the Position Paper (USACE, 2012) to identify SRCs as presented in Section 4.2, “MC Data Evaluation.” The evaluation incorporates the same criteria described in Section 4.2.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, and essential nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected SRCs at the MRS. The SRCs identified for the environmental media sampled during the RI field activities included the following:

- **Surface Soil (0 to 0.5 feet bgs)—**antimony, cadmium, chromium, copper, and strontium

- **Sediment (0 to 0.5 feet bss)—**aluminum, antimony, cadmium, copper, lead, and strontium
- **Surface Water—**chromium, copper, lead, and strontium

To establish COPCs, all chemicals that had not been eliminated to this point were evaluated using the following steps.

- The final FWCUGs developed for the Resident Receptor (Adult and Child) and the National Guard Trainee for each chemical were used. If there were no final FWCUGs developed for a particular chemical, then the RSLs based on residential exposure were used (EPA, 2012). If neither a final FWCUG nor an RSL was available, then a cleanup goal was developed or another approach was developed in concurrence with USACE and the Ohio EPA. Final FWCUGs or RSLs were available for all chemicals not previously eliminated; therefore, development of a final cleanup goal was not needed.
- The final FWCUGs at the 1×10^{-6} (one in a million) excess cancer risk level and noncarcinogenic risk HQ using the 0.1 risk value for each of the receptors was selected.
- A comparison of the selected final FWCUG to the exposure point concentration (EPC) was completed. The EPCs for the Firestone Test Facility MRS are the maximum detected concentrations.
- The chemical was retained as a COPC if the EPC exceeded the most stringent final FWCUG for the Resident Receptor (Adult and Child) or the National Guard Trainee for either one of the 1×10^{-6} excess cancer risk value and the noncarcinogenic HQ using the 0.1 risk value. The EPC was compared to the RSL if no final FWCUG was available.

The Work Plan (Shaw, 2011) specifies that in addition to screening the final FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee, evaluation will also be made against the remaining OHARNG receptors in order to ensure that the most stringent FWCUG is used. For the chemicals detected at the Firestone Test Facility MRS, the final FWCUGs for the Resident Receptor (Adult and Child) or National Guard Trainee FWCUGs were lower than those for any other OHARNG receptor. Documents initiated before finalization of the U.S. Army's technical memorandum (ARNG, 2014) included OHARNG receptors that will no longer be used. Since the most stringent FWCUGs were for the National Guard Trainee, receptors evaluated herein are also the Representative Receptors identified in the technical memorandum. As a result, the National Guard Trainee, the most stringent OHARNG receptor with the most stringent FWCUGs, and the Resident Receptor (Adult and Child) were considered for COPC evaluation. The screening values used to evaluate for the identified human receptors are presented in the data summary tables in **Appendix D**.

Tables 7-2 through **7-4** present the screening results for COPCs for the Resident Receptor (Adult and Child) and the National Guard Trainee in accordance with the FWCUG Guidance (SAIC, 2010). These tables include the final FWCUGs that are based on the lower of the 1×10^{-6} (one in a million) excess cancer risk level and an HQ of 0.1 for noncancer effect values. As previously mentioned, if a chemical was detected for which there was no final FWCUG, the RSLs based on residential exposure (EPA, 2012) were used. The RSLs were based on the lower of values derived considering an excess cancer risk of 10^{-6} and noncancer hazard considering a hazard index (HI) of 1. However, the RSLs included in these tables were derived based on noncancer risk that were adjusted to a HI of 0.1 in order to be consistent with the noncancer final FWCUGs. The RSL for lead was not adjusted in this manner since it was not derived using the HI approach. The RSL for lead in soil was based on the value recommended by the EPA as generally safe for residential settings.

In **Tables 7-2** and **7-3**, the lead and strontium RSLs for residential soil are used for both surface soil and sediment. There are no RSLs established for sediment, however, the RSLs for soil are considered to be conservative values for evaluation purposes, as the sediment final FWCUGs for other chemicals are the same as those for surface soil. In **Table 7-4**, the tap water RSLs for lead and strontium are used for screening as there are no RSLs for surface water. The RSLs for tap water should provide a conservative value for evaluation purposes as exposure (ingestion and dermal contact) is expected to be greater during tap water use than during swimming, wading, or showering in surface water.

7.3.1 COPC Evaluation in Surface Soil

No COPCs were identified in surface soil for the National Guard Trainee or the Resident Receptor (Adult and Child). A summary of results for the screening process used to evaluate for COPCs in surface soil for the National Guard Trainee and the Resident Receptor (Adult and Child) is presented in **Table 7-2**.

7.3.2 COPC Evaluation in Sediment

Aluminum was identified as the only COPC in sediment. The maximum detected concentration of aluminum detected was slightly greater than the sediment BSV (**Table 4-3**) and was greater than the noncancer final FWCUG for the National Guard Trainee and the Resident Receptor (Adult and Child) at a HQ of 0.1. A summary of results for the screening process used to evaluate for COPCs in sediment for the National Guard Trainee and the Resident Receptor (Adult and Child) is presented in **Table 7-3**.

Table 7-2
Summary of COPC Evaluation in Surface Soil (0–0.5 feet bgs) for the Resident Receptor and the National Guard Trainee

Site-Related Chemical	Range of Values, mg/kg						NGT FWCUG[1] (mg/kg)	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Antimony	1.5		1.5		0.81	0.81	175	13.6	2.82		No	Below risk screening criteria
Cadmium	0.25		0.25		0.041	0.041	10.9	22.3	6.41		No	Below risk screening criteria
Chromium (as Cr^{+3})	147	J	147	J	0.14	0.14	329,763	19,694	8,147		No	Below risk screening criteria
Copper	56.7	J	56.7	J	0.41	0.41	25,368	2,714	311		No	Below risk screening criteria
Strontium	7.9	J	7.9	J	0.081	0.081	NA	NA	NA	4,700	No	Below risk screening criteria

[1] The FWCUG is the lower of noncarcinogenic FWCUG at hazard quotient of 0.1 and carcinogenic FWCUG at risk of 10^{-6} (see Appendix I of this RI Report).
[2] The RSL is based on noncancer risks and are adjusted to a hazard index (HI) of 0.1 (as opposed to the published value based on HI of 1), except for lead (see Appendix I of this RI Report).
bgs denotes below ground surface.
COPC denotes chemical of potential concern.
Cr^{+3} denotes trivalent chromium.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).
J denotes the result is reported as an estimated value.
mg/kg denotes milligram per kilogram.
NA denotes not available.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
RSL denotes Regional Screening Level for residential soil (EPA, 2012).
VQ denotes validation qualifier.

Table 7-3
Summary of COPC Evaluation in Sediment (0–0.5 feet bss) for the Resident Receptor and the National Guard Trainee

Site-Related Chemical	Range of Values, mg/kg						NGT FWCUG[1] (mg/kg)	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Aluminum	12,600		14,700		0.34	0.34	3,496	52,923	7,380		Yes	Above NGT and R(C) FWCUG
Antimony	0.72	J	0.98	J	1.1	1.1	175	13.6	2.82		No	Below risk screening criteria
Cadmium	0.16		0.21		0.056	0.057	10.9	22.3	6.41		No	Below risk screening criteria
Copper	34.3		50		0.56	0.57	25,368	2,714	311		No	Below risk screening criteria
Lead	24.3		48.2		0.35	0.35	NA		NA	400	No	Below risk screening criteria
Strontium	8		8.7		0.11	0.11	NA	NA	NA	4,700	No	Below risk screening criteria

[1] The FWCUG is the lower of noncarcinogenic FWCUG at hazard quotient of 0.1 and carcinogenic FWCUG at risk of 10^{-6} (see Appendix I of this RI Report).
[2] The RSL is based on noncancer risks and are adjusted to a hazard index (HI) of 0.1 (as opposed to the published value based on HI of 1), except for lead (see Appendix I of this RI Report).
bss denotes below sediment surface.
COPC denotes chemical of potential concern.
Cr^{+3} denotes trivalent chromium.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).
J denotes the result is reported as an estimated value.
mg/kg denotes milligrams per kilogram.
NA denotes not available.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
RSL denotes Regional Screening Level for residential soil (EPA, 2012).
VQ denotes validation qualifier.

Table 7-4
Summary of COPC Evaluation in Surface Water for the Resident Receptor and the National Guard Trainee

	Range of Values, mg/L											
	Detected Concentrations				Reporting Limits							
Site-Related Chemical	Minimum	VQ	Maximum	VQ	Minimum	Maximum	NGT FWCUG[1] (mg/L)	R(A) FWCUG[1] (mg/L)	R(C) FWCUG[1] (mg/L)	RSL[2] (mg/L)	COPC?	COPC Justification
Chromium (total)	0.0013	J	0.0013	J	0.0042	0.0042	6.165	28.442	11.173		No	Below risk screening criteria
Copper	0.0108		0.0108		0.0076	0.0076	7.199	2.788	0.614		No	Below risk screening criteria
Lead	0.0028	J	0.0028	J	0.0098	0.0098	NA	NA	NA	0.015	No	Below risk screening criteria
Strontium	0.0425		0.0425		0.006	0.006	NA	NA	NA	0.93	No	Below risk screening criteria

[1] The FWCUG is the lower of noncarcinogenic FWCUG at hazard quotient of 0.1 and carcinogenic FWCUG at risk of 10^{-6} (see Appendix I of this RI Report).
[2] The RSL is based on noncancer risks and are adjusted to a hazard index (HI) of 0.1 (as opposed to the published value based on HI of 1), except for lead (see Appendix I of this RI Report).
[3] The FWCUG for chromium is based on its trivalent form (Cr^{+3}).
COPC denotes chemical of potential concern.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).
J denotes the result is reported as an estimated value.
mg/L denotes milligrams per liter.
NA denotes not available.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
RSL denotes Regional Screening Level for residential tap water (EPA, 2012).
VQ denotes validation qualifier.

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7.3.3 COPC Evaluation in Surface Water

No COPCs were identified in surface water for the National Guard Trainee or the Resident Receptor (Adult and Child). A summary of results for the screening process used to evaluate for COPCs in surface water for the National Guard Trainee and the Resident Receptor (Adult and Child) is presented in **Table 7-4**.

7.4 COC Evaluation

This section presents the COC evaluation process for the receptors evaluated for the future military training land use and the Unrestricted Land Use in the HHRA. The COCs are identified through additional screening of the COPCs identified in Section 7.2. The determination of COCs for the MRS was conducted in accordance with the Position Paper (USACE, 2012) as follows:

- Selected final FWCUGs for Resident Receptor (Adult and Child) as well as for the receptors identified for the future land use at the MRS: military training. The Representative Receptors that were identified for military training are the National Guard Trainee and the Engineering School Instructor.
- The final FWCUGs were selected at the 1×10^{-5} (one in one hundred thousand) excess cancer risk value and a HQ of 1 for noncancer hazard. Critical effects and target organs were provided for noncancer hazard values.
- EPCs were derived for the MRS medium. In this case, since two samples of sediment were taken, the maximum detected concentration was used for the EPC.
- The EPC was compared to the selected final FWCUGs. The process involved summing ratios for carcinogens, and summing ratios of chemicals that affected similar organs. However, in this case, only one COPC was identified.

As discussed in Section 7.2, “COPC Identification,” aluminum in sediment was the only COPC identified for the environmental media sampled at the Firestone Test Facility MRS for the RI. The potential users associated with military training include the National Guard Trainee and the Engineering School Instructor. Final FWCUGs for sediment are available for the National Guard Trainee only and not for the Engineering School Instructor; therefore, the FWCUGs for the National Guard Trainee are more stringent than those of the OHARNG receptors for the future land use. The final receptors used for the determination for COCs at the MRS include the National Guard Trainee and the Resident Receptor (Adult and Child). The aluminum concentration was not identified as a COC in sediment for any of the receptors. Therefore, no SRCs were identified as COCs in any of the environmental media samples collected at the MRS. The COC evaluation for sediment is provided in **Table 7-5** for the Resident Receptor (Adult and Child) and in **Table 7-6** for the National Guard Trainee.

7.5 Conclusions of the HHRA

None of the MC-related SRCs were determined to pose a hazard to likely human receptors in the evaluated potential exposure pathways of surface soil, sediment, and surface water; therefore, Unrestricted Land Use was achieved for the MRS.

7.6 Uncertainty Analysis

There are various sources of uncertainty in the evaluation of exposure and risk that are common to all risk assessments. These general sources of uncertainty are not described here. However, those specific to this assessment are discussed in the following paragraphs. These uncertainties generally relate to sampling considerations, the determination of EPCs, and the selection of appropriate receptors. There are numerous uncertainties related to the final FWCUGs, including exposure assumptions and toxicity values. These uncertainties are inherent to the use of these values, and are similar for all assessments using them. Therefore, these uncertainties are not discussed here unless there is a particular issue relevant to this evaluation.

Uncertainty can arise from sampling techniques or approaches. In this assessment, surface soil was sampled using ISM techniques. ISM techniques provide a good representation of average concentrations over the area sampled. While it may not identify small areas of higher concentrations, this approach is useful for estimating exposure that is expected to occur over an area and not discrete locations.

Several substances detected at the MRS have no final FWCUGs. In these cases, the RSLs were used as the screening values for all receptors. This provides a conservative evaluation, since the RSLs are based on residential exposure. In addition, the tap water RSL was used for evaluating lead and strontium in surface water. Tap water RSLs are expected to be lower than screening values developed considering surface water exposures.

The evaluation of chromium in this assessment is based on the final FWCUGs for Cr^{+3} for all environmental media. The surface soil and sediment samples were analyzed for Cr^{+6}, and it was not detected in any samples in these media. Therefore, the assumption that the chromium concentrations for surface soil and sediment primarily consist of the Cr^{+3} state represents a minor uncertainty to the risk assessment. The surface water sample was not analyzed for Cr^{+6}; therefore, the chromium result for surface water is considered a total concentration of the combined Cr^{+3} and Cr^{+6} states. Comparison of the total chromium concentration for surface water to the Cr^{+3} HHRA screening criteria is considered to be a conservative evaluation, since Cr^{+6} was not detected in the nearby surface soil and sediment in the pond. Therefore, there is minimal uncertainty to the risk assessment that the total chromium concentration in the surface water sample does not consists primarily in its Cr^{+3} state.

Table 7-5
Sediment COC Evaluation for the Resident Receptor

Cancer Evaluation					Noncancer Evaluation					
Parameter	EPC (mg/kg)	R(A) FWCUG (mg/kg)	Ratio of EPC to R(A) FWCUG	% Contribution to the Total Sum	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to R(C) FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Aluminum	14,700	NA	NA	NA	73,798	Neurotoxicity in offspring	0.1992	100%	No	Sum of Ratios < 1
		Sum of Ratios:	**0.00**				**0.20**			

[1] The FWCUG is the noncarcinogenic FWCUG at a hazard quotient of 1; only the R(C) FWCUG is shown, as this is lower than adult for noncancer effects (see Appendix I of this RI Report).
< denotes less than.
COC denotes chemical of concern.
EPC denotes exposure point concentration. EPC is maximum concentration.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).
mg/kg denotes milligrams per kilogram.
NA denotes no value is available or applicable.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).

Table 7-6
Sediment COC Evaluation for the National Guard Trainee

Cancer Evaluation					Noncancer Evaluation					
Parameter	**EPC (mg/kg)**	**NGT FWCUG (mg/kg)**	**Ratio of EPC to NGT FWCUG**	**% Contribution to the Total Sum**	**NGT FWCUG[1] (mg/kg)**	**Target Organ**	**Ratio of EPC to NGT FWCUG**	**% Contribution to the Total Sum**	**COC?**	**COC Justification**
Aluminum	14,700	NA	NA	NA	34,960	Neurotoxicity in offspring	0.42	100.00%	No	Sum of Ratios < 1
		Sum of Ratios:	**0.00**				**0.42**			

[1] The FWCUG is the noncarcinogenic FWCUG at a hazard quotient of 1 (see Appendix I of this RI Report).
< denotes less than.
COC denotes chemical of concern.
EPC denotes exposure point concentration. EPC is maximum concentration.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant (SAIC, 2010).
mg/kg denotes milligrams per kilogram.
NA denotes no value is available or applicable.
NGT denotes National Guard Trainee.

8.0 ECOLOGICAL RISK ASSESSMENT

The ERA evaluates the potential for adverse effects posed to ecological receptors from potential releases at the Firestone Test Facility MRS. The ERA is consistent with the process described in the EPA *Ecological Risk Assessment Guidance for Superfund* (1997) and the Ohio EPA *Ecological Risk Assessment Guidance Document* (2008), which are hereafter referred to as the EPA guidance and Ohio EPA guidance, respectively. Other supporting documents used in the preparation of the ERA include the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003b) and the *Risk Assessment Handbook Volume II: Environmental Evaluation* (USACE, 2010). The ERA also follows the facility Unified Approach to ERAs (USACE, 2011) established at sites under environmental investigation at the former RVAAP.

Consistent with the RVAAP Unified Approach for performing ERAs, a screening-level ERA (SLERA) was performed for the Firestone Test Facility MRS. The SLERA is an initial screening step in the ERA 8-step approach as described in EPA (1997) guidance. The SLERA comprises Steps 1, 2, and the first part of Step 3 (often referred to as Step 3a), in which a refinement of the chemicals initially selected as chemicals of potential ecological concern (COPECs) is performed prior to determining whether additional investigation is necessary. If the SLERA indicates that additional investigation is warranted, it is followed by a more comprehensive baseline ERA (BERA) by completing the second part of Step 3 (i.e., "Step 3b") through Step 7. Step 8 is a risk management step that occurs after information presented in the previous steps of the ERA has been fully considered. The Ohio EPA Guidance (2008) presents a similar "tiered" approach that allows for a progression through four levels of the ERA as required by the findings and conclusions of each level: Level I Scoping, Level II Screen, Level III Baseline, and Level IV Field Baseline. Levels I and II are approximately equivalent to Steps 1 and 2 of a SLERA. Level III includes food chain modeling using exposure dose and toxicity estimates for generic receptors using conservative assumptions, and is incorporated as part of Step 3a in the SLERA if it is considered necessary to refine COPECs. The Level IV Field Baseline is equivalent to the BERA (Steps 3b through 7), where conservative assumptions used in the Level III Baseline are modified using MRS-specific information.

As stated previously, the SLERA under the Unified Approach includes Steps 1 through 3a of the 8-step process for ERAs (EPA, 1997). This is equivalent to a Level I and II evaluation according to the Ohio EPA process, and is also consistent with the ERA approach described in USACE guidance (2003b and 2010b) and the facility Unified Approach (USACE, 2012). A BERA is not considered necessary for the Firestone Test Facility MRS, and the ERA process is terminated following the completion of the SLERA.

8.1 Scope and Objectives

The goal of the SLERA was to evaluate the potential for adverse ecological effects to ecological receptors from SRCs identified at the Firestone Test Facility MRS. This objective was met by characterizing the ecological communities in the vicinity of the MRS, determining the particular contaminants present, identifying pathways for receptor exposure, and estimating the magnitude of potential adverse effects to identified receptors. The SLERA addressed the potential for adverse effects to the wildlife, threatened and endangered species, and wetlands or other sensitive habitats associated with the MRS.

The objective of this SLERA was to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from former activities at the Firestone Test Facility MRS. The results of the SLERA contribute to the overall characterization of the MRS and were used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives.

The SLERA used MRS-specific analyte concentration data for surface soil, sediment, and surface water from the Firestone Test Facility MRS. Risks to ecological receptors were evaluated by performing a multistep screening process in which, after each step, the detected analytes in each medium were either deemed to pose negligible risk and eliminated from further consideration or carried forward to the next step in the screening process to a final conclusion of being a COPEC. COPECs are analytes whose concentrations are great enough to potentially pose adverse effects to ecological receptors. Following the determination of COPECs, an ecological CSM was developed that describes the selection of receptors, exposure pathways, and assessment and measurement endpoints and accounts for cumulative effects.

8.2 Level I Scoping

The scoping step of the SLERA includes descriptions of habitats, biota, and threatened and endangered and other rare species, selection of EU, and identification of COPECs at the MRS. If a potential threat to ecological receptors is suspected, the SLERA proceeds to Level II.

8.2.1 Site Description and Land Use

The Firestone Test Facility MRS is a 0.41-acre former munitions testing area located within Load Line #6 and was used for the testing of shaped charges. When active, the MRS area consisted of a small building, a man-made pond, and the area surrounding the pond. The building contained a test chamber for shaped charges and has since been demolished. The former MRS activities included the testing of shaped charges within the building test chamber and underwater testing of the shaped charges in the pond. The MRS is currently undeveloped, vacant land with no improvements. Based on unverified anomalies identified during the SI, the SI Report (e^2M, 2008) concluded that there was a potential for MEC at the MRS and recommended further characterization around the perimeter and bottom of the pond and adjacent to the former shaped charge test chamber building to address the MEC concerns.

Current activities at the Firestone Test Facility MRS include security patrols, maintenance activities, environmental sampling, and natural resource management activities. The OHARNG projected future land use for the Firestone Test Facility MRS is military training (USACE, 2005).

8.2.2 Ecological Significance

The ecological features of the MRS are presented in this section. The protection of these features from chemical releases, as assessed by the SLERA, is articulated by the facility management goals (Section 8.2.3).

The topography at the Firestone Test Facility MRS is relatively flat to gently sloping towards the natural drainage channel to the east and adjacent to the MRS. Surface water runoff that enters the natural drainage channel eventually enters the downstream perennial headwater streams to the Michael J. Kirwan reservoir. The shaped charge test pond is man-made and there are no natural streams or ponds located within the MRS; however, an unnamed tributary to Michael J. Kirwan Reservoir is located to the south of the MRS. The MRS is not located within a designated flood plain. The Firestone Test Facility MRS consists of disturbed areas where former test chambers were present and have since been demolished and removed. Most of the MRS is currently covered with ruderal grasses and shrubs (e^2M, 2008).

The vegetation community present at the Firestone Test Facility MRS is categorized as “other land” (AMEC, 2008), which presumably refers to highly disturbed areas that do not support any particular plant community. Vegetation associated with aquatic and semiaquatic conditions (i.e., cattails) are present at the edges of the shaped charge test pond. Additional details pertaining to the ecological significance of the Firestone Test Facility MRS are provided in the following sections.

8.2.3 Management Goals for the Facility

The INRMP (AMEC, 2008) has been developed for the OHARNG as the primary guidance document and tool for managing natural resources at the facility (AMEC, 2008). Several of these management goals have relevance to maintaining the ecological resources at the MRS. Therefore, they are pertinent to the SLERA because they articulate overarching management objectives for ecological resources that should be considered when identifying potential adverse impacts to natural resources. Specifically, the following goals listed in the INRMP are pertinent to the Firestone Test Facility MRS SLERA:

- Protect and maintain populations of rare plant and animal species on the facility in compliance with federal and state laws and regulations.
- Manage wildlife resources in a manner compatible with the military mission and within the limits of the natural habitat.
- Manage wetlands and other surface waters in accordance with applicable federal, state, and local regulations and to protect water quality and ecological function while facilitating the military mission.
- Manage soil to maintain productivity and prevent and repair erosion in accordance with state and federal laws and regulations.

8.2.4 Terrestrial and Aquatic Resources

This section summarizes the terrestrial and aquatic resources identified for the Firestone Test Facility MRS that are evaluated in this SLERA.

8.2.4.1 Special Interest Areas and Important Places and Resources

Special interest areas are ecosystems that are not federally protected and have no legal standing, but are areas that host state-listed species, are representative of historic ecosystems, or are otherwise noteworthy. No special interest areas on or near the Firestone Test Facility MRS have been identified during the natural heritage data searches (AMEC, 2008).

No known important ecological places and resources are known to be present at the MRS. Among many other features, such ecological places and resources may include state or federal wildlife refuges or critical habitat for threatened or endangered species.

8.2.4.2 Wetlands

A planning level survey (i.e., desktop review of wetlands data and resources [National Wetlands Inventory maps, aerials etc.]) for wetlands was conducted for the entire facility, including the MRS. No jurisdictional level or planning level wetlands have been identified at the Firestone Test Facility MRS (AMEC, 2008).

8.2.4.3 Animal Populations

The facility has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas (AMEC, 2008).

Vegetation at the facility can be grouped into three categories: (1) herb dominated, (2) shrub dominated, and (3) tree dominated. Approximately 60 percent of the facility is covered by forest or tree-dominated vegetation. The facility has a total of seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Surface water features within the facility include a variety of streams, ponds, floodplains, and wetlands. Numerous streams drain the facility, including 19 miles of perennial streams. The total combined stream length of streams at the facility is 212 linear miles. Approximately 153 acres of ponds are found on the facility. These ponds generally provide valuable wildlife habitats. The ponds generally support wood ducks, hooded mergansers, mallards, Canada geese, and many other birds and wildlife species. Some ponds have been stocked with fish and are used for fishing and hunting. Wetlands are abundant and prevalent throughout the facility. These wetland areas include seasonal wetlands, wet fields, and forested wetlands. Most of the wetland areas at the facility are the result of natural drainage and beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas (AMEC, 2008).

Available habitat at the Firestone Test Facility MRS is of relatively low quality, given the disturbed soil and lack of an established, mature vegetation community. Nevertheless, the MRS is likely used by several species of animals to some degree, both for foraging activities and the use of the pond as a source of drinking water. The area around the pond is covered by ruderal grasses and shrubs. Common bird species that could be expected to use the forest/riparian habitat adjacent to the creek include the American goldfinch (*Carduelis tristis*), song sparrow (*Melospiza melodia*), and European starling (*Sturnus vulgaris*). Common large mammals include white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and woodchuck (*Marmota monax*), and the eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), and short-tailed shrew (*Blarina brevicauda*) are common small mammals present at the facility (ODNR, 1997) that may use the habitat present at the Firestone Test Facility MRS. Aquatic or semiaquatic species may use the on-site pond as well, although the small size (approximately 40 feet in diameter) would limit the number and types of receptors that would likely use the area to a significant extent. Nevertheless, small amphibians and nongame fish likely populate the pond during the warmer months.

8.2.4.4 Threatened, Endangered, and Other Rare Species Information

The relative isolation and protection of habitat at the facility has created an important area of refuge for a number of plant and animal species considered rare by the State of Ohio. No federally listed species are known to reside at the facility. To date, 77 state-listed species are confirmed to be on the former RVAAP property and are listed in **Table 1-3**. The Firestone

Test Facility MRS has not been specifically surveyed for threatened or endangered species (AMEC, 2008).

8.2.5 Level I Conclusions

Based on the presence of ecological resources at the MRS, and the potential presence of detected SRCs associated with historical MRS processes that could adversely affect these resources, proceeding to the Level II Screening step is recommended for this SLERA. This Level II Screening is presented in Section 8.3.

8.3 Level II Screening

A Level II Screening was performed at the MRS to compare MRS-specific data to appropriate ecological screening values (ESVs) and other criteria to determine the need for further evaluation. An ecological CSM was developed to identify the potential ecological receptors at risk and the exposure pathways by which these receptors could be exposed to contamination in site media. Specific assessment and measurement endpoints are identified based on the CSM to describe ecological features targeted for protection. Then, a COPEC identification step is performed to determine what chemicals, if any, potentially represent a threat to the ecological receptors present at the MRS.

8.3.1 Ecological Conceptual Site Model

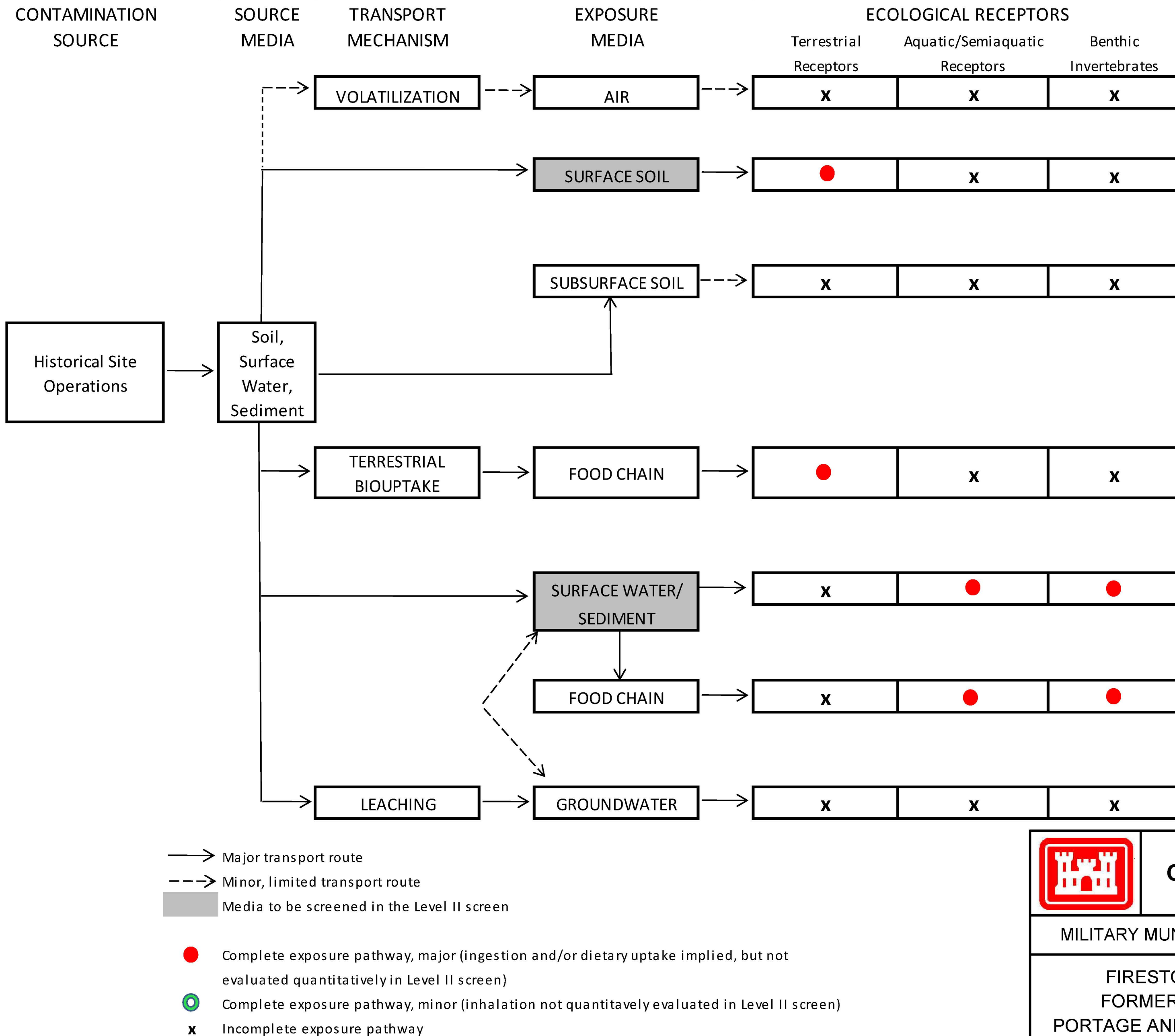
The ecological CSM depicts and describes the known and expected relationships among the stressors, pathways, and assessment endpoints that are considered in the SLERA, along with a rationale for their inclusion. Two ecological CSMs are presented for this Level II Screening. One ecological CSM is associated with the media screening conducted during the Level II Screening (**Figure 8-1**). The other ecological CSM (**Figure 8-2**) represents a preliminary CSM for a Level III Baseline, should one be considered necessary. The ecological CSMs for the Firestone Test Facility MRS were developed using the available MRS-specific information and professional judgment. The contamination mechanism, source media, transport mechanisms, exposure media, exposure routes, and ecological receptors for the ecological CSMs are described below.

8.3.1.1 Contamination Source

The contamination source includes potential releases of MC from the shaped charge detonation testing performed at the shaped charge test pond that may have impacted surface soil around the pond and sediment and surface water in the pond itself.

8.3.1.2 Source Media

The source media at the Firestone Test Facility MRS include potential MC in the surface soil around the former test pond and sediment and surface water in the pond itself. Surface



U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

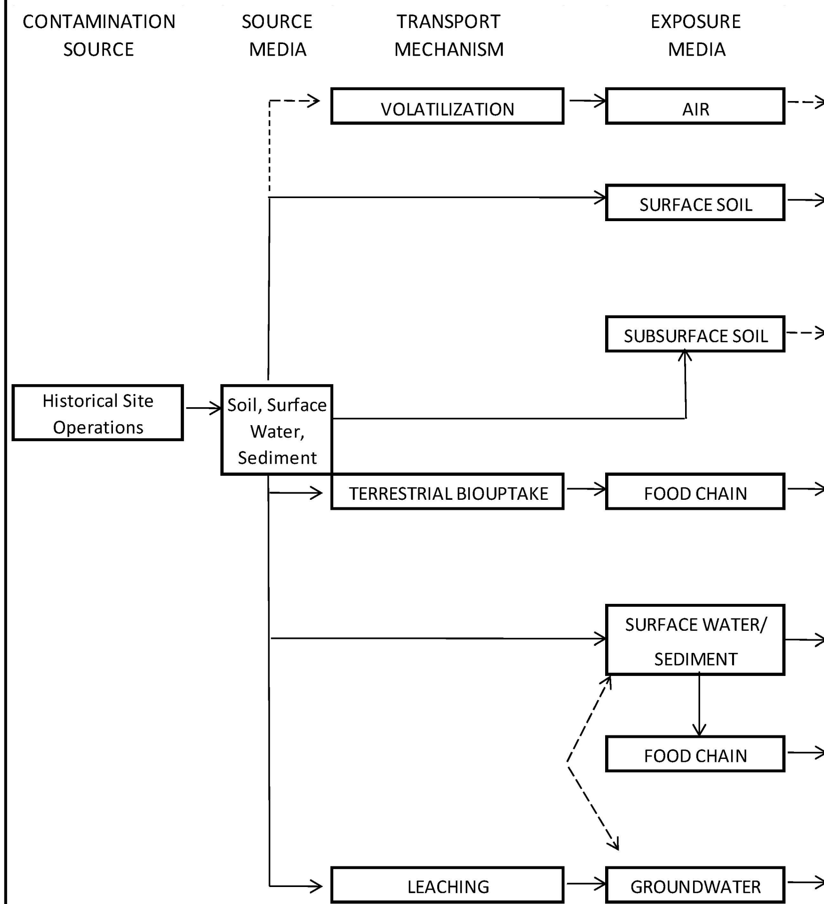
MILITARY MUNITIONS RESPONSE PROGRAM

FIRESTONE TEST FACILITY MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_FirestoneTestFac\2014_June\RVAAP_FTF_016_Fig8_1_LevelII_CSM_r1.mxd; Analyst: gwt; Date: 6/6/2014 4:24:48 PM

FIGURE 8-1 ECOLOGICAL CSM FOR LEVEL II SCREEN



Exposure Media	Exposure Routes	Terrestrial Plants	Terrestrial Inverts	Rabbit Vole	Shrew Robin	Fox Hawk	Aquatic biota	Muskrat Duck	Mink Heron	Benthic Inverts
AIR	INHALATION (VAPORS)	x	x	x	x	x	x	◎	◎	x
SURFACE SOIL	INGESTION	x	●	●	●	●	x	x	x	x
	DIRECT/DERMAL CONTACT	●	●	◎	◎	◎	x	x	x	x
	INHALATION (FUGITIVE DUST)	x	x	◎	◎	◎	x	x	x	x
SUBSURFACE SOIL	INGESTION	x	x	x	x	x	x	x	x	x
	DIRECT/DERMAL CONTACT	x	x	x	x	x	x	x	x	x
	INHALATION (FUGITIVE DUST)	x	x	x	x	x	x	x	x	x
FOOD CHAIN	PLANTS	x	◎	●	◎	◎	x	x	x	x
	INVERTEBRATES	x	◎	x	●	◎	x	x	x	x
	HERBIVORES	x	x	x	◎	●	x	x	x	x
	OMNIVORES	x	x	x	◎	●	x	x	x	x
SURFACE WATER/ SEDIMENT	INGESTION	x	x	x	x	x	●	●	●	◎
	DIRECT/DERMAL CONTACT	x	x	x	x	x	●	◎	◎	●
FOOD CHAIN	PLANTS	x	x	x	x	x	x	●	◎	x
	INVERTEBRATES	x	x	x	x	x	x	◎	●	x
	FISH	x	x	x	x	x	x	x	●	x
GROUNDWATER	INGESTION	x	x	x	x	x	x	x	x	x
	DIRECT/DERMAL CONTACT	x	x	x	x	x	x	x	x	x
	INHALATION (VAPORS)	x	x	x	x	x	x	x	x	x

→ Major route
⇢ Minor route

● Complete exposure pathway, major
◎ Complete exposure pathway, minor
x Incomplete exposure pathway or not evaluated

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

FIRESTONE TEST FACILITY MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

FIGURE 8-2 PRELIMINARY ECOLOGICAL CSM FOR LEVEL III BASELINE

soil at the facility is typically defined as 0 to 1 foot bgs; however, the maximum depth of surface soil sampled during the RI field activities was the 0- to 0.5-foot interval. The 0- to 0.5-foot interval is the maximum depth that MC associated with MEC on or just below the ground surface would be expected to vertically migrate in the soil column. Therefore, surface soil interval evaluated for this SLERA is between 0 and 0.5 feet bgs. The evaluation of sediment at 0 to 0.5 feet below the sediment surface is the typical exposure depth evaluated for wet sediment at the facility (SAIC, 2010).

8.3.1.3 Transport Mechanisms

Transport mechanisms at the MRS include biota uptake, direct transfer to surface water, and sediment, and leaching to groundwater. Biota uptake is a transport mechanism because some of the SRCs are known to accumulate in biota, which may act as a vehicle to spatially disperse contaminants, as well as represent a secondary exposure medium for upper trophic level receptors that prey on the biota. Since shaped charge detonation testing was performed at the test pond, the deposition of eroded soils containing MC into surface water and sediment is also a valid transport mechanism for both ecological CSMs.

8.3.1.4 Exposure Media

Sufficient time has elapsed for contaminants in the source medium to have migrated to potential exposure media, resulting in possible exposure of plants and animals that come in contact with these media. Potential exposure media include surface soil, food chain, surface water, and sediment. Subsurface soil includes soil at depths that ecological receptors typically do not come into contact with, and is not being evaluated at the MRS. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater. If groundwater daylights into surface water as a seep or spring, it is evaluated as surface water. Soil, sediment, surface water, and biota comprising prey items for higher trophic level receptors are the four principle exposure media for the Firestone Test Facility MRS.

8.3.1.5 Exposure Routes

Exposure routes are functions of the characteristics of the media in which the sources occur, and reflect how both the released chemicals and receptors interact with those media. For example, chemicals in surface water may be dissolved or suspended as particulates and be highly mobile, whereas those same constituents in soil may be much more stationary. The ecology of the receptors is important because it dictates their home range, whether the organism is mobile or immobile, local or migratory, burrowing or above ground, plant eating, animal eating, or omnivorous.

For the Level II Screening (**Figure 8-1**), specific exposure routes were not identified because the screen is not receptor specific and only focuses on comparison of maximum detected concentrations of chemicals in the exposure media against published ecological toxicological benchmark concentrations derived for those media. However, the Level III Baseline (**Figure 8-2**) identifies specific exposure routes and indicates whether the exposure routes from the exposure media to the ecological receptors are major or minor. Major exposure routes are evaluated quantitatively, whereas minor routes are evaluated qualitatively. The Level III Baseline (**Figure 8-2**) shows major exposure routes of soil, surface water, and sediment to ecological receptors and an incomplete exposure route of groundwater. Ecological receptors are assumed not to come into direct contact with groundwater.

The major exposure routes for chemical toxicity from surface soil include ingestion (for terrestrial invertebrates, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial invertebrates). The ingestion exposure routes for voles, shrews, robins, foxes, and hawks include soil, as well as plant and/or animal food (i.e., food chain), that was exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust. The major exposure routes for surface water include ingestion (as drinking water) and direct contact (for aquatic and semiaquatic biota and benthic invertebrates). Minor exposure pathways for surface water and sediment include direct contact and inhalation (for muskrats, ducks, mink, and herons). The major exposure routes for sediment include ingestion (for aquatic biota, muskrats, ducks, mink, and herons) and direct contact (for aquatic biota and benthic invertebrates). The ingestion exposure routes for aquatic biota (including vertebrate mammals and birds) include sediment and surface water (as applicable), as well as plant and/or animal food (food chain), that were exposed to the sediment or surface water.

Exposure to groundwater is an incomplete pathway for all terrestrial, aquatic, and semiaquatic ecological receptors because receptors typically do not come into direct contact with groundwater. If the groundwater outcrops via seeps or springs into wetlands or ditches, it becomes part of the surface water and would be evaluated as a surface water pathway.

8.3.1.6 Ecological Receptors

For the Level II Screening, specific ecological receptors were not identified; rather, terrestrial, aquatic, semiaquatic, and benthic receptors are each considered as a whole. However, for the Level III Baseline evaluation, specific terrestrial ecological receptors are identified as part of the ecological CSM (**Figure 8-2**). The terrestrial receptors include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003b). The aquatic receptors include aquatic invertebrates and fish. The semiaquatic receptors include minks and herons. The benthic invertebrates include aquatic insect larvae, mayflies, midges, and non-insects such as crayfish, snails, clams, and bivalves. It is noted that due to the extremely small size of the MRS (0.41 acres), the evaluation of some of these receptors that have a home range of many acres is highly conservative. These receptors are discussed in more detail in the following sections.

8.3.1.7 Selection of MRS-Specific Ecological Receptor Species

The selection of ecological receptors for the MRS-specific analysis screen was based on plant and animal species that are likely to occur in the terrestrial and aquatic habitats at the MRS. Three criteria were used to identify the MRS-specific receptors.

1. **Ecological Relevance—**The receptor has or represents a role in an important function such as nutrient cycling (i.e., earthworms), and population regulation (i.e., hawks). Receptor species were chosen to include representatives of all applicable trophic levels identified by the ecological CSM for the MRS. These species were selected to be predictive of assessment endpoints (including protected species/species of special concern and recreational species).
2. **Susceptibility—**The receptor is known to be sensitive to the chemicals detected at the MRS, and given their food and a habitat preference; their exposure is expected to be high. The species have a likely potential for exposure based upon their residency status, home range size, sedentary nature of the organism, habitat compatibility, exposure to contaminated media, exposure route, and/or exposure mechanism compatibility. Ecological receptor species were also selected based on the availability of toxicological effects and exposure information.
3. **Management Goals—**The receptor represents a valued component of the MRS's ecological significance. Furthermore, as a significant natural resource, its presence should be managed in a manner that is compatible with the military mission at the facility (AMEC, 2008).

At the Firestone Test Facility MRS, the following types of ecological receptors are likely to be present: terrestrial invertebrates, meadow voles (*Microtus pennsylvanicus*), short-tailed shrews (*Blarina brevicauda*), American robins (*Turdus migratoris*), red foxes (*Vulpes vulpes*), and red-tailed hawks (*Buteo jamaicensis*). The terrestrial exposure scenarios for each of these receptors is described in the following sections and are discussed in greater detail in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003b).

Terrestrial Exposure Classes and Receptors

Terrestrial exposures, receptors, and justification for their relevance at the Firestone Test Facility MRS are summarized in the following paragraphs.

Terrestrial Invertebrate Exposure to Soil

Terrestrial invertebrate exposure to soil is applicable to soils for the Firestone Test Facility MRS. Earthworms represent the receptor for the terrestrial invertebrate class, and there is sufficient habitat present for them at the MRS. Earthworms have ecological relevance because they are important for decomposition of detritus and for energy and nutrient cycling in soil (Efroymson et al, 1997a). Earthworms are probably the most important of the terrestrial invertebrates for promoting soil fertility due to the volume of soil that they process.

Earthworms are susceptible to exposure to and toxicity from COPECs in soil. Earthworms are nearly always in contact with soil and ingest soil, which results in constant exposure. Earthworms are sensitive to various chemicals. Toxicity benchmarks are available for earthworms (Efroymson et al., 1997a). Although specific management goals for earthworms are not immediately obvious, the role of earthworms in soil fertility and as a prey item for other organisms is significant. Thus, there is sufficient justification to warrant earthworms as a representative receptor of concern for the Firestone Test Facility MRS.

Mammalian Herbivore Exposure to Soil

Mammalian herbivore exposure to soil is applicable to the Firestone Test Facility MRS. Cottontail rabbits and meadow voles represent mammalian herbivore receptors, and there is suitable habitat present for them at the MRS. Both species have ecological relevance by consuming vegetation, which helps in the regulation of plant populations and in the dispersion of some plant seeds. Small herbivorous mammals such as cottontail rabbits and voles are prey items for top terrestrial predators.

Both cottontail rabbits and meadow voles are susceptible to exposure to and toxicity from, COPCs in soil and vegetation. Herbivorous mammals are exposed primarily through ingestion of plant material and incidental ingestion of contaminated surface soil containing chemicals. Exposures by inhalation of COPECs in air or on suspended particulates, as well as exposures by direct contact with soil, were assumed to be negligible. Dietary toxicity benchmarks are available for many COPECs for mammals (Sample et al., 1996), and there are regulatory statutes for rabbits because they are an upland small game species protected under Ohio hunting regulations. There are no specific regulatory statutes for meadow voles at the Firestone Test Facility MRS. Meadow voles have smaller home ranges than rabbits, which make them potentially more susceptible to localized contamination. Therefore, they are a more conservative selection as a representative mammalian herbivore than rabbits, and are selected as representative receptors of concern for the Firestone Test Facility MRS.

Insectivorous Mammal and Bird Exposure to Soil

Insectivorous mammal and bird exposure to soil is applicable to the Firestone Test Facility MRS. Short-tailed shrews and American robins represent the receptors for the insectivorous mammal and bird terrestrial exposure class, respectively. There is sufficient, suitable habitat present at the MRS for these receptors. Both species have ecological relevance because they help to control above-ground invertebrate community size by consuming large numbers of invertebrates. Shrews and robins are a prey item for terrestrial top predators.

Both short-tailed shrews and American robins are susceptible to exposure to and toxicity from COPECs in soil, as well as contaminants in vegetation and terrestrial invertebrates. Insectivorous mammals such as short-tailed shrews and birds such as American robins are primarily exposed by ingestion of contaminated prey (i.e., earthworms, insect larvae, and slugs), as well as ingestion of soil. In addition, shrews ingest a small amount of leafy vegetation, and the robin's diet consists of 50 percent each of seeds and fruit. Dietary toxicity benchmarks are available for mammals and birds (Sample et al., 1996). Both species are recommended as receptors because there can be different toxicological sensitivity between mammals and birds exposed to the same contaminants. There are regulatory statutes for robins because they are federally protected under the *Migratory Bird Treaty Act of 1993*, as amended, and are consistent with the INRMP (AMEC, 2008) polices and management goals. There are no specific regulatory statutes for shrews at the MRS. Based on the regulatory statutes for robins, plus the susceptibility to contamination and ecological relevance for both species, there is sufficient justification to warrant shrews and robins as representative receptors of concern for the Firestone Test Facility MRS.

Terrestrial Top Predators

Exposure of terrestrial top predators is applicable to the Firestone Test Facility MRS. However, the small size of the MRS reduces the importance of any potential contamination to these types of receptors, which typically have very large home ranges and would not be exposed to such a small area on a regular basis.

Red foxes and red-tailed hawks represent the mammal and bird receptors for the terrestrial top predator exposure class, and there is a limited amount of suitable habitat available for them at the MRS. Both species have ecological relevance; as representatives of the top of the food chain for the terrestrial EUs, they control populations of prey animals such as small mammals and birds.

Both red foxes and red-tailed hawks are susceptible to exposure to and toxicity from COPECs in soil, vegetation, and/or animal prey. Terrestrial top predators feed on small mammals and birds that may accumulate constituents in their tissues following exposure at the MRS. There is a potential difference in toxicological sensitivity between mammals and birds exposed to the same COPECs so it is prudent to examine a species from each taxon (Mammalia and Aves, respectively). Red foxes are primarily carnivorous but consume some plant material. The red-tailed hawk consumes only animal prey. The fox may incidentally consume soil. There are regulatory statutes for both species. Laws (Ohio trapping season regulations for foxes, and federal protection of raptors under the *Migratory Bird Treaty Act of 1993,* as amended) and the INRMP (AMEC, 2008) policies and management goals also protect these species. In addition, both species are susceptible to contamination and have ecological relevance as top predators in the terrestrial ecosystem. Thus, there is sufficient justification to warrant these two species as representative receptors of concern for the Firestone Test Facility MRS.

Aquatic and Semiaquatic Exposure Classes and Receptors

The shaped charge test pond represents limited aquatic habitat at the MRS that may be used by some aquatic and semiaquatic organisms. The aquatic and semiaquatic exposures, receptors, and justification for their relevance at the Firestone Test Facility MRS are presented in the following sections.

Exposure of Aquatic Biota to Water

Exposure of aquatic biota to water is applicable to the Firestone Test Facility MRS. Species that spend some or all of their lifecycles in water (i.e., water-column-dwelling organisms such as aquatic invertebrates and fish) represent the ecological receptors for the aquatic biota exposure class, and aquatic habitat is available at this MRS. Aquatic biota have ecological relevance because they represent the range of living organisms in the aquatic ecosystem and they provide food for various predators.

Aquatic biota is susceptible to exposure to and toxicity from COPECs in surface water. The exposure concentration for aquatic biota is assumed to be equal to the measured environmental concentration because the biota has constant contact with water and the aquatic toxicity benchmarks that are used are expected to protect aquatic life from all exposure pathways, including ingestion of surface water as well as contaminated plants and animals. Toxicity benchmarks are available for aquatic biota, but Ohio Administrative Code 3745-1, *Ohio River Basin Aquatic Life Criteria,* (Ohio EPA, 2011) for surface water must also be met. The INRMP (AMEC, 2008) policies and management goals also protect these species.

There are regulatory statutes for aquatic biota in laws that specify Ohio water quality standards to support designated uses (i.e., survival and propagation of aquatic life) for waters of the state. In addition, aquatic biota is susceptible to contamination by virtue of continual exposure in water, and they have ecological relevance within the aquatic and terrestrial ecosystems. Thus, there is sufficient justification to warrant aquatic biota as representative receptors of concern for the Firestone Test Facility MRS.

Exposure of Sediment-Dwelling Biota to Sediment

Sediment-dwelling biota exposure to sediment is applicable to the MRS-specific analysis. Benthic invertebrates such as aquatic insect larvae like caddisflies (*Trichoptera*), mayflies (*Ephemeroptera*), and midges (*Chironomidae*), as well as non-insects such as crayfish (*Decapoda*), snails (*Gastropoda*), and clams and bivalves (*Pelycypoda*), represent the receptors for the sediment-dwelling biota aquatic exposure class. These biotas have ecological relevance because they provide food for many aquatic species and also for some terrestrial mammals and birds such as raccoons, mallards, and herons.

Benthic invertebrates are susceptible to exposure to and toxicity from COPECs in sediment. This biota has direct contact with sediment and sediment pore water. Toxicity benchmarks are available for benthic invertebrates.

There are regulatory statutes for sediment-dwelling biota because the condition of these biological communities is linked to assessment of Ohio water quality use attainment in streams. This biota is susceptible to contamination by virtue of continual exposure in sediment, and they have ecological relevance as a major food source for aquatic biota. Thus, there is sufficient justification to warrant sediment-dwelling biota as a representative receptor of concern for the Level III Baseline screen.

Herbivore Exposure to Water, Sediment, and the Aquatic Food Web

Aquatic herbivores like muskrats and mallard ducks are exposed to water and sediment. Therefore, these exposures are applicable to the Firestone Test Facility MRS. Although there is suitable habitat for them at the MRS, the size of the pond is very small (approximately 40 feet in diameter), and these receptors would likely utilize other, noncontaminated water bodies as well. Therefore, it is unlikely that these receptors would be regularly exposed to this pond.

Muskrats ingest aquatic vegetation. Mallard ducks are surface-feeding ducks that obtain much of their food by dabbling in shallow water and filtering through soft mud with their bills. Their food consists mostly of seeds of aquatic plants, as well as aquatic invertebrates (EPA, 1993). Animal matter accounts for the majority of the diet for breeding female ducks during the spring and summer, but decreases to less than 10 percent of the diet during the winter. Mallards have ecological relevance as important components of the aquatic food web. As aquatic herbivores, muskrats and mallards help maintain the size and composition of the aquatic vegetation community.

Muskrats and mallards are susceptible to exposure to and toxicity from COPECs in surface water and aquatic vegetation. The potential for exposure to contaminants is high because they consume aquatic and sediment-dwelling plants that can accumulate high concentrations of some chemicals from water. In addition, these species can have further exposure via ingestion of contaminants in surface water that they use for a drinking water source and incidentally ingested sediment. Since there is a potential difference in the toxicological sensitivity of mammals and birds exposed to the same COPECs, one mammal and one bird were examined for exposure to water, sediment, and the aquatic food chain. Dietary toxicity benchmarks for many inorganic and some organic substances are available for mammals and birds.

There are regulatory statutes for muskrats and mallards. For example, there are Ohio trapping season regulations for muskrats, and mallards are federally protected under the *Migratory Bird Treaty Act of 1993*, as amended. Mallard ducks are also federally protected as a game species under the *Migratory Bird Hunting and Conservation Stamp Act of 1934*, as amended. The INRMP (AMEC, 2008) policies and management goals also protect these species. Both species are susceptible to COPECs, especially via ingestion exposure, and they have ecological relevance. Thus, there is sufficient justification to select these species as representative receptors of concern for the Firestone Test Facility MRS.

Semiaquatic Carnivores

Exposure of predators to aquatic biota is applicable to the Firestone Test Facility MRS because persistent, bioaccumulative, and toxic (PBT) chemicals are present at the MRS. Although there is suitable habitat for them at the MRS, the size of the pond is very small (approximately 40 feet in diameter), and these receptors would likely utilize other, noncontaminated water bodies as well. Therefore, it is unlikely that these receptors would be regularly exposed to this pond.

Exposure evaluation for piscivores (fish-eating predators) is required by the Ohio EPA Guidance (2008) when a PBT compound or a COPEC with no screening benchmark is found in surface water or sediment. Mink and great blue herons are semiaquatic carnivores selected to represent mammalian and bird receptors for the fish-eating predator exposure class. These semiaquatic carnivores feed predominantly in and along the riparian zone along the banks of streams. Both species have ecological relevance because they are important components of the aquatic food web representing the top predators. As top predators, they help limit the population size for some aquatic and some sediment-dwelling biota communities.

Both species are susceptible to exposure to and toxicity from COPECs in surface water, aquatic biota, and sediment-dwelling biota. The potential for exposure to COPECs is high for these two species because they consume fish, which can accumulate high concentrations of some chemicals from water. In addition, both species can have further exposure via ingestion of COPECs in surface water that is used for a drinking water source. Dietary toxicity benchmarks are available for mammals and birds. There can be differences in toxicological sensitivity between mammals and birds exposed to the same COPEC, so both species are appropriate for consideration.

There are regulatory statutes for both species because regulations protect both species. For example, mink are regulated by Ohio trapping regulations because they are fur-bearing mammals. Great blue herons are federally protected under the *Migratory Bird Treaty Act of 1993*, as amended, in addition to the INRMP (AMEC, 2008) policies and management goals. Both species are susceptible to contamination, especially via ingestion exposure routes, and they have ecological relevance as predators. Thus, there is sufficient justification to warrant evaluating these two receptors as representative receptors of concern for the Firestone Test Facility MRS.

8.3.1.8 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at Firestone Test Facility MRS were described in the previous sections. There are relevant and complete exposure pathways that are present at the MRS for various ecological receptors including terrestrial invertebrates; aquatic and sediment-dwelling biota; and terrestrial and aquatic herbivores, insectivores, and carnivores. Thus, these types of receptors could be exposed to COPECs in biotic media at the Firestone Test Facility MRS.

8.3.2 Ecologic Endpoint (Assessment and Measurement) Identifications

The protection of ecological resources, such as habitats and species of animals, is a primary motivation for conducting SLERAs. Key aspects of ecological protection are presented as general management goals. These are non-site-specific goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (i.e., the CERCLA and NCP). Other legislation includes the ESA (16 USC § 1538, et seq., 1993, as amended) and the *Migratory Bird Treaty Act* (16 USC 703-711, 1993, as amended). Specific management goals for the MRS pertaining to natural resources management goals for the facility are presented in Section 8.2, "Level I Scoping." Based on these facility management goals, two general management goals were identified for the Firestone Test Facility MRS SLERA based upon the CSM. These general management goals for the SLERA were as follows:

- **General Management Goal 1—**Protect terrestrial animal populations from adverse effect due to the release or potential release of chemical substances associated with past MRS activities.

- **General Management Goal 2—**Protect aquatic and semiaquatic animal populations and communities from adverse effect due to the release or potential release of chemical substances associated with past MRS activities.

To evaluate whether a management goal has been met, assessment endpoints, measures of effects, and decision rules were formulated. An ecological assessment endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor (i.e., COPEC). Assessment endpoints are "explicit expressions of the actual environmental value that is to be protected" (EPA, 1992). Assessment endpoints often reflect environmental values that are protected by law, provide critical resources, or provide an ecological function that would be significantly impaired if the resource was altered. Unlike the HHRA process, which focuses on individual receptors, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. Population responses are also better defined and predictable than are community and ecosystem responses (USACE, 2010b). In the SLERA process, risks to individuals are assessed only if they are protected under the ESA (16 USC § 1538, et seq.) or other species-specific legislation, or if the species is a candidate for listing as a threatened and endangered species. As discussed in Section 8.2.4.4, threatened and endangered species are not a concern at Firestone Test Facility MRS; therefore, potential impacts to populations are the appropriate criterion for consideration.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Therefore, the Ohio EPA Guidance (2008) was used to select assessment endpoints.

For the Level II Screening, the assessment endpoints are any potential adverse effects on ecological receptors, where receptors are defined as any plant or animal population, communities, habitats, and sensitive environments (Ohio EPA, 2008). Although the assessment endpoints for the Level II Screening are associated with General Management Goals 1 and 2, specific receptors are not identified with the assessment endpoints.

Table 8-1 shows the General Management Goals for terrestrial, aquatic, and semiaquatic resources, attendant assessment endpoints, measures of effect, and decision rule by assessment endpoint number. Furthermore, the table provides definitions of Assessment Endpoints 1, 2, 3, and 4 (terrestrial receptors), and 5, 6, 7, and 8 (aquatic and semiaquatic receptors). As stated, the assessment endpoint table includes a column describing the conditions for making a decision depending on whether the HQ is less than or more than 1. If the HQ is greater than 1, the scientific management decision point (SMDP) options from Ohio EPA/U.S. Army guidance are provided (i.e., no further action, risk management, monitoring, remediation, or further investigation).

Table 8-1
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

General Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
General Management Goal 1: The protection of terrestrial populations, communities, and ecosystems	**Assessment Endpoint 1:** Growth, survival, and reproduction of soil invertebrate communities and tissue concentrations of contaminants low enough such that higher trophic levels that consume them are not at risk. Receptors: earthworms	**Measures of Effect 1:** Earthworm soil toxicity benchmarks and measured RME concentrations of constituents in soil.	**Decision Rule for Assessment Endpoint 1:** If HQs, defined as the ratios of COPEC RME concentrations in surface soil to soil toxicity benchmarks for adverse effects on soil invertebrates, are less than or equal to 1, then Assessment Endpoint 1 has been met and soil-dwelling invertebrates are not at risk. If HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs and applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 2: Growth, survival, and reproduction of herbivorous mammal populations and low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk. Receptor: meadow vole	**Measures of Effect 2:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	**Decision Rule for Assessment Endpoint 2**: If HQs, based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on herbivorous mammals are less than or equal to 1, Assessment Endpoint 2 is met, and the receptors are not at risk. If HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 3: Growth, survival, and reproduction of worm-eating and insectivorous mammal and bird populations and low enough concentrations of contaminants in their tissue so that higher trophic level animals that consume them are not at risk. Receptors: shrews and robins	**Measures of Effect 3:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	**Decision Rule for Assessment Endpoint 3:** If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on worm-eating and insectivorous mammals and birds is less than or equal to 1, then Assessment Endpoint 3 is met, and these receptors are not at risk. If HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 4: Growth, survival, and reproduction of carnivorous mammal and bird populations. Receptors: red-tailed hawk and red fox	**Measures of Effect 4:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	**Decision Rule for Assessment Endpoint 4:** If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on carnivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 4 is met, and the receptors are not at risk. If HQs are >1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 8-1 (continued)
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

General Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
	Assessment Endpoint 5: Survival, reproduction, and diversity of benthic invertebrate communities, as well as low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk. Receptor: benthic invertebrates	**Measures of Effect 5:** Measured concentration of contaminants in sediment and sediment toxicity thresholds, i.e., consensus-based threshold effect concentrations, EPA Region 5 ESLs, and Ohio EPA sediment reference values.	**Decision Rule for Assessment Endpoint 5:** If HQs based on ratios of COPEC RME concentrations in sediment-to-sediment toxicity benchmarks are less than or equal to 1, then Assessment Endpoint 5 is met and sediment-dwelling organisms are not at risk. If HQs are > 1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 6: Growth, survival, and reproduction of aquatic biota (including fish and invertebrates). Receptor: aquatic biota	**Measures of Effect 6:** Measured concentrations of contaminants in surface water and Ohio EPA Chemical-Specific Water Quality Criteria.	**Decision Rule for Assessment Endpoint 6:** If HQs based on ratios of COPEC RME concentrations in surface water to aquatic biota toxicity benchmarks are less than or equal to 1, then Assessment Endpoint 6 is met and the receptors are not at risk. If HQs are > 1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
General Management Goal 2: The protection of aquatic populations, communities, and ecosystems	**Assessment Endpoint 7:** Growth, survival, and reproduction of aquatic herbivores that ingest aquatic plants, surface water, and sediment. Receptors: muskrats and mallards	**Measures of Effect 7:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	**Decision Rule 7:** If HQs based on ratios of COPEC RME concentrations in surface water and sediment to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on aquatic herbivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 7 is met and the receptors are not at risk. If HQs are > 1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological receptors, monitoring of the environment, remediation of any MRS-usage-related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 8: Growth, survival, and reproduction of riparian carnivorous mammal and bird communities that feed on aquatic organisms. Receptors: mink and herons	**Measures of Effect 8:** Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	**Decision Rule 8:** If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface water to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on riparian carnivores is less than or equal to 1, then Assessment Endpoint 8 has been met and these receptor populations are not at risk. If HQs are > 1, a SMDP is reached, at which point it will be necessary to decide what is needed: no further action, risk management of ecological receptors, monitoring of the environment, remediation of any MRS usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 8-1 (continued)
General Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for a Level II Screening

COPEC denotes chemical of potential ecological concern.
EPA denotes U. S. Environmental Protection Agency.
ESL denotes ecological screening level.
HQ denotes hazard quotient.
MRS denotes munitions response site.
NOAEL denotes no observed adverse effect level.
Ohio EPA denotes Ohio Environmental Protection Agency.
RME denotes reasonable maximum exposure.
SMDP denotes scientific management decision point.
TRV denotes toxicity reference value.

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If a Level III Baseline evaluation is warranted, the assessment endpoints are more specific and stated in terms of types of specific ecological receptors associated with each of the two general management goals. Assessment endpoints 1, 2, 3, and 4 entail the growth, survival, and reproduction of terrestrial receptors such as terrestrial invertebrates, herbivorous mammals, worm-eating/insectivorous mammals and birds, and carnivorous top predator mammals and birds, respectively. Assessment endpoints 1 through 4 are associated with General Management Goal 1, protection of terrestrial populations and communities. Assessment endpoint 5 deals with the growth, survival, and reproduction of sediment-dwelling biota, which is associated with General Management Goal 2, protection of aquatic and semiaquatic populations and communities. Assessment endpoints 6, 7, and 8 are also associated with General Management Goal 2, and deal with the growth, survival, and reproduction of aquatic biota, aquatic herbivores, and semiaquatic carnivores, respectively.

The assessment endpoints are evaluated through the use of measurement endpoints. EPA defines measurement endpoints as ecological characteristics used to quantify and predict change in the assessment endpoints. They consist of measures of receptor and population characteristics, measures of exposure, and measures of effect. For example, measures of receptor characteristics include parameters such as home range, food intake rate, and dietary composition. Measures of exposure include attributes of the environment such as contaminant concentrations in soil, sediment, surface water, and biota. The measurement endpoints of effect for the Level II Screening evaluation consist of the comparison of the maximum detected concentrations of each contaminant in each medium to ESV benchmarks for chemicals detected in soil and sediment, and *Ohio River Basin Aquatic Life Criteria* (Ohio EPA, 2011) for surface water. Measurement endpoints for the optional Level III Baseline evaluation would include the comparison of predicted doses of chemicals in various receptor animals such as voles, shrews, American robins, and aquatic biota to toxicity reference values.

In the Level II Screening, maximum detected concentrations in soil or sediment at each EU were compared to default soil or sediment ESVs that are expected not to cause harm to ecological populations. The maximum detected concentrations in surface water were compared to *Ohio River Basin Aquatic Life Criteria* (Ohio EPA, 2011). The Level II Screening used the Ohio EPA Guidance (2008) for selecting screening values for soil and sediment, and *Ohio River Basin Aquatic Life Criteria* (Ohio EPA, 2011) for surface water.

The COPECs that were retained after the Level II Screening are potentially subject to a Level III Baseline analysis with exposures that are more representative of the exposures expected for the representative receptors. The Level III Baseline analysis includes evaluation of exposure of a variety of receptors to the reasonable maximum exposure concentrations of COPECs at each EU, using default dietary and uptake factors. The representative ecological receptors may not all be present at each EU. However, all representative receptors are evaluated at this step.

For the optional Level III Baseline evaluation, the decision rules for COPECs came from the Ohio EPA Guidance (2008) for chemicals. Briefly, for COPECs, the first decision rule is based on the ratio (or HQ) of the dose to a given receptor species (i.e., a vole, representing herbivorous mammals) associated with a chemical's concentration in the environment (numerator) to the ecological effects or toxicity reference value (denominator) of the same chemical. A ratio of 1 or smaller means that ecological risk is negligible while a ratio of greater than 1 means that ecological risk from that individual chemical is possible and that additional investigation should follow to confirm or refute this prediction. The second decision rule is that if "no other observed significant adverse effects on the health or viability of the local individuals or populations of species are identified" (Ohio EPA, 2008) and the HI does not exceed 1, "the site is highly unlikely to present significant risks to endpoint species" (Ohio EPA, 2008). There are three potential outcomes for the Level III Baseline evaluation: (1) no significant risks to endpoint species so no further analysis is needed, (2) conduct field baseline assessment to quantify adverse effects to populations of representative species that were shown to be potentially impacted based on hazard calculations in the Level III Baseline evaluation, or (3) remedial action taken without further study.

8.3.3 Identification of COPECs

This section presents the screening of analytical data obtained from samples collected from the Firestone Test Facility MRS in surface soil, sediment, and surface water. After the Level II Screening is complete, any COPECs identified are discussed in greater detail, and a recommendation is made as to whether the ERA should proceed to a Level III Baseline or Level IV Field Baseline.

8.3.3.1 Data Used in the SLERA

Historical sampling activities have included the collection of environmental samples at the Load Line #6 AOC in support of the IRP in which the Firestone Test Facility MRS is collocated. Additionally, an ISM sample was collected within the former MRS boundary during the SI phase of the MMRP. The data sets from these previous investigations were reviewed and the data was determined as not applicable since the samples were collected outside of the current MRS and are not representative of the current conditions within the MRS boundaries investigated during the RI field activities.

Although no MEC or MD has been found to date at the MRS, an MC investigation was performed for the RI to characterize the nature and extent of SRCs associated with previous activities at the MRS in surface soil around the pond and in the pond sediment. The MC investigation consisted of the collection of one ISM surface soil sample at 0 to 0.5 feet bgs and two sediment samples at the 0- to 0.5-foot depth interval below the sediment surface. A surface water sample was initially collected to evaluate options for investigating the test pond sediment, which included approved and controlled discharge to the ground surface or manual diving operations. The surface water sample was also used to characterize for MC in the pond as well. Each medium was evaluated as a separate EU for the MRS. A summary of the Firestone Test Facility MRS environmental media samples used for the SLERA is presented in **Table 8-2**.

Table 8-2
Summary of Data Used in the Ecological Risk Assessment

Sample Location ID	Sample Date	Depth	Sample Type	Analysis
Surface Soil				
FTFSS-004(I)-0001-SS	8/12/11	0–0.5 feet bgs	ISM	Metals[1], Explosives, Nitrocellulose, TOC, pH
Sediment				
FTFSD-002-SD	8/8/11	0–0.5 feet bss	D	Metals[1], Explosives, Nitrocellulose, TOC
FTFSD-003-SD	8/8/11	0–0.5 feet bss	D	
Surface Water				
FTFSW-001-0001-SW	5/5/11	6–7 feet bws	D	Metals[2], Explosives, Nitrocellulose

[1] *Metals includes analysis for aluminum, cadmium, copper, chromium (total and hexavalent), iron, lead, zinc, antimony, strontium, barium, and mercury.*

[2] *Metals includes analysis for aluminum, antimony, barium, cadmium, total chromium, copper, iron, lead, strontium, mercury, and zinc.*

bgs denotes below ground surface.
bss denotes below sediment surface.
bws denotes below water surface.
D denotes discrete.
ID denotes identification.
ISM denotes incremental sample methodology.
MEC denotes munitions and explosives of concern.

The MC analytical data were reviewed and evaluated for quality, usefulness, and uncertainty, as described in Section 4.2, "MC Data Evaluation." From the MC chemical results of samples described above, a COPEC selection process was performed to develop a subset of chemicals that are identified as COPECs.

8.3.3.2 COPEC Selection Criteria

The section describes the selection criteria used to identify COPECs in the SLERA. The screen incorporates the same criteria described in Section 4.2.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, and essential nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected MC-related contaminants at the MRS. With the exceptions of these chemicals, all detected chemicals considered as SRCs associated with the munitions used at the Firestone Test Facility MRS and are included in the COPEC screening step. The SRCs identified for the environmental media sampled during the RI field activities included the following:

- **Surface Soil (0 to 0.5 feet bgs):** antimony, cadmium, chromium, copper, and strontium
- **Sediment (0 to 0.5 feet bss):** aluminum, antimony, cadmium, copper, lead, and strontium
- **Surface Water:** chromium, copper, lead, and strontium

Comparison to Ecological Screening Values

The maximum detected concentrations of chemicals detected in various media were compared with ESVs used as ecological endpoints consistent with the Unified Approach for performing ERAs at the facility and following recommendations in the Ohio EPA Guidance (2008). The SRCs that exceed the ESVs, or for which no ESVs are available, were retained as COPECs. The following hierarchy was used to select ESVs for the ecological evaluation of surface soil, sediment, and surface water:

Surface Soil

For surface soils, the maximum detected concentration of each COPEC was compared to soil ESVs. The hierarchy of sources of soil ESVs, in order of preference, was as follows:

- *Ecological Soil Screening Level Guidance* (EPA, 2010) online updates from http://www.epa.gov/ecotox/ecossl/
- Oak Ridge National Laboratory (ORNL): Efroymson, et al, 1997b. *Preliminary Remediation Goals for Ecological Endpoints*, ES/ER/TM-162/R2
- *Region 5 RCRA Ecological Screening Levels (ESLs)*, (EPA, 2003)
- Los Alamos National Laboratory (LANL): *ECORISK Database (Release 2.5,)* November 2010
- Talmage et al., 1999. *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values*, Rev. Environ. Contamin. Toxicol., 161: 1–156

Sediment

The hierarchy for the sediment ESVs, in order of preference, was as follows:

- MacDonald et al., 2000. *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems,* Arch. Environ. Contam. Toxicol. 39:20–31, Threshold Effect Concentration
- ESLs (EPA, 2003)
- ORNL (Efroymson et al., 1997b)
- LANL, 2010
- Talmage et al., 1999

Surface Water

For surface water, the maximum detected concentrations of COPECs are to be compared to the surface water ESVs. The hierarchy for surface water ESVs, in order of preference, was as follows:

- Ohio Administrative Code 3745-1, *Ohio River Basin Aquatic Life Criteria, OMZA*, March 6, 2011. (Based on total recoverable metals and assuming a hardness value of 100 milligrams per liter [mg/L] for hardness dependent criteria, iron and nitrate/nitrite criteria are based on protection of agricultural use.) (Ohio EPA, 2011)
- ESLs (EPA, 2003)
- ORNL (Efroymson et al., 1997b)
- LANL, 2010
- Talmage et al., 1999

The ESVs used for the SLERA are presented in **Appendix I**.

Essential Nutrients

Evaluating essential nutrients is a special form of risk-based screening applied to certain ubiquitous elements that are generally considered to be required nutrients. Essential nutrients such as calcium, iron, magnesium, potassium, and sodium are usually eliminated as COPECs because they are generally considered to be innocuous in environmental media (EPA, 2001). Iron is considered to be an MC associated with the shaped charge historically used at the MRS and is not eliminated as an essential nutrient.

8.3.4 Summary of COPEC Selection

The results of the COPEC screening for surface soil, sediment, and surface water are presented in **Tables 8-3**, **8-4**, and **8-5**, respectively. The tables present the following information for each medium:

- Identified SRC
- Range of detected concentrations
- Range of detection limits
- BSV
- ESV
- HQ
- Determination as to whether the chemical is a PBT compound (soil and sediment only)
- Determination as to whether the chemical is a COPEC

The HQ is calculated as the detected concentration divided by the ESV. An HQ greater than 1 indicates that the concentration in the medium exceeds the conservative ESV, and may indicate that a potential ecological threat exists. Chemicals with HQs less than 1 are considered to be of low concern, and are not carried forward as COPECs, unless the chemical is a PBT pollutant and its ESV is not protective of food chain effects (Ohio EPA, 2008). A description and summary of the COPECs identified in the media at the Firestone Test Facility MRS is presented in the following sections.

8.3.4.1 Soil COPEC Selection

Initial evaluation of the surface soil SRCs in **Table 8-3** identified four COPECs that consist of antimony, cadmium, chromium, and copper. The antimony, chromium, and copper concentrations in the ISM sample exceed the applicable ESVs and the HQs for antimony and copper are greater than 1. Therefore, all three SRCs are automatically retained as COPECs for further evaluation in surface soil. Cadmium does not exceed its ESV or have an HQ greater than 1 but is retained as COPEC in surface soil since it is PBT and the ESV is not protective of food chain effects.

Table 8-3
Statistical Summary and Ecological Screening of ISM Surface Soil (0–0.5 feet bgs)

Site-Related Chemicals	Range of Values, mg/kg						BSV (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[2]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Antimony	1.50		1.50	J	0.81	0.81	0.96	0.27	No	5.6	No	Yes
Cadmium	0.25		0.25		0.041	0.041	0	0.36	Yes	0.7	Yes	Yes
Chromium (as Cr^{+3})	147	J	147	J	0.14	0.14	17.4	26	Yes	5.7	No	Yes
Copper	56.7	J	56.7	J	0.41	0.41	17.7	28	No	2.0	Yes	Yes
Strontium	7.90	J	7.90	J	0.081	0.081	7.9	96	Yes	0.1	No	No

[1] *See Appendix I of this RI Report.*
[2] *Selection of COPECs:*

Yes = COPEC exceeds the ESV and BSV, or is PBT pollutant.

No = The MDC is less than the ESV, and chemical is not a PBT or the ESV is protective of food chain effects.

BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
ESV denotes ecological screening value.
HQ denotes hazard quotient.
J denotes that result is reported is as an estimated value.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
PBT denotes a persistent, bioaccumulative, and toxic.
VQ denotes validation qualifier.

Table 8-4
Statistical Summary and Ecological Screening of Sediment (0–0.5 feet bss)

Site-Related Chemical	Range of Values, mg/kg						BSV (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[2]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Aluminum	12,600		14,700		0.34	0.34	13,900	280	No	52.5	No	Yes
Antimony	0.72	J	0.98	J	1.1	1.1	0	0.36	No	2.7	No	Yes
Cadmium	0.16		0.21		0.056	0.057	0	0.99	Yes	0.2	Yes	Yes
Copper	34.3		50		0.56	0.57	27.6	31.6	No	1.6	Yes	Yes
Lead	24.3		48.2		0.35	0.35	27.4	35.8	No	1.3	Yes	Yes
Strontium	8		8.7		0.11	0.11	0	1,700	Yes	0.005	No	No

[1] See Appendix I of this RI Report.
[2] Selection of COPECs:
Yes = COPEC exceeds the ESV and BSV, or is PBT pollutant.
No = The MDC is less than the ESV, and chemical is not a PBT or the ESV is protective of food chain effects.
bss denotes below sediment surface.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
ESV denotes ecological screening value.
HQ denotes hazard quotient.
J denotes that result is reported is as an estimated value.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
PBT denotes a persistent, bioaccumulative, and toxic.
VQ denotes validation qualifier.

Table 8-5
Statistical Summary and Ecological Screening of Surface Water

Site-Related Chemical	Range of Values, mg/L						BSV (mg/L)	ESV[1] (mg/L)	Below ESV?	HQ	COPEC?[2]
	Detected Concentrations				Reporting Limits						
	Minimum	VQ	Maximum	VQ	Minimum	Maximum					
Chromium (Total)	0.0013	J	0.0013	J	0.0042	0.0042	0	0.011	Yes	0.1	No
Copper	0.0108		0.0108		0.0076	0.0076	7.9	0.0093	No	1.2	Yes
Lead	0.0028	J	0.0028	J	0.0098	0.0098	0	0.0064	Yes	0.4	No
Strontium	0.0425		0.0425		0.006	0.006	0	21	Yes	0.0	No

[1] *See Appendix I of this RI Report.*
[2] *Selection of COPECs:*
Yes = COPEC exceeds the ESV and/or BSV.
No = The MDC is less than the ESV.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
ESV denotes ecological screening value.
HQ denotes hazard quotient.
J denotes that result is reported is as an estimated value.
MDC denotes maximum detected concentration.
mg/L denotes milligrams per liter.
VQ denotes validation qualifier.

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8.3.4.2 Sediment COPEC Selection

Initial evaluation of the SRCs in sediment in **Table 8-4** identified five COPECs that consist of aluminum, antimony, cadmium, copper, and lead. The minimum and maximum concentrations for aluminum, antimony, copper, and lead concentrations in the sediment samples exceed the applicable ESVs and the HQs for all four analytes are greater than 1. Therefore, all four SRCs are automatically retained as COPECs for further evaluation in sediment. Although cadmium was detected at concentrations lower than its ESV, it is also retained as a COPEC in sediment since it is a PBT chemical and the ESV is not protective of food chain effects.

8.3.4.3 Surface Water COPEC Selection

Evaluation of the SRCs in surface water in **Table 8-5** identified only copper as a COPEC. The copper concentration exceeds the ESV and the HQ for copper is greater than 1. Therefore, copper is retained as a COPEC for further evaluation in surface water.

8.3.5 Refinement of COPECs (Step 3a)

Of primary importance in a SLERA is determining whether any ecological threats exist, and if so, whether they are related to chemical contamination (USACE, 2010b). Prior to making the determination as to whether a Level III Baseline is warranted, it is appropriate to evaluate various lines of evidence that might suggest whether or not additional ecological investigation is needed at the MRS. This portion of the Level II Screening represents the Step 3a COPEC refinement, where additional factors are considered that offer more information as to whether a chemical selected as a COPEC during the conservative screening step truly represents an unacceptable risk for ecological receptors. The additional factors to be considered are presented in the Unified Approach list of possible evaluation and refinement factors. Some of these factors are discussed in the following paragraphs.

Due to the highly conservative nature of the Level II Screening, the identification of initial COPECs does not necessarily indicate that the potential for adverse effects is realistic. Although any chemical with an HQ greater than 1 must be identified as a COPEC and is recognized as being a potential concern, if exceedances are low, and other corroborating information suggests that the potential for ecological impacts is minimal, then a recommendation for no additional investigation may be warranted (Ohio EPA, 2008).

As a general consideration, it should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly scaled statistics. Therefore, an HQ above 1, even exceedingly so, does not definitively indicate that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2005; Bartell, 1996). As a general guideline, HQs less than 10 are considered to represent a low potential for environmental effects, HQs from 10 up to but less than 100 are considered to represent a significant potential that effects could result from greater exposure, and HQs greater than 100 represent the highest potential for expected effects (Wentsel et al., 1996). The findings of the Level II Screening are discussed in additional detail in this section to support final recommendations for this stage of the ERA process.

8.3.6 Weight of Evidence Discussion for Surface Soil Samples

Four SRCs (antimony, cadmium, chromium, and copper) were identified as COPECs in the surface soil sample collected for the RI. **Table 8-6** presents a summary of the sample results for the identified COPECs in the soil sampling EU. **Table 8-7** presents the HQs associated with the identified surface soil COPECs.

The antimony, chromium, and copper concentrations exceeded both the applicable BSVs and the ESVs. Antimony and chromium exceeded their ESVs by a factor of slightly greater than 5, resulting in HQs of 5.6 and 5.7 respectively. The copper concentration of 56.7 milligrams per kilogram (mg/kg) was approximately double the ESV of 28 mg/kg, which resulted in an HQ of 2.

The HQs for antimony and chromium (as Cr^{+3}) did not exceed 10; given the conservative nature of the screening values used to generate the HQs, the detected concentrations are unlikely to be of concern. Chromium was also analyzed as Cr^{+6} at this MRS, and all results for this analysis were nondetect; therefore, chromium is assumed to consist nearly entirely of its Cr^{+3} form. Neither antimony nor chromium is considered as a PBT chemical.

Copper is a malleable metal that is subject to smearing during the grinding portion of the processing for ISM samples which can result in uncertainties regarding the detected concentration, as well as cross-sample contamination. However, because only one sample was collected at this MRS (in addition to a field duplicate), cross-contamination is unlikely an issue at the Firestone Test Facility MRS. Concern regarding overestimation of copper in the ground sample is reduced by the duplicate sample result (49.1 mg/kg) that was within 15 percent of the target sample concentration. Copper was also selected as a COPEC in sediment and surface water, which suggests that copper may be an actual MC associated with the shaped charge munitions historically used at the MRS. However, the detected concentration in soil was only two times that of the conservative ESV, and the associated HQ was less than 5.

Cadmium was detected in the surface soil sample at a concentration below its ESV, but was retained as a COPEC due to bioaccumulation concerns. The small size of the MRS (0.41 acres) precludes the use of this site as a sole source of prey items by predatory receptors such as a fox or hawk that might be exposed to cadmium via food chain pathways.

Table 8-6
Summary of COPECs in Surface Soil

			Sample Location:	FTFSS-004	
			Sample Number:	**FTFSS-004(I)-0001-SS**	
			Sample Date:	**8/22/11**	
			Sample Depth (feet bgs):	**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Results**	**VQ**
Antimony	0.96	0.27	mg/kg	***1.5***	
Cadmium[1]	0	0.36	mg/kg	*0.25*	
Chromium (as Cr^{+3})	17.4	26	mg/kg	***147***	**J**
Copper	17.7	28	mg/kg	***56.7***	**J**

[1] No result exceeds the ESV. The chemical was only retained because of its potential to bioaccumulate.
Detects in bold exceed the ESV; detects in italic exceed the BSV, or indicate that a BSV isn't available.
bgs denotes below ground surface.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
ESV denotes ecological screening value.
J denotes that result is reported is as an estimated value.
mg/kg denotes milligram per kilogram.
VQ denotes validated qualifier.

Table 8-7
Summary of HQs for COPECs in Surface Soil

Sample Location:	FTFSS-004
Sample Number:	**FTFSS-004(I)-0001-SS**
Sample Date:	**8/22/11**
Sample Depth (feet bgs):	**0–0.5**
COPEC	**HQ**
Antimony	5.6
Cadmium[1]	
Chromium (as Cr^{+3})	5.7
Copper	2.0

*Only results that exceeded background and ecological screening values in **Table 8-6** are presented.*
[1] No result exceeds the ESV. The chemical was only retained because of the potential to bioaccumulate.
bgs denotes below ground surface.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
HQ denotes hazard quotient.

There are additional considerations regarding the very small size of the affected area. At 0.41 acres, the likelihood that a single individual would be exposed to contaminated soil at the Firestone Test Facility MRS to a sufficient extent to elicit concern is unlikely. As an example, the chromium and copper ESVs are based on the protection of an American woodcock (see **Appendix I**; EPA, 2008b), which has a home range of between 0.7 and 422 acres (EPA, 1993). Therefore, even using the smallest plausible home range, the MRS comprises only 58 percent of a single woodcock's foraging area. Furthermore, because the assessment endpoints for receptors are defined as populations (**Table 8-1**), the likelihood of adverse effects is reduced to an even greater extent when considering that not just one, but multiple individuals of a given species (i.e., a local population) must be regularly exposed to copper in soil for an ecologically relevant adverse effect to occur. Therefore, due to their low degree of exceedance over their conservative ESVs and the small size of the MRS, antimony, cadmium, chromium, and copper in surface soil are not recommended as final COPECs for further evaluation for ecological purposes.

8.3.7 Weight of Evidence Discussion for Sediment Samples

Five metals were selected as COPECs in sediment: aluminum, antimony, cadmium, copper, and lead. **Table 8-8** presents a summary of the sample results for the identified COPECs in the sediment sampling EU. **Table 8-9** presents the HQs associated with the identified COPECs in sediment.

Table 8-8
Summary of COPECs in Sediment

			Sample Location:	**FTFSD-002**		**FTFSD-003**	
			Sample Number:	**FTFSD-002-SD**		**FTFSD-003-SD**	
			Sample Date:	**8/8/11**		**8/8/11**	
			Sample Depth (feet bss):	**0–0.5**		**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**	**Result**	**VQ**
Aluminum	13,900	280	mg/kg	***14,700***		**12,600**	
Antimony	0	0.36	mg/kg	***0.72***	**J**	***0.98***	**J**
Cadmium[1]	0	0.99	mg/kg	*0.21*		*0.16*	
Copper	27.6	31.6	mg/kg	***50***		***34.3***	
Lead	27.4	35.8	mg/kg	24.3		***48.2***	

Table 8-8 (continued)
Summary of COPECs in Sediment

[1] No result exceeds the ESV. The chemical was only retained because of its potential to bioaccumulate.
Detects in bold exceed the ESV; detects in italic exceed the BSV, or indicate that a BSV isn't available.
bss denotes below sediment surface.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
ESV denotes ecological screening value.
J denotes that result is reported is as an estimated value.
mg/kg denotes milligram per kilogram.
NA denotes not available.
VQ denotes validated qualifier.

Table 8-9
Summary of HQs for COPECs in Sediment

Sample Location:	**FTFSD-002**	**FTFSD-003**
Sample Number:	**FTFSD-002-SD**	**FTFSD-003-SD**
Sample Date:	**8/8/2011**	**8/8/2011**
Sample Depth (feet bss):	**0–0.5**	**0–0.5**
COPEC	**HQ**	**HQ**
Aluminum	**52.5**	
Antimony	2.0	2.7
Cadmium[1]		
Copper	1.6	1.1
Lead		1.3

Values in bold exceed an HQ of 10.
*Only results that exceeded background and ecological screening values in **Table 8-8** are presented.*
[1] No result exceeds the ESV. The chemical was only retained because of its potential to bioaccumulate.
bss denotes below sediment surface.
COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.

All COPECs except aluminum had HQs lower than 5. Aluminum had an elevated HQ of 52.5; however, aluminum is a common element in the earth's crust, and its two detections of 12,600 mg/kg and 14,700 mg/kg approximated its BSV of 13,900 mg/kg. Antimony was detected in both sediment samples at concentrations exceeding its ESV, but its HQ was only 2.7. No BSV is available for this chemical and antimony in sediment may be naturally occurring. Copper was detected in both sediment samples at concentrations exceeding its ESV, but its HQ was low at 1.6, indicating that concentrations only marginally exceeded the conservative screening value. The detected concentrations (34.3 mg/kg and 50 mg/kg) were also only slightly greater than its BSV (27.6 mg/kg). Lead was only detected in one out of two samples at concentrations exceeding its ESV and BSV. Additionally, the HQ for lead is 1.3 but does not exceed 1 when rounded to one significant figure, indicating that the lead concentration is not a potential concern. Cadmium was detected in both samples at concentrations below its ESV, but was retained as a COPEC due to bioaccumulation concerns.

The small size of the shaped charge test pond precludes the regular use of this pond as a source of prey items by predatory receptors such as a heron that might be exposed to cadmium via food chain pathways. While such predators may occasionally use the pond for foraging, these receptors typically have large home ranges that would also result in their foraging in other water bodies in the vicinity.

Because of the low concentrations observed for each COPEC relative to their respective background or toxicity-based screening value, the presence of these metals in the shaped charge test pond are considered insignificant, and proceeding to a Level III Baseline evaluation is not considered necessary, and no final COPECs in sediment are recommended. Because some HQs slightly exceeded 1, localized impacts to ecological receptors cannot be ruled out; however, due to the very small size of the MRS, it is unlikely that populations of receptors, which are the endpoints of concern for ERA, would be affected. Nonmotile (i.e., hydric-adapted vegetation) or small range (i.e., benthic invertebrates, small mammals, etc.) could potentially be affected on a highly local scale, but population compensatory mechanisms, as well as avoidance behavior that many organisms exhibit in the presence of contamination, would likely result in few, if any, population-level impacts.

8.3.8 Weight of Evidence Discussion for Surface Water Samples

Copper was the only chemical identified as a COPEC in surface water. The detected concentration of 0.0108 mg/L only slightly exceeded its ESV of 0.0093 mg/L, resulting in an HQ of 1.2. The HQ does not exceed 1 when rounded to one significant number, indicating that the copper concentration is not a potential concern. Therefore, the potential for copper in surface water to impact populations of ecological receptors at the Firestone Test Facility MRS is considered negligible, and copper is not recommended as a final COPEC in surface water. **Table 8-10** summarizes the concentration of copper that was initially identified as a COPEC in the surface water sample. **Table 8-11** presents the HQ associated with the copper concentration.

Table 8-10
Concentrations of COPECs in Surface Water

			Sample Location:	**FTFSW-001**	
			Sample Number:	**FTFSW-001-0001-SW**	
			Sample Date:	**5/5/11**	
			Sample Depth (feet bws):	**6–7**	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**
Copper	0.0079	0.0093	mg/L	***0.0108***	

Detects in bold exceed the ESV; detects in italic exceed the BSV.
BSV denotes background screening value.
bws denotes below water surface.
COPEC denotes chemical of potential ecological concern.
ESV denotes ecological screening value.
mg/L denotes milligram per liter.
VQ denotes validated qualifier.

Table 8-11
Summary of HQs for COPECs in Surface Water

Sample Location:	**FTFSW-001**
Sample Number:	**FTFSW-001-0001-SW**
Sample Date:	**5/5/11**
Sample Depth (feet bws):	**6–7**
COPEC	**HQ**
Copper	1.2

Only results that exceeded background and ecological screening values in ***Table 8-10*** *are presented.*
bws denotes below water surface.
COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.

8.3.9 Level II Screening Conclusions and Recommendations

Several metals were identified as COPECs in surface soil, sediment, and surface water at the Firestone Test Facility MRS. Copper was present in all three media at slightly elevated concentrations, which suggests that it may be an actual MC related to the MRS's previous history as a test area for shaped charges. Antimony and cadmium were identified as COPECs in soil and sediment. Aluminum and lead were identified as COPECs in sediment only. Chromium (as Cr^{+3}) was identified as a COPEC in surface soil only.

All COPECs were detected at concentrations that are unlikely to be ecologically relevant, and detected concentrations of all COPECs approximate their ESVs, BSVs, or both. With the exception of aluminum in sediment, all COPEC HQs were below 6. The aluminum HQ in sediment was approximately 50, but the aluminum ESV is based upon highly conservative toxicity studies that do not account for natural exposure conditions (i.e., aluminum is often not bioavailable in soil and sediment matrices). Furthermore, concentrations of aluminum in sediment approximate background concentrations, and are not considered elevated. The low concentrations observed compared to conservative screening values do not suggest that populations of ecological receptors are likely to be adversely affected by the presence of these chemicals; however, the presence of chemicals with HQs exceeding 1 indicates that the potential for highly localized effects cannot be entirely discounted. Another important consideration is that the very small size of the MRS (0.41 acres) precludes regular use of the habitat by most receptors. Larger-range receptors for which bioaccumulation concerns may be relevant would only use the shaped charge test pond area for foraging a small proportion of the time, resulting in reduced exposure.

In summary, slightly elevated concentrations of several metals in soil and sediment, and copper in all media, indicate that the potential for localized ecological impacts cannot be completely discounted at the Firestone Test Facility MRS. However; assessment endpoints for this MRS are designed to protect populations of ecological receptors at this MRS. Given the conservativeness of the Phase II Screen and the low overall concentrations detected, the potential that exposure to the COPECs identified in this SLERA to adversely impact populations of ecological receptors at the Firestone Test Facility MRS is considered to be very low. No final COPECs are identified for any media, and no further investigation (i.e., a Level III Baseline) or action is necessary at Firestone Test Facility MRS for ecological purposes. Therefore, there are no chemicals of ecological concern that require additional investigation.

9.0 REVISED CONCEPTUAL SITE MODELS

This section presents the revised CSMs for MEC and MC at the Firestone Test Facility MRS based on the results of the data collected for the RI and previous information provided in the SI Report and the HRR (e^2M, 2008). The preliminary CSMs for MEC and MC were discussed in Section 2.0 and the summary of the RI results were presented in Section 4.0. Potential human health and environmental risks were evaluated in Section 7.0 and Section 8.0, respectively. Following the integration of the RI results into the CSMs for MEC and MC, the MRSPP evaluation for the MRS was reevaluated to include the results of the RI and is discussed at the end of this section.

9.1 MEC Exposure Analysis

This section summarizes the RI data results for the MEC exposure pathway analyses for the MRS. As discussed in Section 2.1, "Preliminary CSM and Project Approach," each pathway includes a source, activity, access, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor.

9.1.1 Source

A MEC source is the location where MPPEH or ordnance is situated or are expected to be found. The Firestone Test Facility MRS was used for munitions testing of shaped charges in a former test chamber building and within a test pond. These activities, in particular the pond testing activities, may have resulted in the potential for MEC to be present in surface soil surrounding the test pond and sediment within the test pond.

The UXO survey activities performed during the SI field activities in 2007 resulted in no findings of MEC or MD; however, multiple closely spaced subsurface anomalies were detected around the pond and the location of the former test chamber. At the end of the SI Report (e^2M, 2008) it was determined that the extent of buried MEC items around the perimeter of the pond and in the pond was not fully understood. Based on historical operations at the MRS, any MEC source would be expected to be found just below the ground surface and/or pond sediment.

All accessible areas within the terrestrial portion of the MRS were effectively covered by the DGM survey during the RI and a statistical sampling approach was used to estimate the required sample size for populations. The recommended amount of anomalies to investigate was 25 percent or 105 of the 423 individual anomalies identified during the DGM survey. The 105 anomaly locations were randomly selected and were intrusively investigated using both hand-digging and trenching methods by UXO-qualified personnel. No MEC or MD items were identified at any of the locations that were intrusively investigated. Following the intrusive investigation, the statistical approach used to quantify the results of the intrusive findings indicated that there was a 99 percent probability there is no MEC present at the remaining anomaly locations that were not investigated. The results of the analysis of the intrusive investigation findings meet the DQO inputs provided in the Work Plan (Shaw, 2011) for the statistical sampling approach.

The underwater tactile investigation at the former test pond consisted of manually inspecting 100 percent of the sediment at the bottom and along the edges of the pond. No MEC or MD was found during the pond investigation. Based on these results, no MEC is present in the sediment or soils surrounding the pond area.

9.1.2 Activity

Activity describes ways that receptors come into contact with a source. Current activities at the Firestone Test Facility MRS include maintenance activities, environmental sampling, and natural resource management activities. Biota activities at the MRS may include foot traffic or burrowing activities. The OHARNG projected future land use for the Firestone Test Facility MRS is military training.

9.1.3 Access

Access describes the degree to which a MEC source or environment containing MEC is available to potential receptors. No MEC was identified at the MRS; therefore, receptors are not exposed to MEC at this MRS. However, access at this MRS is currently limited by a gated perimeter fence that limits the ability of receptors from accessing the MRS.

9.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the Firestone Test Facility MRS include both current and anticipated future land users. Ecological receptors (biota) are based on animal, aquatic, and semiaquatic species that are likely to occur in the terrestrial and aquatic habitats at the MRS.

Potential users associated with the current activities include facility personnel, contractors, and occasional trespassers. The National Guard Trainee and the Engineering School Instructor are the Representative Receptors for the future land use at the MRS: military training. Exposure scenarios for these receptors are provided in the FWCUG Guidance (SAIC, 2010). The National Guard Trainee is considered as the most exposed of the current and future potential users that may become exposed to any potentially remaining MEC at the Firestone Test Facility MRS.

The primary MRS-specific biota identified for the MRS includes receptors associated with the terrestrial and aquatic habitats. Ecological receptors in these habitats at the facility are presented in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003b) and include terrestrial invertebrates (earthworms), voles, shrews, rabbits, robins, foxes, hawks, muskrats, ducks, minks, aquatic invertebrates, fish, and benthic invertebrates (insect larvae, crayfish, snails, clams, and bivalves).

9.1.5 MEC Exposure Conclusions

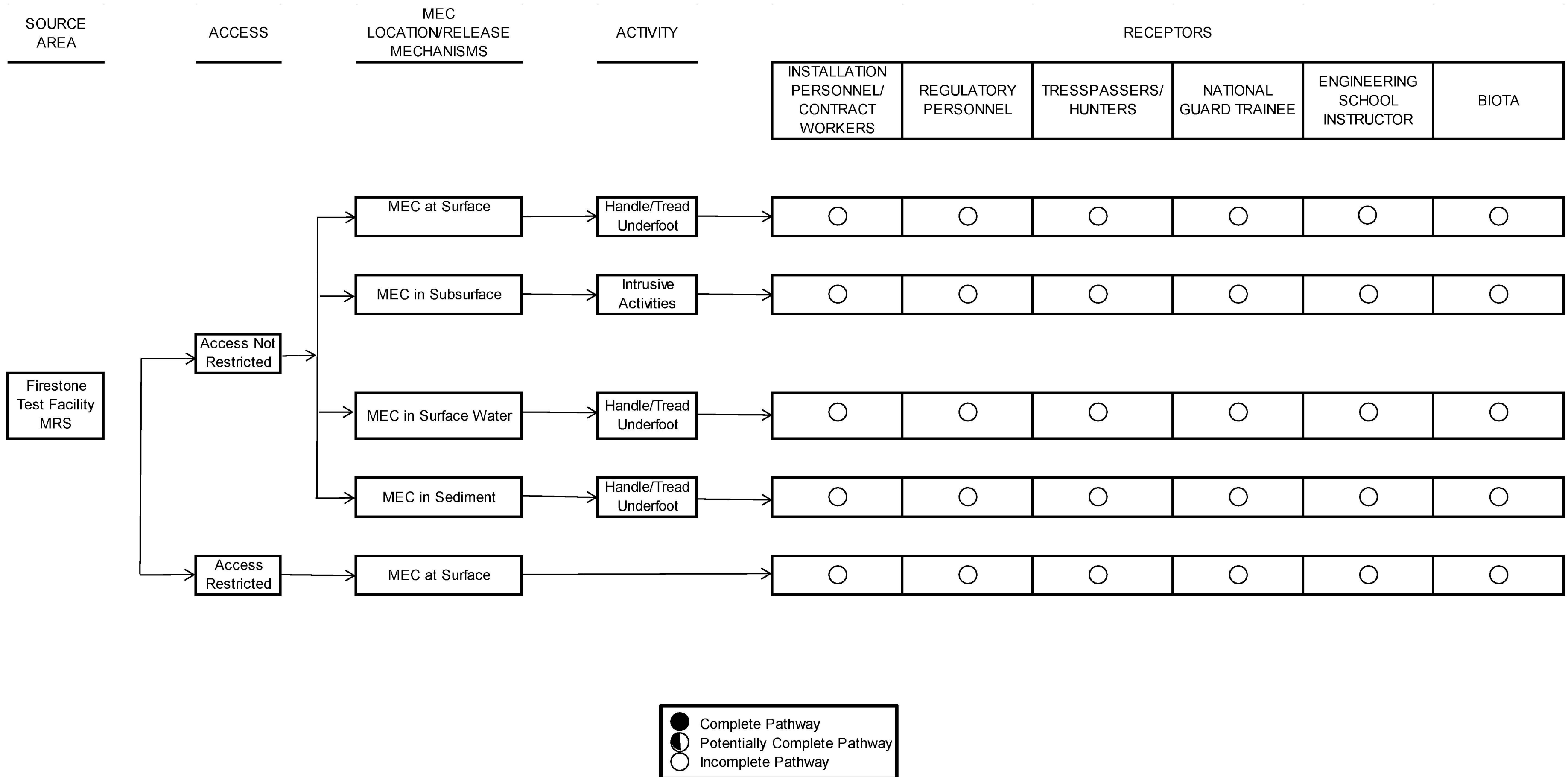
The information collected during the RI was used to update the preliminary MEC CSM for the Firestone Test Facility MRS and to identify all actual, potentially complete, or incomplete source–receptor interactions for the MRS for current and future land uses. The future land use at the MRS is military training, and evaluation of the end use receptors in the revised CSM is consistent with the HHRA approach for the facility as presented in the HHRAM (USACE, 2005). The revised MEC Exposure Pathway Analysis is presented in **Figure 9-1**.

Complete DGM coverage of the accessible terrestrial areas was conducted at the MRS during the RI and a statistical approach was taken for the selection of anomalies for intrusive investigation. An underwater tactile investigation was performed in the former test pond area at the MRS. No MEC or MD was identified at the MRS during the land-based intrusive investigation or in sediment within the former test pond during the RI field activities; therefore, the MEC exposure pathways for surface soil, sediment, and surface water are incomplete for all receptors. Given the lack of a MEC source in surface soil at the MRS, all pathways for subsurface soil for all receptors were determined to be incomplete as well.

9.2 MC Exposure Analysis

A MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and nonexplosive material, and emission degradation, or breakdown elements of such ordnance and munitions (10 USC 2710(e)(4)). The information collected during the RI was used to update the CSM for MC at the Firestone Test Facility MRS and identify all complete, potentially complete, or incomplete source–receptor interactions for the MRS for current and reasonably anticipated future land use activities. The revised MC Exposure Pathway Analysis for the terrestrial and aquatic habitats at the Firestone Test Facility is presented in **Figures 9-2** and **9-3**, respectively.

An MC source is an area where MC has entered (or may enter) the environment. MC contamination may result from a corrosion of munitions or from low-order detonation, the latter of which occurred at the MRS during the testing of shaped charges in the former test pond. No MEC source was identified at the MRS during the RI field activities which could have been a potential source of MC due to corrosion. Additionally, MC that is found at concentrations high enough to pose an explosive safety hazard is considered MEC.



U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

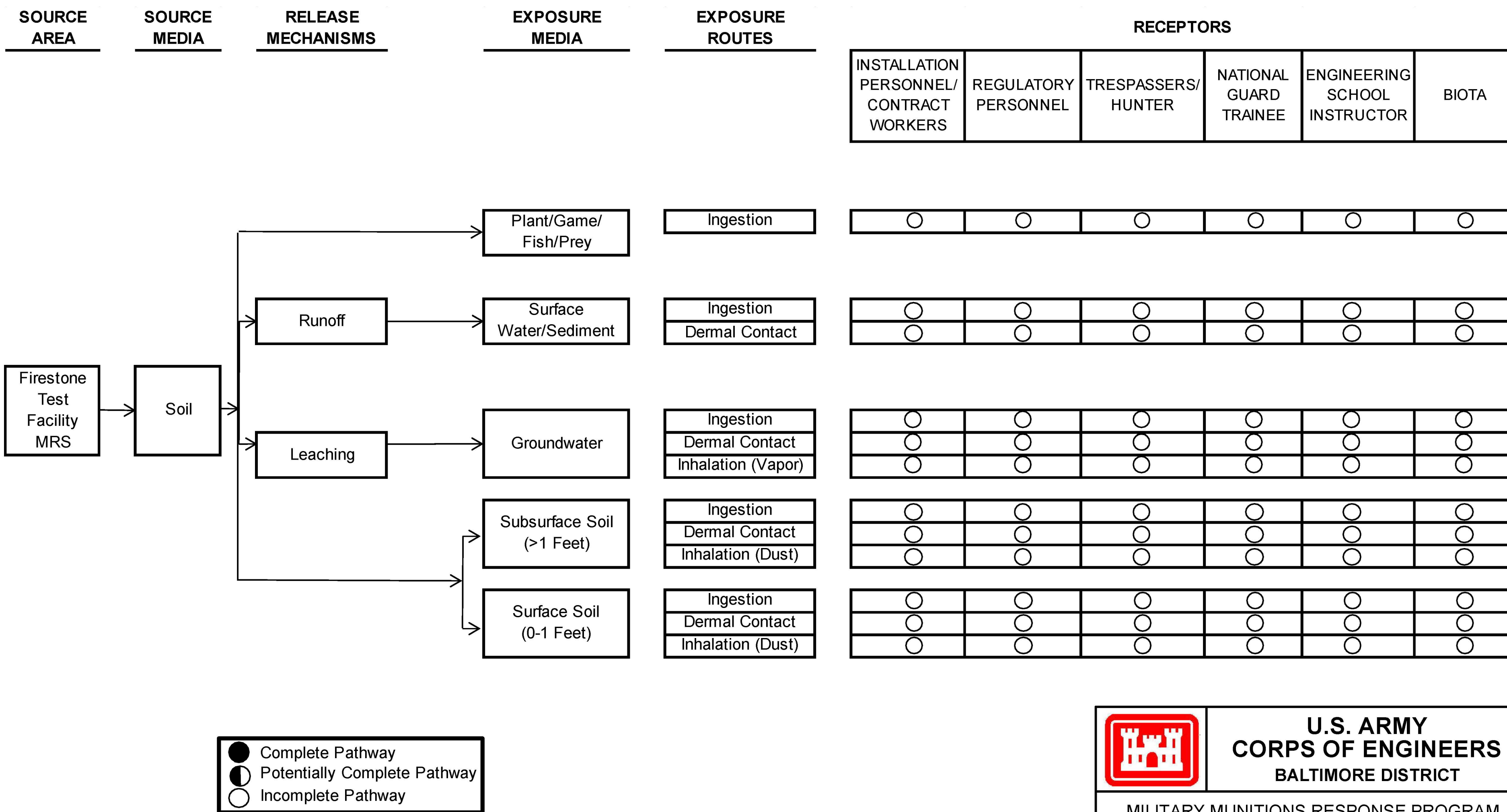
MILITARY MUNITIONS RESPONSE PROGRAM

FIRESTONE TEST FACILITY MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
150 Royall Street
Canton, MA 02021

FIGURE 9-1 REVISED MEC CONCEPTUAL SITE MODEL

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_FirestoneTestFac\2014_June\RVAAP_FTF_018_Fig9_1_Rev_MECCSM_r1.mxd; Analyst: gwt; Date: 8/26/2014 9:52:12 AM



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Canton, MA 02021

FIGURE 9-2 REVISED MC CONCEPTUAL SITE MODEL, TERRESTRIAL ENVIRONMENT

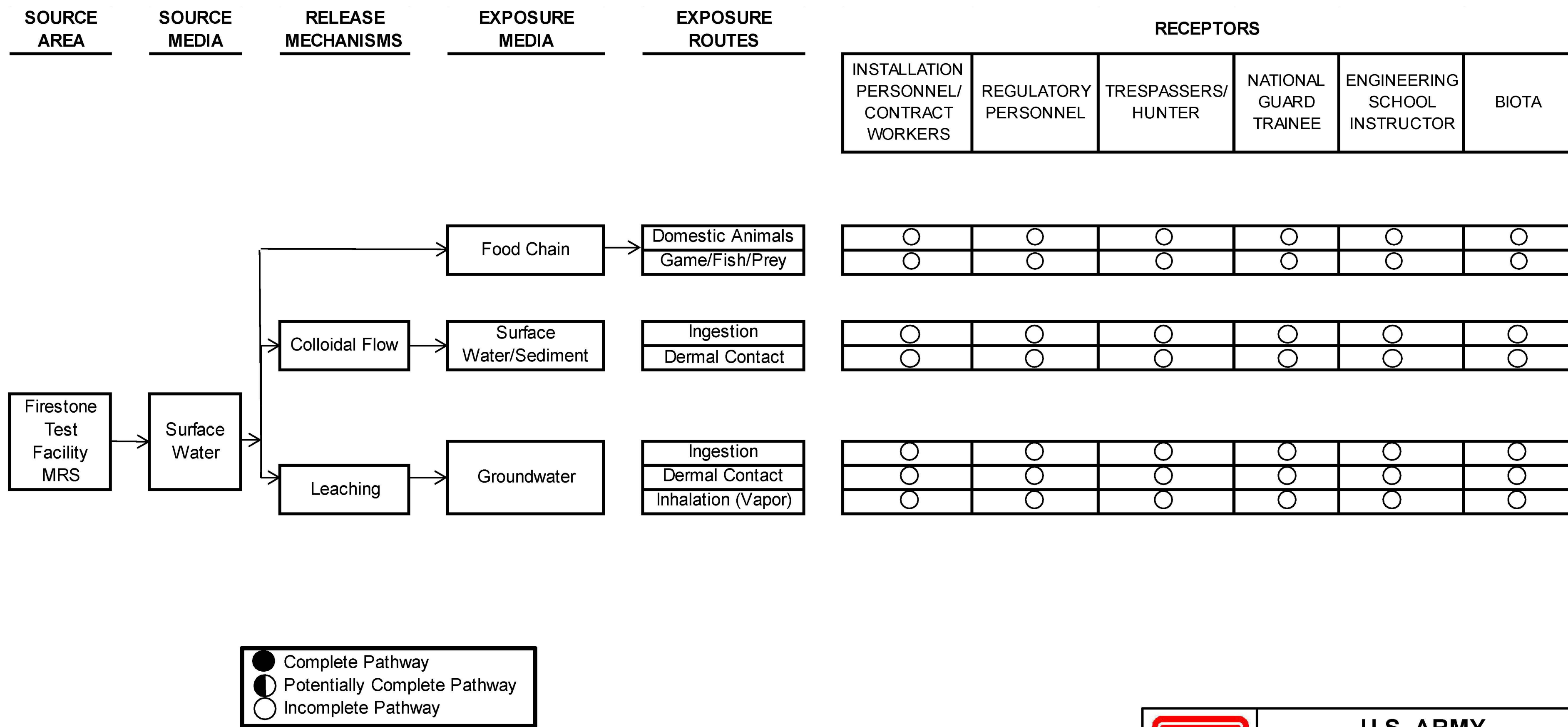

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FIGURE 9-3 REVISED MC CONCEPTUAL SITE MODEL, AQUATIC ENVIRONMENT

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_FirestoneTestFac\2014_June\RVAAP_FTF_020_Fig9_3_Rev_MCCSM_Aquatic_r1.mxd; Analyst: gwt; Date: 8/26/2014 10:03:50 AM

Although a MEC source was not encountered during the RI field activities, sampling for MC was performed at the Firestone Test Facility MRS to characterize the nature and extent of contamination associated with previous activities at the MRS. The detected chemicals were evaluated in accordance with the facility data use evaluation process and the identified SRCs were conservatively evaluated as MC. Samples collected for the evaluation of MC at the MRS included surface soil around the perimeter of the test pond and sediment in the test pond. A surface water sample was originally collected from the pond to evaluate options for investigating the test pond sediment, which included approved and controlled discharge to the ground surface or manual diving operations. The surface water sample was used to evaluate for MC as well.

The SRCs detected consisted of the antimony, cadmium, chromium, copper, and strontium in surface soil; aluminum, antimony, cadmium, copper, lead, and strontium in sediment; and chromium, copper, lead, and strontium in surface water. No concentrations of explosives or propellants were detected in any of the environmental samples collected at the Firestone Test Facility MRS. None of the SRCs were determined to pose risks to likely human or ecological receptors and the MC exposure pathways for surface soil, sediment, and surface water are considered to be incomplete. The MC CSM has been updated to reflect a lack of source and incomplete pathways for all receptors.

Since the RI was completed prior to the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included. However, the MC results for Unrestricted Land Use were achieved; and further evaluation for the Industrial Receptor at the Firestone Test Facility MRS, as well as other modifications to the risk assessment process, are not required.

Groundwater beneath the facility is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. No MEC or MD was found during the RI field activities and although SRCs were identified during the RI through the data screening process, the concentrations were considered low and it is unlikely that groundwater has been impacted. No groundwater samples were collected at the Firestone Test Facility MRS during the RI field work and the MC exposure pathway for groundwater is incomplete for all receptors.

9.3 Uncertainties

There are minimal levels of uncertainties associated with the MEC and MC characterization results at the Firestone Test Facility MRS. The primary uncertainty related to the evaluation of the RI results at the MRS is that very little information is available about the activities conducted there. Based on historical operations at the MRS; any MEC source would have been expected to be found in the subsurface soil and/or pond sediment. In order to determine the quantity and type of MEC present, if any, a combination of DGM survey and anomaly investigations were performed at the Firestone Test Facility MRS for the RI. The DGM survey coverage was designed based on complete (100 percent) coverage of the MRS due to the minimal size (0.41 acres) of the MRS. The actual DGM coverage was limited to 84 percent of the land-based portion of the MRS. The number of anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size of populations. A total of 105 of 423 anomalies, which represent 25 percent of the anomalies within the MRS, were successfully investigated. No MEC was found during the RI field activities and the statistical approach used to quantify the intrusive findings of the RI indicates that there is a 99 percent probability there is no MEC present at the remaining 318 anomaly locations that were not investigated during the RI field activities. These results satisfy the DQOs and reduce uncertainties that MEC is present at the MRS.

Another uncertainty is whether the detected chemicals in the surface soil, sediment and surface water are SRCs associated with historical munitions activities at the MRS. It cannot be definitively stated that the detected chemicals are not SRCs as they are considered to be constituents associated with the munitions used at the MRS. Additionally, the SRCs are all metals and do not readily degrade or mobilize easily even decades after activities have ceased. However, an MC source (MEC or MD) was not found during the RI and regardless of whether the detected chemicals are SRCs, they have been determined to pose no impacts to likely human or ecological receptors.

9.4 Munitions Response Site Prioritization Protocol

The DoD proposed the MRSPP (32 CFR Part 179) to assign a relative risk priority to each defense MRS in the MMRP Inventory for response activities. These response activities are to be based on the overall conditions at each location and taking into consideration various factors related to explosive safety and environmental hazards (68 Federal Regulations 50900 [32 CFR 179.3]). The revised MRSPP document for the Firestone Test Facility MRS is being prepared separately from the RI and is included in **Appendix J** for reference only.

10.0 SUMMARY AND CONCLUSIONS

This section summarizes results of the RI field activities conducted at the Firestone Test Facility MRS. The purpose of the RI was to determine whether the Firestone Test Facility MRS warranted further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the potential hazards and risks posed to human health and the environment by MEC and MC. Additional data were also presented in this RI Report to support the identification and evaluation of alternatives in the FS, if required. A summary of the RI results is presented in **Table 10-1**.

Table 10-1
Summary of Remedial Investigation Results at the Firestone Test Facility MRS

Investigation Area at MRS	Investigation Area Size (Acres)	Accessible Investigation Area Size (Acres)	MEC and/or MD Found?	MC Detected?	MC Risk Analysis
Land-based Area	0.37	0.31	No	Yes	No Further Action
Pond	0.04	0.04	No	Yes	No Further Action
Total:	**0.41**	**0.35**	-	-	-

MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.

10.1 Summary of Remedial Investigation Activities

The information from the Firestone Test Facility MRS relating to the potential presence of MEC and MC were compiled and evaluated in the RI. The source of this information was information obtained during previous investigations, including the ASR (USACE, 2004), the HRR (e^2M, 2007), and the SI Report (e^2M, 2008).

The preliminary MEC and MC CSMs were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used to identify the data needs and DQOs as outlined in the Work Plan (Shaw, 2011). The data needs and DQOs were determined at the planning stage and included characterization for MEC and MC associated with former activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and valid assumptions could be inferred from the data.

The DQOs for the Firestone Test Facility MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform a geophysical investigation to identify if buried MEC or MD was present.
- Perform an intrusive investigation of anomalies identified during the geophysical investigation to evaluate if MEC/MD was present.
- Collect incremental and/or discrete soil samples (surface and subsurface) in areas with concentrated MEC/MD, if any, to evaluate for MC.
- Process the information to evaluate whether there are unacceptable risks to human health and the environment associated with MEC and/or MC and make a determination if further investigation was required under the CERCLA process.

10.1.1 Geophysical Investigation

In May 2011, Shaw performed a DGM survey to identify potential subsurface areas of MEC and/or MD at the Firestone Test Facility MRS. Additional DGM fill-in data were collected in June and July of 2011 over two small areas at the MRS in order to ensure the final DGM dataset represented the MRS characteristics as accurately as possible. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was calculated to be 0.31 acres or nearly 84 percent of the land-based portion at the MRS. No MEC or MD was identified on the ground surface during the DGM survey.

10.1.2 Anomaly Selection

Evaluation of the data collected during the DGM survey identified 423 individual anomalies. Approximately 60 of the anomalies were located within a high anomaly density zone in the central portion of the MRS. The geophysical data indicate that the anomaly density at the MRS is relatively high and considered “cluttered” in the region directly northeast of the pond and “saturated” in the area of the MRS that is located northwest of the pond. At the southern end of the saturated anomaly area, the field crew documented metals objects consisting of rebar and other construction debris protruding through the ground surface that are considered cultural debris.

10.1.3 Intrusive Investigations

Following the completion of the DGM survey in July 2011, an intrusive investigation was conducted for the locations identified as potentially containing subsurface MEC and/or MD based on an analysis of the DGM survey data. A total of 105 of 423 anomalies (25 percent) were selected for intrusive investigation based on the approved statistical sampling method that estimates the required sample size for populations. No MEC or MD was identified at the 105 anomaly locations selected for investigation.

10.1.4 Underwater Investigation

An underwater tactile investigation was performed at the former shaped charge test pond in August 2011 to examine for potential MEC items buried within the pond sediment. The underwater investigation included 100 percent coverage of the walls and floor of the 0.04-acre pond. No MEC or MD was identified in the pond during the RI field activities.

10.1.5 MC Sampling

Investigation of MC was not addressed during the SI for sediment in the pond or the soils surrounding the pond at the current MRS. Based on the identified data gaps for suspected environmental media at the MRS and since the soil sample collected during the SI was outside of the current MRS boundaries, further characterization of MC was addressed in these media at the MRS during the RI. Since no MEC or MD were found during the RI intrusive investigation or underwater tactile investigation, sampling for potential MC focused on surface soil around the edges of the test pond and in the pond sediment.

Two discrete sediment samples were collected on August 8, 2011, at locations just beneath the vegetation surrounding the pond at a depth of approximately 2 feet below the pond water surface. The samples were collected at opposite ends of the pond and the sample interval was from 0 to 0.5 feet beneath the sediment surface.

On August 12, 2011, one surface soil sample was collected around the former test pond using the ISM. The purpose of the ISM surface soil sample was to characterize if former shaped charge test activities had impacted the soils immediately surrounding the pond. The ISM soil sample was collected at 0 to 0.5 feet bgs, since MC would only be expected to be found in the top several inches of soil based on the historical activities at the MRS.

Additionally, a surface water sample was collected from the former test pond on May 5, 2011, to evaluate options for investigating the test pond sediment, which included approved and controlled discharge of the pond water to the ground surface or manual diving operations. This sample is also used in the RI to evaluate for the presence of MC in the pond.

10.2 Nature and Extent of SRCs

The SRCs for the Firestone Test Facility MRS were determined for the ISM surface soil, two discrete sediment, and one surface water sample collected during the RI field activities through the facility data screening process as presented in the FWCUG Guidance (SAIC, 2010). The remaining chemicals identified as SRCs following the screening process consisted of the antimony, cadmium, chromium, copper, and strontium in surface soil; aluminum, antimony, cadmium, copper, lead, and strontium in sediment; and chromium, copper, lead, and strontium in surface water. No concentrations of explosives or propellants were detected in any of the environmental samples collected at the Firestone Test Facility MRS.

10.3 Fate and Transport

No MEC or MD was observed at the Firestone Test Facility MRS during the RI field activities. Since no MEC source is present at the MRS, MEC fate and transport is not a concern. Although a MEC source was not found during the RI, the identified SRCs were conservatively evaluated as MC associated with the shaped charge munitions historically tested at the MRS and fate and transport and potential transport mechanisms were evaluated.

The SRCs detected in the surface soil, sediment, and surface water media collected during the RI field activities are not associated with a current source, since no MEC or MD has been found to date at the MRS. However, since metals don't typically degrade over time, the SRCs may be associated with historical shaped charged testing activities performed at the MRS. The current soil conditions at the facility consist primarily of silty clay loam with low permeability and moderate pH of approximately 6.43. It is expected that the inorganic SRCs detected in soil around the pond at the Firestone Test Facility MRS would tend to bind to the soil and are considered relatively immobile.

Like most metals, aluminum, antimony, cadmium, copper, lead, and strontium in soil and sediment increase in mobility with a decrease in pH. The pH of the water in the test pond is 8.34 (SAIC, 2011a) and the pH of the soil surrounding the pond is 6.43. Analysis for pH was not performed for the RI sediment samples; however, it is assumed that the pH for sediment is similar to the surrounding soil and less than the surface water pH, and is not considered acidic. Therefore, any detected metals in sediment would be expected to be in the top several inches where they were deposited. Although not analyzed for the dissolved fractions, the RI surface water results for metals indicate that elevated levels are not being leached from the surrounding soil or sediment in the pond.

Two of the potential migration pathways at the Firestone Test Facility MRS are infiltration through the unsaturated soil to groundwater and infiltration through the surface water to groundwater. The depth to groundwater at the MRS is approximately 5 feet bgs (MKM, 2007). Precipitation that does not leave the MRS as surface runoff infiltrates into the subsurface or enters the former test pond. Some of the infiltrating water is lost to the atmosphere as evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological conditions throughout the MRS. Based on the aforementioned soil conditions, and given that inorganic SRCs are expected to remain in the top several inches of soil where they were deposited, subsurface soils or groundwater conditions have most likely not be impacted.

10.4 MEC Hazard Assessment

The Interim *Munitions and Explosives of Concern Hazard Assessment Methodology* (EPA, 2008a) addresses human health and safety concerns associated with potential exposure to MEC at a MRS under a variety of site conditions, including various cleanup scenarios and land use assumptions. If an explosive hazard is identified for this RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and provide a scoring summary for the current and future land use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns. No MEC or MD items were identified at the MRS during RI field activities, which indicates that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA score was not warranted for the Firestone Test Facility MRS.

10.5 MC Risk Assessment Summary

Following the identification of the SRCs at the Firestone Test Facility MRS for each of the data aggregates (surface soil, sediment and surface water) through the facility data screening process, the SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions:

10.5.1 Human Health Risk Assessment

A HHRA was conducted for the surface soil, sediment, and surface water samples collected at the Firestone Test Facility MRS to determine if the identified SRCs were COPCs and/or COCs that may pose a risk to future human receptors. The future land use for the Firestone Test Facility MRS is military training, and the Representative Receptors are the National Guard Trainee and the Engineering School Instructor. The Representative Receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor and other modifications to the risk assessment process specified in the technical memorandum are not required for the RI.

Aluminum in sediment was the only SRC identified as a COPC during the first screening step. Aluminum is not considered as a COC in sediment and does not pose a concern to human receptors. Summarily, none of the MC-related SRCs were determined to pose risks to likely human receptors, including the Resident Receptor (Adult and Child), in the evaluated potential exposure pathways of surface soil, sediment, and surface water; and Unrestricted Land Use was achieved for the MRS.

10.5.2 Ecological Risk Assessment

Several metals were identified as COPECs in soil, sediment, and surface water samples collected for the RI at the Firestone Test Facility MRS. COPECs are determined in the ERA and may differ from COPCs. Copper was present in all three media at slightly elevated concentrations. COPECs were identified in sediment only and consisted of aluminum, antimony, cadmium, and lead.

Given the conservativeness of the ERA and the low overall concentrations detected, the potential that exposure to the COPECs identified to adversely impact populations of ecological receptors at the Firestone Test Facility MRS is considered to be very low and not pose a concern to ecological receptors. No final COPECs are identified for any media, and no further investigation (i.e., a Level III Baseline) or action is necessary at Firestone Test Facility MRS for ecological purposes. Therefore, there are no chemicals of ecological concern that require additional investigation.

10.6 Conceptual Site Model

The information collected during the RI field activities was used to update the MEC and MC CSMs for the Firestone Test Facility MRS as presented in the SI Report (e^2M, 2008). The purpose of the CSMs is to identify all complete, potentially complete, or incomplete source–receptor interactions for reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, activity, access, and receptor.

10.6.1 MEC Exposure Analysis

Complete DGM coverage of accessible land-based areas was conducted at the MRS during the RI and a statistical approach was taken for the selection of anomalies for intrusive investigation. An underwater tactile investigation was performed in the former test pond area at the MRS. No MEC or MD was identified at the MRS during the land-based intrusive investigation or in sediment within the former test pond during the RI field activities; therefore, the MEC exposure pathways for surface soil, sediment, and surface water are incomplete for all receptors. Given the lack of a MEC source in surface soil at the MRS, incomplete pathways were considered for subsurface soil for all receptors as well.

10.6.2 MC Exposure Analysis

Sampling for MC was performed at the Firestone Test Facility MRS based upon the potential for MEC items to be buried on the ground surface around the former shaped charge test pond and within the sediment of the pond. Although a MEC source was not encountered during the RI field activities, identified SRCs were conservatively evaluated as MC. None of the SRCs were determined to pose a hazard to likely human or ecological receptors and the MC exposure pathways for surface soil, sediment, and surface water are incomplete for all receptors.

Since the RI was completed prior to the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included. However, the MC results for Unrestricted Land Use were achieved, and further evaluation for the Industrial Receptor at the Firestone Test Facility MRS is not required.

Groundwater beneath the facility is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. No MEC or MD was found during the RI field activities and although SRCs were identified during the RI through the data screening process, the concentrations were considered low. No groundwater samples were collected at the Firestone Test Facility MRS during the RI field work; however, it is unlikely that groundwater has been impacted. Therefore, the MC exposure pathway for groundwater is incomplete for all receptors.

10.7 Uncertainties

There are minimal levels of uncertainties associated with the MEC and MC characterization results at the Firestone Test Facility MRS. The primary uncertainty related to the evaluation of the RI results at the MRS is that very little information is available about the activities conducted there. Based on historical operations at the MRS; any MEC source would have been expected to be found in the subsurface soil and/or pond sediment. In order to determine the quantity and type of MEC present, if any, a combination of DGM survey and anomaly investigations were performed at the Firestone Test Facility MRS for the RI. The DGM survey coverage was designed based on complete (100 percent) coverage of the MRS due to the minimal size (0.41 acres) of the MRS. The actual DGM coverage was limited to 84 percent of the land-based portion of the MRS. The number of anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size of populations. A total of 105 of 423 anomalies, which represent 25 percent of the anomalies within the MRS, were successfully investigated. No MEC was found during the RI field activities and the statistical approach used to quantify the intrusive findings of the RI indicates that there is a 99 percent probability there is no MEC present at the remaining 318 anomaly locations that were not investigated during the RI field activities. These results satisfy the DQOs and reduce uncertainties that MEC is present at the MRS.

Another uncertainty is whether the detected chemicals in the surface soil, sediment and surface water are SRCs associated with historical munitions activities at the MRS. It cannot be definitively stated that the detected chemicals are not SRCs as they are considered to be constituents associated with the munitions used at the MRS. Additionally, the SRCs are all inorganic and do not readily degrade or mobilize easily even decades after activities have ceased. However, an MC source (MEC or MD) was not found during the RI and regardless of whether the detected chemicals are SRCs, they have been determined to pose no impacts to likely human or ecological receptors.

10.8 Conclusions

The RI was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose risks to likely receptors. The following statements can be made for the Firestone Test Facility MRS based on the results of the RI field activities:

- Complete DGM coverage of accessible land-based areas (0.31 acres) was conducted at the MRS during the RI and 84 percent coverage of the 0.368-acre land-based portion of the MRS was achieved.
- A full coverage (100 percent) underwater tactile investigation was performed in the former test pond area (0.04 acres) at the MRS and no MEC or MD was found.
- The nature and extent of MEC or MD has been adequately defined at the MRS and no explosive safety hazard is present at the MRS.
- The SRCs that were conservatively evaluated as MC in surface soil, sediment, and surface water do not pose potential hazards to human or ecological receptors at the MRS; therefore, no further action is required for MC at the MRS.

Based on these conclusions, it is determined that the Firestone Test Facility MRS has been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. No Further Action is recommended for the Firestone Test Facility MRS under the MMRP, and the next course of action will be to proceed to a No Further Action Proposed Plan.

Since the RI was initiated before the finalization of the U.S. Army's technical memorandum (ARNG, 2014) and No Further Action (Unrestricted Land Use) was determined for MEC and MC, evaluation for the Commercial Industrial Land Use using the Industrial Receptor was not included. The CERCLA investigations for the IRP are still being completed at this time. If results in the IRP investigations do no indicate that Unrestricted Land Use has been achieved, then the evaluation for the Commercial Industrial Land Use will be incorporated along with the Unrestricted (Residential) Land Use and the Military Training Land Use under the IRP, as specified in the technical memorandum (ARNG, 2014).

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11.0 REFERENCES

Ainsworth, 1988. *Distribution and Biological Effects of Antimony in Contaminated Grassland*, Dissertation.

Agency for Toxic Substances and Disease Registry (ATSDR), 1992. *Toxicological Profile for Antimony and Compounds*, <http://www.atsdr.cdc.gov/toxprofiles/tp23.pdf>.

ATSDR, 2008. *Toxicological Profile for Aluminum*, September.

ATSDR, 2011. *Toxicological Profile for Strontium*, <http://www.atsdr.cdc.gov/substances/toxsubstance.asp>, March 3.

AMEC Earth and Environmental, Inc. (AMEC), 2008. *Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site*, March.

Bartell, S.M., 1996. *Ecological/Environmental Risk Assessment Principles and Practices*, Kulluru, R., Bartell, S., Pitblado, R. et al. (eds), Risk Assessment and Management Handbook, McGraw-Hill, New York.

Callahan, M.A. et al., 1979. *Water-Related Environmental Fate of 129 Priority Pollutants*, Volume 1 EPA-440/4-79-029a, pp. 5-1 to 5-8.

Camp Ravenna Joint Military Training Center, 2010. *Rare Species List*, April 27.

Efroymson, R.A., G.W. Suter II, and M.E. Will (Efroymson et al.), 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process*, 1997 Revision, Report No. ES/ER/TM-126/R2, Oak Ridge National Laboratory.

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones (Efroymson, et al), 1997b. *Preliminary Remediation Goals for Ecological Endpoints*, Report No. ES/ER/TM-162/R2, Oak Ridge National Laboratory.

Elinder, Cad-Gustaf, 1985. "Cadmium: Uses, Occurrence, and Intake," *Cadmium and Health: A Toxicological and Epidemiological Appraisal*, CRC Press, Inc., Boca Raton, Florida.

engineering-environmental Management, Inc. (e^2M), 2008. *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio, Military Munitions Response Sites*, May.

Environmental Quality Management, Inc., 2012. *Final Facility-Wide Groundwater Program,* 10 *Report on the July 2011 Sampling Event, Ravenna Army Ammunition Plant*, February.

Fiejtel, T.S., R.D. Dalaune, and W. H Patrick, Jr., 1988. *Seasonal Pore Water Dynamics in Marshes of Barataria Basin, Louisiana*, Soil Sci. Sot. Am. J. 52:59–67.

Foster, R.B., 1989. *Antimony Mobility in Soil using Soil TLC*, prepared by Springborn Life Sciences, Inc., Wareham, MA for the Antimony Oxide Industry Association, Washington, D.C.

Gerritse, R.G. and W. van Driel, 1984. *The Relationship Between Adsorption of Heavy Metals, Organic Matter and pH in Temperate Soils*, Journal of Environm. Qual. 13 (2), 197–204.

Harrison, P.L. and D.J. Bishop, 1984. *A Review of the Impact of Copper Released into Freshwater Environments*, UCRL-53488, National Technical Information Service, Springfield, Virginia.

Hemond, H.F. and E.J. Fechner-Levy, 1999. *Chemical Fate and Transport in the Environment*, 2nd edition, Academic Press, October.

Kammer, H.W., 1982. *A Hydrologic Study of the Ravenna Arsenal, Eastern Portage and Western 1 Trumbull Counties, Ohio*, Master Thesis, Kent State University. 1982.

King, L.D., 1988. *Retention of Metals by Several Soils of the Southeastern United States*, J Environ Qua1 17:239–246.

Los Alamos National Laboratory (LANL), 2010. *ECORISK Database (Release 2.5)*, Environmental Restoration Project, Los Alamos National Laboratory, Los Alamos, New Mexico, September.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger (McDonald et al.), 2000. *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems*, Arch. Environ. Contam. Toxicol. 39:20–31.

MKM Engineers, Inc. (MKM), 2007. *Final Report for the Phase I Investigation at Load Line 6 (RVAAP-33), Ravenna Army Ammunition Plant, Ravenna, Ohio*, August.

Muntau, H. and R. Baudo, 1992. *Source of Cadmium, It's Distribution and Turnover in the Freshwater Environment*, IARC Sci. Publ. (118):133–48.

National Oceanic and Atmospheric Administration, 2004. *Climatography of the United States No. 20 1971–2000, Station Youngstown Municipal AP, OH*, <http://hurricane.ncdc.noaa.gov/climatenormals/clim20/oh/339406.pdf>.

Ohio Environmental Protection Agency (Ohio EPA), 2004. *Director's Final Findings and Orders (DFFO) for RVAAP*, June 10.

Ohio EPA, 2008. *Ecological Risk Assessment Guidance Document*, Division of Emergency and Remedial Response, Columbus, OH, April.

Ohio EPA, 2011. Ohio Administrative Code 3745-1, *Ohio River Basin Aquatic Life Criteria, OMZA*, March 6.

Ohio Department of Natural Resources (ODNR), 1997. *Species and Plant Communities Inventory, Ravenna Army Ammunition Plant*, prepared by ODNR, Division of Natural Areas and Preserves in cooperation with The Nature Conservancy, Ohio Chapter.

Rai, D., J.M. Zachara, A.P. Schwab, R.L. Schmidt, D.C. Girvin, and J.E. Rogers (Rai, et al.), 1984. *Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Volume I, A Critical Review,* Electric Power Research Institute, Palo Alto, California.

Sample, B.E., D.M. Opresko, and G.W. Suter II (Sample, et al.), 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*, prepared for the U.S. Department of Energy by Health Sciences Research Division, Oak Ridge National Laboratory.

Science Applications International Corporation (SAIC), 1996. *Final Preliminary Assessment for Characterization of Areas of Contamination, Ravenna Army Ammunition Plant, Ravenna, Ohio*, prepared for the U.S. Army Corps of Engineers Nashville District, February.

SAIC, 2010. *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio,* March 23.

SAIC, 2011a. *Draft Phase II Remedial Investigation Report for Soil, Sediment and Surface Water at RVAAP Load Line 6, Ravenna Army Ammunition Plant, Ravenna, Ohio,* November 4.

SAIC, 2011b. *Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP*, February 24.

Shaw Environmental and Infrastructure, Inc. (Shaw), 2009. *Final Project Management Plan for Environmental Services at 14 Military Munitions Response Program Sites, Version 1.0, Ravenna Army Ammunition Plant, Ravenna Ohio*, September 14.

Shaw, 2011. *Final Work Plan for Military Munitions Response Program Remedial Investigation Environmental Services, Ravenna Army Ammunition Plant, Ravenna, Ohio,* Version 1.0, March 1.

Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program, 2012. *Munitions Constituents*, <http://www.serdp.org/Featured-Initiatives/Range-Sustainment/Munitions-Constituents>.

Talmage S.S., D.M. Opresko, C.J. Maxwell, C.J. Welsh, F.M. Cretella, P.H. Reno, and F.B. Daniel (Talmage et al.), 1999. *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values*, Rev. Environ. Contamin. Toxicol., 161:1–156.

Tannenbaum, L., 2005. *A Critical Assessment of the Ecological Risk Assessment Process: A Review of Misapplied Concepts, Integrated Environmental Assessment and Management*, 1(1):66–72.

U.S. Army, 2009. *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance*, November.

U.S. Army Corps of Engineers (USACE), 1998. *Phase I Remedial Investigation Report of High-Priority Areas of Concern at the Ravenna Army Ammunition Plant, Ravenna Ohio*. February.

USACE, 2003a. *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*, Engineer Manual (EM) 1110-1-1200, February 3.

USACE, 2003b. *RVAAP Facility-Wide Ecological Risk Assessment Work Plan*, Final, April.

USACE, 2004. *Final Archives Search Report for Ravenna Army Ammunition Plant*, June 1.

USACE, 2005. *RVAAP's Facility-Wide Human Health Risk Assessor Manual*, December 5.

USACE, 2007. *Military Munitions Response*, EM 1110-1-4009, June 15.

USACE, 2009a. *Geophysics*, DID MMRP-09-004, Huntsville Center, August 19.

USACE, 2009b. *Interim Guidance 09-02, Implementation of Incremental Sampling of Soil for the Military Munitions Response Program*.

USACE, 2010a. Geophysics Attachment D, *Table D-1, Performance Requirements for Remedial Investigation/Feasibility Study Using DGM Methods*, DID WERS-004.01, Huntsville Center, April 28.

USACE, 2010b. *Risk Assessment Handbook Volume II: Environmental Evaluation*, EM-200-1-4, December.

USACE, 2012. *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals*.

U.S. Army National Guard Bureau (ARNG), 2014. *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program, Portage/Trumbull Counties, Ohio,* February 4.

U.S. Army Toxic and Hazardous Materials Agency, 1978. *Installation Assessment of Ravenna Army Ammunition Plant, Records Evaluation Report No. 132.*

U.S. Department of Agriculture, Soil Conservation Service, in cooperation with Ohio Department of Natural Resources, Division of Land and Soils, and Ohio Agriculture Research and Development Center (USDA et al.), 1978. *Soil Survey of Portage County*.

U.S. Department of Defense (DoD), 2010. *DoD Quality Systems Manual for Environmental Laboratories*, Version 4.2, October 25.

U.S. Department of the Interior (DOI), 1983. *Removal of Leachable Metals and Recovery of Alumina from Utility Coal Ash*, U.S. Department of the Interior, Bureau of Mines, PB83191650, Washington, D.C.

DOI, 1984. *Study of Availability and Composition of Metal Bearing Wastes (Generated in Titanium Extraction and Fabrication, Aluminum Smelters, Chromite Bearing Refractory and Foundry Sands and Mercury Battery Industries)*, U.S. Department of the Interior, Bureau of Mines, PB84207091, Washington, D.C.

DOI, 1985. *Cadmium in Mineral Facts and Problems*, U.S. Department of the Interior, Bureau of Mines, Bulletin 675, pp. 111–119.

U.S. Environmental Protection Agency (EPA), 1979. *Water-Related Environmental Fate of 129 Priority Pollutants*, EPA-440/4-79-029.

EPA, 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, Interim Final, EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, D.C.

EPA, 1990. *Uptake/Biokinetic Model for Lead*, Version 0.50, December.

EPA, 1992. *Framework for Ecological Risk Assessment, Risk Assessment Forum*, EPA/630/R-92/001, Washington, D.C.

EPA, 1993. *Wildlife Exposure Factors Handbook*, Volumes I and II, EPA/600/R-93/187a, Office of Research and Development, Washington, D.C.

EPA, 1996. *Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Guidance Bulletin No. 1*, Chicago, Illinois.

EPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, EPA/540-R-97-006.

EPA, 1998. *Toxicological Review of Hexavalent Chromium*, Washington, D.C., August.

EPA, 2000. *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW, Office of Environmental Information, Washington, D.C., January.

EPA, 2001. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*, ECO Update, EPA 540/F-01/014, June.

EPA, 2003. *Region 5 RCRA Ecological Screening Levels (ESLs)*, <http://www.epa.gov/reg5rcra/ca/edql.htm>.

EPA, 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols*, Revision 6, February.

EPA, 2008a. *Munitions and Explosives of Concern Hazard Assessment Methodology*, Interim, Washington, D.C., October.

EPA, 2008b. *Guidance for Developing Ecological Soil Screening Levels, Office of Solid Waste and Emergency Response*, Directive 92857.7-55 (soil screening level values online at http://epa.gov/ecotox/ecossl/index.html), Washington, D.C.

EPA, 2010. *Ecological Soil Screening Level Guidance*, Directive No. 9285.7-55, <http://www.epa.gov/ecotox/ecossl/>, Office of Solid Waste and Emergency Response, Washington, D.C., April.

EPA, 2012. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*, <http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm>. November.

Wentsel, R.S., T.W. LaPoint, M. Simini, R.T. Checkai, D. Ludwig, and L.W. Brewer (Wentsel et al.), 1996. *Tri-Service Procedural Guidelines for Ecological Risk Assessments*, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, Maryland.

Winslow, J.D., and G.W. White, 1966. *Geology and Ground-water Resources of Portage County, Ohio*. Geological Survey Professional Paper 511. 1966

Appendix A
Digital Geophysical Mapping Report

Appendix B
Field Documentation

Appendix C
Data Validation Report

Project Data Validator: Maqsud Rahman, PhD.

Appendix D
Summary of Laboratory Analytical Results

Note: Laboratory data packages prepared by CT Laboratories are submitted on a separate compact disc.

Appendix E
Investigation-Derived Waste Management

Appendix F
Photographic Documentation

Appendix G
Intrusive Investigation Results Summary Table

Appendix H
Statistical Analysis of Intrusive Findings

Statistical Analysis of Intrusive Findings at the Firestone Test Facility MRS

It is challenging to predict the occurrence of munitions and explosives of concern (MEC) in a population of anomalies when only a portion of the anomalies are investigated and no MEC are identified in the sample population. In order to meet this challenge, a Bayesian statistical approach is warranted instead of a classical statistical approach. The Bayesian approach is applicable, as it uses the information from the sampled anomaly population in conjunction with previous knowledge regarding the occurrence of MEC to predict the occurrence of MEC in the unsampled population of anomalies. For the investigation at the Firestone Test Facility Munitions Response Site (MRS) an assumption was made that the percentage of MEC items is between 1 and 0.1 percent (i.e., 1 in 100 or 1 in 1,000 anomalies are MEC).

The Bayesian approach is a valid method to predict the occurrence of MEC for the anomalies that were not investigated at the Firestone Test Facility MRS. A total of 423 anomalies were identified using digital geophysical mapping and 105 of these were randomly selected and intrusively investigated. For comparative purposes, the mean value of the MEC amongst the 423 anomalies identified was estimated to be 1 percent, 4 percent, or 50 percent before any intrusive information was acquired. The assumption that 4 percent and 50 percent of the anomalies at the MRS are MEC is intended to provide information that errs on the side of conservatism. **Table H-1** presents a summary of the Bayesian approach and estimations used to predict the probability of MEC at unsampled anomalies at the Firestone Test Facility MRS.

Table H-1
Probabilities of Remaining MEC for Unsampled Anomalies

Estimated Mean Population of MEC	Probability that there is no MEC in Remaining 318 Unsampled Anomalies	95th Percentile of Prediction Distribution for Count of MEC in Remaining 318 Unsampled Anomalies	99th Percentile of Prediction Distribution for Count of MEC in Remaining 318 Unsampled Anomalies
1%	0.99	0	0
4%	0.94	0	1
50%	0.25	9	14

MEC denotes munitions and explosives of concern.

If the mean MEC population at the MRS is estimated to be 1 percent and 4 percent, then the predicted probability that there is no MEC in the remaining 318 samples using the actual intrusive results is 99 and 94 percent, respectively. In the case where the mean MEC population is estimated to be 50 percent, there is only a 25 percent prediction probability that there is no MEC in the remaining 318 anomalies based on the intrusive results. In this scenario, 400 of the anomalies would need to be sampled to obtain a prediction probability of 95 percent that there is no MEC in the remaining 23 samples.

After observing the initial *m* sample anomalies and counting the number of anomalies, *y*, that are MEC, the Bayesian estimator of the mean proportion, $\hat{p}_B$,of MEC is

$$\hat{p}_B = \left(\frac{m}{\alpha+\beta+m}\right)\left(\frac{y}{m}\right) + \left(\frac{\alpha+\beta}{\alpha+\beta+m}\right)\left(\frac{\alpha}{\alpha+\beta}\right)$$

This estimator is a weighted linear combination of the sample proportion, *y/m*, and the *a priori* beta distribution mean of $\alpha/(\alpha+\beta)$. Thus the Bayesian estimator can never be 0 even when *y/m* is 0. Note however that as *m* gets larger that the estimated proportion approaches *y/m*.

Once the proportion is estimated in the Bayesian framework, then the predictive distribution for the count of MEC in the unsampled anomalies can readily be obtained and follows a beta-binomial distribution. This distribution can be used to predict the count of MEC in the remaining unsampled anomalies.

References:

Casella, George and R. Berger, 1990. *Statistical Inference*, Wadsworth & Brooks, New York, New York.

Lee, Peter M., 1989. *Bayesian Statistics*, Oxford University Press, New York, New York.

Appendix I
Ecological Screening Values

Appendix J
Munitions Response Site Prioritization Protocol Worksheets

Appendix K
Ohio EPA Correspondence

Appendix L
Reponses to Ohio EPA Comments

Appendix M
Ohio EPA Approval Letter