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14. ABSTRACT

This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at RVAAP-034-R-01 Sand Creek Dump Munitions Response Site (MRS) between August 2010 and August 2013 at the former Ravenna Army Ammunition Plant. The purpose of the RI was to determine whether the Sand Creek Dump 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 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 hazards and risks posed to likely human and ecological receptors by MEC and MC. Also, this RI Report presents additional data to support the identification and evaluation of alternatives in the Feasibility Study, if necessary. This RI Report was prepared in accordance with the Army's Final Munitions Response RI/FS guidance dated November 2009.

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CB&I Federal Services LLC has completed the *Final Remedial Investigation Report for RVAAP-034-R-01 Sand Creek Dump MRS* at the former Ravenna Army Ammunition Plant, 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.

Reviewed/Approved by:  Date: March 24, 2015

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Project Manager

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Laura O'Donnell
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Final Remedial Investigation Report for RVAAP-034-R-01 Sand Creek Dump 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:

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Acronyms and Abbreviations

°F	degrees Fahrenheit
ACM	asbestos-containing material
AEDB-R	Army Environmental Database-Restoration
AMEC	AMEC Earth and Environmental, Inc.
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
Army	U.S. Army
ARNG	Army National Guard
ASR	*Final Archives Search Report*
bgs	below ground surface
BHC	benzene hexachloride
Camp Ravenna	Camp Ravenna Joint Military Training Center
CB&I	CB&I Federal Services LLC
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
cm/s	centimeters per second
CMCOPC	contaminant migration chemicals of potential concern
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DID	Data Item Description
DOD	U.S. Department of Defense
DPT	direct-push technology
DQO	data quality objective
e^2M	engineering-environmental Management, Inc.
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FS	Feasibility Study
FWCUG	Facility-Wide Cleanup Goal
FWSAP	Facility-Wide Sampling and Analysis Plan
gpm	gallons per minute
HA	Hazard Assessment
HHRA	human health risk assessment
HHRAM	*Facility-Wide Human Health Risk Assessor Manual*
HRR	*Final Military Munitions Response Program Historical Records Review*
IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip

Acronyms and Abbreviations (continued)

lb	pound
MC	munitions constituents
MD	munitions debris
MEC	munitions and explosives of concern
MKM	MKM Engineering, Inc.
mm	millimeter(s)
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
mV	millivolts
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NS	not sampled
nT/m	nanoteslas per meter
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PRG	Preliminary Remediation Goal
QC	quality control
RI	Remedial Investigation
RRSE	Relative Risk Site Evaluation
RTS	robotic total station
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
Shaw	Shaw Environmental & Infrastructure, Inc.
SI	Site Inspection
SLERA	screening-level ecological risk assessment
SRC	site-related chemical
SVOC	semivolatile organic compound
TAL	Target Analyte List
TNT	trinitrotoluene
U.S.	United States
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventative Medicine
USDA	U.S. Department of Agriculture
USP&FO	U.S. Property and Fiscal Officer
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report documents the findings and conclusions of the RI field activities for the Sand Creek Dump (RVAAP-034-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 Sand Creek Dump 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 Pollution Contingency Plan*. More specifically, it was intended in this RI Report to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and to subsequently determine the potential hazards and risks posed to human and ecological receptors 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 for Ravenna Army Ammunition Plant* (USACE, 2004), the *Final Military Munitions Response Program Historical Records Review, Ravenna Army Ammunition Plant, Ohio* (engineering-environmental Management, Inc. [e^{2}M], 2007), and the *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio, Military Munitions Response Sites* (e^{2}M, 2008).

The Sand Creek Dump MRS is located in the eastern portion of the facility and is a former open dump area. The area of the Sand Creek Dump MRS is 0.85 acres and overlaps with an Installation Restoration Program (IRP) Area of Concern (AOC) known as the Sand Creek Disposal Road Landfill (Army Environmental Database-Restoration #RVAAP-34). The Sand Creek Dump operated from 1950 to 1960; however, details regarding the operational history of disposal activities are incomplete including the types of materials and quantities dumped at the site. Construction and debris type material were delivered and dumped over an embankment located immediately adjacent to Sand Creek. Although there are no historical records indicating that munitions-related items were intentionally disposed at the dump along with the construction and debris materials, demilitarized munitions that were inspected to be

munitions debris (MD) only were identified at and in the vicinity of the MRS during previous investigations.

In October 2003, a Removal Action was performed under the IRP to remove all surface and subsurface debris that posed risks to human and ecological receptors. While performing the confirmation sampling, the two demilitarized 75 millimeter (mm) projectiles considered as MD were found.

A Site Inspection (SI) was conducted at the MRS in 2007 under the MMRP, and the field activities included a meandering path magnetometer and metal-detector assisted MEC survey at all open areas. Multiple subsurface anomalies were recorded; however, the nature of the anomalies could not be determined since an intrusive investigation was not performed during the SI. No evidence of MEC was found on the ground surface during the SI field work; however, a 105mm projectile was observed on the bottom of Sand Creek at the portion of the creek located adjacent to the northern boundary of the MRS. A determination was not made as to whether the projectile was empty and, therefore, whether it represented an explosive hazard. Based on historical findings and SI field observations made, the *Final Site Inspection Report* recommended further characterization of potential MEC concerns. Sampling for MC was not conducted for the SI, since chemical contamination was being addressed under the IRP (e^2M, 2008).

Current activities at the Sand Creek Dump MRS include maintenance and natural resource management activities. Potential users identified for the MRS based on the current activities include facility personnel, contractors, and potential trespassers.

The future land use at the MRS will be military training. The Representative Receptor is the National Guard Trainee (USACE, 2012a).

ES.2 Summary of Remedial Investigation Activities

The preliminary MEC and MC conceptual site models (CSMs) for the MRS were evaluated based on the historical background reviews and data needs, and the data quality objectives (DQOs) were determined as outlined in the *Final Work Plan Addendum for Military Munitions Response Program Remedial Investigation Environmental Services* (Work Plan Addendum) (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011a). The data needs included characterization of MEC and/or 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 their intended use; and the inference of valid assumptions from the data. The DQOs for the Sand Creek Dump MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform a geophysical investigation at the remaining portions of the MRS that weren't covered during the 2010 digital geophysical mapping (DGM) survey under the IRP to identify buried metallic anomalies that had the potential to be MEC.
- Perform an intrusive investigation of anomalies identified following the geophysical investigation to evaluate if MEC was present.
- Collect incremental and/or discrete samples (surface and subsurface soil) in areas with concentrated MEC and/or MD to evaluate for MC, if necessary.
- Process the information to evaluate whether there were unacceptable hazards or risks to humans and the environment associated with MEC and/or MC, and make a determination if further investigation was required under the CERCLA process.

Geophysical Investigation

Between late December 2011 and early January 2012, a DGM survey was conducted at the Sand Creek Dump MRS that encompassed the remainder of the MRS that was not covered during the 2010 DGM survey. This survey included the additional 150-foot (0.13-acre) section north of the AOC boundary as well as a number of small fill-in areas within the MRS. The DGM survey was conducted over the steep slopes of the MRS as well the low floodplain areas and upgradient locations at the top of slope where dump activities most likely occurred. Full coverage DGM data were acquired over all accessible areas of the MRS between the combined DGM surveys which resulted in a spatial coverage of 94.3 percent (0.8 acres).

Anomaly Selection

Evaluation of the data collected during the DGM survey identified two primary areas of high anomaly densities with signal strengths greater than or equal to 8 millivolts (Channel 2). Outside of these areas with high anomaly density, there were a total of 225 anomalies identified for potential investigation as individual target locations.

Intrusive Investigation

Following the completion of the DGM surveys, reacquisition and intrusive investigation activities for the locations identified as potentially containing buried MEC were performed in August 2013 based on an analysis of the DGM survey data. The data interpreter selected eight locations for trenches as the primary investigative technique within the two localized areas with high densities of anomalies. A total of 128 individual anomaly locations were identified for intrusive investigation to characterize the nature and extent of MEC using a statistics module in accordance with the approved Work Plan Addendum (Shaw, 2011a). More than 25 of the individual anomalies were selected in several areas of the MRS that are

likely associated with single anomaly sources related to cultural features (expansive sections of concrete foundation from the former treatment facility). These localized areas could not be fully investigated with DGM due to steep terrain and dense vegetation consisting of close knit trees, which prevented further analysis and classification of the anomaly source(s). Therefore, the data interpreter selected 25 additional anomaly selections in areas away from these features to provide a better distribution of targets across the MRS that are not associated with potential cultural features. An additional 12 anomaly locations were selected to ensure there is a 95 percent probability that a minimum of 4 items of interest were identified. In all, a total of 165 target locations were selected for intrusive investigation, which equates to an investigation percentage of approximately 73 percent of the individual anomalies. All proposed locations were reviewed and agreed upon by the U.S. Army (Army) and the Ohio Environmental Protection Agency prior to the initiation of intrusive activities. No MEC was found at the MRS during the intrusive investigation activities at the high density anomaly areas or the individual anomaly locations.

MC Sampling

The DQOs stated that incremental samples and discrete samples (surface and subsurface soil) would be collected in areas with concentrated MEC or MD. No MEC or MD was identified at the Sand Creek Dump MRS during the RI field activities and sampling for MC was not warranted.

ES.3 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (U.S. Environmental Protection Agency, 2008) 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 Hazard Assessment (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 was identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA was not warranted for the Sand Creek Dump MRS.

ES.4 Conceptual Site Model

The information collected during the RI field activities was used to update the CSM for MEC and to evaluate if the development of a revised CSM for MC was warranted. The purpose of the 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.

Between 2010 and 2012, full DGM coverage was completed at the collocated AOC and MRS. A subsequent intrusive investigation was performed within the boundaries of the MRS and no MEC was identified. To date, no confirmed MEC has been found at the Sand Creek Dump MRS. Two demilitarized 75mm projectiles were found following the 2003 Removal Action at the collocated AOC and were considered MD. A 105mm projectile was observed in Sand Creek during the SI field work; however, it is not known from where the projectile originated. The projectile appeared to be empty but it was not inspected to determine the explosive safety status as either "safe" or "hazardous." The projectile was not observed in the creek during the RI field work, and the disposition of this projectile is unknown. No MEC was found during the RI field work, and no explosive safety hazard is present at the Sand Creek Dump MRS. Therefore, the MEC exposure pathways for surface and subsurface soil are considered incomplete for all receptors.

Based on the results of the MC sampling during the SI field activities and the MEC investigation portion of the RI field activities, it was determined that no potential source of MC is present at the Sand Creek Dump MRS. Therefore, no media sampling was conducted at the MRS and incomplete pathways exist for MC for all receptors. A Phase I RI was completed at the collocated AOC in 2010, and the chemicals of concern that were identified will continue to be addressed under the IRP.

ES.5 Conclusions and Recommendations

This RI Report was prepared in accordance with the project DQOs and includes evaluations for explosives hazards and potential sources of MC that may pose threats to human and ecological receptors. The following statements can be made for the Sand Creek Dump MRS based on the results of the RI field activities:

- Complete DGM coverage of accessible areas (0.8 acres) was conducted at the current MRS between the combined 2010 and the 2012 DGM surveys, and 94.3 percent coverage of the 0.85-acre MRS was achieved.
- No MEC has been discovered in or around the MRS to date, and an explosive safety hazard does not exist at the MRS.
- MC sampling was not warranted because concentrated areas of MEC or MD were not found at the MRS during the RI field activities.

No explosive safety hazards or potential sources of MC have been identified for the MRS during the RI field work. Based on these results, it is concluded that the nature and extent of MEC and MC at the Sand Creek Dump MRS have been adequately characterized and the DQOs presented in the Work Plan Addendum (Shaw, 2011a) have been satisfied. No Further Action is recommended for the Sand Creek Dump 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 Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Army National Guard, 2014) and No Further Action was recommended at the MRS 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 the collocated AOC at this time. If Unrestricted Land Use is not achieved under the IRP investigations, then the evaluation for the Commercial Industrial Land Use will be incorporated along with the Unrestricted Land Use and the Military Training Land Use under the IRP, as specified in the Army’s technical memorandum.

1.0 INTRODUCTION

This Remedial Investigation (RI) Report documents the findings and conclusions of the RI field activities for the Sand Creek Dump (RVAAP-034-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* 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 Sand Creek Dump MRS between December 2011 and January 2012 and in August 2013. This RI Report was developed in accordance with the *Final Work Plan Addendum for Military Munitions Response Program Remedial Investigation Environmental Services* (Work Plan Addendum) (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011a) at the RVAAP and the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army [Army], 2009).

1.1 Purpose and Scope

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 and ecological receptors 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, 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 Sand Creek Dump MRS warranted further response action pursuant to CERCLA and the NCP. More specifically, it was intended in this RI Report to determine the nature and extent of MEC and MC and to subsequently determine the potential hazards and risks posed to human and environmental

receptors. Additional data are also presented in this RI Report to assist in the identification and evaluation of alternatives in the FS, if required.

1.2 Problem Identification

The area covered by the Sand Creek Dump MRS overlaps with an Installation Restoration Program (IRP) Area of Concern (AOC) known as the Sand Creek Disposal Road Landfill (Army Environmental Database-Restoration [AEDB-R] #RVAAP-34). The Sand Creek Dump operated from 1950 to 1960. Construction and debris type material were delivered to the site and dumped over an embankment located immediately adjacent to Sand Creek. Although there are no historical records indicating that munitions-related items were intentionally disposed at the dump along with the construction and debris materials, demilitarized munitions that were inspected to be munitions debris (MD) only were identified at and in the vicinity of the MRS during previous investigations.

In October 2003, a Removal Action was performed under the IRP to remove all surface and subsurface debris in order to eliminate source contamination to protect human and ecological receptors. While performing the confirmation sampling, the two demilitarized 75 millimeter (mm) projectiles that were verified as MD were found. No MEC was found during the Removal Action.

A Site Inspection (SI) was conducted at the MRS in 2007 under the MMRP, and the field activities included a meandering path magnetometer and metal detector-assisted MEC survey at all open areas. Multiple subsurface anomalies were recorded. However, the nature of the anomalies could not be determined because an intrusive investigation was not performed during the SI. No MEC was discovered at the MRS during the SI; however, a 105mm projectile was observed at the bottom of Sand Creek adjacent to the northern boundary of the MRS. The projectile appeared to be empty, but it was not inspected to determine the explosive safety status as either "safe" or "hazardous." Based on historical findings and SI field observations made, the *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio, Military Munitions Response Sites* (SI Report) recommended further characterization of potential MEC concerns. Sampling for MC was not conducted for the SI because chemical contamination was being addressed under the IRP (engineering-environmental Management, Inc. [e^2M], 2008).

1.3 Physical Setting

This section presents the physical characteristics of the facility, the Sand Creek Dump MRS, and the surrounding environment that are factors in understanding fate and transport, the conceptual site model (CSM), receptors, and exposure scenarios for potential human and ecological 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) and the *Final Updated Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site and the Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio* (AMEC Earth and Environmental, Inc. [AMEC], 2008) that was prepared for the Ohio Army National Guard (OHARNG).

1.3.1 Location

The 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**).

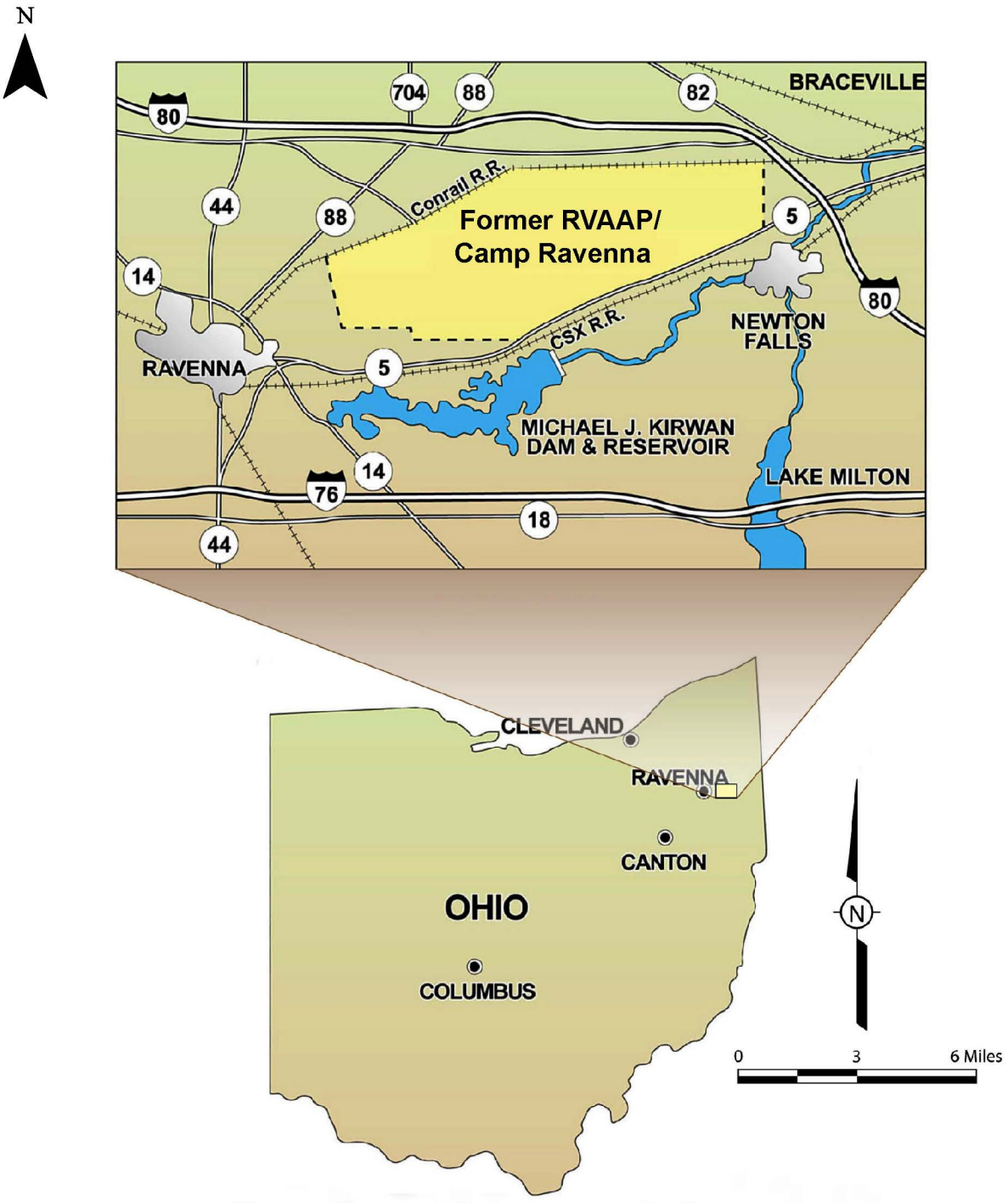
Administrative control of the 21,683-acre facility has been transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the OHARNG for use as a training site, Camp Ravenna. The restoration program involves cleanup of former production areas across the facility related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

The Sand Creek Dump MRS is an approximate 0.85-acre parcel located in the eastern portion of the facility within Portage County (**Figure 1-2**). 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 Sand Creek Dump MRS including the facility AEDB-R numerical designation for the MRS, the MRS acreage, and the agencies responsible for the MRS.

Table 1-1
Administrative Summary of the Sand Creek Dump MRS

MRS Name	AEDB-R MRS Number	MRS Area (Acres)	Property Owner	MRS Management Responsibility
Sand Creek Dump	RVAAP-034-R-01	0.85	USP&FO	ARNG/OHARNG

AEDB-R denotes Army Environmental Database-Restoration.
ARNG denotes Army National Guard.
MRS denotes Munitions Response Site.
OHARNG denotes Ohio Army National Guard.
USP&FO denotes U.S. Property & Fiscal Officer.



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

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS_RamsdellQuarry\Landfill\2014 April rev1\RVAAP_RQL_001_Fig1_1_SiteLoc_r1.mxd; Analyst: jclarke; Date: 4/1/2014 4:12:20 PM

FIGURE 1-1 INSTALLATION LOCATION MAP

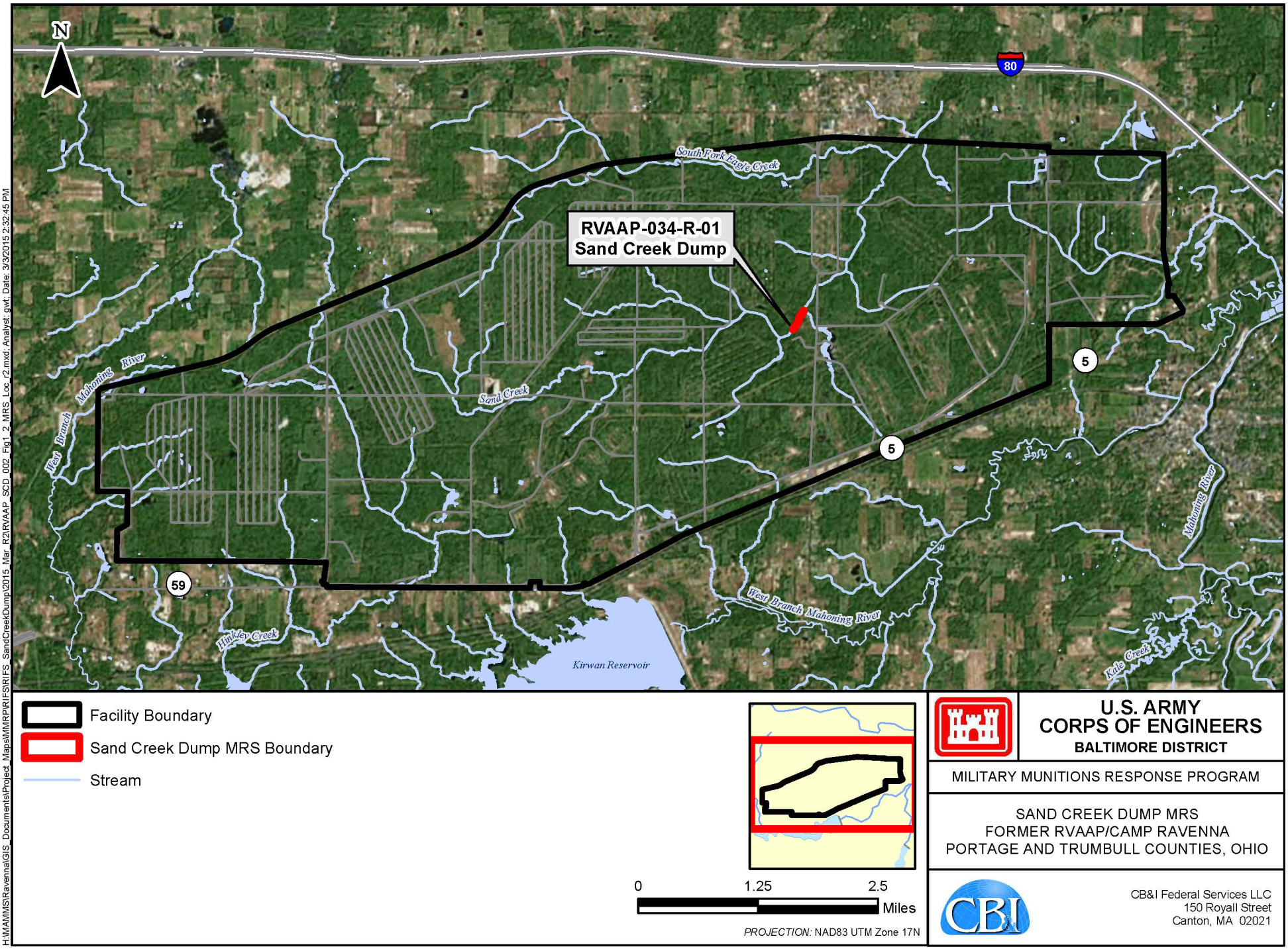


FIGURE 1-2 MRS LOCATION MAP

1.3.2 Current Projected Land Use

This section presents the current and future land use for the Sand Creek Dump MRS. The future land use is based on the Land Use Exposure Scenarios as presented in the *RVAAP's Facility-Wide Human Health Risk Assessor Manual, Amendment 1* (Human Health Risk Assessor Manual [HHRAM]) (USACE, 2005a) and information provided by the OHARNG during preparation of the Work Plan Addendum (Shaw, 2011a).

Current activities at the Sand Creek Dump MRS include maintenance and natural resource management activities. Human receptors identified for the MRS include facility personnel, contractors, and potential trespassers.

The future land use for the MRS will be military training. The Representative Receptor is the National Guard Trainee (USACE, 2012a).

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 identifies 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. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 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; however, no bogs, kettle lakes, or kames were identified at the Sand Creek Dump MRS. Old stream drainage patterns were disturbed and wetlands were created within the province because of past glacial activity (e^2M, 2008).

Sand Creek Dump MRS Topography

The Sand Creek Dump MRS is located in the eastern portion of the facility and encompasses 0.85 acres along the eastern bank of Sand Creek. The bank slopes from east to west towards Sand Creek 40 to 60 degrees from horizontal. Topographic relief between the top of embankment and the surface of Sand Creek varies across the MRS, but ranges from approximately 15 to 25 feet. The slope of the embankment is the area at the MRS where construction debris was historically dumped. A former railroad bed bisects the MRS and the top of the embankment at both the northern and southern portions of the MRS are relatively level with elevations ranging between approximately 965 to 970 feet above mean sea level (amsl). A narrow floodplain occupies the land between the bottom of the embankment and Sand Creek. The bottom of the embankment represents the lowest elevation at the MRS at approximately 950 amsl. The topography for the MRS and the surrounding area is presented in **Figure 1-3**.

1.3.5 Facility 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-age Lavery Till and Hiram Till in the western and eastern portions of the facility, respectively. The thickness of the glacial deposits varies throughout the facility, 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, including Load Line 1 at the east end of the RVAAP. 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

FIGURE 1-3 TOPOGRAPHY

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 Conglomerate where it was deposited in a broad channel cut into Mississippian 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 erosional surface. Thin shale lenses occur intermittently within the upper part of the conglomerate unit.

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 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 is 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 Conglomerate, 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 (MKM Engineering, Inc. [MKM], 2007).

The soils identified at the facility are generally derived from the Wisconsin-age silty clay glacial till. The majority of native soil at the facility has been reworked or removed during construction activities (MKM, 2007). The major soil types found at the facility are silt or

clay loams, ranging in permeability from 6.0×10^{-7} to 1.4×10^{-3} centimeters per second (cm/s) (U.S. Department of Agriculture [USDA] et al., 1978).

Sand Creek Dump Geology and Soils

As a former dump site, it is expected that much of the native soil at the Sand Creek Dump MRS was reworked, removed, or used as cover material during dumping activities. Borings were advanced during the Phase I RI field activities that were conducted under the IRP at the collocated AOC in 2010. Evidence of fill material that included coal ash and glass debris was encountered in borings advanced along the top of the embankment as deep as 8 feet bgs, primarily at the northern portion of the AOC. The depth of fill material along the top of the slopes appeared to decrease to less than 2 feet bgs as the borings were advanced south towards the former railroad bed. Only native glacial materials were observed in the one boring that was advanced at the southern portion of the AOC, south of the former railroad bed. Glacial materials encountered in the borings were consistent with the deposits associated with the silt loam types at the facility that include light brown to dark brown, gray, and mottled silt with sand. Associated sediments were observed below the till and consisted of well-sorted, saturated gray silt with clay lenses and unconsolidated fine- to medium-grained sands. The depth to sediments ranged from 13 to 15 feet bgs across the MRS, which was the approximate depth where groundwater was encountered in three borings at the northern portion of the MRS. Bedrock was not encountered at any of the boring locations that were advanced to a maximum depth of 20 feet bgs (Shaw, 2012).

The two native soil types at the Sand Creek Dump MRS include the Hornell Silt Loam with 3 to 8 percent slopes and the Orville Silt Loam (AMEC, 2008). **Figure 1-4** depicts the soil types at the Sand Creek Dump MRS.

The Hornell Silt Loam is the predominant soil type at the MRS. The soil type consists of moderately deep, somewhat poorly drained to moderately well drained gently sloping soils that formed partly in glacial till and partly in residuum from the underlying shale bedrock. This soil has a moderately deep root zone and low available water capacity. Permeability is very slow in this soil type and is seasonally saturated with water. The average permeability of the Hornell Silt Loam with a 3 to 8 percent slope is also 9.1×10^{-5} cm/s (USDA et al., 1978).

The Orville Silt Loam soil type is situated at the low land portions of the MRS along Sand Creek. This soil type is characterized with deep, somewhat poorly drained, nearly level soils that formed in loamy alluvium on flood plains. Orville soils have a deep root zone in summer when the water table is low and in drained areas. The available water capacity is high and permeability is moderate. These soils are subject to occasional flooding and they have a

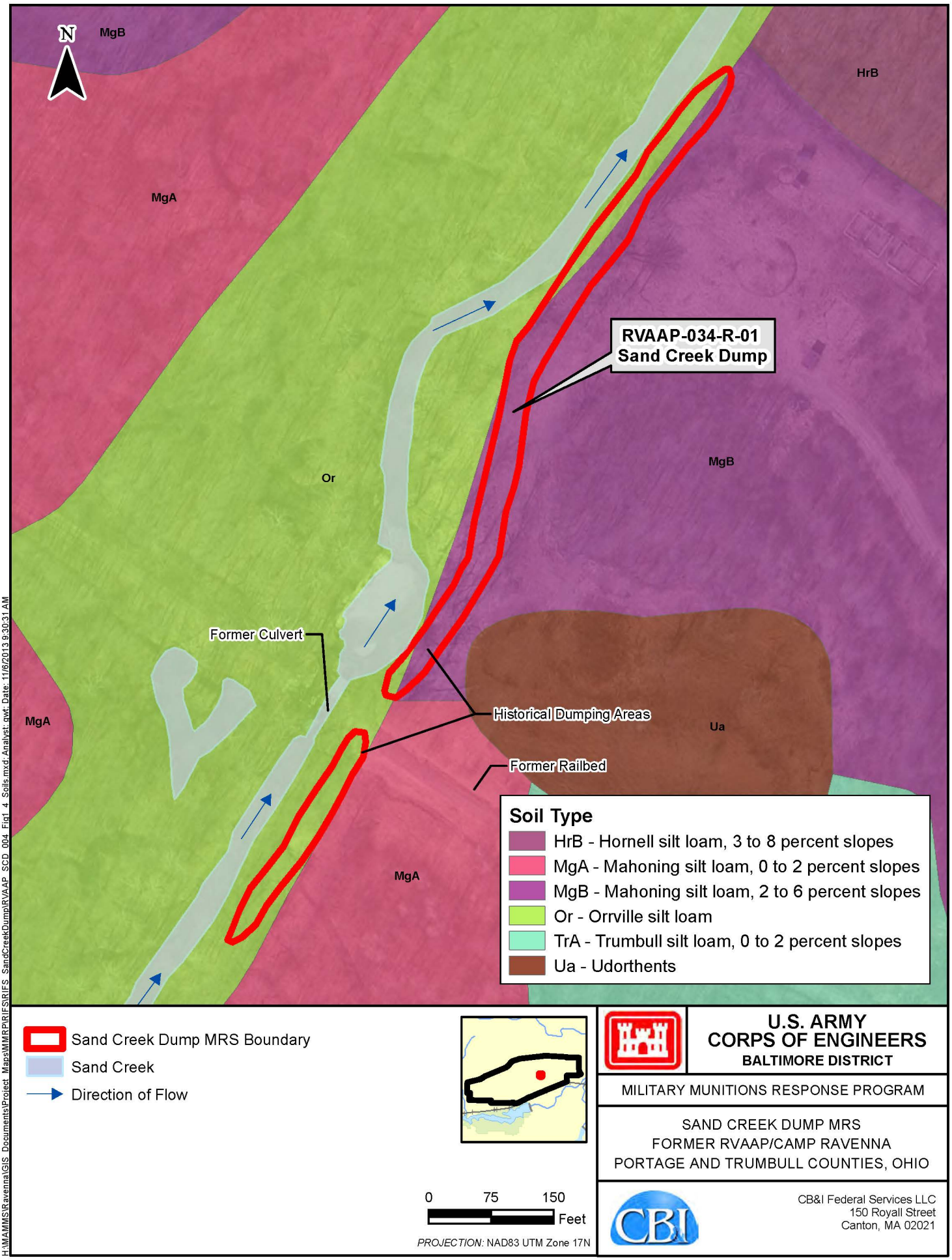


FIGURE 1-4 SOILS MAP

water table near the surface late in winter and in spring. The average permeability of the Orville Silt Loam is 1.31×10^{-3} cm/s (USDA et al., 1978).

The Sand Creek Dump MRS straddles two bedrock formations, the Sharon Sandstone Conglomerate Unit and the Berea Sand Stone. The Berea Sandstone consists of isolated deposits beneath the facility and is the primary formation beneath the MRS (AMEC, 2008). No bedrock formations were observed at the MRS, and bedrock was not encountered in the borings advanced to 20 feet bgs during the Phase I RI for the collocated AOC (Shaw, 2012). **Figure 1-5** depicts the bedrock formation and elevation of the bedrock beneath the Sand Creek Dump MRS.

1.3.6 Facility Surface Water

The facility is located within the Ohio River Basin. The major surface stream at the RVAAP 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 that is located 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, which 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 [National Wetland Inventory maps, aerials, etc.]) for wetlands was conducted for the entire facility, including the Sand Creek Dump 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

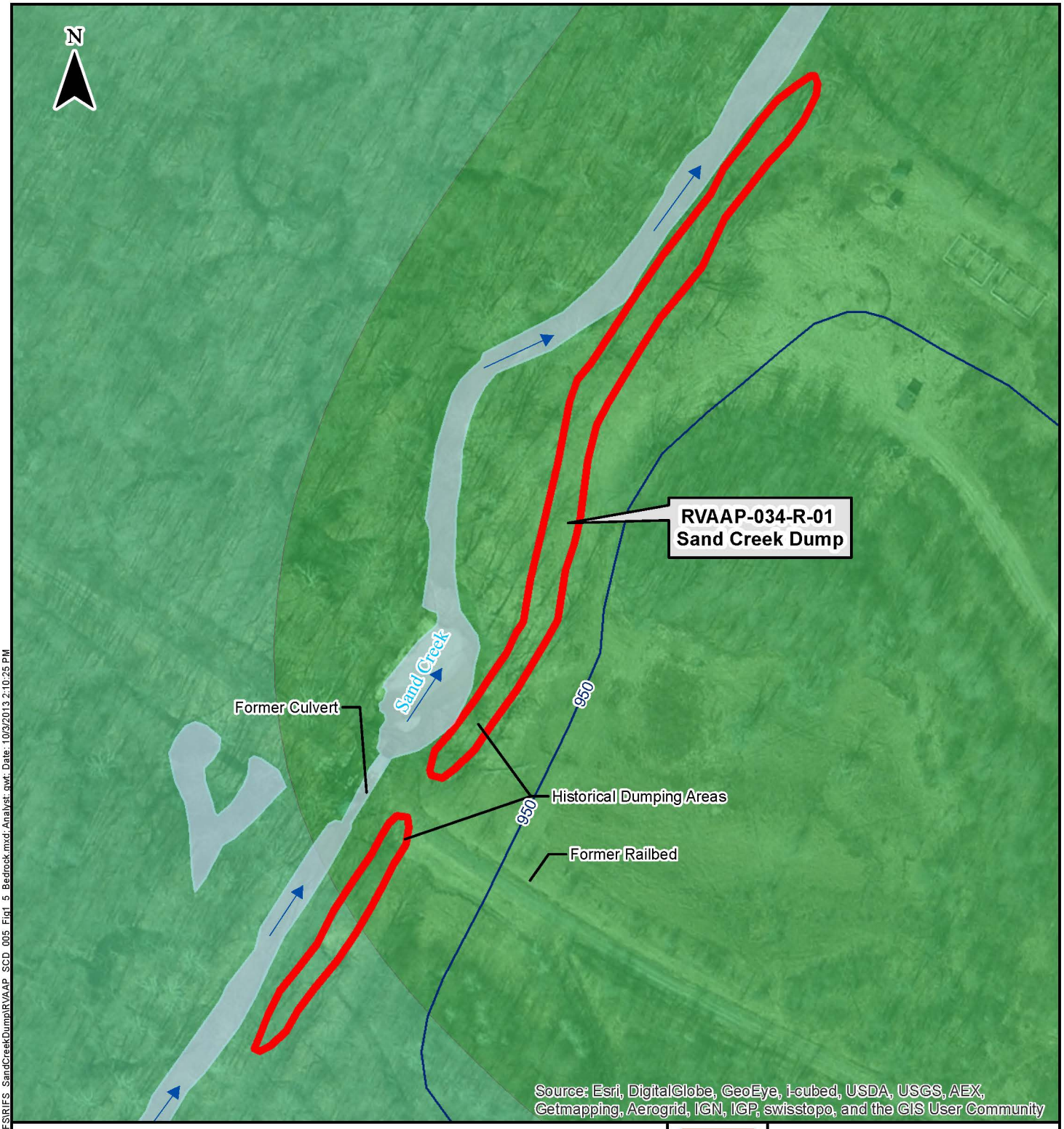


FIGURE 1-5 BEDROCK MAP

residential water supplies. Wells located on the facility were primarily located within the sandstone facies of the Sharon Member (MKM, 2007).

Sand Creek Dump MRS Surface Water Features

There are various depressions and several areas of standing water at the top of the embankment which is indicative of the silt-clay soils that are present in the surface and subsurface soils. However, in general surface water runoff follows the topography of the site and flows in a westerly direction where it enters Sand Creek. Sand Creek flows in a southwest to northeast direction along the western edge of the MRS. Sand Creek flows approximately 1,300 feet downstream of the MRS into Cobb's Pond, which forms the headwaters of a perennial stream. The perennial stream flows south and exits the facility beneath State Route 5. The local and regional surface water features associated with the MRS are presented in **Figure 1-6**.

Typical wetlands located within the facility consist of seasonally saturated wetlands, wet fields, and forested wetlands (MKM, 2007). No wetlands were identified at the Sand Creek Dump MRS; however, the lower portions of the embankments for the MRS run along Sand Creek and the MRS is located within a 100-year floodplain.

A facility-wide surface water investigation was conducted for the facility in 2003 by the USACE with cooperation of the Ohio Environmental Protection Agency (Ohio EPA). For the investigation, water and sediment samples were taken from locations along major streams and tributaries, ponds, and wetlands throughout the facility at locations that could have been impacted by former facility activities and sites where the streams entered the facility. The investigation included eight sampling locations along Sand Creek including one sample station that was adjacent to the MRS.

For all eight of the Sand Creek sampling locations, there were no exceedances of the Ohio Water Quality Standards aquatic life maximum or average water quality criteria. None of the chemicals measured in the investigation exceeded criteria protective of the Warmwater Habitat aquatic life use. Metals concentrations were very low, with many of the results less than laboratory detection limits. Parameters with measurable concentrations were below applicable Ohio Water Quality Standards aquatic life criteria. Low nutrient and dissolved solids levels in Sand Creek were largely reflective of the undeveloped condition of the watershed. It was determined in the 2003 facility-wide surface water investigation that the streams in the facility, inclusive of Sand Creek, are mostly undisturbed and are a good quality resource for aquatic biota and that contamination is not present in the surface water (USACE, 2005b).

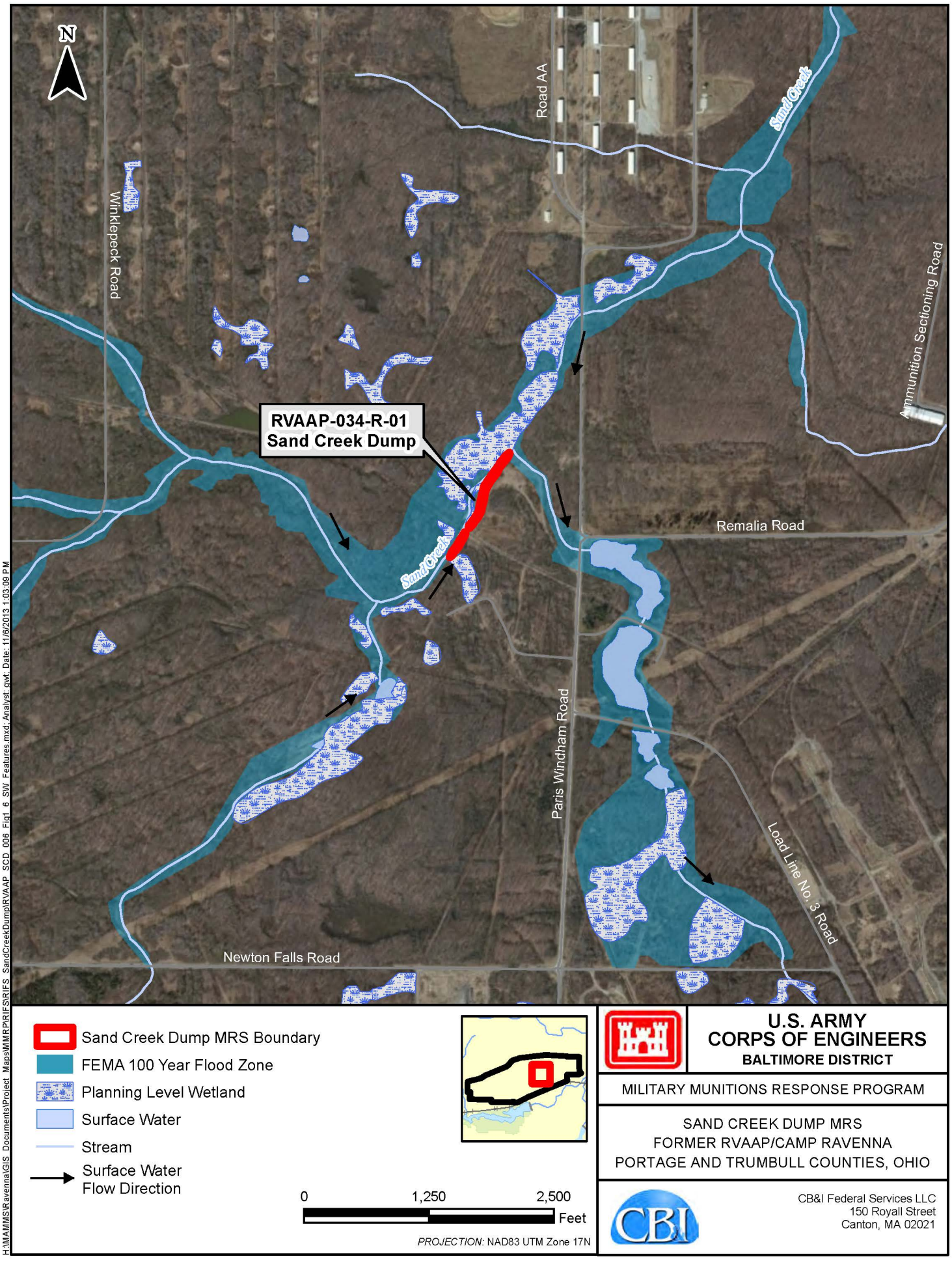


FIGURE 1-6 SURFACE WATER FEATURES MAP

1.3.7 Facility 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 the facility ranges from thin to absent in the eastern and northeastern portion of the facility to an estimated 150 feet in its south-central portion. 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 as well as 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 Member ranges from an unconfined to a leaky artesian aquifer. Water yields from water supply wells at the facility that were completed in the Sharon Member 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 bedrock wells that were completed at the facility in the Sharon Member (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 less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow and White, 1966).

Sand Creek Dump 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 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 Sand Creek Dump MRS is located at the more level, eastern portion of the facility and is not presumed to be located in the recharge zone.

No groundwater monitoring wells have been specifically installed for the Sand Creek Dump MRS. Throughout the facility, average depth to groundwater is as deep as 50 feet bgs with static water levels occurring between 958 and 1,184 feet amsl (Kammer, 1982). However, groundwater has been encountered at much shallower depths in the upper unconsolidated aquifer across the facility. The latter is most likely the case at the Sand Creek site where the top of the embankment ranges from 15 to 25 feet above the surface of Sand Creek, and saturated soil was encountered in the soil borings at the northern portion of the AOC during the Phase I RI in 2010 where the embankment is the shortest, at depths of approximately 13 feet bgs (Shaw, 2012).

1.3.8 Facility 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).

Sand Creek Dump MRS Vegetation

The vegetation community present at the Sand Creek Dump MRS is categorized as a "Mixed Swamp Forest Community." The vegetation formation in this community is typically associated with floodplains near streams and rivers and other temporarily flooded areas. The dominant species consist of green ash, American elm, hackberry, and red maple. Black walnut, white ash, swamp white oak, cottonwood, and black willow are also present (AMEC, 2008). **Figure 1-7** illustrates the plant communities at the Sand Creek Dump MRS.

1.3.9 Threatened and Endangered and Other Rare Species

Federal status as a candidate, threatened, or endangered species is derived from the Endangered Species Act (16 U.S. Code § 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 RVAAP. State-listed plant and animal species are determined by the Ohio Department of Natural Resources. Although biological inventories have not occurred within the MRS boundary and no confirmed sightings of federal- and/or state-listed species have been reported, there is the potential for federal- and/or state-listed species to be within the MRS boundary. Information regarding federal- and state-listed endangered, threatened, and candidate species at the facility was obtained from the 2*013 Federal and State Listed Species* (Camp Ravenna, 2013). **Table 1-3**

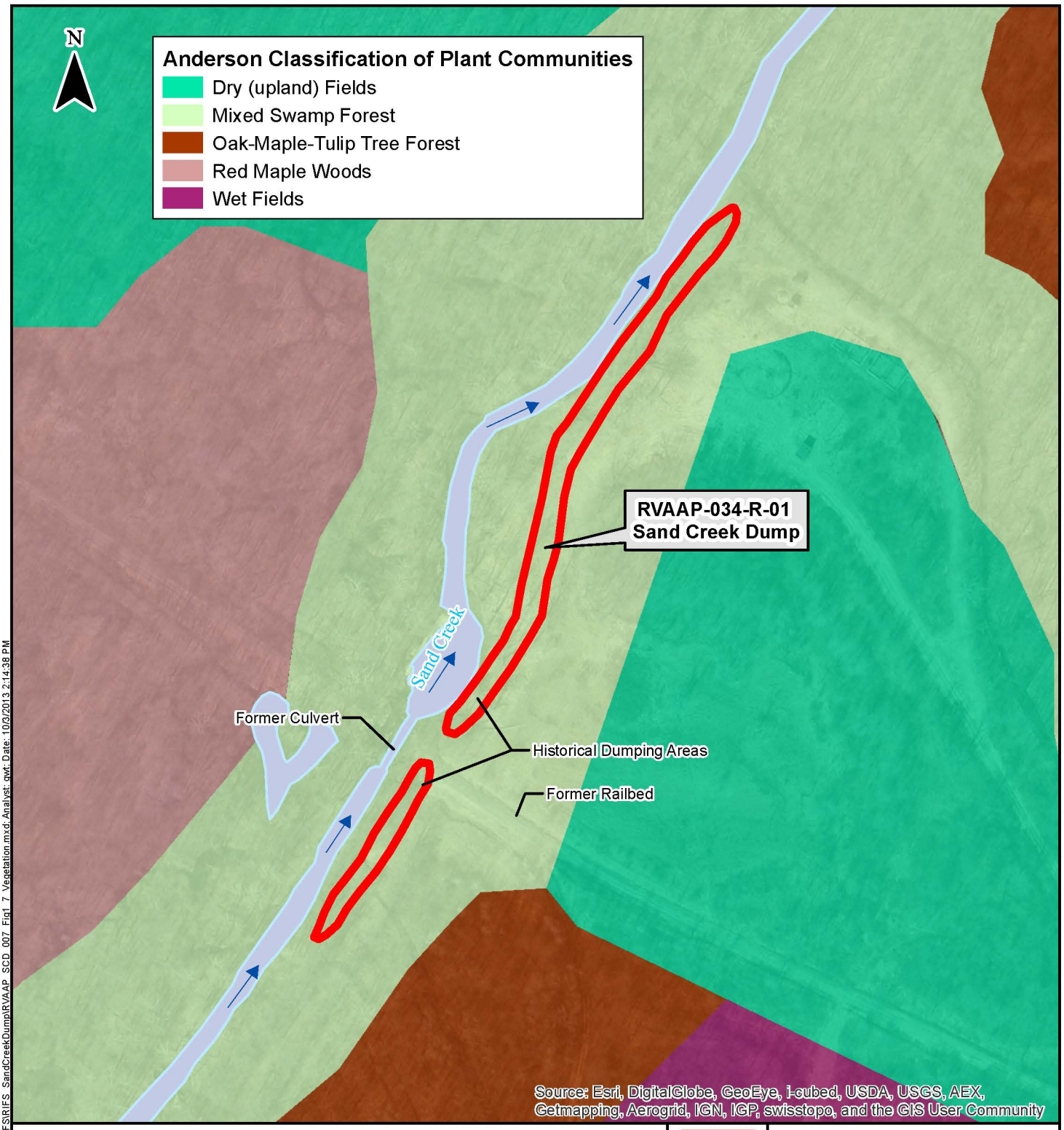


FIGURE 1-7 VEGETATION MAP

presents the federal- and state-listed species that have been identified to be on the facility by biological inventories and confirmed sightings.

Table 1-3
Camp Ravenna Federal and State Listed Species

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Brush-tipped emerald	*Somatochlora walshii*
False arrow-feather	*Aristida necopina*
Graceful underwing	*Catocala gracilis*
Handsome sedge	*Carex formosa*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Narrow-necked Pohl's moss	*Pohlia elongata* Var. *elongata*
Northern harrier	*Circus cyaneus*
Philadelphia panic-grass	*Panicum philadelphicum*
Sandhill crane	*Grus canadensis*
Tufted moisture-loving moss	*Philonotis fontana* Var. *caespitosa*
Variegated scouring-rush	*Equisetum variegatum*
State Threatened	
Barn owl	*Tyto alba*
Bobcat	*Felis rufus*
Caddisfly	*Psilotreta indecisa*
Hobble-bush	*Viburnum alnifolium*
Least bittern	*Ixobrychus exilis*
Lurking leskea	*Plagiothecium latebricola*
Simple willow-herb	*Epilobium strictum*
Trumpeter swan	*Cygnus buccinator*
Strict blue-eyed grass	*Sisyrinchium montanum*
State Potentially Threatened Plants	
Arborvitae[1]	*Thuja occidentalis*

Common Name	Scientific Name
False hop sedge	*Carex lupuliformis*
Greenwhite sedge	*Carex albolutescens*
Long beech fern	*Phegopteris connectilis*
Pale sedge	*Carex pallescens*
Sharp-glumed manna-grass	*Glyceria acutifolia*
Shining ladies-tresses	*Spiranthes lucida*
Straw sedge	*Carex straminea*
Water avens	*Geum rivaled*
Woodland horsetail	*Equisetum sylvatic*
Federal Species of Concern	
Bald eagle	*Haliaetus leucocephalus*
Butternut	*Juglans cinerea*
Handsome sedge	*Carex formosa*
State Species of Concern	
Big brown bat	*Eptesicus fuscus*
Bobolink	*Dolichonyx oryzivorus*
Cerulean warbler	*Dendroica cerulea*
Common moorhen	*Gallinula chloropus*
Creek heelsplitter	*Lasmigona compressa*
Deer mouse	*Peromyscus maniculatus*
Eastern box turtle	*Terrapene carolina*
Eastern garter snake	*Thamnophis sirtalis*
Eastern red bat	*Lasiurus borealis*
Eastern sand darter	*Ammocrypta pellucida*
Four-toed salamander	*Hemidactylium scutatum*
Great egret	*Ardea alba*
Henslow’s sparrow	*Ammodramus henslowii*
Hoary bat	*Lasiurus cinereus*
Little brown bat	*Myotis lucifugus*

Common Name	Scientific Name
Marsh wren	*Cistothorus palustris*
Mayfly	*Stenonema ithica*
Moth	*Apamea mixta*
Moth	*Brachylomia algens*
Northern bobwhite	*Colinus virginianus*
Northern long-eared bat	*Myotis septentrionalis*
Prothonotary warbler	*Protonotaria citrea*
Pygmy shrew	*Sorex hovi*
Scurfy quaker	*Homorthodes furfurata*
Sedge wren	*Cistothorus platensis*
Sharp-shinned hawk	*Accipiter striatus*
Smooth green snake	*Opheodrys vernalis*
Sora rail	*Porzana carolina*
Southern bog lemming	*Svnaptomys cooperi*
Star-nosed mole	*Condylura cristata*
Tri-colored bat	*Perimyotis subflavus*
Virginia rail	*Rallus limicola*
Woodland jumping mouse	*Napaeozapus insignis*
Yellow-bellied sapsucker	*Sphyrapicus varius*
State Special Interest	
American black duck	*Anas rubripes*
Blackburnian warbler	*Dendroica fusca*
Black-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Canada warbler	*Wilsonia canadensis*
Dark-eyed junco	*Junco hyemalis*
Gadwall	*Anas strepera*
Golden-crowned kinglet	*Regulus satrapa*
Green-winged teal	*Anas crecca*

Common Name	Scientific Name
Hermit thrush	*Catharus guttatus*
Least flycatcher	*Empidonax minimus*
Magnolia warbler	*Dendroica magnolia*
Mourning warbler	*Oporornis philadelphia*
Northern shoveler	*Anas clypeata*
Northern waterthrush	*Seiurus noveboracensis*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*
Subflava sedge borer moth	*Archanara subflava*
Wilson's snipe	*Gallinago delicata*
Winter wren	*Troglodytes troglodytes*
State Extirpated	
Golden-winged warbler	*Vermivora chrysoptera*

Source: Camp Ravenna Joint Military Training Center Federal and State Listed Species, May 16, 2013.

[1] denotes Arborvitae was planted and does not occur naturally within the facility.

1.3.10 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility and cultural and archeological resources have been identified. The Sand Creek Dump MRS has not been previously surveyed for cultural or archeological resources (AMEC, 2008). However, due to the disturbed nature of the area from former operations, it is unlikely that cultural/archeological resources exist at the MRS.

1.4 Facility History and Background

During operations as an ammunition plant, the RVAAP was a government-owned and contractor-operated industrial facility. Industrial operations at the facility 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 (TNT) 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-TNT 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. 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 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 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. Other AOCs present at the facility include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities (MKM, 2007).

Sand Creek Dump MRS History and Background

The Sand Creek Dump MRS is an approximately 0.85-acre area that is located in the eastern portion of the facility. The Sand Creek Dump is a former open dump area that operated from 1950 to 1960. Details regarding the operational history of disposal activities are incomplete, including the types of materials and quantities dumped at the site; however, the following kinds of construction and debris materials have been verified during previous actions at the collocated AOC:

- Asbestos-containing material (ACM) (i.e., large piles of corrugated transite roofing and flat transite siding)
- Rubble (i.e., concrete, brick, and masonry fragments)
- Drywall and plaster
- Glass bottles, fluorescent light tubes, and broken glass
- Scrap metal items including wire fencing
- Wooden debris

In general, it is assumed that the construction and debris type material were delivered and dumped over an embankment located immediately adjacent to Sand Creek. The dump site extended along the embankment for approximately 1,200 feet and varied in width from 20 to 40 feet from the top of the bank to the bottom. The bank slopes from east to west towards Sand Creek at 40 to 60 degrees from horizontal.

In October 2003, a Removal Action was performed under the IRP to remove all surface and subsurface debris in order to eliminate source contamination to protect human and ecological receptors. Prior to the Removal Action, the entire site was littered with the aforementioned types of construction and debris materials with large piles of debris concentrated mostly in the southern portion of the AOC.

During confirmation sampling following the Removal Action, two 75mm projectile shells were discovered at the northern portion of the AOC and were inspected and verified as MD by unexploded ordnance (UXO)-qualified personnel. Evaluation of the Sand Creek Dump as an MRS was initiated following the MD findings during the Removal Action.

There are currently no cultural features at the MRS but several buildings associated with the former Sand Creek Sewage Treatment Plant are located northeast of the MRS (MKM, 2004). A former rail bed bisects the site, and the former rail bed culvert that crossed over Sand Creek was removed in 2013. **Figure 1-8** depicts the current MRS boundaries and significant site features.

1.5 Previous Investigations

This section briefly summarizes the previous investigations that were conducted as it pertains to the Sand Creek Dump discussed in this RI Report. This discussion is inclusive of investigations and other actions that were conducted at the collocated AOC and MRS under the IRP and the MMRP. This information was obtained primarily from the *Final Military Munitions Response Program Historical Records Review, Ravenna Army Ammunition Plant, Ohio* (e^2M, 2007), hereafter referred to as the HHR; the SI Report (e^2M, 2008); and the *Draft Phase I Remedial Investigation Report for RVAAP-34 Sand Creek Disposal Road Landfill* (Shaw, 2012), hereafter referred to as the Phase I RI Report.

1.5.1 1996 USACHPPM Relative Risk Site Evaluation

In 1996, the U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) conducted a Relative Risk Site Evaluation (RRSE) for previously uninvestigated sites at the facility. From the 19 sites that were evaluated, 4 were classified as "high" priority AOCs and the others were classified as "low" or "medium." The four high-

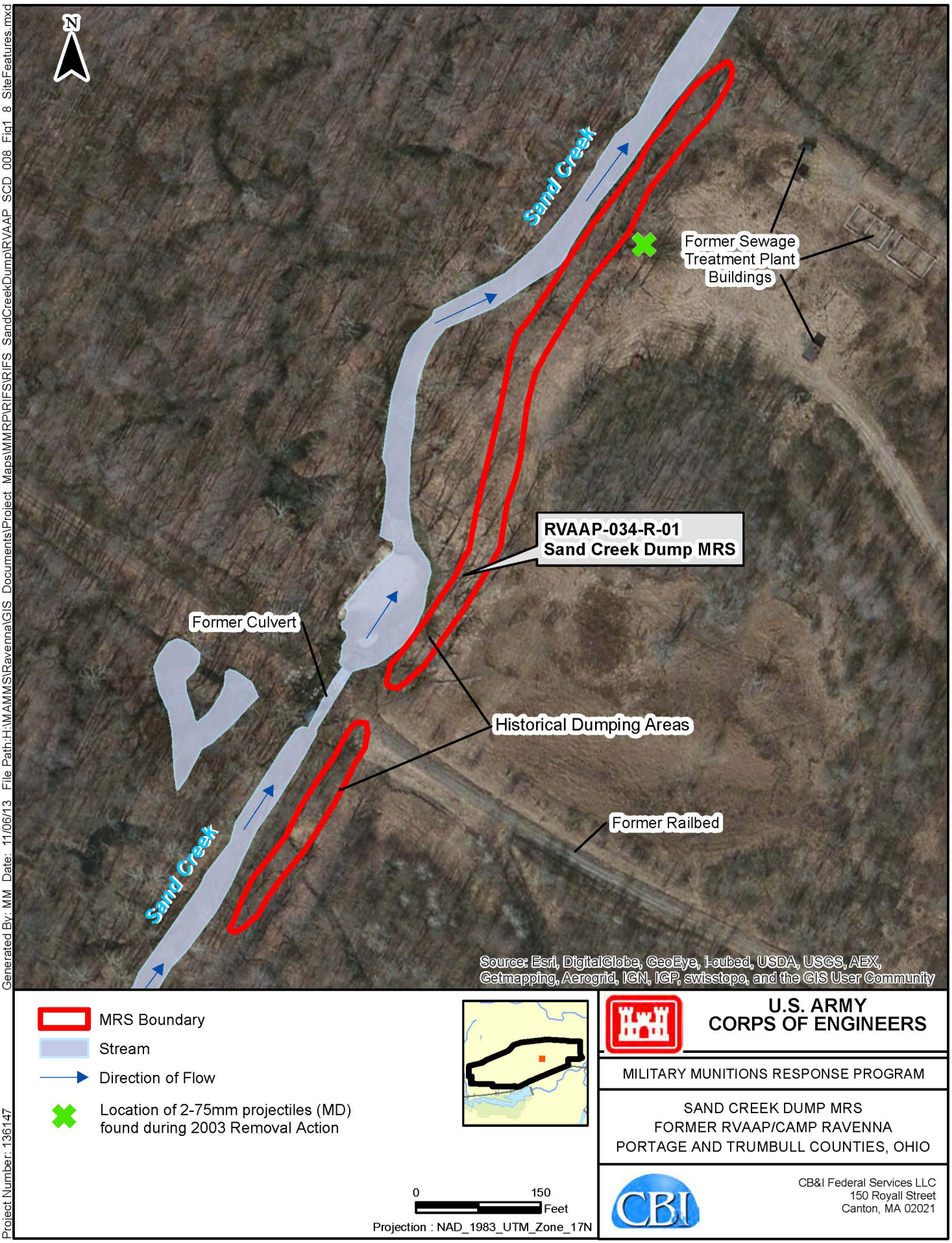


FIGURE 1-8 SITE FEATURES MAP

priority AOCs included the Sand Creek Disposal Road Landfill that is collocated with the Sand Creek Dump MRS. The 1996 USACHPPM Report identified surface soil and sediments to be potential media for contaminant migration at the Sand Creek Dump due to the lack of any physical barriers/fence around the AOC and its proximity to Sand Creek. Three shallow soil samples and one sediment sample were collected at and in the vicinity of the AOC during the RRSE. The study identified arsenic as exceeding RRSE screening values for sediments and identified the potential for arsenic to migrate into Sand Creek. The RRSE for this AOC was scored "high" since Sand Creek is a habitat for state endangered species (mountain brook lamprey, and the river otter). Under the CERCLA process, a site which registers a RRSE rating of "high" requires further investigation and/or removal (USACHPPM, 1998). Arsenic is not considered a MC associated with the munitions historically found at the MRS.

1.5.2 2003 MKM Removal Design/Removal Action

A Removal Action was conducted at the Sand Creek Disposal Road Landfill AOC by MKM in 2003. The removal effort at the AOC consisted of removing all existing unconsolidated surface debris, the limited removal of subsurface debris, transportation and disposal of debris and restoration activities. Due to the presence of transite, all debris was disposed of as ACM special waste. Approximately 1,118 tons of ACM material, including the subsurface transite, glass, and miscellaneous debris were removed from the AOC (MKM, 2004).

Confirmatory surface soil, surface water, and sediment samples were collected in and around the AOC by MKM following the removal efforts to evaluate the success of the Removal Action and to characterize potential impact to Sand Creek and the neighboring floodplain. Prior to sampling, the AOC was divided into 31 sampling units to facilitate collection of discrete soil samples. A total of 33 surface soil samples (0 to 1 foot), not including duplicates and quality control (QC) samples, were collected from the grid locations that each measured approximately 40 feet by 40 feet. Surface water was collected at 3 locations, and sediment samples were collected at 12 locations within Sand Creek and neighboring floodplains, respectively, to characterize potential impact associated with surface water runoff from the site. All of the surface soil, sediment, and surface water samples collected for the Removal Action were analyzed for Target Analyte List (TAL) metals and asbestos. The remaining analyses included explosives, propellants, cyanide, pesticides, polychlorinated biphenyls, semivolatile organic compounds (SVOCs), and volatile organic compounds. These analyses were only conducted on a representative number of samples that was generally 10 to 15 percent of the total samples collected.

Confirmation samples collected following the Removal Action revealed elevated concentrations of heavy metals, SVOCs, and explosives above the U.S. Environmental

Protection Agency (EPA) Region 9 Residential Preliminary Remediation Goals (PRGs) in the surface soils at the AOC. The PRGs were the screening criteria used at that time. For the purposes of this RI, discussion of the Removal Action confirmation sample results only focuses on site-related chemicals (SRCs) that are considered as potential MC associated with the munitions that may be found at the collocated MRS. Theses SRCs include the detected concentrations of selected metals (cadmium, total chromium, iron, lead, and mercury), SVOCs, and explosives. Iron was the most prevalent of the SRCs considered as MC in surface soil that was detected above the PRGs at 15 of the 33 discrete sampling locations. SVOCs consisting of chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3)pyrene, and dibenzo(a,h)anthracene were detected above the PRGs at one discrete surface soil sample location. The detected explosives that exceeded the PRGs in the surface soil samples consisted of 2,4,6-TNT and 2,6-dinitrotoluene. Nitrocellulose is a propellant that was detected in the surface soil samples; however, there is no PRG available for nitrocellulose. Iron was the only metal SRC considered as MC that was detected above its PRG in one of the sediment samples. Nitrocellulose was detected in a surface water sample and in two sediment samples. As for surface soil, there is no PRG available for nitrocellulose in surface water or sediment. **Figure 1-9** illustrates the Removal Action sample locations and where the SRCs considered as potential MC were detected.

It was during confirmation sampling following the removal action that the two MD 75mm projectiles shells were discovered. The location where the MD were identified during the 2003 removal action is presented in **Figure 1-8**.

1.5.3 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 facility (USACE, 2004). The *Final Archives Search Report for Ravenna Army Ammunition Plant* (Archives Search Report [ASR]) 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.

The 2004 ASR indicated that the Sand Creek Dump MRS was “considered to have no explosive ordnance presence.” The report stated that only inert 75mm projectiles were found

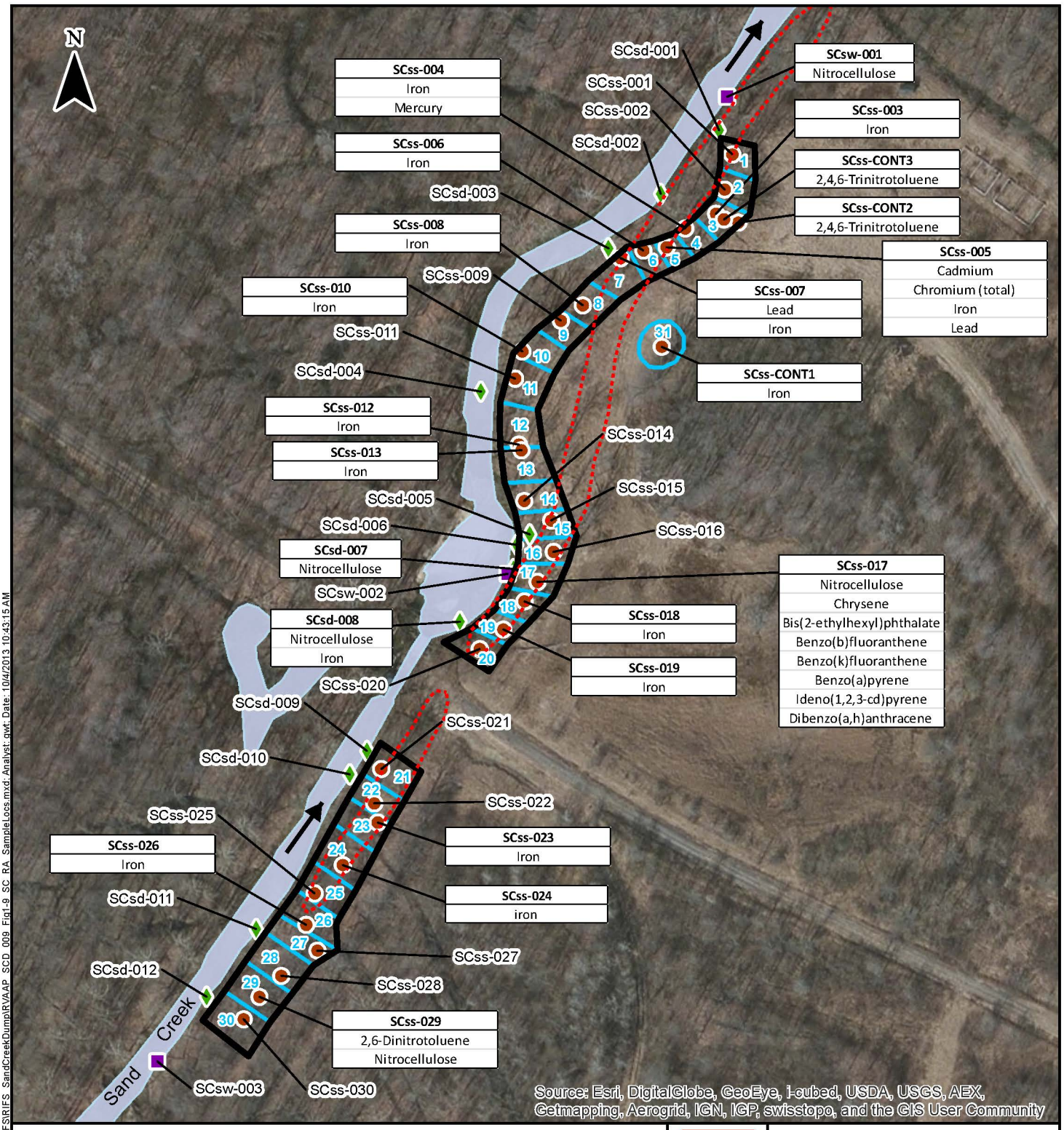


FIGURE 1-9 2003 REMOVAL ACTION SAMPLE LOCATIONS AND AREAS WITH POTENTIAL MC

at the MRS and that the discovery of inert metal parts often are found in landfills. Further, the report concluded that other than being examined by a knowledgeable individual, no further action should be required at the MRS (USACE, 2004).

1.5.4 2007 e^{2}M Historical Records Review

The *Final Military Munitions Response Program Historical Records Review* (HRR) was performed 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 facility, to supplement the U.S. 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 Inventory, the HRR identified 18 MRS that qualified for the MMRP due to the demolition and/or dump activities that were conducted on the MRSs which resulted in the possible presence of MEC and/or MC, and where the releases occurred prior to September 2002 (e^{2}M, 2007). These 18 MRS identified during the HRR included 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 RVAAP to 17.

Based on the two inert 75mm projectiles identified at the Sand Creek Disposal Road Landfill AOC during the 2003 Removal Action, the HHR identified the release mechanism of MEC items at the MRS as the surface disposal of munitions. The HHR confirmed that evaluation for MC would not be conducted during the SI process under the MMRP since chemical contamination was being addressed under the IRP. It was concluded in the HHR that while MEC had not been found at the MRS to date, the possibility existed that items may have been buried and mixed with general waste material that had been deposited over the years. Considering this, it was determined that the extent of MEC at the Sand Creek Dump was not fully understood, specifically whether MEC was mixed with the general waste material and was buried (e^2M, 2007).

1.5.5 2008 e^2M Site Inspection Report

In 2007, e^2M conducted an SI at each of the 17 active MRSs that were identified in the HRR (e^2M, 2007). The primary objectives of the SI 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 applicable MRS. Out of the 17 MRSs evaluated during the SI phase, 14 were recommended for Further Characterization under the MMRP that included the Sand Creek Dump MRS. A summary of the of the SI Report recommendations for the Sand Creek Dump MRS is presented in **Table 1-4**.

Table 1-4
Site Inspection Report Recommendations

MRS	MRSPP Priority	Recommendations	Basis for Recommendation	
			MEC	MC
Sand Creek Dump (RVAAP-034-R-01)	6	Further Characterization of MEC	MEC potentially buried	MC is covered under IRP AOC RVAAP-34.

AOC denotes Area of Concern.
IRP denotes Installation Restoration Program.
MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
MRSPP denotes Munitions Response Site Prioritization Protocol.
RVAAP denotes Ravenna Army Ammunition Plant.

During the SI field activities, a meandering path magnetometer and metal-detector assisted MEC survey was performed at all open areas of the Sand Creek Dump MRS. The survey instruments used included a Schonstedt handheld magnetic gradiometer and a White Matrix M6 metal detector. Multiple subsurface anomalies were recorded. However, the nature of the anomalies could not be determined since an intrusive investigation was not performed during the SI field activities. A 105mm projectile was observed at the bottom of Sand Creek at a location adjacent to the northern boundary of the MRS. It was noted in the SI Report that a determination was not made as to the explosive safety status (i.e., "safe" or "hazardous") of the projectile. Based on historical findings and field observations made during the SI, it was concluded in the SI Report that there was a potential for MEC at the MRS that required further characterization. Samples for MC were not collected during the SI because chemical contamination was being addressed under the IRP (e^2M, 2008). The areas investigated during the SI field activities are presented in **Figure 1-10**.

The SI Report (e^2M, 2008) assigned the Sand Creek Dump MRS a Munitions Response Site Prioritization Protocol (MRSPP) priority of 6. The MRSPP is a funding mechanism that is typically initially performed during the preliminary assessment/SI stage to prioritize funding for MRSs and is updated after every phase of the MMRP (i.e., RI, FS, and removal action completion). The MRSPP has a priority scale of 1 to 8 with a priority of 1 being the highest relative priority. Based on the MRSPP score presented in the SI Report (e^2M, 2008), the Sand Creek Dump MRS was selected for inclusion for further characterization under the MMRP.

1.5.6 2010 Shaw Digital Geophysical Mapping Survey

CB&I conducted a digital geophysical mapping (DGM) survey under the IRP in 2010 at and in the immediate vicinity of the Sand Creek Disposal Road Landfill AOC where historical

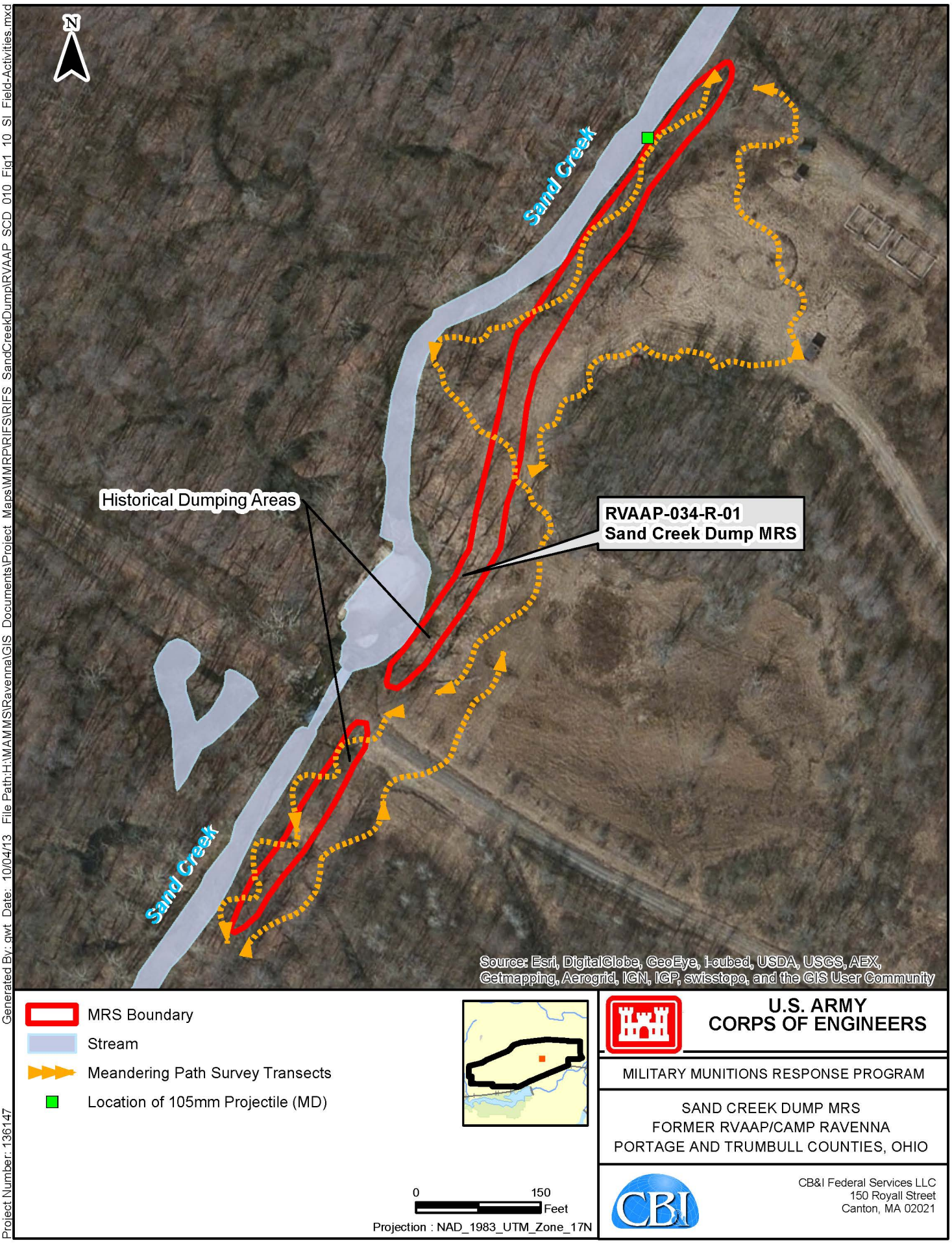


FIGURE 1-10 SI FIELD ACTIVITIES AND FINDINGS

dumping activities occurred. The primary objective of the survey was to determine the horizontal extent of potential MEC contamination and other suspected buried anomalies without performing intrusive activities. The secondary objective was to evaluate the data to characterize the anomaly density at the AOC. The primary geophysical instrumentation used for the 2010 DGM survey consisted of an EM61-MK2 time-domain electromagnetic instrument and a Leica 1200 robotic total station (RTS) positioning system. The Geometrics G-858G cesium vapor magnetometer instrument magnetometer was used at the locations at the AOC where steep terrain limited the safe deployment of the EM61-MK2 system.

Geophysical data were collected south and north of the former rail bed that bisects the site, along the steep slopes of the embankment in the central portion of the AOC, and east of the steep embankment in the open area. During this effort, data were acquired in accessible areas void of thick vegetation and fallen trees and where the embankments and other localized slopes were navigable by the field crew (Shaw, 2011b). The areas at and adjacent to the Sand Creek Disposal Road Landfill AOC that the DGM survey covered are presented in **Figure 1-11**.

The 2010 DGM data were able to determine the broader limits of metallic waste materials as well as to define more localized regions within and outside the AOC footprint that contain relatively higher metal content. The survey data indicated that the largest portion of the metal debris is present northeast of the former railroad bed. Several areas characterized by relatively higher density of anomalies are located between the stream and the edge of the eastern plateau. The large oval-shaped area that trends southwest–northeast in the northeastern portion of the survey area (contiguous pink colors on **Figure 1-11**) is approximately 0.8 acres in size. Areas characterized by relatively lower density of anomalies are present throughout the southern portion of the survey area.

1.5.7 2010 Shaw Phase I Remedial Investigation

The Phase I RI field activities were conducted under the IRP at the collocated Sand Creek Disposal Road Landfill AOC in 2010 and included the collection of surface soil, subsurface soil, and sediment samples. The surface soil samples were collected using the incremental sampling methodology (ISM) and the subsurface soil samples were collected using a modified version of the ISM that was specified by the USACE, Louisville District. Based on the data gaps and need for additional information regarding contaminants identified during the previous investigations at the AOC, the following samples were collected for the Phase I RI:

- 18 ISM surface soil samples from 0 to 1 foot bgs from along the AOC source area slopes and upgradient locations at the top of slope where historical dumping activities occurred.

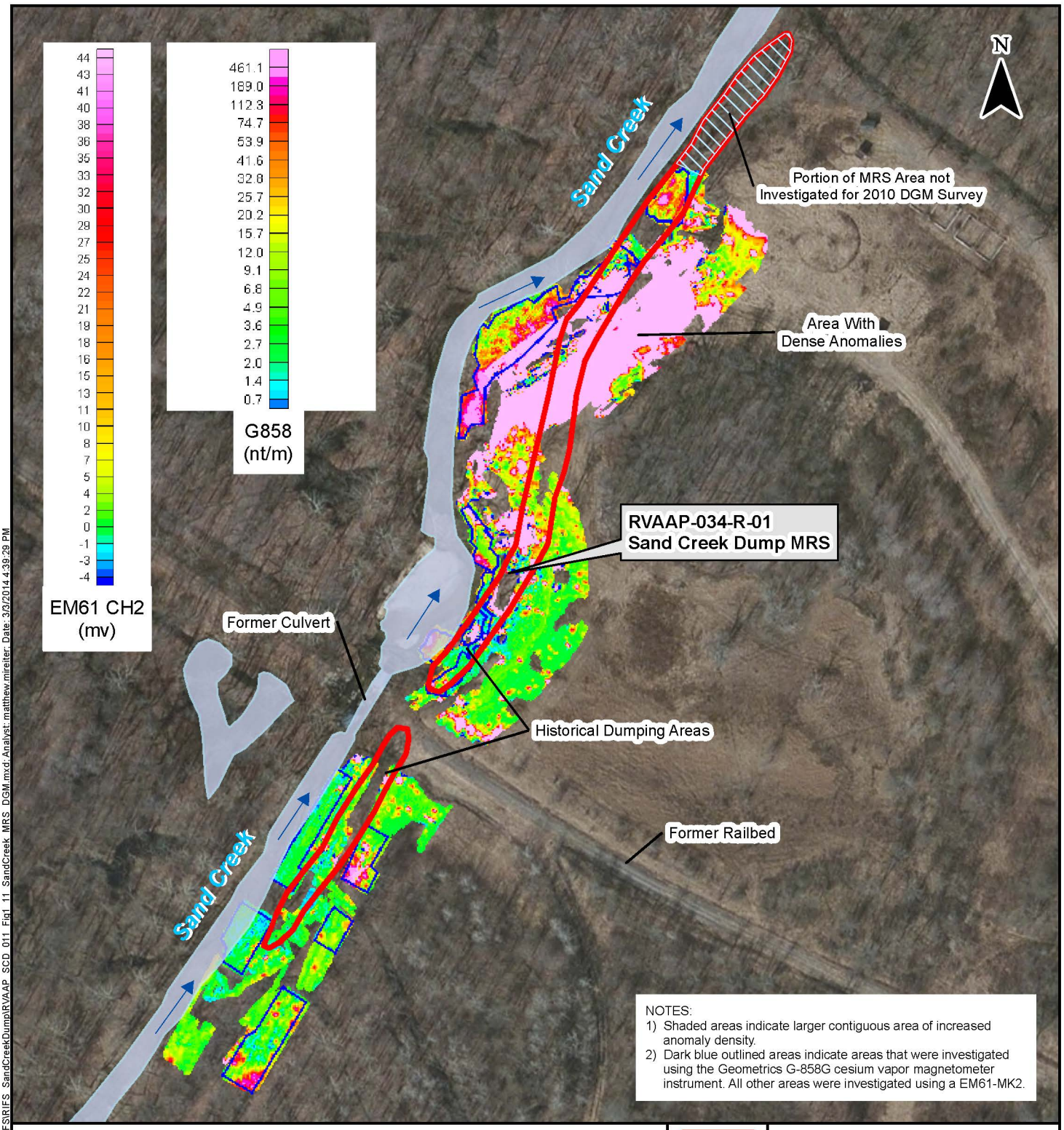


FIGURE 1-11 2010 DGM SURVEY RESULTS

- 2 ISM sediment samples from 0 to 0.5 feet bgs along the floodplain downgradient of the AOC source area slopes and adjacent to Sand Creek.
- 58 modified ISM subsurface soil samples using direct-push technology (DPT) and manual hand augers. The DPT samples were collected at the top of slope upgradient of the AOC source areas at the following intervals: 1 to 5 feet, 5 to 9 feet, 9 to 13 feet, 13 to 17 feet, and 17 to 20 feet. The hand-augered samples were collected at the 1-to-5-foot sample intervals along the sloped areas of the AOC where DPT sampling could not be performed.

Each surface soil and subsurface soil sample location was analyzed for TAL metals, SVOCs, and explosives. Approximately 10 percent of the soil samples and both sediment samples were analyzed for the RVAAP full suite that included volatile organic compounds, pesticides, polychlorinated biphenyls, total cyanide, and propellants. Five of the surface and five of the subsurface soil samples were submitted for hexavalent chromium analysis (Shaw, 2012). For the purposes of this RI under the MMRP, only select metals (aluminum, antimony, barium, cadmium, total chromium, hexavalent chromium, copper, iron, lead, strontium, mercury, and zinc), explosives, and SVOCs are SRCs that are considered as MC associated with the munitions that may found at the collocated MRS (Shaw, 2011a).

The results of the Phase I RI samples were then aggregated with the qualified historical data to identify SRCs in accordance with the evaluation process presented in the *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (Science Applications International Corporation [SAIC], 2010), hereafter referred to as the Facility-Wide Cleanup Goal (FWCUG) guidance. The SRCs were then used to evaluate for contaminant fate and transport and were carried forward into the risk assessments for human and ecological receptors.

1.5.7.1 Fate and Transport Analysis

The contaminant migration chemicals of potential concern (CMCOPCs) identified in the Phase I RI as having the potential for impacting groundwater and surface water include 2,4,6-TNT and 2-amino-4,6- dinitrotoluene, 1,4-dichlorobenzene, carbazole, pentachlorophenol, benzene, alpha-benzene hexachloride (BHC), and beta-BHC. The CMCOPCs identified represent a conservative comparison, since groundwater at the Sand Creek Dump has not been investigated and the hydrogeologic parameters are either assumed values or literature values for comparable lithologies. Alpha-BHC and beta-BHC are pesticides that are not considered as MC under the MMRP.

1.5.7.2 Human Health Risk Assessment

A human health risk assessment (HHRA) is currently being prepared as part of the Phase I RI. Information from the Draft HHRA was incorporated into the RI to assist in the preparation of the CSM. The Draft HHRA includes an evaluation to determine whether conditions at the collocated AOC may pose a risk to current or future human receptors and to identify which, if any on-site conditions need to be addressed in the FS.

The AOC is considered as a single exposure unit in the Draft HHRA; however, soil data collected within and adjacent to the AOC were aggregated by depth intervals to better define exposure at various depths. The Draft HHRA includes analyses to assess for subsurface soil. The soil intervals for Unrestricted Land Use, which includes evaluation for the Resident Receptors (Adult and Child), is also assessed. Sediment samples collected for the Phase I RI and the results of the surface water samples collected from Sand Creek at stations located adjacent to the AOC (as part of previous investigations, namely the 2003 Removal Action and 2003 Facility-Wide Biological and Water Quality Study) are evaluated in the same manner for the identified receptors. The sample intervals evaluated in the Draft HHRA are as follows:

- Surface soil (0 to 1 foot and 0 to 4 feet bgs)
- Subsurface soil (1 to 13 feet and 4 to 7 feet bgs)
- Sediment (0 to 0.5 feet bgs)
- Surface water

The Draft HHRA was prepared using the streamlined approach to risk decision making as described in the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals* (USACE, 2012b). The approach identifies chemicals of potential concern (COPCs) by comparing detected concentrations to background values, eliminating essential nutrients, and comparing those concentrations to the cleanup goals in the FWCUG guidance (SAIC, 2010). The chemicals of concern (COCs) were identified through additional screening of the COPCs by comparing detected concentrations to specific FWCUGs and using a "Sum of Ratios" approach to account for cumulative effects.

As mentioned previously, only chemicals associated with the munitions that may have been historically used and/or disposed at the MRS are considered MC for evaluation under the MMRP. As such, not all of the COCs identified at the collocated AOC under the IRP are considered as MC. A summary of the COCs identified in the Draft HHRA that are considered as potential MC are as follows:

- Antimony, copper, mercury, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene in surface soil (0 to 1 foot bgs) for the Resident Receptor (Adult and Child)
- Benzo(a)pyrene in subsurface soil (1 to 13 feet bgs) for the Resident Receptor (Adult and Child)
- Benzo(a)pyrene and benzo(b)fluoranthene in surface soil (0 to 4 feet bgs) for the National Guard Trainee
- Lead in subsurface soil (4 to 7 feet bgs) for the National Guard Trainee

No COCs were identified in sediment or surface water for the Resident Receptor (Adult and Child) or the National Guard Trainee. **Figure 1-12** illustrates the sampling locations at the AOC for the Phase I RI and presents the results where COCs considered as potential MC were identified at the collocated MRS. The HHRA results are summarized in **Table 1-5**.

Table 1-5
Phase I RI COCs Considered as Potential MC

Receptor/Exposure Point	COCs Identified[b]
Surface Soil (0 to 1 foot bgs)	
Resident Receptor (Adult and Child)	Antimony Copper Mercury Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(a,h)anthracene
Surface Soil (0 to 4 feet bgs)	
National Guard Trainee	Benzo(a)pyrene Benzo(b)fluoranthene
Subsurface Soil	
Resident Receptor (Adult and Child) (1 to 13 feet bgs)	Benzo(a)pyrene
National Guard Trainee (4 to 7 feet bgs)	Lead
Sediment (0 to 0.5 feet bgs) and Surface Water	
Resident Receptor (Adult and Child) and the National Guard Trainee	None

bgs denotes below ground surface.
COC denotes chemical of concern.
MC denotes munitions constituents.

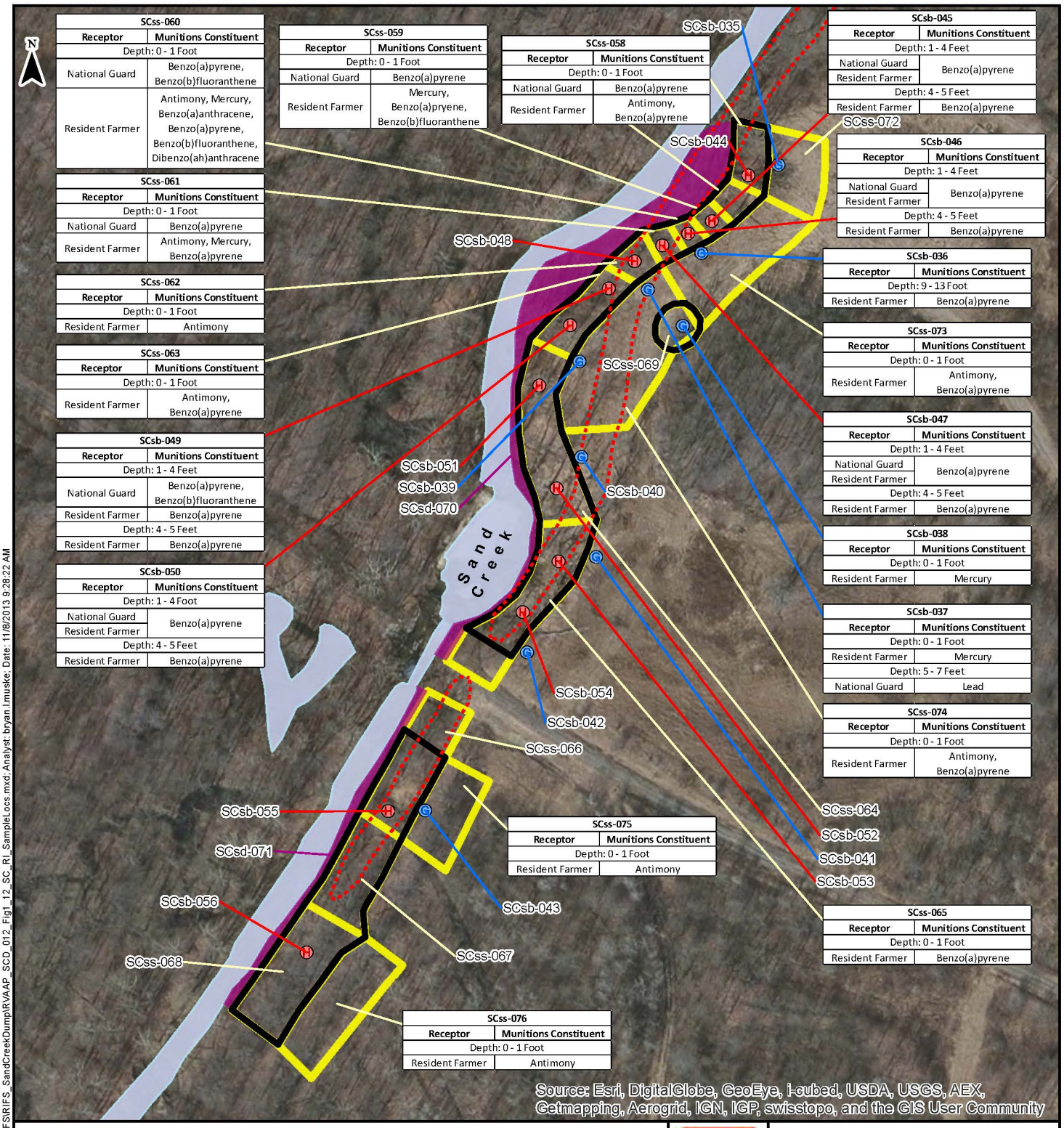


FIGURE 1-12 2010 PHASE I RI SAMPLE LOCATIONS AND AREAS WITH POTENTIAL MC

1.5.7.3 Ecological Risk Assessment

An ecological risk assessment (ERA) is being prepared as part of the Phase I RI to evaluate the potential for adverse ecological effects to ecological receptors from SRCs at the AOC and to determine if any ecological receptors need to be recommended for further evaluation in the FS under the IRP. The ERA includes characterizing the ecological communities in the vicinity of the AOC determining the particular contaminants present, identifying pathways for receptor exposure, and estimating the magnitude of the likelihood of potential adverse effects to identified receptors. AOC-specific analyte concentration data for surface soil, along with sediment data collected during the Phase I RI and surface water from previous investigations (the 2003 Removal Action and 2003 Facility-Wide Biological and Water Quality Study) are included in the ERA. The ecological receptor species selected for evaluation in the ERA are identified in the *Final RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003a).

Consistent with the RVAAP Unified Approach for performing ERAs, a screening-level ERA (SLERA) was performed for the Sand Creek Disposal Road Landfill AOC. 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 (2003a and 2010a). The Level I Scoping is designed to efficiently determine whether further ecological risk should be evaluated at a particular site. The Level II Screen is to be completed after the full nature and extent of the site contamination has been determined. The purpose of a Level II Screen is to select the list of detected chemicals per media as appropriate, evaluate aquatic habitats potentially impacted by the site, and if necessary, revise the CSM, complete a list of ecological receptors, identify chemicals of potential ecological concern (COPECs) and nonchemical stressors, and other tasks required for further ecological evaluation of the site and impacted habitats. The purpose of a Level III Baseline is to identify the potential for ecological harm at a site. Specifically, the Level III Baseline is a formal ERA process that includes an exposure assessment, toxicity assessment, risk characterization, and an uncertainty analysis. Potential ecological hazards are evaluated by using the COPECs and nonchemical stressors identified in a Level II Screen, generic receptors, direct contact evaluations, and food-web models that are provided in the guidance document.

Mercury in surface soil was identified as a COPEC that is considered a potential MC for evaluation under the MMRP. Mercury is the only COPEC recommended to be evaluated under the Level III Baseline evaluation following the Level II Screen. The only species identified as having a hazard quotient greater than 1 associated with mercury is the American robin, which indicates that potential hazards may exist to omnivorous birds foraging at the

AOC. It is important to state that the finding of hazard quotients greater than 1 does not necessarily indicate that adverse impacts are occurring. Weight of evidence suggests that it would be highly unlikely that sufficient exposure would occur to local populations of robins such that adverse populations would occur at the AOC that is also collocated with the Sand Creek Dump MRS.

1.6 Remedial Investigation 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* (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 Model
- **Section 10.0**—Summary and Conclusions
- **Section 11.0**—References

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

- **Appendix A**—Geophysical Mapping Report
- **Appendix B**—Photograph Documentation Log
- **Appendix C**—Intrusive Investigation Results
- **Appendix D**—Asbestos Abatement Report
- **Appendix E**—Statistical Analysis of Intrusive Findings
- **Appendix F**—Munitions Response Site Prioritization Protocol Worksheets
- **Appendix G**—Ohio EPA Correspondence
- **Appendix H**—Ohio EPA Approval Letter

2.0 PROJECT OBJECTIVES

This section presents the preliminary CSM for the Sand Creek Dump MRS based on historical information, identifies data gaps associated with the preliminary CSM, and details the data quality objectives (DQOs) necessary to achieve the project objectives.

A CSM for an 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 because of some human or ecological activity. Interactions associated with activities describe ways that receptors are exposed to 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 burrowing.
- **Access—**Access is the ease in which a receptor can be exposed to 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 and associated MC in subsurface soils 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

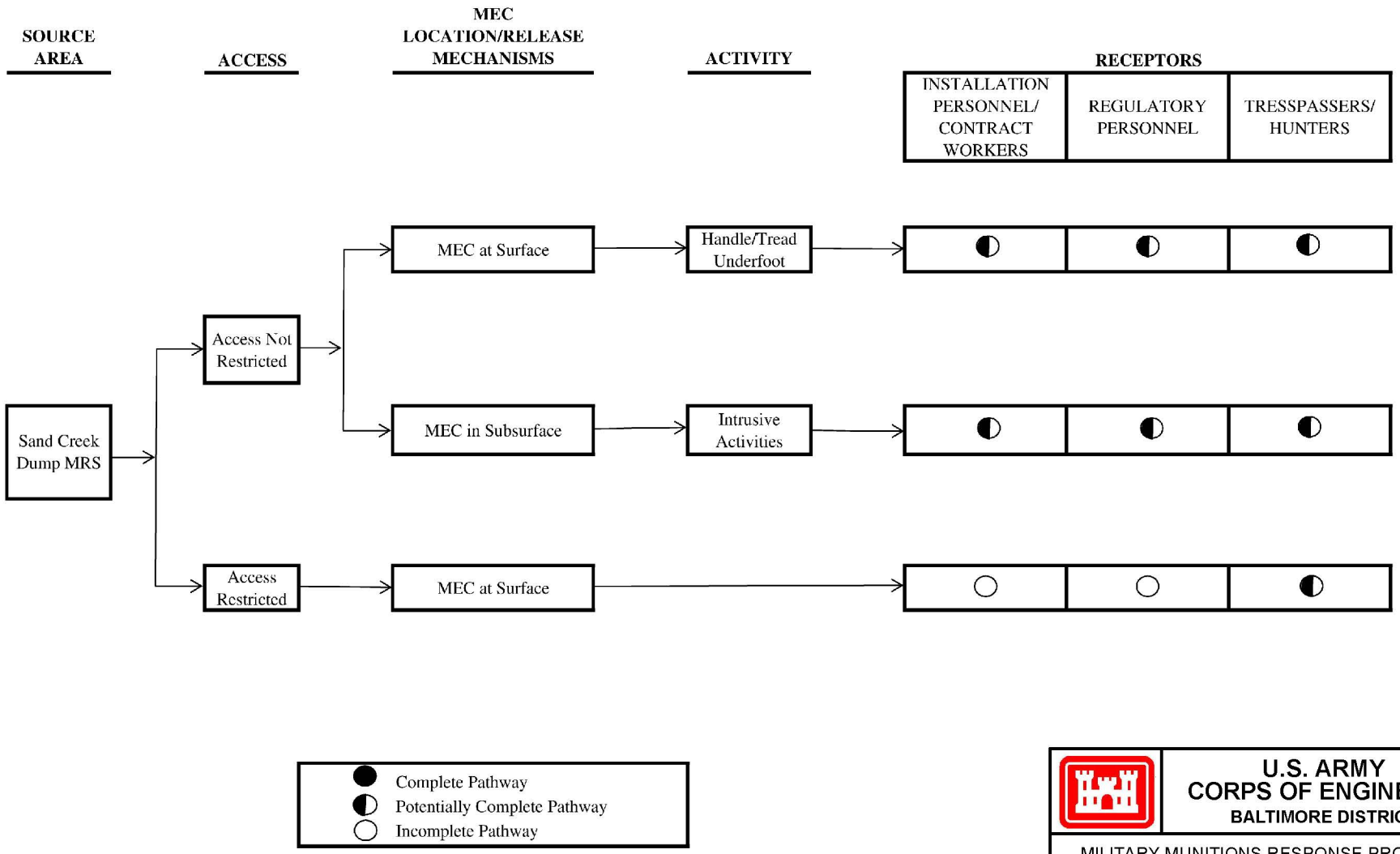
and reasonably anticipated future land use and activities, as receptors are determined on that basis. If present, MEC and/or MC on the ground surface and near the surface can be accessed by potential receptors.

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 that 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 that results in contact with the source. Lastly, an incomplete pathway is any case where one of the four components (source, activity, access, 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 Sand Creek Dump MRS is presented in the following section. The preliminary CSM for MEC is as presented in the SI Report (e^2M, 2008). The SI Report stated that chemical contamination would continue to be addressed under the IRP; therefore, evaluation for MC was not conducted as part of the SI. Extensive sampling has occurred under the IRP since the SI field work and the presence of metals, explosives, and SVOCs has been established at the collocated MRS. Therefore, the IRP data is considered useful in establishing a preliminary CSM for MC at the Sand Creek Dump MRS.

2.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSMs for the Sand Creek Dump MRS are based on MRS-specific data and general historical information including literature reviews, maps, training manuals, technical manuals, and field observations. The preliminary CSM for MEC exposure was originally developed during the 2007 SI based on guidance from Engineer Manual 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects* (USACE, 2003b) and is represented by the diagram provided as **Figure 2-1**. The preliminary CSM for MC exposure is represented by the diagram provided as **Figure 2-2** and is based on the SRCs associated with the munitions historically found at the MRS as identified in the Phase I RI Report (Shaw, 2012). A summary of each of the factors evaluated for the preliminary CSM is discussed below.



Source: *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ravenna, Ohio (e² M, 2008)*

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BALTIMORE DISTRICT

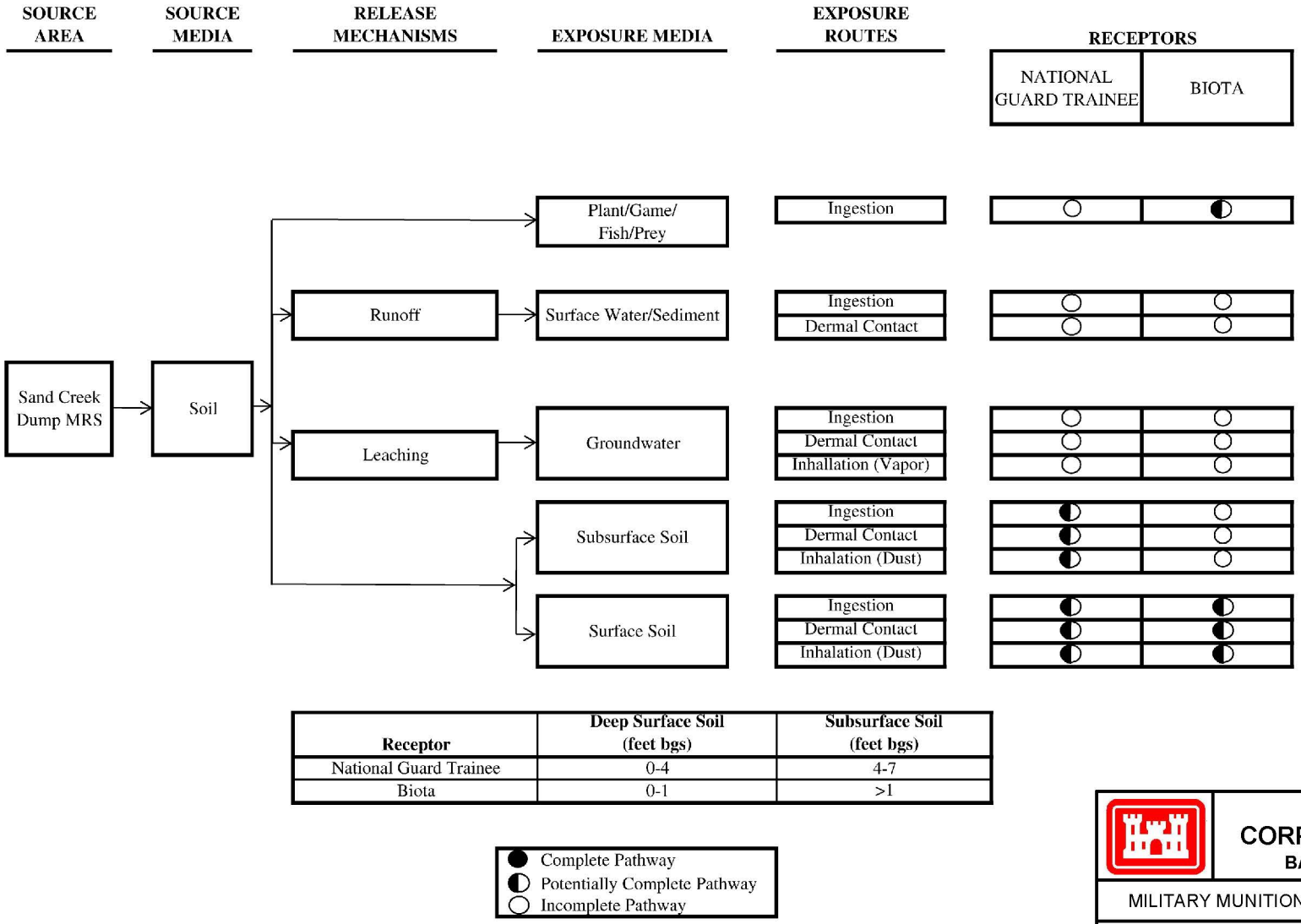
MILITARY MUNITIONS RESPONSE PROGRAM

SAND CREEK DUMP MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

Generated By: gwl Date: 11/06/13 File Path:H:\MAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS SandCreekDump\RVAAP SCD 013 Fig2 1 Prelim MEC CSM.mxd
Project Number: 136147

FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL



Receptor	Deep Surface Soil (feet bgs)	Subsurface Soil (feet bgs)
National Guard Trainee	0-4	4-7
Biota	0-1	>1

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Source: *Draft Phase I Remedial Investigation for RVAAP-34 Sand Creek Disposal Road Landfill, Ravenna Army Ammunition Plant (Shaw, 2012)*

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Project Number: 136147

FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL

- **Sources**—It was determined in the SI Report (e^2M, 2008) that based on historical information and the findings of the SI, the presence of MEC has not been fully determined at the MRS. MEC had the potential to be present on the ground surface hidden by vegetation or potentially buried within the former dump. Significant sources of MEC, either on the ground surface or buried, would have the potential to leach MC into the environment.
- **Activity—**Human activities considered for the preliminary CSM included natural resource management, maintenance activities, and security patrols that were performed at an infrequent basis.
- **Access—**Access to the Sand Creek Dump MRS at the time of the SI was not restricted. With the exception of the facility perimeter fence, there were no known access controls present at the Sand Creek Dump MRS.
- **Receptors—**The SI Report (e^2M, 2008) was prepared prior to the specification of facility-wide receptors at the facility, and the current and future receptors for MEC exposure at the time of the SI included facility personnel and contract workers (including maintenance personnel), soldiers, regulatory personnel, and possibly trespassers and hunters. Since the SI Report, receptors have been identified for the MRS based on military training. The Representative Receptor is the National Guard Trainee. The biotas are considered to be state-listed species identified as being present at the facility. In order to maintain consistency between the preliminary CSMs for MEC and MC, the receptors are considered to be the ones that have been established in the FWCUG guidance (SAIC, 2010) for the future land use. If present, MEC and associated MC on the ground surface and near the surface could have been accessed by receptors.

The information collected during the SI and the Phase I RI field activities was used to prepare the preliminary CSMs for MEC and MC, respectively, for the Sand Creek Dump MRS, and to identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS (e^2M, 2008).

Since there was no conclusive evidence that MEC was not present on the ground surface beneath dense vegetation or buried at the MRS, the SI Report identified the potential MEC exposure pathway for human receptors as the handling or treading underfoot of MEC and through the disturbance of subsurface soils. The SI Report concluded that transport of buried MEC was unlikely, although due to the steep slopes of the MRS, it was considered possible that transport of MEC could occur through erosion and surface water flow (e^2M, 2008). The preliminary CSM for MEC is presented in **Figure 2-1**.

No MC sampling was conducted during the SI field work; however, the presence of metals, explosives, and SVOCs in environmental media sampled at the collocated MRS under the IRP has been established. The environmental media sampled consisted of surface soil, subsurface soil, sediment, and surface water. These media were not addressed in the SI Report since they were being addressed under the IRP. The Phase I RI identified COCs that are considered as potential MC associated with the munitions that may be found at the MRS. The COCs consisted of metals and SVOCs that were found in both surface soil (0 to 4 feet bgs) and in subsurface soil (4 to 7 feet bgs) for the National Guard Trainee that is the Representative Receptor (Shaw, 2012). For evaluation of the preliminary CSM for MC, SRCs have the potential to leach to the environment at the MRS based on the potential presence of MEC and potentially complete exposure and transport pathways for MC are considered to be present in surface and subsurface soil for the National Guard Trainee. The preliminary CSM for MC is presented in **Figure 2-2**.

2.2 Preliminary Identification of Applicable or Relevant and Appropriate Requirements and "To Be Considered" Information

Applicable or relevant and appropriate requirements (ARARs) and "to be considered" guidance for future anticipated and reasonable remedial actions at the facility under the MMRP are currently under development. The identified ARARs and "to be considered" 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 Addendum (Shaw, 2011a). The data needs included characterization of MEC and/or 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 their intended use; and the inference of valid assumptions from the data.

2.3.1 Data Quality Objectives

The DQOs were developed for MEC in accordance with the *Final Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (SAIC, 2011), hereafter referred to as the Facility-Wide Sampling and Analysis Plan (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 Sand Creek Dump MRS as presented in the Work Plan Addendum (Shaw, 2011a).

Table 2-1
Data Quality Objectives Process at the Sand Creek Dump MRS

Step	Data Quality Objectives
1. State the problem.	The Sand Creek Dump was used as a construction landfill from 1950 to 1960. Debris reportedly disposed within the landfill included concrete, wood, asbestos debris, lab bottles, 55-gallon drums, and fluorescent light tubes. During a 2003 IRP Removal Action, two 75mm projectiles inspected to be MD were identified. During the SI, a 105mm projectile that was not verified as either MEC or MD was observed at the bottom of Sand Creek, adjacent to the northern boundary of the MRS. Based on this information, there is a potential for surface and subsurface MEC at the MRS. In addition, there is a potential for environmental impacts from MC at the MRS.
2. Identify the decision.	The goal of the investigation at Sand Creek Dump is to identify the areas impacted by MEC from potential dumping activities. MC sampling may be performed in order to further characterize the type and amount of contamination associated with munitions activities at the MRS based on the decision rules discussed in Step 5. The information obtained during the RI will be used to assess the risk and hazards posed to human and ecological receptors.
3. Identify inputs to the decision.	• Historical information • IRP investigation information • Intrusive investigation • Discrete environmental media sampling (as needed)
4. Define the study boundaries.	The RI will be performed in the Sand Creek Dump MRS boundaries as defined at the conclusion of the SI.
5. Develop a decision rule.	A full coverage DGM survey was performed in all accessible areas of the AOC boundaries as part of the IRP. The majority of the MRS is collocated with the AOC; however, an additional 0.13 acres of the 0.85-acre MRS requires investigation. Since anomalous areas have been detected at collocated portions of the MRS, test pit excavation is expected be utilized at the MRS for intrusive investigation purposes. The test pit locations will be based on the final DGM data and will be sent to USACE and Ohio EPA for approval prior to reacquisition. Although no formal visual survey transects are planned at the MRS, the presence of surface MEC will be investigated during the intrusive survey. Based on the extensive data collected at the Sand Creek Dump MRS under the IRP, additional sampling for MC is not proposed. However, discrete samples may be collected if concentrated areas of MEC/MD items are identified during the intrusive investigation based on the DGM results. If samples are collected, they will be analyzed for aluminum, antimony, barium, cadmium, total and hexavalent chromium, copper, iron, lead, zinc, and mercury; explosives; and SVOCs, nitrocellulose, total organic carbon, and pH. The samples will also be analyzed for geochemical metal parameters (calcium, magnesium, strontium, and manganese).
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 Addendum (Shaw, 2011a).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Sand Creek Dump will be used to determine what risks or hazards, if any, are present at the MRS. If MEC is identified, a MEC HA will be completed 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 and ecological receptors 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.

Table 2-1 (continued)
Data Quality Objectives Process at the Sand Creek Dump MRS

AOC denotes Area of Concern.
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.
IRP denotes Installation Restoration Program.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
mm denotes millimeter(s).
MRS denotes Munitions Response Site.
Ohio EPA denotes Ohio Environmental Protection Agency.
QC denotes quality control.
RI denotes Remedial Investigation.
SI denotes Site Inspection.
SVOC denotes semivolatile organic compound.
USACE denotes United States Army Corps of Engineers.

2.3.2 Data Needs

For MEC, data needs include determining the types, locations, condition, and quantity of MEC items present at the MRS so that the potential hazard to human receptors can be assessed and remedial decisions can be made. The DQOs were developed in accordance with the FWSAP (SAIC, 2011), the EPA DQO guidance (2000), and 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 to potential receptors by performing a HHRA and an ERA. More specifically, the data needed are concentrations of SRCs in surface and subsurface soil where concentrated areas of MEC and/or MD are found. Samples for MC were only to be collected if concentrated area of MEC and/or MD were identified at the MRS (Shaw, 2011a).

2.4 Data Incorporated into the RI

Whenever possible, existing data are incorporated into this RI Report. The following is a summary of the existing data and how the existing data were used:

- **HRR—**The HRR (e^2M, 2007) provides historical documentation regarding the MRS and identifies the types of activities previously conducted, the types of munitions used, and historical finds and incidents. These data were used to identify the expected baseline conditions and other hazards that may be present.

- **IRP Data—**Data collected under the IRP at various MRSs that may be collocated with AOCs include analytes considered MC associated with previous activities at the MRS, although not all analytes are considered as MC. The IRP data set may be incorporated with sampling data collected during the RI on a site-by-site basis in order to close data gaps. However, if no samples are collected during the RI field activities, then concentrated areas of MEC and/or MD were not encountered and the evaluation of previously collected data will not be required in this RI.
- **SI Data—**The SI conducted at the facility under the MMRP in 2007 (e^2M, 2008) provides reconnaissance data identifying surface MD that was used in conjunction with historical aerial photography data to preliminarily delineate areas with munitions-related activity. MC sampling was not performed for the SI at the Sand Creek Dump MRS; therefore, there is no SI data available for inclusion in this RI Report.

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3.0 CHARACTERIZATION OF MEC AND MC

This section documents the approaches used to investigate MEC and MC at the Sand Creek Dump MRS and the expanded investigation area in accordance with the DQOs presented in Section 2.0. The MEC and MC characterization activities were conducted in accordance with Section 3.0, "Field Investigation Plan," of the Work Plan Addendum (Shaw, 2011a).

3.1 MEC Characterization

In 2010, CB&I completed a DGM survey at the Sand Creek Disposal Road Landfill AOC under the IRP and has documented the investigation findings in a report entitled *Final Digital Geophysical Mapping Report for the RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area #1, and RVAAP-28 Mustard Agent Burial Site* (Shaw, 2011b). Much of the AOC and Sand Creek Dump MRS boundaries overlap; however, the MRS boundary extends an additional 150 feet north of the AOC boundaries where the uninspected 105mm projectile was observed in Sand Creek during the SI field activities. This portion of the MRS, which is approximately 0.13 acres in size, was not surveyed during the 2010 DGM event and required investigation under the MMRP RI field activities. The results of the DGM survey at the collocated AOC and MRS and the additional areas of DGM investigation that were conducted at the remaining areas of the MRS were merged to provide coverage of the entire MRS footprint under the MMRP. Visual surveys of surface conditions were performed at the MRS in conjunction with the geophysical investigation.

A summarization of the visual and geophysical survey activities that were conducted at the remaining areas of the Sand Creek Dump MRS that were not investigated under the IRP is presented in the following sections. The discussion of anomaly selection and subsequent intrusive investigations that were performed at the MRS are based on the combined results of the DGM surveys that were completed under the IRP and the MMRP. Results of the visual survey, DGM survey, and intrusive investigation activities are discussed in Section 4.0.

3.1.1 Geophysical Survey Activities

Between late December 2011 and early January 2012, a DGM survey was conducted at the Sand Creek Dump MRS that encompassed the remainder of the MRS that was not covered during the 2010 DGM survey. This survey included the additional 150-foot (0.13-acre) section north of the AOC boundary as well as a number of small fill-in areas within the MRS. The DGM survey was conducted over the steep slopes of the MRS as well the low floodplain areas and upgradient locations at the top of slope where the dumping activities most likely occurred.

Full coverage DGM data were acquired over all accessible areas of the MRS on lines spaced at approximately 2.5-foot intervals. The combined DGM surveys, resulted in a spatial coverage of 94.3 percent of the MRS. In all, approximately 0.80 of the 0.85 acres within the MRS were investigated with DGM. The remaining area of 0.05 acres (2,178 square feet) could not be investigated using DGM due to obstructions (fallen trees, thick vegetation, localized areas of reinforced concrete, and slopes as steep as 30 degrees that presented safety concerns). The 2.5-foot spaced transects are within the 3.5-foot performance metric that was specified in Section 3.3.12 of the Work Plan Addendum. The *Digital Geophysical Mapping Report for the Sand Creek Dump MRS (RVAAP-034-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 QC program.

Geophysical instruments used for the DGM survey consisted of an EM61-MK2 time-domain electromagnetic instrument and a Leica 1200 RTS positioning system. The EM61-MK2 system used at the Sand Creek Dump MRS consisted of two 1-meter-by-0.5-meter rectangular coils arranged in a coaxial geometry and separated by 40 centimeters. The coils were mounted on a wheeled platform 42 centimeters above the ground surface. The team that performed the DGM survey consisted of a geophysicist and a UXO-qualified person that was familiar with the munitions that may have been disposed at the MRS.

The DGM system used for the Sand Creek Dump MRS investigation and other MRSs at the facility was initially validated during the startup 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* that is presented in the DGM Report in **Appendix A**. A localized test strip at the Sand Creek Dump MRS was used to ensure the functionality of the DGM system on a daily basis during DGM activities at the MRS as discussed in Section 3.1.1.4, “Geophysical Quality Control Program.”

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 licensed Ohio surveyor established two survey monuments at the Sand Creek Dump 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 to set up the RTS, which streamed positional data directly to the EM61-MK2. All of the survey

data documenting MRS features and obstructions are referenced to the established survey monuments.

For QC purposes, the RTS positioning system was used to reacquire a known, fixed location each time the system was set up on one of the two survey monuments. Per the project metrics defined in the Work Plan Addendum (Shaw, 2011a), static measurements for the positioning system were required not to exceed 0.5 feet. The RTS positioning system provides centimeter level accuracy, and 100 percent of location checks satisfied the metric.

3.1.1.2 Data Collection and MRS Coverage

A one-dimensional transect survey methodology was employed to collect uniform geophysical data at the Sand Creek Dump MRS. The DGM data were acquired over all accessible areas of the current MRS, which resulted in nearly 100 percent spatial coverage (94.3 percent or 0.8 acres). At the accessible areas, greater than 99 percent of the data were acquired at a line spacing of less than 3.5 feet, which meets the metric specified in Section 3.13.13 of the Work Plan Addendum (Shaw, 2011a). The general DGM procedures performed for data acquisition at the Sand Creek Dump 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, including evaluation of surface MEC, which would create 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 “check shot” 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 field computer where the data were 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, 2009).

Figure 3-1 provides the existing and proposed areas of DGM coverage as presented in the Work Plan Addendum (Shaw, 2011a). A summary and discussion of the DGM data is in Section 4.0.

3.1.1.3 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan Addendum (Shaw, 2011a). An 8-millivolt (mV) threshold for Channel 2 of the EM61-MK2 was used initially to select anomalies as presented in the Work Plan Addendum (Shaw, 2011a). From previous experience at the facility, locations that have signal strengths (Channel 2) greater than 8 mV are more likely to be munitions-related items than locations with signal strengths less than 8 mV. Important factors that were considered during the interpretation process include the following:

- Data acquisition methodology (full coverage as is the case for the Sand Creek Dump 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

An approximately 0.06-acre (2,800-square-foot) area at the northern portion of the collocated AOC/MRS was surveyed using a G-858 magnetometer during the 2010 DGM survey. This instrument was used at areas that were inaccessible for the EM61-MK2. The reading output for the G-858 magnetometer is in units of nanoteslas per meter (nT/m). There is no anomaly selection criterion in the Work Plan Addendum for this instrument; however, sensitivity readings of approximately 20 nT/m correlate to the 8 mV threshold and was the threshold

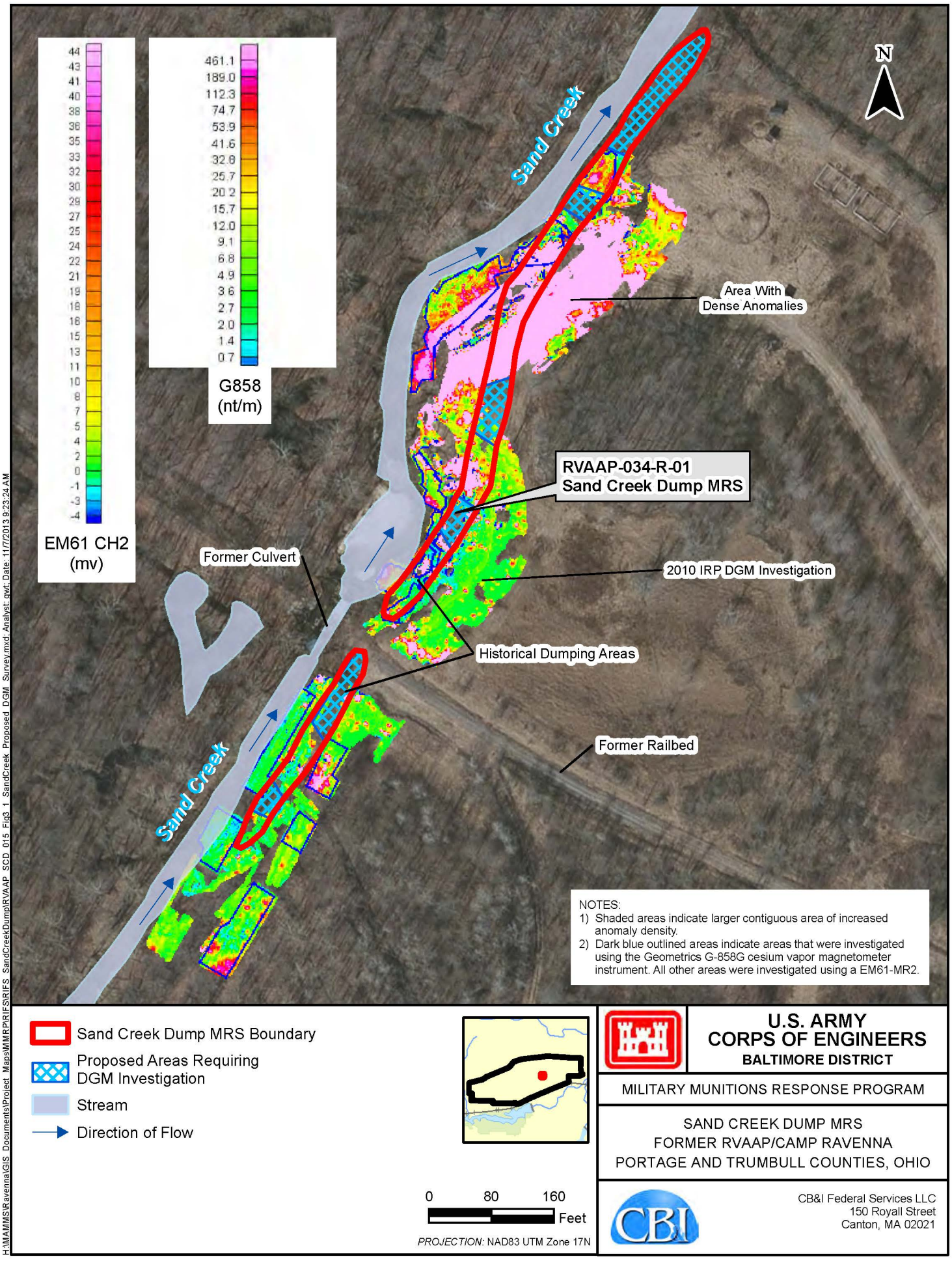

FIGURE 3-1 EXISTING AND PROPOSED DGM SURVEY AREA

used to select anomalies at this small area of the MRS. The correlation between the two instrument types can be seen on the sensitivity bars in **Figure 3-1**. The data processing and interpretation procedures used to evaluate the anomalies are provided in the DGM Report in **Appendix A**.

3.1.1.4 Geophysical Quality Control 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 Addendum (Shaw, 2011a). The performance metrics for the DGM system were derived from a combination of DID MMRP-09-004, *Geophysics* (USACE, 2009) and DID WERS-004.01, Attachment D, Table D-1—*Performance Requirements for RI/FS using DGM Methods* (USACE, 2010b). 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 review. Additional details of the DGM QC program are included in the DGM Report in **Appendix A**.

3.1.2 Anomaly Selection

This section presents a discussion of the results of the anomaly selection and target dig list development process for the combined DGM data collected at the MRS under the IRP and the MMRP. The results of the DGM survey that was completed at the MRS during the RI field activities and the proposed intrusive investigation locations resulting from the combined DGM surveys were submitted to the USACE and Ohio EPA for review and approval in the *DGM Survey Results and Proposed Dig Locations for the Sand Creek Dump MRS (RVAAP-034-R-01)* technical memorandum included as Attachment 3 to the DGM Report in **Appendix A**.

3.1.2.1 Anomaly Selection for High-Density Areas

Evaluation of the data collected between the combined DGM surveys identified two primary areas of high anomaly densities with signal strengths greater than or equal to 8 mV (Channel 2). The data interpreter selected eight locations for trenches as the primary investigative technique within the two areas with localized high anomaly densities. Once the proposed trench locations were approved by the USACE and the Ohio EPA, they were transferred to a dig sheet and provided to Shaw's Geographical Information System Department for inclusion in its database for the facility that is used to track the investigation

results. The results of the DGM investigation at the proposed trench locations are presented in Section 4.0.

3.1.2.2 Target Dig List Selection for Individual Anomalies

Outside of these high density areas, there were a total of 225 anomalies identified for potential investigation as individual target locations. To determine the number of anomalies to sample in order to characterize the nature and extent of MEC at the Sand Creek Dump MRS, the hypergeometric statistical method was applied. Use of such a statistical sampling method is in accordance with guidance provided in Engineer Manual 1110-1-4009, *Military Munitions Response* (USACE, 2007), which states the following:

> "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), 5 percent probability (p), and 2.5 percent error limits (E), 128 anomalies, representing nearly 57 percent of the total population of 225 anomalies (N), were selected and met the DQOs. More than 25 of the individual anomalies were selected in several areas of the MRS that are likely associated with single anomaly sources related to cultural features (expansive sections of concrete foundation from the former treatment facility). These localized areas could not be fully investigated with DGM due to steep terrain and dense vegetation consisting of close knit trees, which prevented further analysis and classification of the anomaly source(s). Therefore, the data

interpreter selected 25 additional anomaly selections in areas away from these features to provide a better distribution of targets across the MRS that are not associated with potential cultural features. An additional 12 anomaly locations were selected to ensure there was a 95 percent probability that a minimum of four items of interest were investigated, which is consistent with the investigation strategy used at the other MRSs that were investigated at the facility under the MMRP. In all, a total of 165 target locations were selected for intrusive investigation that equates to an investigation percentage of approximately 73 percent of the individual anomalies.

The 165 target locations were transferred to a dig sheet and provided to Shaw's geographical information system department for inclusion in the its database 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.

The Microsoft© Excel "HYPGEOMDIST" 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.

3.1.3 Anomaly Investigation Procedures

This section presents a discussion of the intrusive investigation procedures for the evaluation of MEC at the Sand Creek Dump MRS. Following USACE and Ohio EPA approval of the technical memorandum (**Appendix A**) that presented the areas and individual anomalies selected for intrusive investigation, reacquisition and intrusive investigations were conducted to assess the potential for buried MEC at the MRS. The areas with high densities of anomalies required excavation using mechanical equipment whereas individual target anomalies were manually investigated (i.e., hand dug). All anomaly investigation activities were conducted by UXO-qualified personnel that included a Senior UXO Supervisor, a UXO QC Specialist (UXOQCS), and at least one Level I or II UXO Technician in accordance with the Work Plan Addendum (Shaw, 2011a). The UXO-qualified personnel were also conscious of encountering any cultural artifacts associated with historical cultural or archeological resources.

3.1.3.1 Individual Anomaly Reacquisition and Investigation Procedures

For the anomaly reacquire task, the field geophysicists used the dig sheet coordinates to guide the reacquisition of each anomaly location. The area around each anomaly was scanned with an EM61-MK2 and the optimum dig location 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.

All anomaly investigation activities were performed by UXO-qualified personnel that were familiar with the munitions that may have been disposed at the MRS. The UXO-qualified personnel used a Schonstedt magnetometer to investigate anomalies. These personnel used hand tools to unearth an item and as the excavation progressed toward the anomaly source. The UXO-qualified personnel continued to use the Schonstedt magnetometer to determine the item location both horizontally and vertically. Reacquisition of any sampling or dig sheet locations (i.e., interpreted location) was performed to approximately 0.5 feet of the coordinates specified on the dig sheet.

Once found, the item was determined if it was MEC or other cultural debris. If the item was determined that it was not munitions related, 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 was present, the item was replaced and the soil was returned back into the investigation hole in reverse order from which it was excavated.

3.1.3.2 High-Density Anomalous Area Reacquisition and Investigation Procedures

Locating the ground position for the anomalies in the high-density areas was similar to the individual target anomalies except on a larger scale. The navigational system "Waypoint Location" mode was used for the RTS positioning system to locate the coordinates of the trench boundary. Nonmetallic pin flags, labeled with the unique anomaly identification, were placed in the ground at the interpreted location of the trench. As for the individual target anomaly locations, 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 trenches were mechanically excavated using an excavator. Each trench started out at approximately 3 feet in width and was continued in depth until the target anomalies were identified, native material was identified and a clear, distinct boundary between the native and fill material was evident, a maximum depth of 10 feet was attained, or the water table was reached. Soil material in each trench was removed in layers at approximately 1-foot intervals. The proposed length of each trench was approximately 20 feet or the distance across the area of high anomaly density if the area was smaller than 20 feet in diameter.

During the excavation activities, one UXO-qualified person 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 munitions-related items. If an anomaly was uncovered in a trench, the UXO-qualified personnel worked to identify the anomaly before it was

removed. If an item was determined not to be munitions related, 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. The soils that were excavated in 1-foot lifts were spread on 6-mil polyethylene sheeting in an adjacent area where the UXO-qualified person visually examined it for MEC. Once confirmed that the source had been identified and no MEC was present, the cultural debris was replaced and the soil was returned back into the investigation trench in reverse order from which it was excavated. No soil was segregated for off-site disposal.

3.1.3.3 Anomaly Investigation Documentation

All anomalies identified during the intrusive investigation and anomaly reacquisition activities were logged and recorded in accordance with DID MMRP-09-004, *Geophysics* (USACE, 2009). CB&I's 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 intrusive investigation results are further discussed in Section 4.0.

3.1.3.4 Anomaly Field Quality Control

Ground-truth excavation data reported on anomaly-specific dig sheets were the primary basis for field QC. The dig sheets documented the item description; location; and approximate weight, shape, orientation, and depth. The 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 UXOQCS.

3.2 MC Characterization

The DQOs in the Work Plan Addendum (Shaw, 2011a) stated that incremental samples and discrete samples (surface and subsurface soil) would be collected in areas of the MRS with concentrated MEC or MD. No MEC or MD was identified at the Sand Creek Dump MRS during the field activities; therefore, sampling for MC or evaluation of previous data collected at the collocated AOC under the IRP was not warranted.

4.0 REMEDIAL INVESTIGATION RESULTS

This section presents a discussion of the results of the RI data that were collected for MEC at the Sand Creek Dump MRS in accordance with the procedures discussed in Section 3.0. These results were used to determine the nature and extent of MEC and subsequently determine the potential hazards posed to human and ecological receptors. Once the hazards were determined, they were integrated into the preliminary CSMs developed during the SI (e^2M, 2008) that are presented in Section 2.0. Photographs of the RI field activities performed at the MRS are presented in **Appendix B**.

4.1 MEC Investigation Results

The following sections present the results of the RI field activities that were performed to achieve the DQOs defined in Section 2.3.1, "Data Quality Objectives," and define the nature and extent of MEC in the surface and subsurface at the Sand Creek Dump MRS. These efforts included visual and DGM surveys and intrusive investigations that were conducted in accordance with the Work Plan Addendum (Shaw, 2011a).

4.1.1 Visual Survey Results

While no visual surveys were proposed for the MRS, the potential presence of MEC on the ground surface and along the banks of Sand Creek was investigated during the geophysical investigation as part of MEC avoidance activities. The visual survey included investigation of the 105mm projectile that was observed during the SI field work in Sand Creek adjacent to the northern portion of the MRS. Complete (100 percent) DGM surface coverage of the MRS was conducted under both the IRP and the MMRP field activities, and no MEC was identified on the ground surface or in Sand Creek. The uninspected 105mm projectile that was observed during the SI field work was not located during the RI field work, and the disposition of this projectile is unknown.

4.1.2 Geophysical Survey Results

A total of 0.8 acres of full-coverage DGM data was collected within the current MRS boundary between the 2010 and 2012 DGM surveys. Data were acquired in all accessible areas of the MRS and the area surveyed equates to 94.3 percent coverage. The remaining area of 0.05 acres (2,178 square feet) within the MRS boundary could not be investigated using DGM due to obstructions (fallen trees, thick vegetation, localized areas of reinforced concrete, and slopes as steep as 30 degrees that presented safety concerns). The data were processed and interpreted consistent with the Work Plan Addendum (Shaw, 2011a).

Evaluation of the data collected during the DGM surveys identified two areas with localized high anomaly densities and signal strengths greater than or equal to 8 mV (Channel 2). Both of the areas of high anomaly densities are located at the northern portion of the MRS where

the dumping activities are suspected to have occurred. Outside of the high anomaly density zones, 222 individual anomalies were selected that were greater than or equal to 8 mV (Channel 2). Another three individual anomalies were selected that were greater than or equal to 20 nT/m based on the correlative results of the G-858G magnetometer used during the 2010 DGM survey at locations inaccessible to the EM61-MK2. In general, areas of high anomaly density are situated at the northern portion of the MRS with an area of approximately 0.8 acres. Smaller and isolated areas with buried anomalies are scattered throughout the remainder of the MRS. The individual anomalies decrease towards the northern and southern extremities of the MRS.

Based on the review of the DGM data, the MRS was divided into two distinct areas for anomaly reacquisition and investigation. **Table 4-1** presents the areas where the anomalies were identified, the suspected distribution of anomalies (i.e., segregated or high-density areas), the rationale for the point source anomaly or combined investigation due to high-density areas, and the method of investigation.

Table 4-1
Summary of Proposed Intrusive Investigation Activities

Area at MRS	Anomalies Identified[1]	Proposed Investigation Areas	Investigation Rationale and Proposed Method
Two areas of relatively high anomaly density at the northern portion of the MRS.	Two well-defined regions with high densities of anomalies that represent aggregates of subsurface metal	Two well-defined regions with high densities of anomalies	Two well-defined regions with high densities of anomalies to be excavated by eight trenches[2].
Individual target anomalies throughout the remainder of the MRS	165 individual target anomalies	165 individual target anomalies[3]	Hand digging at all 165 individual target anomalies

[1] Based on response of 8 millivolts (Channel 2) for the EM61-MK2. Three individual targets were based on 20 nanoteslas per meter response for the G-858 magnetometer.

[2] All trenches to be excavated mechanically.

[3] Based on the hypergeometric statistic method presented in Section 3.1.2.2.

MRS denotes Munitions Response Site.

Figures 4-1a and **4-1b** display the results of the EM61-MK2 DGM survey and provide a color-scale that highlights all anomalies that were selected for intrusive investigation above signal thresholds of 8 mV (Channel 2) or 20 nT/m on the G-858 magnetometer. A comprehensive discussion of the DGM survey results is presented in the DGM Report in **Appendix A**.

N

G858 (nt/m)
461.1
189.0
112.3
74.7
53.9
41.6
32.8
25.7
20.2
15.7
12.0
9.1
6.8
4.9
3.6
2.7
2.0
1.4
0.7

EM61-MK2 CH2 (mv)
-4.2
-2.7
-1.1
0.5
2.0
3.6
5.2
6.7
8.3
9.8
11.4
13.0
14.5
16.1
17.7
19.2
20.8
22.3
23.9
25.5
27.0
28.6
30.2
31.7
33.3
34.8
36.4
38.0
39.5
41.1
42.7
44.2

Sand Creek

Historical Dumping Area

G858 Data

Match Line

222 221 220 219 218 216 215 213 211 210 209 206 205 204 203 198 197 196 193 191 190 189 188 186 184 182 180 179 177 176 175 173 172 171 169 170 167 166 165 163 162 161 160 158 157 155 154 153 151 150 148 147 146 144 143 142 141 139 138 137 136 135

MRS Boundary
High Anomaly Density Zone
Obstructions and Other Features That Prevented DGM Data from Being Collected
Stream
Direction of Flow

Anomaly Selected for Investigation
Anomaly Not Selected for Investigation
8" Nail Spike Installed by Shaw
Sand Creek Control Installed by Vista

Embedded Fence Post
Metal Lid, 6" Diameter
Reinforced Concrete Debris
Siebert Stake
Proposed Trench Location

0 40 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

TARGET DIGS LOCATION MAP
SAND CREEK DUMP MRS - NORTHERN HALF
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\AAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS SandCreekDump\RVAAP 078 Fig4-1a SandCreek MRS Interpretation North.mxd: Analyst: matthew.mireiter: Date: 11/8/2013 12:23:59 PM

FIGURE 4-1A DGM RESULTS AND ANOMOLIES SELECTED FOR INTRUSIVE INVESTIGATION - NORTH SECTION

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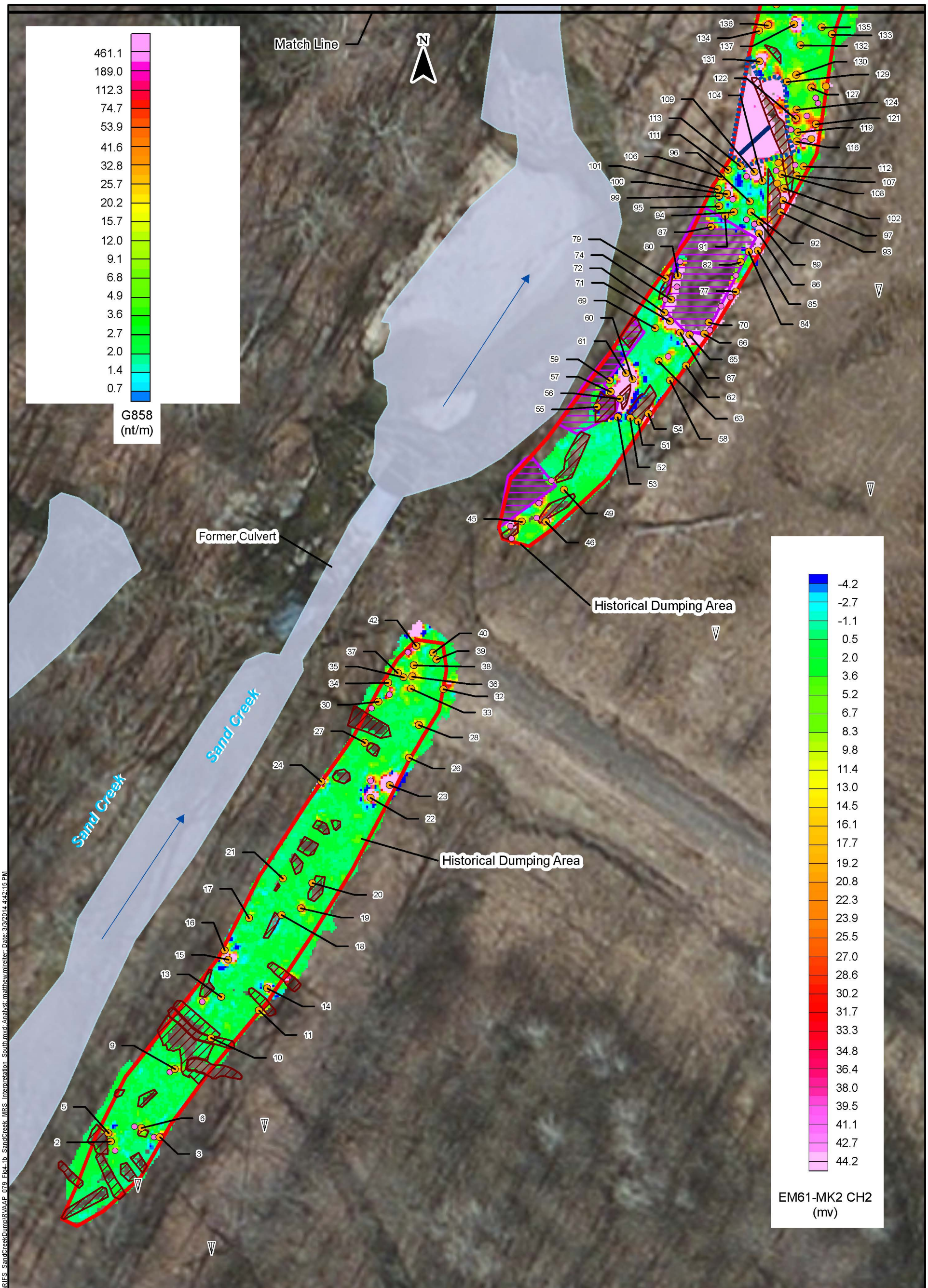

FIGURE 4-1B DGM RESULTS AND ANOMOLIES SELECTED FOR INTRUSIVE INVESTIGATION - SOUTH SECTION

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4.1.3 Geophysical Quality Control Results

The DGM data were processed and interpreted consistent with the Work Plan Addendum (Shaw, 2011a). Data were acquired in all areas void of trees, thick vegetation, dead fall, and steep slopes. 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**.

4.2 Intrusive Investigation Results

This section presents the results of the intrusive investigations performed at the Sand Creek Dump MRS based on the DGM survey findings. The individual target anomalies selected for intrusive investigation were excavated by hand. The high-density anomalous areas were investigated using mechanical excavation methods. A summary of the proposed intrusive activities is presented **Table 4-1**. The results of the intrusive investigation activities are presented in **Figures 4-2a** and **4-2b**. The investigation results for the intrusive investigation activities are presented in the data sheets in **Appendix C**.

4.2.1 Trench Investigations

No MEC was discovered during the intrusive activities conducted at the eight exploratory trench locations. The investigation criteria for trenching were to excavate at a location until the target anomalies were identified, native material was identified and a clear, distinct boundary between the native and fill material was evident, a maximum depth of 10 feet was attained, or the water table was reached. The actual maximum depth of excavation was 30 inches (2.5 feet) bgs at trench location SCD-03.

A total of 755 pounds (lbs) of "Other Debris" items were identified within the eight trenches. The "Other Debris" was construction debris that included primarily miscellaneous scrap metal and ACM consisting of transite panels. **Table 4-2** summarizes the results at each trench location, the maximum depth attained, a description of "Other Debris" uncovered, and the estimated weight of the debris.

Table 4-2
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Description of "Other Debris"	Approximate Weight (lbs)
SCD-01	24	Scrap metal	25
SCD-02	12	ACM	35
	24	Scrap metal	30

Table 4-2 (continued)
Trench Investigation Results

Trench Number	Maximum Depth (inches bgs)	Description of "Other Debris"	Approximate Weight (lbs)
SCD-03	18	ACM	25
	30	Scrap metal	75
SCD-04	24	Scrap metal	50
SCD-05	18	Scrap metal	20
SCD-06	24	Scrap metal	225
SCD-07	0	Scrap metal	20
SCD-08	24	Scrap metal	250
		Total:	**755**

ACM denotes asbestos-containing material.
bgs denotes below ground surface.
lb denotes pound.

The transite ACM that was encountered as part of the trenching activities was removed in accordance with the approved *Accident Prevent Plan Addendum for Asbestos Abatement for Military Munitions Response Program Remedial Investigation Environmental Services* (Shaw, 2013). In general, any ACM that impeded the advancement of intrusive activities was properly removed and disposed off site. A total of 60 lbs of ACM was removed from two trench locations (trenches SCD-02 and SCD-03) during the intrusive investigation activities at the MRS. Additional details regarding the ACM removal activities are presented in the *Asbestos Abatement Report* in **Appendix D**. All "Other Debris" items, with the exception of the ACM, were left in place or returned back to the excavation from which it was removed and the trenches were backfilled with the excavated material.

4.2.2 Individual Target Anomaly Investigations

A total of 165 individual target anomalies were discovered for reacquisition following evaluation of the combined DGM surveys and 157 of the anomalies were successfully reacquired. The eight anomalies that were not located were targets 15, 39, 53, 55, 59, 197, 203, and 204. Targets 55, 59, and 197 had relatively low initial detection responses on the EM61-MK2 (less than 20 mV). Targets 203 and 204 were selected as anomalies for intrusive investigation based on the 2010 DGM survey results using the G-858 magnetometer and also had relatively low initial detection responses (less than 60 nT/m). The combination of the low responses and difficult terrain at the MRS may have contributed to the difficulty for reacquisition at these locations. Targets 15 and 53 had relatively high initial detection responses (between 87 and 254 mV) but were not able be reacquired. Debris consisting of

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N

G858 (nt/m)
461.1
189.0
112.3
74.7
53.9
41.6
32.8
25.7
20.2
15.7
12.0
9.1
6.8
4.9
3.6
2.7
2.0
1.4
0.7

EM61-MK2 CH2 (mv)
-4.2
-2.7
-1.1
0.5
2.0
3.6
5.2
6.7
8.3
9.8
11.4
13.0
14.5
16.1
17.7
19.2
20.8
22.3
23.9
25.5
27.0
28.6
30.2
31.7
33.3
34.8
36.4
38.0
39.5
41.1
42.7
44.2

Sand Creek

Historical Dumping Area

G858 Data

Match Line

SCD-2
SCD-3
SCD-4
SCD-5
SCD-6
SCD-7
SCD-8

222 221 220 219 218 216 215 213 211 210 209 206 205 204 203 198 197 196 193 191 190 189 188 186 184 182 180 179 177 176 175 173 172 171 170 169 167 166 165 163 162 161 160 158 157 155 154 153 152 151 150 149 148 147 146 144 143 142 141 139 138 137 136 135

MRS Boundary
High Anomaly Density Zone
Obstructions and Other Features That Prevented DGM Data from Being Collected
Stream
Direction of Flow
8" Nail Spike Installed by Shaw
Sand Creek Control Installed by Vista
Embedded Fence Post
Metal Lid, 6" Diameter
Reinforced Concrete Debris
Siebert Stake
Trench Investigated-Other (non-munitions) Debris Identified
Anomaly Not Selected for Investigation
Anomaly Investigated-Other (non-munitions) Debris identified

0 40 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
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BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

INTRUSIVE RESULTS
SAND CREEK DUMP MRS - NORTHERN HALF
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 4-2A INTRUSIVE RESULTS - NORTH SECTION

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Match Line

N

SCD-1

Former Culvert

Historical Dumping Area

Historical Dumping Area

Sand Creek

Sand Creek

G858 (nt/m)
461.1
189.0
112.3
74.7
53.9
41.6
32.8
25.7
20.2
15.7
12.0
9.1
6.8
4.9
3.6
2.7
2.0
1.4
0.7

EM61-MK2 CH2 (mv)
-4.2
-2.7
-1.1
0.5
2.0
3.6
5.2
6.7
8.3
9.8
11.4
13.0
14.5
16.1
17.7
19.2
20.8
22.3
23.9
25.5
27.0
28.6
30.2
31.7
33.3
34.8
36.4
38.0
39.5
41.1
42.7
44.2

MRS Boundary
High Anomaly Density Zone
Obstructions and Other Features That Prevented DGM Data from Being Collected
Stream
Direction of Flow
8" Nail Spike Installed by Shaw
Sand Creek Control Installed by Vista

Embedded Fence Post
Metal Lid, 6" Diameter
Reinforced Concrete Debris
Siebert Stake
Trench Investigated-Other (non-munitions) Debris Identified
Anomaly Not Selected for Investigation
Anomaly Investigated-Other (non-munitions) Debris Identified

0 40 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
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MILITARY MUNITIONS RESPONSE PROGRAM

INTRUSIVE RESULTS
SAND CREEK DUMP MRS - NORTHERN HALF
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 4-2B INTRUSIVE RESULTS - SOUTH SECTION

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wire was encountered at Target 15 with a very low peak reacquisition reading of 0.8 mV, which was not considered adequate to account for the initial response. Both targets were initially identified along the steep slopes of the MRS which may have offset the actual location or negatively impacted the initial results due to the motions of the equipment along the slopes. Target 39 was located adjacent to the former rail bed at the southern portion of the MRS. Based on the initial detection of 22.09 mV, this anomaly was not considered to be large. The target was located in an area that had recently regarded by another contractor during removal of the former rail bed culvert in Sand Creek between July and August 2013. It is possible that the anomaly had been moved during the culvert removal and subsequent site restoration activities.

No MEC was identified at any of the individual target anomaly locations that were reacquired, but approximately 322 lbs of "Other Debris" items were identified during the intrusive investigation activities. The "Other Debris" items consisted mainly of bolts, cables, fence posts, nails, pipes, scrap metal, and wire that were found at depths just below ground surface to a maximum depth of 14 inches. The average depth of the items identified for all locations was approximately 2–3 inches. The quantities of "Other Debris" were determined by the UXO-qualified personnel in the field and were either left in place or returned back to the excavation location from where it came.

4.2.3 Post-Excavation Field Quality Control

Forty-one anomaly locations were randomly selected for post-excavation QC checks (i.e., intrusive anomaly verification) with the EM61-MK2 and the number of anomalies selected were based on the requirements in the USACE *Acceptance Sampling Table* (USACE, 2010b). At nine locations, the residual signal was greater than 8 mV. For anomaly 56, the residual signal is due to a steel culvert that could not be removed. For the other eight anomalies (34, 67, 100, 109, 161, 163, 175, and 184) the residual readings were reduced to background levels which were elevated due to the presence of additional subsurface anomalies. At the remaining 32 locations, the residual signal from the sensor was less than 8 mV (Channel 2) and no additional excavation locations were required to be checked.

4.2.4 Statistical Analysis of Intrusive Findings

Following completion of the intrusive investigation activities, a statistical approach was then used to quantify the intrusive findings of the RI. Since no MEC 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 anomaly locations that were not investigated during the RI field activities. These results achieved the DQOs established in the Work Plan Addendum (Shaw, 2011a). A summary of the statistical analysis of the intrusive findings is presented in **Appendix E**.

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5.0 FATE AND TRANSPORT

This intent of this section is to describe the fate of chemicals detected in the environment and potential transport mechanisms for MEC and MC identified at the Sand Creek Dump MRS. 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 of MEC and MC away from the source area.

5.1 Fate and Transport of MEC

Transport of MEC at a MRS is dependent on many factors, including natural processes and human activities that may result in some movement of MEC, if present. Natural processes or "weathering" are primarily characterized as mechanical and biological. Mechanical processes include expansion and contraction caused by sudden changes in temperature, the expansive force of water freezing in cracks, the splitting caused by plant roots, and the impact of running water. Biological processes include oxidation, hydration, carbonization, and loss of chemical elements by solution in water. 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.

With regards to the terrain, soil types, and climate conditions at the MRS, the erosion potential is considered to be potentially moderate to severe. The MRS has steep slopes ranging from 30 to 60 degrees from horizontal that are located adjacent to Sand Creek that is prone to periodic flooding. The types of plants and trees at the MRS consist primarily of shrubs and open fields that have shallow root systems (AMEC, 2008) that are not as adept at preventing erosion along the slopes as would deeper root systems. The soil types at the MRS have a high water capacity and poor permeability. As is noted in Section 1.3.3, January is the coldest month of the year with a normal minimal temperature of 17.4 degrees Fahrenheit. The maximum frost depth in northern Ohio is approximately 36 inches bgs. Based on the terrain, soil types, and climate conditions at the MRS, any munitions-related items within 3 feet of ground surface are considered as being susceptible to freeze-thaw cycling, which may expose any buried MEC. In addition, munitions-related items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment. This is evidenced by photographs for the two MD 75mm projectiles that were encountered during the 2003 Removal Action where obvious corrosion is present (MKM, 2004).

No munitions-related items that would justify a concern for potential MEC was found at the MRS or surrounding expanded investigation area during the RI field activities. Therefore, an explosive hazard does not exist and a discussion on the fate and transport of MEC at the MRS is not warranted.

5.2 Fate and Transport of MC

Since no MEC was found during the RI field activities, there is no source of potential release of MC at the MRS. As such, MC sampling was not warranted and discussion on the fate and transport of MC at the MRS is not applicable.

6.0 MEC HAZARD ASSESSMENT

In accordance with the Work Plan Addendum (Shaw, 2011a), an evaluation of the MEC hazard at the Sand Creek Dump MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008). The MEC Hazard Assessment (HA) allows a project team to evaluate the potential explosive hazard associated with an MRS given current conditions and under various cleanup, land use activities, and land use control alternatives. It was developed through a collaborative, consensus approach to promote consistent evaluation of potential explosive hazards at MRSs (EPA, 2008). The MEC HA addresses human health and safety concerns associated with potential exposure to MEC at a MRS but does not address hazards (explosive or toxic) posed by chemical warfare materiel, MEC that is present underwater, nor environmental or ecological hazards that may be associated with MEC. No MEC was identified at the MRS during either the SI or RI field activities and there is no explosive safety hazard present at the MRS. Based on the findings of the RI field work, the calculation of a MEC HA score is not warranted for the Sand Creek Dump MRS.

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7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of a HHRA is to document whether MRS conditions may pose a risk to current or future receptors and to identify which, if any, MRS conditions need to be addressed further in the CERCLA process. As no MEC was discovered at the MRS during the SI or the RI field activities, media sampling for MC was not warranted. Therefore, a HHRA was not required for inclusion in this RI Report.

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8.0 ECOLOGICAL RISK ASSESSMENT

An ERA evaluates the potential for adverse effects posed to ecological receptors from potential releases at a MRS. As no MEC was discovered at the MRS during the SI or the RI field activities, media sampling for MC was not warranted. Therefore, an ERA was not required for inclusion in this RI Report.

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9.0 REVISED CONCEPTUAL SITE MODEL

This section presents the revised CSMs for MEC and MC at the Sand Creek Dump MRS based on the results of the data collected for the RI and previous information provided in the SI Report (e^2M, 2008), the HRR (e^2M, 2007), and the Phase I RI (Shaw, 2012). 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. Following the integration of the RI results into the CSMs, the MRSPP evaluation for the MRS was reevaluated to include the results of the RI.

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 Conceptual Site Model and Project Approach," each pathway includes a source, activity, access, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. 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 that 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 four components (source, activity, access, or receptors), is missing from the MRS.

9.1.1 Source

A MEC source area is the location where MPPEH or other forms of ordnance are expected to be found. The Sand Creek Dump MRS is a former open dump area and the operational history of disposal activities that occurred here is incomplete. Construction and debris type material were delivered and dumped over an embankment located immediately adjacent to Sand Creek. No records of historical munitions disposal or evidence of MEC have been found for the MRS. Items historically verified as MD consist of the two demilitarized 75mm projectiles that were found following the 2003 Removal Action at the collocated AOC (MKM, 2004). The 105mm projectile that was observed during the 2007 SI field work in Sand Creek adjacent to the northern boundary of the MRS appeared to be empty; however, the projectile was not inspected to determine the explosive safety status as either "safe" or "hazardous." The projectile was not observed in the creek during the RI field work, and the disposition of this projectile is unknown. No MEC was found during the RI field work. Based on the lack of a historical MEC source to date, no explosive safety hazard is considered to be present in surface or subsurface soils at the Sand Creek Dump MRS.

9.1.2 Activity

Activity describes ways that receptors are exposed to a source. Current activities at the Sand Creek Dump MRS include maintenance and natural resource management activities. Biota activities may include occasional meandering and occupation at the MRS by assorted species as well as burrowing activities. The MRS will be used for military training activities (USACE, 2012a).

9.1.3 Access

Access describes the degree to which a MEC source or environment containing MEC is available to potential receptors. There are no physical barriers around the MRS; however, the MRS boundary is marked with Siebert stakes and signage that warn receptors about the MRS to help deter access.

9.1.4 Receptors

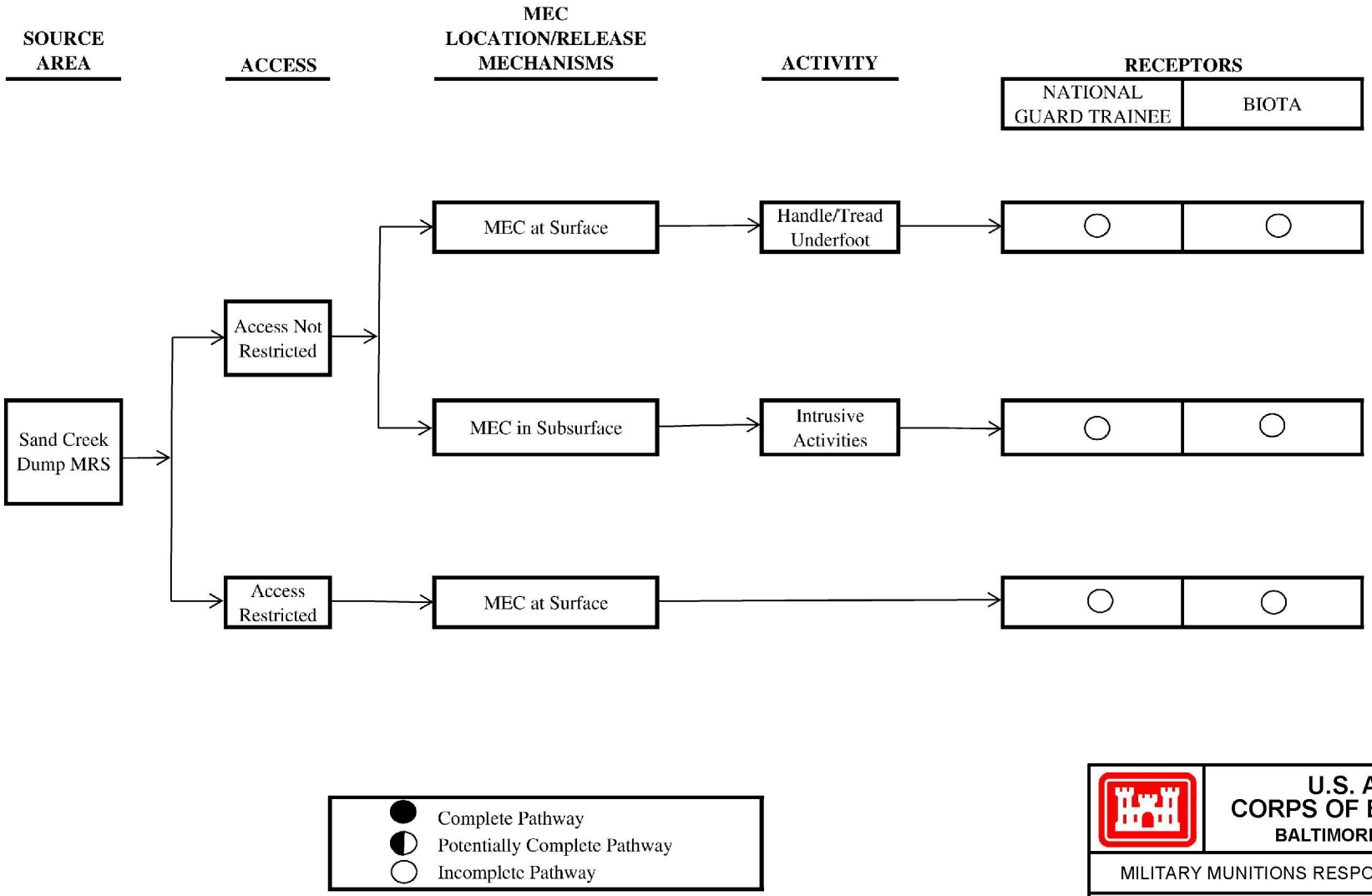
A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the Sand Creek Dump MRS include both current and future land users. Potential users include facility personnel, contractors, and potential trespassers (e^2M, 2007). The National Guard Trainee is considered the Representative Receptor.

Ecological receptors (biota) are based on animal species that are likely to occur in the terrestrial habitats at the MRS. The *Final RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003a) identifies the primary biota types at the facility as terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, barn owls, and hawks. In the absence of an ERA, these ecological receptors are considered applicable to the Sand Creek Dump MRS as well.

9.1.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary CSM for MEC at the Sand Creek Dump MRS and to identify actual, potentially complete, or incomplete source-receptor interactions for the MRS, for current and anticipated future land uses. Evaluation of end use receptors for future land use in the revised CSM is consistent with the facility HHRA approach presented in the HHRAM (USACE, 2005a). The revised MEC Exposure Pathway Analysis is presented on **Figure 9-1**.

Between 2010 and 2012, full DGM coverage was completed at the collocated AOC and MRS. A subsequent intrusive investigation was performed within the boundaries of the MRS and no MEC was identified. To date, no confirmed MEC has been found at the Sand Creek Dump MRS. Two demilitarized 75mm projectiles were found following the 2003 Removal Action at the collocated AOC and were inspected and verified to be MD. A 105mm projectile was observed in Sand Creek during the 2007 SI field work; however, it is not



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Project Number: 136147

U.S. ARMY
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BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

SAND CREEK DUMP 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

known from where the projectile originated. The projectile appeared empty but was not inspected to determine the explosive safety status as either "safe" or hazardous." The projectile was not observed in the creek during the RI field work, and the disposition of this projectile is unknown. No MEC was found during the RI field work, and no explosive safety hazard is present at the Sand Creek Dump MRS. Therefore, the MEC exposure pathways for surface and subsurface soil are considered incomplete for all receptors.

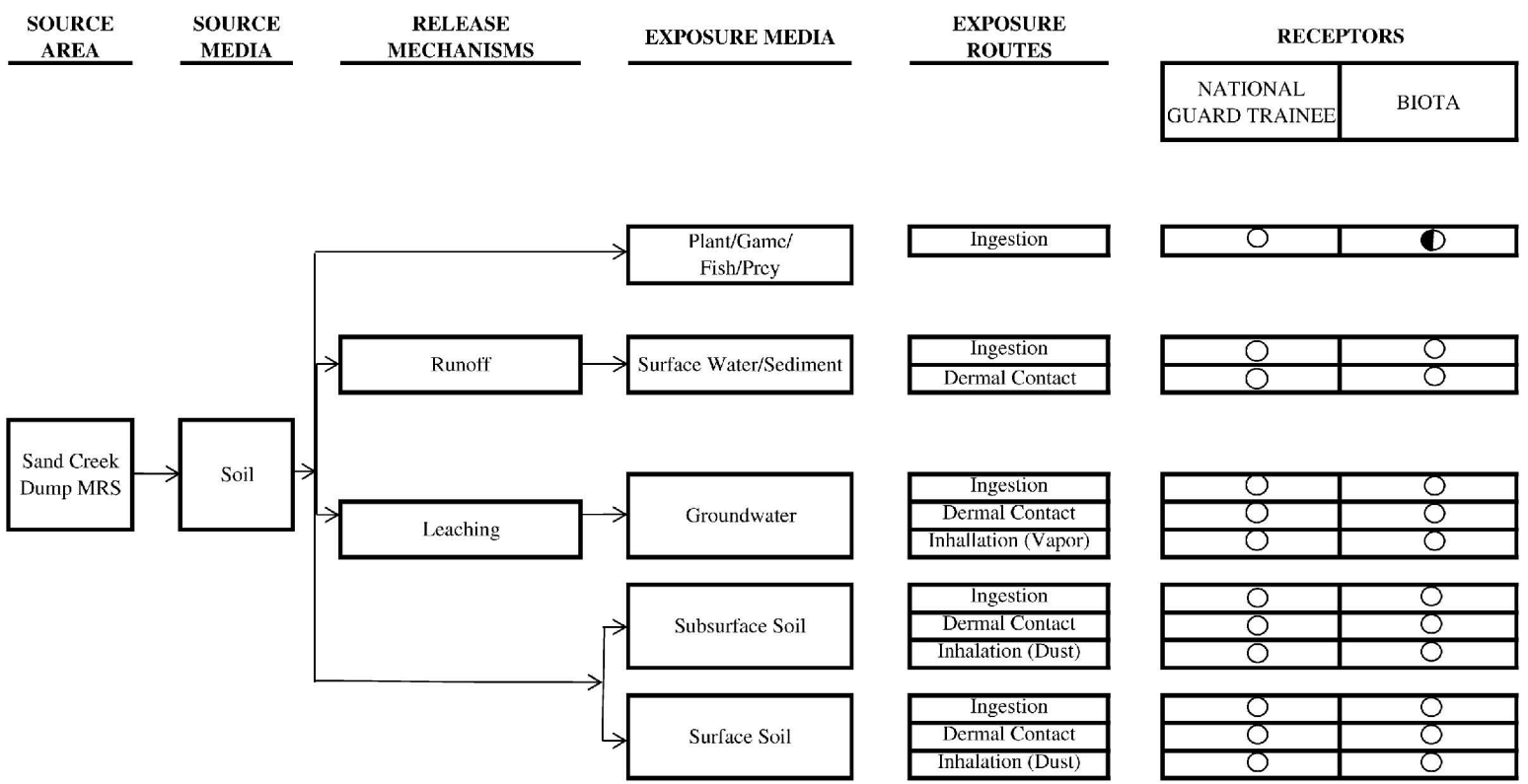
9.2 MC Exposure Analysis

Based on the results of the MEC investigation portion of the RI field activities, it was determined that no potential source of MC is present at the Sand Creek Dump MRS. Therefore, no media sampling was conducted at the MRS and incomplete pathways exist for MC for all receptors. The COCs identified during the Phase I RI under the IRP will continue to be addressed under the IRP. The revised MC Exposure Pathway Analysis for the Sand Creek Dump is presented on **Figure 9-2**.

9.3 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Sand Creek Dump MRS is associated with the incomplete record of the historical operations at the MRS. Although MD has been found at the MRS, there are no records of intentional disposal of munitions related items at the former Sand Creek Dump. No MEC was found during the RI or any of the previous investigations at the MRS and the no findings of MEC during the RI intrusive investigation activities suggest that bulk disposal of munitions related items did not occur at the MRS.

In order to determine the quantity and type of MEC present, if any, a combination of DGM surveys and intrusive anomaly investigations were completed at the Sand Creek Dump MRS. The evaluation for buried anomalies was designed based on complete (100 percent) DGM coverage of the accessible areas of the MRS that included the combined data from the 2010 DGM survey, performed at the collocated AOC under the IRP, and the remaining portions of the MRS that were surveyed during the RI under the MMRP. Two areas with high densities of anomalies were identified at the MRS and intrusive activities at these areas consisted of eight trenches. No MEC was found at any of the trench locations. In addition, 225 individual anomalies were identified throughout the MRS and outside the two areas of high anomaly density. The number of individual anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size for populations. A total of 165 individual anomaly locations (over 73 percent of the identified 225 individual anomalies) were identified for intrusive investigation, and 157 anomalies were successfully reacquired. No MEC was found at the individual anomaly locations during the RI field activities, and the statistical approach used to quantify the intrusive findings of



Receptor	Surface Soil (feet bgs)	Subsurface Soil (feet bgs)
National Guard Trainee	0-4	4-7
Biota	0-1	>1

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

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Project Number: 136147

FIGURE 9-2 REVISED MC CONCEPTUAL SITE MODEL

the RI indicates there is a 99 percent probability there is no MEC present at the remaining individual anomaly locations that were not investigated during the RI field activities. These results of the intrusive investigations at the areas with the high densities of anomalies and the individual anomaly locations satisfy the DQOs and reduce the uncertainties that MEC is present at the MRS.

9.4 Munitions Response Site Prioritization Protocol

The DOD proposed the MRSPP (32 Code of Federal Regulations Part 179) to assign a relative potential 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, taking into consideration various factors related to explosive safety and environmental hazards (68 Federal Regulations 50900 [32 Code of Federal Regulations 179.3]). The revised MRSPP document for the Sand Creek Dump MRS is being prepared separately and is included in this RI Report as **Appendix F** for reference only.

10.0 SUMMARY AND CONCLUSIONS

This section summarizes results of the RI field activities conducted at the Sand Creek Dump MRS. The purpose of the RI was to determine whether the Sand Creek Dump MRS warranted further response action pursuant to CERCLA and the NCP. More specifically, this RI Report was intended to determine the nature and extent of MEC and MC and to subsequently determine the potential hazards and risks posed to human and ecological receptors by MEC and MC. Additional data are also presented in this RI Report to assist in the identification and evaluation of alternatives in the FS, if required. As a result of the investigation activities, the objectives of the RI have been satisfied. A summary of the RI results is presented in **Table 10-1**.

Table 10-1
Summary of Remedial Investigation Results

Investigation Area	Investigation Methods	Proposed Investigation Area (Acres)	Actual Area Investigated (Acres)	MEC Found?	MC Detected?
Sand Creek Dump MRS	DGM and intrusive activities	0.85	0.8	No	NS

DGM denotes digital geophysical mapping.
MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
NS denotes not sampled.

10.1 Summary of Remedial Investigation Activities

Information from the Sand Creek Dump MRS relating to the potential presence of MEC and associated MC was compiled and evaluated in this RI Report. The sources of this information were obtained from previous investigations and historical records including the ASR (USACE, 2004), the HRR (e^2M, 2007), the SI Report (e^2M, 2008), and the Phase I RI (Shaw, 2012).

The preliminary CSMs for the MRS was evaluated based on the historical background reviews and data needs, and the DQOs were determined as outlined in the Work Plan Addendum (Shaw, 2011a). The data needs included characterization of MEC and/or 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 their intended use; and the

inference of valid assumptions from the data. The DQOs for the Sand Creek Dump MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform a geophysical investigation at the remaining portions of the MRS that weren't covered during the 2010 DGM survey under the IRP to identify buried metallic anomalies that had the potential to be MEC.
- Perform an intrusive investigation of anomalies identified following the geophysical investigation to evaluate if MEC was present.
- Collect incremental and/or discrete samples (surface and subsurface soil) in areas with concentrated MEC and/or MD to evaluate for MC, if necessary.
- Process the information to evaluate whether there were unacceptable hazards or risks to humans 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

Between late December 2011 and early January 2012, a DGM survey was conducted at the Sand Creek Dump MRS that encompassed the remainder of the MRS that was not covered during the 2010 DGM survey. This survey included the additional 150-foot (0.13-acre) section north of the AOC boundary as well as a number of small fill-in areas within the MRS. The DGM survey was conducted over the steep slopes of the MRS as well the low floodplain areas and upgradient locations at the top of slope where dump activities most likely occurred. Full coverage DGM data were acquired over all accessible areas of the MRS between the combined DGM surveys which resulted in a spatial coverage of 94.3 percent (0.8 acres).

10.1.2 Anomaly Selection

Evaluation of the data collected during the DGM survey identified two primary areas of high anomaly densities with signal strengths greater than or equal to 8 mV (Channel 2). Outside of these high density areas, there were a total of 225 anomalies identified for potential investigation as individual target locations.

10.1.3 Intrusive Investigations

Following the completion of the DGM survey, reacquisition and intrusive investigation activities for the locations identified as potentially containing buried MEC were performed in August 2013 based on an analysis of the DGM survey data. The data interpreter selected eight locations for trenches as the primary investigative technique within the two localized areas with high densities of anomalies. A total of 128 individual anomaly locations were identified for intrusive investigation to characterize the nature and extent of MEC using a

statistics module in accordance with the approved Work Plan Addendum (Shaw, 2011a). More than 25 of the individual anomalies were selected in several areas of the MRS that are likely associated with single anomaly sources related to cultural features (expansive sections of concrete foundation from the former treatment facility). These localized areas could not be fully investigated with DGM due to steep terrain and dense vegetation consisting of close knit trees, which prevented further analysis and classification of the anomaly source(s). Therefore, the data interpreter selected 25 additional anomaly selections in areas away from these features to provide a better distribution of targets across the MRS that are not associated with potential cultural features. An additional 12 anomaly locations were selected to ensure there was a 95 percent probability that a minimum of four items of interest were identified, which is consistent with the investigation strategy used at the other MRSs that were investigated at the facility under the MMRP. In all, a total of 165 target locations were selected for intrusive investigation that equates to an investigation percentage of approximately 73 percent of the individual anomalies. No MEC was found at the MRS during the intrusive investigation activities at the high density anomaly areas or the individual anomaly locations.

10.1.4 MC Sampling

The DQOs stated that incremental samples and discrete samples (surface and subsurface soil) would be collected in areas with concentrated MEC or MD. No MEC or MD was identified at the Sand Creek Dump MRS during the RI field activities and sampling for MC was not warranted.

10.2 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008) 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 was identified at the MRS during the RI field activities. These results indicate that no MEC source or explosive safety hazard is present at the MRS. Therefore, calculation of a MEC HA was not warranted for the Sand Creek Dump MRS.

10.3 Conceptual Site Model

The information collected during the RI field activities was used to update the CSM for MEC and to evaluate if the development of a revised CSM for MC was warranted. The purpose of

the 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.

10.3.1 MEC Exposure Analysis

Between 2010 and 2012, full DGM coverage was completed at the collocated AOC and MRS. A subsequent intrusive investigation was performed within the boundaries of the MRS and no MEC was identified. To date, no confirmed MEC has been found at the Sand Creek Dump MRS. Two demilitarized 75mm projectiles that were inspected and verified as MD by UXO-qualified personnel were found following the 2003 Removal Action at the collocated AOC. A 105mm projectile was observed in Sand Creek during the 2007 SI field work; however, it is not known from where the projectile originated. The projectile appeared to be empty, but it was not inspected to determine the explosive safety status as either "safe" or "hazardous." The projectile was not observed in the creek during the RI field work, and the disposition of this projectile is unknown. No MEC was found during the RI field work, and no explosive safety hazard is present at the Sand Creek Dump MRS. Therefore, the MEC exposure pathways for surface and subsurface soil are considered incomplete for all receptors.

10.3.2 MC Exposure Analysis

Based on the results of the MC sampling during the SI field activities and the MEC investigation portion of the RI field activities, it was determined that no potential source of MC is present at the Sand Creek Dump MRS. Therefore, no media sampling was conducted at the MRS and incomplete pathways exist for MC for all receptors. The COCs identified during the Phase I RI under the IRP will continue to be addressed under the IRP.

10.4 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Sand Creek Dump MRS is associated with the incomplete record of the historical operations at the MRS. Although MD has been found at the MRS, there are no records of intentional disposal of munitions related items at the former Sand Creek Dump. No MEC was found during the RI or any of the previous investigations at the MRS and the no findings of MEC during the RI intrusive investigation activities suggest that bulk disposal of munitions related items did not occur at the MRS.

In order to determine the quantity and type of MEC present, if any, a combination of DGM surveys and intrusive anomaly investigations were completed at the Sand Creek Dump MRS. The evaluation for buried anomalies was designed based on complete (100 percent) DGM

coverage of the accessible areas of the MRS that included the combined data from the 2010 DGM survey, performed at the collocated AOC under the IRP, and the remaining portions of the MRS that were surveyed during the RI under the MMRP. Two areas with high densities of anomalies were identified at the MRS, and intrusive activities at these areas consisted of eight trenches. No MEC was found at any of the trench locations. In addition, 225 individual anomalies were identified throughout the MRS and outside the two areas of high anomaly density. The number of individual anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size for populations. A total of 165 individual anomaly locations (over 73 percent of the identified 225 individual anomalies) were identified to for intrusive investigation, and 157 anomalies were successfully reacquired. No MEC was found at the individual anomaly locations during the RI field activities, and the statistical approach used to quantify the intrusive findings of the RI indicates there is a 99 percent probability there is no MEC present at the remaining individual anomaly locations that were not investigated during the RI field activities. These results of the intrusive investigations at the areas with the high densities of anomalies and the individual anomaly locations satisfy the DQOs and reduce the uncertainties that MEC is present at the MRS.

10.5 Conclusions and Recommendations

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 threats to human and ecological receptors. The following statements can be made for the Sand Creek Dump MRS based on the results of the RI field activities:

- Complete DGM coverage of accessible areas (0.8 acres) was conducted at the current MRS between the combined 2010 and the 2012 DGM surveys and 94.3 percent coverage of the 0.85-acre MRS was achieved.
- No MEC has been discovered in or around the MRS to date, and an explosive safety hazard does not exist at the MRS.
- MC sampling was not warranted because concentrated areas of MEC or MD were not found at the MRS during the RI field activities.

No explosive safety hazards or potential sources of MC have been identified for the MRS during the RI field work. Based on these results, it is concluded that the nature and extent of MEC and MC at the Sand Creek Dump MRS have been adequately characterized and the DQOs presented in the Work Plan Addendum (Shaw, 2011a) have been satisfied. No Further Action is recommended for the Sand Creek Dump 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 Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014) and No Further Action was recommended at the MRS 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 the collocated AOC at this time. If Unrestricted Land Use is not achieved under the IRP investigations, then the evaluation for the Commercial Industrial Land Use will be incorporated along with the Unrestricted Land Use and the Military Training Land Use under the IRP, as specified in the Army's technical memorandum.

11.0 REFERENCES

AMEC Earth and Environmental, Inc. (AMEC), 2008. *Final Updated Integrated Natural Resources Management Plan for the Ravenna Training and Logistics Site and the Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio*, prepared for the Ohio Army National Guard, March.

Camp Ravenna Joint Military Training Center, 2013. *Federal and State Listed Species*, May 16.

engineering-environmental Management, Inc. (e^2M), 2007. *Final Military Munitions Response Program Historical Records Review, Ravenna Army Ammunition Plant, Ohio*, January (revised).

e^2M, 2008. *Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio, Military Munitions Response Sites*, May.

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

MKM Engineering, Inc. (MKM), 2004. *Final Report for the Remedial Design/Removal Action at RVAAP-34 Sand Creek Disposal Road Landfill*, Ravenna Army Ammunition Plant, Ravenna, Ohio, prepared for U.S. Army Joint Munitions Command (JMC), Rock Island, Illinois, March.

MKM, 2007. *Final Characterization of 14 AOCs at the Ravenna Army Ammunition Plant*, March.

National Oceanic and Atmospheric Administration. *Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971–2000*, retrieved from <http://hurricane.ncdc.noaa.gov/climatenormals/clim81/OHnorm.pdf>.

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

Science Applications International Corporation (SAIC), 2010. *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio*, March 23.

SAIC, 2011. *Final Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant, Ravenna, Ohio*, February.

Shaw Environmental & Infrastructure, Inc. (Shaw), 2011a. *Final Work Plan Addendum for Military Munitions Response Program Remedial Investigation Environmental Services*, Ravenna Army Ammunition Plant Ravenna, Ohio, December.

Shaw, 2011b. *Final Digital Geophysical Mapping Report for the RVAAP-34 Sand Creek Disposal Road Landfill, RVAAP-03 Open Demolition Area #1, and RVAAP-28 Mustard Agent Burial Site,* January 11.

Shaw, 2012. *Draft Phase I Remedial Investigation Report for RVAAP-34 Sand Creek Disposal Road Landfill*, Ravenna Army Ammunition Plant, Ravenna, Ohio, July 19.

Shaw, 2013. *Accident Prevent Plan Addendum for Asbestos Abatement for Military Munitions Response Program Remedial Investigation Environmental Services*, July 9.

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

U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM), 1998. *Relative Risk Site Evaluation for Newly Added Sites at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* Hazardous Medical Waste Study No. 37-EF-5360-99.

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. *Final RVAAP Facility-Wide Ecological Risk Assessment Work Plan*, April 21.

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

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

USACE, 2005a. *RVAAP's Facility-Wide Human Health Risk Assessor Manual, Amendment 1*, December.

USACE, 2005b. *Facility-Wide Biological and Water Quality Study 2003*, Ravenna Army Ammunition Plant, Final, November.

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

USACE, 2009. *Geophysics*, Data Item Description (DID) MMRP-09-004, Huntsville Center, August 19.

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

USACE, 2010b. *Geophysics*, DID WERS-004.01, Huntsville Center, April 28.

USACE, 2012a. Microsoft© Excel spreadsheet titled, "*final_receptor_descriptions_MMRP_4 MRS_apr2012_rev.xls,*" provided to Shaw Environmental & Infrastructure, Inc. by the U.S. Army Corps of Engineers, Louisville District, April.

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

U.S. Army National Guard (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.* Prepared for Nancy Zikmanis Environmental Supervisor, Ohio EPA, DERR-NEDO, Northeast District Office, 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 the Ohio Department of Natural Resources, Division of Land and Soils, and Ohio Agriculture Research and Development, 1978. *Soil Survey of Portage County*.

U.S. Environmental Protection Agency (EPA), 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, EPA/540-R-97-006.

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

EPA, 2008. *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology*, Washington, D.C., October.

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

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Appendix A
Geophysical Mapping Report

Appendix B
Photograph Documentation Log

Appendix C
Intrusive Investigation Results

Appendix D
Asbestos Abatement Report

Appendix E
Statistical Analysis of Intrusive Findings

Statistical Analysis of Intrusive Findings at the Sand Creek Dump 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 is 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 Sand Creek Dump 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 Sand Creek Dump MRS. In total, 222 anomalies were identified using digital geophysical mapping (DGM), and 137 of these were randomly selected and intrusively investigated. Three other anomalies were selected for intrusive sampling by means other than the random selection process. These are not included in this statistical evaluation because they represent a different population of geophysical anomalies. In actuality, 6 of the 222 individual target anomalies randomly selected for intrusive sampling were not able to be reacquired. For purposes of this statistical evaluation, CB&I assumes that these anomalies did not exist. Thus, the original population of anomalies is reduced to 216 (222 - 6) and the targets selected and recovered during the intensive sampling was 131 (137 - 6).

As stated above, a realistic assumption was made that the percentage of MEC items as between 0.1 and 1 percent. But for comparative purposes, the mean value of the MEC among the 216 anomalies to be acquired by intrusive sampling 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 and demonstrates the robustness of this Bayesian analysis with respect to this important assumption.

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 as follows:

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

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 zero even when *y/m* is zero. Note however, that as *m* gets larger, the estimated proportion approaches *y/m*.

Once the proportion is estimated in the Bayesian framework, the predictive distribution for the count of MEC in the unsampled anomalies is readily obtained and follows a beta-binomial distribution. This distribution can be used to predict the count of MEC in the remaining unsampled anomalies. Assuming a priori that MEC was at 1 percent or less, no MEC items are anticipated in the remainder of samples.

Table E-1 presents a summary of the Bayesian approach and estimations used to predict the probability of MEC at the unsampled anomalies at the Sand Creek Dump MRS.

Table E-1
Probabilities of Remaining MEC for Unsampled Anomalies

Estimated Mean Population of MEC	Probability that there is no MEC in Remaining 85 Unsampled Anomalies	95th Percentile of Prediction Distribution for Count of MEC in Remaining 85 Unsampled Anomalies	99th Percentile of Prediction Distribution for Count of MEC in Remaining 85 Unsampled Anomalies
0.1%	0.999	0	0
1%	0.99	0	0
4%	0.97	0	1
50%	0.53	3	4

MEC denotes munitions and explosives of concern.

If the mean MEC population at the MRS is estimated to be 0.1 percent, 1 percent and 4 percent, then the predicted probability that there is no MEC in the remaining 85 (216 - 131) unsampled anomalies using the actual intrusive results is 99.9, 99, and 97 percent, respectively. In the case where the mean MEC population is estimated to be 50 percent, there is only a 53 percent prediction probability that there is no MEC in the remaining 85 unsampled anomalies based on the intrusive results. In this scenario, 196 of the anomalies would need to be sampled to obtain a prediction probability of 90 percent that there is no MEC in the remaining 209 samples. Based on the results of the intrusive investigation as well as previous investigations, CB&I assumed a priori that MEC was at 1 percent or less. Based on this assumption, no MEC items are anticipated to be present at any of the remaining 85 unsampled anomalies.

References:

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

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

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Appendix F
Munitions Response Site Prioritization Protocol Worksheets

Appendix G
Ohio EPA Correspondence

Appendix H
Ohio EPA Approval Letter

Note: This is a placeholder page. CB&I Federal Services LLC will supply a signed authorization page to be inserted into the final hard copy document as soon as it becomes available. Replacement CDs that include the signed authorization page will also be supplied.