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14. ABSTRACT

This Remedial Investigation (RI) Report presents the findings and conclusions of the RI field activities conducted at the RVAAP-063-R-01 Group 8 Munitions Response Site (MRS) between October 2011 and February 2012 at the former Ravenna Army Ammunition Plant. The purpose of this RI Report is to determine whether the Group 8 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, this RI Report is intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the likely hazards and risks posed to human and ecological receptors by MEC and MC. This RI Report also presents additional data to assist in determining which remediation alternatives, if any, are appropriate. 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-063-R-01 Group 8 MRS* at the former Ravenna Army Ammunition Plant in Portage and Trumbull Counties, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy, principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets customer's needs consistent with law and existing U.S. Army Corps of Engineers policy.

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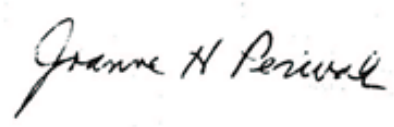
Reviewed/Approved by:  Date: May 19, 2015

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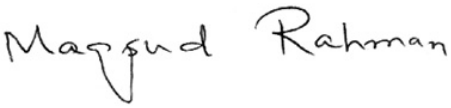
Reviewed/Approved by:  Date: May 19, 2015

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Portage and Trumbull Counties, Ohio

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ADD	average daily dose
AEDB-R	Army Environmental Data Base Restoration
AGP	above ground plant tissue concentration
AMEC	AMEC Earth and Environmental, Inc.
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ARNG	Army National Guard
ASR	*Final Archives Search Report*
ASTM	American Society of Testing and Materials
atm-m^3/mole	atmospheric cubic meters per mole
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BERA	baseline ecological risk assessment
bgs	below ground surface
BRAC	Base Realignment and Closure
BSV	background screening value
CAS	Chemical Abstracts Service
CB&I	CB&I Federal Services LLC
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CRJMTC	Camp Ravenna Joint Military Training Center
CSM	conceptual site model
CT Laboratories	CT Laboratories, Inc.
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DGM Report	*Digital Geophysical Mapping Report for the Group 8 MRS (RVAAP-063-R-01)*
DID	Data Item Description
DMM	discarded military munitions
DoD	U.S. Department of Defense
DQO	data quality objectives
e^2M	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency

Acronyms and Abbreviations (continued)

EPC	exposure point concentration
EQM	Environmental Quality Management, Inc.
ERA	ecological risk assessment
ESA	Endangered Species Act
ESQD	explosive safety-quantity distance
ESV	ecological screening value
EU	exposure unit
EW	earthworm tissue concentration
FS	Feasibility Study
FWCUG	facility-wide cleanup goal
FWSAP	*Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP*
ha	hectare
HE	high explosive
HEAT	high explosive anti-tank
Hg	mercury
HHRA	human health risk assessment
HHRAM	*Facility-Wide Human Health Risk Assessor Manual*
HQ	hazard quotient
HRR	*Final Historical Records Review*
HSDB	Hazardous Substances Data Bank
IAEA	International Atomic Energy Agency
IDW	investigation-derived waste
INRMP	*Integrated Natural Resources Management Plan*
IRP	Installation Restoration Program
ISM	incremental sampling methodology
IVS	instrument verification strip
kg	kilogram
K_{oc}	organic carbon/water partition coefficient
K_{ow}	octanol/water partition coefficient
L	liter
lb	pound
LCS	laboratory control sample
LOAEL	lowest observed adverse effect level
LOD	limit of detection
M	mammal tissue concentration
MB	method blank
MC	munitions constituents
MD	munitions debris
MDC	maximum detected concentration
MDL	method detection limit
MEC	munitions and explosives of concern
MEC HA	Munitions and Explosives of Concern Hazard Assessment

Acronyms and Abbreviations (continued)

mg/kg	milligrams per kilogram
MKM	MKM Engineers, 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
MS/MSD	matrix spike/matrix spike duplicate
mV	millivolt
NA	not applicable/available
NCBI	National Center for Biotechnology Information
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NGT	National Guard Trainee
nm	nanometer
NOAEL	no observed adverse effect level
OB	open burn
OD	open detonation
ODNR	Ohio Department of Natural Resources
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PBA	Performance-Based Acquisition
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
Position Paper	*Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals*
PRG	Preliminary Remediation Goal
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
redox	oxidation/reduction
R(A)	Resident Receptor (Adult)
R(C)	Resident Receptor (Child)
RI	remedial investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RSL	Regional Screening Level
RTS	robotic total station
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation, Inc.

Acronyms and Abbreviations (continued)

SAP Addendum	*Final Sampling and Analysis Plan and Quality Assurance Project Plan Addendum*
SDG	sample delivery group
Shaw	Shaw Environmental and Infrastructure, Inc.
SI	site inspection
SI Report	*Final Site Inspection Report*
SLERA	screening level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
SRC	site-related chemical
SSL	soil screening level
SVOC	semivolatile organic compound
TBC	to be considered
TDS	total dissolved solid
TEC	threshold effect concentration
Technical Memorandum	*Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program*
TNT	2,4,6-trinitrotolune
TOC	total organic carbon
TRV	toxicity reference value
U.S.	United States
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USC	United States Code
USP&FO	U.S. Property and Fiscal Officer
UV	ultraviolet
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist
VOC	volatile organic compound
VQ	validation qualifier

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report documents the findings and conclusions of the RI field activities for the Group 8 (RVAAP-063-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 RVAAP 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, Baltimore District (USACE) on May 27, 2009.

The purpose of the RI was to determine whether the Group 8 MRS warrants further response action pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) 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.

ES.1 MRS Description

Whenever possible, existing information and data were incorporated into this RI Report. Background information related to the MRS was taken from the *Final Archives Search Report* (USACE, 2004), the *Final MMRP Historical Records Review* (engineering-environmental Management, Inc. [e^2M], 2007), and the *Final Site Inspection Report* (Site Inspection [SI] Report) (e^2M, 2008).

The Group 8 MRS is a 2.65-acre MRS located between Buildings 846 and 849, which was used for an undetermined amount of time to burn construction debris and rubbish. Although it has not been documented, previous discoveries of MEC and munitions debris (MD) indicate that the area may have also received various munitions items, including M397 series 40 millimeter (mm) high explosive (HE) grenades, M49 series 60mm mortars, M72 series 75mm projectiles, M557 series fuzes, 175mm projectiles, HE anti-tank warheads, and assorted fuzes, which may have been burned at the MRS. The area was used by the Ohio Army National Guard (OHARNG) as a vehicle staging area until it was designated as a MRS. The OHARNG still utilizes the road network within the MRS to access adjacent buildings. The MRS is currently vacant, grassy land with no improvements.

In 1996, one antipersonnel fragmentation bomb with HE and a demilitarized (i.e., cut in half) 175mm projectile were both found on the ground surface within the Group 8 MRS boundary. The antipersonnel fragmentation bomb was removed from the MRS and detonated at Open Demolition Area #2. The demilitarized 175mm projectile was considered as MD and was removed and taken to Building 1501 (e^2M, 2007).

A large amount of material potentially presenting an explosive hazard (MPPEH) was recovered at the MRS during the 2007 SI field activities, and most of it was documented as safe (i.e., MD). Two of the MPPEH items were determined to be MEC and consisted of two unidentifiable T-bar fuzes.

Sampling for MC was conducted at the MRS during the SI field activities and included the collection of five incremental sampling methodology (ISM) surface soil samples. Various metals consisting of antimony, arsenic, aluminum, cadmium, copper, iron, lead, manganese, and thallium were detected at concentrations that exceeded the screening criteria (e^2M, 2008).

Current activities at the Group 8 MRS include maintenance and use as access to the road network to access adjacent buildings. The future land use for the Group 8 MRS is military training.

ES.2 Summary of Remedial Investigation Activities

The preliminary MEC and MC conceptual site models (CSMs) were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used to identify the data needs and data quality objectives (DQOs) as outlined in the *Final Work Plan Addendum for MMRP Remedial Investigation Environmental Services* (Shaw, 2011). The data needs and DQOs were determined at the planning stage and included characterization of MEC and MC associated with former activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and valid assumptions could be inferred from the data. The DQOs for the Group 8 MRS identified the following decision rules that were implemented in evaluating the MRS:

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

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

Geophysical Investigation

Between October 31, 2011, and November 14, 2011, a full-coverage digital geophysical mapping (DGM) investigation was performed to identify potential subsurface areas of MEC at the Group 8 MRS. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was 2.563 acres or nearly 97 percent of the 2.65-acre MRS. No MPPEH was identified on the ground surface during the DGM survey.

Anomaly Selection

Evaluation of the data collected during the DGM survey identified 2,690 anomalies which had signal strength greater than or equal to 8 millivolts (Channel 2) for an average anomaly density of 1,015 anomalies per acre. Three areas were considered to have localized high anomaly densities, which accounted for 1,049 of the 2,690 anomalies. The majority of the high density areas were located south of the gravel roadways. Outside of these high density areas, the remaining 1,641 anomalies were identified as individual target locations for potential investigations. In general, the geophysical data indicate that the anomaly density at the MRS is high and dispersed throughout the MRS with defined localized areas of higher density than found throughout the other areas at the MRS.

Intrusive Investigations

Following the completion of the DGM survey in November 2011, an intrusive investigation was conducted for the locations identified as potentially containing buried munitions-related items based on an analysis of the DGM survey data. A total of 264 of the 1,641 single point anomalies (16 percent) and 14 trenches within the three areas of high anomaly density were successfully investigated. The intrusive investigation activities were conducted at increments of 12 inches from 1 inch to 4 feet in depth, which allowed the unexploded ordnance (UXO)-qualified personnel to visually inspect the soil with a Schonstedt magnetometer as it was removed. A total of 359 MPPEH items that weighted approximately 1,418 pounds were recovered during the intrusive investigation. All of the MPPEH was documented as safe and was determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the intrusive investigations.

MC Sampling

The determination as to whether MC characterization was required at the MRS was made based on historical evidence and the results of the MEC investigation. In accordance with the Work Plan Addendum (Shaw, 2011), four ISM surface soil samples were collected from

sampling units of the same size for the entire MRS at depths between 0 and 0.5 feet below ground surface (bgs). Additional samples were proposed in areas with concentrated MEC/MD and three additional ISM soil samples were collected from the bottom of the trenches at depths of 4 to 4.5 feet bgs where the buried MD was encountered during the intrusive investigation activities. The trench samples were evaluated/considered as subsurface samples in the human health and ecological risk assessments.

ES.3 MEC Hazard Assessment

The MEC Hazard Assessment (HA) evaluation in this RI Report is inclusive of the information available for the MRS up to and including the RI field activities and provides a scoring summary for the current and future land use activities, assuming no response actions. A MEC HA is performed for an MRS when an explosive safety hazard is identified. In the case for the Group 8 MRS, MEC items were reportedly found on the ground surface at the MRS by OHARNG personnel in the past and during the 2007 SI field activities; however, only MD items were found during complete coverage of the MRS during the RI field activities. Taking into consideration the amount of buried MD that was removed during the RI field work (1,418 pounds), the various types of MD found, the distribution and depth at which the MD was found, the relatively minimal size of the MRS at 2.65 acres, and that MEC was found at the MRS prior to the RI field activities; it was determined that a potential explosive safety hazard may be present at the Group 8 MRS and calculation of a MEC HA score was warranted.

The MEC HA score for current conditions at the Group 8 MRS was calculated to be 705, which equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The future land use at the MRS will be military training with the potential for intrusive activities, and resulted in a MEC HA score of 805. This equates to a Hazard Level of 2 (high potential explosive hazard condition). The increase in the hazard level score was solely the result of an increase in receptor hours for the future land use.

ES.4 MC Risk Assessment Summary

Site-related chemicals (SRCs) for the Group 8 MRS were determined for the surface and subsurface soil collected during the RI field activities through the data screening process as presented in the *Final Facility-Wide Human Health Cleanup Goals for the RVAAP* (Science Applications International Corporation, Inc. [SAIC], 2010). The detected chemicals retained as SRCs were as follows:

- Surface Soil (0 to 0.5 feet bgs):
  - *Explosives and Propellants*: nitroguanidine and 2,4,6-trintrotoluene

  - *Metals:* antimony, barium, cadmium, chromium, copper, iron, lead, mercury, strontium, and zinc
  - *Semivolatile Organic Compounds:* 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, carbazole, chrysene, dibenzo(a,h)anthracene, dibenzofuran, di-n-butyl phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
  - *Polychlorinated Biphenyls:* Aroclor-1254 and Aroclor-1260

- Subsurface Soil (4 to 4.5 feet bgs):
  - *Metals:* antimony, cadmium, copper, iron, lead, mercury, strontium, and zinc
  - *Semivolatile Organic Compounds:* 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenzofuran, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
  - *Polychlorinated Biphenyls:* Aroclor-1254 and Aroclor-1260

No explosives or propellants were detected in subsurface soils. The identified SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions.

Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted for the surface and subsurface soil samples to determine if the identified SRCs were chemicals of potential concern (COPCs) and/or chemicals of concern (COCs) that may pose a risk to future human receptors. The future land use for the Group 8 MRS is military training, and the Representative Receptor is the National Guard Trainee. Evaluation of the Representative Receptor for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, forms the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA and as outlined in the *Facility-Wide Human Health Risk Assessor Manual* (HHRAM) (USACE, 2005b). Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Technical Memorandum) (Army National Guard [ARNG], 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

The facility has defined exposure depth scenarios for the identified receptors. The defined surface soil exposure depths for the Resident Receptor (Adult and Child) and the National Guard Trainee are 0 to 1 foot and 0 to 4 feet, respectively. The defined exposure depths in subsurface soil for the Resident Receptor (Adult and Child) and the National Guard Trainee are 1 to 13 feet and 4 to 7 feet, respectively (SAIC, 2010). Sampling for MC under the MMRP is selective in general to evaluate identified munitions-related source areas and the potential that MC may have been released from the source areas. The data used in the HHRA are used to evaluate for the receptors at the depths that the samples were collected; however, the data are not intended to evaluate for predefined exposure depth scenarios as is typically performed under the Installation Response Program. The presence of munitions-related source areas at an MRS is the primary driver for determining future actions under the MMRP; however, the HHRA is valuable in identifying potential releases of MC from the source areas and if the MC poses risks to likely human receptors.

The ISM surface soil and bottom of trench samples collected during the RI field activities at the Group 8 MRS were all collected at 0- to 0.5-foot (6-inch) increments since this is the maximum depth that contamination from the presumed burning activities at the MRS or directly beneath MEC or MD on the ground surface or buried in trenches would be expected to vertically migrate in the soil column. This sampling methodology is consistent with the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Therefore for this RI Report, surface soil for the Resident Receptor (Adult and Child) and the National Guard Trainee are evaluated as 0 to 0.5 feet bgs; the depths at which the ISM surface soil samples were collected. The ISM subsurface soils were collected at sample depths of 4 to 4.5 feet bgs at the trench locations and are the exposure depth for the evaluation of subsurface soil for both the Resident Receptor (Adult and Child) and the National Guard Trainee.

Nine COCs that included cadmium, iron, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, Aroclor-1254, and Aroclor-1260, were identified in surface soils for the Resident Receptor (Adult and Child). Cadmium and lead were identified as two COCs in surface soil for the National Guard Trainee. Only iron was identified as a COC in subsurface soil for the Resident Receptor (Adult and Child). No COCs were identified for the National Guard Trainee in subsurface soils.

Based on the results of the HHRA, it can be concluded that COCs in surface soils pose potential risks to the Resident Receptor (Adult and Child) and the National Guard Trainee. Weight of evidence suggests that the iron concentrations in subsurface soil are unlikely to pose a hazard to either of these receptors.

Ecological Risk Assessment

Ten chemicals of potential ecological concern (COPECs) in the surface soil were recommended to be evaluated under the Level III Baseline evaluation following the Level II Screening. COPECs are determined in the ecological risk assessment and may differ from COPCs. The COPECs identified included antimony, cadmium, copper, lead, mercury, zinc, bis(2-ethylhexly)phthalate, di-n-butyl phthalate, Aroclor-1254, and Aroclor-1260.

Multiple COPECs were identified for the MRS that resulted in elevated hazard quotients in many of the ISM sampling units. These COPECs represent a potential for localized impacts to soil invertebrates and small range receptors (particularly the short-tailed shrew and American robin) at the Group 8 MRS. Based on the small size of the MRS (less than 3 acres), the conservative nature of the Level III Baseline, and the low habitat quality of the MRS, the potential for adverse effects to populations of ecological receptors is most likely overestimated; however, the potential risks posed to the ecological receptors at the MRS are not discounted in this RI and are considered to be representative of the site conditions.

ES.5 Conceptual Site Model

The information collected during the RI field activities was used to update the CSM for MEC and MC for the Group 8 MRS as presented in the SI Report (e^2M, 2008). 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.

MEC Exposure Analysis

Complete DGM coverage of accessible areas was conducted at the MRS during the RI and a statistical approach was taken for the selection of anomalies for intrusive investigation. Numerous MPPEH items of various types were identified at the MRS during the RI intrusive investigation activities. All of the MPPEH was documented as safe and determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the RI field work. The depths of the MD ranged from 1 inch to 4 feet bgs. Although a MEC explosive hazard was not identified at the MRS during the RI and statistical analysis of the intrusive investigation results indicates that no MEC is present at a 99 percent confidence level, the amount of MD encountered (359 items), the distribution of the MD items throughout the MRS, and the previously documented MEC items at the MRS is taken into consideration. Therefore, a MEC explosive hazard may remain at the MRS and potentially complete pathways are identified for all receptors accessing surface or subsurface soils.

MC Exposure Analysis

Sampling for MC was performed at the Group 8 MRS based on historical evidence and the results of the RI intrusive investigation. Although no MEC was found during the RI, various MD items were encountered and detected SRCs were evaluated as MC. The SRCs were carried through the risk assessment processes to determine if they were COCs or COPECs that may pose risks to the likely human and ecological receptors, respectively.

The National Guard Trainee is identified as the Representative Receptor for the current and future activities at the MRS and has the greatest opportunity for exposure to MC that may be present at the MRS. The COCs in surface soil (0 to 0.5 feet bgs) were considered to pose a risk to the National Guard Trainee, but the COCs identified for the National Guard Trainee in subsurface soil (4 to 4.5 feet bgs) were not considered to be present at concentrations great enough to pose a risk. Therefore, the MC CSM for the National Guard Trainee has been updated to reflect a complete pathway for surface soil and incomplete pathway for subsurface soil.

Sufficient time has elapsed for COCs and COPECs in the surface soil to have migrated to potential exposure media including surface water and sediment, resulting in possible exposure of plants, fish, and animals that come into contact with these media. With the exception of a small drainage ditch along the south side of the MRS, there are no significant surface water features where COCs or COPECs in surface soil may have migrated. Therefore, the MC exposure pathways for all receptors at the MRS to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

The major exposure routes for chemical toxicity from surface soil to the environmental receptors include ingestion (for terrestrial invertebrates, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial plants and invertebrates). The ingestion exposure routes for voles, shrews, robins, foxes, owls, and hawks include soil, as well as plant and/or animal food (i.e., food chain) that was exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust. Various COPECs in surface soil were determined to present potential threats to likely ecological receptors; therefore, the MC exposure pathways for ecological receptors in surface soil are considered complete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis, and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MC source. The soil conditions at the MRS are considered low to moderately permeable, and the depth to groundwater is approximately 15 to 20 feet, 11 feet below the maximum depth that MD was found. The detected concentrations of explosives are low, and the detected metals, semivolatile organic compounds, and polychlorinated

biphenyls are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath concentrated areas of buried MD where they were deposited. Based on this rationale, no groundwater samples were required to be collected at the Group 8 MRS during the RI field work. Furthermore, it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the MRS and the groundwater exposure pathway is considered incomplete for all receptors.

ES.6 Conclusions

This RI was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose threats to likely receptors. The following statements can be made for the Group 8 MRS based on the results of the RI field activities:

- Complete DGM coverage was performed at the MRS for the RI and nearly 97 percent coverage of the 2.65-acre MRS was achieved.
- Buried MPPEH items were encountered at various locations throughout the MRS at depths ranging between 1 inch and 4 feet bgs and were determined to be MD.
- No MEC was encountered during the RI field activities; however, the MEC items identified at the MRS prior to the RI and the amount, types, distribution, and depth of MD encountered during the intrusive investigations are taken into consideration, and an explosive hazard may be present at the MRS.
- The HHRA indicates that detected COCs in surface soil present potential risks to the Resident Receptor (Adult and Child) that is evaluated for Unrestricted (Residential) Land Use and the National Guard Trainee, the Representative Receptor for the future land use at the MRS.
- The ecological risk assessment indicates that detected COPECs in surface soil have the potential for localized impacts to soil invertebrates and small range receptors.

The RI for the Group 8 MRS included risk assessments for explosive hazards and MC that may pose risks to likely receptors. The buried MPPEH items that were encountered during the RI field work were solid and/or inert, posed no explosive safety hazard, and were determined to be MD by the UXO-qualified personnel in the field. No MEC was discovered at the MRS during the RI field work; however, MEC has been reported to have been encountered at the MRS during previous investigations. The HHRA and the ecological risk assessment identified the potential for impact from MC in surface soil to the likely human and ecological receptors. A Feasibility Study is recommended as the next course of action for

the Group 8 MRS to assess possible response action alternatives for likely remaining MPPEH and associated MC.

Since the RI was completed prior to the finalization of the U.S. Army's Technical Memorandum (ARNG, 2014), evaluation of the Commercial Industrial Land Use using the Industrial Receptor, and other modifications to the HHRA specified in the Technical Memorandum, were not included in the HHRA. Because Unrestricted (Residential) Land Use in subsurface soils was not achieved in the HHRA, modifications to the HHRA process required by the Technical Memorandum (i.e., evaluation of the Commercial Industrial Land Use) will be incorporated into the Feasibility Study.

1.0 INTRODUCTION

This Remedial Investigation (RI) Report documents the finding and conclusions of the RI field activities for the Group 8 (RVAAP-063-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 RVAAP under the Multiple Award Military Munitions Services Performance-Based Acquisition (PBA) Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers, Baltimore District (USACE) on May 27, 2009.

This RI Report presents the results of the RI field activities that were conducted at the Group 8 MRS between November 2011 and February 2012. This report was developed in accordance with the *Final Work Plan Addendum for Military Response Program Remedial Investigation Environmental Services, Version 1.0* (Work Plan Addendum) (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011) and the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

1.1 Purpose

Environmental cleanup decision making under the MMRP follows the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) 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 likely 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 this RI Report was to determine whether the Group 8 MRS warrants 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 identify the potential hazards and risks posed to likely human and ecological receptors by MEC and

MC. Additional data was also presented in this RI Report to support the identification and evaluation of alternatives in the FS, if required.

1.2 Problem Identification

The Group 8 MRS is approximately 2.65 acres and is located between Buildings 846 and 849, southeast of Load Line #12 and just north of the facility's southern boundary. This area is disturbed land that has been used for vehicle staging and historically was used for the open burning (OB) of construction debris and rubbish in the past.

MEC consisting of an antipersonnel fragmentation bomb with high explosive (HE) has been found at the MRS in addition to munitions debris (MD) consisting of a demilitarized 175-millimeter (mm) projectile (engineering-environmental Management, Inc. [e^2M, 2008]). A large amount of material potentially presenting an explosive hazard (MPPEH) was recovered at the MRS during the 2007 site inspection (SI) field activities, and most of it was documented as safe (i.e., MD). Two of the MPPEH items were determined to be MEC and consisted of two unidentifiable T-bar fuzes.

Sampling for MC was conducted at the MRS during the SI field activities and included the collection of five incremental sampling methodology (ISM) surface soil samples. Various metals consisting of antimony, arsenic, aluminum, cadmium, copper, iron, lead, manganese and thallium were detected at concentrations that exceeded the screening criteria (e^2M, 2008). Based on the results of the SI field activities, the *Final Site Inspection Report* (SI Report) (e^2M, 2008), recommended further characterization of MEC and MC at the MRS.

1.3 Physical Setting

This section presents the physical characteristics of the facility, the Group 8 MRS, and the surrounding environment that are factors in understanding fate and transport, receptors, and exposure scenarios for potential human health 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) that included the Group 8 MRS and the *Integrated Natural Resources Management Plan* (INRMP) (AMEC Earth and Environmental, Inc. [AMEC], 2008), which 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 former operations under the RVAAP.

The Group 8 MRS is an approximately 2.65-acre parcel located at the south 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 managed by the Army National Guard (ARNG) and the OHARNG. **Table 1-1** summarizes the administrative description for the Group 8 MRS. The table includes the facility Army Environmental Database-Restoration Module (AEDB-R) numerical designation for the MRS, the current MRS acreage, and the agencies responsible for the MRS.

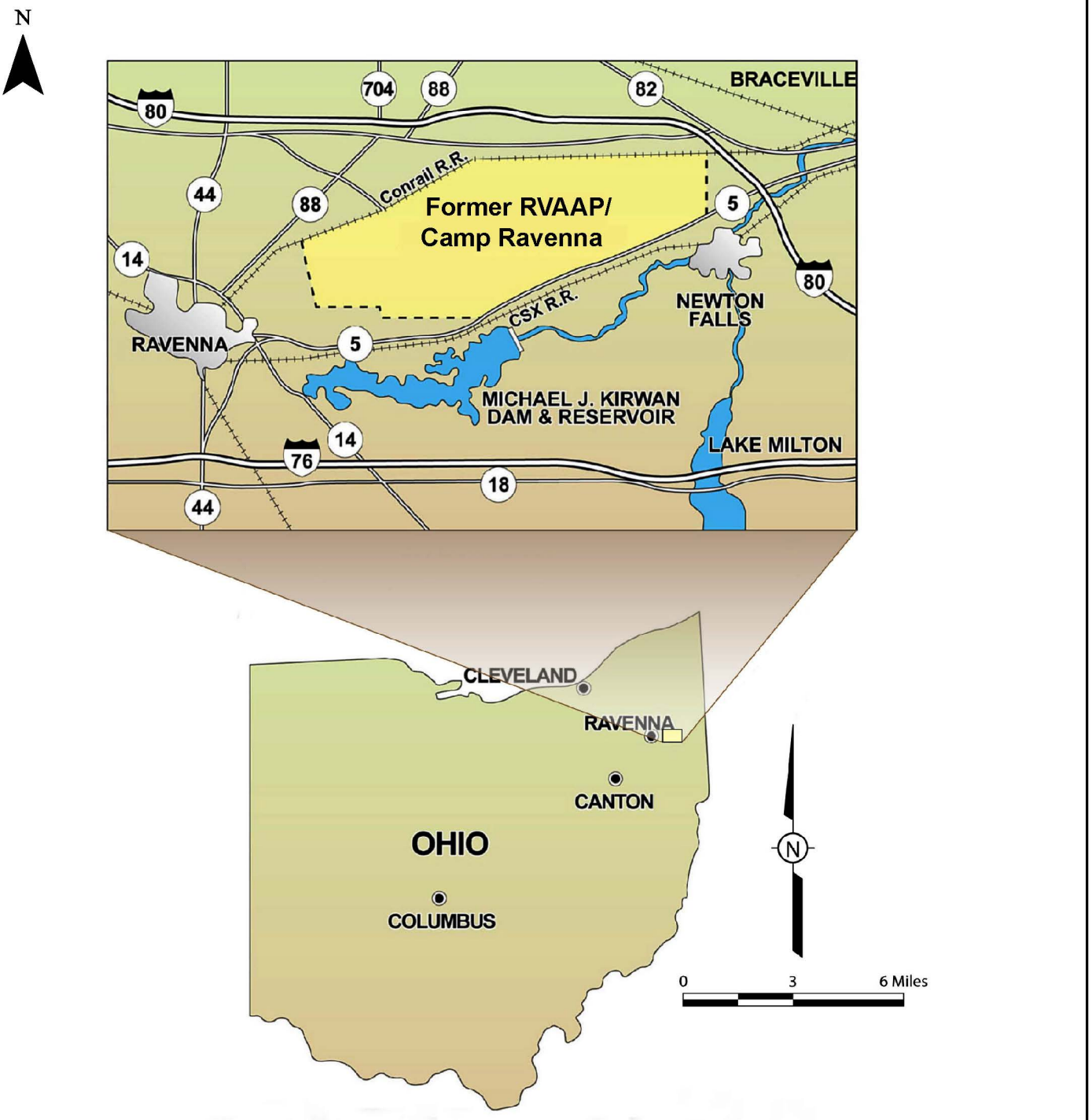
Table 1-1
Administrative Summary of the Group 8 MRS

MRS Name	AEDB-R MRS Number	MRS Area (Acres)	Property Owner	MRS Management Responsibility
Group 8	RVAAP-063-R-01	2.65	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.
RVAAP denotes former Ravenna Army Ammunition Plant.
USP&FO denotes U.S. Property and Fiscal Officer.

1.3.2 Current and Projected Land Use

This section presents the current and future activities for the Investigation Area that is inclusive of the MRS. The future activities are based on the Land Use Exposure Scenarios provided in the *Facility-Wide Human Health Risk Assessor Manual* (HHRAM) (USACE, 2005b) and information provided by the OHARNG during preparation of the Work Plan Addendum (Shaw, 2011).



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

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MILITARY MUNITIONS RESPONSE PROGRAM

FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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FIGURE 1-1 INSTALLATION LOCATION MAP

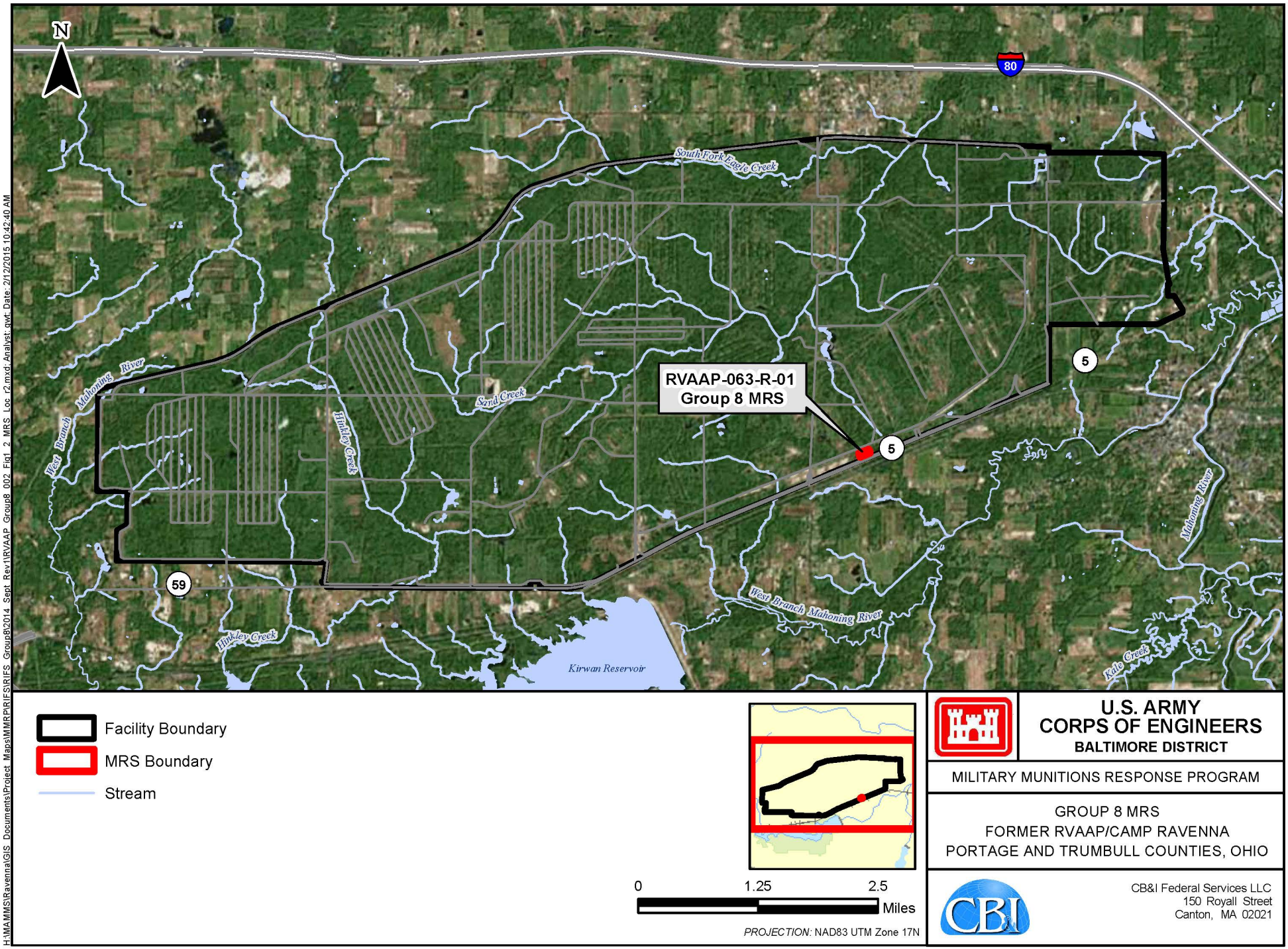

FIGURE 1-2 MRS LOCATION MAP

Current activities at the Group 8 MRS include maintenance and use as access to the road network to access adjacent buildings. Potential users associated with the current activities at the MRS include facility personnel and contractors.

The future land use for the Group 8 MRS is military training and the Representative Receptor is the National Guard Trainee (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Technical Memorandum) (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

1.3.3 Climate

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

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

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

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

1.3.4 Topography

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

Group 8 MRS Topography

The topography at the Group 8 MRS is flat and the relative elevation at the MRS is approximately 985 feet above mean sea level (amsl). There are no natural streams or ponds located within the MRS and the MRS is not located within a flood plain. No bogs, kettle lakes, or kames are present at the MRS. The topography for the Group 8 MRS is presented in **Figure 1-3**.

1.3.5 Hydrology and Hydrogeology

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

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

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

Approximately 153 acres of ponds are found on the facility (AMEC, 2008). 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.

Planning level surveys (i.e., desktop review of wetlands data and resources [National Wetland Inventory maps, aerials, etc.]) for wetlands were conducted for the facility, including the Group 8 MRS. A jurisdictional wetlands delineation has not been completed at the MRS. Wetlands located within the facility include seasonally saturated wetlands, wet fields, and forested wetlands (MKM Engineers, Inc. [MKM], 2007). Sand and gravel aquifers are present within the buried-valley and outwash deposits in Portage County. In general, the aquifer is too thin and localized to provide large quantities of water; however, yields are sufficient for residential water supplies. Wells located on the facility were primarily located within the sandstone facies of the Sharon Member (MKM, 2007).

Although groundwater recharge and discharge areas have not been delineated at the facility, it is assumed that the extensive uplands areas, located at the western portion of the facility,

Facility Boundary
MRS Boundary
Elevation Contour (2 Foot Intervals)

0 500 1,000 Feet

Projection : NAD_1983_UTM_Zone_17N

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FIGURE 1-3 TOPOGRAPHY

are regional recharge zones. Sand Creek, Hinkley Creek, and Eagle Creek are presumed to be major groundwater discharge areas (e^2M, 2008).

Group 8 MRS Hydrology and Hydrogeology

Surface water drainage at the Group 8 MRS generally flows into drainage ditches along the roadside where it eventually infiltrates the soil. No wetlands were identified within the MRS boundary (AMEC, 2008).

No groundwater monitoring wells have been installed at the Group 8 MRS. Based on the data collected for the facility-wide groundwater monitoring program, the groundwater elevation at the MRS and the immediate vicinity is approximated at a potentiometric high of 960 feet amsl. Groundwater flow direction is towards the southeast. The approximate depth to groundwater in the unconsolidated aquifer at the Group 8 MRS is between 15 to 20 feet below ground surface (bgs) (Environmental Quality Management [EQM], 2012).

1.3.6 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 seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008).

Group 8 MRS Vegetation

The habitat at the Group 8 MRS has been influenced and impacted by man-made improvements, including gravel roads. Additionally, historical use of the Group 8 MRS as a burning area has also influenced the habitat at the site. The vegetation community present at the Group 8 MRS is categorized as “other land” (AMEC, 2008), which presumably refers to disturbed areas that do not support any particular plant community.

1.3.7 Threatened, Endangered, and Other Rare Species

Federal status as a threatened or endangered species is derived from the *Endangered Species Act* (ESA; 16 United States Code [USC] § 1538, et seq.) and is administered by the United States Fish and Wildlife Service. While there are species under federal review for listing, there are currently no federally listed species or critical habitats at the facility. State-listed plant and animal species are determined by the Ohio Department of Natural Resources (ODNR). Although biological inventories have not occurred within the MRS boundary and

no confirmed sightings of state-listed species have been reported, there is the potential for state-listed or rare species to be within the MRS boundary. Information regarding threatened, endangered, and candidate species at the facility was obtained from the *Camp Ravenna Rare Species List* (2010). **Table 1-3** presents state-listed species that have been identified to be on the facility by biological inventories and confirmed sightings.

Table 1-3
Camp Ravenna Rare Species List

Common Name	Scientific Name
State Endangered	
American bittern	*Botaurus lentiginosus*
Northern harrier	*Circus cyaneus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-winged warbler	*Vermivora chrysoptera*
Osprey	*Pandion haliaetus*
Trumpeter swan	*Cygnus buccinators*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Graceful underwing	*Catocala gracilis*
Bobcat	*Felis rufus*
Narrow-necked Pohl's moss	*Pohlia elongate* Var. *Elongata*
Sandhill crane (probable nester)	*Grus canadensis*
Bald eagle (nesting pair)	*Haliaetus leucocephalus*
State Threatened	
Barn owl	*Tyto alba*
Dark-eyed junco (migrant)	*Junco hyemalis*
Hermit thrush (migrant)	*Catharus guttatus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Caddisfly	*Psilotreta indecisa*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*
Lurking leskea	*Plagiiothecium latebricola*
Pale sedge	*Carex pallescens*
State Potentially Threatened Plants	

Common Name	Scientific Name
Gray birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum* Var. *Roseum*
Hobblebush	*Viburnum alnifolium*
Long beech fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Tall St. John's wort	*Hypercium majus*
Water avens	*Geum rivale*
Shining ladies-tresses	*Spiranthes lucida*
Swamp oats	*Sphenopholis pensylvanica*
Arbor vitae	*Thuja occidentalis*
American chestnut	*Castanea dentate*
Tufted moisture-loving moss	*Philonotis fontana* Var. *Caespitosa*
State Species of Concern	
Pygmy shrew	*Sorex hovi*
Woodland jumping mouse	*Napaeozapus insignis*
Star-nosed mole	*Condylura cristata*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*
Cerulean warbler	*Dendroica cerulean*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chlorpus*
Great egret (migrant)	*Ardea alba*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*

Common Name	Scientific Name
Mayfly	*Stenonema ithica*
Coastal plain apamea	*Apamea mixta*
Willow peasant	*Brachylomia algens*
Sedge wren	*Cistothorus platensis*
State Special Interest	
Canada warbler	*Wilsonia canadensis*
Little blue heron	*Egretta caerula*
Magnolia warbler	*Dendroica magnolia*
Northern waterthrush	*Seiurus noveboracensis*
Winter wren	*Troglodytes troglodytes*
Back-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Mourning warbler	*Oporornis philadelphia*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta canadensis*
Golden-crowned kinglet	*Regulus satrapa*
Blackburnian warbler	*Dendroica fusca*
Blue grosbeak	*Guiraca caerulea*
Common snipe	*Gallinago gallinago*
American wigeon	*Anas americana*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Redhead duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*

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

1.3.8 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility. Cultural and archeological resources have been identified at the facility during past surveys. The Group 8 MRS has not been previously surveyed for cultural or archaeological resources; however,

due to the disturbed nature of the ground from former activities, it is unlikely that cultural/archaeological resources exist at the MRS.

1.3.9 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/mile. The bedrock is overlain by unconsolidated glacial deposits of varying thickness.

Bedrock is overlain by deposits of Wisconsin-aged Lavery Till and Hiram Till in the western and eastern portions of the facility, respectively. The thickness of the glacial deposits varies throughout the 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. 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 bgs, the Mississippian Cuyahoga Group is present throughout most of the facility. In the northeastern corner of the facility, the Meadville Shale Member of the Cuyahoga Group is present close to the surface. The Meadville Shale Member of the Cuyahoga Group is blue-gray silty shale characterized by alternating thin beds of sandstone and siltstone.

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

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

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

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

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

Group 8 MRS Geology and Soil

The Group 8 MRS is located over the Sharon Member conglomerate unit. The bedrock elevation is approximately 975 feet amsl. **Figure 1-4** illustrates the bedrock formations beneath the Group 8 MRS.

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. The major soil types found in the Group 8 MRS are silt or clay loams, ranging in permeability from 6.0×10^{-7} to 1.4×10^{-3} centimeters per second (U.S. Department of Agriculture et al., 1978). The soil type at the Group 8 MRS is the Mahoning-Urban land complex with undulating 2 to 6 percent slopes (AMEC, 2008). **Figure 1-5** illustrates the soil types at the Group 8 MRS.

1.4 Facility History and Background

During operations as a former ammunition plant, the RVAAP was a government-owned and contractor-operated industrial facility. Industrial operations at the RVAAP consisted of 12 munitions assembly facilities, referred to as “load lines.” Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene (TNT) and Composition B into large caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that

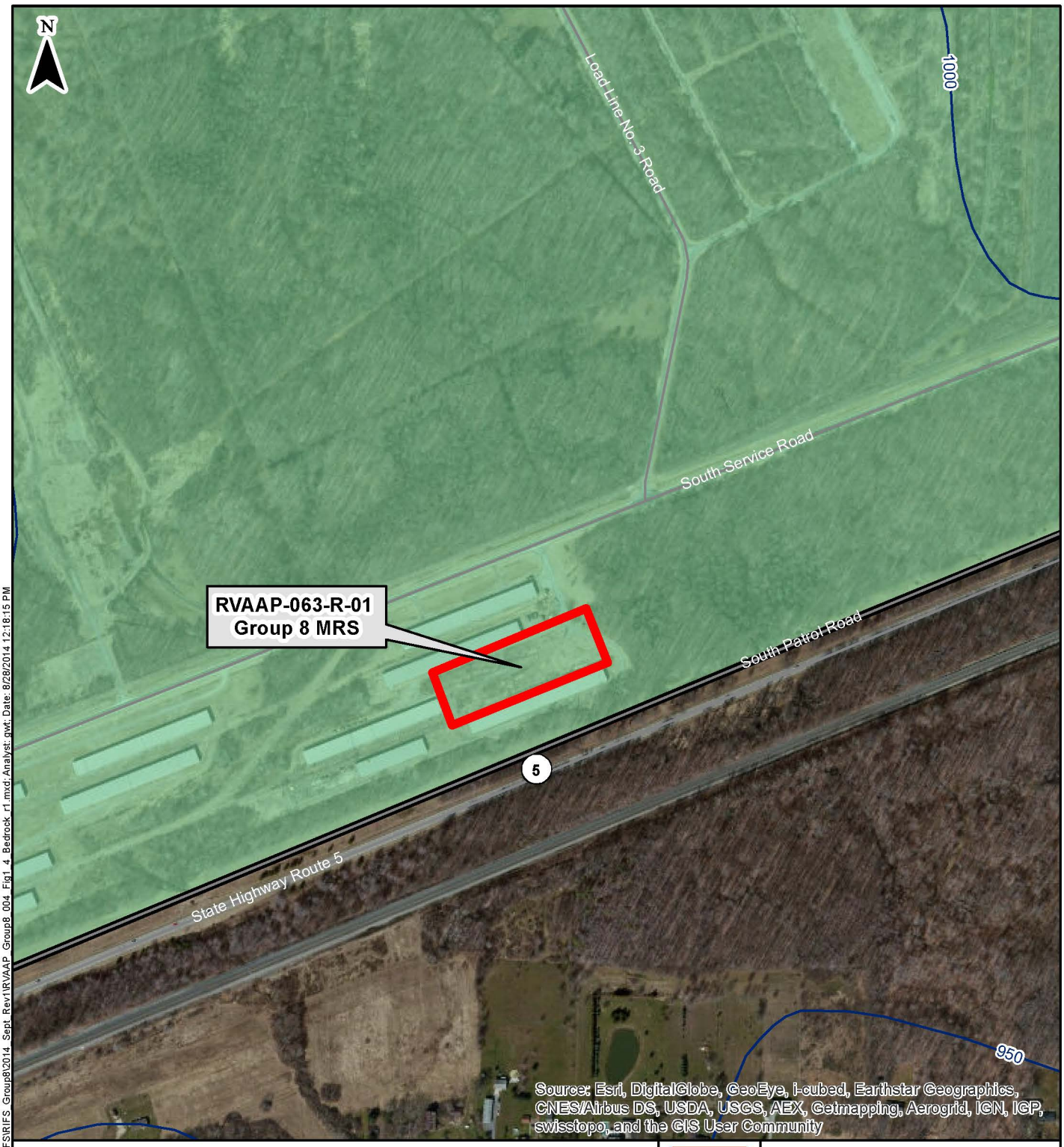

FIGURE 1-4 BEDROCK MAP

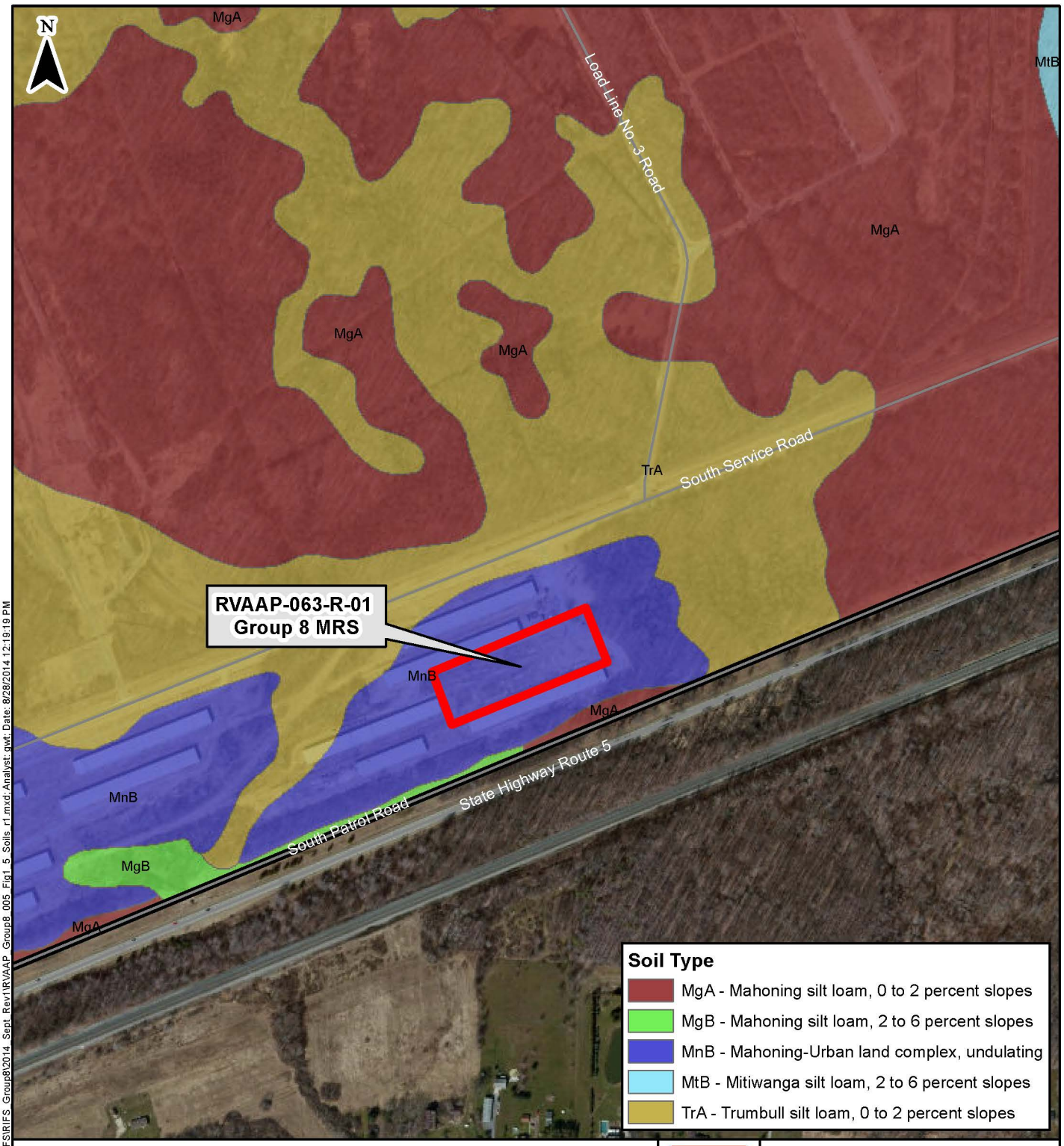

FIGURE 1-5 SOILS MAP

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 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 consisted of large parcels of open space or abandoned quarries. Other areas of concern (AOCs) present at facility include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities (Science Applications International Corporation, Inc. [SAIC], 2011).

Group 8 MRS History and Background

The Group 8 MRS is a 2.65-acre MRS located between Buildings 846 and 849, which was used for an undetermined amount of time to burn construction debris and rubbish. Although it has not been documented, previous discoveries of MEC and MD indicate that the area may have also received various munitions items, including M397 series 40mm HE grenades, M49 series 60mm mortars, M72 series 75mm projectiles, M557 series fuzes, 175mm projectiles, HE anti-tank warheads, and assorted fuzes, which may have been burned at the MRS. The area was used as a staging area for military vehicles until it was designated as a MRS. The OHARNG still utilizes the road network within the MRS to access adjacent buildings. The MRS is currently vacant, grassy land with no improvements.

In 1996, one antipersonnel fragmentation bomb with HE was found at the MRS by OHARNG personnel. The antipersonnel fragmentation bomb was detonated at Open Demolition Area #2 by an ordnance company that had been dispatched from Wright-Patterson Air Force Base. In addition, MD consisting of one demilitarized (i.e., cut in half) 175mm projectile was found on the ground surface at the MRS. The MD item was removed

and taken to Building 1501 (e^2M, 2008). The MRS layout and primary features are presented in **Figure 1-6**.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions as it pertains to the Group 8 MRS. This information was obtained primarily from the *Final Historical Records Review* (HRR) (e^2M, 2007) and the SI Report (e^2M, 2008).

1.5.1 2004 USACE Final 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. The *Final Archives Search Report* (ASR) was prepared by the USACE in 2004 and identified 12 AOCs as well as 4 additional locations with the potential for MEC. Based on the ASR, Ramsdell Quarry Landfill, Erie Burning Grounds, Open Demolition Area #1, Load Line 12 and Dilution/Settling Pond, Building 1200 and Dilution/Settling Pond, Quarry Landfill/Former Fuze and Booster Burning Pits, 40mm Firing Range, Building 1037—Laundry Waste Water Sump, Anchor Test Area, Atlas Scrap Yard, Block D Igloo, and Tracer Burning Furnace were identified as potential MRSs containing MEC. Confirmed MEC was identified at Open Demolition Area #2, Landfill North of Winklepeck, Load Line #1 and Dilution/Settling Pond, and Load Line 3 and Dilution/Settling Pond (USACE, 2004). The Group 8 MRS was not identified as one of the original sites that contained MEC as part of the 2004 ASR.

1.5.2 2007 e^2M Final Historical Records Review

The HRR was completed by e^2M 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 MRSs identified at the facility, to supplement the U.S. Army Closed, Transferring, and Transferred Range/Site Inventory, and to support the technical project planning process designed to facilitate decisions on those areas where more information was needed to determine the next step(s) in the CERCLA process.

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

Facility Boundary
Group 8 MRS Boundary
Planning Level Wetland Area
Standing Water Area
Utility Pole

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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H:\MAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS Group8\2014 Sept Rev1\RVAAP Group8 006 Fig1 6 MRS Features r1.mxd: Analyst: gwt: Date: 8/28/2014 12:20:27 PM

FIGURE 1-6 MRS FEATURES MAP

- 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 MRSs at the RVAAP to 17.

The HRR identified the Group 8 MRS as the 2.65-acre "Area Between Buildings 846 and 849" and also documented the requested name change to the Group 8 MRS. At the time the records research was being performed for the HRR, the area was being used by the OHARNG as a vehicle staging area. Historical activities at the MRS included the burning of construction debris and rubbish. The time frame for these activities is not known. In 1996, MEC in the form of a single antipersonnel fragmentation bomb with HE and MD in the form of a demilitarized (i.e. cut in half) 175mm projectile was found at the MRS. The

antipersonnel fragmentation bomb with HE was removed and detonated at Open Demolition Area #2. The 175mm projectile was also removed from the MRS and was taken to Building 1501.

1.5.3 2008 e^{2}M Final Site Inspection Report

In 2007, e^{2}M conducted an SI at each the 17 MRSs under the MMRP. The primary objectives of the SI activities were to collect the appropriate amount of information to support recommendations of "no further action, immediate response, or further characterization" concerning the presence of MEC and/or MC at each of the MRSs. The SI also included a review of the HRR for each of the applicable MRSs. Out of the 17 MRSs evaluated during the SI, 14 were further recommended for additional characterization under the MMRP that included the Group 8 MRS (RVAAP-063-R-01). A summary of the SI Report (e^{2}M, 2008) recommendations for the Group 8 MRS are presented in **Table 1-4** and are discussed below.

Table 1-4
Site Inspection Report Recommendation

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
Group 8 MRS (RVAAP-063-R-01)	4	Further characterization of MEC and MC	The presence of potential MEC was identified during the SI.	MC was found in concentrations exceeding screening levels.

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

The Group 8 MRS was assigned a Munitions Response Site Prioritization Protocol (MRSPP) priority of 4. The MRSPP is a funding mechanism typically performed during the preliminary assessment/SI stage to prioritize funding for MRSs on a priority scale of 1 to 8 with a Priority 1 being the highest relative priority. Based on the MRSPP priority identified for the MRS in the SI Report (e^{2}M, 2008), the Group 8 MRS was selected for inclusion for "further characterization" under the MMRP. The following summarizes the investigation activities performed at the Group 8 MRS during the 2007 SI and the conclusions and recommendations for the MRS as identified in the SI Report (e^{2}M, 2008).

During the SI field activities, magnetometer and metal detector assisted MEC surveys were completed over 100 percent of the MRS. Two unidentifiable T-bar fuzes were found partially buried in the southwest portion of the MRS and were determined to be MPPEH. MD items

identified during the SI field activities included metal fragments from casings and projectiles, burster tubes, and fragments of fuzes. The majority of the MD items found had most likely been pressed into the surface soils by the heavy equipment and vehicles that had been stored at the MRS prior to the SI. In addition to the MPPEH and MD a significant amount of nonmunitions related debris consisting of metal trash, fence materials, and wood scraps were found in the general areas where the MPPEH and MD were found. No MPPEH or other debris was identified on the ground surface at the northeast portion of the MRS during the SI field activities.

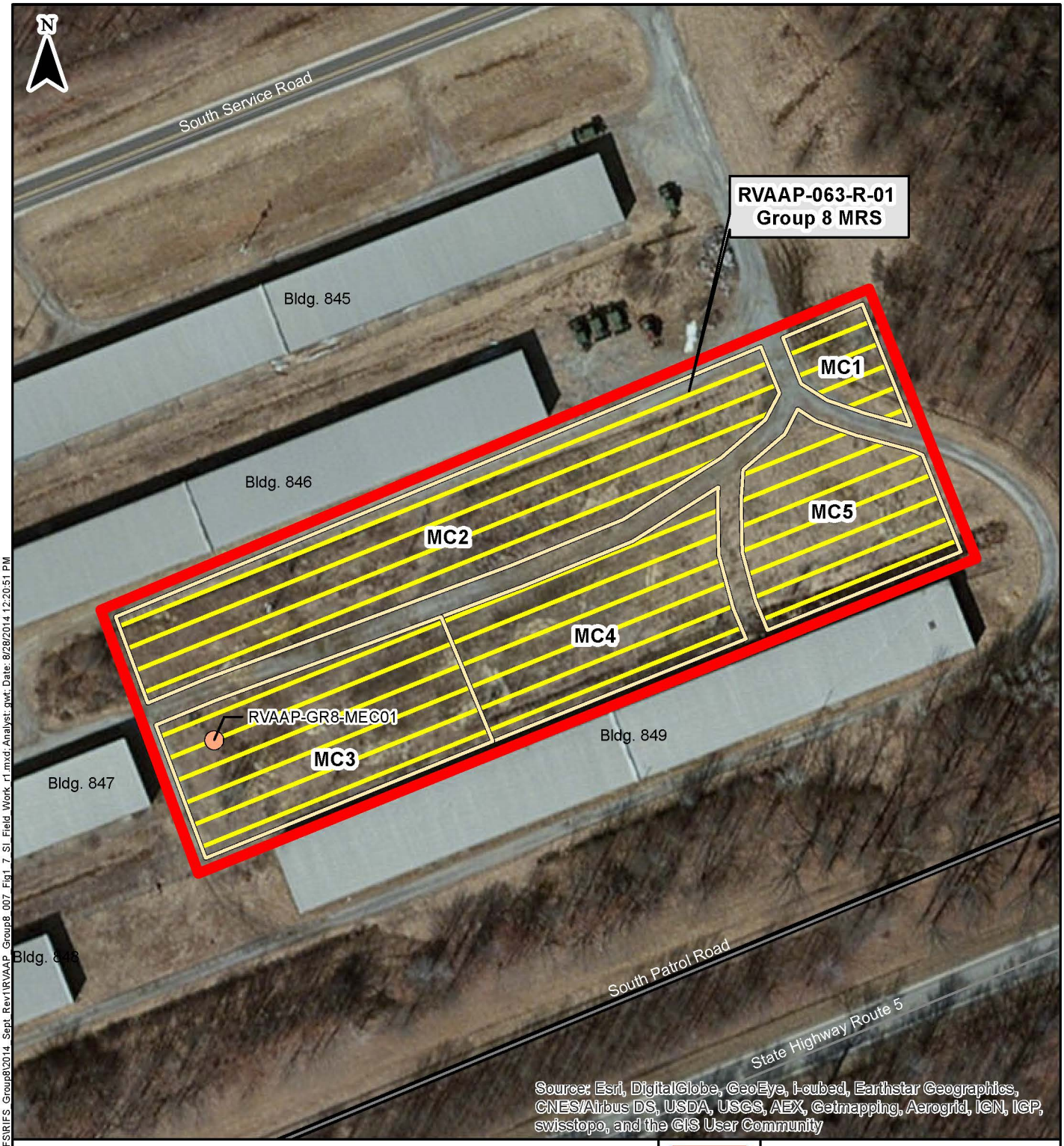
Five ISM surface soil samples were collected at the MRS during the SI field activities and were analyzed for explosives, propellants, and target analyte list metals. Lead and thallium were detected in all five samples above the facility screening criteria for background values and the U.S. Environmental Protection (EPA) residential soil Preliminary Remediation Goals (PRGs). Thallium was dismissed as an MC as it was nonmunitions related. Antimony, arsenic, aluminum, cadmium, copper, iron, lead, and manganese were detected in at least one sample at concentrations greater than the facility screening criteria and were considered as MC. Explosives and propellants were also detected; however no exceedances of above the PRGs were identified. **Figure 1-7** provides a summary of the investigation activities conducted at the Group 8 MRS during the SI field activities.

Based on the finding of the SI field work, both MEC and MC were identified as concerns at the MRS. The SI Report recommended that the 2.65 acre MRS footprint remain the same and that further characterization was necessary to address the MEC and MC concerns (e^2M, 2008).

1.6 RI Report Organization

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

- **Section 1.0**—Introduction
- **Section 2.0**—Project Objectives
- **Section 3.0**—Characterization of MEC and MC
- **Section 4.0**—Remedial Investigation Results
- **Section 5.0**—Fate and Transport
- **Section 6.0**—MEC Hazard Assessment
- **Section 7.0**—Human Health Risk Assessment



Facility Boundary
Group 8 MRS Boundary
Multi-incremental Sample Area
Line Abreast Survey Area
Suspect MEC Location

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
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Canton, MA 02021

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FIGURE 1-7 SI FIELD WORK AND FINDINGS

- **Section 8.0**—Ecological Risk Assessment
- **Section 9.0**—Revised Conceptual Site Models
- **Section 10.0**—Summary and Conclusions
- **Section 11.0**—References

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

- **Appendix A**—Digital Geophysical Mapping Report
- **Appendix B**—Field Documentation
- **Appendix C**—Data Validation Report
- **Appendix D**—Laboratory Data Reports
- **Appendix E**—Investigation-Derived Waste Management
- **Appendix F**—Photograph Documentation Log
- **Appendix G**—Intrusive Investigation Results
- **Appendix H**—Statistical Analysis of Intrusive Findings
- **Appendix I**—Waste Shipment and Disposal Records for Munitions Debris
- **Appendix J**—MEC Hazard Assessment Workbook
- **Appendix K**—Ecological Screening Values
- **Appendix L**—SLERA Risk Characterization Worksheets
- **Appendix M**—Munitions Response Site Prioritization Protocol Worksheets
- **Appendix N**—Responses to Ohio EPA Comments
- **Appendix O**—Ohio EPA Approval Letter

2.0 PROJECT OBJECTIVES

This chapter presents the preliminary conceptual site models (CSMs) for MEC and MC at the Group 8 MRS based on historical information, identified data gaps associated with the preliminary CSMs, and 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 MPPEH or ordnance is situated or is expected to be found. An MC source is a location where MC has entered the environment.
- **Activity—**The hazard from MEC and/or MC arises from direct contact as a result of some human or ecological activity. Interactions associated with activities describe ways that receptors come into contact with a source. For MEC, movement is not typically significant, and interaction will occur only at the source area as described above, limited by access and activity. However, there can be some movement of MEC through natural processes such as frost heave, erosion, and stream conveyance. For MC, this can include physical transportation of the contaminant and transfer from one medium to another through various processes such that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. Ecological exposure can include coming into contact with MEC or MC lying on the ground surface or through disturbing buried MEC/MC while digging or performing other activities, such as burrowing.
- **Access—**Access is the ease with which a receptor can come into contact with a source. The presence of access controls helps determine whether an exposure pathway to a receptor is complete, as fences or natural barriers can limit human access to a source area. Furthermore, the depth of MEC items in subsurface soils and associated MC may also limit access by a receptor. Ease of entry for adjacent populations (i.e., lack of fencing) can facilitate trespassing at the MRS, either intentional or accidental.

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

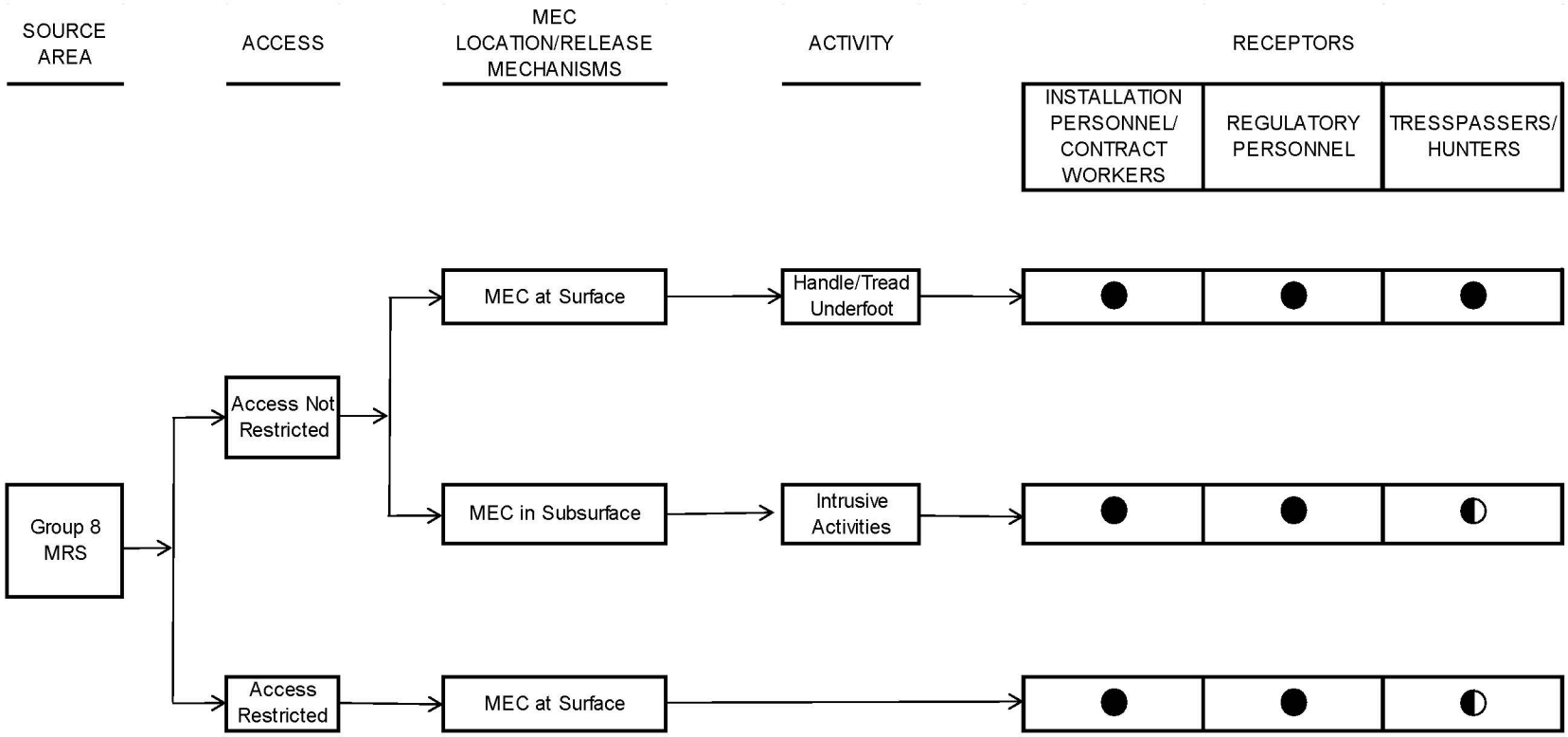
A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in some activity that results in contact with the source. A pathway is considered potentially complete when a source has not been confirmed but is suspected to exist and when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

In general, the CSM for each MRS is intended to assist in planning, interpreting data, and communicating MRS-specific information. The CSMs are used as a planning tool to integrate information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to evolve through an iterative process of further data collection or action. A discussion of the preliminary CSMs identified for the Group 8 MRS, as presented in the SI Report (e^2M, 2008), is presented in the following section. The data collected during the RI are evaluated in the following chapters and are incorporated into this model as discussed in Section 9.0, "Revised Conceptual Site Models."

2.1 Preliminary CSM and Project Approach

The preliminary CSMs for the Group 8 MRS are based on site-specific data and general historical information including literature reviews, maps, training and technical manuals, and field observations. The preliminary MEC and MC CSMs were originally developed during the SI process based on guidance from USACE Engineer Manual (EM) 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects* (USACE, 2003a). The preliminary MEC and MC CSMs are represented by the diagrams provided as **Figure 2-1** and **Figure 2-2**, respectively. A summary of each of the factors evaluated for the preliminary MEC and MC CSMs is discussed below:

- **Sources—**Munitions-related burning was considered to be the primary source of MPPEH at the Group 8 MRS. Based on a review of the archival records and available documentation, the principle source areas at the Group 8 MRS have not been identified; however, potential burning of munitions followed by compaction



Complete Pathway
Potentially Complete Pathway
Incomplete Pathway

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

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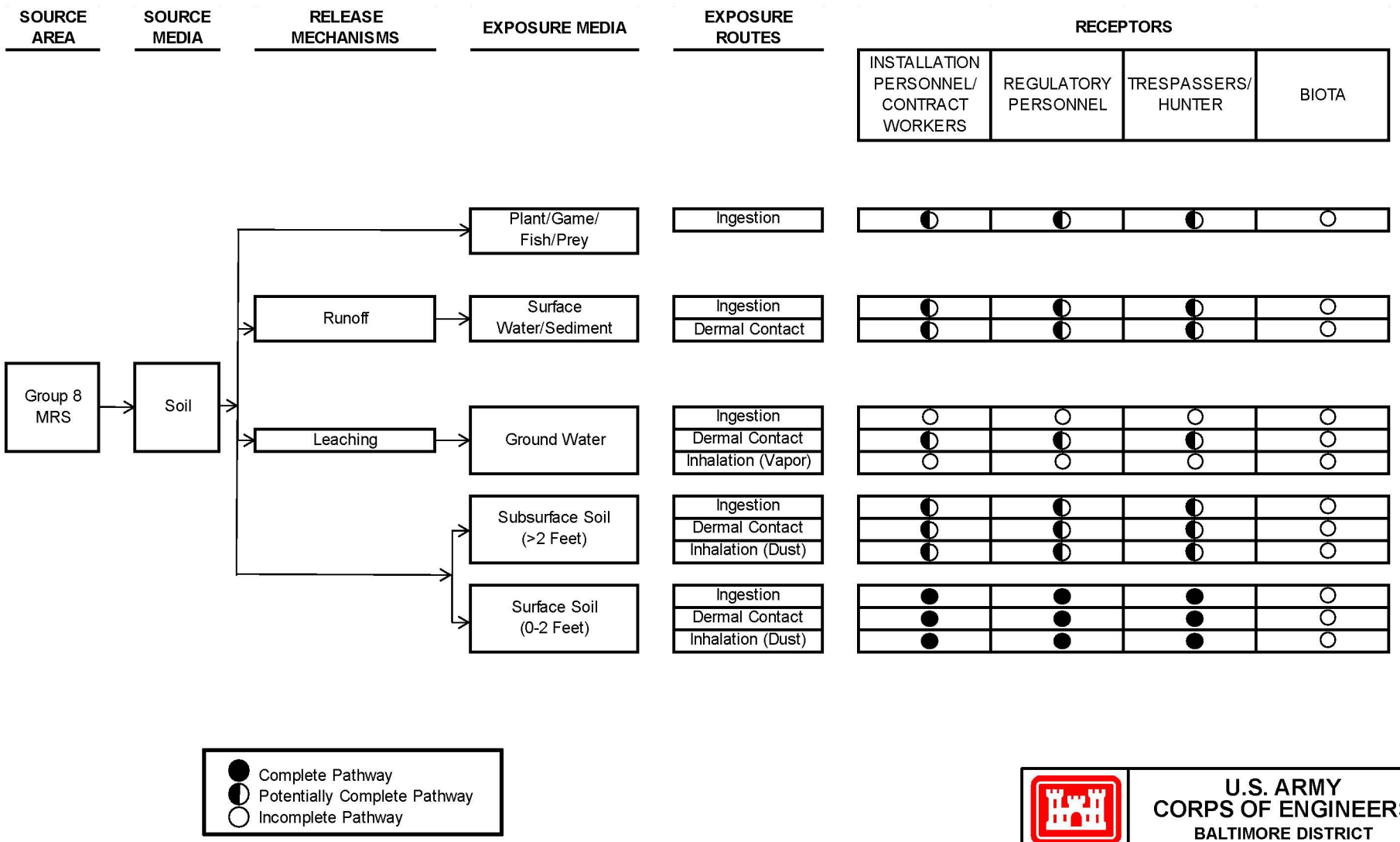
FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL



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

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FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL

of soils, as a result of vehicles moving through the MRS, resulted in the potential for MPPEH to be present in the surface and subsurface soil at the Group 8 MRS. The source of MC at the MRS also includes the potential residual contamination in soils as a result of the burning activities on the ground surface.

- **Activity—**Human activities considered for the preliminary CSM include maintenance of the grounds and security checks that were being performed on an infrequent basis.
- **Access—**Access to the MRS is unrestricted and military vehicles and the identified receptors may drive or walk through/over the MRS to gain access to adjacent storage buildings.
- **Receptors—**At the time of the SI, current and reasonably anticipated receptors included facility personnel, contractors, regulatory personnel, hunters, and trespassers. The SI considered biota to be state-listed species identified as being present at the facility. If present, MEC and associated MC on the ground surface and near the surface could have been accessed by receptors.

MPPEH determined as hazardous (i.e., MEC) was observed lying on the ground surface and partially buried at the MRS during the SI field activities. Human exposure pathways were identified as contact with MEC lying on the ground surface and disturbance of shallow subsurface soil. For buried MEC, transport and migration was not considered likely to occur, unless disturbed. MEC lying on the ground surface was considered able to be transported by erosion, surface water flow, and by frost heave. Therefore, the SI Report identified the complete MEC human exposure pathways as handle or tread under foot and disturbance of shallow surface soil (i.e., 0–0.5 feet bgs). The preliminary CSM for MEC at the Group 8 MRS, as presented in the SI Report (e^2M, 2008), is shown in **Figure 2-1**.

During preparation of the SI Report, the surface soil exposure depths for all receptors were defined as 0 to 2 feet bgs and subsurface soil was defined as depths greater than 2 feet. The SI Report predates the *Final Facility-Wide Human Health Cleanup Goals for the RVAAP* (facility-wide cleanup goal [FWCUG] guidance) (SAIC, 2010) and does not reflect the exposure depths for the current and future land use receptors, which are defined in later sections of this RI Report. MC consisting of metals (antimony, aluminum, arsenic, cadmium, copper, iron, lead, and manganese) was found to be present at the MRS following the SI field work. Complete pathways were considered to be present for surface soil and potentially complete pathways were considered as present for subsurface soil. The SI Report identified the exposure pathways as dermal contact, ingestion, and inhalation of contaminated soil. Potential transport was considered possible via surface water, erosion of soils, and through a release to groundwater and surface water. The exposure pathways for biota were considered

as incomplete since no federally listed species or critical habitats were present at the facility at the time of the SI field activities. The preliminary CSM for MC at the Group 8 MRS, as presented in the SI Report (e^2M, 2008), is shown in **Figure 2-2**.

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

Applicable or relevant and appropriate requirements (ARARs) and "to be considered" (TBC) guidance for future anticipated and reasonable remedial actions at the facility under the MMRP are currently under development. Once ARARs and/or TBC materials have been identified, PRGs, and remedial action objectives will be developed. The identified ARARs, TBC, PRGs, and remedial action objectives 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, 2011). The data needs included characterization for MEC and/or MC associated with the former activities or incidents at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and the inference of valid assumptions from the data.

2.3.1 Data Quality Objectives

The DQOs were developed for MEC and MC in accordance with the *Facility-Wide Sampling and Analysis Plan for Environmental Investigations at the RVAAP* (FWSAP) (SAIC, 2011) 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 Group 8 MRS as presented in the Work Plan Addendum (Shaw, 2011).

Table 2-1
Data Quality Objectives Process for the Group 8 MRS

Step	Data Quality Objective
1. State the problem.	The Group 8 MRS was used to burn construction debris and rubbish. In 1996, one antipersonnel fragmentation bomb with high explosives verified as MEC and one 175 millimeter projectile considered as MD was observed at the MRS by OHARNG personnel. During the SI, two MEC items (partially buried fuzes) were identified in addition to numerous MD items found throughout the MRS. Therefore, there is a potential for MEC associated with potential burning activities on the ground surface and subsurface. In addition, there is a potential for environmental impacts from MC at the MRS.

Step	Data Quality Objective
2. Identify the decision.	The goal of the investigation at the Group 8 MRS is to identify areas that may potentially contain MEC. In addition, MC sampling will be performed in order to further characterize the type and amount of contamination associated with activities at the MRS. The information obtained during the RI will be used to assess the potential risks and hazards posed to human health and the environment.
3. Identify inputs to the decision.	• Historical information • DGM survey • Intrusive inspection • Incremental environmental media sampling
4. Define the study boundaries.	The RI investigation will be performed in the Group 8 MRS boundaries as defined at the conclusion of the SI Report (e^2M, 2008).
5. Develop a decision rule.	Although no formal visual survey transects are planned at the MRS, the presence of surface MPPEH will be investigated during the DGM survey. 100 percent DGM coverage will be performed in all accessible areas within the MRS boundaries. Since full coverage is proposed at the Group 8 MRS, the number of anomalies investigated will be based on a prioritized ranking system and statistical sampling. The SI recommended additional MC sampling at the Group 8 MRS based on previous surface soil results above screening criteria. Currently, a total of four ISM surface soil samples are proposed at the MRS. Additional soil samples may be collected based on the results of the DGM field activities and target anomaly investigation if MEC/MD is identified. The final location and number of samples will be proposed at the conclusion of the MEC investigation. Collected samples will be analyzed for aluminum, antimony, barium, cadmium, total and hexavalent chromium, copper, iron, lead, strontium, mercury, and zinc; explosives; and semivolatile organic compounds, nitrocellulose, total organic carbon, and pH. The samples will also be analyzed for geochemical metal parameters (calcium, magnesium, and manganese).
6. Specify limits of decision errors.	Quality control procedures are in place so that all field work will be performed in accordance with all applicable standards. Further details on the QC process implemented during the RI are located in Section 4.0 of the Work Plan Addendum (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Group 8 MRS will be used to determine what potential risks or hazards, if any, are present at the MRS. CB&I will perform a MEC HA to identify the potential MEC hazards. In addition, MRS site-specific human health and ecological risk assessments will be performed on the analytical results. If unacceptable potential risks or hazards to human health and the environment are determined to exist at the MRS at the conclusion of the investigation, then the MRS will be identified for further evaluation under the CERCLA process.

CERCLA denotes Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

DGM denotes digital geophysical mapping.

HA denotes hazard assessment.

ISM denotes incremental sampling methodology.

MC denotes munitions constituents.

MD denotes munitions debris.

MEC denotes munitions and explosives of concern.

MPPEH denotes material potentially presenting an explosive hazard.

MRS denotes Munitions Response Site.

OHARNG denotes Ohio Army National Guard.

RI denotes remedial investigation.

SI denotes site inspection.

2.3.2 Data Needs

For MEC, data needs include determining the types, locations, condition, and number of MEC items present at the MRS so that the potential hazard to likely human and environmental 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 past experience with MRSs containing MEC. These data needs for MEC were evaluated using the most applicable methods and technologies, such as UXO Estimator® (USACE, 2003b), which are discussed in the following chapters.

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

2.4 Data Incorporated into the RI

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

- **Historical Records Review—**The HRR 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.
- **Installation Restoration Program Data—**Data collected under the Installation Restoration Program (IRP) at various MRSs includes analytes considered to be MC associated with previous activities at the MRS, although it should be noted that not all analytes are considered MC. No sampling has been conducted at the

Group 8 MRS under the IRP; therefore, evaluation for the inclusion of IRP data in the RI was not applicable.

- **Site Inspection Data—**The MMRP SI Report (e^2M, 2008) provides reconnaissance data identifying surface MEC and MD that will be used in conjunction with historical data to preliminarily delineate areas with munitions-related activity. MC sampling was conducted during the SI; however, incorporation of the data was not required because sufficient MC samples were collected during the RI field effort along with a more robust suite of analyses. The RI samples are considered representative of current conditions.

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3.0 CHARACTERIZATION OF MEC AND MC

This chapter documents the approaches used to investigate MEC and MC at the Group 8 MRS in accordance with the DQOs presented in Section 2.0, "Project Objectives." The MEC and MC characterization activities were conducted in accordance with Section 3.0, "Field Investigation Plan," of the Work Plan Addendum (Shaw, 2011).

3.1 MEC Characterization

The following section summarizes the geophysical investigation, anomaly reacquisition and subsequent intrusive investigation activities that were performed at the Group 8 MRS during the RI field activities. Based on the documented discoveries of MEC and MD, it was determined in the SI reporting stage that there is a potential for MEC on the ground surface and subsurface at the MRS. The initial step in evaluating for MEC at the Group 8 MRS was to remove from the surface nonmunitions debris consisting of scrap metal, fence materials, and wood scraps. These items were placed at a nearby location off of the MRS to minimize interference from surface metallic items during the digital geophysical mapping (DGM) survey. Visual surveys of surface conditions were performed in conjunction with the geophysical investigation. The results of the DGM survey and intrusive investigation activities are discussed in Section 4.0, "Remedial Investigation Results."

3.1.1 Geophysical Survey Activities

Between October 31, 2011, and November 14, 2011, CB&I performed a DGM investigation to identify potential subsurface areas of MEC at the Group 8 MRS. The approved sampling coverage presented in the Work Plan Addendum (Shaw, 2011) required full coverage DGM data to be collected over the accessible areas of the 2.65-acre MRS. The actual coverage obtained during the DGM survey is discussed and presented in Section 4.1.2, "Geophysical Survey Results." The *Digital Geophysical Mapping Report for the Group 8 MRS (RVAAP-063-R-01)* (DGM Report) is presented in **Appendix A** and provides a comprehensive review of the DGM survey at the MRS with regards to data acquisition, processing and analysis, anomaly reacquire, and results of the DGM quality control (QC) program.

Geophysical instruments used for the DGM survey consisted of an EM61-MK2 time domain electromagnetic instrument and a Leica TPS1200 series robotic total station (RTS) for positioning. The DGM platform consisted of a modified standard wheeled configuration with the lower coil 16 inches above the ground surface. The field team that performed the DGM survey consisted of a geophysicist and an unexploded ordnance (UXO)-qualified assistant.

The DGM system used for the Group 8 MRS investigation and other MRSs at the facility was initially validated during the start-up phase of the project at an instrument verification

strip (IVS) located near Load Line 7. The results of the initial IVS effort are documented in the *Instrument Verification Strip Technical Memorandum in Support of Digital Geophysical Mapping Activities for Military Munitions Response Program Remedial Investigation Environmental Services*, which is included in the DGM Report (**Appendix A**). A localized IVS at the Group 8 MRS was used to ensure the functionality of the DGM system on a daily basis during DGM activities at the MRS.

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

3.1.1.1 Survey Controls

A Registered Ohio Land Surveyor established three survey monuments at the Group 8 MRS. Each monument was established with third order horizontal accuracy (residual error less than or equal to 1 part in 10,000). In areas where data could be acquired using the RTS, the survey monuments were used to provide positional data streamed directly to the EM61-MK2. All of the survey data documenting the MRS features and obstructions is referenced to the three 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, 2011), static measurements for the positioning system were required not to exceed 0.5 feet. The RTS system provides centimeter-level accuracy, and 100 percent of location checks satisfied the metric. All mapping was developed in the North American Datum 1983 Universal Transverse Mercator Zone 17 North Coordinate System.

3.1.1.2 Vegetation Clearance and Inaccessible Areas

The Group 8 MRS is an open area and lacks significant vegetative growth. With the exception of sparse grass and shrub groundcover, no vegetation removal was required along transects in order to provide adequate ground clearance for the DGM equipment. Inaccessible areas for the DGM equipment included a small stand of trees and barbed wire fence at the southwest corner of the MRS, utility poles that are spaced approximately 100 feet apart along the northern boundary of the MRS, and lengths of barbed wire fence near the northern MRS boundary. In all, a total of 0.087 acres (or 3.2 percent) of the 2.65-acre MRS were considered inaccessible.

3.1.1.3 Data Collection

Full coverage DGM data were acquired over all accessible areas of the MRS on lines spaced at approximately 2.5-foot intervals, which resulted in a spatial coverage of nearly 97 percent of the 2.65-acre MRS. Within the areas accessible to DGM, 99 percent of the data were

acquired at a line spacing of less than 3.5 feet, which meets the metric specified in the Work Plan Addendum (Shaw, 2011). One-dimensional transect survey methodology was employed to collect uniform geophysical data. Along each data acquisition line, positioning system data were recorded at a minimum rate of 1 hertz, and the EM61-MK2 measurements were recorded at a rate of 15 hertz, which translates into a measurement sample density along the ground surface of approximately 0.5 feet. The EM61-MK2 and position data were digitally recorded using the EM61-MK2 software on a Juniper Allegro CX data logger. The general DGM procedures performed for data acquisition at the Group 8 MRS consisted of the following:

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

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

3.1.1.4 Data Processing and Interpretation

The geophysical data were processed, analyzed, and interpreted using the methods and approach outlined in the Work Plan Addendum (Shaw, 2011). An 8-millivolt (mV) threshold for Channel 2 of the EM61-MK2 was used to initially select the anomalies for potential investigation. From previous experience at the RVAAP, locations which have signal strength (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 included the following:

- Data acquisition methodology (full coverage as is the case for Group 8 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

Based on the responses, the anomaly locations were evaluated to determine if they were high-density anomalous areas that required excavation using mechanical equipment or were individual target anomalies that could be manually investigated (hand dug). Detailed processing and interpretation procedures are provided in the DGM Report in **Appendix A**.

3.1.1.5 Geophysical Field Quality Control Procedures

The geophysical field QC procedures consisted of tests performed at the start and end of each day along with the MRS specific IVS to ensure the geophysical sensor and positioning equipment were functioning properly and the data was of sufficient quantity and quality to meet the performance metrics defined in the Work Plan Addendum (Shaw, 2011). The performance metrics proposed for the EM61-MK2 sensor was derived from a combination of DID MMRP-09-004, *Geophysics* (USACE, 2009a) and the USACE Table, "*Performance Requirements for RI/FS using DGM Methods*" (U.S. Army, 2009). Quality objectives and metrics associated with MRS coverage, signal quality during data acquisition, anomaly reacquire, and the intrusive investigation were also developed from the referenced documents. The DGM field team and the data processor/analyst reviewed and documented the results of the DGM QC program on a Microsoft© Excel spreadsheet that was updated on

a daily basis and delivered to the client for approval. The Microsoft© Excel spreadsheet is part of the geophysics digital data deliverable in the DGM Report (**Appendix A).**

3.1.2 Anomaly Investigation Activities

This section presents a discussion of the target dig list development and the intrusive investigation procedures performed for the evaluation of MEC at the MRS. Following the completion of the DGM survey in November 2011, anomaly selection, reacquisition, and an intrusive investigation was conducted to assess the potential for buried MEC at the Group 8 MRS. Based on the results of the DGM survey, the locations were evaluated to determine if they were high-density anomalous areas that required excavation using mechanical equipment or were individual target anomalies that could be manually investigated (hand dug). All anomaly investigation activities were conducted by UXO-qualified personnel, which 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, 2011). The results of the DGM survey and proposed intrusive investigation locations were submitted to the USACE and Ohio Environmental Protection Agency (Ohio EPA) for review and approval in the *DGM Survey Results and Proposed Dig Locations for the Group 8 MRS (RVAAP-063-R-01)* technical memorandum included as an attachment to the DGM Report in **Appendix A**.

3.1.2.1 Selection of High-Density Anomaly Areas for Intrusive Investigation

Evaluation of the data collected during the DGM survey identified 2,690 anomalies that had signal strength greater than or equal to 8 mV (Channel 2). Three areas were considered to have localized high anomaly densities, which accounted for 1,049 of the 2,690 anomalies. Outside of these high density areas, there were a total of 1,641 anomalies identified for potential investigation as individual target locations.

The data interpreter selected 11 locations for trenches as the primary investigative technique within the three areas with localized high anomaly densities. Three additional exploratory trenches were included, for a total of 14 trenches, based on Ohio EPA's review and comments of the initial target list presented in the technical memorandum. Once the proposed trench locations were approved by the USACE and the Ohio EPA, they were transferred to a dig sheet and provided to CB&I'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 4.2.1, "Trench Investigations."

3.1.2.2 Target List Development for Individual Anomalies

To determine the number of individual target anomalies to sample in order to characterize the nature and extent of MEC at the Group 8 MRS, the hypergeometric statistical method was

applied to the remaining 1,641 individual target anomalies. Use of such a statistical sampling method is in accordance with guidance provided in EM 1110-1-4009, *Military Munitions Response Actions* (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), 248 anomalies, representing nearly 15 percent of the total population of the 1,641 individual target anomalies (N), were selected and met the DQOs. An additional 24 individual anomaly target locations were added based on Ohio EPA's review and comments of the initial target list presented in the technical memorandum. This resulted in a total of 272 targets or 16.6 percent of the total population. The 272 locations were transferred to a dig sheet and provided to CB&I's Geographical Information System Department for inclusion in 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 4.2.4, "Statistical Analysis of Intrusive Results." The results of DGM investigation and the hypergeometric statics module calculation are discussed in Section 4.1.2.

3.1.2.3 Individual Anomaly Reacquisition and Investigation Procedures

The UXO-qualified personnel used a Schonstedt magnetometer to first reacquire and then investigate ferrous anomalies identified during the DGM survey as individual target 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. To locate the ground position of the interpreted anomaly coordinates, the navigational system "Waypoint Location" mode was used for the RTS positioning system. A nonmetallic pin flag, labeled with the unique anomaly identification, was placed in the ground at the interpreted location. Reacquisition of any sampling or dig sheet locations (i.e., interpreted location) was performed to ±0.5 feet of the coordinates specified on the dig sheet.

Once the item was determined not to be munitions related, it was temporarily removed from the excavation and the Schonstedt magnetometer was used to confirm no additional ferrous items were located beneath the first item. Nonmunitions-related items were replaced and the soil was returned to the investigation hole in reverse order from which it was excavated. All munitions related items (i.e., MEC/MD) were managed and disposed in accordance with the Work Plan Addendum (Shaw, 2011) and as discussed in Section 4.2.5, "Management and Disposal of Munitions Debris". The UXO-qualified personnel were also conscious of encountering any cultural artifacts associated with historical cultural or archeological resources.

3.1.2.4 High-Density Anomalous Area Reacquisition and Investigation Procedures

Locating the ground position for 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.

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. Once the item was determined not to be munitions related, 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 personnel visually examined it for MPPEH. Once confirmed that the source had been identified and no MPPEH was present, the soil was returned to the investigation trench in reverse order from which it was excavated. No soil was segregated for off-site disposal. Any munitions-related items found (i.e., MEC/MD) were to be managed and disposed in accordance with the Work Plan Addendum (Shaw, 2011) and as discussed in Section 4.2.5, "Management and Disposal of Munitions Debris."

3.1.2.5 Anomaly Investigation Documentation

All anomalies identified during the reacquisition and intrusive investigation activities were logged and recorded in accordance with DID MMRP-09-004, *Geophysics* (USACE, 2009a). 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 anomaly reacquisition and investigation results are further discussed in Section 4.2, "Intrusive Investigation Results."

3.1.2.6 Anomaly Field Quality Control Procedures

Ground-truth excavation data reported on anomaly-specific dig sheets was the primary basis for field QC. The dig sheets documented the item description; location; and approximate weight, shape, orientation, and depth. Dig sheets were reviewed by the field geophysicist on a daily basis to determine whether the excavation data were representative of the mV 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 following section summarizes the MC characterization activities and decision making process at the Group 8 MRS. The determination as to whether MC characterization was required at the MRS was made based on historical evidence and the results of the MEC investigation. In accordance with the Work Plan Addendum (Shaw, 2011), four ISM surface

soil samples were collected from sampling units of the same size for the entire MRS. Additional samples were proposed in areas with concentrated MEC/MD and three additional ISM soil samples were collected from the bottom of the trenches where concentrated buried MD was encountered at the MRS. All MC samples were collected in accordance with the *Final Sampling and Analysis Plan and Quality Assurance Project Plan Addendum* (SAP Addendum) included in Appendix A of the Work Plan Addendum (Shaw, 2011). The results of the MC sampling activities are presented in Section 4.4, "Nature and Extent of SRCs."

3.2.1 Sampling Approach

The ISM surface soil samples and ISM trench soil samples were collected at the Group 8 MRS to evaluate for the nature and extent of contamination associated with previous activities at the MRS and to determine whether or not there is unacceptable risk. For the purposes of this RI and the sampling approach discussion, surface soil is considered to be any soil samples collected between 0 to 1 foot bgs and subsurface soil is considered to be samples collected at depths greater than 1 foot bgs. These definitions of soil depths do not take into account the facility's definition of surface and subsurface soil for the receptors that are identified in the FWCUG guidance (SAIC, 2010). Discussion regarding the samples collected at depths in relation to the identified facility receptors is discussed in Section 7.0, "Human Health Risk Assessment."

The 2.65-acre MRS is considered the ISM decision unit for surface soil and was split into four predetermined sampling units (approximately 0.67 acres each). The ISM surface soil sampling units are considered areas of equally probably anticipated use by potential receptors to further evaluate the nature and extent of contamination associated with previous activities at the MRS. The MRS was split into equal size sampling units for the RI to provide a more representative comparison of various portions of the MRS than for the five variously sized sample units collected during the SI Report (e^2M, 2008).

The ISM was also used to collect soil samples at the bottoms of three trenches. The trenches were similar in area (40 to 156 square feet) and depth (48 inches), and were considered as separate sampling units. The sample units at the bottoms of the trenches make up the subsurface decision unit for the MRS. Discrete samples were originally proposed at concentrated areas of MEC and MD in the SAP Addendum (Shaw, 2011); however, the ISM approach was considered applicable for sampling the trenches due to the distribution of the buried MD. ISM samples are more suited for providing an estimate of the mean analyte concentration over a sampling unit than are discrete samples collected at individual locations.

The ISM samples collected during the SI were analyzed for limited analytes that included metal, explosives, and propellants. Further review of the OB activities that occurred at the MRS resulted in requiring additional MC analyses for the RI that included semivolatile

organic compounds (SVOCs) and polychlorinated biphenyls (PCBs) associated with waste oils and their potential byproducts that may have been used.

Table 3-1 summarizes the sample locations and types of samples collected for the RI and the rationale for the sample strategy.

Table 3-1
Summary and Rationale for Remedial Investigation Sample Collection

Medium	Sample Type	Sample Depth (feet bgs)	No. of Samples[1]	Rationale
Surface Soil	ISM	0–0.5	4	To characterize for potential MC released during OB activities on the ground surface at the MRS.
Subsurface Soil (Burial Trenches)	ISM	4.0–4.5	3	To characterize for potential MC beneath concentrated MD in burial trenches at the MRS.

[1] *denotes number of samples does not include duplicate or other quality control samples.*
bgs denotes below ground surface.
ISM denotes incremental sample methodology.
MC denotes munitions constituents.
MD denotes munitions debris.
MRS denotes Munitions Response Site.
OB denotes open burning.

The methods used for the collection of soil samples during the RI are summarized below. Detailed presentation of the procedures for sample collection is presented in the SAP Addendum (Shaw, 2011). The collection methodology for ISM is presented in the SAP Addendum and is based upon the procedures presented in the *Interim Guidance 09-02, Implementation of Incremental Sampling of Soil for the Military Munitions Response Program* (USACE, 2009b) and the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

3.2.1.1 Surface Soil Sample Collection

The ISM surface soil samples (GR8ss-001M-0001-SO, GR8ss-002M-0001-SO, GR8ss-003M-0001-SO, and GR8ss-004M-0001-SO) were collected on February 8, 2012. Each sample consisted of 30 increments collected at each of the four sampling units at sample depths of 0 to 0.5 feet (0 to 6 inches) bgs. The increments were collected in a systematic random pattern at each designated sampling unit. The four sampling units combined to make up the decision unit for surface soil.

The 0.5-foot (6-inch) bgs sample interval is considered appropriate in accordance with the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) and is the maximum depth that

MC released from the historical OB activities on the ground surface would be expected to vertically migrate. The entire length of the soil collected at each of the 0- to 0.5-foot increments within a sampling unit was used to make up each of the ISM samples.

The ISM surface soil samples were collected in accordance with the Work Plan Addendum (Shaw, 2011), and there were no deviations during the RI field activities. The combined proposed sampling units cover the entire MRS that is considered the decision unit.

The key steps for collection of a systematic ISM sample were: (1) subdivide the sampling unit into a uniform grid (i.e., pace out the area and divide into at least 30 grids for a 30-increment sample), (2) randomly select a single increment location in the first grid, and (3) collect increments from the same relative location within each of the other grids.

The sampling units were established by placing nonmetallic pin flags at the corners of each decision unit. The ISM samples were collected from the predetermined number of increment sample locations using a $^{7}/_{8}$-inch stainless steel step probe sample collection device. The increments of soil were placed into a plastic lined bucket and combined to make a single sample weighing between 1 to 2 kilograms.

The QC samples included a field duplicate sample and a matrix spike/matrix spike duplicate sample (MS/MSD). The collection of the QC samples required similar increments of soil as the original sample. Therefore, at the ISM sampling unit where a QC sample was required, an additional ISM sample was collected from within the same sampling unit consisting of at least 30 increments of soil. The increments for the field duplicate were collected at randomly selected locations different from the initial sample increments. The field duplicate was labeled with a different sample number (GR8SS-005M-0001-SO) and submitted to the laboratory for processing as a blind field duplicate. Due to sufficient soil volume, additional collection of soil for the MS/MSD was not required and a sample (GR8SS-004M-0001-SO) was designated as the MS/MSD on the chain of custody prior to shipment.

All data and observations at each sample location were recorded in a sampling field log, which is included in **Appendix B**. **Figure 3-1** presents the MC sample locations at the Group 8 MRS.

H:\MMRS\RavennaGIS Documents\Project Maps\MMRP\RIFS\RIFS Group8\2014 Sept Rev1\RVAAP Group8 012 Fig3 1 SoilSampleLocs r1.mxd;Analyst: gwt; Date: 8/28/2014 12:26:46 PM

Facility Boundary
Group 8 MRS Boundary
Surface ISM Soil Sample Location
Subsurface ISM Soil Sample Location (Burial Trenches)
Original Sample Path
Duplicate Sample Path

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 3-1 MC SAMPLE LOCATIONS

3.2.1.2 Trench Soil Sample Collection

The ISM trench soil samples (GR8ss-006M-0001-SO, GR8ss-007M-001-SO, and GR8ss-008M-0001-SO) were collected on February 8, 2012, from Trenches 13-1, 11-1, and 14-1, respectively. Each sample consisted of 30 increments collected from the bottom of each of the three trenches that were excavated to 4 feet bgs. Each of the trenches was considered as sampling units that were combined to make up the subsurface decision unit. The ISM increments were collected at sample depths of 0 to 0.5 feet (0 to 6 inches) at the bottoms of the trenches. The increments were collected in a systematic random pattern from each designated sampling unit. The sample depths were 4 to 4.5 feet bgs and, although the soil samples in the trenches were collected at the exposed surface at the bottoms of the trenches, the samples were evaluated as subsurface soil samples due to the sample depths at all three trenches being greater than 1 foot bgs.

The 0.5-foot (6-inch) bgs sample interval at the bottom of each trench is considered appropriate in accordance with the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) and is the distance that MC released from buried MEC or MD would be expected to vertically migrate. The entire length of the soil collected at each of the 0- to 0.5-foot increments within a sampling unit (i.e., each trench location) was used to make up each of the ISM samples.

The collection of ISM samples from beneath concentrated areas of MEC/MD is considered a deviation from the Work Plan Addendum (Shaw, 2011) since discrete sample were originally proposed; however, the ISM is considered the more applicable approach for providing an estimate of the mean analyte concentration over a sampling unit when possible. The procedures used to collect the ISM trench soil samples were conducted in accordance with the Work Plan Addendum (Shaw, 2011).

The ISM soil samples from the trenches were collected in the same manner as the surface soil ISM samples. The key steps for collection of a systematic ISM sample were: (1) subdivide the bottom of the trench into a uniform grid (i.e., measure out the area and divide into at least 30 grids for a 30-increment sample), (2) randomly select a single increment location in the first grid, and (3) collect increments from the same relative location within each of the other grids.

The ISM trench soil samples were collected from the predetermined number of increment sample locations using a $^{7}/_{8}$-inch stainless steel step probe sample collection device. The increments of soil were placed into a plastic lined bucket and combined to make a single sample weighing between 1 to 2 kilograms.

A QC field duplicate sample was also collected along with one of the original trench samples. Therefore, at the ISM sampling unit (i.e., trench bottom) where the field duplicate QC sample was required, an additional ISM sample was collected in a systematic random pattern consisting of 30 increments of soil. The increments were collected at randomly selected locations different from the initial sample increments. The field duplicate was labeled with a different sample number (GR8ss-009M-0001-SO) and submitted to the laboratory for processing as a blind field duplicate.

All data and observations at each sample location were recorded in sampling field logs, each of which are included in **Appendix B**. The ISM soil samples from the bottoms of trenches where MD was found are presented in **Figure 3-1**.

3.2.2 Sample Analysis

Analytical services for chemical samples were provided by CT Laboratories, Inc. (CT Laboratories) of Baraboo, Wisconsin, which is accredited through the DoD Environmental Laboratory Accreditation Program (ELAP) and the National Environmental Laboratory Accreditation Conference. The selection of chemical analyses for surface and subsurface soil at the Group 8 MRS was based on the types of munitions historically identified for the MRS, the potential MC association with those munitions, and the history of burning debris, rubbish, and potentially munitions items which may have utilized waste oils during the burning operations. To date, the munitions items identified at the Group 8 MRS include the antipersonnel fragmentation bomb with HE, the demilitarized 175mm projectile, and fuzes of unknown types that were considered as potential MEC; although, any munitions item used at the facility may be present at the MRS. Based on this information, the proposed analytical suites and methods were presented in the *MC Sampling Rationale* included in the SAP (Shaw, 2011) and included the following:

- Metals (aluminum, antimony, barium, cadmium, chromium [total and hexavalent], copper, iron, lead, mercury, strontium and zinc)—Method EPA SW846 6010C
- Explosives—Method EPA SW846 8330B
- Nitrocellulose—Method EPA SW846 9056 Modified
- SVOCs—Method EPA SW846 8270C
- PCBs—Method EPA SW846 8082B
- Total organic carbon (TOC)—Lloyd Kahn Method
- pH—Method EPA SW846 9045D

In addition to the above analyses, the surface soil and subsurface soil samples were also analyzed for geochemical parameters via EPA Method 6010C in order to potentially evaluate natural high metal concentrations and distinguish them from potential contamination. The geochemical parameters analyzed for the Group 8 MRS include calcium, magnesium, and manganese.

For the ISM surface soil, subsurface soil, and duplicate samples, each 1- to 2-kilogram sample was submitted to the contracted laboratory for processing and analysis. Processing consisted of drying out the sample and sieving the sample through a #10 sieve. Any material larger than the #10 sieve was discarded. The remaining air-dried, sieved material was then ground using a puck mill to reduce the particle size, as sampling splitting and particle size reduction are necessary to reduce fundamental error. The final reduced portions of the ISM field samples were analyzed for metals, explosives, nitrocellulose, SVOCs, and PCBs. The ISM field samples were analyzed for TOC and pH following processing of the sample and prior to grinding. A summary of the number and types of samples collected are presented in **Table 3-2**.

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

Location	Sample Name	Sample Type	Depth (feet bgs)	Analytical Parameters	No. Samples	Field Duplicate
Surface Soil						
Northwest Quadrant	GR8ss-001M-0001-SO	ISM	0–0.5	Metals[1], Geochemical Metals[2], Explosives, Nitrocellulose, SVOCs, PCBs, TOC, pH	1	
Northeast Quadrant	GR8ss-002M-0001-SO				1	
Southwest Quadrant	GR8ss-003M-0001-SO				1	
Southeast Quadrant	GR8ss-004M-0001-SO				1	1
Subsurface Soil (Burial Trenches)						
Trench 13-1	GR8ss-006M-0001-SO	ISM	4.0–4.5	Metals[1], Geochemical Metals[2], Explosives, Nitrocellulose, SVOCs, PCBs, TOC, pH	1	
Trench 11-1	GR8ss-007M-0001-SO				1	
Trench 14-1	GR8ss-008M-0001-SO				1	1

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

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

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

bgs denotes below ground surface.

ISM denotes incremental sampling methodology.

PCB denotes polychlorinated biphenyl.

SVOC denotes semivolatile organic compound.

TOC denotes total organic carbon.

VOC denotes volatile organic compound.

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

3.2.3 Laboratory Analysis

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

Strict adherence to the requirements set forth in the FWSAP (SAIC, 2011) and the SAP Addendum (Shaw, 2011) was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with DoD *Quality Systems Manual (QSM) for Environmental Laboratories* (DoD, 2010), EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007) or as specified in the FWSAP. SW-846 chemical analytical procedures were followed for the analyses of metals, explosives, nitrocellulose, SVOCs, PCBs, pH. TOC was performed using the Lloyd Kahn Method. The contracted

laboratory was required to comply with all methods as written; recommendations were considered requirements.

The QA/QC samples for this project included field blanks, laboratory method blanks, laboratory control samples (LCSs), laboratory duplicates, and MS/MSDs. An equipment rinsate blank was submitted for analysis along with the field duplicate samples to provide a means to assess the quality of the data resulting from the field sampling program. **Table 3-3** presents a summary of QA/QC samples utilized during the RI field activities for the Group 8 MRS.

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

Sample Type	Rationale
Field Duplicate	Analyzed to determine sample heterogeneity and sampling methodology reproducibility
Equipment Rinsate	Analyzed to assess the adequacy of the equipment decontamination processes for soil and groundwater
Laboratory Method Blanks	Analyzed to determine the accuracy and precision of the analytical method as implemented by the laboratory
Laboratory Duplicate Samples	Analyzed to assist in determining the analytical reproducibility and precision of the analysis for the samples of interest and provide information about the effect of the sample matrix on the measurement methodology
Matrix Spike/Matrix Spike Duplicate	

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

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

- Raw data produced by the analyst were turned over to the respective area supervisor.

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

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

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

3.2.4 Data Validation

Following receipt of the analytical data packages, CB&I performed data validation on all surface and subsurface soil samples collected from Group 8 MRS (including field duplicates and QC samples) to ensure that the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary dataset and a comparison of primary sample and field duplicate sample. This validation also attempted to minimize the potential of using false-positive or false-negative results in the decision-making process (i.e., to ensure accurate identification of detected versus nondetected compounds). This approach was consistent with the DQOs for the project and with the analytical methods, and was appropriate for determining contaminants of concern and calculating risk.

Analytical results were reported by the laboratory in electronic format and were issued to CB&I on compact disc. Data validation was performed to ensure all requested data were received and complete. Data were validated in accordance with specifications outlined in the SAP Addendum (Shaw, 2011), FWSAP (SAIC, 2011), and the *QSM Version 4.2* (DoD, 2010). Data use qualifiers were assigned to each result based on laboratory QA review and verification criteria. Results were qualified as follows:

- "U"—Analyte was not detected or reported less than the level of detection.
- "UJ"—Not detected. The detection limits and quantitation limits are approximate.
- "J"—The reported result is an estimated value.
- "R"—The reported result is rejected.

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

3.2.5 Data Review and Quality Assessment

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

The QA program was designed to achieve the DQOs for the RI. The program was developed in accordance with the specifications contained and the data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the SAP Addendum (Shaw, 2011), FWSAP (SAIC, 2011), the QSM Version 4.2 (DoD, 2010) and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance. The DQOs were developed concurrently with the Work Plan Addendum (Shaw, 2011) to ensure the following:

- The reliability of field sampling, chemical analyses, and physical analyses
- The sufficiency of collected data
- The applicability of data for intended use
- The validity of assumptions inferred from the data

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

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

Criteria for QC results were compared to laboratory established criteria in accordance with the method and work plan requirements. Further details and discussion are provided in the *Data Validation Report* in **Appendix C**.

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

- **General Review—**The EPA guidance entitled, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A, Interim Final* (1989), states that the data qualified during the validation process as estimated "J" or "UJ" may be included in quantitative assessments indicating the associated numerical value is an estimated quantity, i.e., the guidance states to "use J-qualified concentrations the same way as positive data that do not have this qualifier." All project samples were analyzed in one batch sample delivery group (SDG), 89284. In review of analytical information, the sample results qualified as "J" (i.e., estimated or nondetect estimated values) during the validation process are considered usable data points (EPA, 1989), and are included in the data summary tables of this report. The majority of the "J"-qualified samples were the result of the common condition of reported values being below the certainty range

of detection (i.e., either less than the method reporting limit and greater than the MDL, or less than three times the MDL, whichever is greater) as well as analytical column confirmation or accuracy recoveries found outside criteria. The holding time criterion was exceeded for hexavalent chromium for sample GR8-RB-01; therefore, was qualified estimated "J" based upon this outlier. Select surrogates were outside criteria for samples GR8-RB-01, G8SS-001M-0001-SO, G8SS-008M-0001-SO, G8SS-009M-0001-SO resulting in "J" or "UJ" estimations. Target compounds 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2,4-dinitrophenol, and 4,6-dinitro-2-methylphenol were qualified rejected "R" for the aqueous rinse blank sample GR8-RB-01 because no aqueous LCS recoveries were found in the associated run batch. The solid LCS passed criteria and the aforementioned associated target compounds were nondetect for all field soil samples collected for this RI; therefore, there were no impacts resultant from these outliers. There were no other data rejections (i.e., R-flagged results) as a result from the data validation reviews.

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

  All laboratory duplicate and/or MSD pairs were within RPD criteria limits; therefore, did not warrant further qualification. Blind field duplicate sample pairs G8SS-004M-0001-SO/G8SS-005M-0001-SO and G8SS-008M-0001-SO/G8SS-009M-0001-SO were collected for all parameter groups. All target analytes were within precision criteria for duplicate pair G8SS-008M-0001-SO/G8SS-009M-0001-SO. For the field duplicate pair G8SS-004M-0001-SO/G8SS-005M-0001-SO, acenaphthene, acenaphthylene, anthracene, antimony, barium, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, cadmium, carbazole, copper, di-n-butyl phthalate, fluoranthene, fluorene, mercury, Aroclor-1254, Aroclor-1260, phenanthrene, and pyrene were outside criteria and were qualified estimated "J" for the duplicate pair based upon these outliers. For all other parameter groups, all criteria were met for the field duplicates. Although these results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). The reasons for the invariability between the duplicate pair

are likely associated with the history of the Group 8 MRS as a vehicle staging area, an area where open burning of construction debris and rubbish occurred, and areas of disturbed ground as evidenced by the burial pits found during the RI field work. Based on these historical activities, there is the likely to be a lack of homogeneity across the MRS. The results for field duplicate sample GR8SS-005M-001-SO suggest that smaller controlled sampling units may be required if a greater degree of precision is required. Further discussion regarding QC sample precision is provided in the *Data Validation Report* in **Appendix C**.

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

  All MS/MSD recoveries were within criteria for all parameters. The aqueous LCS recoveries were outside limits for target compounds 2-chlorophenol, 2-nitrophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2,4-dinitrophenol, and 4,6-dinitro-2-methylphenol. Associated sample GR8-RB-01 was qualified as estimated "UJ" for compounds 2-chlorophenol, 2-nitrophenol, and rejected "R" for 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2,4-dinitrophenol, and 4,6-dinitro-2-methylphenol based upon these outliers. The solid LCS passed criteria and the aforementioned rejected target compounds were nondetect for all field soil samples collected for this RI; therefore, there were no resultant impacts from these outliers.

  Select surrogates were outside criteria for samples GR8-RB-01, G8SS-001M-0001-SO, G8SS-008M-0001-SO, and G8SS-009M-0001-SO. Associated compounds were qualified estimated "J" for detections and "UJ" for nondetections based upon these outliers. The method and laboratory blanks, as well as the LCS, had acceptable surrogate recoveries. All other surrogates were within criteria for the soil samples.

  Although some data results were qualified as estimated or were rejected due to the outliers noted, the estimated data are still considered useable (EPA, 1989) and the rejected data had no direct impact on the field soil samples. Further discussion is presented in the *Data Validation Report* in **Appendix C**.

- **Representativeness—**Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled. It is a qualitative

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

For this sampling round, the sample collection was performed using CB&I SOPs and the analytical testing was performed using the EPA methodology with the ELAP-accredited laboratory. Sampling protocols were properly followed to assure that samples collected are representative of the media including the field handling protocols (i.e., storage, handling in the field, and shipping) of the collected samples. Sample identification and integrity were maintained (i.e., chain of custody) during this sampling event as determined during data validation. In review of the analytical data, data validation reports, and field records, no significant nonconformances were noted for holding times, QC blanks, accuracy, precision, and completeness evaluations. All analytical data were deemed representative in accordance with EPA guidance (1989), with no sample or data rejections for the compounds of concern.

A QC field audit was conducted for field sampling activities at the facility in accordance with the Work Plan Addendum (Shaw, 2011). The audit was activity-based and covered ISM surface soil sample collection conducted at the Group 8 MRS in February 2012. The QC field audit results are presented along with the field documentation in **Appendix B**.

Several nonconformances were observed during the QA audit by the CB&I UXOQCS. The noncomformances included not having the sampling SOPs on site during the beginning of field sampling activities, and the potential for cross-contaminating equipment with used sampling gloves. These noncomformances were remedied in the field. The corrective action included retrieving the sampling SOPs from the field office and ensuring that new sampling gloves were donned after handling used equipment. The primary nonconformance that had the potential to affect the data was the handling of decontaminated equipment with used gloves. This incident was observed by the UXOQCS prior to actual sampling activities and during the removal of the sampling equipment and

materials from the vehicle. There was no contact with used gloves on the end of the step probe used to collect the ISM samples and the handle and stem of the step probe was recleaned prior to sample collection. Results of the rinsate blank (GR8-RB-01) for the sampling equipment step probes provide supporting evidence that equipment was properly decontaminated during field activities.

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

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

  The sampling percent completeness is determined by taking the number of planned samples (including QC samples) and dividing that number by the number of samples actually collected during the current round of sampling. Five ISM surface soil samples (including a field duplicate sample) and one rinsate blank were intended to be collected and sent to CT Laboratories for analyses in accordance with the Work Plan Addendum (Shaw, 2011). In addition, four ISM soil samples (including a field duplicate sample) were collected from the bottom of trenches where buried MD was encountered during the RI field activities. Excluding rinsate blanks, the overall sampling completeness was 100 percent (or 9 surface and subsurface soil samples collected divided by 9 planned surface and subsurface soil samples).

  The overall analytical percent completeness is calculated from the number of usable data inputs divided by the number of analyzed data inputs. The evaluation of completeness for the surface and subsurface soil samples, field duplicates, and rinse blank resulted in 1,140 useable data points of possible 1,144 data points, resulting in an overall analytical completeness quotient of 99.7 percent for all parameter groups. The completeness statistics were computed as follows:

- 1,140 represents the total number of accepted analytes as usable data points (no analytes were rejected).
- 1,144 represents the number of analyzed inputs, which is equal to the total number of analytes for all field samples.

The rejected data points applied to select SVOCs that were resultant from very low surrogate recoveries (i.e. less than 10 percent) for the rinse blank sample GR8-RB-01. The SVOC completeness was 666 useable data points of possible 670 data points, resulting in an overall analytical completeness quotient of 99.4 percent. There were no rejected data points for any of the parameters for explosives, metals, hexavalent chromium, trivalent chromium, PCBs, TOC, pH, or nitrocellulose for this event; therefore, their analytical completeness quotients were each 100 percent. All of the overall and parameter-specific analytical completeness and soil sampling completeness quotients were above the predefined completeness goal of 90 percent. Further discussion is presented in the *Data Validation Report* in **Appendix C**.

- **Comparability—**Comparability is the confidence with which one data set can be compared to another. Comparability was controlled through the use of SOPs that have been developed to standardize the collection of measurements, samples, and approved analytical techniques with defined QC criteria. The laboratory chemical analyses were performed by an ELAP-accredited laboratory in accordance with the approved SAP Addendum (Shaw, 2011) using cited EPA methodology. Where applicable, the EPA-approved methods and QSM, Version 4.2 (DoD, 2010) provided the QC criteria guidelines for the analytical methods and the ELAP accrediting body provided the QA oversight. The laboratory adapted its processes accordingly into an applicable working SOP specific to the laboratory's capabilities (i.e., instrumentation, prep method, sample volumes, etc.) in applying the EPA methods. The SOPs were followed throughout the process by the laboratory, as reviewed by the ELAP accreditation body. Furthermore, laboratory data were validated in accordance with established SOPs, and the validation qualifiers were applied when QC nonconformances were identified (as applicable). The consistent use of the laboratory SOPs provides confidence with which one data set could be compared to another previous data set.

  Established field SOPs that were preapproved in the SAP Addendum (Shaw, 2011) for the RI program was applied to on-site work during the sampling event at the MRS. The field SOPs were followed, as established in the SAP Addendum (Shaw, 2011) to ensure that protocols meet project DQOs. The recorded field

documentation provided verification (i.e., field calibration, etc.) that proper field procedures were followed. The consistent application of field SOPs over the course of the RI program from sampling event to sampling event lends confidence in the comparison of field data sets.

- **Sensitivity—**The sensitivities are dependent on the analytical method, the sample volumes, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, MRLs, limits of detection [LODs] etc.) and analyte detections were compared to the screening criteria for the each of the samples collected. The analytical laboratory updated their sensitivity reporting convention from MDLs/MRLs to MDLs/LODs/MRLs during the sampling and analysis phase for this RI. The screening criteria are presented in *Attachment F–Table 12, "Proposed Human Health and Ecological Screening Level for Ravenna Army Ammunition Plant MRSs"* of the Work Plan Addendum (Shaw, 2011). Upon comparing the soil sample results to the minimum project screening criteria, the method sensitivity requirements were met. All MDLs, LODs or MRLs were less than the project screening criteria.

- **QC Blanks—**Method blanks, calibration blanks, and rinsate blanks were evaluated to identify potential non-site-related contamination from sample collection through laboratory analyses. Analytical results found within the "5 times" and "10 times" rules were qualified "U" and considered nondetect at the LOD or level of contamination, whichever was greater. From the EPA guidance entitled *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (1989), the definitions of the "5 times" and "10 times" rules are as follows:

  – "If the blank contains detectable levels of one or more organic or inorganic chemicals, then consider site sample results as positive only if the concentration of the chemical in the site sample exceeds five times the maximum amount detected in any blank for compounds that are not considered by EPA to be common laboratory contaminants. Consider 10 times the maximum amount for common laboratory contaminants acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene, and the phthalate esters. Treat samples containing less than 5 times (10 times for common laboratory contaminants) the amount in any blank as nondetects and consider the blank-related chemical concentration to be the quantitation limit for the chemical in that sample."

The rinsate blank (GR8-RB-01) was analyzed for all scoped parameters and contained trace levels of naphthalene, bis(2-ethylhexyl)phthalate, benzyl alcohol, HMX, and aluminum at concentrations below the LOD. All other target analytes were nondetect (less than or equal to the limit of detection). No samples required qualification based upon these low concentrations. All calibration blanks (metals) were within criteria (i.e. less than LOD) therefore, no data qualification was required.

For batch SDG 89284, bis(2-ethylhexyl)phthalate was detected below the LOD in the associated method blank (MB). The results for bis(2-ethylhexyl)phthalate in the associated soil samples were either not detected or (if detected) were all greater than 10 times the MB results; therefore, no data qualification was required. For all other analytes, all MB criteria (less than LOD) were met. Further discussion is provided in the *Data Validation Report* in **Appendix C**.

The Group 8 (RVAAP-063-R-01) MRS data were determined to be of sufficient quality to make informed decisions for the surface and subsurface soil samples collected. Further discussions of data qualifications are provided in the *Data Validation Report* in **Appendix C**.

3.3 Decontamination Procedures

Decontamination of dedicated sampling equipment was performed in accordance with the procedures presented in the SAP (Shaw, 2011) with the exception that the hydrochloric acid step was eliminated due to previous observations of surface corrosion on the sampling equipment when applied. The sampling equipment consisted of individual $^{7}/_{8}$-inch-diameter stainless steel step probes used to collect each of the ISM and the field duplicate surface soil samples. The step probes were decontaminated following the collection of an ISM sample at each sampling unit. All sampling decontamination procedures were performed at Building 1036, the facility contractors' building. In summary, the decontamination procedures consisted of the following:

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

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

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

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

3.4 Investigation-Derived Waste

The investigation-derived waste (IDW) generated during the field activities at the Group 8 MRS consisted of solid waste that included expendable waste debris (personal protective equipment) and equipment decontamination materials. Due to the minimal number of sampling equipment and in an effort to minimize waste generation, the decontamination liquids were applied using hand-held spray bottles and the residual liquids were collected on absorbent pads. No free liquid wastes were generated.

The disposal of IDW was performed in accordance with the procedures presented in the Work Plan Addendum (Shaw, 2011). The expendable waste debris and equipment decontamination materials generated was containerized along with similar materials generated from other MRSs and were staged at Building 1036 in accordance with the FWSAP (Shaw, 2011). IDW management, which describes the waste characterization analyses performed; waste characterization screening; and IDW transport and disposal are presented in **Appendix E**.

4.0 REMEDIAL INVESTIGATION RESULTS

This chapter presents a discussion of the results of the RI data that were collected for MEC and MC at the Group 8 MRS in accordance with the procedures discussed in Section 3.0, "Characterization of MEC and MC." These results will be used to determine the nature and extent of MEC and/or MC and subsequently determine the potential hazards and risks posed to likely human and environment receptors. Once the risks are determined, they will then be integrated into the preliminary CSMs developed during the SI (e^2M, 2008) that were presented in Section 2.0. Photographs of the RI activities performed at the MRS are presented in **Appendix F**.

4.1 MEC Investigation Results

The following subsections present the results of the RI field efforts that were performed to achieve the DQOs defined in Section 2.3.1, "Data Quality Objectives" and define the nature and extent of MEC at the Group 8 MRS. These efforts included a combination of surface debris removal, visual and DGM surveys, and intrusive investigations at the Group 8 MRS that were conducted in accordance with the Work Plan Addendum (Shaw, 2011).

4.1.1 Visual Survey Results

While no visual surveys were proposed for the MRS, the potential presence of MEC on the ground surface was investigated during the geophysical investigation. Complete (100 percent) surface coverage of the MRS was conducted during the RI field activities and no MEC was identified on the ground surface.

4.1.2 Geophysical Survey Results

A total of 2.563 acres of full coverage DGM data were collected at the Group 8 MRS. Data were acquired in all accessible areas of the MRS on line spacing of approximately 2.5 feet and the area surveyed equates to nearly 97 percent coverage over the 2.65 acre MRS. The remaining 0.087 acres could not be investigated due to obstructions consisting of trees, utility poles, and barbed wire fence. The data were processed and interpreted consistent with the Work Plan Addendum (Shaw, 2011).

Evaluation of the data collected during the DGM survey identified 2,690 anomalies that had signal strength greater than or equal to 8 mV (Channel 2) for an average anomaly density of 1,015 anomalies per acre. Three areas were considered to have localized high anomaly densities, which accounted for 1,049 of the 2,690 anomalies. The majority of the high density areas were located south of the gravel roadway. Outside of these high density areas, there were a total of 1,641 anomalies identified for potential investigation. In general, the geophysical data indicate that the anomaly density at the MRS was high and dispersed

throughout the MRS with defined localized areas of higher density than found throughout the other areas at the MRS. **Figure 4-1** illustrates the actual DGM survey transects at the MRS during the RI field activities.

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
3 areas of relatively high anomaly density of varying shape and size distributed throughout the MRS	1,049 clusters of anomalies that represent aggregates of subsurface metal over 3 well-defined regions	3 high density anomaly regions representing the 1,049 cluster of anomalies	3 high-density anomaly regions to be excavated by 14 trenches[2]
Individual target anomalies throughout the remainder of the MRS	1,641 individual target anomalies	272 individual target anomalies[3]	Hand digging at all 272 individual target anomalies

[1] denotes based on response of 8 mV (Channel 2) for the EM61-MK2.

[2] denotes all trenches to be excavated mechanically.

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

MRS denotes Munitions Response Site.

Figures 4-2 and **4-3** display the results of the EM61-MK2 DGM survey. **Figure 4-2** provides a sensitive color-scale that highlights all individual target anomalies above a signal threshold of 8 mV, while **Figure 4-3** uses a coarse color-scale to delineate the major aggregates of the localized high density areas with increased definition.

Geophysical Quality Control Results

The DGM data were processed and interpreted consistent with the Work Plan Addendum (Shaw, 2011) and the DGM quality metrics were achieved for all data collected, excepting two occurrences. The first occurrence was the exceedance of the DGM quality metric for platform speed due to adverse surface conditions on November 1, 2011; however, the sampling interval for these data achieved the required metric (98 percent of the data collected were to have a sample to sample interval of less than 0.24 meters). The second occurrence was on November 14, 2011, when low-level external noise was noted by the field crew during the morning static test. The noise was attributed to the intermittent operation of

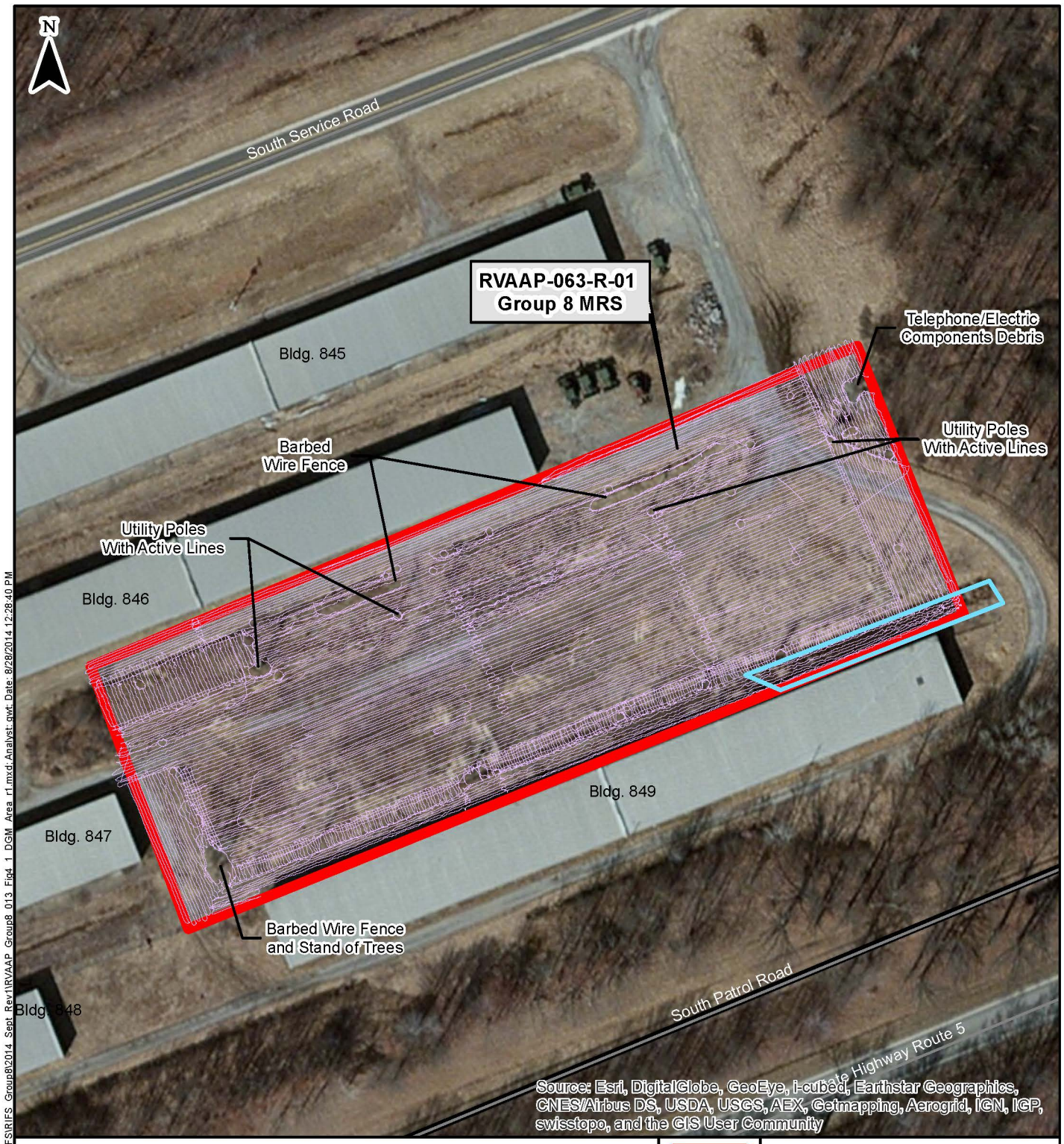
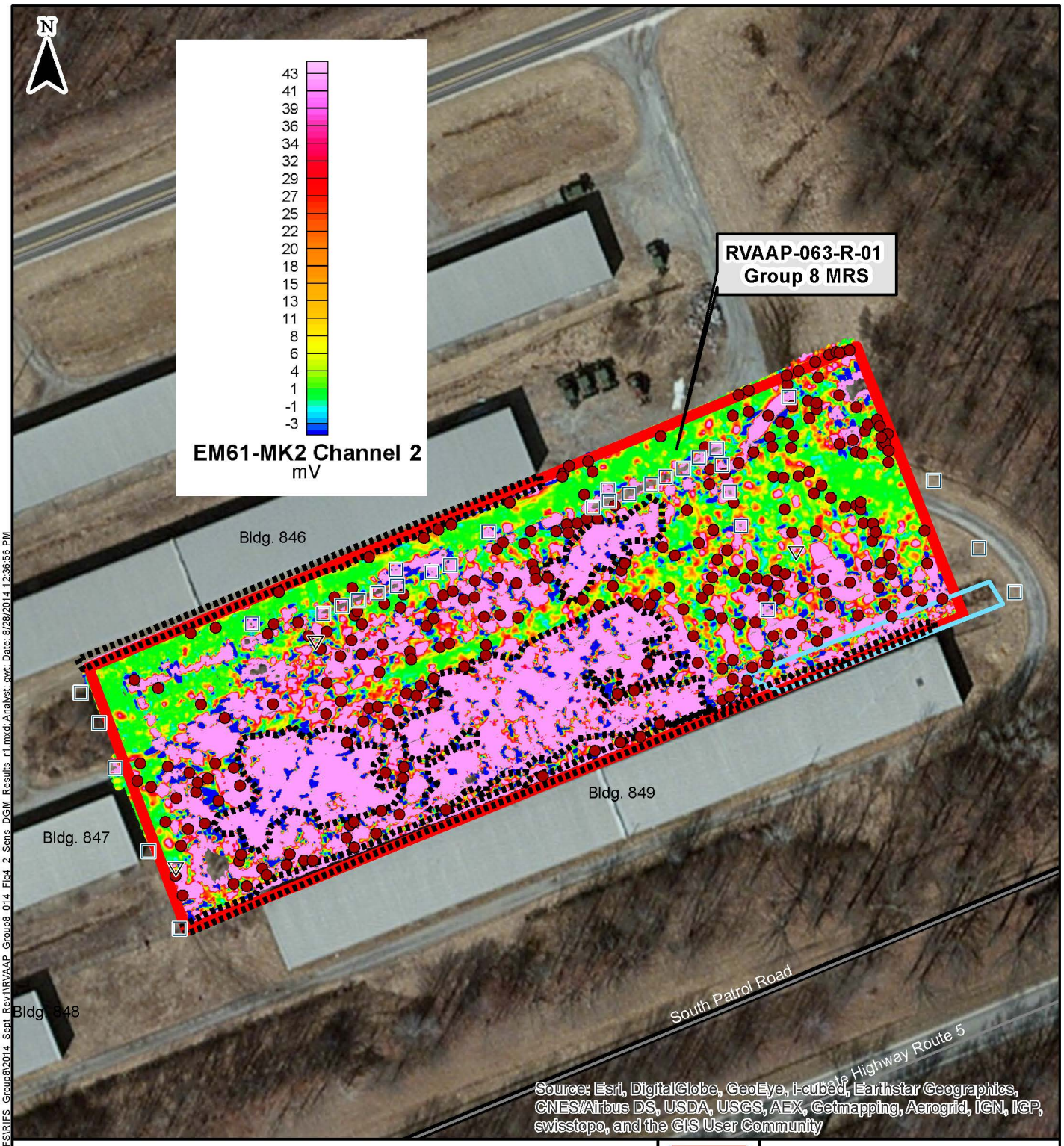


FIGURE 4-1 ACTUAL DGM COVERAGE



Facility Boundary
Group 8 MRS Boundary
Standing Water Area
High Anomaly Density Area
Anomaly Selected for Investigation
Control Point (QC)
Surface Metal

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

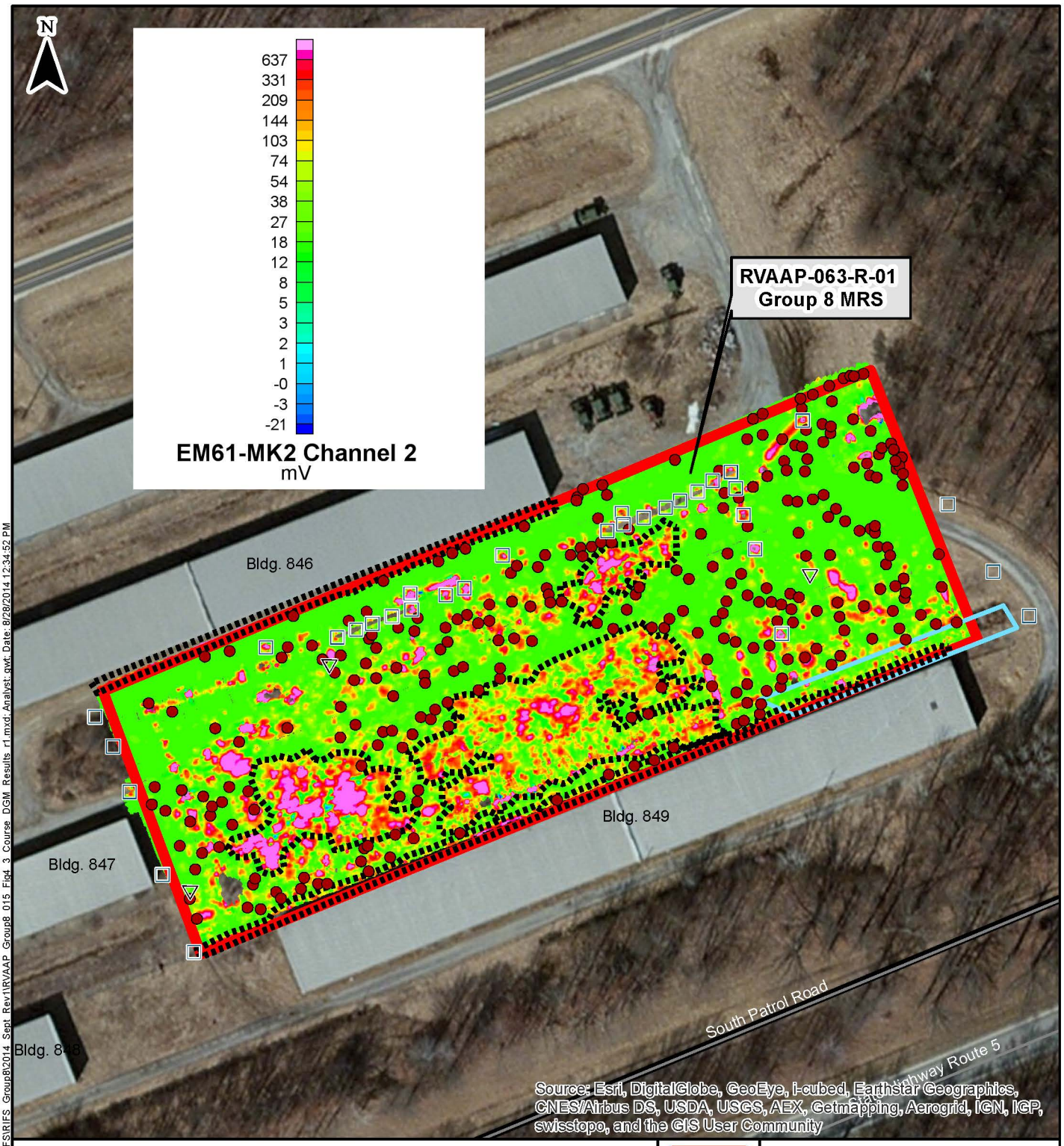
MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
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 Group8\2014 Sept Rev1\RVAAP Group8 014 Fig4 2 Sens DGM Results r1.mxd Analyst: gwt Date: 8/28/2014 12:36:56 PM

FIGURE 4-2 SENSITIVE COLOR-SCALE DGM RESULTS



Facility Boundary
Group 8 MRS Boundary
Standing Water Area
High Anomaly Density Area
Anomaly Selected for Investigation
Control Point (QC)
Surface Metal

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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FIGURE 4-3 COARSE COLOR-SCALE DGM RESULTS

electrical equipment in the nearby buildings. The data collected on November 14 represent a very small amount of fill-in data in one of the high anomaly density zones. All the data results were interpreted, including the identified exceptions, and the data quality was considered to be acceptable. Additional discussion regarding the geophysical quality control results is presented in the DGM Report in **Appendix A**.

4.2 Intrusive Investigation Results

This section presents the results of the intrusive investigations performed at the Group 8 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. The inspections for any MPPEH found and estimation of quantities were made by the UXO-qualified personnel in the field. A summary of the proposed intrusive activities is presented in **Table 4-1**. The results of the intrusive investigation activities are presented in **Figure 4-4**. The investigation results for the intrusive investigation activities are presented in the data sheets in **Appendix G**.

4.2.1 Trench Investigations

Various types and amounts of MPPEH were uncovered in 9 of the 14 trenches at depths ranging from 4 to 48 inches bgs. All the MPPEH items were documented as safe and determined to be MD. No MEC was found during the intrusive investigation. 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 maximum depth that any of the trenches at the MRS were excavated to was 48 inches bgs, which is the maximum depth that native soils were encountered. Approximately 1,180 pounds (lbs) (277 individual MD items) of MD items were recovered from 9 trenches and 1,281 lbs of "Other Debris" were identified within all 14 trenches. All nonmunitions debris was left in place. All MD was managed in accordance with the Work Plan Addendum (Shaw, 2011) and is discussed further in Section 4.2.5. **Table 4-2** summarizes the results at each trench location, the maximum depth attained, a description of MD and "Other Debris" uncovered, and the estimated weight of the debris.

Table 4-2
Trench Investigation Results Summary

Trench Number	Maximum Depth (inches)	Description of MD	Approximate Weight (lbs)	"Other Debris" Description	Approximate Weight (lbs)
01-1	48	NA	0	Scrap metal	350
02-1	48	NA	0	Scrap metal	400

Trench Number	Maximum Depth (inches)	Description of MD	Approximate Weight (lbs)	"Other Debris" Description	Approximate Weight (lbs)
03-1	48	Assorted MD Components	15	Scrap metal	25
04-1	48	Assorted MD Components	8	Scrap metal	25
05-1	12	NA	0	Scrap metal	50
06-1	48	Assorted MD Components	19	Scrap metal	15
07-1	48	¼ of a 40mm HE M397 series (inert)	1	Scrap metal	50
08-1	48	NA	0	Nails and pipe	65
09-1	12	Assorted fuze adaptors, inert HEAT warhead, expended 60mm M49 series mortar	29	Scrap metal	51
10-1	12	Expended M84 fuze	1	Scrap metal	100
11-1	48	Assorted MD components, 75mm M72 series projectile, M532 series fuze, 40mm cartridge case	1,054.25	NA	0
12-1	48	NA	0	Fence parts and scrap metal	100
13-1	48	Expended M557 series fuze	2	Scrap metal	50
14-1	48	Assorted MD components	50	NA	0
		Total:	**1,179.25**	**---**	**1,281**

HE denotes high explosive.
HEAT denotes high explosive anti-tank.
lb denotes pound.
MD denotes munitions debris.
mm denotes millimeter.
NA denotes not applicable.

4.2.2 Individual Target Anomaly Investigations

A total of 272 single point source anomalies were agreed upon for reacquisition as presented in the *DGM Survey Results and Proposed Dig Locations for the Group 8 MRS (RVAAP-063-R-01)* technical memorandum presented as an attachment in **Appendix A**. The dig locations were approved by the USACE Project Geologist and the Ohio EPA Project Manager. Seven of the 272 anomalies could not be reacquired successfully due to significant interference from adjacent buildings. One anomaly (target 1,647) was located beneath a small area of asphalt at the northeast entrance to the MRS and was not intrusively investigated. In all, a

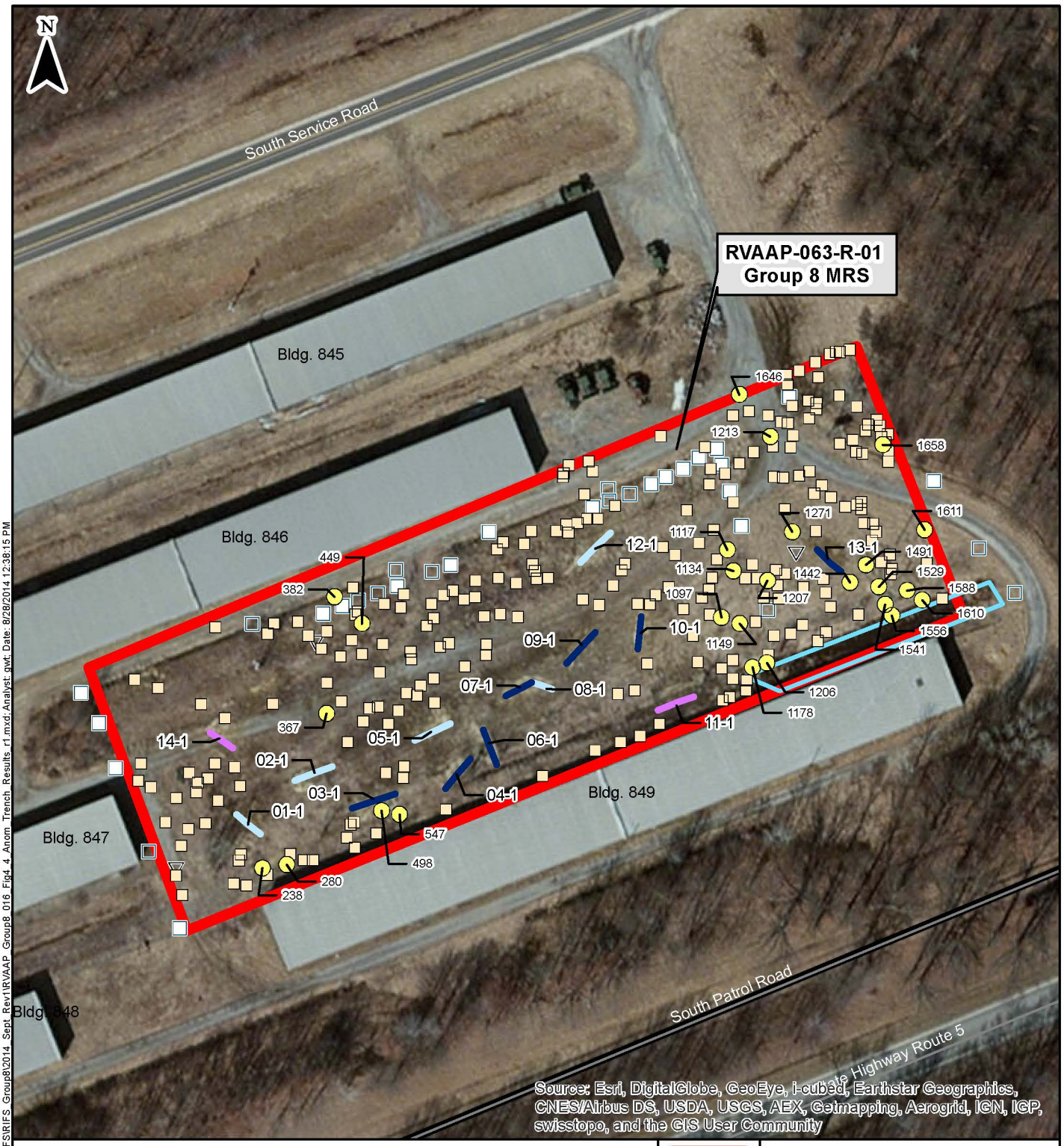


FIGURE 4-4 SINGLE ANOMALY AND TRENCH INVESTIGATION RESULTS

total of 264 of the 272 proposed anomalies were successfully reacquired during the intrusive investigation.

A total of 238.5 lbs (82 individual items) of MPPEH were recovered from 26 single point anomaly locations. All the MPPEH items were documented as safe and determined to be MD. No MEC was found during the single point anomaly investigation. The depth of the MD encountered at the single point anomaly locations ranged from 1 inch to 36 inches bgs. The MD recovered from the single point anomaly locations was found to be consistent with the types of MD uncovered during the intrusive trench investigation: assorted expended fuzes, 75mm projectile pieces, 20mm cartridges, ammunition cans with residue, and miscellaneous unidentified MD components. The remaining 238 single point anomalies were intrusively investigated without an MD discovery. A total of 3,020 lbs of "Other Debris" items were identified during the single point anomaly investigation. All MD was managed in accordance with the Work Plan Addendum (Shaw, 2011) and is discussed further in Section 4.2.5, "Management and Disposal of Munitions Debris."

Three of the MD items were encountered along the northeast and east MRS boundaries during the individual target anomaly intrusive investigation activities. Starting at the northernmost anomaly and going clockwise, these items were numbered as targets 1646, 1658, and 1611 and are presented on **Figure 4-4**. In order to evaluate for potential MEC outside of the MRS, Schonstedt-assisted visual survey step-outs were performed where possible but were not tracked with the global positioning system. Investigation beyond the northeast boundary where target 1646 was found was limited by OHARNG vehicle storage and interference to the Schonstedt magnetometer along the access road due to slag. The step-out surveys along the east boundary were conducted for approximately 50 feet until dense tree and vegetation was encountered. The only anomalies found along the step-outs from the MRS were surface metal debris. No MPPEH was encountered outside of the MRS boundaries during the Schonstedt-assisted step-out surveys.

4.2.3 Post-Excavation Field Quality Control

A total of 44 anomaly locations were randomly selected for post-excavation QC with the EM61-MK2 following the intrusive investigation in accordance with the Work Plan Addendum (Shaw, 2011). The purpose of the post-excavation QC checks were to perform intrusive anomaly verification to ensure that at a 90 percent confidence, less than 5 percent of the remaining anomalies are "unresolved" (i.e., there is a low probability that a significant item related to MEC is present within the dig locations that were not checked post-excavation). At 42 of the locations, the residual signal from the sensor was less than 4 mV (Channel 2). Two locations (Anomalies 1,550 and 1,556) were classified as trash pits and all

of the metal could not be removed. Based on the results of the post-excavation QC, no additional excavation locations were required to be investigated.

4.2.4 Statistical Analysis of Intrusive Results

A statistical approach was used to quantify the intrusive findings of the RI as is discussed in Section 3.1.2.2, "Target List Development for Individual Anomalies." 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 in any of remaining 1,369 anomalies that were not investigated during the RI field activities. These results support the DQOs established in the Work Plan Addendum (Shaw, 2011). A summary of the statistical analysis of the intrusive findings is presented in **Appendix H**.

4.2.5 Management and Disposal of Munitions Debris

This section presents the management and disposal practices for the MD items that were encountered during the RI intrusive investigation activities at the Group 8 MRS. In all, a total of 1,418 lbs of MD, as determined by the UXO-qualified personnel in the field, were recovered during the visual survey and intrusive investigation activities at the MRS. Once the MPPEH were verified as MD, they were placed into 55-gallon steel drums for off-site disposal. The drums were verified by the UXO-qualified personnel as "Material Documented as Safe" and were transported to a designated area for temporary storage; the former Ready Magazine Area (Building 1501) at Open Demolition Area #2 MRS. The drums were labeled as "Scrap Steel" and were shipped off-site for demilitarized disposal at Demil Metals, Inc. in Glencoe, Illinois on May 11, 2012. Waste shipment documentation for MD disposal is presented in **Appendix I** and is inclusive of all MD that was generated by CB&I at the Group 8 MRS and other facility MRSs investigated under the MMRP between September 8, 2011, and May 10, 2012.

4.3 MC Data Evaluation

This section presents the results of the RI data screening process for MC that may be associated with past activities that occurred at the Group 8 MRS and to evaluate the occurrence and distribution of the site-related chemicals (SRCs) in the media sampled. The data evaluated for the Group 8 MRS in this section is inclusive of the results of the RI sampling event only. Analytical data from previous samples collected during the 2007 SI field activities were not included in this evaluation based on the rationale discussed in Section 2.4, "Data Incorporated into the RI."

The data reduction and screening process presented herein describes the statistical methods and facility-wide background screening criteria used to distinguish constituents present at

ambient concentrations from those present at concentrations that indicate potential impacts related to historical operations within the MRS. The nature and extent of identified MC within the sampled environmental media (surface soil and subsurface soil) established for this RI Report are also presented below. A summary of the complete laboratory analytical results for the RI data and the laboratory data reports are presented in **Appendix D**.

4.3.1 Data Evaluation Method

Data evaluation methods for the Group 8 MRS are consistent with those established in the FWCUG guidance (SAIC, 2010). These methods consist of three general steps: (1) define data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

4.3.1.1 Definition of Aggregates

Samples were grouped (aggregated) at the Group 8 MRS based on the type of environmental sample and consistency in sample type, area, and depth. The data aggregates identified for the MRS included the following:

- **Surface Soil (0 to 0.5 feet bgs)**—This data aggregate consists of four surface soil samples collected using ISM at evenly sized sampling units (0.67 acres each). This medium is evaluated as an MRS-wide aggregate since the surface soil samples cover the entire MRS and the sample units are considered as areas of equally probable anticipated use by likely human and ecological receptors. For consideration of this MC exposure analysis at the Group 8 MRS, the defined exposure unit (EU) for surface soil will be the entire MRS to the 0- to 0.5-foot sample depth.
- **Subsurface Soil (4 to 4.5 feet bgs)—**This data aggregate consists of three subsurface soil samples collected using ISM from the bottom of three trench locations where concentrated areas of MD were encountered during the RI field activities. The three trenches were selected for additional sampling for MC due to the concentrated areas of MD that were encountered, in accordance with the Work Plan Addendum (Shaw, 2011). The trenches were of the approximate same size, with areas ranging from 40 to 156 square feet, and were excavated to similar depths of 48 inches bgs. The trenches were spaced out within the MRS and the medium is evaluated as an MRS-wide aggregate for likely human receptors only since ecological receptors are not typically evaluated for depths greater than 1 foot bgs. For consideration of this MC exposure analysis at the Group 8 MRS, the defined EU for subsurface soil will be to the 4- to 4.5-foot sample depth.

For risk assessment purposes and consideration of MC exposure analysis, the surface soil aggregate will be used to define human health and ecological exposure in the risk

assessments as discussed in Section 7.0, "Human Health Risk Assessment" and Section 8.0, "Ecological Risk Assessment." Ecological risk is typically evaluated for samples collected within the 0- to 1-foot surface soil interval; therefore, the subsurface soil aggregate will be used to evaluate for potential risk for human receptors only in Section 7.0.

4.3.1.2 Data Validation

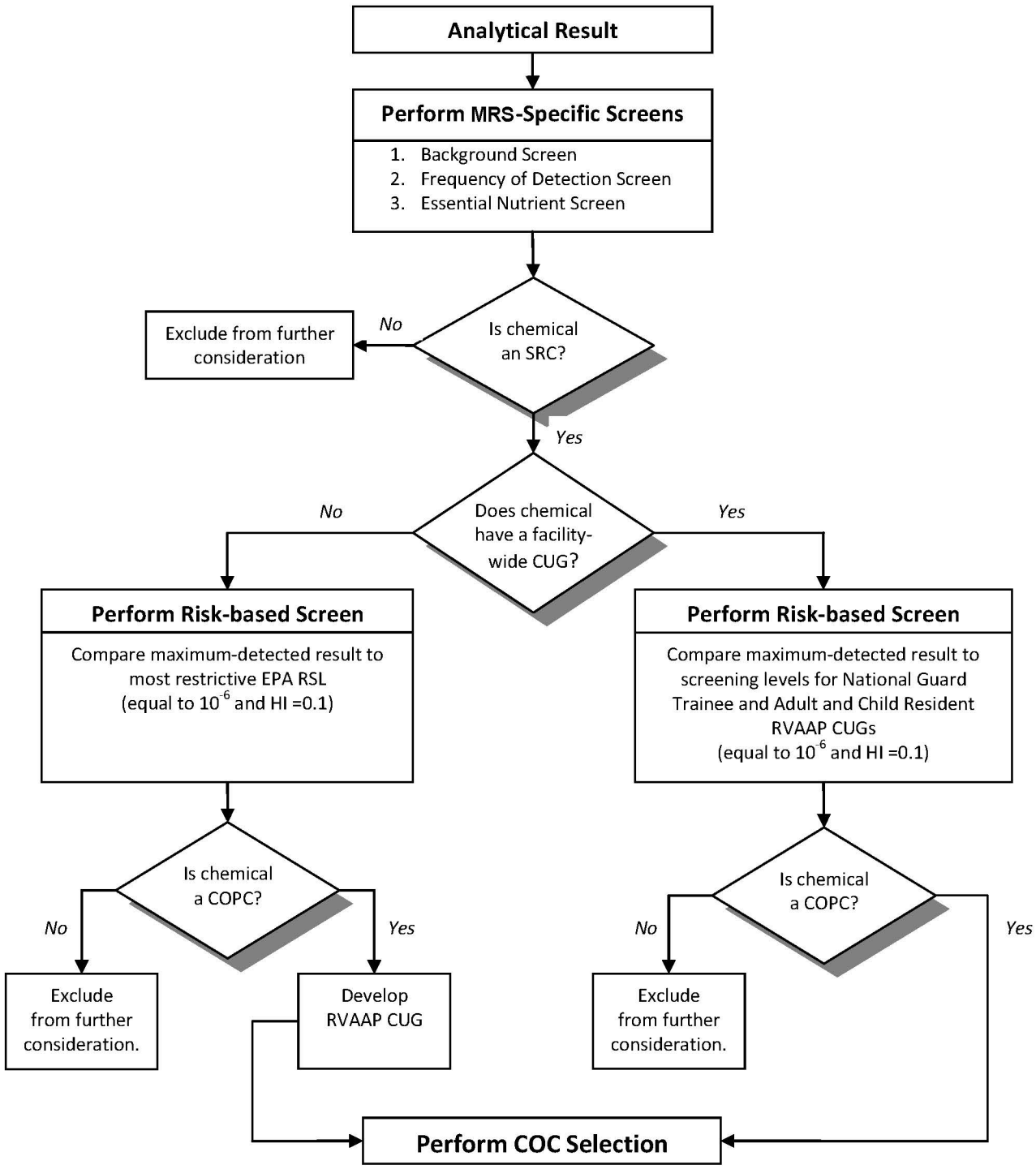
Data validation was performed on all ISM surface and subsurface soil samples collected from the Group 8 MRS (including field duplicates and QC samples) during the RI field activities to ensure the precision and accuracy of the analytical data were adequate for their intended use. The review constituted comprehensive validation of 100 percent of the primary data set, as discussed in Section 3.2.4, "Data Validation."

4.3.1.3 Data Reduction and Screening

The data reduction process employed to identify SRCs involves identifying frequency of detection summary statistics, comparison to facility-wide background screening values (BSVs) for metals only, and evaluation of essential nutrients. QC and field duplicates were excluded from the screening data sets. All analytes having at least one detected value were included in the data reduction process. Summary statistics calculated for each data aggregate included the minimum, maximum and average (mean) detected values and the proportion of detected results to the number of samples collected. For calculation of mean detected values, nondetected results were included by using one half of the reported detection limit as a surrogate value during calculation of the mean result for each compound. Following data reduction, the data was screened to identify SRCs using the processes outlined in the following sections. **Figure 4-5** shows the data screening process to identify SRCs and perform selection of chemicals of potential concern (COPCs) and chemicals of concern (COCs), as necessary. The determination of COPCs and COCs is for human health evaluation only.

Frequency of Detection

Chemicals that are detected infrequently, except explosives and propellants, may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to the MRS activities or disposal practices. For sample aggregations, except for explosives and propellants, with at least 20 samples and frequency of detection of less than 5 percent, a weight of evidence approach may be used to determine if the chemical is MRS-related. Since surface soil samples were collected at only four locations (four ISMs) and subsurface soil samples were collected at only three locations (three ISMs), frequency of detection was not utilized for the Group 8 MRS data set.



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

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

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMMS\RavennaGIS Documents\Project Maps\MMRP\RIFS\RIFS Group8\2014 Sept Rev1\RVAAP Group8 017 Fig4 5 Data Screening Process r1.mxd:Analyst: gwt: Date: 8/28/2014 12:40:26 PM

FIGURE 4-5 RVAAP DATA SCREENING PROCESS

Facility-Wide Background Screen

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

For the RI field efforts across the facility MRS being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical analysis. Geochemical analysis is typically used when metals are found to be only slightly elevated above background levels and risk assessment identifies potential risk to receptors due to metals. A geochemical evaluation is then used to determine if metals are background related or actually developed due to site history. Use of the geochemical evaluation in this manner requires approval from the USACE and the Ohio EPA prior to implementing geochemical evaluation results as a comparison tool for background results. A geochemical analysis was not required for the Group 8 MRS based on the evaluation of the metal results in Section 4.0, and the HHRA and ERA conclusions in Section 7.0 and Section 8.0, respectively.

Essential Nutrient Screen

Chemicals that are considered to be essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the food supply and are often added to foods as supplements. The EPA recommends that these chemicals not be evaluated as COPCs as long as they are present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and toxic at very high doses (i.e., much higher than those that could be associated with contact at the site) (USACE, 2005). For the RI field effort, analyses were conducted for calcium, magnesium, and manganese to be used for geochemical analysis, should one be required. These three constituents were eliminated as SRCs in the environmental media since they are not considered as MC associated with the Group 8 MRS. Iron is identified as an MC associated with MEC and MD historically found at the MRS; and therefore, is not eliminated as an essential nutrient.

4.3.1.4 Data Presentation

Data summary statistics for SRCs in surface and subsurface soil collected at the Group 8 MRS are presented for each media evaluated in the following sections. The designated use of

the RI field samples collected at the Group 8 MRS and the sample collection rationale are discussed in Section 4.3.2, "Data Use Evaluation" and summarized in **Table 4-3**. The summary of surface soil and subsurface soil results are presented in **Table 4-4** and **Table 4-6**, respectively. Data summary statistics and screening results for the surface soil samples are presented in **Table 4-5 and Table 4-7**, respectively. **Figure 4-6** through **Figure 4-9** present the distribution of SRCs in surface soils for the Group 8 MRS. The complete RI data summary tables and the laboratory data report for the samples collected at the Group 8 MRS are presented in **Appendix E**.

4.3.2 Data Use Evaluation

During the RI field effort surface soil samples were collected at four predetermined ISM sampling units based on the historical information for the Group 8 MRS. Additional subsurface ISM soil samples were collected from trenches where MD was uncovered during the intrusive investigation. Available sample data were evaluated to determine suitability for use in the various key RI data screens, which includes evaluation of nature and extent of contamination, fate and transport, and human and ecological risk assessments. Evaluation of data suitability for use in this RI report involved representativeness with respect to current MRS conditions.

All data from the MRS collected during the 2007 SI were evaluated and it was determined that the samples collected for the RI were more representative of current conditions. Therefore, only the samples collected during the RI field effort were screened for MC considered as SRCs and carried forward into the risk assessment for human health and ecological receptors.

4.4 Nature and Extent of SRCs

This section presents the nature and extent of SRCs within the surface soil and subsurface soil data aggregates evaluated in this RI Report.

4.4.1 Surface Soil

Data from the RI surface soil samples were screened to identify SRCs representing current conditions at the Group 8 MRS. The SRC screening data for surface soil (not including field duplicates or QC samples) included samples G8ss-001M-0001-SO, G8ss-002M-0001-SO, G8ss-003M-0001-SO and G8ss-004M-0001-SO. These samples were collected using the ISM and the sample depth for each increment was from 0 to 0.5 feet bgs.

The ISM samples were collected at grid locations that encompassed the entire MRS and each sample was representative of one quarter of the MRS to characterize the entire MRS for residual MC in surface soils. All ISM surface soil samples collected during the RI sampling

Table 4-3
Data Use Summary and Sample Collection Rationale

Sample Location ID	Date	Depth (feet bgs)	Sample Type	Data Use Type	Sample Location
Surface Soil					
G8ss-001M-0001-SO	2/8/2012	0–0.5	ISM	N&E, F&T, RA	Northwest quadrant of MRS (300- by 95-foot ISM grid)
G8ss-002M-0001-SO	2/8/2012	0–0.5	ISM	N&E, F&T, RA	Northeast quadrant of MRS (300- by 95-foot ISM grid)
G8ss-003M-0001-SO	2/8/2012	0–0.5	ISM	N&E, F&T, RA	Southwest quadrant (300- by 95-foot ISM grid)
G8ss-004M-0001-SO	2/8/2012	0–0.5	ISM	N&E, F&T, RA	Southeast quadrant (300- by 95-foot ISM grid)
Subsurface Soil					
G8ss-006M-0001-SO	2/8/2012	4.0–4.5	ISM	N&E, F&T, RA	Trench 13-1, MD uncovered (27- by 2-foot ISM grid)
G8ss-007M-0001-SO	2/8/2012	4.0–4.5	ISM	N&E, F&T, RA	Trench 11-1, MD uncovered (52- by 3-foot ISM grid)
G8ss-008M-0001-SO	2/8/2012	4.0–4.5	ISM	N&E, F&T, RA	Trench 14-1, MD uncovered (20- by 2-foot ISM grid)

bgs denotes below ground surface.
F&T denotes fate and transport evaluation.
ID denotes identification.
ISM denotes incremental sampling methodology.
MD denotes munitions debris.
N&E denotes nature and extent evaluation.
RA denotes risk assessment evaluation.

Table 4-4
Summary of Surface Soil Results

	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Metals									
Aluminum	*17,700*	11,300		16,300		11,200		15,200	J
Antimony	*0.96*	**5**		**6.6**		**11.7**		**22.8**	**J**
Barium	*88.4*	**127**		**152**		**247**		**257**	**J**
Cadmium	*0*	**6.6**		**23.3**		**21.3**		**396**	**J**
Chromium (as Cr^{+3})	*17.4*	**23**		**22.8**		**39**		**27.9**	
Copper	*17.7*	**470**		**225**		**585**		**711**	**J**
Iron	*23,100*	**34,300**		**37,200**		**54,400**		**50,300**	
Lead	*26.1*	**493**		**300**		**977**		**887**	**J**
Mercury	*0.036*	**0.26**		**0.21**		**0.89**		**0.63**	
Strontium	*0*	**48.3**		**103**		**75.2**		**119**	
Zinc	*61.8*	**470**		**346**		**1,060**		**1,020**	**J**
Geochemical Metals[2]									
Calcium	*15,800*	14,200		**42,600**		**19,700**		**39,600**	**J**
Magnesium	*3,030*	**3,860**		**6,760**		**4,230**		**6,000**	
Manganese	*1,450*	816		1,380		1,090		1,280	J
Explosives and Propellants									
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U

	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
2,4,6-Trinitrotoluene	*NA*	<0.2	U	<0.2	U	**0.3**	**J**	<0.2	U
2,4-Dinitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
2,6-Dinitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
3,5-Dinitroaniline	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
HMX	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
m-Nitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
Nitrobenzene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
Nitroglycerin	*NA*	<1	U	<1	U	<1	U	<1	U
Nitroguanidine	*NA*	<0.125	U	**0.12**	**J**	<0.125	U	**0.17**	**J**
o-Nitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
PETN	*NA*	<1	U	<1	U	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
RDX	*NA*	<0.25	U	<0.25	U	<0.25	U	<0.25	U
Tetryl	*NA*	<0.2	U	<0.2	U	<0.2	U	<0.2	U
Semivolatile Organic Compounds									
1,2,4-Trichlorobenzene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
1,2-Dichlorobenzene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
1,3-Dichlorobenzene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
1,4-Dichlorobenzene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U

	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
2,4,5-Trichlorophenol	*NA*	<0.305	U	<0.3	U	<0.305	U	<0.305	UJ
2,4,6-Trichlorophenol	*NA*	<0.305	U	<0.3	U	<0.305	U	<0.305	UJ
2,4-Dichlorophenol	*NA*	<0.305	U	<0.3	U	<0.305	U	<0.305	U
2,4-Dimethylphenol	*NA*	<0.305	U	<0.3	U	<0.305	U	<0.305	U
2,4-Dinitrophenol	*NA*	<1	U	<1	U	<1	U	<1	UJ
2-Chloronaphthalene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
2-Chlorophenol	*NA*	<1	U	<1	U	<1	U	<1	U
2-Methylnaphthalene	*NA*	**0.092**	**J**	**0.12**		**0.4**		**0.28**	
2-Nitroaniline	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
2-Nitrophenol	*NA*	<0.5	U	<0.5	U	<0.5	U	<0.5	U
3,3'-Dichlorobenzidine	*NA*	<0.255	UJ	<0.25	U	<0.255	U	<0.255	UJ
3-Nitroaniline	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	UJ
4,6-Dinitro-2-Methylphenol	*NA*	<0.5	U	<0.5	U	<0.5	U	<0.5	UJ
4-Bromophenyl Phenyl Ether	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
4-Chloro-3-Methylphenol	*NA*	<1	U	<1	U	<1	U	<1	U
4-Chloroaniline	*NA*	<0.1	UJ	<0.1	U	<0.1	U	<0.1	UJ
4-Chlorophenyl Phenyl Ether	*NA*	<0.1	UJ	<0.1	U	<0.1	U	<0.1	U
4-Nitrobenzenamine	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
4-Nitrophenol	*NA*	<1	U	<1	U	<1	U	<1	U
Acenaphthene	*NA*	<0.06	UJ	<0.06	U	**0.11**	**J**	**0.045**	**J**
Acenaphthylene	*NA*	**0.038**	**J**	<0.06	U	<0.06	U	**0.051**	**J**

	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Anthracene	*NA*	**0.048**	**J**	**0.041**	**J**	**0.19**		**0.1**	**J**
Benzo(a)anthracene	*NA*	**0.11**	**J**	**0.13**		**0.41**		**0.27**	
Benzo(a)pyrene	*NA*	**0.069**	**J**	**0.092**	**J**	**0.27**		**0.21**	
Benzo(b)fluoranthene	*NA*	**0.15**	**J**	**0.19**		**0.46**		**0.38**	
Benzo(ghi)perylene	*NA*	**0.06**	**J**	**0.065**	**J**	**0.15**		**0.13**	**J**
Benzo(k)fluoranthene	*NA*	**0.042**	**J**	**0.047**	**J**	**0.23**		**0.16**	
Benzoic Acid	*NA*	<1.5	U	<1.5	U	<1.5	U	<1.55	U
Benzyl Alcohol	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
Bis(2-Chloroethoxy)methane	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
Bis(2-Chloroethyl)ether	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
Bis(2-Ethylhexyl)phthalate	*NA*	**0.79**	**J**	**0.29**	**J**	<0.205	U	**2**	
Butyl Benzyl Phthalate	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
Carbazole	*NA*	**0.045**	**J**	**0.032**	**J**	**0.15**		**0.1**	**J**
Chrysene	*NA*	**0.11**	**J**	**0.13**		**0.43**		**0.29**	
3&4-Methylphenol	*NA*	<1.85	U	<1.8	U	<1.8	U	<1.85	U
Dibenzo(a,h)anthracene	*NA*	<0.06	UJ	**0.026**	**J**	**0.064**	**J**	**0.049**	**J**
Dibenzofuran	*NA*	**0.036**	**J**	**0.037**	**J**	**0.16**		**0.095**	**J**
Diethyl Phthalate	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
Dimethyl Phthalate	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
Di-n-Butyl Phthalate	*NA*	**0.14**	**J**	**0.1**	**J**	**0.11**	**J**	**0.46**	

	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Di-n-Octyl Phthalate	*NA*	<0.1	UJ	<0.1	U	<0.1	U	<0.1	U
Fluoranthene	*NA*	**0.28**	**J**	**0.29**		**1.2**		**0.78**	
Fluorene	*NA*	<0.06	UJ	<0.06	U	**0.091**	**J**	**0.044**	**J**
Hexachlorobenzene	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
Hexachlorobutadiene	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
Hexachlorocyclopentadiene	*NA*	<0.1	UJ	<0.1	U	<0.1	U	<0.1	UJ
Hexachloroethane	*NA*	<0.06	UJ	<0.06	U	<0.06	U	<0.06	U
Indeno(1,2,3-cd)pyrene	*NA*	**0.048**	**J**	**0.07**	**J**	**0.16**		**0.12**	
Isophorone	*NA*	<0.1	UJ	<0.1	U	<0.1	U	<0.1	U
Naphthalene	*NA*	**0.081**	**J**	**0.11**	**J**	**0.36**		**0.28**	
N-Nitroso-di-n-Propylamine	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
N-Nitrosodiphenylamine	*NA*	<0.205	UJ	<0.2	U	<0.205	U	<0.205	U
2-Methylphenol	*NA*	<1	U	<1	U	<1	U	<1	U
Phenanthrene	*NA*	**0.23**	**J**	**0.19**		**0.99**		**0.57**	
Pyrene	*NA*	**0.2**	**J**	**0.23**		**0.87**		**0.55**	
Polychlorinated Biphenyls									
Aroclor-1016	*NA*	<0.05	U	<0.05	U	<0.1	U	<0.05	U
Aroclor-1221	*NA*	<0.05	U	<0.05	U	<0.1	U	<0.05	U
Aroclor-1232	*NA*	<0.05	U	<0.05	U	<0.1	U	<0.05	U
Aroclor-1242	*NA*	<0.05	U	<0.05	U	<0.1	U	<0.05	U
Aroclor-1248	*NA*	<0.05	U	<0.05	U	<0.1	U	<0.05	U

Analyte	Location ID:	GR8SS-001M		GR8SS-002M		GR8SS-003M		GR8SS-004M	
	Sample ID:	GR8SS-001M-001-SO		GR8SS-002M-001-SO		GR8SS-003M-001-SO		GR8SS-004M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	0–0.5		0–0.5		0–0.5		0–0.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Aroclor-1254	*NA*	**0.51**		**0.3**		**0.74**		**0.58**	
Aroclor-1260	*NA*	**0.41**		**0.15**		**0.23**		**0.16**	
General Chemistry									
Hexavalent Chromium	*NA*	<4.95	U	<5	U	<5	U	<5	UJ
Nitrocellulose	*NA*	<100	U	<100	U	<100	U	<100	U
Total organic carbon	*NA*	47,000		41,000		89,000		64,000	
pH (pH units)	*NA*	7.19		7.92		7.68		8.24	

[1] denotes background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).

[2] Geochemical parameters are not considered as munitions constituents at the Group 8 MRS and are not considered further in the data evaluation process.

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

< denotes less than.

bgs denotes below ground surface.

BSV denotes background screening value.

Cr^{+3} denotes trivalent chromium.

ID denotes identification.

mg/kg denotes milligrams per kilogram.

MRS denotes Munitions Response Site.

NA denotes that a BSV is not available.

TNT denotes 2,4,6-trinitrotolune.

VQ denotes validation qualifier.

Validation Qualifiers:

J denotes the reported results is an estimated value.

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

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

Table 4-5
SRC Screening Summary for Surface Soil

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Metals										
Aluminum	7429-90-5	4/4	11,200		16,300		13,500	*17,700*	No	Below BSV
Antimony	7440-36-0	4/4	5		22.8		11.5	*0.96*	Yes	Above BSV
Barium	7440-39-3	4/4	127		257		196	*88.4*	Yes	Above BSV
Cadmium	7440-43-9	4/4	6.6		396	J	112	*0*	Yes	Above BSV
Chromium (as Cr^{+3})	7440-47-3	4/4	22.8		39		28.2	*17.4*	Yes	Above BSV
Copper	7440-50-8	4/4	225		711		498	*17.7*	Yes	Above BSV
Iron	4739-89-3	4/4	34,300		54,400		44,050	*35,200*	Yes	Above BSV
Lead	7439-92-1	4/4	300		977		664	*26.1*	Yes	Above BSV
Mercury	7439-97-6	4/4	0.21		0.89		0.5	*0.036*	Yes	Above BSV
Strontium	7440-24-6	4/4	48.6		119		92	*0*	Yes	Above BSV
Zinc	7440-66-0	4/4	346		1,060		724	*61.8*	Yes	Above BSV
Explosives and Propellants										
2,4,6-Trinitrotoluene	118-96-7	1/4	0.3	J	0.3	J	0.23	*NA*	Yes	Detected organic
Nitroguanidine	556-88-7	2/4	0.12	J	0.17	J	0.14	*NA*	Yes	Detected organic
Semivolatile Organic Compounds										
2-Methylnaphthalene	91-57-6	4/4	0.092	J	0.40		0.22	*NA*	Yes	Detected organic
Acenaphthene	83-32-9	2/4	0.045		0.11	J	0.07	*NA*	Yes	Detected organic
Acenaphthylene	208-96-8	2/4	0.051		0.051	J	0.051	*NA*	Yes	Detected organic
Anthracene	120-12-7	4/4	0.041	J	0.19		0.09	*NA*	Yes	Detected organic
Benzo(a)anthracene	56-55-3	4/4	0.11	J	0.41		0.23	*NA*	Yes	Detected organic
Benzo(a)pyrene	50-32-8	4/4	0.069	J	0.27		0.16	*NA*	Yes	Detected organic

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Benzo(b)fluoranthene	205-99-2	4/4	0.15	J	0.46		0.30	*NA*	Yes	Detected organic
Benzo(ghi)perylene	191-24-2	4/4	0.06	J	0.15		0.06	*NA*	Yes	Detected organic
Benzo(k)fluoranthene	207-08-9	4/4	0.042	J	0.23		0.12	*NA*	Yes	Detected organic
Bis(2-Ethylhexyl)phthalate	117-81-7	3/4	0.29	J	2.0		0.82	*NA*	Yes	Detected organic
Carbazole	86-74-8	4/4	0.032	J	0.15		0.08	*NA*	Yes	Detected organic
Chrysene	218-01-9	4/4	0.11	J	0.43		0.24	*NA*	Yes	Detected organic
Dibenzo(a,h)anthracene	53-70-3	3/4	0.026	J	0.064	J	0.05	*NA*	Yes	Detected organic
Dibenzofuran	132-64-9	4/4	0.036	J	0.16		0.08	*NA*	Yes	Detected organic
Di-n-Butyl Phthalate	84-74-2	4/4	0.10	J	0.46		0.20	*NA*	Yes	Detected organic
Fluoranthene	206-44-0	4/4	0.28	J	1.2		0.64	*NA*	Yes	Detected organic
Fluorene	86-73-7	2/4	0.044	J	0.091	J	0.06	*NA*	Yes	Detected organic
Indeno(1,2,3-cd)pyrene	193-39-5	4/4	0.048	J	0.16		0.10	*NA*	Yes	Detected organic
Naphthalene	91-20-3	4/4	0.081	J	0.36		0.21	*NA*	Yes	Detected organic
Phenanthrene	85-01-8	4/4	0.19		0.99		0.50	*NA*	Yes	Detected organic
Pyrene	129-00-0	4/4	0.20	J	0.87		0.46	*NA*	Yes	Detected organic
Polychlorinated Biphenyls										
Aroclor-1254	11097-69-1	4/4	0.30		0.74		0.53	*NA*	Yes	Detected organic
Aroclor-1260	11096-82-5	4/4	0.15		0.41		0.24	*NA*	Yes	Detected organic

[1] denotes background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).
BSV denotes background screening value.
CAS denotes Chemical Abstracts Service.
Cr^{+3} denotes trivalent chromium.
J denotes that the reported result is an estimated value.
mg/kg denotes milligrams per kilogram.
NA denotes that a BSV is not available.
SRC denotes site-related chemical.
VQ denotes validation qualifier.

Table 4-6
Summary of Subsurface Soil Results

Analyte	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Metals							
Aluminum	*19,500*	14,500		10,900		11,800	
Antimony	*0.96*	**3.4**		**5.9**		**2.3**	
Barium	*124*	86.3		113		80	
Cadmium	*0*	**3.4**		**6.3**		**1.1**	
Chromium (as Cr^{+3})	*27.2*	20.1		22.7		16.1	
Copper	*32.3*	**32.7**		**112**		**50.9**	
Iron	*35,200*	31,600		**39,500**		**36,200**	
Lead	*19.1*	**125**		**202**		**44.3**	
Mercury	*0.044*	0.041		**0.24**		0.018	
Strontium	*0*	**43.1**		**38.8**		**27.6**	
Zinc	*93.3*	**144**		**299**		**106**	
Geochemical Metals[2]							
Calcium	*35,500*	11,300		10,800		9,450	
Magnesium	*8,790*	3,830		3,370		4,130	
Manganese	*3,030*	604		846		448	
Explosives and Propellants							
1,3,5-Trinitrobenzene	*NA*	<0.25	U	<0.25	U	<0.25	U
1,3-Dinitrobenzene	*NA*	<0.2	U	<0.2	U	<0.2	U

	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
2,4,6-Trinitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U
2,4-Dinitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U
2,6-Dinitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U
3,5-Dinitroaniline	*NA*	<0.2	U	<0.2	U	<0.2	U
4-Amino-2,6-Dinitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U
HMX	*NA*	<0.2	U	<0.2	U	<0.2	U
m-Nitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U
Nitrobenzene	*NA*	<0.2	U	<0.2	U	<0.2	U
Nitroglycerin	*NA*	<1	U	<1	U	<1	U
Nitroguanidine	*NA*	<0.125	U	<0.125	U	<0.125	U
o-Nitrotoluene	*NA*	<0.25	U	<0.25	U	<0.25	U
PETN	*NA*	<1	U	<1	U	<1	U
p-Nitrotoluene	*NA*	<0.2	U	<0.2	U	<0.2	U
RDX	*NA*	<0.25	U	<0.25	U	<0.25	U
Tetryl	*NA*	<0.2	U	<0.2	U	<0.2	U
Semivolatile Organic Compounds							
1,2,4-Trichlorobenzene	*NA*	<0.06	U	<0.06	U	<0.06	U
1,2-Dichlorobenzene	*NA*	<0.06	U	<0.06	U	<0.06	U
1,3-Dichlorobenzene	*NA*	<0.06	U	<0.06	U	<0.06	U
1,4-Dichlorobenzene	*NA*	<0.06	U	<0.06	U	<0.06	U

	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
Analyte	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
2,4,5-Trichlorophenol	*NA*	<0.305	U	<0.305	U	<0.305	UJ
2,4,6-Trichlorophenol	*NA*	<0.305	U	<0.305	U	<0.305	UJ
2,4-Dichlorophenol	*NA*	<0.305	U	<0.305	U	<0.305	UJ
2,4-Dimethylphenol	*NA*	<0.305	U	<0.305	U	<0.305	UJ
2,4-Dinitrophenol	*NA*	<1	U	<1	U	<1	UJ
2-Chloronaphthalene	*NA*	<0.06	U	<0.06	U	<0.06	U
2-Chlorophenol	*NA*	<1	U	<1	U	<1	UJ
2-Methylnaphthalene	*NA*	<0.06	U	**0.13**		<0.06	U
2-Nitroaniline	*NA*	<0.06	U	<0.06	U	<0.06	U
2-Nitrophenol	*NA*	<0.5	U	<0.5	U	<0.5	UJ
3,3'-Dichlorobenzidine	*NA*	<0.255	U	<0.255	U	<0.255	U
3-Nitroaniline	*NA*	<0.06	U	<0.06	U	<0.06	U
4,6-Dinitro-2-Methylphenol	*NA*	<0.5	U	<0.5	U	<0.5	UJ
4-Bromophenyl Phenyl Ether	*NA*	<0.06	U	<0.06	U	<0.06	U
4-Chloro-3-Methylphenol	*NA*	<1	U	<1	U	<1	UJ
4-Chloroaniline	*NA*	<0.1	U	<0.1	U	<0.1	U
4-Chlorophenyl Phenyl Ether	*NA*	<0.1	U	<0.1	U	<0.1	U
4-Nitrobenzenamine	*NA*	<0.06	U	<0.06	U	<0.06	U
4-Nitrophenol	*NA*	<1	U	<1	U	<1	UJ
Acenaphthene	*NA*	<0.06	U	<0.06	U	<0.06	U
Acenaphthylene	*NA*	<0.06	U	<0.06	U	<0.06	U

	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Anthracene	*NA*	<0.06	U	<0.06	U	<0.06	U
Benzo(a)anthracene	*NA*	<0.06	U	**0.055**	**J**	<0.06	U
Benzo(a)pyrene	*NA*	<0.06	U	**0.04**	**J**	<0.06	U
Benzo(b)fluoranthene	*NA*	<0.06	U	**0.09**	**J**	<0.06	U
Benzo(ghi)perylene	*NA*	<0.06	U	**0.038**	**J**	<0.06	U
Benzo(k)fluoranthene	*NA*	<0.06	U	**0.043**	**J**	<0.06	U
Benzoic Acid	*NA*	<1.5	U	<1.5	U	<1.5	UJ
Benzyl Alcohol	*NA*	<0.205	U	<0.2	U	<0.205	U
Bis(2-Chloroethoxy)methane	*NA*	<0.06	U	<0.06	U	<0.06	U
Bis(2-Chloroethyl)ether	*NA*	<0.06	U	<0.06	U	<0.06	U
Bis(2-Chloroisopropyl)ether	*NA*	<0.06	U	<0.06	U	<0.06	U
Bis(2-Ethylhexyl)phthalate	*NA*	**0.26**	**J**	<0.2	U	<0.205	U
Butyl Benzyl Phthalate	*NA*	<0.205	U	<0.2	U	<0.205	U
Carbazole	*NA*	<0.06	U	<0.06	U	<0.06	U
Chrysene	*NA*	<0.06	U	**0.072**	**J**	<0.06	U
3&4-Methylphenol	*NA*	<1.85	U	<1.8	U	<1.85	U
Dibenzo(a,h)anthracene	*NA*	<0.06	U	<0.06	U	<0.06	U
Dibenzofuran	*NA*	<0.06	U	**0.039**	**J**	<0.06	U
Diethyl Phthalate	*NA*	<0.205	U	<0.2	U	<0.205	U
Dimethyl Phthalate	*NA*	<0.205	U	<0.2	U	<0.205	U
Di-n-Butyl Phthalate	*NA*	<0.205	U	<0.2	U	<0.205	U

Analyte	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
	BSV[1] (mg/kg)	Result (mg/kg)	VQ	Result (mg/kg)	VQ	Result (mg/kg)	VQ
Di-n-Octyl Phthalate	*NA*	<0.1	U	<0.1	U	<0.1	U
Fluoranthene	*NA*	<0.06	U	**0.12**		<0.06	U
Fluorene	*NA*	<0.06	U	<0.06	U	<0.06	U
Hexachlorobenzene	*NA*	<0.06	U	<0.06	U	<0.06	U
Hexachlorobutadiene	*NA*	<0.205	U	<0.2	U	<0.205	U
Hexachlorocyclopentadiene	*NA*	<0.1	U	<0.1	U	<0.1	U
Hexachloroethane	*NA*	<0.06	U	<0.06	U	<0.06	U
Indeno(1,2,3-cd)pyrene	*NA*	<0.06	U	**0.038**	**J**	<0.06	U
Isophorone	*NA*	<0.1	U	<0.1	U	<0.1	U
Naphthalene	*NA*	**0.023**	**J**	**0.13**		<0.06	U
N-Nitroso-di-n-Propylamine	*NA*	<0.205	U	<0.2	U	<0.205	U
N-Nitrosodiphenylamine	*NA*	<0.205	U	<0.2	U	<0.205	U
2-Methylphenol	*NA*	<1	U	<1	U	<1	U
Phenanthrene	*NA*	<0.06	U	**0.12**		<0.06	U
Pyrene	*NA*	<0.06	U	**0.1**	**J**	<0.06	U
Polychlorinated Biphenyls							
Aroclor-1016	*NA*	<0.05	U	<0.05	U	<0.05	U
Aroclor-1221	*NA*	<0.05	U	<0.05	U	<0.05	U
Aroclor-1232	*NA*	<0.05	U	<0.05	U	<0.05	U
Aroclor-1242	*NA*	<0.05	U	<0.05	U	<0.05	U
Aroclor-1248	*NA*	<0.05	U	<0.05	U	<0.05	U

	Location ID:	GR8SS-006M		GR8SS-007M		GR8SS-008M	
	Sample ID:	GR8SS-006M-001-SO		GR8SS-007M-001-SO		GR8SS-008M-001-SO	
	Sample Date:	2/8/12		2/8/12		2/8/12	
	Depth (feet bgs):	4–4.5		4–4.5		4–4.5	
Analyte	**BSV[1] (mg/kg)**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**	**Result (mg/kg)**	**VQ**
Aroclor-1254	*NA*	<0.05	U	**0.33**		<0.05	U
Aroclor-1260	*NA*	<0.05	U	**0.12**		<0.05	U
General Chemistry							
Hexavalent Chromium	*NA*	<5	U	<5	U	<5	U
Nitrocellulose	*NA*	<100	U	<100	U	<100	U
Total organic carbon	*NA*	9,200		23,000		3,300	
pH (pH units)	*NA*	7.09		7.9		7.64	

[1] denotes background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).

[2] Geochemical parameters are not considered as munitions constituents at the Group 8 MRS and are not considered further in the data evaluation process.

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

< denotes less than.

bgs denotes below ground surface.

BSV denotes background screening value.

Cr^{+3} denotes trivalent chromium.

ID denotes identification.

mg/kg denotes milligrams per kilogram.

MRS denotes Munitions Response Site.

NA denotes that a BSV is not available.

VQ denotes validation qualifier.

Validation Qualifiers:

J denotes the reported result is an estimated value.

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

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

Table 4-7
SRC Screening Summary for Subsurface Soil

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Results (mg/kg)	VQ				
Metals										
Aluminum	7429-90-5	3/3	10,900		14,500		12,400	*19,500*	No	Below BSV
Antimony	7440-36-0	3/3	2.3		5.9		3.9	*0.96*	Yes	Above BSV
Barium	7440-39-3	3/3	80		113		93	*124*	No	Below BSV
Cadmium	7440-43-9	3/3	1.1		6.3		3.6	*0*	Yes	Above BSV
Chromium (as Cr^{+3})	7440-47-3	3/3	16.1		22.7		19.6	*27.2*	No	Below BSV
Copper	7440-50-8	3/3	32.7		112		65.2	*32.3*	Yes	Above BSV
Iron	4739-89-3	3/3	31,600		39,500		35,767	*35,200*	Yes	Above BSV
Lead	7439-92-1	3/3	44.3		202		127.8	*19.1*	Yes	Above BSV
Mercury	7439-97-6	3/3	0.018		0.24		0.10	*0.044*	Yes	Above BSV
Strontium	7440-24-6	3/3	27.6		43.1		34.2	*0*	Yes	Above BSV
Zinc	7440-66-0	3/3	106		299		183.0	*93.3*	Yes	Above BSV
Semivolatile Organic Compounds										
2-Methylnaphthalene	91-57-6	1/3	0.13		0.13		0.08	*NA*	Yes	Detected organic
Benzo(a)anthracene	56-55-3	1/3	0.055	J	0.055	J	0.055	*NA*	Yes	Detected organic
Benzo(a)pyrene	50-32-8	1/3	0.04	J	0.04	J	0.05	*NA*	Yes	Detected organic
Benzo(b)fluoranthene	205-99-2	1/3	0.09	J	0.09	J	0.07	*NA*	Yes	Detected organic
Benzo(ghi)perylene	191-24-2	1/3	0.038	J	0.038	J	0.032	*NA*	Yes	Detected organic
Benzo(k)fluoranthene	207-08-9	1/3	0.043	J	0.043	J	0.034	*NA*	Yes	Detected organic
Bis(2-Ethylhexyl)phthalate	117-81-7	1/3	0.26	J	0.26	J	0.22	*NA*	Yes	Detected organic
Chrysene	218-01-9	1/3	0.072	J	0.072	J	0.06	*NA*	Yes	Detected organic
Dibenzofuran	132-64-9	1/3	0.039	J	0.039	J	0.05	*NA*	Yes	Detected organic

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV[1] (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Results (mg/kg)	VQ				
Fluoranthene	206-44-0	1/3	0.12		0.12		0.08	*NA*	Yes	Detected organic
Indeno(1,2,3-cd)pyrene	193-39-5	1/3	0.038	J	0.038	J	0.05	*NA*	Yes	Detected organic
Naphthalene	91-20-3	2/3	0.023	J	0.13		0.07	*NA*	Yes	Detected organic
Phenanthrene	85-01-8	1/3	0.12		0.12		0.08	*NA*	Yes	Detected organic
Pyrene	129-00-0	1/3	0.1	J	0.1	J	0.07	*NA*	Yes	Detected organic
Polychlorinated Biphenyls										
Aroclor-1254	11097-69-1	1/3	0.33		0.33		0.14	*NA*	Yes	Detected organic
Aroclor-1260	11096-82-5	1/3	0.12		0.12		0.07	*NA*	Yes	Detected organic

[1] denotes background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).

BSV denotes background screening value.

CAS denotes Chemical Abstracts Service.

Cr^{+3} denotes trivalent chromium.

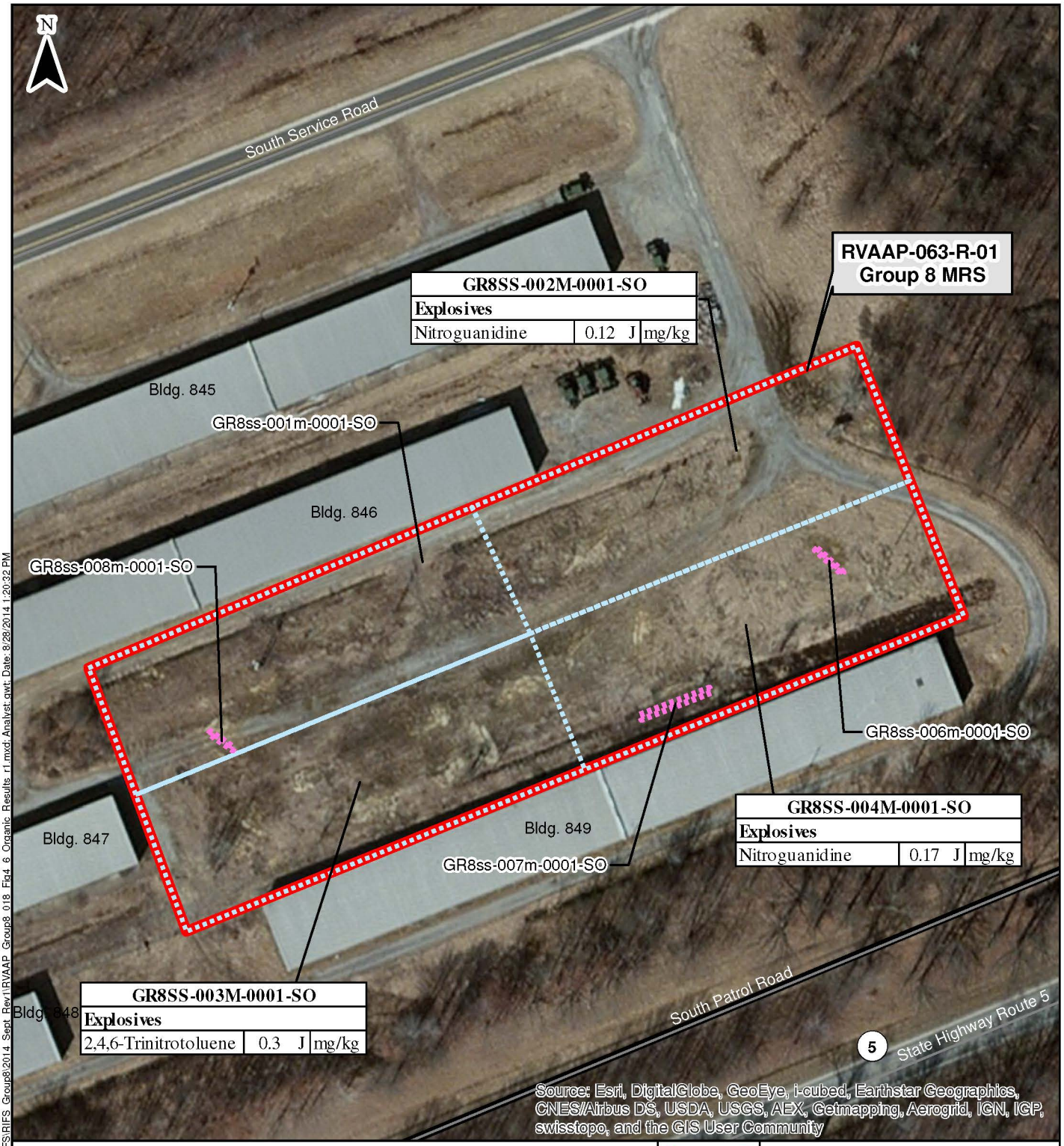
J denotes that the reported result is an estimated value.

mg/kg denotes milligrams per kilogram.

NA denotes that a BSV is not available.

SRC denotes site-related chemical.

VQ denotes validation qualifier.



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Facility Boundary
Group 8 MRS Boundary
Surface ISM Soil Sample Location
Subsurface ISM Soil Sample Location

Notes:
1) J = Result is less than reporting limit but greater than or equal to the method detection limit
2) mg/kg = milligrams per kilogram

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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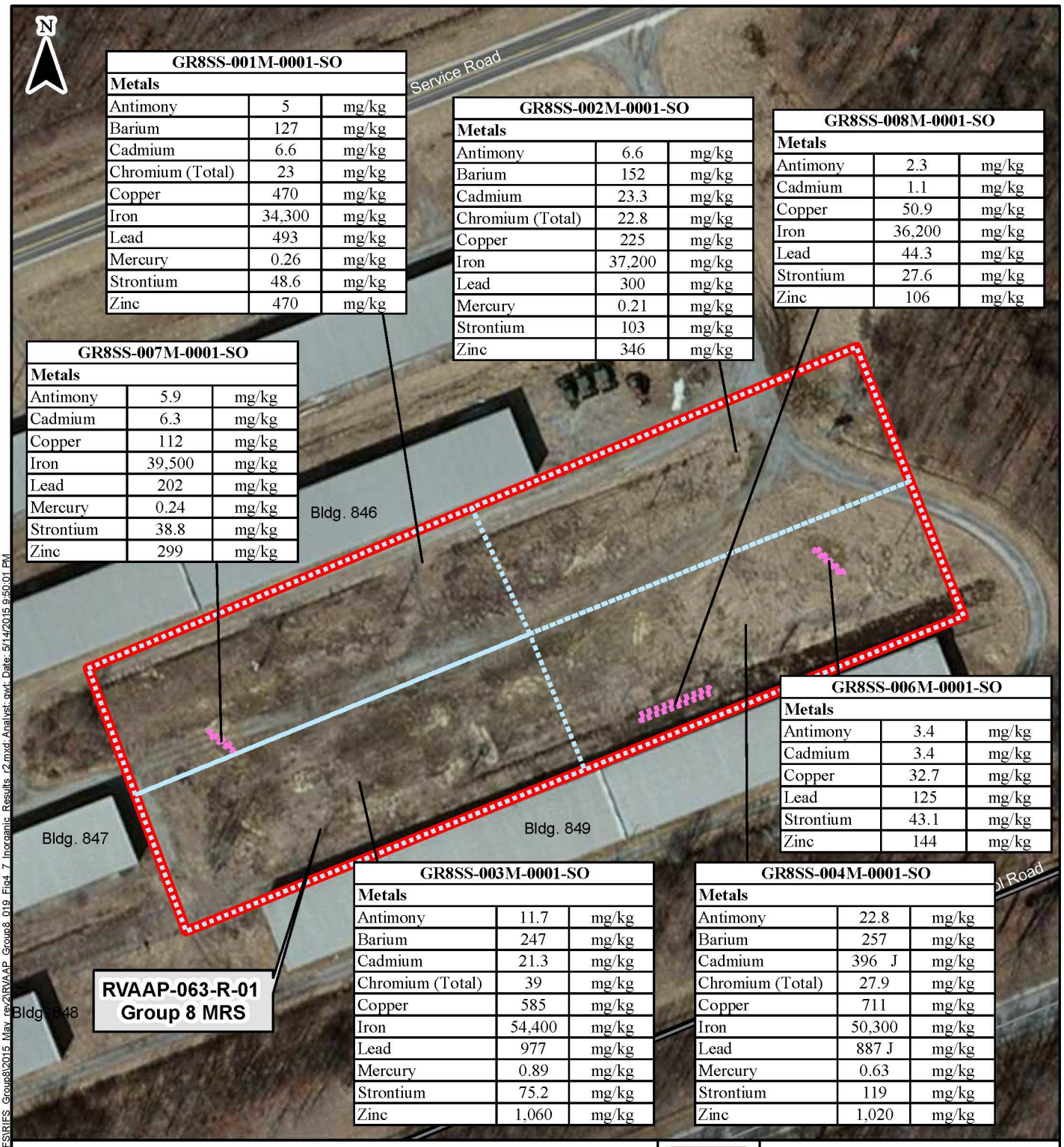
MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 4-6 MC RESULTS, EXPLOSIVES SRCs



GR8SS-001M-0001-SO		
Metals		
Antimony	5	mg/kg
Barium	127	mg/kg
Cadmium	6.6	mg/kg
Chromium (Total)	23	mg/kg
Copper	470	mg/kg
Iron	34,300	mg/kg
Lead	493	mg/kg
Mercury	0.26	mg/kg
Strontium	48.6	mg/kg
Zinc	470	mg/kg

GR8SS-002M-0001-SO		
Metals		
Antimony	6.6	mg/kg
Barium	152	mg/kg
Cadmium	23.3	mg/kg
Chromium (Total)	22.8	mg/kg
Copper	225	mg/kg
Iron	37,200	mg/kg
Lead	300	mg/kg
Mercury	0.21	mg/kg
Strontium	103	mg/kg
Zinc	346	mg/kg

GR8SS-008M-0001-SO		
Metals		
Antimony	2.3	mg/kg
Cadmium	1.1	mg/kg
Copper	50.9	mg/kg
Iron	36,200	mg/kg
Lead	44.3	mg/kg
Strontium	27.6	mg/kg
Zinc	106	mg/kg

GR8SS-007M-0001-SO		
Metals		
Antimony	5.9	mg/kg
Cadmium	6.3	mg/kg
Copper	112	mg/kg
Iron	39,500	mg/kg
Lead	202	mg/kg
Mercury	0.24	mg/kg
Strontium	38.8	mg/kg
Zinc	299	mg/kg

GR8SS-006M-0001-SO		
Metals		
Antimony	3.4	mg/kg
Cadmium	3.4	mg/kg
Copper	32.7	mg/kg
Lead	125	mg/kg
Strontium	43.1	mg/kg
Zinc	144	mg/kg

GR8SS-003M-0001-SO		
Metals		
Antimony	11.7	mg/kg
Barium	247	mg/kg
Cadmium	21.3	mg/kg
Chromium (Total)	39	mg/kg
Copper	585	mg/kg
Iron	54,400	mg/kg
Lead	977	mg/kg
Mercury	0.89	mg/kg
Strontium	75.2	mg/kg
Zinc	1,060	mg/kg

GR8SS-004M-0001-SO		
Metals		
Antimony	22.8	mg/kg
Barium	257	mg/kg
Cadmium	396 J	mg/kg
Chromium (Total)	27.9	mg/kg
Copper	711	mg/kg
Iron	50,300	mg/kg
Lead	887 J	mg/kg
Mercury	0.63	mg/kg
Strontium	119	mg/kg
Zinc	1,020	mg/kg

Facility Boundary
Group 8 MRS Boundary
Surface ISM Soil Sample Location
Subsurface ISM Soil Sample Location

Notes:
1) J = Result is less than reporting limit but greater than or equal to the method detection limit
2) mg/kg = milligrams per kilogram

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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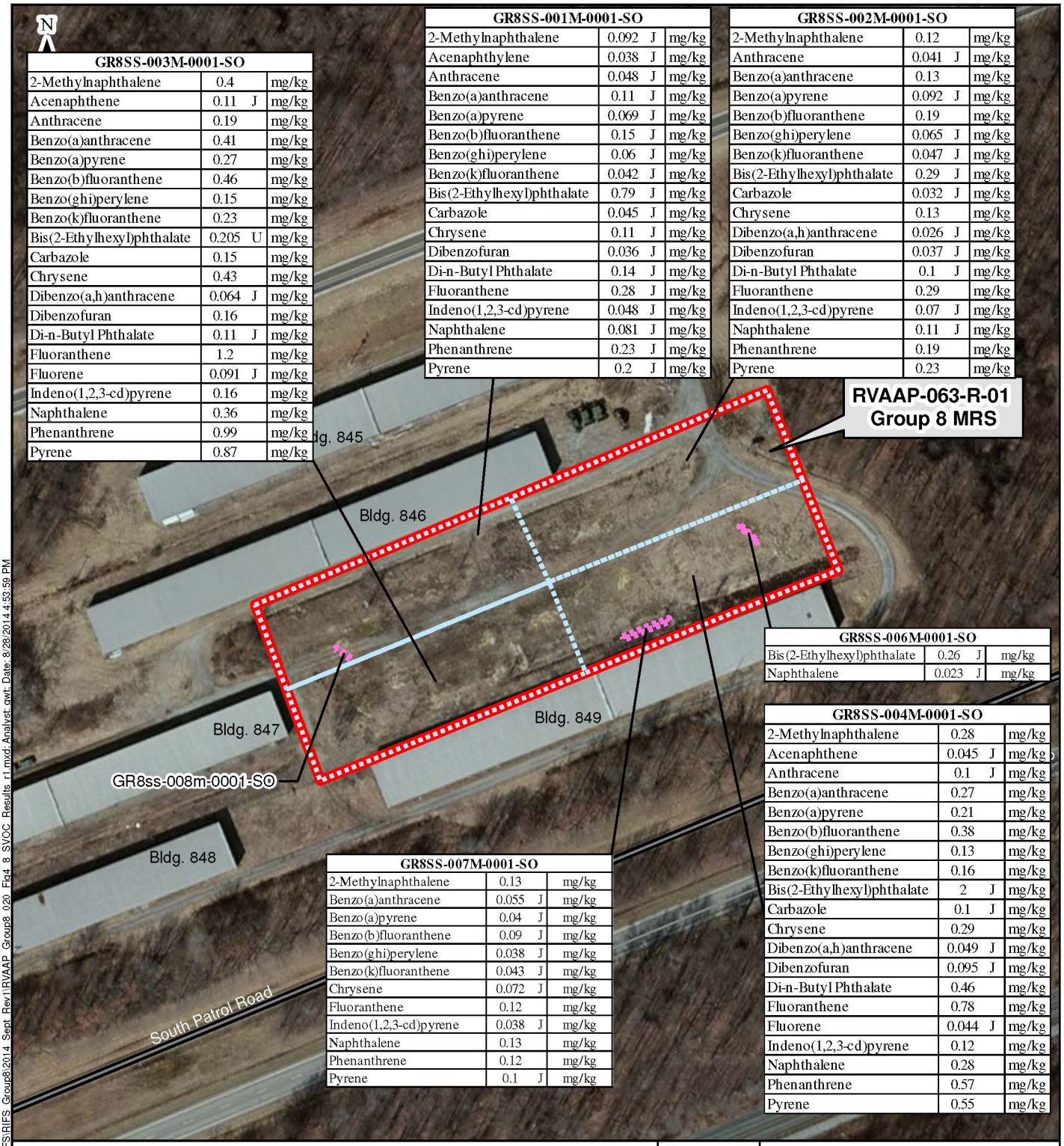
FIGURE 4-7 MC RESULTS, INORGANIC SRCs



GR8SS-003M-0001-SO		
2-Methylnaphthalene	0.4	mg/kg
Acenaphthene	0.11 J	mg/kg
Anthracene	0.19	mg/kg
Benzo(a)anthracene	0.41	mg/kg
Benzo(a)pyrene	0.27	mg/kg
Benzo(b)fluoranthene	0.46	mg/kg
Benzo(ghi)perylene	0.15	mg/kg
Benzo(k)fluoranthene	0.23	mg/kg
Bis(2-Ethylhexyl)phthalate	0.205 U	mg/kg
Carbazole	0.15	mg/kg
Chrysene	0.43	mg/kg
Dibenzo(a,h)anthracene	0.064 J	mg/kg
Dibenzofuran	0.16	mg/kg
Di-n-Butyl Phthalate	0.11 J	mg/kg
Fluoranthene	1.2	mg/kg
Fluorene	0.091 J	mg/kg
Indeno(1,2,3-cd)pyrene	0.16	mg/kg
Naphthalene	0.36	mg/kg
Phenanthrene	0.99	mg/kg
Pyrene	0.87	mg/kg

GR8SS-001M-0001-SO		
2-Methylnaphthalene	0.092 J	mg/kg
Acenaphthylene	0.038 J	mg/kg
Anthracene	0.048 J	mg/kg
Benzo(a)anthracene	0.11 J	mg/kg
Benzo(a)pyrene	0.069 J	mg/kg
Benzo(b)fluoranthene	0.15 J	mg/kg
Benzo(ghi)perylene	0.06 J	mg/kg
Benzo(k)fluoranthene	0.042 J	mg/kg
Bis(2-Ethylhexyl)phthalate	0.79 J	mg/kg
Carbazole	0.045 J	mg/kg
Chrysene	0.11 J	mg/kg
Dibenzofuran	0.036 J	mg/kg
Di-n-Butyl Phthalate	0.14 J	mg/kg
Fluoranthene	0.28 J	mg/kg
Indeno(1,2,3-cd)pyrene	0.048 J	mg/kg
Naphthalene	0.081 J	mg/kg
Phenanthrene	0.23 J	mg/kg
Pyrene	0.2 J	mg/kg

GR8SS-002M-0001-SO		
2-Methylnaphthalene	0.12	mg/kg
Anthracene	0.041 J	mg/kg
Benzo(a)anthracene	0.13	mg/kg
Benzo(a)pyrene	0.092 J	mg/kg
Benzo(b)fluoranthene	0.19	mg/kg
Benzo(ghi)perylene	0.065 J	mg/kg
Benzo(k)fluoranthene	0.047 J	mg/kg
Bis(2-Ethylhexyl)phthalate	0.29 J	mg/kg
Carbazole	0.032 J	mg/kg
Chrysene	0.13	mg/kg
Dibenzo(a,h)anthracene	0.026 J	mg/kg
Dibenzofuran	0.037 J	mg/kg
Di-n-Butyl Phthalate	0.1 J	mg/kg
Fluoranthene	0.29	mg/kg
Indeno(1,2,3-cd)pyrene	0.07 J	mg/kg
Naphthalene	0.11 J	mg/kg
Phenanthrene	0.19	mg/kg
Pyrene	0.23	mg/kg

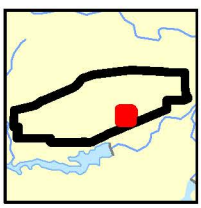
GR8SS-006M-0001-SO		
Bis(2-Ethylhexyl)phthalate	0.26 J	mg/kg
Naphthalene	0.023 J	mg/kg

GR8SS-004M-0001-SO		
2-Methylnaphthalene	0.28	mg/kg
Acenaphthene	0.045 J	mg/kg
Anthracene	0.1 J	mg/kg
Benzo(a)anthracene	0.27	mg/kg
Benzo(a)pyrene	0.21	mg/kg
Benzo(b)fluoranthene	0.38	mg/kg
Benzo(ghi)perylene	0.13	mg/kg
Benzo(k)fluoranthene	0.16	mg/kg
Bis(2-Ethylhexyl)phthalate	2 J	mg/kg
Carbazole	0.1 J	mg/kg
Chrysene	0.29	mg/kg
Dibenzo(a,h)anthracene	0.049 J	mg/kg
Dibenzofuran	0.095 J	mg/kg
Di-n-Butyl Phthalate	0.46	mg/kg
Fluoranthene	0.78	mg/kg
Fluorene	0.044 J	mg/kg
Indeno(1,2,3-cd)pyrene	0.12	mg/kg
Naphthalene	0.28	mg/kg
Phenanthrene	0.57	mg/kg
Pyrene	0.55	mg/kg

GR8SS-007M-0001-SO		
2-Methylnaphthalene	0.13	mg/kg
Benzo(a)anthracene	0.055 J	mg/kg
Benzo(a)pyrene	0.04 J	mg/kg
Benzo(b)fluoranthene	0.09 J	mg/kg
Benzo(ghi)perylene	0.038 J	mg/kg
Benzo(k)fluoranthene	0.043 J	mg/kg
Chrysene	0.072 J	mg/kg
Fluoranthene	0.12	mg/kg
Indeno(1,2,3-cd)pyrene	0.038 J	mg/kg
Naphthalene	0.13	mg/kg
Phenanthrene	0.12	mg/kg
Pyrene	0.1 J	mg/kg

Facility Boundary
Group 8 MRS Boundary
Surface ISM Soil Sample Location
Subsurface ISM Soil Sample Location

Notes:
1) J = Result is less than reporting limit but greater than or equal to the method detection limit
2) U = Not detected or the result is below the detection limit
3) mg/kg = milligrams per kilogram



0 150 300 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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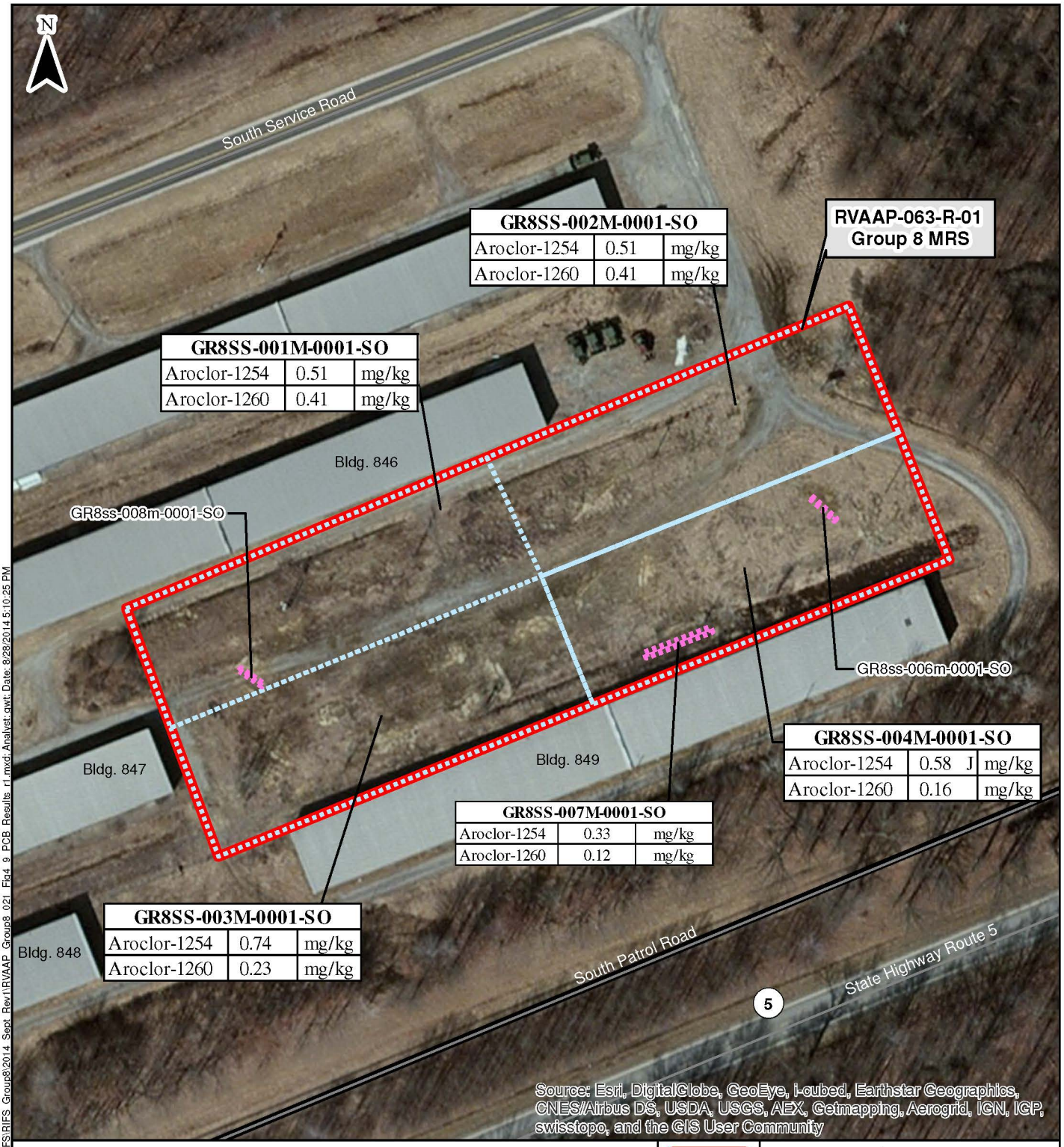
FIGURE 4-8 MC RESULTS, SVOC SRCs



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Facility Boundary
Group 8 MRS Boundary
Surface ISM Soil Sample Location
Subsurface ISM Soil Sample Location

Notes:
1) J = Result is less than reporting limit but greater than or equal to the method detection limit
2) mg/kg = milligrams per kilogram

0 100 200 Feet

Projection : NAD_1983_UTM_Zone_17N

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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 4-9 MC RESULTS, PCB SRCs

event were submitted for laboratory analysis for metals, explosives, nitrocellulose, SVOCs, PCBs, TOC, and pH. Metals analysis consists of inorganic MCs that are attributed to munitions historically used or disposed at an MRS and may be expected to be found at that MRS. For the Group 8 MRS, inorganic MCs identified as metals consist of aluminum, antimony, barium, cadmium, chromium (total), hexavalent chromium, copper, iron, lead, mercury, strontium, and zinc. Analysis for PCBs and SVOCs, including polycyclic aromatic hydrocarbons (PAHs), were recommended at the Group 8 MRS since these chemicals are potentially associated with waste oils and byproducts may have been used or resulted from the burning operations that occurred at the MRS.

The surface soil samples were also submitted for geochemical parameters that included calcium, magnesium and manganese for the rationale discussed in Section 4.3.1.3, "Data Reduction and Screening." However, since a geochemical analysis was not performed for the MRS, geochemical parameters are not evaluated further in this RI.

4.4.1.1 Explosives and Propellants

Two explosives, nitroguanidine and TNT, were detected in the ISM surface soil samples. The facility does not have established BSVs for explosives; therefore, both explosives analytes were retained as SRCs in surface soil for the Group 8 MRS. **Figure 4-6** shows the locations where the explosives identified as SRCs were detected at the Group 8 MRS.

Nitroguanidine was detected in two of the ISM surface soil samples, GR8ss-002M-0001-SO and GR8ss-004M-0001-SO, at a maximum concentration of 0.17 J milligrams per kilogram (mg/kg). The "J"-flagged data are considered estimated and are retained as a detected value. The ISM sample GR8ss-002M-0001-SO was collected from the northeast quadrant of the MRS and the ISM sample GR8ss-004M-0001-SO was collected at the southeast quadrant.

The TNT concentration was detected in one ISM surface soil sample, GR8ss-003M-0001-SO, at a concentration of 0.3 J mg/kg. The sample was collected from the southwest quadrant of the MRS.

4.4.1.2 Metals

Ten of the 11 metals considered as MC associated with munitions potentially burned and disposed at the MRS were detected in the ISM surface soil samples. Antimony, barium, chromium, copper, iron, lead, mercury, and zinc were metals with detected concentrations that exceeded the BSVs and are retained as SRCs. Since the analysis results for hexavalent chromium were not detected, the chromium results in surface soil are assumed to consist nearly entirely in its trivalent (Cr^{+3}) form and is compared to the trivalent screening values in the FWCUG guidance (SAIC, 2010). Cadmium and strontium were detected and retained as SRCs since no facility BSV is available for either metal. Concentrations of aluminum were

detected in the four surface soil samples but were below the BSV. The distribution of the elevated metal concentrations was uniform across the MRS. All of the identified metal SRCs had detected concentrations that exceeded the BSVs at each of the four ISM surface soil sample locations. **Figure 4-7** shows the locations and distribution of inorganic SRCs detected at the Group 8 MRS.

4.4.1.3 SVOCs

A total of 21 SVOCs, 17 of which are PAHs, were identified as SRCs in the ISM surface soil samples collected at the Group 8 MRS. The sample location with the greatest number of detected SVOCs (21) was in ISM sample GR8ss-004M-0001-SO. This sample was collected at the southeast quadrant of the MRS. The distribution of SVOCs across the MRS was relatively uniform as evidenced by the number of SVOCs that were detected in the other three ISM surface soil samples GR8ss-001M-0001-SO (17 detects), GR8ss-002M-0001-S0 (18 detects), and GR8ss-003M-0001-SO (19 detects). **Figure 4-8** shows the locations where the SVOCs SRCs were detected at the Group 8 MRS.

4.4.1.4 PCBs

Two PCBs consisting of Aroclor-1254 and Aroclor-1260 were detected in all four ISM surface soil samples and were retained as SRCs. The Aroclor-1254 concentrations ranged from 0.3 to 0.74 mg/kg, with the maximum concentration detected at ISM sample location GR8ss-003M-0001M-SO collected at the southwest quadrant of the MRS. The Aroclor-1260 concentrations ranged from 0.15 to 0.41 mg/kg, with the maximum concentration detected at ISM sample location GR8ss-001M-0001-SO that was collected at the northwest quadrant of the MRS. **Figure 4-9** shows the locations where the PCB SRCs were detected at the Group 8 MRS.

4.4.2 Subsurface Soil

Data from the RI subsurface soil samples were screened to identify SRCs representing current conditions at the Group 8 MRS. The SRC screening data for the subsurface soil (not including field duplicates or QC samples) included samples G8ss-006M-0001-SO, G8ss-007M-0001-SO, and G8ss-008M-0001-SO. These samples were collected using the ISM and the sample depth for each increment was from 0 to 0.5 feet at the bottom of trench locations where concentrated MD was encountered during the RI field activities. The total depth beneath the ground surface at which the ISM samples were collected within the trenches was 4 to 4.5 feet bgs and represents the subsurface medium.

The ISM subsurface samples were collected at grid locations that encompassed the entire bottom of each trench that was sampled to characterize the subsurface soils for residual MC associated with the buried MD. All ISM subsurface soil samples collected during the RI sampling event were submitted for the same laboratory analyses as for the ISM surface soil

samples that included metals (aluminum, antimony, barium, cadmium, total chromium, hexavalent chromium, copper, iron, lead, mercury, strontium, and zinc), explosives, nitrocellulose, SVOCs, PCBs, TOC, and pH.

The subsurface soil samples were also submitted for geochemical parameters that included calcium, magnesium and manganese for the rationale discussed in Section 4.3.1.3. However, since a geochemical analysis was not performed for the MRS, geochemical parameters are not evaluated further in this RI.

4.4.2.1 Explosives and Propellants

No explosives or propellants were detected in the subsurface soil samples collected from the bottoms of the trenches where buried MD was encountered during the RI field activities at the Group 8 MRS.

4.4.2.2 Metals

Eight of the 11 metals considered as MC associated with munitions potentially burned and disposed at the MRS were detected in the ISM subsurface soil samples. Antimony, copper, iron, lead, mercury, and zinc were metals with detected concentrations that exceeded the BSVs in the subsurface soil samples and are retained as SRCs. Cadmium and strontium were detected and retained as SRCs since no facility BSV is available for either metal. Concentrations of aluminum, barium, and chromium were detected in all three subsurface soil samples, but were below the BSVs. Since the analysis results for hexavalent chromium were not detected, the chromium results in subsurface soil are assumed to consist nearly entirely in its trivalent (Cr^{+3}) form and is compared to the trivalent screening values in the FWCUG guidance (SAIC, 2010). The distribution of the elevated metal concentrations was relatively uniform across the bottoms of the trenches. All of the detected results for antimony, cadmium, copper, lead, strontium, and zinc exceeded the BSVs at each of the three trench locations. Iron concentration exceeded its BSV at two sample locations; ISM sample GR8ss-007M-0001-SO collected at Trench 11-1 and ISM sample GR8ss-008M-0001-SO collected at Trench 14-1. Mercury exceeded its BSV in ISM sample GR8ss-007M-0001-SO only. **Figure 4-7** shows the locations and distribution of inorganic SRCs detected in the trenches at the Group 8 MRS.

4.4.2.3 SVOCs

A total of 14 SVOCs, 12 of which are PAHs, were identified as SRCs in the ISM subsurface soil samples collected at the Group 8 MRS. The subsurface soil sample location with the greatest number of detected SVOCs (13) was in ISM sample GR8ss-007M-0001-SO collected at the bottom of Trench 11-1. Only two SVOCs, bis(2-ethylhexyl)phthalate and naphthalene, were detected in ISM sample GR8ss-006M-0001-SO that was collected at Trench 13-1. This was the only subsurface sample location that bis(2-ethylhexyl)phthalate

was detected. No SVOCs were detected in ISM GR8ss-008M-0001-SO that was collected at Trench 14-1. **Figure 4-8** shows the distribution of the SVOCs identified as SRCs in the burial trenches at the Group 8 MRS.

4.4.2.4 PCBs

Two PCBs consisting of Aroclor-1254 and Aroclor-1260 were detected in the ISM subsurface soil sample GR8ss-007M-0001-SO collected at Trench 11-1 and were retained as SRCs. The detected concentrations for Aroclor-1254 and Aroclor-1260 were 0.33 mg/kg and 0.12 mg/kg, respectively. **Figure 4-9** shows the locations and distribution of where the PCB SRCs were detected in the trenches at the Group 8 MRS.

4.4.3 Summary of Nature and Extent of SRCs

This section presents a summary of the nature and extent of SRCs identified in surface and subsurface soils at the Group 8 MRS following the data evaluation process.

4.4.3.1 Surface Soil

In general, the majority of the SRCs identified in the surface soil medium evaluated for the nature and extent of SRCs occurred throughout the MRS. A total of 35 SRCs were identified in surface soil that included 21 SVOCs, 10 metals, 2 explosives, and 2 PCB analytes, considered as MC associated with past activities at the MRS. The SRCs were identified in the four ISM surface soil samples that were collected across the MRS from same sized sampling units (0.67 acres each) at similar depths of 0 to 0.5 feet bgs. The spatial distribution of the SRCs, in particular the types of metals and SVOCs, are consistent between the sampling units that make up the decision unit for surface soil.

4.4.3.2 Subsurface Soil

A total of 24 SRCs were identified in the ISM soil samples collected from the bottom of three trenches (Trenches 11-1, 13-1, and 14-1) where buried MD was encountered during the RI field activities. The ISM samples consisted of 0.5-foot increments collected at the bottom of each of the trenches at similar depths of 4 to 4.5 feet bgs and were evaluated as subsurface soil in accordance with the FWCUG guidance (SAIC, 2010). These SRCs consisted of 14 SVOCs, 8 metals, and 2 PCB analytes that are considered as MC associated with past activities at the MRS. The spatial distributions of the various metal SRCs are consistent among the three trenches that make up the decision unit for subsurface soil. The SVOC and PCBs SRCs are primarily prevalent at Trench 11-1, where over 1,000 lbs of assorted MD were removed during the RI field activities.

5.0 FATE AND TRANSPORT

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

5.1 Fate and Transport of MEC

Transport of MEC at a MRS is dependent on many factors, including precipitation, soil erosion and freeze/thaw events. These natural processes, in addition to human activity, may result in some movement (primarily vertical) of MEC if present at the MRS. The result of these mechanisms and processes is a potentially different distribution of MEC than the one that may have existed at the time of original release. In addition, MEC items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment. Numerous types of MPPEH were found at the Group 8 MRS during the RI field activities that were documented as safe and determined to be MD. No MEC was found during the RI field work. The MD items located at or near the surface appeared to have succumbed to oxidation caused by exposure to water and air, which may have released MC to the environment.

5.2 Fate and Transport of MC

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

Several important physical and chemical properties of environmental media govern the distribution and behavior of contaminants in these media. Depending upon the specific contaminant and soil conditions, a contaminant may migrate from surface soil to subsurface

soil, stream/wetland sediments, or surface water. A contaminant may also migrate from each of the aforementioned media to the air. The propensity for a contaminant to attain equilibrium conditions in the environment and migrate from one medium to another is an important factor in determining the mobility of a contaminant.

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

Once a contaminant is released to the aquatic environment, it can either volatilize or remain in the aquatic environment. In the aquatic environment, contaminants may be dissolved in the surface water or sorbed to the sediment. Contaminants may move between dissolved and sorbed states depending on a variety of physical and chemical factors. However, no aquatic environments are present within the MRS boundary to be impacted by the presence of MC.

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

5.2.1 Contaminant Sources

This section presents a discussion of each of the SRCs that may result from potential contaminant sources in the environmental media at the Group 8 MRS. A summary of the SRCs identified in the data aggregates at the Group 8 MRS is as follows:

- **Surface Soils (0 to 0.5 feet bgs)**—TNT, nitroguanidine, antimony, barium, cadmium, chromium, copper, iron, lead, mercury, strontium, zinc, PAHs, bis(2-ethylhexyl)phthalate, carbazole, dibenzofuran, di-n-buytl phthalate, and PCBs
- **Subsurface Soils (4 to 4.5 feet bgs)—**antimony, cadmium, copper, iron, lead, mercury, strontium, zinc, PAHs, bis(2-ethylhexyl)phthalate, dibenzofuran, and PCBs

The chemicals analyzed for the MRS were agreed upon in the Work Plan Addendum (Shaw, 2011) and were considered as MC associated with the previous activities at the MRS. The physical and chemical properties and potential release mechanisms and routes of migration for each of the SRCs are discussed in the following sections.

5.2.1.1 Explosives

An explosive compound degradation rate is a function of low-temperature kinetics as well as the influence of light, infrared, ultraviolet (UV) radiation, and microbial action. Degradation products such as nitric oxide, nitrogen dioxide, water, nitrogen, acids, aldehydes, ketones, and large fragments of the parent explosive molecule may be formed. Abiotic and microbial degradation rates are a function of temperature, which varies throughout the year. The fate and transport of the explosives identified at the Group 8 MRS are as follows:

- **TNT**—TNT is a munitions compound currently used for commercial and military purposes. TNT is characterized as being insoluble in water. The vapor pressure of TNT is 1.28×10^{-6} mm of mercury (Hg), which indicates that it will not volatilize to the atmosphere. This is further supported by the Henry's law constant, which for TNT is equal to 1.10×10^{-8} atmospheric cubic meters per mole (atm-m^3/mole). The logarithm (log10) of the organic carbon/water partition coefficient (K_{oc}) is 2.48. This value indicates that TNT will tend to sorb to the organic fraction of soil rather than leaching into groundwater or surface water runoff. TNT can be biotransformed, mineralized, or conjugated into higher molecular weight complex products. It has been shown that a reductive pathway exists for biotransformation of TNT (McCormick et al., 1976; Carpenter et al., 1978; Kaplan and Kaplan 1982a–e, 1985; Greene et al., 1985). This pathway has been observed in a number of systems including aqueous, sewage, soil, and compost. Under anoxic conditions, one or more of the nitro groups is reduced through nitroso and hydroylamino intermediates to form aminodinitrotoluenes (2-amino-4,6-dinitrotolune and 4-amino-2,6-dinitrotolune) and diaminonitrotoluenes (2,4-diamino-6-nitrotoluene and 2,6-diamino-4-nitrotoluene). Biodegradation is the most probable degradative process that may occur for TNT in soil at the Group 8 MRS. Research has shown that TNT can be completely biotransformed through a series of successive denitration steps. Complete degradation of these compounds is anticipated at rates that vary as a function of MRS-specific conditions (Walker and Kaplan, 1992).
- **Nitroguanidine—**Nitroguanidine (also called 1-nitroguanidine) is used as an explosive propellant in munitions. The nitroguanidine reduces the propellant's flash and flame temperature without sacrificing chamber pressure. Nitroguanidine is manufactured from guanine, a naturally occurring substance typically found in the excrement of bats and birds (guano). It is not flammable and is an extremely low sensitivity explosive; however, its detonation velocity is high. Nitroguanidine is expected to have high mobility in soil, and volatilization from soils is not anticipated to be a primary fate process given an estimated Henry’s law constant of 4.45×10^{-16} atm-m^3/mole based upon its vapor pressure and water solubility. In

aquatic environments, nitroguanidine is not expected to adsorb to suspended solids or sediment, and volatilization is also not anticipated (Gorontzy et al., 1994). The aquatic fate of nitroguanidine is dominated by photolysis and is not anticipated to bioconcentrate (Haag et al., 1990). In the atmosphere, nitroguanidine is expected to exist solely in the particulate phase and to be removed from the atmosphere through either wet or dry deposition. As it absorbs light at approximately 260 nanometers (nm) and above, nitroguanidine is susceptible to direct photolysis (National Institute of Standards and Technology Chemistry WebBook, 2010).

5.2.1.2 Metals

Since most metals are indigenous to the earth, they are usually found at varying concentration levels in most environmental media. Some metals concentrate in animal tissue (example, zinc accumulation in fish) while some metals accumulate in plants (example, vanadium). In soil, metal contaminants are dissolved in the soil pore water, adsorbed or ion-exchanged on the surfaces of inorganic soil constituents, complexed with soluble soil organic matter, and precipitated as pure or mixed solids. Metals dissolved in the soil pore water are subject to movement with water and may be transported through the vadose zone to groundwater, and then either volatilized or consumed by plants and aquatic organisms. Unlike organic constituents, metals cannot be degraded; however, the mobility and toxicity of some metals (i.e., arsenic, chromium and mercury) can be altered due to changes in oxidation states. The fate and transport of the metals identified as SRCs at the Group 8 MRS are as follows:

- **Antimony**—Antimony is naturally occurring in the earth's crust. Antimony is sensitive to oxidation/reduction (redox) conditions, and its ability to bind to soil depends on the nature of the soil and the form of antimony. Some studies suggest that antimony is fairly mobile under diverse environmental conditions (Rai et al., 1984), while others suggest that it is strongly adsorbed to soil (Ainsworth, 1988; Foster, 1989; King, 1988). In water, antimony has the capability to undergo photochemical reactions. However, these reactions do not appear to have a significant effect on its aquatic fate (Callahan et al. 1979).
- **Barium**—Barium is a naturally occurring element that is found in small but widely distributed amounts in the earth's crust, especially in igneous rocks, sandstone, shale, and coal (Kunesh, 1978; Miner, 1969). It is an alkaline earth group element, with chemical behavior similar to calcium. Barium enters the environment naturally through the weathering of rocks and minerals. Anthropogenic releases are primarily associated with industrial processes. The element is soluble in low total dissolved solids (TDSs) water, but it will

precipitate with sulfate or carbonate as the minerals barite ($BaSO_4$) or witherite ($BaCO_3$), respectively if those anions are present. These minerals have low solubilities and frequently control barium mobility, especially in higher TDS groundwater. Barium also has a strong affinity to adsorb on manganese oxides as well as iron oxides and clays to a lesser extent. Barium is not very mobile in most soil systems due to its affinity to adsorb on minerals surfaces and its tendency to precipitate as low-solubility sulfate or carbonate minerals. The element does not form volatile compounds in the aquatic environment; therefore, partitioning from water into the atmosphere doesn't occur (EPA, 1979).

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

- **Chromium**—Chromium exists in two valence states in the environment: trivalent (Cr^{+3}) and hexavalent (Cr^{+6}). Typically, trivalent chromium in an aqueous environment is associated with particles, while hexavalent chromium remains in solution. Trivalent chromium is the most thermodynamically stable form of chromium under common environmental conditions. Trivalent chromium has a low solubility and a strong tendency to adsorb to negatively charged soil clay particles. As a result, trivalent chromium is generally immobile and remains close to the origin of deposition. Hexavalent chromium occurs in the environment as the negatively charged species chromate (CrO_4^{-2}) or dichromate ($Cr_2O_7^{-2}$), which are highly soluble and have a low affinity to adsorb on mineral surfaces. As a result, hexavalent chromium tends to be mobile in the environment. Hexavalent chromium will reduce to the trivalent state if it encounters strongly reducing conditions. This process will immobilize the chromium (EPA, 1998).

- **Copper**—Copper is strongly sorbed by soil particles (i.e., clays, metal oxides, and organic matter). Copper binds to soil much more strongly than other divalent cations, and the distribution of copper in the soil solution is less affected by pH than other metals (Gerritse and Van Driel, 1984). The adsorption of copper

generally increases with increasing pH. Like other heavy metals, the movement of copper in soil is also influenced by the permeability of the soil and the amount of clay and iron oxides that are present. These factors tend to attenuate the mobility of copper through adsorption and cation exchange. Volatilization of copper happens to a slight degree, but is insignificant relative to other processes that aid in the reduction of copper concentrations. It sorbs significantly to suspended organic materials and bed sediments, thus reducing its mobility. Much of copper discharged to waterways is in particulate matter and settles out; precipitates out; or adsorbs to organic matter, hydrous iron and manganese oxides, and clay in sediment or in the water column. A significant fraction of the copper is adsorbed within the first hour, and in most cases, equilibrium is obtained with 24 hours (Harrison and Bishop, 1984).

- **Iron**—The redox state of the environment has the greatest influence on the fate and transport of iron. Iron naturally occurs in the environment in two oxidation states: ferrous iron (Fe^{+2}) and ferric iron (Fe^{+3}). Ferric iron is commonly present in oxic soils as iron oxides and hydroxides, which are present as discrete minerals or as coatings on the surfaces of other minerals (Kabata-Pendias, 2001). Iron oxides are relatively insoluble in oxic soils under circumneutral pH conditions and are soluble only under very low pH (below about 4) or high pH (above about 11) (Langmuir et al., 2004). The physical transport of ferric iron occurs mostly due to the erosion of soil material and sediments with the deposition of the minerals occurring at a downgradient point. Under reducing conditions (low redox conditions), ferric iron is reduced to ferrous iron. Free ferrous iron is very soluble and is easily transported under reducing conditions. Precipitation of ferrous iron is possible under strongly reducing conditions in the presence of sulfide (S^{-2}). The precipitation of iron sulfide minerals limits the mobility of ferrous iron; however, if conditions become oxidizing, the precipitated ferrous iron is released to solution and may be subject to reprecipitation (as ferric iron oxides or hydroxides) if oxic conditions are encountered (Kabata-Pendias, 2001).

- **Lead**—Lead is a naturally occurring metal found in small amounts in the earth's crust. Lead salts were used as a ballistic modifying agent in triple-base propellants to modify the general laws of combustion (Folly and Mader, 2004). The use of lead in the manufacture of propellants has been phased out over the years due to its toxicity. The most common form of lead (Pb) found in nature is Pb^{+2}, although lead also exists to a lesser extent as Pb^{+4} and in the organic form with up to four lead-carbon bonds (Kabata-Pendias, 2001). Most lead deposited on surface soil is retained and eventually becomes mixed into the surface layer. However, lead can migrate into subsurface environments. The migration of lead

in the subsurface environment is controlled by the solubility of lead complexes and adsorption to aquifer materials. Adsorption to soil and aquifer material greatly limits the mobility of lead in the subsurface environment. The capacity of soil to adsorb lead increases with pH, cation exchange capacity, organic carbon content, redox potential, and phosphate levels. At pH values above 6, lead is either adsorbed on clay surfaces or forms lead carbonate. Lead exhibits a high degree of adsorption in clay-rich soil (Kabata-Pendias, 2001).

- **Mercury**—Mercury is a naturally occurring metal that can exist in several valence states, including +1, +2, and the elemental form. Mercury has a strong tendency to sorb to the organic fractions of soils, which is influenced by the organic matter content of the soils or sediment. In addition, mercury is strongly sorbed to sesquioxides in soil at a pH higher than 4 (Blume and Brummer, 1991) and to the surface layer of peat (Lodenius and Autio, 1989). The transport and partitioning of mercury in surface waters and soils is influenced by the particular form of the compound. It can be microbally transformed to organic forms such as methyl mercury which is mobile and volatile. Volatile forms of mercury are anticipated to evaporate to the atmosphere, whereas dissolved solid forms partition to particulates in the soil or water column and are transported downward in the water column to the sediments (Hurley et al., 1991). Vaporization of methylated and elemental forms of mercury from soil and surface water is be controlled by temperature, with emissions from contaminated soils being greater in warmer weather (Lindberg et al., 1991). Mercury has been shown to volatilize from the surface of more acidic soils (Warren and Dudas, 1992). It should be noted that mercury does not have a tendency to leach into water. However, surface water may cause mercury in particulate form to move from soil to water, especially in soils with high humic content (Meili, 1991).

- **Strontium**—Strontium is a naturally occurring element with typical soil concentrations around 0.2 mg/kg. It is an alkaline earth element with chemical properties similar to calcium and barium. Elevated concentrations of strontium can be attributed to the disposal of coal ash, incinerator ash, and industrial wastes (Agency for Toxic Substances and Disease Registry [ATSDR], 2004). In addition, strontium nitrate is a component of munitions used/produced at the facility. In soils and sediments, strontium has moderate mobility and sorbs moderately to metal oxides and clays (Hayes and Traina, 1998). It will also precipitate as carbonate or sulfate minerals in higher TDS groundwater. Strontium can be transported through dry or wet deposition (National Council and Radiation Protection & Measurements, 1984). There is limited information about the bioavailability of strontium from environmental media.

- **Zinc**—Zinc occurs naturally in the earth's crust with an average concentration of about 70 mg/kg (Hazardous Substances Data Bank [HSDB], 2012a). The zinc content of noncontaminated soils ranges between 10 and 300 mg/kg (Efroymson et al., 1997a). Zinc is found virtually in all living organisms as an essential element for life; however, it is toxic particularly to aquatic organisms at elevated concentrations. Zinc is expected to adsorb to suspended particles and sediment in the water column and volatilization is not anticipated to be a primary transport pathway (HSDB, 2012a; Eisler, 1993). Zinc generally demonstrates low mobility in the subsurface environment because it is strongly adsorbed to soil at pH 5 or greater (Evans, 1989; Blume and Brummer, 1991). Mobility is also reduced as permeability decreases, and the amount of clay, lime, anhydrous iron oxides, and other ions such as phosphate increases. Volatilization of zinc from soil or water surfaces is not an important transport process because of the ionic nature of zinc salts (Efroymson et al., 1997a).

5.2.1.3 SVOCs

A total of 21 SVOCs were identified as SRCs at the Group 8 MRS, of which 17 analytes were PAHs. The fate and transport of the SVOCs identified as SRCs at the Group 8 MRS is as follows:

- **PAHs—**A combined group of 17 PAHs [acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, 2-methylnaphthalene, phenanthrene, and pyrene] were identified as SRCs in the surface and subsurface soils at the Group 8 MRS. PAHs are a group of more than 100 organic compounds consisting of two or more fused aromatic rings. As a general rule, when PAH compounds grow in molecular weight, their solubility in water decreases, solubility in fat tissues increases, their melting and boiling points increase, and their volatilities decrease. The vapor pressure ranges of the PAHs present indicates that these compounds do not readily volatilize into the atmosphere and is further supported by the Henry's law constant values. The (K_{oc} is a measure of the tendency of a chemical to be sorbed to the organic fraction of soil. The K_{oc} values for the PAHs detected indicate these PAHs have high sorption potentials and will not tend to leach into surface water runoff. This further supported by the octanol/water partition coefficient (K_{ow}) which is an indication of whether a compound will dissolve in a solvent (i.e., n-octanol) or water. The PAHs detected are nonpolar and hydrophobic and, as mentioned

above, will tend to sorb to surface soil rather than partition into the polar water phase (Environment Canada, 1998).

- **Phthalates—**Phthalates are a family of SVOC compounds that are various esters of phthalic acid. The compounds bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were identified as SRCs. The most common uses for these two compounds are as plasticizers, which are added to plastic formulations such as polyvinyl chloride to make them more flexible and increase their durability (Montgomery and Welcom, 1989). They are also added to "plastic explosives" (such as C-4) at concentrations up to several weight percent which allows the explosive to be molded into any desired shape. Both of these compounds have fairly low solubilities so they are slowly leached from their source material. Their high K_{oc} values indicate that they will adsorb on soil particles, which will limit their mobility in the soil column. Their volatilities are low so vapor inhalation is not a key exposure pathway (Group, 1986). The aerobic microbial degradation rates in oxic soil and aquatic environments are high, but they may persist under anaerobic conditions as found in organic-rich soil or wetland sediments (Stales et al., 1997).

- **Carbazole—**Carbazole is an aromatic heterocyclic organic compound. It has a tricyclic structure, consisting of two six-membered benzene rings fused on either side of a five-membered nitrogen-containing ring. Carbazole is formed and released to the atmosphere along with PAH compounds during combustion of organic material (Mackay, 2006). It is present in emissions from waste incineration; tobacco smoke; and rubber, petroleum, coal, and wood combustion. If released to the atmosphere, vapor-phase carbazole is rapidly degraded by photochemically produced hydroxyl radicals (estimated half-life of 3 hours). In the particulate phase, the rate of degradation depends upon the adsorbing substrate. Substrates containing carbon (greater than 5 percent) stabilize carbazole and permit long-range atmospheric transport. Physical removal via wet and dry deposition is important. If released to surface soil, the presence of organic carbon materials, such as peat, will adsorb carbazole and may limit or prevent photolysis. Biodegradation in soil should be the dominant fate process providing the presence of specific degrading bacteria in the microbial community (biodegradation half-life of 4.3 minutes to 6.2 hours in screening studies). If released to water, volatilization and bioconcentration in aquatic organisms is not predicted to be important. Biodegradation and photolysis should be the dominant fate processes in aquatic systems providing specific degrading bacteria and sufficient sunlight. However, carbazole may partition from the water column to sediment and suspended matter, thus limiting the rate of photolysis. Human exposure to

carbazole occurs through inhalation of contaminated air and consumption of contaminated water (HSDB, 2003).

- **Dibenzofuran—**Dibenzofuran is a heterocyclic aromatic compound that has two benzene rings fused to one furan ring in the middle (Montgomery and Welcom, 1989). Its structure is similar to carbazole except it has oxygen instead of an N-H group on the center ring. Dibenzofuran's presence in coal-tar, as a component of heat-transfer oils, as a carrier for dyeing and printing textiles, as an intermediate for production of dyes, and as an antioxidant in plastics may result in its release to the environment through various waste streams. It also forms along with PAH compounds during combustion of organic materials such as wood, coal, and municipal waste. If released to air, a vapor pressure of 0.00248 mm of Hg at 25 degrees Celsius (°C) indicates dibenzofuran will exist solely as a vapor in the ambient atmosphere (National Center for Biotechnology Information [NCBI], 2012). Vapor-phase dibenzofuran will be degraded in the atmosphere by reaction with photochemically produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 4 days. Dibenzofuran absorbs little UV light above 300 nm, but UV absorption rises sharply below 300 nm, which indicates the potential for direct photolysis in the environment. If released to soil, dibenzofuran is expected to have limited mobility based upon an estimated K_{oc} of 4,200. Volatilization from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's law constant of 2.1×10^{-4} atm-m^3/mole. However, adsorption to soil is expected to attenuate volatilization. Indigenous soil microorganisms at contaminated sites can degrade dibenzofuran if stimulated. If released into water, dibenzofuran is expected to adsorb to suspended solids and sediment based upon the estimated K_{oc}. Biodegradation screening tests indicate that dibenzofuran is not readily biodegradable. However in laboratory studies, dibenzofuran was degraded in a few days using subsurface materials which had been contaminated by creosote chemicals. Once microbial adaptation had occurred, dibenzofuran rapidly biotransformed under aerobic conditions. Volatilization from water surfaces is expected to be an important fate process based upon the estimated Henry's law constant. Estimated volatilization half-lives for a model river and model lake are 5 hours and 7 days, respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment. Hydrolysis is not expected to be an important environmental fate process since this compound lacks functional groups that hydrolyze under environmental conditions. Occupational exposure to dibenzofuran may occur through inhalation and dermal, particularly at sites where coal tar, coal tar derivatives, and creosote is produced or used (i.e., the handling of creosote-

treated wood). Monitoring data indicate that the general population may be exposed to dibenzofuran via inhalation of ambient air and dermal contact with wood products containing dibenzofuran (NCBI, 2012).

5.2.1.4 PCBs

PCBs, also known by the Monsanto trade name "Aroclor," were produced by the partial chlorination of biphenyl in the presence of a catalyst. PCBs are distinguished by a four-digit code in which the first two digits indicate the production process and the second two digits indicate the weight percent of chlorine. PCBs as a group are considered to be highly immobile, persistent in the environment, and resistance to oxidation and hydrolysis. In general, the persistence of PCBs increases with an increase in the degree of chlorination (HSDB, 2012b).

- **Aroclor-1254—**Aroclor-1254 is a PCB with an average chlorine content of 54 percent. The vapor pressure of Aroclor-1254 is 7.71×10^{-5} mm of Hg at 25°C and therefore volatilization is not anticipated from dry soils (EPA, 1981). Volatilization from wet soils is possible based on the Henry's law constant of 2.83×10^{-4} atm-m^3/mole (Burkhard et al., 1985). However, the tendency for Aroclor-1254 to adsorb strongly to soils is expected to attenuate volatilization. The log K_{oc} for Aroclor-1254 ranges from 4.6 to 6.1, which indicates that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff, or volatilizing to the atmosphere (EPA, 1981). Based on the same principle volatilization from surface water to the atmosphere is also not anticipated to occur as the PCB will adsorb to sediment and suspended particles in the water column.
- **Aroclor-1260—**Aroclor-1260 is a PCB with an average chlorine content of 60 percent. The vapor pressure of Aroclor-1260 is 4.05×10^{-5} mm of Hg at 25°C and therefore volatilization is not anticipated from dry soils (EPA, 1981). Volatilization from wet soils is possible based on the Henry's law constant of 3.36×10^{-4} atm-m^3/mole (Burkhard et al., 1985). However, the tendency for Aroclor-1254 to adsorb strongly to soils is expected to attenuate volatilization. The log K_{oc} for Aroclor-1260 ranges from 4.8 to 6.8, which indicates that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff, or volatilizing to the atmosphere (EPA, 1981). Based on the same principle volatilization from surface water to the atmosphere is also not anticipated to occur as the PCB will adsorb to sediment and suspended particles in the water column.

5.3 Summary of Fate and Transport

During the RI field activities, buried MD was found at a maximum depth of 4 feet bgs, and native soil was not encountered until 4 feet bgs at 11 of the 14 trench locations. Therefore, at a minimum, surface soil conditions at some areas of the MRS have been disturbed or reworked to approximately 4 feet bgs. The average pH of the soils at the MRS is 7.72.

The explosives SRCs, nitroguanidine and TNT, are considered mobile in soil and the impact to subsurface soils beneath the buried MD to a maximum depth of 4.5 feet bgs were evaluated for this RI. The concentrations of nitroguanidine and TNT that were detected in the surface soil (0 to 0.5 feet bgs) were low and no concentrations of these explosives were detected in the subsurface soils (4.0 to 4.5 feet bgs). Based on the detected results, significant sources of nitroguanidine and TNT were most likely not released during previous activities at the MRS and the low to medium permeability of the soils at the MRS mitigated any potential migration of residual concentrations to subsurface soils.

The metal SRCs have a tendency to sorb to soil at soil pH of 4 or greater depending on the specific analyte. The MRS-specific pH of 7.72 indicates that metal SRCs would be expected to be found in the top several inches where they were released, with only limited downward migration. The detected PCBs and SVOCs that include PAHs are also anticipated to sorb to soils based on the K_{oc} values (i.e., have the tendency to be sorbed to the organic fraction of soil) and are not expected to leach into surface water runoff or migrate through the soil column.

One of the principle migration pathways at the Group 8 MRS is infiltration through the unsaturated soil to groundwater. The depth to groundwater at the MRS is approximately 15 to 20 feet bgs. Evaluation of the groundwater beneath the Group 8 MRS was not included in the most recent *Final Facility-Wide Groundwater Program, Report on the July 2011 Sampling Event* (EQM, 2012), therefore releases of SRCs to groundwater at the Group 8 MRS have not been investigated.

A distinct boundary between native material and fill material was identified at approximately 4 feet at 11 of the 14 trench locations during the RI field activities. The native material is described primarily as the Mahoning-Urban land complex that is somewhat poorly drained to moderately well-drained (AMEC, 2008). Based on the local topography, some of the precipitation falling as rainfall and snow likely leaves the MRS as surface runoff to the drainage ditch along the southern portion of the MRS. The precipitation that does not leave the MRS as surface runoff infiltrates into the subsurface. Some of the infiltrating water is lost to the atmosphere as evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological

conditions throughout the MRS. Based on the aforementioned soil conditions, the low concentrations of explosives, and that metals, SVOCs, and PCBs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath the concentrated areas of buried MD where they were deposited.

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6.0 MEC HAZARD ASSESSMENT

The chapter presents an evaluation of the MEC hazards that may be associated with the Group 8 MRS in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008a). The MEC HA method was developed to evaluate the potential explosive hazard associated with conventional MEC present at an MRS under a variety of MRS-specific conditions, including various cleanup scenarios and land-use assumptions. The MEC HA addresses human health and safety concern 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.

A MEC HA is performed for an MRS when an explosive safety hazard is identified. In the case for the Group 8 MRS, MEC items were reportedly found on the ground surface at the MRS by OHARNG personnel in the past and during the 2007 SI field activities; however, only MD items were found during complete coverage of the MRS during the RI field activities. Taking into consideration, the amount of buried MD that was removed during the RI field work (1,418 lbs), the various types of MD found, the distribution and depth at which the MD was found, the relatively minimal size of the MRS at 2.65 acres, and that MEC was found at the MRS prior to the RI field activities, it was determined that a potential explosive safety hazard may be present at the Group 8 MRS and calculation of a MEC HA score was warranted.

The MEC HA is structured into three components consisting of severity, accessibility, and sensitivity. Each of these components requires input factors that have two or more categories. These input factors are assigned a numeric score that is summed to calculate a hazard level. **Table 6-1** presents the four hazard levels and the corresponding minimum and maximum scores for each level of the MEC HA.

Table 6-1
Summary of the MEC HA Hazard Levels

Hazard Level	Maximum MEC HA Score	Minimum MEC HA Score	Description
1	1000	840	Highest potential explosive hazard condition
2	835	725	High potential explosive hazard condition
3	720	530	Moderate potential explosive hazard condition
4	525	125	Low potential explosive hazard condition

MEC HA denotes Munitions and Explosives of Concern Hazard Assessment.

The MEC 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, 2008a). The MEC HA evaluated in this section is inclusive of the information available for the MRS up to and including the RI field activities and provides a scoring summary for the current and future land use activities, assuming no response actions. The MEC HA in this RI Report does not provide an evaluation of various cleanup and land use control alternatives for the MRS.

The MEC HA workbook prepared for the Group 8 MRS is provided in **Appendix J**. The following sections discuss the components that comprise the MEC HA and provide rationale for the input factors chosen:

6.1 Severity

This component is defined in the MEC HA guidance (EPA, 2008a) as "[t]he potential consequences of the effect (i.e., injury or death) on a human receptor should a MEC item detonate." Two input factors are required to determine this component: (1) *Energetic Material Type* and (2) *Location of Human Receptors*. The first factor describes the hazard associated with MEC known or suspected to be present at the MRS. The second factor accounts for the possibility that secondary receptors could be affected in addition to the receptor that initiated the detonation of a MEC item.

6.1.1 Energetic Material Type

While no MEC items were identified on the surface or during the subsurface intrusive investigation, multiple types of MPPEH that were determined to be MD were uncovered as discussed in Section 4.2, "Intrusive Investigation Results." These MD items consisted of the 40mm grenade, 20mm projectile, 60mm projectile, and 75mm projectile that were expended. These items were conservatively used as input factors to evaluate for the energetic material type, which was determined to be "High Explosives."

6.1.2 Location of Human Receptors

Unintentional detonation of a MEC item would result not only in injury (or death) to the individual initiating the detonation, but also to other receptors that may be exposed to the overpressure or fragmentation hazards from the MEC detonation. For this factor, a determination is made whether there are places where people congregate that are either within the MRS or within the explosive safety-quantity distance (ESQD). The largest ESQD for the Group 8 MRS was determined to be 1,873 feet and is based on the maximum fragment distance-horizontal for a 75mm HE MK1 series, which was one of the MD items

encountered during the RI intrusive investigation activities. **Figure 6-1** presents the ESQD for the Group 8 MRS.

There are no specific areas at the facility within the Group 8 MRS ESQD where people consistently congregate. The vicinity of the MRS at the facility includes controlled-humidity preservation buildings that are currently used for the cold storage of OHARNG equipment and vehicles. State Highway Route 5 is located approximately 250 feet south of the MRS and residential properties are located to the south of State Highway Route 5. The buildings, state highway, and several residential properties are located well within the ESQD. Additionally, current activities at the MRS include maintenance activities and access to the road network to access the adjacent buildings. Therefore, there is the potential for human receptors to be located within the MRS or the ESQD arc.

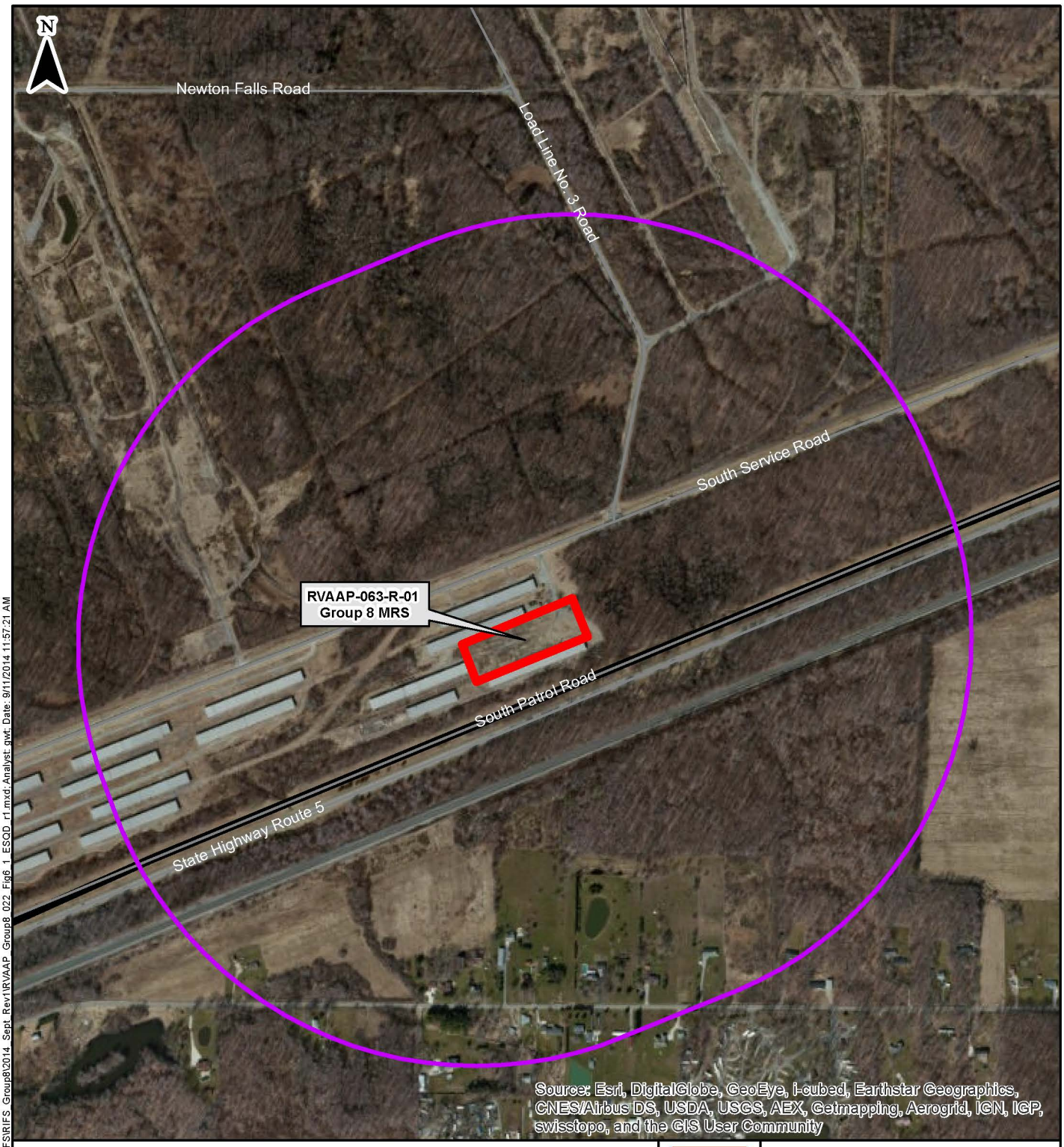
Future land use at the Group 8 MRS will be military training. The input factors for *Location of Human Receptors* will not change for the future land use scenario.

6.2 Accessibility

The accessibility component is defined in the MEC HA guidance (EPA, 2008a) as "[t]he likelihood that a human receptor will be able to come into contact with a MEC item." The following five input factors are required to determine this component:

1. *Site Accessibility*, which describes the ease with which people can access the MRS.
2. *Potential Contact Hours*, which is an estimate of the total number of receptor hours per year. Both the number of receptors and the amount of time they spend at the MRS can affect the likelihood of the receptor encountering MEC.
3. *Amount of MEC* that may be present due to past munitions-related activities at the MRS. This input factor is assessed by determining the type of munitions activities that took place at the MRS (some of the categories are target area, open burning/open detonation area, maneuver area, safety buffer area, storage, etc.)
4. *Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth*, which describes whether MEC items are located where receptor activities take place.
5. *Migration Potential*, which describes the likelihood that MEC items can be moved and potentially exposed by natural processes such as erosion or frost heaving (repeated freeze/thaw cycles).

Details for each of the five input factors are described in the following sections.



Facility Boundary
Group 8 MRS Boundary
Explosive Safety Quantity-Distance Arc:
1,873 feet (Based on 75mm Mk1)

0 700 1,400 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\RavennaGIS_Documents\Project Maps\MMRP\RIFS\RIFS Group8\2014 Sept Rev1\RVAAP Group8 022 Fig6 1 ESQD r1.mxd Analyst: gwt Date: 9/11/2014 11:57:21 AM

FIGURE 6-1 EXPLOSIVE SAFETY QUANTITY-DISTANCE ARC

6.2.1 Site Accessibility

Site Accessibility describes how receptors access the MRS. The Group 8 MRS is located in the south-central portion of facility and is located within the installation perimeter fence. Siebert stakes and warning signs are currently present along the boundary of the MRS warning personnel to stay on the road and/or keep out. There are no additional barriers preventing access to the MRS. The input factor for Site Accessibility is determined to be "Full Accessibility," which indicates that there are no barriers to entry. The anticipated future land use is military training and it is assumed that the current condition at the MRS, which is "Full Accessibility", is the applicable input factor for future use.

6.2.2 Potential Contact Hours

The input factor for Potential Contact Hours estimates the total number of receptor hours per year. Both the number of receptors and the amount of time they spend at the MRS can affect the likelihood of the receptor encountering MEC. In coordination with the OHARNG and the USACE, the Potential Contact Hours at the Group 8 MRS were developed. The Potential Contact Hours took into consideration the activities performed at the MRS as well as the facility receptor/exposure scenarios that are presented in the FWCUG guidance (SAIC, 2010). The following types of activities/receptors/hours were assumed for current use activities at the MRS:

- Security Guard/Maintenance Worker—1 hour per day × 250 days per year = 250 receptor hours per year
- Trespassers—125 people per year × 1 day per person × 2 hours per day = 250 receptor hours per year

Future use activities at the MRS were also calculated, and the following types of activities, receptors, and hours were developed with the USACE and the OHARNG:

- National Guard Trainee—8 people per year × 39 days per person × 24 hours per day = 7,488 receptor hours per year

The receptor hours per year for each activity are then summed and determined to be in one of the following four categories:

1. Many hours (greater than 1,000,000 receptor hours/year)
2. Some hours (100,000 to 999,999 receptor hours/year)
3. Few hours (10,000 to 99,999 receptor hours/year)
4. Very few hours (less than 10,000 receptor hours/year)

Based on the activities that are assumed to be currently taking place, the approximate number of receptor hours per year was determined to be 500 resulting in a category of "very few hours." Even though the assumptions for calculating this input factor are somewhat idealized, the calculated number of receptor hours per year is less than 10 percent of the number for the next highest category; therefore, even if the usage assumptions are changed slightly, the category does not change. For the future use scenario, the number of receptor hours per year increases to 7,488 but the resulting category would remain "very few hours."

6.2.3 Amount of MEC

This input factor qualitatively describes the amount of MEC that may be present due to past munitions-related activities at the MRS. This input factor is assessed by determining the type of munitions activities that took place at the MRS (some of the categories are target area, OB/open detonation (OD) area, maneuver area, safety buffer area, storage, etc.). Based on the MRS history and the results of the intrusive investigation activities performed during the RI field activities that encountered MD which had been demilitarized via burning operations, "Open Burn/Open Detonation (OB/OD) Area" was selected as the applicable category.

6.2.4 Minimum MEC Depth Relative to Maximum Receptor Intrusive Depth

The Minimum MEC Depth Relative to Maximum Receptor Intrusive Depth input factor describes whether MEC items are located where receptor activities take place. Results of the RI intrusive investigation did not find any MPPEH on the ground surface; however, buried MPPEH items that were determined as MD were found. The Group 8 MRS is surrounded by Seibert stakes and signs to warn unauthorized personnel from entering the area. Intrusive activities are not allowed or anticipated for current land uses at the Group 8 MRS; therefore, the input factor for current use activities of "Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth does not overlap with minimum MEC depth" was selected.

The anticipated future land use at the Group 8 MRS is military training with the potential for intrusive activities (USACE, 2005). The input factor for future land use is "Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth overlaps with minimum MEC depth."

6.2.5 Migration Potential

The Migration Potential input factor describes the likelihood that MEC items can be moved and potentially exposed by natural processes such as erosion or frost heaving (repeated freeze/thaw cycles). The frost line for northeast Ohio is 30 inches. MD was found at the Group 8 MRS at depths between ground surface and 48 inches, indicating that any MEC at

the MRS to 30 inches bgs is susceptible to frost heave. Additionally, seasonal heavy rains have the potential to cause frost heave and erosion of soils at the MRS.

In general, the facility has very little difficulty with erosion since slope is typically 5 percent or less (AMEC, 2008). The MRS itself is relatively flat and the soils are compacted due to vehicle traffic and past use of the MRS for equipment storage which has the potential to minimize both frost heave and erosion. Vegetation and small brush provides ground cover for the MRS at areas that are not used for vehicle access to the nearby buildings and is further protection against frost heave and erosion. Based on the current conditions at the MRS, vertical migration of buried MEC that may be present in soil may occur; however, significant overland migration once exposed on the ground surface is unlikely.

6.3 Sensitivity

The Sensitivity component is defined in the MEC HA guidance (EPA, 2008a) as "the likelihood that a MEC item will detonate if a human receptor interacts with it." Two input factors are required to determine this component: (1) *MEC Classification* (Sensitive UXO, UXO, Fuzed Sensitive Discarded Military Munitions [DMM], Fuzed DMM, Unfuzed DMM, and Bulk Explosives) and (2) *MEC Size*. The *MEC Size* input factor is used to account for the ease with which a MEC item can be moved by a receptor, which increases the likelihood that a receptor will pick it up or otherwise disturb the item. Two categories are used to describe the MEC size: (1) "small" (MEC items that weigh less than 90 lbs) or (2) "large" (MEC items that weigh 90 lbs or more).

6.3.1 MEC Classification

The MEC HA guidance (EPA, 2008a) defines six categories of MEC for the following MEC classification input factors:

1. UXO Special Case
2. UXO
3. Fuzed DMM Special Case
4. Fuzed DMM
5. Unfuzed DMM
6. Bulk Explosives

Based on the MRS classification as an "OB/OD Area," and the potential for 40mm projectiles (40mm grenades) and fuzes to be present, as evidenced from the MD encountered during the RI intrusive investigation activities, the MEC HA selected the MEC classification of UXO Special Case."

6.3.2 MEC Size

The MD items identified at the Group 8 MRS included various expended fuzes and casings of 40mm grenades, 20mm projectiles, 60mm projectiles, and 75mm projectiles. All of these items individually weighed less than 90 lbs and category selection for MEC size was "small."

6.4 MEC HA Results

The input factors for the components that comprise the MEC HA are discussed in this section and an explosive hazard level determination has been generated for both the current and future land use activities at the Group 8 MRS.

Based on current conditions at the MRS and the current use scenario for security patrols and maintenance activities, the MEC HA methodology resulted in a score of 705. This equates to a Hazard Level of 3 (moderate potential explosive hazard condition).

The future land use at the MRS will be military training with the potential for intrusive activities. The MEC HA methodology resulted in a score of 805, which equates to a Hazard Level of 2 (high potential explosive hazard condition).

7.0 HUMAN HEALTH RISK ASSESSMENT

The purpose of the HHRA is to document whether SRCs are COPCs and COCs that are present at the Group 8 MRS and pose a risk to current or future human receptors, and to identify which, if any MRS conditions need to be addressed further under the CERCLA process. This HHRA has been prepared in accordance with the Work Plan Addendum (Shaw, 2011) using the streamlined approach to risk decision-making, as described in the FWCUG guidance (SAIC, 2010). In particular, the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals* (Position Paper) (USACE, 2012) describes the applicability and use of the FWCUGs in the following steps:

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

The HHRA was initiated before the finalization of the U.S. Army's Technical Memorandum (ARNG, 2014); therefore, evaluation for the Commercial Industrial Land Use using the Regional Screening Levels (RSLs) for industrial exposure (EPA, 2012) was not included. The following sections discuss the HHRA approach, the data used in the HHRA, and the COPC and COC evaluation for the samples collected at the Group 8 MRS during the RI field activities.

7.1 Data Used in the HHRA

Although no MEC was found at the Group 8 MRS during the RI intrusive activities, a significant quantity of MPPEH that was determined as MD (1,418 lbs) was identified at depths ranging from 1 inch to 4 feet bgs. Based on the MD findings, an MC investigation was performed for the RI to characterize the nature and extent of SRCs associated with previous activities at the MRS. The MC investigation consisted of the collection of four ISM surface soil samples at sampling units that covered the entire MRS and three ISM samples from the bottoms of trenches where concentrated MD was encountered. The increments for the ISM surface soil samples were collected at depths between 0 and 0.5 feet bgs whereas the increments for the ISM soil samples from the trench bottom were collected at 0.5-foot

increments as well but at total depths of 4 to 4.5 feet bgs and were evaluated as subsurface soils as part of the data evaluation process in Section 4.0.

The Group 8 MRS is considered as a single EU based on the future land use. Although, the MRS is being evaluated as a single EU, the soil data collected within the MRS were aggregated by depth intervals for surface and subsurface soil since different future use receptors with different depths of potential exposure are required to be evaluated. The available data used in this HHRA are presented in **Table 7-1**.

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

Sample ID	Sample Date	Depth (feet bgs)	Sample Type	Analysis
Surface Soil				Metals[1], Explosives, Nitrocellulose, SVOCs, PCBs, TOC, pH
GR8SS-001M-0001-SO	2/8/12	0 to 0.5	ISM	
GR8SS-002M-0001-SO				
GR8SS-003M-0001-SO				
GR8SS-004M-0001-SO				
Subsurface Soil				
GR8SS-005M-0001-SO	2/8/12	4 to 4.5	ISM	
GR8SS-006M-0001-SO				
GR8SS-007M-0001-SO				

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

bgs denotes below ground surface.

ID denotes identification.

ISM denotes incremental sampling methodology.

PCB denotes polychlorinated biphenyl.

SVOC denotes semivolatile organic compound.

TOC denotes total organic carbon.

7.2 Human Receptors

The future land use for the Group 8 MRS is military training, and the Representative Receptor is the National Guard Trainee. Evaluation of the Representative Receptor, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, forms the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005b).

The facility has defined exposure depth scenarios for the identified receptors. The defined surface soil exposure depths for the Resident Receptor (Adult and Child) and the National Guard Trainee are 0 to 1 foot bgs and 0 to 4 feet bgs, respectively. The defined exposure depths in subsurface soil for the Resident Receptor (Adult and Child) and the National Guard Trainee are 1 to 13 feet bgs and 4 to 7 feet bgs, respectively (SAIC, 2010). Sampling for MC under the MMRP is selective in general to evaluate identified munitions-related source areas and the potential that MC may have been released from the source areas. The data used in the HHRA are used to evaluate for the receptors at the depths that the samples were collected; however, the data are not intended to evaluate for predefined exposure depth scenarios as is typically performed under the Installation Response Program. The presence of munitions-related source areas at an MRS is the primary driver for determining future actions under the MMRP; however, the HHRA is valuable in identifying potential releases of MC from the source areas and if the MC poses risks to likely human receptors.

The ISM surface soil and bottom of trench samples collected during the RI field activities at the Group 8 MRS were all collected at 0- to 0.5-foot (6-inch) increments because this is the maximum depth that contamination from the presumed burning activities at the MRS or directly beneath MEC or MD on the ground surface or buried in trenches would be expected to vertically migrate in the soil column. This sampling methodology is consistent with the *Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Therefore for this RI Report, surface soil for the Resident Receptor (Adult and Child) and the National Guard Trainee are evaluated as 0 to 0.5 feet bgs, the depths at which the ISM surface soil samples were collected. The ISM subsurface soils were collected at sample depths of 4 to 4.5 feet bgs at the trench locations and are the exposure depth for the evaluation of subsurface soil for both the Resident Receptor (Adult and Child) and the National Guard Trainee. The exposure scenarios for the Resident Receptor (Adult and Child) and the National Guard Trainee based on the RI sample strategy at the Group 8 MRS are summarized as follows:

- Surface soil—0 to 0.5 feet bgs
- Subsurface soil—4 to 4.5 feet bgs

7.3 COPC Identification

The section presents the evaluation of the MRS data and the identification of COPCs for the intended receptors based on future land use. The data for this RI Report was evaluated in accordance with the initial evaluation step presented in the Position Paper (USACE, 2012) to identify SRCs as presented in Section 4.3, "MC Data Evaluation." The evaluation incorporates the same criteria described in Section 4.3.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, and essential

nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected MC at the MRS. To establish COPCs, all chemicals that had not been eliminated to this point were evaluated using the following steps.

- The FWCUGs developed for the Resident Receptor (Adult and Child) and the National Guard Trainee for each chemical were used. If there were no FWCUGs developed for a particular chemical, then the EPA's Residential RSLs were used (2012). If neither a FWCUG nor a RSL was available, then a cleanup goal was developed or another approach was developed in concurrence with USACE and the Ohio EPA. FWCUGs or RSLs were available for all chemicals not previously eliminated; therefore, development of a cleanup goal was not needed.
- The FWCUGs at the 1×10^{-6} (one in a million) excess cancer risk level and noncarcinogenic risk HQ using the 0.1 risk value for each of the receptors was selected.
- A comparison of the selected FWCUG to the exposure point concentration (EPC) was completed. The EPCs for the Group 8 MRS are the maximum detected concentrations.
- The chemical was retained as a COPC if the EPC exceeded the most stringent FWCUG for the Resident Receptor (Adult and Child) or the National Guard Trainee for either one of the 1×10^{-6} excess cancer risk values and the noncarcinogenic HQ using the 0.1 risk value. The EPC was compared to the RSL if no FWCUG was available.

The Work Plan Addendum (Shaw, 2011) specifies that in addition to screening the FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee, evaluation will also be made against the remaining OHARNG receptors in order to ensure that the most stringent receptor is identified. For the chemicals detected at the Group 8 MRS, the FWCUGs for the Resident Receptor (Adult and Child) or National Guard Trainee were less than those for any other OHARNG receptor. As a result, the National Guard Trainee, the most stringent OHARNG receptor, and the Resident Receptor (Adult and Child) were considered for COPC evaluation. The screening values used to evaluate for the identified human receptors are presented in the data summary tables in **Appendix D**.

Tables 7-2 and **7-3** present the screening results for COPCs for the Resident Receptor (Adult and Child) and the National Guard Trainee in accordance with the FWCUG guidance (SAIC, 2010). These tables include the FWCUGs that are based on the lower of the 1×10^{-6} (one in a million) excess cancer risk level and an HQ of 0.1 for noncancer effect values. As previously

mentioned, if a chemical was detected for which there was no FWCUG, the EPA Residential RSLs (2012) were used. The RSLs were based on the lower of values derived considering an excess cancer risk of 10^{-6} and noncancer hazard considering a HQ of 1. However, the RSLs included in these tables were derived based on noncancer risk that were adjusted to a HQ of 0.1 in order to be consistent with the noncancer FWCUGs. The RSL for lead was not adjusted in this manner since it was not derived using the HQ approach. The RSL for lead in soil was based on the value recommended by the EPA as generally safe for residential settings. In some cases, FWCUGs or RSLs were not available for the detected chemical, and values for a closely related compound are used. All such substitutions are noted in the tables.

The COPCs are identified by comparing the maximum detected concentration to the applicable screening criteria. Substances that are considered SRCs as identified in Section 4.0, and for which the maximum detected concentrations is greater than the lowest FWCUG, or the RSL if no FWCUGs are available, are considered COPCs. COPCs identified for the Resident Receptor (Adult and Child) and the National Guard Trainee are summarized in **Table 7-4**.

7.3.1 COPCs in Surface Soil

In all, 11 COPCs were identified in surface soil (0 to 0.5 feet) for the Resident Receptor (Adult and Child) and 2 COPCs were identified for the National Guard Trainee. The COPCs identified for the land use receptors are as follows:

- **Resident Receptor (Adult and Child):** antimony, cadmium, copper, iron, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, Acrolor-1254, and Aroclor-1260
- **National Guard Trainee:** cadmium and lead

Table 7-2 presents the SRC screening process for the COPCs in surface soil. A summary of the COPCs for the Resident Receptor (Adult and Child) and the National Guard Trainee in surface soil is presented in **Table 7-4**.

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Table 7-2
Summary of Screening Results for COPCs in Surface Soil (0–0.5 feet) for the Resident Receptor and the National Guard Trainee

Chemical	Range of Values, mg/kg						Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	NGT FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Metals													
Antimony	5		22.8	J	0.81	0.81	GR8ss-004M	13.6	2.82	175		Yes	Above risk screening criteria for R(A) and R(C)
Barium	127		257	J	0.051	0.25	GR8ss-004M	8,966	1,413	351		No	Below risk screening criteria
Cadmium	6.6		396	J	0.04	0.2	GR8ss-004M	22.3	6.41	10.9		Yes	Above risk screening criteria for R(A), R(C), and NGT
Chromium (as Cr^{+3})	22.8		39		0.14	0.14	GR8ss-003M	19,694	8,147	329,763		No	Below risk screening criteria
Copper	225		711	J	0.4	0.41	GR8ss-004M	2,714	311	25,368		Yes	Above risk screening criteria for R(C)
Iron	34300		54,400		9.1	9.1	GR8ss-003M	19,010	2,313	184,370		Yes	Above risk screening criteria for R(A) and R(C)
Lead	300		977		0.25	0.25	GR8ss-003M	NA	NA	NA	400	Yes	Above risk screening criteria for RSL
Mercury	0.21		0.89		0.0084	0.042	GR8ss-003M	16.5	2.27	172		No	Below risk screening criteria
Strontium	48.3		119		0.081	0.081	GR8ss-004M	NA	NA	NA	4700	No	Below risk screening criteria
Zinc	346		1,060		0.3	0.3	GR8ss-003M	19,659	2,321	187,269		No	Below risk screening criteria
Explosives and Propellants													
2,4,6-Trinitrotoluene	0.3	J	0.3	J	0.4	0.4	GR8ss-003M	21.1	3.65	249		No	Below risk screening criteria
Nitroguanidine	0.12	J	0.17	J	0.25	0.25	GR8ss-004M	NA	NA	NA	610	No	Below risk screening criteria
Semivolatile Organic Compounds													
2-Methylnaphthalene	0.092	J	0.4		0.12	0.12	GR8ss-003M	238	30.6	2,384		No	Below risk screening criteria
Acenaphthene	0.045	J	0.11	J	0.12	0.12	GR8ss-003M	207	122	3,815		No	Below risk screening criteria
Acenaphthylene	0.038	J	0.051	J	0.12	0.12	GR8ss-004M	207	122	3,815		No	Below risk screening criteria
Anthracene	0.041	J	0.19		0.12	0.12	GR8ss-003M	207	122	3,815		No	Below risk screening criteria
Benzo(a)anthracene	0.11	J	0.41		0.12	0.12	GR8ss-003M	0.221	0.65	4.77		Yes	Above risk screening criteria for R(A)
Benzo(a)pyrene	0.069	J	0.27		0.12	0.12	GR8ss-003M	0.022	0.065	0.477		Yes	Above risk screening criteria for R(A) and R(C)
Benzo(b)fluoranthene	0.15	J	0.46		0.12	0.12	GR8ss-003M	0.221	0.65	4.77		Yes	Above risk screening criteria for R(A)
Benzo(ghi)perylene	0.06	J	0.15		0.12	0.12	GR8ss-003M	207	122	3,815		No	Below risk screening criteria
Benzo(k)fluoranthene	0.042	J	0.23		0.12	0.12	GR8ss-003M	2.21	6.5	47.7		No	Below risk screening criteria
Bis(2-Ethylhexyl)phthalate	0.29	J	2	J	0.4	0.41	GR8ss-004M	NA	NA	NA	35	No	Below risk screening criteria
Carbazole	0.032	J	0.15		0.12	0.12	GR8ss-003M	69.4	44.6	835		No	Below risk screening criteria
Chrysene	0.11	J	0.43		0.12	0.12	GR8ss-003M	22.1	65	477		No	Below risk screening criteria
Dibenzo(a,h)anthracene	0.026	J	0.064	J	0.12	0.12	GR8ss-003M	0.022	0.065	0.477		Yes	Above risk screening criteria for R(A)
Dibenzofuran	0.036	J	0.16		0.12	0.12	GR8ss-003M	119	15.3	1,192		No	Below risk screening criteria
Di-n-Butyl Phthalate	0.1	J	0.46		0.4	0.41	GR8ss-003M	NA	NA	NA	610	No	Below risk screening criteria
Fluoranthene	0.28	J	1.2		0.12	0.12	GR8ss-003M	276	163	5,087		No	Below risk screening criteria
Fluorene	0.044	J	0.091	J	0.12	0.12	GR8ss-003M	737	243	11,458		No	Below risk screening criteria

Chemical	Range of Values, mg/kg						Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	NGT FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Indeno(1,2,3-cd)pyrene	0.048	J	0.16		0.12	0.12	GR8ss-003M	0.221	0.65	4.77		No	Below risk screening criteria
Naphthalene	0.081	J	0.36		0.12	0.12	GR8ss-003M	368	122	1,541		No	Below risk screening criteria
Phenanthrene	0.19		0.99		0.12	0.12	GR8ss-003M	207	122	3,815		No	Below risk screening criteria
Pyrene	0.2	J	0.87		0.12	0.12	GR8ss-003M	207	122	3,815		No	Below risk screening criteria
Polychlorinated Biphenyls													
Aroclor-1254	0.3		0.74		0.1	0.2	GR8ss-003M	0.203	0.12	3.46		Yes	Above risk screening criteria for R(A) and R(C)
Aroclor-1260	0.15		0.41		0.1	0.2	GR8ss-001M	0.203	0.349	3.46		Yes	Above risk screening criteria for R(A) and R(C)

[1] denotes FWCUG is lower noncarcinogenic FWCUG at a HQ of 0.1 and excess carcinogenic FWCUG risk of 10^{-6}.

[2] denotes RSL is for residential soil and is based on noncancer risk adjusted to HQ of 0.1 (as opposed to published value based on a HQ of 1), except lead.

COPC denotes chemical of potential concern.

Cr^{+3} denotes trivalent chromium.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

FWCUGs for pyrene used for acenaphthene, acenaphthylene, anthracene, benzo(g,h,i) perylene, naphthalene, and phenanthrene.

HQ denotes hazard quotient.

J denotes that the result is less than the reporting limit but greater than or equal to the method detection limit.

MDC denotes maximum detected concentration.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

NGT denotes National Guard Trainee.

R(A) denotes Resident Receptor (Adult).

R(C) denotes Resident Receptor (Child).

RSL denotes Regional Screening Level for residential soil (April 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1), except lead.

VQ denotes validation qualifier.

Table 7-3
Summary of Screening Results for COPCs in Subsurface Soil (4.0–4.5 feet) for the Resident Receptor and the National Guard Trainee

Chemical	Range of Values, mg/kg						Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	NGT FWCUG[1] (mg/kg)	RSL[2] (mg/kg)	COPC?	COPC Justification
	Detected Concentrations				Reporting Limits								
	Minimum	VQ	Maximum	VQ	Minimum	Maximum							
Metals													
Antimony	2.3		5.9		0.81	0.81	GR8SS-007M	13.6	2.82	175		Yes	Above risk screening criteria for R(C)
Barium	80		113		0.051	0.051	GR8SS-007M	8,966	1,413	351		No	Below risk screening criteria
Cadmium	1.1		6.3		0.041	0.041	GR8SS-007M	22.3	6.41	10.9		No	Below risk screening criteria
Chromium (as Cr^{+3})	16.1		22.7		0.14	0.14	GR8SS-007M	19,694	8,147	329,763		No	Below risk screening criteria
Copper	32.7		112		0.41	0.41	GR8SS-007M	2,714	311	25,368		No	Below risk screening criteria
Iron	31,600		39,500		9.1	9.1	GR8SS-007M	19,010	2,313	184,370		Yes	Above risk screening criteria for R(A) and R(C)
Lead	44.3		202		0.25	0.25	GR8SS-007M	NA	NA	NA	400	No	Below risk screening criteria
Mercury	0.018		0.24		0.0084	0.0084	GR8SS-007M	16.5	2.27	172		No	Below risk screening criteria
Strontium	27.6		43.1		0.081	0.081	GR8SS-006M	NA	NA	NA	4,700	No	Below risk screening criteria
Zinc	106		299		0.3	0.3	GR8SS-007M	19,659	2,321	187,269		No	Below risk screening criteria
Semivolatile Organic Compounds													
2-Methylnaphthalene	0.13		0.13		0.12	0.12	GR8SS-007M	238	30.6	2,384		No	Below risk screening criteria
Benzo(a)anthracene	0.055	J	0.055	J	0.12	0.12	GR8SS-007M	0.221	0.65	4.77		No	Below risk screening criteria
Benzo(a)pyrene	0.04	J	0.04	J	0.12	0.12	GR8SS-007M	0.022	0.065	0.477		Yes	Above risk screening criteria for R(A)
Benzo(b)fluoranthene	0.09	J	0.09	J	0.12	0.12	GR8SS-007M	0.221	0.65	4.77		No	Below risk screening criteria
Benzo(ghi)perylene	0.038	J	0.038	J	0.12	0.12	GR8SS-007M	207	122	3,815		No	Below risk screening criteria
Benzo(k)fluoranthene	0.043	J	0.043	J	0.12	0.12	GR8SS-007M	2.21	6.5	47.7		No	Below risk screening criteria
Bis(2-Ethylhexyl)phthalate	0.26	J	0.26	J	0.4	0.41	GR8SS-006M	NA	NA	NA	35	No	Below risk screening criteria
Chrysene	0.072	J	0.072	J	0.12	0.12	GR8SS-007M	22.1	65	477		No	Below risk screening criteria
Dibenzofuran	0.039	J	0.039	J	0.12	0.12	GR8SS-007M	119	15.3	1,192		No	Below risk screening criteria
Fluoranthene	0.12		0.12		0.12	0.12	GR8SS-007M	276	163	5,087		No	Below risk screening criteria
Indeno(1,2,3-cd)pyrene	0.038	J	0.038	J	0.12	0.12	GR8SS-007M	0.221	0.65	4.77		No	Below risk screening criteria
Naphthalene	0.023	J	0.13		0.12	0.12	GR8SS-007M	368	122	1,541		No	Below risk screening criteria
Phenanthrene	0.12		0.12		0.12	0.12	GR8SS-007M	207	122	3,815		No	Below risk screening criteria
Pyrene	0.1	J	0.1	J	0.12	0.12	GR8SS-007M	207	122	3,815		No	Below risk screening criteria
Polychlorinated Biphenyls													
Aroclor-1254	0.33		0.33		0.1	0.1	GR8SS-007M	0.203	0.12	3.46		Yes	Above risk screening criteria for R(A) and R(C)
Aroclor-1260	0.12		0.12		0.1	0.1	GR8SS-007M	0.203	0.349	3.46		No	Below risk screening criteria

Table 7-3 (continued)
Summary of Screening Results for COPCs in Subsurface Soil (4.0–4.5 feet) for the Resident Receptor and the National Guard Trainee

[1] denotes FWCUG is lower noncarcinogenic FWCUG at a HQ of 0.1 and excess carcinogenic FWCUG risk of 10^{-6}.
[2] denotes RSL is for residential soil and is based on noncancer risk adjusted to a HQ of 0.1 (as opposed to published value based on a HQ of 1), except lead.
COPC denotes chemical(s) of potential concern.
Cr^{+3} denotes trivalent chromium.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*
FWCUGs for pyrene used for naphthalene and phenanthrene.
HQ denotes hazard quotient.
J denotes that the result is less than the reporting limit but greater than or equal to the method detection limit.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable/available.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
RSL denotes Regional Screening Level for residential soil (April 2012). Those based on noncancer risk are adjusted to a HQ of 0.1 (as opposed to published value based on HQ of 1), except lead.
VQ denotes validation qualifier.

Table 7-4
Summary of COPCs for the Resident Receptor and the National Guard Trainee

Receptor	COPCs Identified[1]
Surface Soil (0 to 0.5 feet bgs)	
Resident Receptor (Adult and Child)	Antimony
	Cadmium
	Copper
	Iron
	Lead
	Benzo(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Dibenzo(a,h)anthracene
	Aroclor-1254
	Aroclor-1260
National Guard Trainee	Cadmium
	Lead
Subsurface Soil (4 to 4.5 feet bgs)	
Resident Receptor (Adult and Child)	Antimony
	Iron
	Benzo(a)pyrene
	Aroclor-1254

[1] denotes COPCs identified by screening surface and subsurface soil data; see Table 7-2 and Table 7-3 for screening.
bgs denotes below ground surface.
COPC denotes chemical of potential concern.

7.3.2 COPCs in Subsurface Soil

In all, four COPCs were identified in subsurface soil (4 to 4.5 feet) for the Resident Receptor (Adult and Child). No COPCs were identified for the National Guard Trainee in subsurface soil. The COPCs identified for the Resident Receptor (Adult and Child) in subsurface soil consisted of antimony, iron, benzo(a)pyrene, and Aroclor-1254.

Table 7-2 presents the SRC screening process for the COPCs in subsurface soil. A summary of the COPCs identified for the Resident Receptor (Adult and Child) in subsurface soil is presented in **Table 7-4**.

7.4 COC Evaluation

This section presents the COC evaluation process for the human health risk receptors. The COCs are identified through additional screening of the COPCs identified in Section 7.2. The

determination of COCs for the Group 8 MRS was conducted in accordance with the Position Paper (USACE, 2012) as follows:

- The FWCUG values for the Resident Receptor (Adult and Child) and the Representative Receptor for the planned use by the OHARNG were selected using the 1×10^{-5} carcinogenic value and the noncancer value at an HQ of 1.
- All carcinogenic and noncarcinogenic risk values for all receptors and all critical effects and target organs are reported.
- A comparison of the FWCUG to the EPC was conducted. The EPC was the maximum detected concentration due to the small number of samples.
- For carcinogens and noncarcinogens, the EPCs were compared to the target risk FWCUG using the Sum of Ratios method presented in the Position Paper (USACE, 2012).
- The chemical was retained as a COC if: (1) the EPC exceeded the most stringent risk value for either the Resident Receptor (Adult), Resident Receptor (Child), or the Representative Receptor(s) for the future land use, considering the 1×10^{-5} (one in one hundred thousand) carcinogenic value and the noncancer value for an HQ of 1.0, or (2) the Sum of Ratios for all carcinogens or all noncarcinogens that may affect the same organ was greater than 1 and the chemical contributed at least 5 percent to the sum.

The use of the Sum of Ratios approach is intended to account for additive effects from exposure to multiple chemicals that can cause the same effect (i.e., cancer) or affect the same target organ. Each of these steps is discussed in more detail below.

7.4.1 FWCUG Selection for COC Determination

The FWCUGs that are used to reflect the future use of the Group 8 MRS by the OHARNG are based on the most likely future receptor that will use the property. For the future use of this area, the Representative Receptor is the National Guard Trainee. The FWCUGs used also include those for the Resident Receptor (Adult and Child) receptors to evaluate COCs for future unrestricted land use. The FWCUGs selected are those based on a 1×10^{-5} (one in one hundred thousand) excess cancer risk for carcinogenic effects and an HQ of 1 for noncarcinogenic effects.

The FWCUGS for the identification of COCs in surface and subsurface soils for the Resident Receptor (Adult and Child) are provided in **Table 7-5** and **Table 7-6**, respectively. The FWCUGS for the identification of COCs in surface soil for the National Guard Trainee is provided in **Table 7-5**.

Table 7-5
Summary of COC Evaluation for Noncancer Risk Effects in Surface Soil (0–0.5 feet) for the Resident Receptor

Parameter	EPC (mg/kg)	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to R(C) FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Neurotoxicity							
Lead	977	400	Neurotoxicity, behavioral effects	2.44	100%	Yes	Sum of ratios by target organ > 1
			Sum of Ratios—Neurotoxicity:	**2.4**			
Gastrointestinal Effects							
Copper	711	3,106	Gastrointestinal, hepatic, and renal effects	0.229	9%	No	Contribution to sum > 5%, but ≤ 10% (see text)
Iron	54,400	23,125	Gastrointestinal effects	2.35	91%	Yes	Contribution to sum > 5%
			Sum of Ratios—Gastrointestinal Effects:	**2.6**			
Vascular Effects							
Antimony	22.8	28.2	Longevity, blood glucose, and cholesterol	0.809	100%	No	Sum of ratios by target organ ≤ 1
			Sum of Ratios—Vascular Effects:	**0.81**			
Renal Effects							
Cadmium	396	64.1	Significant proteinuria	6.18	96%	Yes	Contribution to sum > 5%
Copper	711	3,106	Gastrointestinal, hepatic, and renal effects	0.229	4%	No	Contribution to sum ≤ 5%
			Sum of Ratios—Renal Effects:	**6.4**			
Liver Effects							
Copper	711	3,106	Gastrointestinal, hepatic, and renal effects	0.229	100%	No	Sum of ratios by target organ ≤ 1
			Sum of Ratios—Liver Effects:	**0.23**			

Table 7-5 (continued)
Summary of COC Evaluation for Noncancer Risk Effects in Surface Soil (0–0.5 feet) for the Resident Receptor

Parameter	EPC (mg/kg)	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to RFC FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Skin/Eye Effects							
Aroclor-1254	0.74	1.2	Ocular exudate, inflamed and prominent Meibomian glands	0.617	100%	No	Sum of ratios by target organ ≤ 1
			Sum of Ratios—Skin Effects:	**0.62**			

[1] *denotes FWCUG is noncarcinogenic FWCUG at HQ of 1. Only child FWCUG is shown, as this is lower than adult for noncancer effects. Value for lead is residential soil RSL.*

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum concentration.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

mg/kg denotes milligrams per kilogram.

R(C) denotes Resident Receptor (Child).

RSL denotes Regional Screening Level.

Table 7-6
Summary of COC Evaluation for Cancer Risk in Surface Soil (0–0.5 feet) for the Resident Receptor

Parameter	EPC (mg/kg)	BSV (mg/kg)	R(A) FWCUG[1] (mg/kg)	Ratio of EPC to R(A) FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Antimony	22.8	0.96	NA	NA	NA	No	Not carcinogenic
Cadmium	396	ND	12,491	0.0317	1.27%	No	Contribution to sum < 5%
Copper	711	17.7	NA	NA	NA	No	Not carcinogenic
Iron	54,400	23,100	NA	NA	NA	No	Not carcinogenic
Lead	977	26.1	NA	NA	NA	No	Not carcinogenic
Aroclor-1254	0.74	NA	2.03	0.3645	14.56%	Yes	Contribution to sum > 5%
Aroclor-1260	0.41	NA	2.03	0.2020	8.07%	Yes	Contribution to sum > 5%
Benzo(a)anthracene	0.41	NA	2.21	0.1855	7.41%	Yes	Contribution to sum > 5%
Benzo(a)pyrene	0.27	NA	0.221	1.2217	48.81%	Yes	Contribution to sum > 5%
Benzo(b)fluoranthene	0.46	NA	2.21	0.2081	8.32%	Yes	Contribution to sum > 5%
Dibenzo(a,h)anthracene	0.064	NA	0.221	0.2896	11.57%	Yes	Contribution to sum > 5%
			Sum of Ratios:	**2.5**			

[1] denotes FWCUG is cancer risk FWCUG at risk of 10^{-5} for adult; values for child are higher.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum concentration.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

mg/kg denotes milligrams per kilogram.

NA denotes not applicable.

ND denotes not detected.

R(A) denotes Resident Receptor (Adult).

7.4.2 EPC Development

The maximum detected concentrations were used for the COC evaluation due to the small number of samples taken from Group 8 MRS and because all samples were taken using ISM techniques. The EPCs used are provided in **Table 7-5** through **Table 7-7**.

7.4.3 Comparison of EPCs to FWCUGs

The EPCs are compared to the FWCUGs for cancer and noncancerous effects through the development of a ratio (USACE, 2012). These ratios are summed to account for potential cumulative effects. For noncancerous effects, the ratios are summed for target organs, which are shown for each COPC as reported in the FWCUG guidance (SAIC, 2010). COCs are identified if one of the following occurs:

- The cancer or noncancer ratio for a given COPC is greater than 1.
- The sum of the ratios for cancer or noncancer effects for any target organ is greater than 1, and the COPC contributes more than 5 percent to the sum.

Table 7-5 through **Table 7-10** evaluate which COPCs have been identified as COCs, and the justification for COPCs that are not considered COCs. The COCs identified for all receptors are summarized in **Table 7-11**.

7.4.4 COCs in Surface Soil

As part of the COC evaluation in surface soils (0 to 0.5 feet), copper was identified as contributing 9 percent to the Sum of Ratios for gastrointestinal effects (**Table 7-5**). In general, the Position Paper (USACE, 2012) dictates that chemicals contributing greater than 5 percent to the Sum of Ratios for a given effect be identified as COCs. However, if the contribution is less than 10 percent the chemical can be excluded with justification. In the case of the Group 8 MRS, the concentration of copper was much less than the FWCUG for the Resident Receptor (Adult) at an HQ of 1. Since the contribution of copper to the Sum or Ratios is less than 10 percent, it was excluded as a COC.

COCs were identified in surface soil for both the Resident Receptor (Adult and Child) and the National Guard Trainee. In all, nine COCs, cadmium, iron, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, Aroclor-1254, and Aroclor-1260, were identified in surface soil for the Resident Receptor (Adult and Child). Cadmium and lead were identified as two COCs in surface soil for the National Guard Trainee. **Table 7-11** presents the screening results for the COCs in the surface soil for the Resident Receptor (Adult and Child) and the National Guard Trainee.

Table 7-7
Summary of COC Evaluation for Noncancer Risk Effects in Subsurface Soil (4–4.5 feet) for the Resident Receptor

Parameter	EPC (mg/kg)	R(C) FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to R(C) FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Gastrointestinal Effects							
Iron	39,500	23,125	Gastrointestinal effects	1.71	100%	Yes	Sum of ratios by target organ > 1
			Sum of Ratios—Gastrointestinal Effects:	**1.7**			
Vascular Effects							
Antimony	5.9	28.2	Longevity, blood glucose, and cholesterol	0.21	100%	No	Sum of ratios by target organ ≤ 1
			Sum of Ratios—Vascular Effects:	**0.21**			
Skin/Eye Effects							
Aroclor-1254	0.33	1.2	Ocular exudate, inflamed and prominent Meibomian glands	0.28	100%	No	Sum of ratios by target organ ≤ 1
			Sum of Ratios—Skin Effects:	**0.28**			

[1] denotes FWCUG is noncarcinogenic FWCUG at HQ of 1. Only child FWCUG is shown, as this is lower than adult for noncancer effects. Value for lead is residential soil RSL.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum concentration.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

HQ denotes hazard quotient.

mg/kg denotes milligrams per kilogram.

R(C) denotes Resident Receptor (Child).

RSL denotes Regional Screening Level.

Table 7-8
Summary of COC Evaluation for Cancer Risk in Subsurface Soil (4–4.5 feet) for the Resident Receptor

Parameter	EPC (mg/kg)	BSV (mg/kg)	R(A) FWCUG[1] (mg/kg)	Ratio of EPC to R(A) FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Antimony	5.90	0.96	NA	NA	NA	No	Not carcinogenic
Iron	22,523	35,200	NA	NA	NA	No	Not carcinogenic
Aroclor-1254	0.33	NA	2.03	0.1626	47.32%	No	Sum of ratios $\leq$ 1
Benzo(a)pyrene	0.040	NA	0.221	0.1810	52.68%	No	Sum of ratios $\leq$ 1
			Sum of Ratios:	**0.34**			

[1] denotes FWCUG is cancer risk FWCUG at risk of 10^{-5} for adult; values for child are higher.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum concentration.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

mg/kg denotes milligrams per kilogram.

NA denotes not applicable.

R(A) denotes Resident Receptor (Adult).

Table 7-9
Summary of COC Evaluation for Noncancer Risk Effects in Surface Soil (0–0.5 feet) for the National Guard Trainee

Parameter	EPC (mg/kg)	NGT FWCUG[1] (mg/kg)	Target Organ	Ratio of EPC to NGT FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Neurotoxicity							
Lead	977	800	Neurotoxicity, behavioral effects	1.22	100%	Yes	Sum of ratios by target organ > 1
			Sum of Ratios—Neurotoxicity:	**1.2**			
Renal Effects							
Cadmium	396	3,292	Significant proteinuria	0.120	100%	No	Sum of ratios by target organ ≤ 1
			Sum or Ratios—Renal Effects:	**0.12**			

[1] *denotes FWCUG is noncarcinogenic FWCUG at HQ of 1; value for lead is industrial soil RSL.*

COC denotes chemical of concern.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

EPC denotes exposure point concentration. EPC is maximum concentration.

HQ denotes hazard index.

mg/kg denotes milligrams per kilogram.

NGT denotes National Guard Trainee.

RSL denotes Regional Screening Level.

Table 7-10
Summary of COC Evaluation for Cancer Risk in Surface Soil (0–0.5 feet) for the National Guard Trainee

Parameter	EPC (mg/kg)	BSV (mg/kg)	NGT FWCUG[1] (mg/kg)	Ratio of EPC to NGT FWCUG	% Contribution to the Total Sum	COC?	COC Justification
Cadmium	396	ND	109	3.63	100%	Yes	Sum of ratios > 1
Lead	977	NA	NA	NA	NA	No	Not carcinogenic
			Sum of Ratios:	**3.6**			

[1] denotes FWCUG is cancer risk FWCUG at risk of 10^{-5} for adult.

BSV denotes background screening value.

COC denotes chemical of concern.

EPC denotes exposure point concentration. EPC is maximum concentration.

FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP *(SAIC, 2010).*

mg/kg denotes milligrams per kilogram.

NA denotes not applicable.

ND denotes not detected.

NGT denotes National Guard Trainee.

Table 7-11
Summary of COCs for the Resident Receptor and the National Guard Trainee

Receptor	COCs Identified[1]
Surface Soil (0 to 0.5 feet bgs)	
Resident Receptor (Adult and Child)	Cadmium
	Iron
	Lead
	Benzo(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Dibenzo(a,h)anthracene
	Acrolor-1254
	Acrolor-1260
	Iron
National Guard Trainee	Cadmium
	Lead
Subsurface Soil (4 to 4.5 feet bgs)	
Resident Receptor (Adult and Child)	Iron

[1] denotes COCs are identified by evaluating noncancerous hazard and cancer risk, see Tables 7-5 through 7-10.
bgs denotes below ground surface.
COC denotes chemical of concern.

7.4.5 COCs in Subsurface Soil

Iron was the only COC identified for the Resident Receptor (Adult and Child) in subsurface soils (4 to 4.5 feet bgs). No COCs were identified for the National Guard Trainee in subsurface soils. **Table 7-11** presents the screening results for the COCs in the subsurface soil.

7.5 Conclusions of the HHRA

The HHRA indicates that detected COCs in surface soil present potential risks to the Resident Receptor (Adult and Child) that is evaluated for Unrestricted (Residential) Land Use and the National Guard Trainee; the Representative Receptor for the future land use at the MRS.

Iron was detected above the background screening criteria in two of the three subsurface soil samples (GR8SS-007M-0001-SO and GR8SS-008M-0001-SO). The most stringent FWCUG for iron in subsurface soil is 23,125 mg/kg and is less than its BSV of 35,200 mg/kg. The maximum iron concentration of 39,500 mg/kg is well within an order of magnitude above the BSV for iron and is most likely representative of existing background conditions.

While iron is identified as a COC based on the two ISM subsurface soil sample results above the screening criteria, the further consideration of iron as a COC is not recommended. Although evaluated as an MC associated with the MRS, iron is typically evaluated as an essential nutrient and the EPA does not consider iron to be a concern if it is present at concentrations that are slightly above naturally occurring levels (USACE, 2005). Therefore, the iron concentrations detected are unlikely to pose risks to human receptors.

7.6 Uncertainty Assessment

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

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

The identification of COPCs and COCs is based on the identification of SRCs. The identification of SRCs is largely based on facility BSVs for surface and subsurface soils. As shown in **Table 7-4**, several metals were identified as COPCs. This comparison is subject to uncertainties in both the MRS data and background data sets.

The evaluation of chromium in this assessment is based on the FWCUGs for trivalent chromium (Cr^{+3}). This assumption was made since soil samples were analyzed for hexavalent chromium, and it was not detected in any sample. Therefore, this assumption represents a minor uncertainty to the risk assessment.

A number of substances detected at the MRS have no FWCUGs. In these cases, the EPA's Residential RSLs for soil (2012) were used as the screening values for all receptors. This provides a conservative evaluation since RSLs used are based on residential exposure. In some cases, if no FWCUGs or RSLs were available, screening values for closely related chemicals were used. This assumption represents an uncertainty to the risk assessment, although the frequency of detection and concentrations of most substances without FWCUGs

or RSLs were quite low. In addition, the chemicals for which there was a FWCUG available were the ones that had been detected in previously completed investigations at the facility. This means that if a chemical lacks a FWCUG, it is likely not an SRC from a facility-wide perspective.

The selection of the maximum detected concentration as the EPC provides a conservative evaluation of potential exposures at the Group 8 MRS, and may overestimate exposure and risk for the entire site. The selection of receptors also represents an uncertainty to the risk assessment. However, the Resident Receptor (Adult and Child) is assumed to be a future receptor in both the COPC and COC evaluations, representing a conservative evaluation of possible future exposures. In addition, the National Guard Trainee is used to evaluate the future use at the MRS. Therefore, risks are not expected to be underestimated for other future uses.

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8.0 ECOLOGICAL RISK ASSESSMENT

The ERA evaluates the potential for adverse effects posed to ecological receptors from potential releases at Group 8 MRS and was prepared in accordance with the Unified Approach to ERAs that was established at sites under environmental investigation at the facility (USACE, 2011). The ERA is consistent with the process described in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) and the *Risk Assessment Handbook Volume II: Environmental Evaluation* (USACE, 2010). Other supporting documents used in the preparation of the ERA include the EPA *Ecological Risk Assessment Guidance for Superfund* (EPA guidance) (1997) and the *Ohio EPA Ecological Risk Assessment Guidance Document* (Ohio EPA guidance) (2008); the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996); and the *Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Guidance Bulletin No. 1* (EPA, 1996).

Consistent with the Unified Approach for performing ERAs at the facility (USACE, 2011), a screening level ERA (SLERA) was performed on the Group 8 MRS. The SLERA is an initial screening step in the ERA 8-step approach as described in EPA (1997) guidance. The SLERA comprises Steps 1, 2, and the first part of Step 3 (often referred to as Step 3a), in which a refinement of the chemicals initially selected as chemicals of potential ecological concern (COPECs) is performed prior to determining whether additional investigation is necessary. If the SLERA indicates that additional investigation is warranted, it is followed by a more comprehensive baseline ERA (BERA) by completing the second part of Step 3 (i.e., "Step 3b") through Step 7. Step 8 is a risk management step that occurs after information presented in the previous steps of the ERA has been fully considered. The Ohio EPA guidance (2008) presents a similar "tiered" approach that allows for a progression through four levels of the ERA as required by the findings and conclusions of each level: Level I Scoping, Level II Screen, Level III Baseline, and Level IV Field Baseline. Levels I and II are approximately equivalent to Steps 1 and 2 of a SLERA. Level III includes food chain modeling using exposure dose and toxicity estimates for generic receptors using conservative assumptions, and is incorporated as part of Step 3a in the SLERA if it is considered necessary to refine COPECs. The Level IV Field Baseline is equivalent to the BERA (Steps 3b through 7), where conservative assumptions used in the Level III Baseline are modified using MRS-specific information.

As stated previously, the SLERA under the Unified Approach includes Steps 1 through 3a of the 8-step process for ERAs (EPA, 1997). This is equivalent to a Level I and II evaluation according to the Ohio EPA process, and is also consistent with the ERA approach described in USACE guidance (2003b and 2010) and the facility Unified Approach (USACE, 2011). A

BERA is not considered necessary for this MRS, and the ERA process is terminated following the completion of the SLERA.

8.1 Scope and Objectives

The goal of the SLERA was to evaluate the potential for adverse ecological effects to ecological receptors from MC at the Group 8 MRS. This objective was met by characterizing the ecological communities in the vicinity of the MRS, determining the particular contaminants present, identifying pathways for receptor exposure, and estimating the magnitude of the likelihood of potential adverse effects to identified receptors. The SLERA addressed the potential for adverse effects to the vegetation, wildlife, threatened and endangered species, and wetlands or other sensitive habitats associated with the MRS.

The objective of the SLERA was to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from former activities at the Group 8 MRS. The results of the SLERA would contribute to the overall characterization of the MRS and may be used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives.

The SLERA uses MRS-specific analyte concentration data for surface soil from the Group 8 MRS. Risks to ecological receptors were evaluated by performing a multistep screening process in which, after each step, the detected analytes in soil were either deemed to pose negligible risk and eliminated from further consideration or carried forward to the next step in the screening process to a final conclusion of being a COPEC. COPECs are analytes whose concentrations are great enough to pose potential adverse effects to ecological receptors. Following the determination of COPECs, an ecological CSM is developed that describes the selection of receptors, exposure pathways, assessment and measurement endpoints, and accounts for cumulative effects.

8.2 Level I Scoping

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

8.2.1 Site Description and Land Use

The Group 8 MRS is flat and includes gravel roads and grass areas. Buildings near the MRS are currently used to store military equipment. The area is used by vehicles to access the adjacent storage buildings. Both MEC and MC were identified as concerns at the MRS

during the 2007 SI field activities and the SI Report recommended that further characterization was necessary to address the MEC and MC concerns (e^2M, 2008).

Current activities at the Group 8 MRS include maintenance activities and access to the road network to access adjacent buildings. The future land use at the MRS is military training (USACE, 2005).

8.2.2 Ecological Significance

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

The topography across the MRS is relatively flat and local surface water drainage is toward the drainage ditch along southern MRS boundary. There are no streams or ponds located within the MRS and the MRS is not located within a designated floodplain.

The Group 8 MRS is categorized as "Other Land" in the Anderson Classification of plant communities, which is a category typically used for disturbed and/or paved areas lacking identifiable vegetation communities. The MRS abuts an Oak-Maple Swamp Forest community to its east (AMEC, 2008). Because of its small size, lack of vegetation structure and other habitat features required by most organisms, and human presence, the Group 8 MRS represents a low-quality habitat for most ecological receptors other than ruderal plants and some small-range receptors (i.e., robins, mice, etc.).

8.2.3 Facility Management Goals

The INRMP (AMEC, 2008) was developed by the OHARNG as the primary guidance document and tool for managing natural resources at the facility. The management goals presented in the INRMP have relevance to maintaining the ecological resources at the facility and, in some instances, the MRS as well. There are no populations of rare plants, animal species, wildlife resources, wetlands, or surface waters at the MRS. Therefore, the management goals for these natural resources as presented in the INRMP are not applicable. A drainage ditch is present along the southeast corner of the MRS and receives surface water from the surrounding area, and military vehicles drive through the MRS to access nearby buildings. Therefore, the most appropriate management goal for the MRS is to manage soils to maintain productivity and to prevent and repair erosion in accordance with state and federal laws and regulations.

8.2.4 Terrestrial Resources

This section summarizes the terrestrial resources identified for the Group 8 MRS that are evaluated in this SLERA.

8.2.4.1 Special Interest Areas and Important Places and Resources

Special interest areas are ecosystems that are not federally protected and have no legal standing, but are areas that host state-listed species, are representative of historical ecosystems, or are otherwise noteworthy. No special interest areas on or near the Group 8 MRS have been identified from the natural heritage data searches (AMEC, 2008).

8.2.4.2 Wetlands

Planning level surveys (i.e., desktop review of wetlands data and resources [National Wetlands Inventory maps, aerials etc.]) for wetlands were conducted for the entire facility, including the Group 8 MRS. A jurisdictional wetlands delineation has not been completed at the MRS. No wetlands have been identified at the Group 8 MRS (AMEC, 2008).

8.2.4.3 Animal Populations

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

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

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

An abundance of wildlife is present at the facility. A total of 35 species of land mammals, 214 species of birds, 41 species of fish, and 34 species of amphibians and reptiles have been identified on the facility (AMEC, 2008). Available habitat at the Group 8 MRS is extremely limited, and consists of a mixture of mowed grass, gravel access roads, and patches of ruderal vegetation. Only species adapted to such impacted environments, such as the

American robin (*Turdus migratorius*) and deer mouse (*Peromyscus maniculatus*), are likely to use the MRS with any regularity. Other birds such as the song sparrow (*Melospiza melodia*), white-tailed deer (*Odocoileus virginianus*), and raccoon (*Procyon lotor*), and woodchuck (*Marmota monax*) are present at the installation (ODNR, 1997) and may use the habitat present at the Group 8 MRS sporadically.

8.2.4.4 Threatened, Endangered, and Other Rare Species Information

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

Biological inventories have been performed across the facility. There are no known documented sightings of threatened, endangered, or rare species at the MRS (AMEC, 2008).

8.2.5 Level I Conclusions and Recommendations

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

8.3 Level II Screening

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

8.3.1 Ecological CSM

The ecological CSM depicts and describes the known and expected relationships among the stressors, pathways, and assessment endpoints that are considered in the SLERA, along with a rationale for their inclusion. Two ecological CSMs are presented for this Level II Screen. One ecological CSM is associated with the media screening conducted during the Level II Screen (**Figure 8-1**). The other ecological CSM (**Figure 8-2**) represents a preliminary CSM for a Level III Baseline, should one be considered necessary. The ecological CSMs for the Group 8 MRS were developed using the available MRS-specific information and

professional judgment. The contamination mechanism, source media, transport mechanisms, exposure media, exposure routes, and ecological receptors for the ecological CSMs are described below.

8.3.1.1 Contamination Source

The contamination source includes potential releases of MC associated with reported OB operations and MD burial activities that occurred at the MRS that may have impacted surface soil.

8.3.1.2 Source Medium

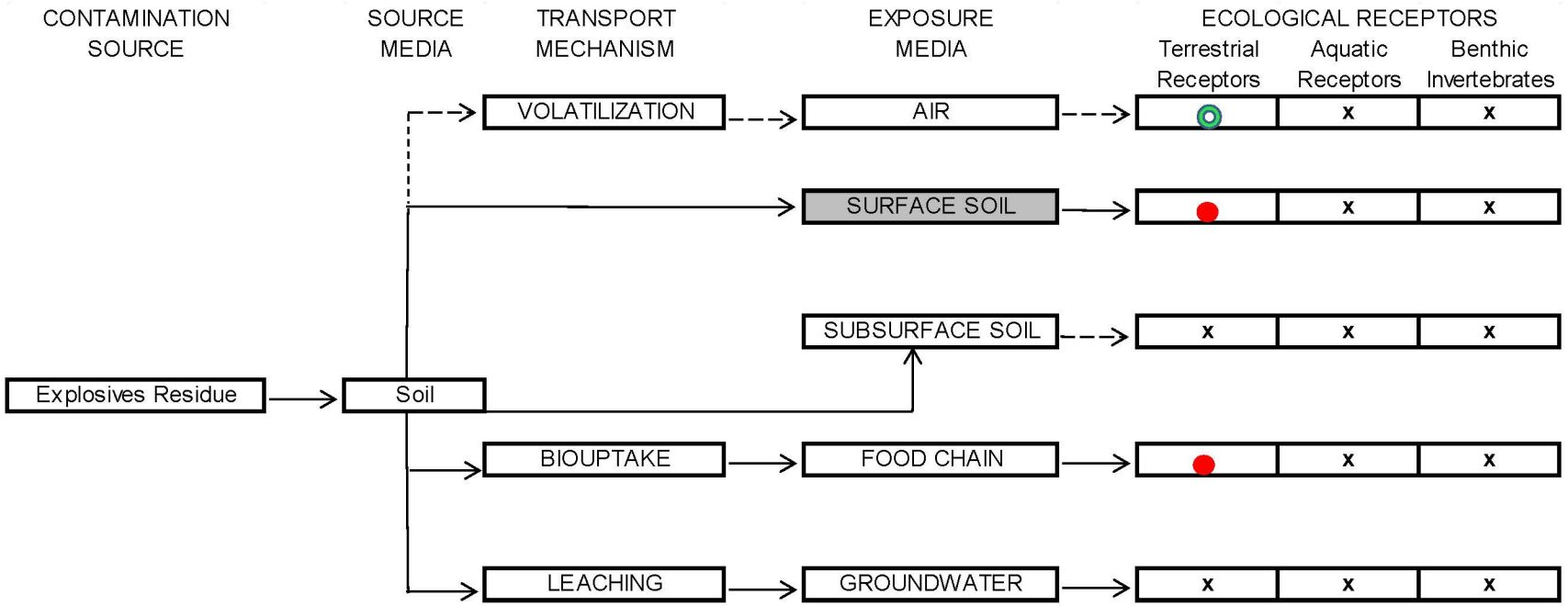
The source media at the Group 8 MRS includes MD and MC in the surface soil. Surface soil for the facility is typically defined as 0 to 1 foot bgs (SAIC, 2010); however, the maximum depth of surface soil sampled for this RI was from 0 to 0.5 feet bgs. This is the anticipated depth interval that MC would be expected to be found, assuming historical OB activities occurred on the ground surface at the MRS and released MC directly into the surrounding soil. Therefore, the applicable surface soil interval for evaluation in this SLERA is between 0 to 0.5 feet bgs.

8.3.1.3 Transport Mechanisms

Potential transport mechanisms at the MRS include volatilization into the air and biota uptake. Biota uptake is a transport mechanism because some of the MRS contaminants are known to accumulate in biota, which may act as a vehicle to spatially disperse contaminants, as well as represent a secondary exposure medium for upper trophic level receptors that prey on the biota.

8.3.1.4 Exposure Media

Sufficient time has elapsed for contaminants in the source medium to have migrated to potential exposure media, resulting in possible exposure of plants and animals that come in contact with these media. Potential exposure media include air, surface soil, and the food chain. Surface soil (typically 0 to 1 foot bgs for the facility) was not collected greater than 0.5 feet bgs at the MRS since most MC from OB activities would be expected to have concentrated in the top several inches of soil. Subsurface soil includes soil at depths that ecological receptors typically do not come into contact with (greater than 1 foot), and is not being evaluated at the Group 8 MRS. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater. Therefore, soil and biota comprising of prey items for higher trophic level receptors are the two principle exposure media for the Group 8 MRS.



U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
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 Group8\2014 Sept Rev1\RVAAP Group8 023 Fig8 1 LevelII CSM r1.mxd Analyst: gwt Date: 9/11/2014 12:58:38 PM

FIGURE 8-1 ECOLOGICAL CSM FOR LEVEL II SCREEN

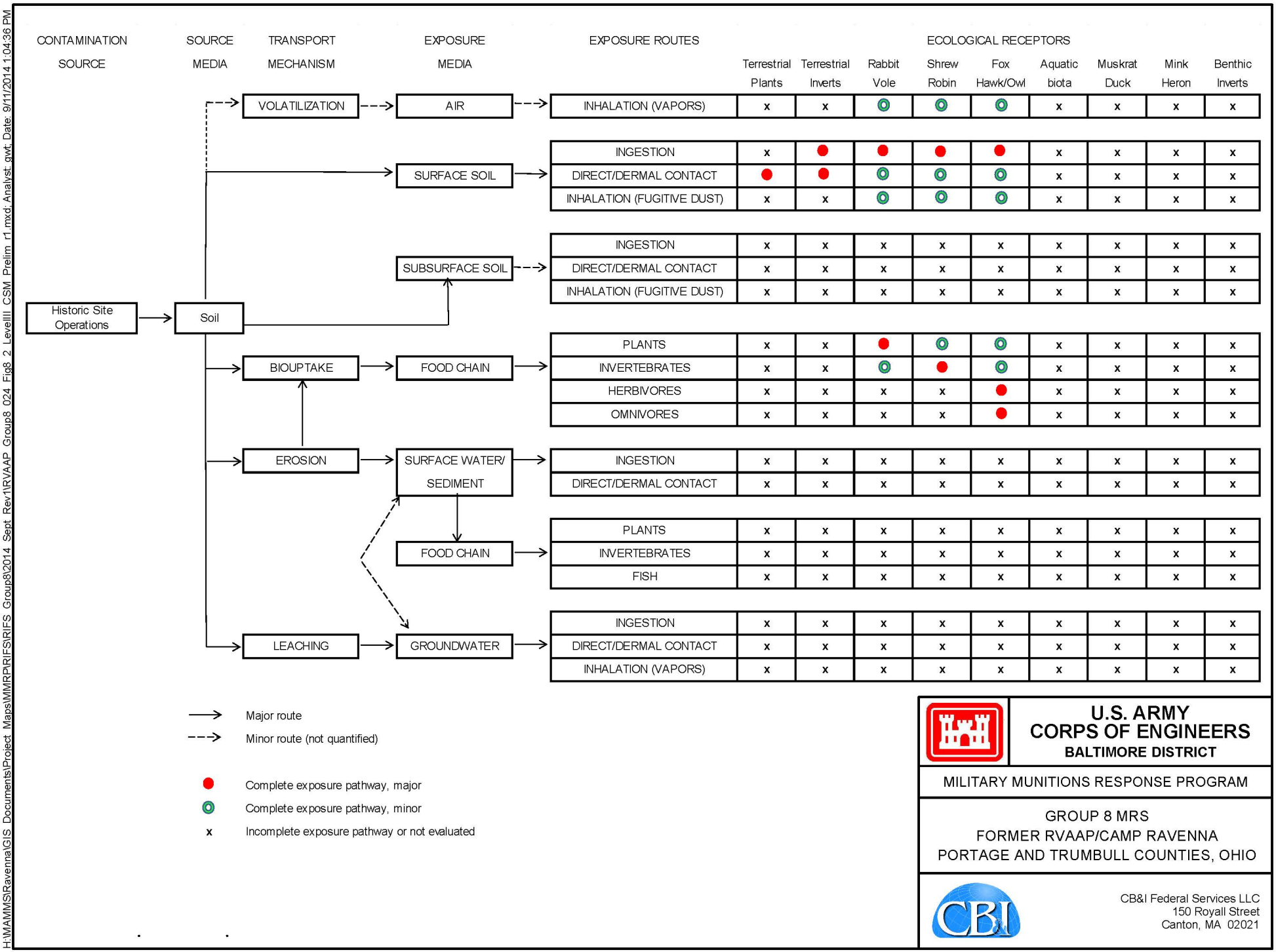


FIGURE 8-2 PRELIMINARY ECOLOGICAL CSM FOR LEVEL III BASELINE

8.3.1.5 Exposure Routes

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

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

Ecological receptors to be evaluated in the Level II Screening are presented in Section 8.3.1.6. The major exposure routes for chemical toxicity from surface soil to the receptors include ingestion (for terrestrial invertebrates, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial plants and invertebrates). The ingestion exposure routes for voles, shrews, robins, foxes, owls, and hawks include soil, as well as plant and/or animal food (i.e., food chain) that was exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust.

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

8.3.1.6 Ecological Receptors

For the Level II Screening, specific ecological receptors were not identified; rather, terrestrial biota is considered as a whole. However, for the Level III Baseline evaluation, specific terrestrial ecological receptors are identified as part of the ecological CSM (**Figure 8-2**). The terrestrial receptors include plants, terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, owls, and hawks. It is noted that due to the small size of the MRS (2.65 acres),

the evaluation of some of these receptors that have a home range of many acres (i.e., the raccoon) is highly conservative. These receptors are discussed in more detail in the following sections.

8.3.1.7 Selection of MRS-Specific Ecological Receptor Species

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

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

At the Group 8 MRS, although the small size and low-quality habitat of the MRS would limit the number and types of receptors that regularly use the terrestrial area being evaluated, the following types of ecological receptors may use the MRS to a limited degree and are conservatively included:

- Terrestrial plants
- Terrestrial invertebrates
- Mammalian herbivores such as meadow voles (*Microtus pennsylvanicus*)
- Mammalian and avian insectivores such as short-tailed shrews (*Blarina brevicauda*) and American robins (*Turdus migratoris*)

- Mammalian and avian carnivores such as red foxes (*Vulpes vulpes*) and red-tailed hawks (*Buteo jamaicensis*)

The terrestrial exposures for each of these receptors is described in the following sections and are discussed in greater detail in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c).

Terrestrial Vegetation Exposure to Soil

Terrestrial vegetation exposure to soil is applicable to the Group 8 MRS. Terrestrial plants have ecological relevance because they represent the base of the food web and are the primary producers that turn energy from the sun into organic material (plants) that provides food for many animals. There is sufficient habitat present for them at the MRS. In addition, plants are important in providing shelter and nesting materials to many animals, thus, plants are a major component of habitat. Plants provide natural cover and stability to soil and stream banks, thereby reducing soil erosion.

Terrestrial plants are susceptible to toxicity from chemicals. Plants have roots that are in direct contact with surface soil, which provides them with direct exposure to contaminants in the soil. They also can have exposure to contaminants via direct contact on the leaves. There are published toxicity benchmarks for plants (Efroymson et al., 1997b), and there are management goals for plants because of their importance in erosion control. Thus, there is sufficient justification to warrant plants as a candidate receptor for the Group 8 MRS.

Terrestrial Invertebrate Exposure to Soil

Terrestrial invertebrate exposure to soil is applicable to soils for the Group 8 MRS. Earthworms represent the receptor for the terrestrial invertebrate class, and there is sufficient habitat present for them on the MRS. Earthworms have ecological relevance because they are important for decomposition of detritus and for energy and nutrient cycling in soil (Efroymson et al., 1997c), and as prey items for other species. Earthworms are probably the most important of the terrestrial invertebrates for promoting soil fertility due to the volume of soil that they process.

Earthworms are susceptible to exposure to and toxicity from COPECs in soil. Earthworms are nearly always in contact with soil and ingest soil, which results in constant exposure. Earthworms are sensitive to various chemicals. Toxicity benchmarks are available for earthworms (Efroymson et al., 1997c). Although management goals for earthworms are not immediately obvious, the role of earthworms in soil fertility and as a food source is significant. Thus, there is sufficient justification to warrant the earthworm as a representative receptor for the Group 8 MRS.

Mammalian Herbivore Exposure to Soil

Mammalian herbivore exposure to soil is applicable to the Group 8 MRS. Cottontail rabbits and meadow voles represent mammalian herbivore receptors, and although habitat quality is low at this MRS, there is suitable habitat present for them at the MRS. Both species have ecological relevance by consuming vegetation, which helps in the regulation of plant populations and in the dispersion of some plant seeds. Small herbivorous mammals such as cottontail rabbits and voles are prey items for top terrestrial predators. Both cottontail rabbits and meadow voles are susceptible to exposure to and toxicity from COPECs in soil and vegetation. Herbivorous mammals are exposed primarily through ingestion of plant material and incidental ingestion of contaminated surface soil containing chemicals. Exposures by inhalation of COPECs in air or on suspended particulates, as well as exposures by direct contact with soil, were assumed to be negligible. Dietary toxicity benchmarks are available for many COPECs for mammals (Sample et al., 1996), and there are management goals for rabbits because they are an upland small game species protected under Ohio hunting regulations. There are no specific management goals for meadow voles at the Group 8 MRS. Meadow voles have smaller home ranges than rabbits, which make them potentially more susceptible to localized contamination. Therefore, they are a more conservative selection as a representative mammalian herbivore than rabbits, and are selected as representative receptors for the Group 8 MRS.

Insectivorous Mammal and Bird Exposure to Soil

Insectivorous mammal and bird exposure to soil is applicable to the Group 8 MRS. Short-tailed shrews and American robins represent the receptors for the insectivorous mammal and bird terrestrial exposure class, respectively. Although habitat quality is low at this MRS, there is sufficient, suitable habitat present at the MRS for these receptors. Both species have ecological relevance because they help to control above-ground invertebrate community size by consuming large numbers of invertebrates. Shrews and robins are prey items for terrestrial top predators.

Both short-tailed shrews and American robins are susceptible to exposure to and toxicity from COPECs in soil, as well as contaminants in vegetation and terrestrial invertebrate. Insectivorous mammals such as short-tailed shrews and birds such as American robins are primarily exposed by ingestion of contaminated prey (i.e., earthworms, insect larvae, and slugs), as well as ingestion of soil. In addition, shrews ingest a small amount of leafy vegetation, and the robin's diet consists of 50 percent seeds and fruit. Dietary toxicity benchmarks are available for mammals and birds (Sample et al., 1996). Both species are recommended as receptors because there can be different toxicological sensitivity between mammals and birds exposed to the same contaminants. There are management goals for robins because they are federally protected under the *Migratory Bird Treaty Act of 1993*, as

amended. There are no specific management goals for shrews at the MRS. Based on the management goals for robins, plus the susceptibility to contamination and ecological relevance for both species, there is sufficient justification to warrant shrews and robins as representative receptors for the Group 8 MRS.

Terrestrial Top Predators

Exposure of terrestrial top predators is applicable to the Group 8 MRS. Red foxes, barn owls, and red-tailed hawks represent the mammal and bird receptors for the terrestrial top predator exposure class, and there is a very limited amount of suitable habitat available for them to use the MRS. Both species have ecological relevance; as representatives of the top of the food chain for the MRS terrestrial EUs, they control populations of prey animals such as small mammals and birds.

Red foxes, barn owls, and red-tailed hawks are susceptible to exposure to and toxicity from, COPECs in soil, vegetation, and/or animal prey. Terrestrial top predators feed on small mammals and birds that may accumulate constituents in their tissues following exposure at the site. There is a potential difference in toxicological sensitivity between mammals and birds exposed to the same COPECs so it is prudent to examine a species from each taxon (Mammalia and Aves, respectively). Red foxes are primarily carnivorous but consume some plant material. The barn owl and red-tailed hawk consume only animal prey. The fox may incidentally consume soil. There are management goals for all three species. Laws (Ohio trapping season regulations for foxes, and federal protection of raptors under the Migratory Bird Treaty Act) also protect these species. In addition, all three species are susceptible to contamination and have ecological relevance as top predators in the terrestrial ecosystem. Thus, there is sufficient justification to warrant these three species as representative receptors for the Group 8 MRS.

8.3.1.8 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at the Group 8 MRS were described in the previous sections. As previously discussed, there are relevant and complete exposure pathways for various ecological receptors including terrestrial vegetation and invertebrates and terrestrial herbivores, insectivores, and carnivores. Thus, these types of receptors could be exposed to COPECs in surface soil at the Group 8 MRS.

8.3.2 Ecological Endpoint (Assessment and Measurement) Identification

The protection of ecological resources, such as habitats and species of plants and animals, is a primary motivation for conducting SLERAs. Key aspects of ecological protection are presented as management goals. These are general goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and

government agency policies (i.e., the CERCLA, *National Environmental Policy Act*). Other legislation includes the ESA of 1993, as amended (16 USC 1531-1544) and the *Migratory Bird Treaty Act* 1993, as amended (16 USC 703–711). To evaluate whether a management goal has been met, assessment endpoints, measures of effects, and decision rules were formulated. The management goals, assessment endpoints, measures of effects, and decision rules are discussed below.

Because only terrestrial habitat is being evaluated at the Group 8 MRS, there is only one primary management goal for this MRS. However, the assessment endpoints differ between the general screen and the MRS-specific analysis screen. The management goal for the SLERA is to protect terrestrial plant and animal populations from adverse effects due to the release or potential release of chemical substances associated with past MRS activities.

Ecological assessment endpoints are selected to determine whether this management goal is met at the unit. An ecological assessment endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor (i.e., COPEC). Assessment endpoints are "explicit expressions of the actual environmental value that is to be protected" (EPA, 1992). Assessment endpoints often reflect environmental values that are protected by law, provide critical resources, or provide an ecological function that would be significantly impaired if the resource was altered. Unlike the HHRA process, which focuses on individual receptors, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. Accordingly, assessment endpoints generally refer to characteristics of populations and communities. In the SLERA process, risks to individuals are assessed only if they are protected under the ESA or other species-specific legislation, or if the species is a candidate for listing as a threatened and endangered species. Because threatened and endangered species are not a concern at the Group 8 MRS, potential impacts to populations is the appropriate criterion for consideration at the MRS.

Due to the uniqueness of local flora and fauna communities, as well as varying societal values placed on these ecological features, a universally applicable list of assessment endpoints does not exist. The Ohio EPA guidance (2008) was used to select assessment endpoints for this SLERA.

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

Table 8-1 shows the management goals for terrestrial resources, associated assessment endpoints, measures of effect, and decision rules by assessment endpoint number.

Furthermore, the table provides definitions of assessment endpoints 1 through 4 for terrestrial receptors. As stated, the assessment endpoint table includes a column describing the conditions for making a decision depending on whether the HQ is less than or more than 1. If the HQ is greater than 1, the scientific management decision point options from the Ohio EPA/U.S. Army guidance are provided (i.e., no further action, risk management, monitoring, remediation, or further investigation).

For the Level III Baseline evaluation, the assessment endpoints are more specific and stated in terms of types of specific ecological receptors associated with the management goal. Assessment endpoints 1 through 4 entail the growth, survival, and reproduction of terrestrial receptors such as vegetation and terrestrial invertebrates, herbivorous mammals, worm-eating/insectivorous mammals and birds, and carnivorous top predator mammals and birds, respectively. Assessment endpoints 1 through 4 are associated with Management Goal 1, protection of terrestrial populations and communities.

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

In the Level II Screening, maximum detected concentrations in soil were used as the EPC for comparison to generic soil screening values that are expected not to cause harm to ecological populations. Any COPECs retained following the Level II Screening are potentially subject to a Level III Baseline analysis using EPCs that are more representative of the exposures expected for the representative receptors. The Level III Baseline analysis includes evaluation of exposure of a variety of receptors to the reasonable maximum exposure concentrations of COPECs at each EU, using default dietary and uptake factors. The representative ecological receptors may not all be present at each EU. However, all representative receptors are evaluated at this step.

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

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

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

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

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

COPEC denotes constituent of potential concern.
ESL denotes ecological screening level.
HQ denotes hazard quotient.
NOAEL denotes no observed adverse effect level.
RME denotes reasonable maximum exposure.
SMDP denotes scientific management decision point.
TEC denotes threshold effect concentration.
TRV denotes toxicity reference value.

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

8.3.3 Identification of COPECs

This section presents the screening of analytical data obtained from samples collected from the Group 8 MRS in surface soil. After the Level II Screen is complete, any COPECs identified are discussed in greater detail, and a recommendation is made as to whether the ERA should proceed to a Level III Baseline or Level IV Field Baseline.

8.3.3.1 Data Used in the SLERA

The available data set used in this SLERA consists of four ISM surface soil samples collected as part of the RI field effort to characterize the nature and extent of SRCs associated with previous activities at the MRS. ISM samples were collected at the MRS during the 2007 SI, but was not included in this SLERA based on the rationale discussed in Section 2.4.

The ISM samples were collected from nonoverlapping spatial areas that covered the entire MRS. Only surface soil (typically defined as 0 to 1 foot bgs, but represented by ISM samples collected from the 0- to 0.5-foot-bgs soil interval) samples were used in the SLERA because most ecological exposure occurs within the top 1 foot of soil. Also, as an MRS, it is expected that much of the native soil has been reworked, removed, or used as cover material, which would likely decrease the attractiveness to burrowing receptors. Therefore, the 0- to 0.5-foot-bgs interval is assumed to represent the zone of maximum exposure for most ecological receptors. Samples included in the ecological risk assessment data set are identified in **Table 8-2**.

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

Sample ID	Sample Date	Depth (feet bgs)	Sample Type	Analysis
Surface Soil				
GR8SS-001M-0001-SO	2/8/12	0 to 0.5	ISM	Metals[1], Explosives, Nitrocellulose, SVOCs, PCBs, TOC, pH
GR8SS-002M-0001-SO				
GR8SS-003M-0001-SO				
GR8SS-004M-0001-SO				

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

bgs denotes below ground surface.

ID denotes identification.

ISM denotes incremental sampling methodology.

PCB denotes polychlorinated biphenyl.

SVOC denotes semivolatile organic compound.

TOC denotes total organic carbon.

The MC analytical data were reviewed and evaluated for quality, usefulness, and uncertainty, as described in Section 4.3. From the MC chemical results of samples described above, a COPEC selection process was performed to develop a subset of chemicals that are identified as COPECs.

8.3.3.2 COPEC Selection Criteria

The section describes the selection criteria used to identify COPECs in the SLERA. The screen incorporates the same criteria described in Section 4.3.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, and essential nutrients). Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected MC-related contaminants at the MRS. With the exceptions of these chemicals, all detected chemicals considered as SRCs associated with the munitions that may been burned or buried at the Group 8 MRS and are included in the COPEC screening step. The SRCs identified for the surface soil sampled during the RI field activities are presented in Section 4.4.1 and evaluated in **Table 8-3**.

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

Chemical	Range of Values, mg/kg						BSV[1] (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[3]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Metals												
Antimony	5		22.8	J	0.81	0.81	0.96	0.27	No	84.4	No	Yes
Barium	127		257	J	0.051	0.051	88.4	330	Yes	0.8	No	No (b)
Cadmium	6.6		396	J	0.04	0.04	0	0.36	No	1,100	Yes	Yes
Chromium (as Cr^{+3})	22.8		39		0.14	0.14	17.4	26	No	1.5	No	Yes
Copper	225		711	J	0.4	0.4	17.7	28	No	25	Yes	Yes
Iron	34,300		54,400		9.1	9.1	23,100	NA	NA	NA	No	Yes
Lead	300		977		0.25	0.25	26.1	11	No	88.8	Yes	Yes
Mercury	0.21		0.89		0.0084	0.0084	0.036	0.00051	No	1,745	Yes	Yes
Strontium	48.3		119		0.081	0.081	0	96	No	1.2	No	Yes
Zinc	346		1,060		0.3	0.3	61.8	46	No	23	Yes	Yes
Explosives and Propellants												
2,4,6-Trinitrotoluene	0.3	J	0.3	J	0.4	0.4	NA	6.4	Yes	0.05	No	No (b)
Nitroguanidine	0.12	J	0.17	J	0.25	0.25	NA	NA	NA	NA	No	Yes
Semivolatile Organic Compounds												
2-Methylnaphthalene	0.092	J	0.04		0.12	0.12	NA	3.24	Yes	0.1	Yes	No (b)
Acenaphthene	0.045	J	0.11	J	0.12	0.12	NA	29	Yes	0.004	No	No (b)
Acenaphthylene	0.038	J	0.051	J	0.12	0.12	NA	29	Yes	0.002	No	No (b)
Anthracene	0.041	J	0.19		0.12	0.12	NA	29	Yes	0.007	No	No (b)
Benzo(a)anthracene	0.11	J	0.41		0.12	0.12	NA	1.1	Yes	0.4	No	No (b)
Benzo(a)pyrene	0.069	J	0.27		0.12	0.12	NA	1.1	Yes	0.2	No	No (b)
Benzo(b)fluoranthene	0.15	J	0.46		0.12	0.12	NA	1.1	Yes	0.4	No	No (b)
Benzo(ghi)perylene	0.06	J	0.15		0.12	0.12	NA	1.1	Yes	0.14	No	No (b)
Benzo(k)fluoranthene	0.042	J	0.23		0.12	0.12	NA	1.1	Yes	0.2	No	No (b)
Bis(2-Ethylhexyl)phthalate	0.29	J	2	J	0.4	0.4	NA	0.925	No	2.2	Yes	Yes
Carbazole	0.032	J	0.15		0.12	0.12	NA	0.00008	No	1,875	No	Yes
Chrysene	0.11	J	0.43		0.12	0.12	NA	1.1	Yes	0.4	No	No (b)
Dibenzo(a,h)anthracene	0.026	J	0.064	J	0.12	0.12	NA	1.1	Yes	0.1	No	No (b)
Dibenzofuran	0.036	J	0.16		0.12	0.12	NA	6.1	Yes	0.03	Yes	No (b)
Di-n-Butyl Phthalate	0.1	J	0.46		0.4	0.4	NA	200	Yes	0.002	Yes	Yes
Fluoranthene	0.28	J	1.2		0.12	0.12	NA	29	Yes	0.04	No	No (b)
Fluorene	0.044	J	0.091	J	0.12	0.12	NA	29	Yes	0.003	No	No (b)

Chemical	Range of Values, mg/kg						BSV[1] (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[3]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Indeno(1,2,3-cd)pyrene	0.048	J	0.16		0.12	0.12	NA	1.1	Yes	0.1	No	No (b)
Naphthalene	0.081	J	0.36		0.12	0.12	NA	29	Yes	0.01	No	No (b)
Phenanthrene	0.19		0.99		0.12	0.12	NA	29	Yes	0.03	No	No (b)
Pyrene	0.2	J	0.87		0.12	0.12	NA	1.1	Yes	0.8	No	No (b)
Polychlorinated Biphenyls												
Aroclor-1254	0.3		0.74		0.1	0.2	NA	0.371	No	2.0	Yes	Yes
Aroclor-1260	0.15		0.41		0.1	0.2	NA	0.371	No	1.1	Yes	Yes

[1] denotes see screening values in Appendix K.

[2] denotes chemicals with MDCs lower than the BSV are not considered as SRCs.

[3] denotes selection of COPECs:

Yes = COPEC exceeds the ESV and BSV, or is a PBT pollutant whose ESV is not protective of food chain effects.

No(a) = Chemical is not site-related (MDC is less than the BSV).

No(b) = The MDC is less than the ESV and the chemical is either not a PBT or is a PBT chemical but the ESV is protective of food chain effects.

bgs denotes below ground surface.

BSV denotes background value.

COPEC denotes chemical of potential ecological concern.

Cr^{+3} denotes trivalent chromium.

ESV denotes ecological screening value.

HQ denotes hazard quotient.

J denotes that the reported result is an estimated value.

MDC denotes maximum detected concentration.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable/available.

PBT denotes persistent, bioaccumulative, and toxic.

VQ denotes validation qualifier.

Comparison to Ecological Screening Values

The maximum detected concentrations of chemicals detected in the surface soil samples were compared with ESVs used as ecological endpoints following recommendations in the Ohio EPA guidance (2008), and consistent with the Unified Approach for performing ERAs at the facility (USACE, 2011). The SRCs that exceed the ESVs, or for which no ESVs are available, were retained as COPECs. Chemicals that were considered as a persistent, bioaccumulative, and toxic (PBT) were retained as COPECs even if they were detected at concentrations below their ESVs, unless the ESV was protective of food chain effects (Ohio EPA, 2008). PBT compounds include those chemicals listed in the Ohio EPA guidance (2008), including chemicals whose log octanol-water partition coefficient values are greater than or equal to 3, and chemicals listed as important bioaccumulative compounds in the EPA DQO guidance (2000). The following ESV hierarchy was used for the ecological evaluation of soil:

- *Ecological Soil Screening Levels* (EPA, 2010), with online updates from <http://www.epa.gov/ecotox/ecossl/>
- Preliminary Remediation Goals for Ecological Endpoints (Efroymson et al., 1997b)
- Region 5 Resource Conservation and Recovery Act Ecological Screening Levels (ESLs) (EPA, 2003)
- *EcoRisk Database,* Release 2.5 (Los Alamos National Laboratory, 2010)
- *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Values* (Talmage et al., 1999)

The ESVs used for the SLERA were approved in the Work Plan Addendum (Shaw, 2011) and are presented in **Appendix K**.

Essential Nutrients

Evaluating essential nutrients is a special form of risk-based screening applied to certain ubiquitous elements that are generally considered to be required nutrients. Essential nutrients such as calcium, iron, magnesium, potassium, and sodium are usually eliminated as COPECs because they are generally considered to be innocuous in environmental media. For this MRS, iron is considered to be an MC, and cannot be eliminated as an essential nutrient. Calcium, magnesium, and manganese were the only other essential nutrients analyzed. These analytes are not considered an MC and were analyzed for potential use in a geochemical evaluation of background concentrations. Evaluation for calcium, magnesium, and manganese was not carried through in the SLERA since a geochemical evaluation was not prepared for the RI.

8.3.4 Summary of COPEC Selection

The results of the COPEC screening for surface soil samples evaluated in the SLERA are presented in **Table 8-3**. The tables present the following information for each medium:

- Identified SRC
- Range of detected concentrations
- Range of detection limits
- Mean concentration (for media with more than one sample)
- BSV
- ESV
- HQ
- Determination as to whether the chemical is a PBT compound (soil and sediment only)
- Determination as to whether the chemical is a COPEC

The HQ is calculated as the detected concentration divided by the ESV. An HQ greater than 1 indicates that the concentration in the medium exceeds the conservative ESV, and may indicate that a potential ecological threat exists. Chemicals with HQs less than 1 are considered to be of low concern, and are not carried forward as COPECs, unless the chemical is a PBT pollutant and its ESV is not protective of food chain effects. A description and summary of the COPECs identified in the media at the Group 8 MRS is presented in the following sections.

8.3.4.1 Soil COPEC Selection

For the ISM surface soil samples, a total of 35 chemicals were detected and evaluated as SRCs that include 14 metals, 2 explosives compounds, 2 PCBs, and 21 SVOCs (**Table 8-3**). One metal, one explosives compound, and 18 SVOCs were eliminated because their maximum detected concentrations were lower than their ESVs and either they are not PBT compounds, or they are classified as a PBT compound but their ESV is protective of food chain effects. Following the screen, one explosives compound (nitroguanidine), nine metals (antimony, cadmium, chromium, copper, iron, lead, mercury, strontium, and zinc), three SVOCs [bis(2-ethylhexyl) phthalate, carbazole, and di-n-butyl phthalate], and two PCBs (Aroclor-1254 and Aroclor-1260) and were identified as COPECs.

8.3.5 Refinement of COPECs (Step 3a)

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

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

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

8.3.6 Weight of Evidence Discussion for Surface Soil

Fifteen COPECs were identified in discrete soil samples, including one explosives compound (nitroguanidine), nine metals (antimony, cadmium, chromium, copper, iron, lead, mercury, strontium, and zinc), three SVOCs [bis(2-ethylhexyl)phthalate, carbazole, and di-n-butyl phthalate], and two PCBs (Aroclor-1254 and Aroclor-1260). It is noted that chromium was also analyzed for as hexavalent chromium, and all results for this analysis were nondetect; therefore, chromium is assumed to consist nearly entirely of its trivalent (Cr^{+3}) form, and is compared to trivalent screening values in this SLERA. **Table 8-4** presents the concentrations of all COPECs by ISM sample, and **Table 8-5** presents the HQs associated with each

COPEC in the individual samples. Additional discussion of some of the COPECs is provided in the following paragraphs.

Iron is a commonly occurring metallic element, comprising nearly 5 percent of igneous and sedimentary rocks. It is also essential for plant growth, and is generally considered to be a micronutrient. Iron was selected as a COPEC because it lacks an ESV. An ESV is not available for iron because iron's bioavailability to plants and associated toxicity are dependent upon MRS-specific soil conditions, especially pH. In soils with pH between 5 and 8, the iron demand of plants is higher than the amount available, and toxicity is not expected. Therefore, EPA recommends no further action for iron in soils with a pH of 5 or greater (EPA, 2008b). The pH data for the four ISM surface soil samples (plus the one field duplicate sample) collected at the Group 8 MRS ranged from 7.19 to 8.24. Therefore, iron is not expected to pose a threat to ecological receptors at this MRS, and is not considered further.

Chromium, strontium, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and the 2 PCBs had HQs below 10 (**Table 8-2**). The HQs for strontium and Aroclor-1260 did not exceed 1 when rounded. Strontium also lacked a BSV; therefore, its detected concentrations may fall within the range that is naturally occurring. Chromium (HQ = 1.5) and strontium (HQ = 1.2) had HQs that approximated 1, neither metal is bioaccumulative (hexavalent chromium, which is considered bioaccumulative, was determined not to comprise any significant proportion of the total chromium detected at this MRS), and strontium may be background-related. Therefore, further evaluation of these two metals is not recommended. The HQs for bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and the two PCBs are also very low. In fact, di-n-butyl phthalate had an HQ three orders of magnitude below 1, and was only retained as a COPEC because it is a PBT chemical, and its ESV may not be protective of food chain effects. Because these four chemicals are bioaccumulative and may represent more significant hazards to receptors at higher trophic levels, they are initially retained as COPECs for further evaluation.

Antimony, copper, lead, and zinc had HQs in the 10 to 100 range (**Table 8-2**). For these four metals, elevated concentrations resulting in HQs greater than 10 were detected in all four ISM units for antimony and lead, and in three of the four ISM units for copper and zinc (**Table 8-5**). Copper, lead, and zinc are PBT chemicals. All four of these metals are retained initially as COPECs for further evaluation.

Table 8-4
Summary of COPECs in Surface Soil (0–0.5 feet)

			Sample Location:	**GR8SS-001M**		**GR8SS-002M**		**GR8SS-003M**		**GR8SS-004M**	
			Sample Number:	**GR8SS-001M-0001-SO**		**GR8SS-002M-0001-SO**		**GR8SS-003M-0001-SO**		**GR8SS-004M-0001-SO**	
			Sample Date:	**2/8/12**		**2/8/12**		**2/8/12**		**2/8/12**	
			Sample Depth (feet bgs):	**0–0.5**		**0–0.5**		**0–0.5**		**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
Metals											
Antimony	0.96	0.27	mg/kg	***5***		***6.6***		***11.7***		***22.8***	***J***
Cadmium	0	0.36	mg/kg	***6.6***		***23.3***		***21.3***		***396***	***J***
Chromium (as Cr^{+3})	17.4	26	mg/kg	*23*		*22.8*		***39***		***27.9***	***J***
Copper	17.7	28	mg/kg	***470***		***225***		***585***		***711***	***J***
Iron	23100	NA	mg/kg	***34300***		***37200***		***54400***		***50300***	***J***
Lead	26.1	11	mg/kg	***493***		***300***		***977***		***887***	***J***
Mercury	0.036	0.00051	mg/kg	***0.26***		***0.21***		***0.89***		***0.63***	
Strontium	0	96	mg/kg	*48.3*		***103***		*75.2*		***119***	
Zinc	61.8	46	mg/kg	***470***		***346***		***1060***		***1020***	***J***
Explosives and Propellants											
Nitroguanidine	NA	NA	mg/kg	ND		0.12	J	ND		0.17	J
Semivolatile Organic Compounds											
Bis(2-Ethylhexyl)phthalate	NA	0.925	mg/kg	0.79	J	0.29	J	ND		**2**	**J**
Carbazole	NA	0.00008	mg/kg	**0.045**	**J**	**0.032**	**J**	**0.15**		**0.1**	**J**
Di-n-Butyl Phthalate	NA	200	mg/kg	0.14		0.1		0.11		0.46	
Polychlorinated Biphenyl											
Aroclor-1254	NA	0.371	mg/kg	**0.51**		0.3		**0.74**		**0.58**	
Aroclor-1260	NA	0.371	mg/kg	**0.41**		0.15		0.23		0.16	

Detects in bold exceed the ESV; detects in italics exceed the BSV or indicate that a BSV is not available (metals only).
bgs denotes below ground surface.
BSV denotes background screening value.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
ESV denotes ecological screening value.
J denotes that the reported result is an estimated value.
mg/kg denotes milligrams per kilogram.
NA denotes not applicable; a screening value was not available for this chemical.
ND denotes not detected.
VQ denotes validation qualifier.

Table 8-5
Summary of HQs for COPECs in Surface Soil (0–0.5 feet)

Sample Location:	GR8SS-001M	GR8SS-002M	GR8SS-003M	GR8SS-004M
Sample Number:	GR8SS-001M-0001-SO	GR8SS-002M-0001-SO	GR8SS-003M-0001-SO	GR8SS-004M-0001-SO
Sample Date:	2/8/12	2/8/12	2/8/12	2/8/12
Sample Depth (feet bgs):	0–0.5	0–0.5	0–0.5	0–0.5
COPEC	HQ	HQ	HQ	HQ
Metals				
Antimony	**18.5**	**24.4**	**43.3**	**84.4**
Cadmium	**18.3**	**64.7**	**59.2**	**1,100**
Chromium (as Cr^{+3})			1.5	1.1
Copper	**16.8**	8.0	**20.9**	**25.4**
Lead	**44.8**	**27.3**	**88.8**	**80.6**
Mercury	**510**	**412**	**1,745**	**1,235**
Strontium		1.1		1.2
Zinc	**10.2**	7.5	**23.0**	**22.2**
Explosives				
Nitroguanidine	NA	NA	NA	NA
Semivolatile Organic Compounds				
Bis(2-Ethylhexyl)phthalate				
Carbazole	**563**	**400**	**1,875**	**1,250**
Di-n-Butyl Phthalate				
Polychlorinated Biphenyls				
Aroclor 1254	1.4		2.0	1.6
Aroclor 1260	1.1			

Cells in bold exceed an HQ of 10.
Shaded cells exceed and HQ of 100.
Only results that exceed the background and ecological screening values in Table 8-4 are present.
bgs denotes below ground surface.
COPEC denotes chemical of potential ecological concern.
Cr^{+3} denotes trivalent chromium.
HQ denotes hazard quotient.
NA denotes not applicable; a screening value was not available for this chemical.

The HQs for cadmium (HQ = 1,100), mercury (HQ = 1,235) and carbazole (HQ = 1,250) were highly elevated, and exceeded an HQ of 100. Cadmium exceeded an HQ of 100 only at surface sample location GR8ss-004M (**Table 8-5**), but exceeded an HQ of 10 at the other three ISM units (although it should be noted that cadmium lacks a BSV, and it is unknown to what degree cadmium exceeds naturally occurring concentrations). The maximum detected concentration for mercury of 0.89 mg/kg was slightly more than an order of magnitude greater than its BSV of 0.036 mg/kg, and only the sample at location GR8ss-003M had a detected concentration that exceeded both its BSV and ESV. The reason for mercury's elevated HQ values in spite of being present at concentrations approximating background is that the extremely low ESV of 0.00051 mg/kg likely exaggerates predicted hazard associated with this metal, particularly in terrestrial systems. The mercury ESV was calculated using the toxicity properties of methylmercury (Efroymson et al., 1997a), which may not be appropriate for a soil benchmark value. Methylmercury is a highly toxic, organometallic form of mercury that forms naturally in water from the bioconversion of inorganic forms of mercury (HSDB, 2012c). Inorganic mercury compounds can be methylated by microorganisms indigenous to soil under both aerobic and anaerobic conditions; however, the methylation rate is generally considered to be quite low (EPA, 2005) and the process is balanced by microbial processes that reduce inorganic cationic mercury and methylmercury to elemental mercury, which is free to volatilize from soil. Therefore, methylmercury is not the dominant form of mercury in terrestrial systems. The EPA (2005) assumes that 98 percent of the mercury in soil exists as cationic compounds and that 2 percent exists as methylmercury, except in wetland areas. Thus, the use of methylmercury toxicity values to calculate an ESV protective of soil receptors is highly conservative at a site such as the Group 8 MRS that lacks wetland areas. It is noted that alternate mercury ESVs available for the facility are approximately three orders of magnitude greater than the selected ESV, likely because they were based on less toxic forms of mercury that are more common in terrestrial systems (**Appendix K)**. If the EPA Region 5 (EPA, 2003) alternate ESV of 0.1 mg/kg is used, mercury in ISM soil samples at the Group 8 MRS would have an HQ of less than 10 (HQ = 8.9). Cadmium and mercury are retained as COPECs for additional analysis.

The final COPEC with highly elevated HQs is carbazole. Carbazole, is a heterocycle, which is a PAH in which one of the carbons within the aromatic structure is substituted by a nitrogen atom. Carbazole occurs as a natural constituent of creosote and coal tar (ATSDR, 2002) and is often collocated with PAHs in the environment. Carbazole was detected in all four ISM surface soil samples at concentrations ranging from 0.032 to 0.15 mg/kg, which is consistent with other PAHs detected in surface soil (**Table 8-2**). Unlike the PAHs, carbazole had very high HQs (maximum HQ = 1,875) in many sampling units (**Table 8-5**) owing to its very low ESV of 0.00008 mg/kg, which is approximately five orders of magnitude lower than the ESVs for PAHs such as benzo(a)pyrene (ESV of 1.1 mg/kg). Given the structural

similarity of carbazole to PAHs, the appropriateness of using such a conservative ESV is highly questionable, particularly in light of the fact that soil toxicity studies have shown carbazole exhibits similar toxic responses as PAHs in soil invertebrates (Wassenberg et al., 2005; Sverdrup et al., 2001, 2002a, and 2002b). Therefore, the presence of carbazole represents a slight uncertainty at the MRS, but further investigation of this chemical in soil is not recommended for ecological purposes.

The one explosive and propellant compound selected as a COPEC, nitroguanidine, could not be evaluated in the initial Level II Screening because no ESV was identified for this compound. The compound was detected in two out of four samples at concentrations below its reporting limit (**Table 8-2**). Explosive and propellant compounds typically are not bioaccumulative, and this chemical is not a PBT compound. Therefore, although the presence of this chemical represents a small uncertainty in this SLERA, nitroguanidine is unlikely to pose a significant threat to ecological receptors, and is not recommended for further evaluation.

8.3.7 Level II Screening Conclusions and Recommendations

Several chemicals detected in surface soil samples collected at the Group 8 MRS were at elevated concentrations in multiple ISM sampling units. Furthermore, nine of the COPECs identified in the ISM samples are considered PBT chemicals that may bioaccumulate in the food chain at the Group 8 MRS. Because multiple chemicals were present at elevated concentrations in a relatively widespread area (particularly as demonstrated by elevated concentrations detected in multiple ISM sampling units), and because several of these chemicals are bioaccumulative, a Level III Baseline is recommended for COPECs in the Group 8 MRS soil to estimate ecological hazards to specific target receptors. The Level III Baseline more accurately refines hazard estimates for various ecological receptor guilds likely to be present at the site. A few chemicals that were identified as COPECs in ISM soil samples are not recommended for further evaluation in the Level III Baseline, for reasons stated in Section 8.3.6, including chromium, iron, strontium, nitroguanidine, and carbazole. The remaining COPECs [i.e., antimony, cadmium, copper, lead, mercury, zinc, bis(2-ethyhexyl)phthalate, di-n-butyl phthalate, Aroclor-1254, and Aroclor-1260] were evaluated further in the Level III Baseline.

8.4 Level III Baseline Evaluation

The objective of a Level III Baseline evaluation was to estimate hazards to representative endpoint species using a deterministic risk assessment approach (Ohio EPA, 2008). This evaluation is performed in accordance with the ecological CSM presented during the Level II Screening (Section 8.3), modified based on recommendations from the Level II Screening. According to the recommendations from the Level II Screening, the scope of the Level III

evaluation is limited to only evaluating the COPECs identified in the ISM surface soil samples for food chain effects in soil, with the exception of iron, which was not carried forward to the Level III Baseline. A revised Level III CSM reflecting this scope is presented in **Figure 8-3**.

8.4.1 Exposure Assessment

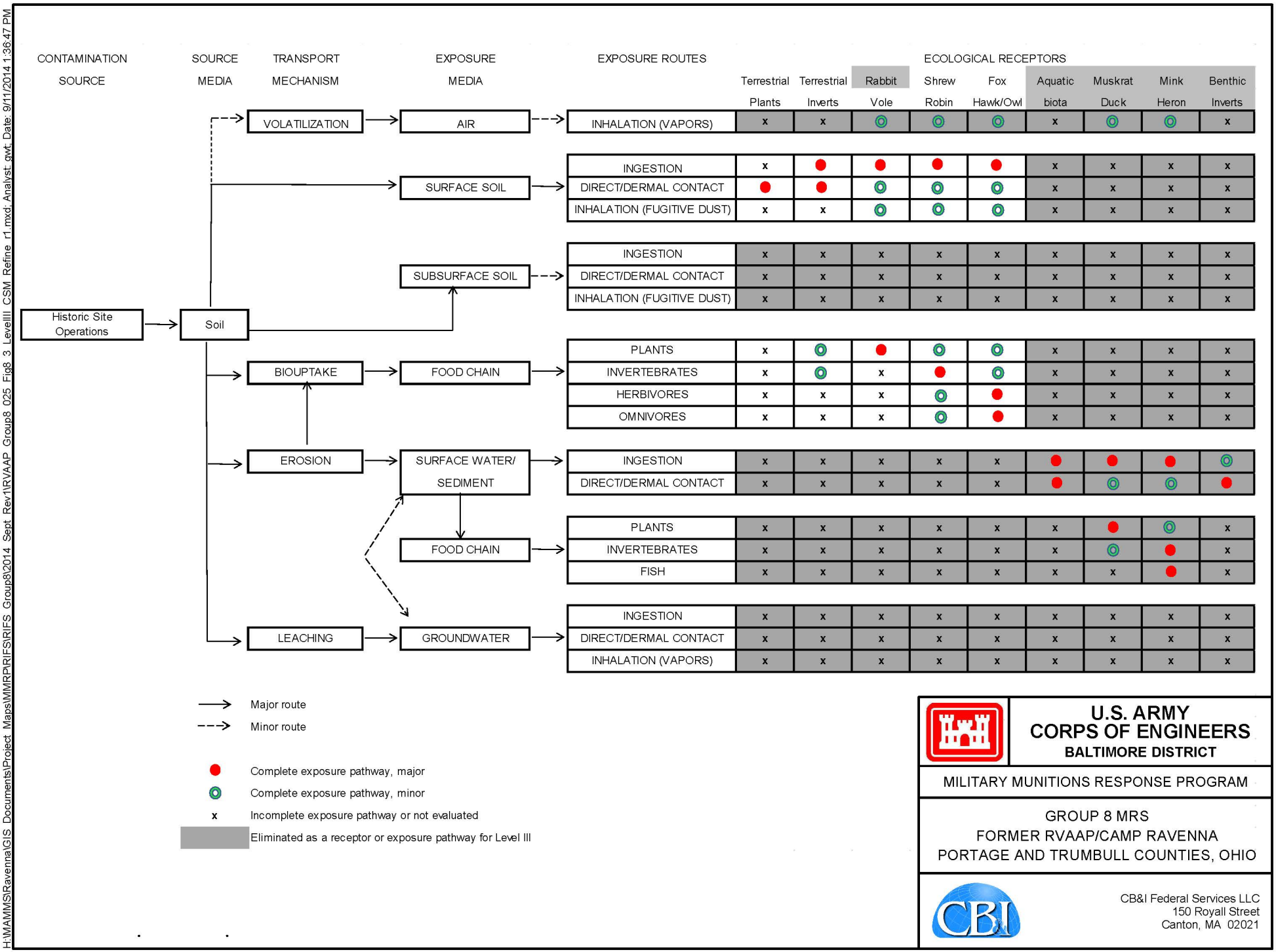
An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the MRS is presented in this section, considering both current and reasonably plausible future use of the MRS. Exposure characterization is critical in further evaluating the risk of chemicals identified as COPECs during the screening process. The exposure assessment has been conducted by linking the magnitude (concentration) and distribution (locations) of the contaminants detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which organisms found in the study area may contact contaminants.

8.4.1.1 Exposure Analysis

An exposure analysis was performed that combines the spatial and temporal distribution of the ecological receptors with those of the COPECs to evaluate exposure. The exposure analysis focuses on the bioavailable chemicals and the means by which the ecological receptors are exposed (i.e., exposure pathways). The focus of the analysis is dependent on the assessment receptors being evaluated as well as the assessment and measurement endpoints.

Exposure pathways consist of four primary components: (1) source and mechanism of contaminant release, (2) transport medium, (3) potential receptors, and (4) exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. All of these components are described in the ecological CSM (Section 8.3.1). If any of these components is not complete, then contaminants in the affected media do not constitute an environmental risk at the MRS. The major fate and transport properties associated with typical MRS contaminants are described in subsequent sections. These properties directly affect a contaminant's behavior in each of the exposure pathway components.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (biomagnification). Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment (i.e., during burrowing or dust-bathing activities), animals ingesting surface water, plants absorbing contaminants by uptake from contaminated sediment or soil, and the dermal contact of aquatic organisms with contaminated surface water or sediment. Given the scarcity of



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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

CB&I Federal Services LLC
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FIGURE 8-3 REFINED ECOLOGICAL CSM FOR LEVEL III BASELINE

available data for wildlife dermal and inhalation exposure pathways, potential risk from these pathways is not estimated in this SLERA. In addition, these pathways are generally considered to be incidental for most species, with the possible exceptions of burrowing animals and dust-bathing birds.

Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants.

Bioavailability is an important contaminant characteristic that influences the degree of chemical-receptor interaction. The bioavailability of a chemical refers to the degree to which a receptor is able to absorb a chemical from the environmental medium. A chemical's bioavailability is a function of several physical and chemical factors such as grain size, organic carbon content, water hardness, and pH. Unless MRS-specific data are available, bioavailability is conservatively assumed to be 100 percent.

Daily doses of COPECs for vertebrate receptors were calculated using standard exposure algorithms. These algorithms incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and also use MRS-specific area use factors, as follows:

Equation 8.1:

$$Total\ Daily\ Dose = \left(\frac{\left(\left[Soil_j * IR_{soil} \right] + \left[Water_j * IR_{water} \right] + \left[\sum_{i=1}^{N} B_{ji} * P_i * IR_{food} \right] \right)}{Body\ Weight} \right) * AUF$$

Where:

$Soil_j$ = Concentration of COPEC "j" in soil
$Water_j$ = Concentration of COPEC "j" in surface water
B_{ji} = Concentration of COPEC "j" in food type "i"
IR_{soil} = Soil ingestion rate
IR_{water} = Surface water ingestion rate
IR_{food} = Food ingestion rate
P_i = Proportion of food type in receptor diet
AUF = Area use factor (equal to area of exposure unit/home range of receptor)
Body Weight = Body weight of receptor

If sediment was a medium of concern, sediment could be evaluated by replacing soil in Equation 8.1 for aquatic or semiaquatic receptors. Because soil is the only medium of concern for this MRS, the exposure equation for terrestrial organisms is as follows:

$$Total\ average\ daily\ dose = ADD_P + ADD_A + ADD_S \times AUF \times TUF$$

Where:

ADD_P = Average daily dose by ingestion of plant matter (mg/kg body wt/d)
ADD_A = Average daily dose by ingestion of animal matter (mg/kg body wt/d)
ADD_S = Average daily dose by ingestion of soil (mg/kg body wt/d)
AUF = Area use factor (unitless)
TUF = Temporal use factor (unitless)

Feeding and drinking rates for MRS receptors have been established and are described in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c). To estimate dose associated with ingested food items, concentrations of COPECs in the vegetation or prey in the species' diet is estimated using bioaccumulation factors (BAFs) (sometimes referred to as bioconcentration factors [BCFs]). BAFs are based on regression models or scalar variables that reflect the potential for the COPECs to be present in food items at concentrations different from (usually greater than) the ambient environment. Differences in concentration are due to chemical-specific properties of the COPEC that affect its tendency to bioaccumulate in tissue, balanced by the innate ability of the species to regulate body burden levels of the chemical via metabolic and excretory processes.

Selection of appropriate BAFs is a critical component to food chain modeling. General approaches for BAF selection have been discussed in Sample and Suter (1994), EPA (1999a), U.S. Army Environmental Center (2005), and EPA (2008b). An approach that is consistent with these sources was followed in the selection of BAFs for facility. The general hierarchy for selection of BAFs based on types of sources is as follows:

1. Use of regression equations derived from paired field- or laboratory-based measurements
2. Ratio-derived BAFs developed based on paired data of tissue concentrations compared to media concentrations where the BAF is equal to the tissue concentration divided by the concentration in the abiotic medium
3. Modeled equilibrium partitioning-derived BAFs based on physical or chemical characteristics
4. Assumptions based on values common to chemical class

Both U.S. Army Environmental Center (2005) and EPA (1999a) support the use of ratio BAFs in preference to equilibrium partitioning-based BAFs, which are typically calculated based on factors such as log K_{ow} values, fraction of organic carbon in soil, or percent of lipids in invertebrates. Other general recommendations provided in EPA (2008) were also followed, including the following:

- For selection of ratio-based BAFs, median values are selected over maximum or other high-end BAFs.
- BAFs for PAH accumulation into mammalian prey are assumed to equal zero due to the high metabolic breakdown of PAHs in mammals.

Regression equations used to calculate prey tissue concentrations of a specific chemical typically take the following general equation form:

Equation 8.2:

$$Ln\ (C_{food}) = slope\ value \times ln\ (C_{abiotic\_media}) + intercept\ value$$

Where:

C_{food} = Concentration of chemical in food type

$C_{abiotic\_media}$ = Concentration of chemical in abiotic media

Ratio BAFs can be generally presented as follows:

Equation 8.3:

$$C_{food} = BAF \times (C_{abiotic\_media})$$

Where:

C_{food} = Concentration of chemical in food type
$C_{abiotic\_media}$ = Concentration of chemical in abiotic media
BAF = Bioaccumulation factor

BAFs calculated based on equilibrium partitioning typically use a physical constant of a chemical to generate a BAF. A generalized form for this calculation would be as follows:

Equation 8.4:

$$Log\ (BAF) = slope\ value \times Log\ (K_{ow}) + intercept\ value$$

Where:

$Log\ (BAF)$ = Log of the BAF for chemical in food type
K_{ow} = Octanol/water partition coefficient

BAFs calculated based on equilibrium partitioning are applied in the same fashion as ratio-based BAFs to generate a tissue concentration value. K_{ow} values needed for BAFs based on equilibrium partitioning are obtained using the K_{ow} WIN application in EPA's Estimation Programs Interface Suite software (http://www.epa.gov/oppt/exposure/pubs/episuite.htm).

Finally, where ratio-based BAFs are missing and where no equilibrium partitioning method has been developed for calculating BAFs, other methods, such as using BAFs for chemicals in the same class as surrogates, may be presented for establishing ratio-based BAFs. The hierarchies used to select BAFs specific to the various types of biota are presented below.

Soil-to-plants BAFs are also used to evaluate sediment-to-plant uptake at facility. Soil-to-plants BAFs are selected using the following specific hierarchy of sources:

1. EPA (2008b) selected regressions
2. Efroymson et al. (2001) regressions
3. EPA (2008b) recommended nonregression BAFs
4. International Atomic Energy Agency (IAEA) (1994) BAFs
5. Baes et al. (1984) BAFs (these values were often updated in the more recent IAEA [1994] publication)

Soil-to-invertebrates BAFs are selected using the following hierarchy of sources:

1. EPA (2008b) selected regressions
2. Sample et al. (1998a) regressions
3. Sample et al. (1998a) median BAFs
4. Equilibrium BAF calculation method in EPA (2008b) based on Jager (1998)

Soil-to-mammals BAFs are selected using the following hierarchy or sources:

1. EPA (2008b) or Sample (1998b) selected regressions
2. EPA (2008b) referenced BAFs (Note: Per EPA [2008b], a BAF of zero is used for all PAHs, TNT, and research department explosives.)
3. Sample et al. (1998b) median BAFs
4. IAEA (1994) BAFs
5. Baes et al. (1984) BAFs (these values were often updated in the newer IAEA [1994] publication)
6. EPA (1999b) maximum calculated BAFs/BCFs for feeding guilds

The BAFs used for the soil COPECs are presented in **Table 8-6**.

8.4.1.2 Exposure Point Concentrations

Ideally, the mean concentration that a receptor is exposed to on a daily basis would be used to calculate the intake dose that receptor is exposed to for a given chemical. Because of the uncertainty associated with characterizing contamination in environmental media, a reasonable maximum exposure concentration is appropriately used as the EPC. The 95 percent upper confidence limit (UCL) of the mean serves as the reasonable maximum exposure EPC in this Level III Baseline when data sets comprised of discrete samples are being evaluated. However, because ISM samples represent average concentrations over a single decision unit, calculation of a 95 percent UCL for ISM samples is not appropriate. Therefore, the maximum detected concentrations for COPECs identified in the ISM soil samples were conservatively used as the EPCs for the Level III Baseline to provide an initial indication as to whether any ISM sampling unit exceeds criteria for each COPEC.

8.4.1.3 Terrestrial Ecological Receptor Species

The exposed ecological receptors for the Level III Baseline were identified in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) based on three criteria, including their ecological relevance, susceptibility to the contaminants likely to be found at the MRS, and consistency with management goals, including protection of threatened and endangered species. Based on these criteria, the following terrestrial receptors were selected for evaluation, representing specific taxonomic and foraging guilds likely to be found at the MRS:

- Vegetation
  - Variety of grasses, forbs, and trees
- Soil-dwelling invertebrates
  - Earthworms
- Mammalian herbivores
  - Meadow vole
- Worm-eating and/or insectivorous mammals and birds
  - Short-tailed shrew
  - American robin
- Terrestrial top predators
  - Red-tailed hawk
  - Red fox

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Table 8-6
Bioaccumulation Factors or Regression Equations Used to Model Uptake

COPEC in Soil	Soil-to-Plant BAF	Source	Soil-to-Earthworm BAF	Source	Soil-to-Mammal BAF	Source
Metals						
Antimony	ln (AGP)=0.938(ln[soil])-3.233	EPA, 2008b	ln (EW)=0.706(ln[soil])-1.421	EPA, 2008b	0.05	EPA, 2008b
Cadmium	ln (AGP)=0.546(ln[soil])-0.475	EPA, 2008b	ln (EW)=0.795(ln[soil])+2.114	EPA, 2008b	ln (M)=0.4723(ln[soil]) -1.2571	EPA, 2008b
Copper	ln (AGP)=0.394(ln[soil])+0.668	EPA, 2008b	ln (EW)=0.24(ln[soil])+1.8	EPA, 2008b	ln (M)=0.1444(ln[soil]) +2.042	EPA, 2008b
Lead	ln (AGP)=0.561(ln[soil])-1.328	EPA, 2008b	ln (EW)=0.807(ln[soil])-0.218	EPA, 2008b	ln (M)=0.4422(ln[soil]) +0.0761	EPA, 2008b
Mercury	ln (AGP)=0.54(ln[soil])-1.00	Efroymson et al., 2001[1]	ln (EW)=0.33(ln[soil])+0.078	Sample et al., 1998a	0.192	Sample et al., 1998b
Zinc	ln (AGP)=0.554(ln[soil])+1.575	EPA, 2008b	ln (EW)=0.328(ln[soil])+4.449	EPA, 2008b	ln (M)=0.0706(ln[soil]) + 4.3632	EPA, 2008b
Semivolatile Organic Compounds						
Bis(2-Ethylhexyl)phthalate	0.00055	Travis and Arms (1988) K_{ow} Regression Equation	17.3	See Footnote 1	0.000132	EPA (1999b), maximum for any taxa in Table D-3
Di-n-Butyl Phthalate	0.276	Travis and Arms (1988) K_{ow} Regression Equation	15	See Footnote 1	0.000132	Bis(2-Ethylhexyl)phthalate used as surrogate
Polychlorinated Biphenyls						
Aroclor-1254	0.0036	Travis and Arms (1988) K_{ow} Regression Equation	16.4	See Footnote 1	0.00132	EPA (1999b), maximum for any taxa in Table D-3
Aroclor-1260	0.00064	Travis and Arms (1988) K_{ow} Regression Equation	17.3	See Footnote 1	0.00132	EPA (1999b), maximum for any taxa in Table D-3

[1] *denotes for Organics:* Ecological Soil Screening Level (SSL) Guidance *(EPA, 2008b), Section 3.2.2 in Appendix 4-1, given MRS-specific soil total organic carbon (TOC).*

The biota/soil water partitioning coefficient of $10^{(logKow-0.6)}$ *was replaced with Equation 3 from Jager (1998) of* $F_{lipid} \times K_{ow}$. *The* F_{water} *variable of Equation 3 was not included, since it only improves the model fit for extremely hydrophilic compounds (i.e., chemicals with log* $K_{ow} < 2$, *approximately).*

$$BAF - Flipid \times K_{ow}$$

$$FOC \times 10^{(0.983 \times logKow + 0.00028)}$$

$$F_{lipid} = 0.079$$

The lipid content in insects was estimated at 3.1 percent fresh weight (Taylor, 1975), which is 7.9 percent of dry weight, using a value of 61 percent water content in beetles (EPA, 1993), calculated as follows: 0.031/(1-0.61) = 0.079, or 7.9 percent.

K_{ow} *values obtained from EPA Estimation Programs Interface Suite Version 4.0, http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm.*

AGP denotes above ground plant tissue concentration.

BAF denotes bioaccumulation factor.

COPEC denotes chemical of potential concern.

EPA denotes U.S. Environmental Protection Agency.

EW denotes earthworm tissue concentration.

K_{ow} *denotes octanol/water partition coefficient.*

M denotes mammal tissue concentration.

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In addition to the above receptors, the barn owl, an Ohio state endangered species that is found at the facility, is broad ranging, and may use any part of the facility, was also evaluated. These receptors are likely to be present at the facility and were selected consistent with Ohio EPA guidance (Ohio EPA, 2008). Evaluation of these receptors addresses the assessment endpoints presented in the Level II Screening evaluation. Additional descriptions of these receptors and justification for their selection are presented in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c).

For the Level III Baseline, plants and invertebrates are not quantitatively assessed, as the protection of soil plants and invertebrates was previously addressed by the comparisons to ESVs in the Level II Screening evaluation. Exposure parameters used for the terrestrial ecological receptor species are presented in the *RVAAP Facility-Wide Ecological Risk Assessment Work Plan* (USACE, 2003c) and summarized in **Table 8-7**.

8.4.1.4 Exposure Characterization Summary

The estimated chemical intakes for each exposed receptor group under each exposure pathway and scenario are presented in the risk characterization spreadsheets in **Appendix L**. These intake estimates are combined with the COPEC toxicity values, discussed in the following section, to derive estimates and characterize potential ecological risk.

8.4.2 Toxicity Assessment

The toxicity assessment primarily describes the development of TRVs. TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant and are compared against calculated receptor doses. TRVs are not used for evaluating plants or invertebrates, which are evaluated in terms of potential hazards at a community scale rather than a species scale.

TRVs focusing on the growth, survival, and reproduction of species and/or populations have been developed for the Group 8 MRS SLERA. Empirical data are available for the specific receptor-endpoint combinations in some instances. The no observed adverse effect level (NOAEL) is a dose of each COPEC that produced no known adverse effects in the test species.

The NOAEL was judged to be an appropriate toxicological endpoint since it would provide the greatest degree of protection to the receptor species. In addition, the lowest observed adverse effect level (LOAEL) was used as a point of comparison for risk management decisions. The LOAEL is the lowest concentration in a laboratory test setting that is associated with an effect, and is considered to be a more realistic (although still conservative) endpoint (SAIC, 2008). In instances where data are unavailable for a MRS-associated COPEC, toxicological information for surrogate chemicals or groups of chemical was used.

Table 8-7
Exposure Parameters for Target Ecological Species

Ecological Receptor Species	Class/Order	Average Body Weight[1] (kg)	Average Home Range[1] (ha)	Dietary Intake[1] (kg[dw]/day)	Soil/Sed. Intake (kg[dw]/day)	Water Intake[1] (L/day)	Temporal Use Factor	Trophic Level	Dietary Composition[1] (percent)
Short-tailed shrew (*Blarina brevicauda*)	Mammalia/ Insectivora	0.017	0.39	0.00952	0.0012 (13%)	0.0038	1	Insectivore	Terrestrial Invertebrates: 87 Plants: 13
American robin (*Turdus migratorius*)	Aves/ Passeriformes	0.081	0.25	0.0972	0.00486 (5%)	0.011	1	Omnivore	Terrestrial Invertebrates: 50 Plants: 50
Meadow vole (*Microtus pennsyvanicus*)	Mammalia/ Rodentia	0.033	0.027	0.01089	0.00022 (2%)	0.00594	1	Herbivore	Plants: 100
Red-tailed hawk (*Buteo jamaicensis*)	Aves/ Falconiformes	1.13	697	0.1243	0	0.06441	1	Carnivore	Animals: 100
Barn owl (*Tyto alba*)	Aves/ Strigiformes	0.466	250	0.05825	0	0.0163	1	Carnivore	Animals: 100
Red fox (*Vulpes vulpes*)	Mammalia/ Carnivora	4.69	596	0.324	0.009 (2.8%)	0.399	1	Carnivore	Animals: 95.4 Plants: 4.6

[1] *denotes obtained from USACE, 2003c,* RVAAP Facility Wide Ecological Risk Work Plan, *April.*

dw denotes dry weight.

ha denotes hectares.

kg denotes kilogram.

L denotes liter.

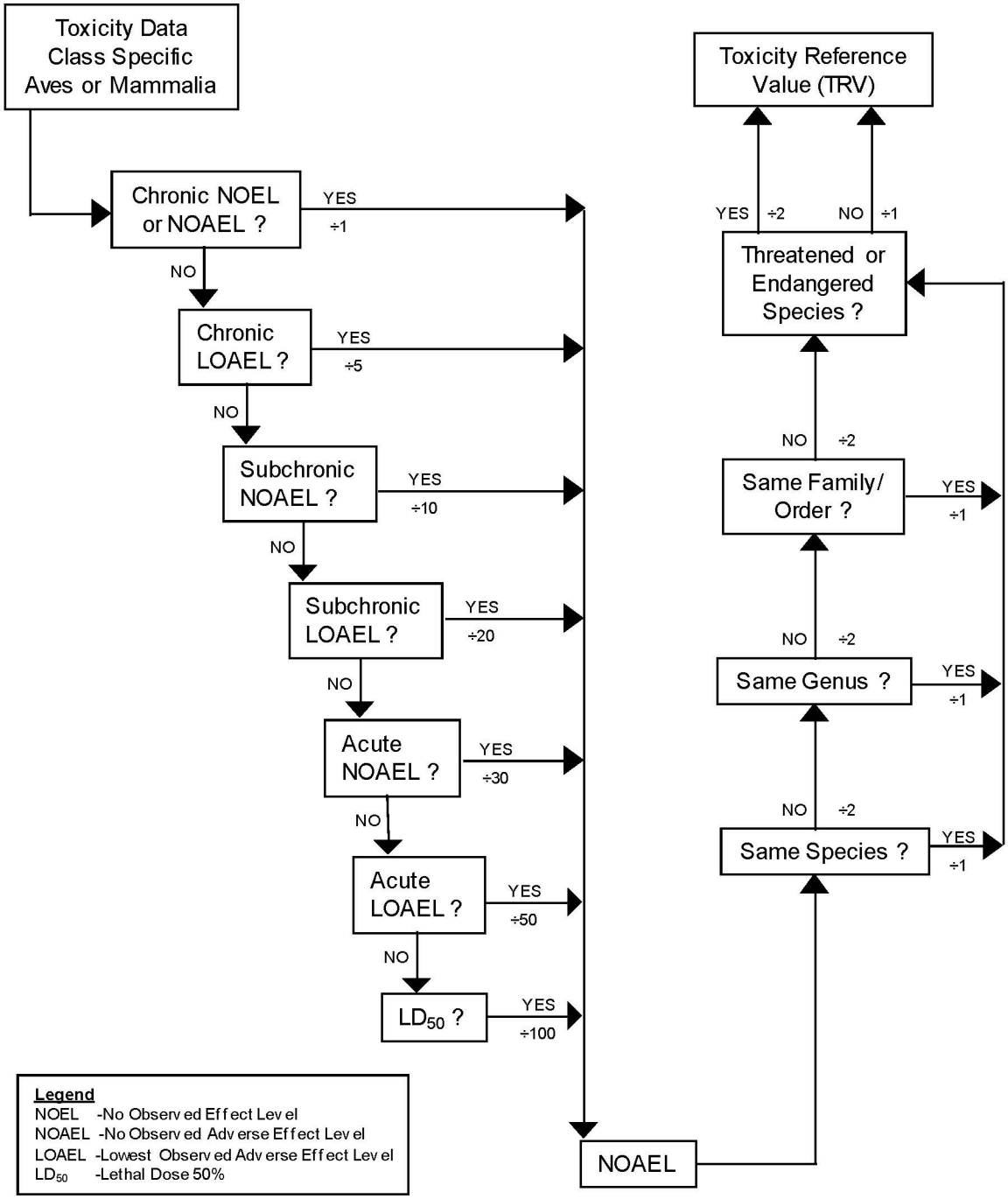
Safety factors were used to adjust for these differences and extrapolate risks to the MRS' receptors at the NOAEL and/or LOAEL endpoint. This process is described in the following paragraphs.

Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference is given to chronic studies noting concentrations at which no adverse effects were observed and those for which the lowest concentrations associated with adverse effects were observed. Where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical or group of chemicals may be considered.

The TRVs are developed separately for birds and mammals, as it is inappropriate to apply TRVs across classes (i.e., a TRV for a bird species may not be used to estimate hazard for a mammal species). In instances where TRVs for multiple avian or mammalian species are supported, the TRV for the most similar species to the measurement receptor based on feeding strategy and physiological attributes were used. For example, a mammalian TRV for mercury based on both mink and mouse test species data are available. The mink TRV was used in the food chain model to evaluate the terrestrial mammalian carnivore (i.e., the red fox), while the mouse TRV was used for the short-tailed shrew and meadow vole due to closer taxonomic similarity and foraging patterns. Two avian TRVs were available for lead. A TRV based on the quail test species was used for the robin, while a TRV based on a kestrel was used to evaluate the red-tailed hawk and barn owl.

The TRVs represent NOAELs and LOAELs with the safety factors presented in Wentsel et al. (1996) applied to toxicity information that were derived from studies other than no-effects or lowest-effects studies (**Figure 8-4**). Because NOAELs and LOAELs for the selected wildlife receptor species are based on data from test species that are usually different from the species of concern, previous ERA guidance documents often applied a mathematical adjustment to the TRVs using a power function of the ratio of species body weights (i.e., Sample et al., 1996). This practice is often referred to as allometric scaling.

Alternately, uncertainty factors have also been used to adjust the TRVs when the toxicity values were based on a different species from the evaluated receptor to account for the potential differences in species' chemical sensitivities. However, in recent years, these practices have been discouraged by most scientific and regulatory groups. Recent reviews of these practices (EPA, 2008b; Allard et al., 2009) have concluded that the use of allometric scaling of TRVs does not reflect a sound application of toxicological or ecological risk practices because supporting data for this practice are limited, and the ratio relationships used for the mathematical conversions were developed based on acute (rather than chronic) toxicity data. Allard et al. (2009) also concluded that uncertainty factors based on an arbitrary multiplier should not be used without a scientific basis for their application. Therefore, the use of toxicity data without adjustments as reported in the literature is



Credit: Adapted from Ford et al. (1992) in *Tri-Service Procedural Guidelines for Ecological Risk Assessments*, 1996

U.S. ARMY
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MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRP\RIFS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS Group8\2014 Sept Rev1\RVAAP Group8 026 Fig8 4 Proced Flow Chart Toxicity r1.mxd Analyst: gwt Date: 9/11/2014 1:43:57 PM

FIGURE 8-4 PROCEDURAL FLOW CHART FOR DERIVING TOXICITY REFERENCE VALUES

regarded as the most technically sound approach, and is the adopted approach for this SLERA.

The TRVs used for the Level III Baseline are summarized in **Tables 8-8** and **8-9** for mammals and birds, respectively. Because the barn owl represents a threatened and endangered species, as an extra level of protectiveness, only the most conservative toxicity endpoints (i.e., the NOAEL TRVs) are used to evaluate this receptor.

8.4.3 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Because potential adverse effects to terrestrial and aquatic plants and invertebrates have been qualitatively assessed during the Level II Screening (Section 8.3), the Level III Baseline risk characterization focuses on potential impacts to assessment receptors.

For the semiquantitative predictive assessment, TRVs and ADDs were calculated and used to generate food chain HQs (Wentsel et al., 1996). The HQs are calculated by summing intake doses across all exposure pathways for each chemical for a given receptor to generate an ADD and dividing by the TRV. The HQs for those chemicals that have a similar mode of toxicological action are typically summed to account for cumulative effects. Only the PCBs were considered toxicologically similar enough to warrant summing their HQs.

8.4.3.1 Hazard Estimation for Terrestrial Wildlife

The hazard estimation was performed through a series of quantitative HQ calculations that compare receptor-specific exposure doses with TRVs. The same HQ guidelines for assessing the risk posed from contaminants as described in the Level II Screening (Section 8.3) apply to the Level III Baseline as well. HQs for the identified COPECs based on both NOAEL and LOAEL values were calculated for all six representative receptor species, i.e., the meadow vole, short-tailed shrew, American robin, red-tailed hawk, barn owl, and red fox. For ISM soil samples, the maximum detected concentrations of all the sampling units are used as the EPCs because a statistical estimate of the mean (i.e., a 95 percent UCL on the mean) is not an appropriate approach for evaluating ISM decision units collectively. The Group 8 MRS area of concern of 2.65 acres was used for the purposes of calculating area use factors for the various receptors.

Results for the food chain model are provided in **Table 8-10** for the combined ISM sampling units that make up the MRS decision unit and in **Tables 8-11** through **8-14** for each of the individual four ISM sampling units, respectively. In general, chemicals whose HQs using

Table 8-8
Toxicity Reference Values for Mammals

COPEC	Toxicity Value	NOAEL (mg/kg/d)	Test Species	References	Toxicity Value	LOAEL (mg/kg/d)	Test Species	References
Metals								
Antimony	--	0.125	mouse	Sample et al., 1996	--	1.25	mouse	Sample et al., 1996
Cadmium	--	1	rat	Sample et al., 1996	--	10	rat	Sample et al., 1996
Copper	--	11.7	mink	Sample et al., 1996	--	15.14	mink	Sample et al., 1996
Lead	--	8	rat	Sample et al., 1996	--	80	rat	Sample et al., 1996
Mercury (mink)	--	1	mink	Sample et al., 1996	1.0 (NOAEL)	5	mink	Sample et al., 1996
Mercury (mouse)	--	13.2	mouse	Sample et al., 1996	--	132	mouse	Sample et al., 1996
Zinc	--	160	rat	Sample et al., 1996	--	320	rat	Sample et al., 1996
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	--	18.33	mouse	Sample et al., 1996	--	183	mouse	Sample et al., 1996
Di-n-Butyl Phthalate	--	550	mouse	Sample et al., 1996	--	1833	mouse	Sample et al., 1996
Polychlorinated Biphenyls								
Aroclor-1254 (mink)	--	0.14	mink	Sample et al., 1996	--	0.69	mink	Sample et al., 1996
Aroclor-1254 (mouse)	--	0.068	mouse	Sample et al., 1996	--	0.68	mouse	Sample et al., 1996
Aroclor-1260	Aroclor-1254 used as a surrogate							

COPEC denotes chemical of potential concern.
LOAEL denotes lowest observed adverse effect level.
mg/kg/d denotes milligrams per kilogram per day.
NA denotes not applicable.
NOAEL denotes no observed adverse effect level.

Table 8-9
Toxicity Reference Values for Birds

COPEC	Toxicity Value	NOAEL (mg/kg/d)	Test Species	Reference	Toxicity Value	LOAEL (mg/kg/d)	Test Species	Reference
Metals								
Antimony	NA							
Cadmium	NA	1.45	mallard duck	Sample et al., 1996	NA	20	mallard duck	Sample et al., 1996
Copper	NA	47	chicks	Sample et al., 1996	NA	61.7	chicks	Sample et al., 1996
Lead (quail)	NA	1.13	Japanese quail	Sample et al., 1996	NA	11.3	Japanese quail	Sample et al., 1996
Lead (kestrel)	NA	3.85	Am. Kestrel	Sample et al., 1996	NA	38.5	Am. Kestrel	Sample et al., 1996
Mercury	NA	0.45	Japanese quail	Sample et al., 1996	NA	0.9	Japanese quail	Sample et al., 1996
Zinc	NA	14.5	hens	Sample et al., 1996	NA	131	hens	Sample et al., 1996
Semivolatile Organic Compounds								
Bis(2-ethylhexyl)phthalate	NA	1.11	ringed dove	Sample et al., 1996	NA	11.1	ringed dove	Sample et al., 1996
Di-n-Butyl Phthalate	NA	0.11	ringed dove	Sample et al., 1996	NA	1.1	ringed dove	Sample et al., 1996
Polychlorinated Biphenyls								
Aroclor-1254	NA	0.18	ring neck pheasant	Sample et al., 1996	NA	1.8	ring neck pheasant	Sample et al., 1996
Aroclor-1260	Aroclor-1254 used as a surrogate							

COPEC denotes chemical of potential concern.
LOAEL denotes lowest observed adverse effect level.
mg/kg/d denotes milligrams per kilogram per day.
NA denotes not applicable.
NOAEL denotes no observed adverse effect level.

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Table 8-10
Wildlife Hazard Quotients for all Assessment Receptors—Group 8 MRS Decision Unit

COPEC	Short-tailed Shrew		Robin		Meadow Vole		Red-tailed Hawk		Barn Owl		Red Fox	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals												
Antimony	2.19E+01	2.19E+00	NA	NA	3.17E+00	3.17E-01	NA	NA	NA	NA[1]	1.75E-03	1.75E-04
Cadmium	4.98E+02	4.98E+01	4.21E+02	3.05E+01	8.02E+00	8.02E-01	5.60E-04	4.06E-05	1.77E-03	NA[1]	2.03E-03	2.03E-04
Copper	5.67E+00	4.38E+00	1.61E+00	1.23E+00	1.14E+00	8.78E-01	7.16E-05	5.46E-05	2.27E-04	NA[1]	4.24E-04	3.28E-04
Lead	2.14E+01	2.14E+00	1.69E+02	1.69E+01	1.33E+00	1.33E-01	9.96E-04	9.96E-05	3.16E-03	NA[1]	7.67E-04	7.67E-05
Mercury	4.51E-02	4.51E-03	1.97E+00	9.83E-01	9.09E-03	9.09E-04	6.43E-05	3.21E-05	2.04E-04	NA[1]	2.53E-05	5.06E-06
Zinc	3.13E+00	1.57E+00	4.86E+01	5.38E+00	5.17E-01	2.58E-01	1.50E-03	1.66E-04	4.75E-03	NA[1]	1.26E-04	6.31E-05
Semivolatile Organic Compounds												
Bis(2-Ethylhexyl)phthalate	9.27E-01	9.29E-02	1.88E+01	1.88E+00	7.47E-04	7.48E-05	4.03E-08	4.03E-09	1.28E-07	NA[1]	3.79E-07	3.79E-08
Di-n-Butyl Phthalate	6.19E-03	1.86E-03	3.86E+01	3.86E+00	8.18E-05	2.45E-05	9.34E-08	9.34E-09	2.96E-07	NA[1]	4.22E-09	1.27E-09
Polychlorinated Biphenyls												
Aroclor-1254	8.77E+01	8.77E+00	4.07E+01	4.07E+00	8.55E-02	8.55E-03	9.19E-07	9.19E-08	2.91E-06	NA[1]	1.92E-05	3.89E-06
Aroclor-1260	5.12E+01	5.12E+00	2.38E+01	2.38E+00	4.15E-02	4.15E-03	5.09E-07	5.09E-08	1.61E-06	NA[1]	1.06E-05	2.15E-06
Total PCBs	1.39E+02	1.39E+01	6.45E+01	6.45E+00	1.27E-01	1.27E-02	1.43E-06	1.43E-07	4.52E-06	0	2.98E-05	6.04E-06

Shaded cells indicate a hazard quotient greater than 1 when rounded.
COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
NA denotes no toxicity data is available; hazard quotients not calculated.
NA[1] denotes that the barn owl represents a threatened and endangered species; only hazard quotients based on the NOAEL are calculated.
NOAEL denotes no observed adverse effect level.

Table 8-11
Wildlife Hazard Quotients for all Assessment Receptors—Surface Soil Sampling Unit Location GR8SS-001M

COPEC	Short-tailed Shrew		Robin		Meadow Vole		Red-tailed Hawk		Barn Owl		Red Fox	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals												
Antimony	5.86E+00	5.86E-01	NA	NA	7.38E-01	7.38E-02	NA	NA	NA	NA[1]	3.83E-04	3.83E-05
Cadmium	1.87E+01	1.87E+00	1.64E+01	1.19E+00	6.19E-01	6.19E-02	8.10E-05	5.87E-06	2.56E-04	NA[1]	1.15E-04	1.15E-05
Copper	4.08E+00	3.15E+00	1.22E+00	9.29E-01	8.89E-01	6.87E-01	6.75E-05	5.14E-05	2.14E-04	NA[1]	3.39E-04	2.62E-04
Lead	1.17E+01	1.17E+00	9.43E+01	9.43E+00	7.65E-01	7.65E-02	7.36E-04	7.36E-05	2.33E-03	NA[1]	4.67E-04	4.67E-05
Mercury	2.80E-02	2.80E-03	1.20E+00	5.98E-01	4.57E-03	4.57E-04	1.88E-05	9.39E-06	5.95E-05	NA[1]	7.83E-06	1.57E-06
Zinc	2.23E+00	1.12E+00	3.46E+01	3.83E+00	3.21E-01	1.60E-01	1.42E-03	1.57E-04	4.48E-03	NA[1]	1.05E-04	5.26E-05
Semivolatile Organic Compounds												
Bis(2-Ethylhexyl)phthalate	3.66E-01	3.67E-02	7.43E+00	7.43E-01	2.95E-04	2.96E-05	1.59E-08	1.59E-09	5.04E-08	NA[1]	1.50E-07	1.50E-08
Di-n-Butyl Phthalate	1.88E-03	5.65E-04	1.17E+01	1.17E+00	2.49E-05	7.47E-06	2.84E-08	2.84E-09	9.01E-08	NA[1]	1.28E-09	3.85E-10
Polychlorinated Biphenyls												
Aroclor-1254	6.05E+01	6.05E+00	2.81E+01	2.81E+00	5.89E-02	5.89E-03	6.33E-07	6.33E-08	2.01E-06	NA[1]	1.32E-05	2.68E-06
Aroclor-1260	5.12E+01	5.12E+00	2.38E+01	2.38E+00	4.15E-02	4.15E-03	5.09E-07	5.09E-08	1.61E-06	NA[1]	1.06E-05	2.15E-06
Total PCBs	1.12E+02	1.12E+01	5.18E+01	5.18E+00	1.00E-01	1.00E-02	1.14E-06	1.14E-07	3.62E-06	0	2.38E-05	4.83E-06

Shaded cells indicate a hazard quotient greater than 1 when rounded.
COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
NA denotes no toxicity data is available; hazard quotients not calculated.
NA[1] denotes that the barn owl represents a threatened and endangered species; only hazard quotients based on the NOAEL are calculated.
NOAEL denotes no observed adverse effect level.

Table 8-12
Wildlife Hazard Quotients for all Assessment Receptors—Surface Soil Sampling Unit Location GR8SS-002M

COPEC	Short-tailed Shrew		Robin		Meadow Vole		Red-tailed Hawk		Barn Owl		Red Fox	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals												
Antimony	7.43E+00	7.43E-01	NA	NA	9.63E-01	9.63E-02	NA	NA	NA	NA[1]	5.06E-04	5.06E-05
Cadmium	5.12E+01	5.12E+00	4.43E+01	3.21E+00	1.30E+00	1.30E-01	1.47E-04	1.07E-05	4.65E-04	NA[1]	2.50E-04	2.50E-05
Copper	2.38E+00	1.84E+00	7.81E-01	5.95E-01	5.93E-01	4.58E-01	6.07E-05	4.62E-05	1.92E-04	NA[1]	2.45E-04	1.89E-04
Lead	7.59E+00	7.59E-01	6.20E+01	6.20E+00	5.18E-01	5.18E-02	5.91E-04	5.91E-05	1.87E-03	NA[1]	3.33E-04	3.33E-05
Mercury	2.58E-02	2.58E-03	1.10E+00	5.50E-01	4.07E-03	4.07E-04	1.52E-05	7.58E-06	4.80E-05	NA[1]	6.41E-06	1.28E-06
Zinc	1.98E+00	9.91E-01	3.06E+01	3.39E+00	2.69E-01	1.34E-01	1.38E-03	1.53E-04	4.39E-03	NA[1]	9.98E-05	4.99E-05
Semivolatile Organic Compounds												
Bis(2-Ethylhexyl)phthalate	1.34E-01	1.35E-02	2.73E+00	2.73E-01	1.08E-04	1.09E-05	5.84E-09	5.84E-10	1.85E-08	NA[1]	5.49E-08	5.50E-09
Di-n-Butyl Phthalate	1.35E-03	4.04E-04	8.39E+00	8.39E-01	1.78E-05	5.33E-06	2.03E-08	2.03E-09	6.43E-08	NA[1]	9.18E-10	2.75E-10
Polychlorinated Biphenyls												
Aroclor-1254	3.56E+01	3.56E+00	1.65E+01	1.65E+00	3.47E-02	3.47E-03	3.72E-07	3.72E-08	1.18E-06	NA[1]	7.78E-06	1.58E-06
Aroclor-1260	1.87E+01	1.87E+00	8.70E+00	8.70E-01	1.52E-02	1.52E-03	1.86E-07	1.86E-08	5.90E-07	NA[1]	3.87E-06	7.85E-07
Total PCBs	5.43E+01	5.43E+00	2.52E+01	2.52E+00	4.98E-02	4.98E-03	5.59E-07	5.59E-08	1.77E-06	0	1.17E-05	2.36E-06

Shaded cells indicate a hazard quotient greater than 1 when rounded.
COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
NA denotes no toxicity data is available; hazard quotients not calculated.
NA[1] denotes that the barn owl represents a threatened and endangered species; only hazard quotients based on the NOAEL are calculated.
NOAEL denotes no observed adverse effect level.

Table 8-13
Wildlife Hazard Quotients for all Assessment Receptors—Surface Soil Sampling Unit Location GR8SS-003M

COPEC	Short-tailed Shrew		Robin		Meadow Vole		Red-tailed Hawk		Barn Owl		Red Fox	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals												
Antimony	1.22E+01	1.22E+00	NA	NA	1.67E+00	1.67E-01	NA	NA	NA	NA[1]	8.96E-04	8.96E-05
Cadmium	4.76E+01	4.76E+00	4.12E+01	2.99E+00	1.23E+00	1.23E-01	1.41E-04	1.02E-05	4.46E-04	NA[1]	2.35E-04	2.35E-05
Copper	4.84E+00	3.74E+00	1.41E+00	1.07E+00	1.01E+00	7.81E-01	6.96E-05	5.31E-05	2.21E-04	NA[1]	3.80E-04	2.94E-04
Lead	2.14E+01	2.14E+00	1.69E+02	1.69E+01	1.33E+00	1.33E-01	9.96E-04	9.96E-05	3.16E-03	NA[1]	7.67E-04	7.67E-05
Mercury	4.51E-02	4.51E-03	1.97E+00	9.83E-01	9.09E-03	9.09E-04	6.43E-05	3.21E-05	2.04E-04	NA[1]	2.53E-05	5.06E-06
Zinc	3.13E+00	1.57E+00	4.86E+01	5.38E+00	5.17E-01	2.58E-01	1.50E-03	1.66E-04	4.75E-03	NA[1]	1.26E-04	6.31E-05
Semivolatile Organic Compounds												
Bis(2-Ethylhexyl)phthalate	9.51E-02	9.52E-03	1.93E+00	1.93E-01	7.66E-05	7.67E-06	4.13E-09	4.13E-10	1.31E-08	NA[1]	3.88E-08	3.89E-09
Di-n-Butyl Phthalate	1.48E-03	4.44E-04	9.23E+00	9.23E-01	1.95E-05	5.87E-06	2.23E-08	2.23E-09	7.08E-08	NA[1]	1.01E-09	3.03E-10
Polychlorinated Biphenyls												
Aroclor-1254	8.77E+01	8.77E+00	4.07E+01	4.07E+00	8.55E-02	8.55E-03	9.19E-07	9.19E-08	2.91E-06	NA[1]	1.92E-05	3.89E-06
Aroclor-1260	2.87E+01	2.87E+00	1.33E+01	1.33E+00	2.33E-02	2.33E-03	2.86E-07	2.86E-08	9.04E-07	NA[1]	5.94E-06	1.20E-06
Total PCBs	1.16E+02	1.16E+01	5.40E+01	5.40E+00	1.09E-01	1.09E-02	1.20E-06	1.20E-07	3.81E-06	0	2.51E-05	5.10E-06

Shaded cells indicate a hazard quotient greater than 1 when rounded.
COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
NA denotes no toxicity data is available; hazard quotients not calculated.
NA[1] denotes that the barn owl represents a threatened and endangered species; only hazard quotients based on the NOAEL are calculated.
NOAEL denotes no observed adverse effect level.

Table 8-14
Wildlife Hazard Quotients for all Assessment Receptors—Surface Soil Sampling Unit Location GR8SS-004M

COPEC	Short-tailed Shrew		Robin		Meadow Vole		Red-tailed Hawk		Barn Owl		Red Fox	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals												
Antimony	2.19E+01	2.19E+00	NA	NA	3.17E+00	3.17E-01	NA	NA	NA	NA[1]	1.75E-03	1.75E-04
Cadmium	4.98E+02	4.98E+01	4.21E+02	3.05E+01	8.02E+00	8.02E-01	5.60E-04	4.06E-05	1.77E-03	NA[1]	2.03E-03	2.03E-04
Copper	5.67E+00	4.38E+00	1.61E+00	1.23E+00	1.14E+00	8.78E-01	7.16E-05	5.46E-05	2.27E-04	NA[1]	4.24E-04	3.28E-04
Lead	1.97E+01	1.97E+00	1.56E+02	1.56E+01	1.23E+00	1.23E-01	9.54E-04	9.54E-05	3.02E-03	NA[1]	7.13E-04	7.13E-05
Mercury	3.92E-02	3.92E-03	1.70E+00	8.52E-01	7.48E-03	7.48E-04	4.55E-05	2.28E-05	1.44E-04	NA[1]	1.82E-05	3.63E-06
Zinc	3.08E+00	1.54E+00	4.78E+01	5.30E+00	5.05E-01	2.53E-01	1.49E-03	1.65E-04	4.73E-03	NA[1]	1.25E-04	6.25E-05
Semivolatile Organic Compounds												
Bis(2-Ethylhexyl)phthalate	9.27E-01	9.29E-02	1.88E+01	1.88E+00	7.47E-04	7.48E-05	4.03E-08	4.03E-09	1.28E-07	NA[1]	3.79E-07	3.79E-08
Di-n-Butyl Phthalate	6.19E-03	1.86E-03	3.86E+01	3.86E+00	8.18E-05	2.45E-05	9.34E-08	9.34E-09	2.96E-07	NA[1]	4.22E-09	1.27E-09
Polychlorinated Biphenyls												
Aroclor-1254	6.88E+01	6.88E+00	3.19E+01	3.19E+00	6.70E-02	6.70E-03	7.20E-07	7.20E-08	2.28E-06	NA[1]	1.50E-05	3.05E-06
Aroclor-1260	2.00E+01	2.00E+00	9.28E+00	9.28E-01	1.62E-02	1.62E-03	1.99E-07	1.99E-08	6.29E-07	NA[1]	4.13E-06	8.38E-07
Total PCBs	8.88E+01	8.88E+00	4.12E+01	4.12E+00	8.32E-02	8.32E-03	9.19E-07	9.19E-08	2.91E-06	0	1.92E-05	3.89E-06

Shaded cells indicate a hazard quotient greater than 1 when rounded.
COPEC denotes chemical of potential ecological concern.
LOAEL denotes lowest observed adverse effect level.
NA denotes no toxicity data is available; hazard quotients not calculated.
NA[1] denotes that the barn owl represents a threatened and endangered species; only hazard quotients based on the NOAEL are calculated.
NOAEL denotes no observed adverse effect level.

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both the NOAEL- and LOAEL-based TRVs exceed 1 are interpreted to be present at concentrations of concern; because the NOAEL is based on a no-effect dose, and given other conservative assumptions inherent in the food chain model (i.e., 100 percent bioavailability), chemicals whose NOAEL (but not LOAEL) HQs exceed 1 are unlikely to be present at concentrations harmful to environmental receptors. It is noted from **Tables 8-10** through **8-14** that only small range receptors are potentially at risk from chemicals present at the Group 8 MRS; the MRS is too small to adversely impact large range receptors such as the red-tailed hawk. Chemicals whose NOAEL- and LOAEL-based HQs exceeded 1, when rounded, for the individual ISM sample locations include the following:

- GR8SS-001M (**Table 8-11**)
  - Cadmium (Short-tailed shrew)
  - Copper (Short-tailed shrew)
  - Lead (American robin)
  - Zinc (American robin)
  - Aroclor-1254 (Short-tailed shrew and American robin)
  - Aroclor-1260 (Short-tailed shrew and American robin)
- GR8SS-002M (**Table 8-12**)
  - Cadmium (Short-tailed shrew and American robin)
  - Copper (Short-tailed shrew)
  - Lead (American robin)
  - Zinc (American robin)
  - Aroclor-1254 (Short-tailed shrew and American robin)
  - Aroclor-1260 (Short-tailed shrew)
- GR8SS-003M (**Table 8-13**)
  - Cadmium (Short-tailed shrew and American robin)
  - Copper (Short-tailed shrew)
  - Lead (Short-tailed shrew and American robin)
  - Zinc (Short-tailed shrew and American robin)
  - Aroclor-1254 (Short-tailed shrew and American robin)

  - Aroclor-1260 (Short-tailed shrew)

- GR8SS-004M (**Table 8-14**)
  - Antimony (Short-tailed shrew)
  - Cadmium (Short-tailed shrew and American robin)
  - Copper (Short-tailed shrew)
  - Lead (Short-tailed shrew and American robin)
  - Zinc (Short-tailed shrew and American robin)
  - Aroclor-1254 (Short-tailed shrew and American robin)
  - Aroclor-1260 (Short-tailed shrew)
  - Bis(2-ethylhexyl)phthalate (American robin)
  - Di-n-butyl phthalate (American robin)

8.4.4 Uncertainty Analysis

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error and natural variability of chemical concentrations in environmental media. Laboratory media analyses, sampling design/methods, and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data than to actual ecological conditions at the MRS. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation have uncertainties associated with them. Laboratory studies conducted to obtain MRS-specific, measured information often suffer from poor relevance to the actual exposure and uptake conditions on site (i.e., bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions). Calculating an estimated value based on a large number of assumptions is often the only alternative to the accurate, albeit costly, methods of direct field or laboratory observation, measurement, and/or testing. Finally, habitat- or MRS-specific species may be misidentified if, for example, the observational assessment results are based on only one or two brief MRS reconnaissance surveys.

The uncertainty analysis describes many of the major assumptions made for the SLERA. When discernible, the direction of bias caused by each assumption (i.e., whether the uncertainty results in an overestimate or underestimate of risk) is provided as well. Where possible, a description of recommendations for minimizing the identified uncertainties is also

presented if the SLERA progresses to higher level assessment phases. The most important uncertainties associated with this SLERA are discussed in the following paragraphs.

8.4.4.1 Assumptions of Bioavailability

The assumption that COPECs are 100 percent bioavailable likely overestimates the potential for adverse effects. The duration that has lapsed since the contaminant release affects bioavailability as the contaminant becomes sequestered or transformed within the environmental media. Sequestration, transformation, and bioavailability are influenced by medium characteristics including pH, temperature, and organic carbon content.

8.4.4.2 Use of Laboratory-Derived or Empirically Estimated Partitioning and Transfer Factors

The use of laboratory-derived or empirically estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and prey species, likely overestimates potential risks. As discussed previously, the incorporation of COPECs into the food chain is influenced by the characteristics of the exposure medium, which likely differs from that used in the laboratory to derive partitioning and transfer factors.

8.4.4.3 Use of Laboratory-Derived Toxicity Reference Values

The use of laboratory-derived TRVs may overestimate or underestimate the potential for adverse effects. The method of administration of the contaminant in the laboratory is typically different than that experienced in the wild by the receptors. Also, laboratories typically use "naïve" organisms in their toxicity testing, which are likely to be much more sensitive to toxicants than organisms living in the wild or at the MRS, which have likely developed resistances or have otherwise adapted to ambient concentrations of chemicals in their environment.

8.4.4.4 Use of the HQ Method to Estimate Risks to Populations or Communities

The calculation of HQs also introduces uncertainty. The following limitations associated with HQs (Tannenbaum, 2005) are noted:

- HQs are not measures of risk.
- HQs are not population-based.
- HQs are not linearly scaled.
- HQs are often produced that are unrealistically high and toxicologically impossible (i.e., estimated HQs greater than 1,000, such as the HQ of 1,431 for mercury that was calculated during the initial screen against the ESV).

- Trace soil concentrations of inorganic chemicals (including concentrations well below background levels) can lead to HQ threshold exceedances.

Therefore, it should be understood that HQs greater than 1 do not mean that adverse ecological effects are occurring or may occur in the future.

8.4.4.5 Sampling and Analytical Limitations

It is not possible to completely characterize the nature and extent of contamination on any MRS. Uncertainties arise from limits on the number of locations that can be sampled. The sampling protocol used at the Group 8 MRS, however, was designed to optimize efficiency of the sampling effort and reduce uncertainty by providing coverage of the affected area using an ISM sampling approach that is designed to provide a more realistic estimate of the average concentrations of chemicals at the MRS.

8.4.4.6 Identifying Background Chemicals

Metals are judged to be present at concentrations comparable to background if the maximum detected concentrations does not exceed the BSV. The comparison of "average" concentrations as represented by ISM sampling results to a BSV that is based on discrete background samples may be inappropriate because the distributions of data produced by the two methods are typically different (USACE, 2009b). The direction of bias is unknown. However, because the BSVs are intended to be conservative representatives of background concentrations, comparing an ISM result to the BSV should typically provide the information necessary to make a sound decision as to whether the chemical is present at concentrations greater than background.

8.4.5 Level III Baseline Conclusions and Recommendations

Ten COPECs in ISM soil samples [antimony, cadmium, copper, lead, mercury, zinc, bis(2-ethylhexly)phthalate, di-n-butyl phthalate, Aroclor-1254, and Aroclor-1260] were recommended to be evaluated under the Level III Baseline evaluation following the Level II Screening (Section 8.3). Food chain modeling was used to estimate ecological hazards to three avian and three mammalian representative species to address assessment endpoints designed to be protective of terrestrial receptors (the protection of plants and terrestrial invertebrates were assessment endpoints that were previously addressed during the Level II Screening, which evaluates direct toxicity). Food chain modeling was performed using the ISM data sets. The maximum detected concentrations were used as the EPCs for the ISM sample data, and results were also calculated for each of the individual ISM sampling units that make up the MRS decision unit. For the ISM sample data set, all COPECs evaluated in the Level III Baseline had at least one HQ that exceeded 1 in at least one ISM surface soil sampling unit using both the LOAEL and NOAEL TRVs except mercury. Mercury only

exceeded an HQ of 1 using its more conservative NOAEL-based TRV. Therefore, exposure to mercury is unlikely to result in adverse effects to ecological receptors.

Multiple COPECs were identified for the MRS that resulted in elevated HQs in many of the ISM sampling units. These COPECs represent a potential for localized impacts to soil invertebrates and small range receptors (particularly the short-tailed shrew and American robin) at the Group 8 MRS. Based on the small size of the MRS (less than 3 acres), the conservative nature of the Level III Baseline, and the low habitat quality of the MRS, the potential for adverse effects to populations of ecological receptors is most likely overestimated; however, the potential risks posed to the ecological receptors at the MRS are not discounted in this RI and are considered to be representative of the site conditions.

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9.0 REVISED CONCEPTUAL SITE MODELS

This chapter presents the revised CSMs for MEC and MC at the Group 8 MRS based on the results of the data collected for the RI previous information provided in the HRR (e^2M, 2007) and the SI Report (e^2M, 2008). The preliminary CSMs for MEC and MC were discussed in Section 2.0 and the summary of the RI results were presented in Section 4.0. Potential human health and ecological risks for the Group 8 MRS were evaluated in Section 7.0 and Section 8.0, respectively. Following the integration of the RI results into the CSMs for MEC and MC, the MRSPP evaluation for the MRS was reevaluated to include the results of the RIs and are discussed at the end this chapter.

9.1 MEC Exposure Analysis

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

9.1.1 Source

A MEC source is the location where MPPEH or ordnance is situated or is expected to be found. The Group 8 MRS was reportedly used for the OB of debris trash for an undetermined amount of time and as evidenced by the RI findings, the burning activities may have included munitions demilitarization. These activities may have resulted in the potential for MEC to be present in surface and subsurface soils at the MRS.

MEC has been found at the MRS prior to the RI field activities. In 1996, OHARNG personnel found one antipersonnel fragmentation bomb with HE on the ground surface. The 2007 SI field activities documented the presence of MEC items that consisted of two T-bar fuzes in shallow surface soils (i.e., partially buried). Based on historical operations at the MRS and the RI findings, any MEC would be expected to be found on the surface and/or subsurface soils.

All accessible areas of the MRS were effectively covered by the DGM survey during the RI and a total of 2,690 anomalies were identified for an average anomaly density of 1,015 anomalies per acre. Three areas were considered to have localized high anomaly densities, which accounted for 1,049 of the 2,690 anomalies. Outside of these high density areas, there were a total of 1,641 individual target anomalies identified for potential investigation and a statistical sampling approach was used to estimate the required sample size for populations. The amount of anomalies that were investigated was 16 percent (or 264) of the 1,641

individual anomalies identified during the DGM survey. In addition, 14 exploratory trenches were excavated at the 3 areas at the MRS with high anomaly densities.

Numerous MPPEH of various types were identified at the MRS during the RI intrusive investigation activities. All of the MPPEH were documented as safe and determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the RI field work. The depths of the MD ranged from 1 inch to 4 feet bgs. The statistical analysis of the intrusive findings states that there is a 99 percent probability that there is no MEC present in any of remaining 1,377 anomalies that were not investigated during the RI field activities. However, taking into consideration the amount of buried MD that was removed during the RI field work, the various types of MD found, the distribution and depth at which the MD was found, the relatively minimal size of the MRS at 2.65 acres, and that MEC items were found at the MRS prior to the RI field activities, there is the potential for an explosive hazard at the MRS.

9.1.2 Activity

Activity describes ways that receptors come into contact with a source. Current activities at the MRS include maintenance activities and access to the road network to access adjacent buildings. Biota activities at the MRS may include occasional meandering and occupation on the MRS by assorted species and burrowing activities. The future land use for the Group 8 MRS is military training.

9.1.3 Access

Access describes the degree to which a MEC source or environment containing MEC is available to potential receptors. There is a perimeter fence that helps prevent unauthorized access into the installation. The MRS boundary is marked with Siebert stakes and signage warning 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 Group 8 MRS include both current and anticipated future land users. Ecological receptors (biota) are based on animal species that are likely to occur in the terrestrial habitats at the MRS. The primary MRS-specific biota identified for the MRS include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, barn owls, and hawks (USACE, 2003c).

Human receptors associated with the current activities at the MRS include facility personnel and contractors. The National Guard Trainee is identified as the Representative Receptor for the current and future activities at the MRS and has the greatest opportunity for exposure to MEC that may be present at the MRS.

9.1.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Group 8 MRS and to identify all actual, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land uses. Evaluation of the end use receptors for future land use in the revised CSM is consistent with the facility HHRA approach (USACE, 2005). The revised MEC CSM that presents the exposure pathway analysis for the Group 8 MRS is presented as **Figure 9-1**.

Complete DGM coverage of accessible areas was conducted at the MRS during the RI, and a statistical approach was taken for the selection of anomalies for intrusive investigation. Numerous MPPEH items of various types were identified at the MRS during the RI intrusive investigation activities. All of the MPPEH items were documented as safe and determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the RI field work. The depths of the MD ranged from 1 inch to 4 feet bgs. Although a MEC explosive hazard was not identified at the MRS during the RI and statistical analysis of the intrusive investigation results indicates that no MEC is present at a 99 percent confidence level, the amount of MD encountered (359 items), the distribution of the MD items throughout the MRS, and the previously documented MEC items at the MRS are taken into consideration. Therefore, a MEC explosive hazard may remain at the MRS and potentially complete pathways are identified for all receptors accessing surface or subsurface soils.

9.2 MC Exposure Analysis

A MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and nonexplosive material, and emission degradation, or breakdown elements of such ordnance and munitions (10 USC 2710(e)(4)). The information collected during the RI was used to update the CSM for MC and identify all complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and reasonably anticipated future land-use activities. The revised MC CSM that presents the exposure pathway analysis for the Group 8 MRS is presented as **Figure 9-2**.

An MC source is an area where MC has entered (or may enter) the environment. MC contamination may result from a corrosion of munitions or from low-order detonation. Additionally, MC that is found at concentrations high enough to pose an explosive hazard is considered MEC. Although not documented, OB of munitions may have occurred at the MRS, which may have resulted in MC contamination to the surrounding soil. In addition, corrosion of the buried MD found during the RI intrusive investigation activities may have released MC into the surrounding soil.

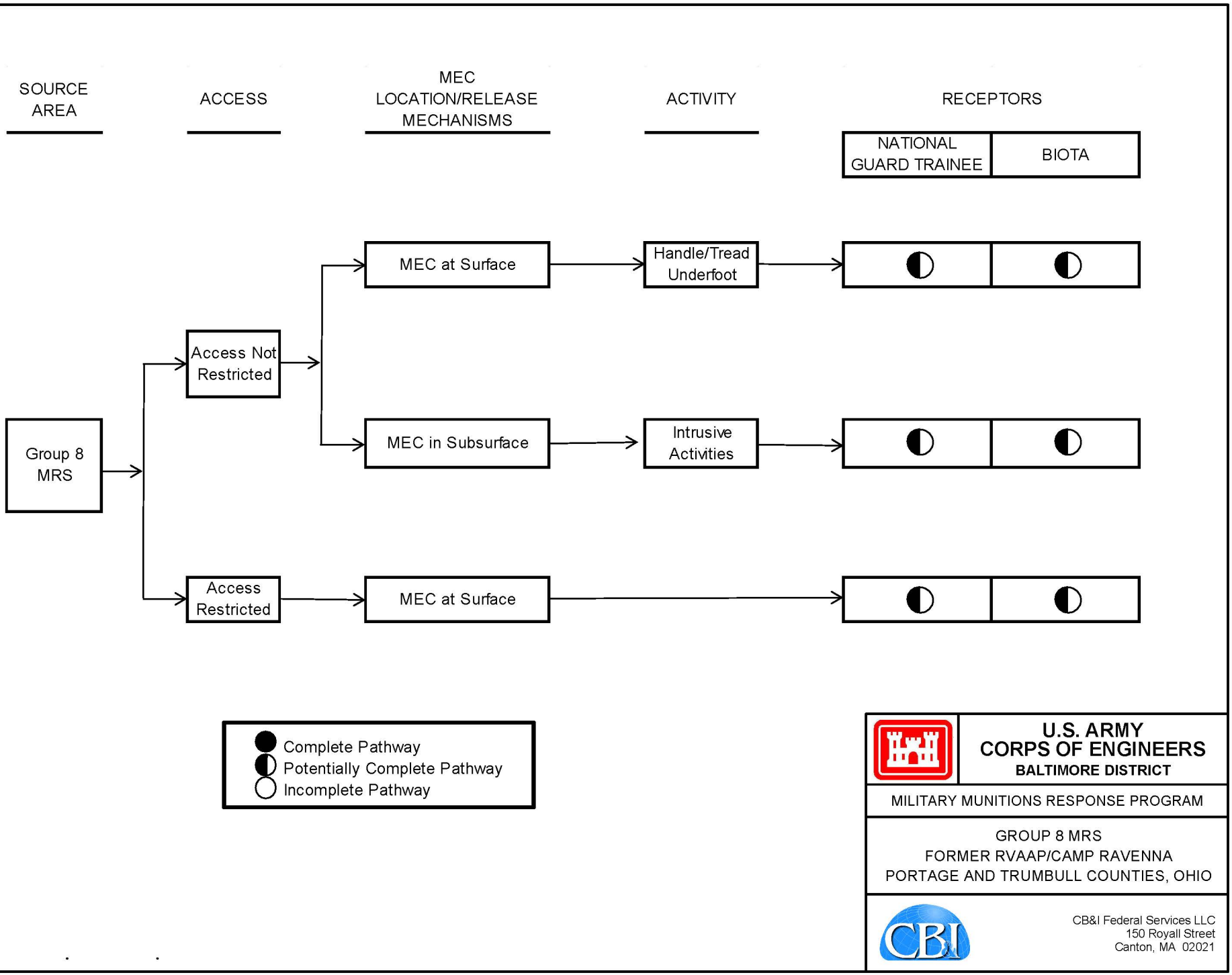

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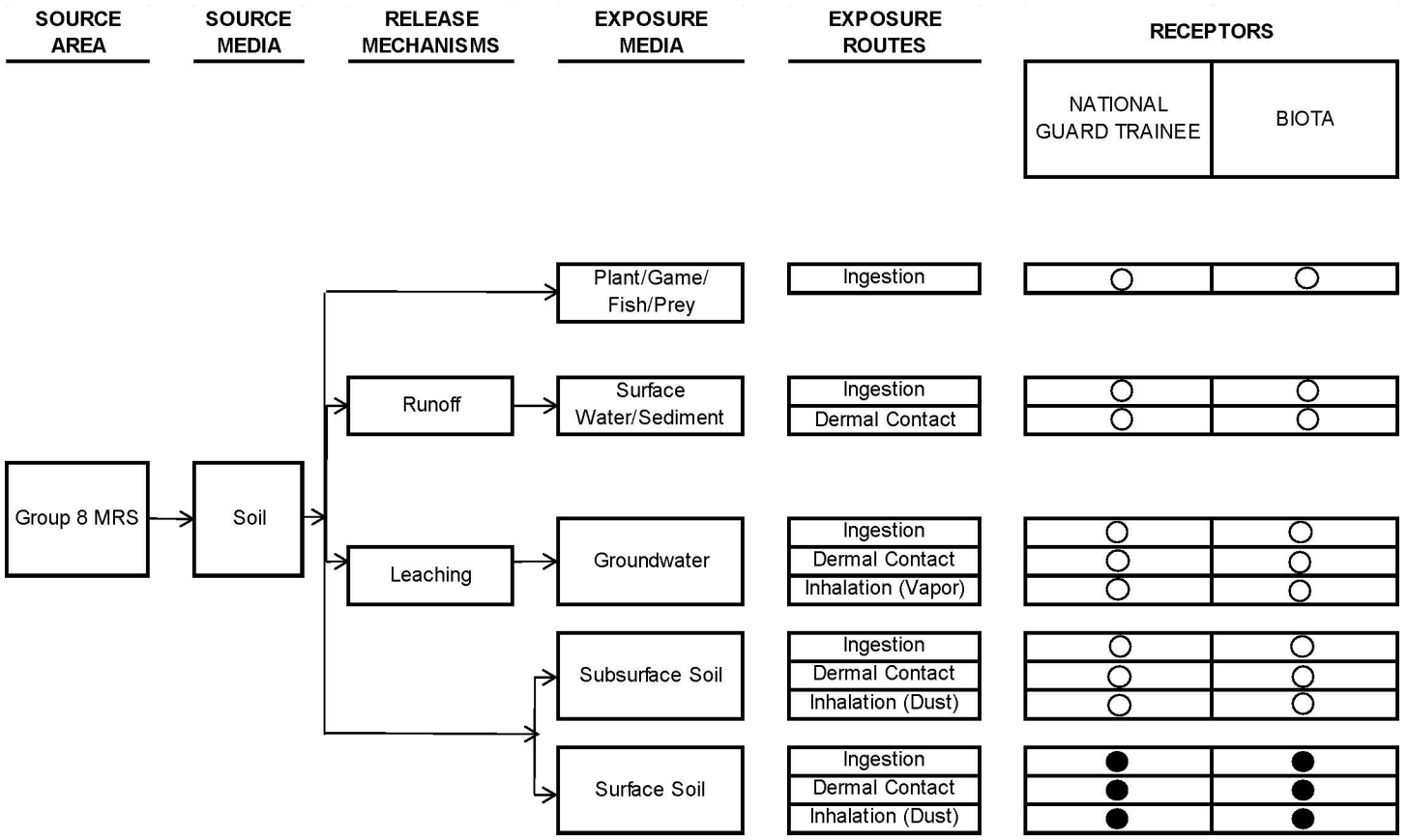
FIGURE 9-1 REVISED MEC CONCEPTUAL SITE MODEL



Receptor Exposure Scenarios		
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

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

GROUP 8 MRS
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

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FIGURE 9-2 REVISED MC CONCEPTUAL SITE MODEL

The determination as to whether MC characterization was required at the MRS was made based on historical evidence and the results of the MEC investigation. In accordance with the Work Plan Addendum (Shaw, 2011), four ISM surface soil samples were collected from sampling units of the same size for the entire MRS. Additional samples were proposed in areas with concentrated MEC/MD and three additional ISM soil samples were collected from the bottom of the trenches where concentrated buried MD was encountered at the MRS. The trench samples were evaluated in the risk assessments as subsurface samples.

The detected chemicals were evaluated in accordance with the data use evaluation process to identify SRCs. In all, 35 SRCs were identified in surface soils (0 to 0.5 feet bgs) and 24 SRCs were identified in subsurface soils (4 to 4.5 feet bgs).

A HHRA was conducted for the surface and subsurface soil samples to determine if the identified SRCs were COPCs and/or COCs that may pose a risk to future human receptors. The future land use for the Group 8 MRS is military training, and the Representative Receptor is the National Guard Trainee. Evaluation of the Representative Receptor, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, forms the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA and as outlined in the HHRAM (USACE, 2005b). Nine COCs that included cadmium, iron, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, Aroclor-1254, and Aroclor-1260 were identified in surface soils for the Resident Receptor (Adult and Child). Cadmium and lead were identified as two COCs in surface soil for the National Guard Trainee. Only iron was identified as a COC in subsurface soil for the Resident Receptor (Adult and Child). No COCs were identified for the National Guard Trainee in subsurface soils.

The COCs in surface soil (0 to 0.5 feet bgs) were considered to pose a risk to the National Guard Trainee, but the COCs identified for the National Guard Trainee in subsurface soil (4 to 4.5 feet bgs) were not considered to be present at concentrations great enough to pose a risk. Therefore, the MC CSM for the National Guard Trainee has been updated to reflect a complete pathway for surface soil and incomplete pathway for subsurface soil.

Ten COPECs in the surface soil were recommended to be evaluated under the Level III Baseline evaluation following the Level II Screening. COPECs are determined in the ERA and may differ from COPCs. The COPECs identified included antimony, cadmium, copper, lead, mercury, zinc, bis(2-ethylhexly)phthalate, di-n-butyl phthalate, Aroclor-1254, and Aroclor-1260.

Sufficient time has elapsed for COCs and COPECs in the surface soil to have migrated to potential exposure media including surface water and sediment, resulting in possible exposure of plants, fish, and animals that come into contact with these media. With the exception of a small drainage ditch along the south side of the MRS, there are no significant surface water features where COCs or COPECs in surface soil may have migrated. Therefore, the MC exposure pathways for all receptors at the MRS to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

The major exposure routes for chemical toxicity from surface soil to the environmental receptors include ingestion (for terrestrial invertebrates, voles, shrews, American robins, foxes, and hawks) and direct contact (for terrestrial plants and invertebrates). The ingestion exposure routes for voles, shrews, American robins, foxes, owls, and hawks include soil, as well as plant and/or animal food (i.e., food chain) that were exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust. Various COPECs in surface soil were determined to present potential threats to likely ecological receptors; therefore, the MC exposure pathways for ecological receptors in surface soil are considered complete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MC source. The soil conditions at the MRS are considered low to moderately permeable and the depth to groundwater is approximately 15 to 20 feet, 11 feet below the maximum depth that MD was found. The detected concentrations of explosives are low, and the detected metals, SVOCs, and PCBs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath concentrated areas of buried MD where they were deposited. Based on this rationale, no groundwater samples were required to be collected at the Group 8 MRS during the RI field work. Furthermore, it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the MRS and the groundwater exposure pathway is considered incomplete for all receptors.

9.3 Uncertainties

The purpose of the DQO process is to adequately characterize and define the hazards/risks posed by the MRS; however, this process does not remove all uncertainty associated with the MRS. There are minimal levels of uncertainties associated with the RI results at the Group 8 MRS that are presented in this section.

The primary uncertainty related to the evaluation of the RI results at the Group 8 MRS is associated with the incomplete record of historical disposal operations pertaining to

munitions items burned along with construction debris. No records have been identified to date stating that munitions items were burned and disposed at the MRS, and only the physical evidence found during the RI field activities most likely indicates that munitions were burned and the demilitarized MD disposed via burial operations at the MRS. The timeframe of the disposal for the MD is unknown. It is also unknown as to whether the burial pits were used for burning or if burial took place after the OB activities were completed on the ground surface. Based on the amount of MD uncovered during the RI field activities, it is likely that the demilitarized MD was buried/disposed at the MRS for an extended time or in volume over a short term. If munitions items were burned and disposed at the MRS, then any remaining MEC type would have been expected to be found in the surface or subsurface soils. This is supported by the fact that MEC items have been found both on the ground surface at the MRS by OHARNG personnel in 1996 and partially buried during the SI field activities in 2007. Therefore, there is uncertainty as to whether MEC is present at the MRS, and the amount of potential MEC within the MRS is not anticipated to be overstated.

In order to determine the quantity and type of MEC present, if any, a combination of DGM survey and anomaly investigations were performed at the Group 8 MRS for the RI. The DGM survey coverage was designed based on complete (100 percent) coverage of the MRS due to the minimal size (2.65 acres) of the MRS and the actual area of coverage was nearly 97 percent. The number of anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size of populations. A total of 264 of 1,641 anomalies, which represent 16 percent of the individual anomalies within the MRS, were successfully investigated. In addition, 14 exploratory trenches were mechanically excavated at three areas at the MRS with high anomaly densities. No MEC was found during the RI field activities and the statistical approach used to quantify the intrusive findings of the RI indicates that there is a 99 percent probability there is no MEC present at the remaining 1,377 anomaly locations that were not investigated during the RI field activities. These results reduce the uncertainty that MEC is present at the MRS.

There are uncertainties and limitations associated with the delineation of MD at the Group 8 MRS. Three MPPEH items that were determined to be MD were found along the northeast and east boundaries of the MRS during the RI intrusive investigation. Starting at the northernmost anomaly and going clockwise, these items were numbered as targets 1646, 1658, and 1611. The maximum depth of the MD point source anomalies found during the intrusive investigation was 36 inches at a trash pit at one location (target 1610) at the southeast portion of the MRS. The MD items found at 24 of the 26 point source anomaly locations were at depths less than 12 inches. The three MD items identified along the northeast and east MRS boundaries were found at a maximum depth of 8 inches. For the MD identified along the boundary of the MRS, Schonstedt-assisted visual survey step-outs were

performed where possible but were not tracked with the global positioning system. Most of the northern and southern MRS boundaries are limited by the adjacent buildings as is a portion of the western MRS boundary. Investigation beyond the northeast boundary where target 1646 was found was limited by OHARNG vehicle storage and interference to the Schonstedt magnetometer along the access road due to slag. The MD items found at the western portion of the MRS were not close to the west boundary; therefore, the Schonstedt-assisted survey was not conducted much further beyond the boundary in this direction. The step-out surveys along the east boundary were conducted for approximately 50 feet until dense tree and vegetation areas were encountered. The only anomalies found along the step-outs from the MRS were surface metal debris. It is possible that the lateral extent of buried MEC for the Group 8 MRS is underestimated and may extend beyond MRS; however, the Schonstedt-assisted visual survey step-outs that were performed outside of the MRS with no findings of MPPEH reduces this uncertainty.

9.4 Munitions Response Site Prioritization Protocol

The DoD proposed the MRSPP (32 Code of Federal Regulations Part 179) to assign a relative risk priority to each defense MRS in the MMRP Inventory for response activities. These response activities are to be based on the overall conditions at each location and taking into consideration various factors related to explosive safety and environmental hazards (68 Federal Regulations 50900 [32 Code of Federal Regulations 179.3]). The revised MRSPP document for the Group 8 MRS is being prepared separately from the RI and is included in **Appendix M** for reference only.

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10.0 SUMMARY AND CONCLUSIONS

This chapter summarizes the results of the RI field activities conducted at Group 8 MRS. The purpose of this RI was to determine whether the Group 8 MRS warrants further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the hazards and risks posed to likely human and ecological receptors by MEC and MC. Additional data was also presented in this RI Report to support the identification and evaluation of alternatives in the FS, if required. A summary of the RI results for each MRS is presented in **Table 10-1**.

Table 10-1
Summary of Remedial Investigation Results

MRS Name	Proposed Investigation Area (Acres)	Actual Investigation Area (Acres)	MEC Found?	MC Detected?	MC Risk Analysis
Group 8 MRS	2.65	2.563	No	Yes	Further action

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

10.1 Summary of Remedial Investigation Activities

The information available for the Group 8 MRS relating to the potential presence of MEC and MC is 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), and the SI Report (e^2M, 2008).

The preliminary MEC and MC CSMs were developed during the SI (e^2M, 2008) phase of the CERCLA process and were used identify the data needs and DQOs as outlined in the Work Plan Addendum (Shaw, 2011). The data needs and DQOs were determined at the planning stage and included characterization for MEC and MC associated with former activities at the MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of data generated for its intended use; and valid assumptions could be inferred from the data. The DQOs for the Group 8 MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform a geophysical investigation to identify if buried MEC was present.

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

Between October 31, 2011, and November 14, 2011, full coverage DGM was performed to identify potential subsurface areas of MEC at the Group 8 MRS. The DGM data were collected in all accessible areas within the MRS and the spatial coverage was 2.563 acres or nearly 97 percent of the 2.65 acres MRS. No MPPEH items were identified on the ground surface during the DGM survey.

Evaluation of the data collected during the DGM survey identified 2,690 anomalies which had signal strength greater than or equal to 8 mV (Channel 2) for an average anomaly density of 1,015 anomalies per acre. Three areas were considered to have localized high anomaly densities, which accounted for 1,049 of the 2,690 anomalies. The majority of the high density areas were located south of the gravel roadway. Outside of these high density areas, there were a total of 1,641 anomalies identified for potential investigation. In general, the geophysical data indicate that the anomaly density at the MRS is high and dispersed throughout the MRS with defined localized areas of higher density than found throughout the other areas at the MRS.

Following the completion of the DGM survey in November 2011, an intrusive investigation was conducted for the locations identified as potentially containing buried munitions-related items based on an analysis of the DGM survey data. A total of 264 of the 1,641 single point anomalies (16 percent) and 14 exploratory trenches within the 3 areas of high anomaly density were successfully investigated. The intrusive investigation activities were conducted at increments of 12 inches from 1 inch to 4 feet in depth, which UXO-qualified personnel to visually inspect the soil with a Schonstedt magnetometer as it was removed. A total of 359 MPPEH items that weighted approximately 1,418 lbs were recovered during the intrusive investigation. All of the MPPEH items were documented as safe and were determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the intrusive investigations.

The determination as to whether MC characterization was required at the MRS was made based on historical evidence and the results of the MEC investigation. In accordance with the Work Plan Addendum (Shaw, 2011), four ISM surface soil samples were collected from

sampling units of the same size for the entire MRS at depths between 0 and 0.5 feet bgs. Additional samples were proposed in areas with buried MEC/MD and three additional ISM soil samples were collected from the bottom of the trenches at depths of 4 to 4.5 feet bgs where concentrated buried MD was encountered at the MRS. The trench samples were evaluated/considered as subsurface samples in the risk assessments.

10.2 Nature and Extent of SRCs

The SRCs for the Group 8 MRS were determined for the ISM surface soil and subsurface soil samples collected during the RI field activities through the data screening process as presented in the FWCUG guidance (SAIC, 2010). A total of 35 SRCs were identified in surface soil (0 to 0.5 feet bgs) and 24 SRCs were identified in subsurface soil (4 to 4.5 feet bgs). The detected chemicals identified as SRCs in surface and subsurface soils following the screening process included the following.

- Surface Soil (0 to 0.5 feet bgs):
  - *Explosives and Propellants*: nitroguanidine and TNT
  - *Metals:* antimony, barium, cadmium, chromium, copper, iron, lead, mercury, strontium, and zinc
  - *SVOCs:* 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, carbazole, chrysene, dibenzo(a,h)anthracene, dibenzofuran, di-n-butyl phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
  - *PCBs:* Aroclor-1254 and Aroclor-1260
- Subsurface Soil (4 to 4.5 feet bgs):
  - *Metals:* antimony, cadmium, copper, iron, lead, mercury, strontium, and zinc
  - *SVOCs:* 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenzofuran, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
  - *PCBs:* Aroclor-1254 and Aroclor-1260

No explosives or propellants were detected in subsurface soils.

10.3 Fate and Transport

Transport of MEC at a MRS is dependent on many factors, including precipitation, soil erosion and freeze/thaw events. These natural processes, in addition to human activity, may result in some movement (primarily vertical movement) of MEC if present at the MRS. The

result of these mechanisms and processes is a potentially different distribution of MEC than the one that may have existed at the time of original release. In addition, MEC items may corrode or degrade based on weather and climate conditions and thereby release MC into the environment. Numerous types of MPPEH items were found at the Group 8 MRS during the RI field activities that were documented as safe and determined to be MD. No MEC was found during the RI field work. The MD items located at or near the surface appeared to have succumbed to oxidation caused by exposure to water and air, which may have released MC to the environment.

The buried MD that was found during the RI field work was encountered at a maximum depth of 4 feet bgs and native soil was not encountered until 4 feet bgs at 11 of the 14 trench locations. Therefore, at a minimum, surface soil conditions at some areas of the MRS have been disturbed or reworked to approximately 4 feet bgs.

The explosives SRCs, nitroguanidine and TNT, are considered mobile in soil and the impact to subsurface soils beneath the buried MD to a maximum depth of 4.5 feet bgs were evaluated for this RI. The concentrations of nitroguanidine and TNT that were detected in the surface soil (0 to 0.5 feet bgs) were low and no concentrations of these explosives were detected in the subsurface soils (4.0 to 4.5 feet bgs). Based on the detected results, significant sources of nitroguanidine and TNT were most likely not released during previous activities at the MRS and the low to medium permeability of the soils at the MRS mitigated any potential migration of residual concentrations to subsurface soils.

The metals SRCs have a tendency to sorb to soil at soil pH of 4 or greater, depending on the specific analyte. The MRS-specific pH of 7.72 indicates that metals SRCs would be expected to be found in the top several inches where they were released, with only limited downward migration. The detected PCBs and SVOCs that include PAHs are also anticipated to sorb to soils based on the K_{oc} values (i.e., have the tendency to be sorbed to the organic fraction of soil) and are not expected to leach into surface water runoff or migrate through the soil column.

One of the principle migration pathways at the Group 8 MRS is infiltration through the unsaturated soil to groundwater that is approximately 15 to 20 feet bgs. A distinct boundary between native and fill material was identified at approximately 4 feet at 11 of the 14 trench locations during the RI field activities. The native material is described primarily as the Mahoning-Urban land complex that is somewhat poorly drained to moderately well-drained (AMEC, 2008). Based on the local topography, some of the precipitation falling as rainfall and snow likely leaves the MRS as surface runoff to the drainage ditch along the southern portion of the MRS. The precipitation that does not leave the MRS as surface runoff infiltrates into the subsurface. Some of the infiltrating water is lost to the atmosphere as

evapotranspiration. The remainder of the infiltrating water recharges the groundwater. The rate of infiltration and eventual recharge of the groundwater is controlled by soil cover, ground slope, saturated hydraulic conductivity of the soil, and meteorological conditions throughout the MRS. Based on the aforementioned soil conditions, the low concentrations of explosives, and that metals, SVOCs, and PCBs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath the concentrated areas of buried MD where they were deposited.

10.4 MEC Hazard Assessment

The MEC HA evaluation in this RI Report is inclusive of the information available for the MRS up to and including the RI field activities and provides a scoring summary for the current and future land use activities, assuming no response actions. A MEC HA is performed for an MRS when an explosive safety hazard is identified. In the case for the Group 8 MRS, MEC items were reportedly found on the ground surface at the MRS by OHARNG personnel in the past and during the 2007 SI field activities; however, only MD items were found during complete coverage of the MRS during the RI field activities. Taking into consideration the amount of buried MD that was removed during the RI field work (1,418 lbs), the various types of MD found, the distribution and depth at which the MD was found, the relatively minimal size of the MRS at 2.65 acres, and that MEC was found at the MRS prior to the RI field activities; it was determined that a potential explosive safety hazard may be present at the Group 8 MRS and calculation of a MEC HA score was warranted.

The MEC HA score for current conditions at the Group 8 MRS was calculated to be 705, which equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The future land use at the MRS will be military training with the potential for intrusive activities and resulted in a MEC HA score of 805. This equates to a Hazard Level of 2 (high potential explosive hazard condition). The increase in the hazard level score was solely the result of an increase in receptor hours for the future land use.

10.5 MC Risk Assessment Summary

Following the identification of the SRCs at the Group 8 MRS for surface and subsurface soil through the data screening process, the SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions:

10.5.1 Human Health Risk Assessment

A HHRA was conducted for the surface and subsurface soil samples to determine if the identified SRCs were COPCs and/or COCs that may pose a risk to future human receptors.

The future land use for the Group 8 MRS is military training, and the Representative Receptor is the National Guard Trainee. Evaluation of the Representative Receptor, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, forms the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005b).

Nine COCs that included cadmium, iron, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, Aroclor-1254, and Aroclor-1260, were identified in surface soils for the Resident Receptor (Adult and Child). Cadmium and lead were identified as two COCs in surface soil for the National Guard Trainee. Only iron was identified as a COC in subsurface soil for the Resident Receptor (Adult and Child). No COCs were identified for the National Guard Trainee in subsurface soils.

Based on the results of the HHRA, it can be concluded that COCs in surface soils pose potential risks to the Resident Receptor (Adult and Child) and the National Guard Trainee. Weight of evidence suggests that the iron concentrations in subsurface soil are unlikely to pose a hazard to either of these receptors.

10.5.2 Ecological Risk Assessment

Ten COPECs in the surface soil were recommended to be evaluated under the Level III Baseline evaluation following the Level II Screening. COPECs are determined in the ERA and may differ from COPCs. The COPECs identified included antimony, cadmium, copper, lead, mercury, zinc, bis(2-ethylhexly)phthalate, di-n-butyl phthalate, Aroclor-1254, and Aroclor-1260.

Multiple COPECs were identified for the MRS that resulted in elevated HQs in many of the ISM sampling units. These COPECs represent a potential for localized impacts to soil invertebrates and small range receptors (particularly the short-tailed shrew and American robin) at the Group 8 MRS. Based on the small size of the MRS (less than 3 acres), the conservative nature of the Level III Baseline, and the low habitat quality of the MRS, the potential for adverse effects to populations of ecological receptors is most likely overestimated; however, the potential risks posed to the ecological receptors at the MRS are not discounted in this RI and are considered to be representative of the site conditions.

10.6 Conceptual Site Model

The information collected during the RI field activities were used to update the CSM for MEC and MC for the Group 8 MRS as presented in the SI Report (e^2M, 2008). 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.

Complete DGM coverage of accessible areas was conducted at the MRS during the RI, and a statistical approach was taken for the selection of anomalies for intrusive investigation. Numerous MPPEH items of various types were identified at the MRS during the RI intrusive investigation activities. All of the MPPEH items were documented as safe and determined to be MD by the UXO-qualified personnel in the field. No MEC was found during the RI field work. The depths of the MD ranged from 1 inch to 4 feet bgs. Although a MEC explosive hazard was not identified at the MRS during the RI and statistical analysis of the intrusive investigation results indicates that no MEC is present at a 99 percent confidence level, the amount of MD encountered (359 items), the distribution of the MD items throughout the MRS, and the previously documented MEC items at the MRS are taken into consideration. Therefore, a MEC explosive hazard may remain at the MRS and potentially complete pathways are identified for all receptors accessing surface or subsurface soils.

Sampling for MC was performed at the Group 8 MRS based on historical evidence and the results of the RI intrusive investigation. Although no MEC was found during the RI, various MD items were encountered and detected SRCs were evaluated as MC. The SRCs were carried through the risk assessment process to determine if they were COCs or COPECs that may pose risks to future human and ecological receptors, respectively.

The COCs in surface soil (0 to 0.5 feet bgs) were considered to pose a risk to the National Guard Trainee, but the COCs identified for the National Guard Trainee in subsurface soil (4 to 4.5 feet bgs) were not considered to be present at concentrations great enough to pose a risk. Therefore, the MC CSM for the National Guard Trainee has been updated to reflect a complete pathway for surface soil and incomplete pathway for subsurface soil.

Sufficient time has elapsed for COCs and COPECs in the surface soil to have migrated to potential exposure media including surface water and sediment, resulting in possible exposure of plants, fish, and animals that come into contact with these media. With the exception of a small drainage ditch along the south side of the MRS, there are no significant surface water features where COCs or COPECs in surface soil may have migrated. Therefore, the MC exposure pathways for all receptors at the MRS to the aquatic environments, including surface water and sediment, and the plant/game/fish/prey exposure media are considered incomplete.

The major exposure routes for chemical toxicity from surface soil to the environmental receptors include ingestion (for terrestrial invertebrates, voles, shrews, American robins, foxes, and hawks) and direct contact (for terrestrial plants and invertebrates). The ingestion

exposure routes for voles, shrews, American robins, foxes, owls, and hawks include soil, as well as plant and/or animal food (i.e., food chain) that was exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust. Various COPECs in surface soil were determined to present potential threats to likely ecological receptors; therefore, the MC exposure pathways for ecological receptors in surface soil are considered complete.

Groundwater beneath the RVAAP is evaluated on a facility-wide basis, and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MC source. The soil conditions at the MRS are considered low to moderately permeable, and the depth to groundwater is approximately 15 to 20 feet, 11 feet below the maximum depth that MD was found. The detected concentrations of explosives are low, and the detected metals, SVOCs, and PCBs are expected to remain in the top several inches of soil on the ground surface or in subsurface soils beneath concentrated areas of buried MD where they were deposited. Based on this rationale, no groundwater samples were required to be collected at the Group 8 MRS during the RI field work. Furthermore, it is not expected that the likely human and ecological receptors will come into contact with groundwater beneath the MRS and the groundwater exposure pathway is considered incomplete for all receptors.

10.7 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Group 8 MRS is associated with the incomplete record of historical disposal operations pertaining to munitions items burned along with construction debris. No records have been identified to date stating that munitions items were burned and disposed at the MRS, and only the physical evidence found during the RI field activities most likely indicates that munitions were burned and the demilitarized MD disposed via burial operations at the MRS. The timeframe of the disposal for the MD is unknown. It is also unknown as to whether the burial pits were used for burning or if burial took place after the OB activities were completed on the ground surface. Based on the amount of MD uncovered during the RI field activities, it is likely that the demilitarized MD was buried/disposed at the MRS for an extended time or in volume over a short term. If munitions items were burned and disposed at the MRS then any remaining MEC type would have been expected to be found in the surface or subsurface soils. This is supported by the fact that MEC items have been found both on the ground surface at the MRS by OHARNG personnel in 1996 and partially buried during the SI field activities in 2007. Therefore, there is uncertainty as to whether MEC is present at the MRS and the amount of potential MEC within the MRS is not anticipated to be overstated.

In order to determine the quantity and type of MEC present, if any, a combination of DGM survey and anomaly investigations were performed at the Group 8 MRS for the RI. The DGM survey coverage was designed based on complete (100 percent) coverage of the MRS due to the minimal size (2.65 acres) of the MRS. The actual area of coverage was nearly 97 percent. The number of anomalies requiring intrusive investigation was designed based on a hypergeometric statistics module that estimates the required sample size of populations. A total of 264 of 1,641 anomalies, which represent 16 percent of the individual anomalies within the MRS, were successfully investigated. In addition, 14 exploratory trenches were mechanically excavated at 3 areas at the MRS with high anomaly densities. No MEC was found during the RI field activities. The statistical approach used to quantify the intrusive findings of the RI indicates that there is a 99 percent probability there is no MEC present at the remaining 1,377 anomaly locations that were not investigated during the RI field activities. These results reduce the uncertainty that MEC is present at the MRS.

There are uncertainties and limitations associated with the delineation of MD at the Group 8 MRS. Three MPPEH items that were determined to be MD were found along the northeast and east boundaries of the MRS during the RI intrusive investigation. Starting at the northernmost anomaly and going clockwise, these items were numbered as targets 1646, 1658, and 1611. The maximum depth of the MD point source anomalies found during the intrusive investigation was 36 inches at a trash pit at one location (target 1610) at the southeast portion of the MRS. The MD items found at 24 of the 26 point source anomaly locations were at depths at less than 12 inches. The three MD items identified along the northeast and east MRS boundaries were found at a maximum depth of 8 inches. For the MD identified along the boundary of the MRS, Schonstedt-assisted visual survey step-outs were performed where possible but were not tracked with the global positioning system. Most of the northern and southern MRS boundaries are limited by the adjacent buildings as is a portion of the western MRS boundary. Investigation beyond the northeast boundary where target 1646 was found was limited by OHARNG vehicle storage and interference to the Schonstedt magnetometer along the access road due to slag. The MD items found at the western portion of the MRS were not close to the west boundary; therefore, the Schonstedt-assisted survey was not conducted much further beyond the boundary in this direction. The step-out surveys along the east boundary were conducted for approximately 50 feet until dense tree and vegetation areas were encountered. The only anomalies found along the step-outs from the MRS were surface metal debris. It is possible that the lateral extent of buried MEC for the Group 8 MRS is underestimated and may extend beyond MRS; however, the Schonstedt-assisted visual survey step-outs that were performed outside of the MRS with no findings of MPPEH reduces this uncertainty.

10.8 Conclusions

This RI was prepared in accordance with the project DQOs and included evaluations for explosives hazards and potential sources of MC that may pose threats to likely receptors. The following statements can be made for the Group 8 MRS based on the results of the RI field activities:

- Complete DGM coverage was performed at the MRS for the RI and nearly 97 percent coverage of the 2.65 acres MRS was achieved.
- Buried MPPEH was encountered at various locations throughout the MRS at depths ranging between 1 inch and 4 feet bgs and was determined to be MD.
- No MEC was encountered during the RI field activities; however, the MEC items identified at the MRS prior to the RI and the amount, types, distribution, and depth of MD encountered during the intrusive investigations are taken into consideration, and an explosive hazard may be present at the MRS.
- The HHRA indicates that detected COCs in surface soil present potential risks to the Resident Receptor (Adult and Child) that is evaluated for Unrestricted (Residential) Land Use and the National Guard Trainee, the Representative Receptor for the future land use at the MRS.
- The ERA indicates that detected COPECs in surface soil have the potential for localized impacts to soil invertebrates and small range receptors.

The RI for the Group 8 MRS included risk assessments for explosive hazards and MC that may pose risks to likely receptors. The buried MPPEH items that were encountered during the RI field work were solid and/or inert and posed no explosive safety hazard and therefore were determined to be MD by the UXO-qualified personnel in the field. No MEC was discovered at the MRS during the RI field work; however, MEC has been reported to have been encountered at the MRS during previous investigations. The HHRA and the ERA identified the potential for impact from MC in surface soil to the likely human and ecological receptors. A Feasibility Study is recommended as the next course of action for the Group 8 MRS to assess possible response action alternatives for likely remaining MPPEH and associated MC.

Since the RI was completed prior to the finalization of the U.S. Army's Technical Memorandum (ARNG, 2014), evaluation of the Commercial Industrial Land Use using the Industrial Receptor, and other modifications to the HHRA specified in the Technical Memorandum, were not included in the HHRA. Because Unrestricted (Residential) Land Use in subsurface soils was not achieved in the HHRA, modifications to the HHRA process

required by the Technical Memorandum (i.e., evaluation of the Commercial Industrial Land Use) will be incorporated in the Feasibility Study.

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Appendix A
Digital Geophysical Mapping Report

Appendix B
Field Documentation

Appendix C
Data Validation Report

Appendix D
Laboratory Data Reports

Note: Data submitted on compact disc.

Appendix E
Investigation-Derived Waste Management

Appendix F
Photograph Documentation Log

Appendix G
Intrusive Investigation Results

Appendix H
Statistical Analysis of Intrusive Findings at the Group 8 MRS

Statistical Analysis of Intrusive Findings at the Group 8 MRS

It is challenging to predict the occurrence of munitions and explosives of concern (MEC) in a population of anomalies when only a portion of the anomalies are investigated and no MEC are identified in the sample population. In order to meet this challenge, a Bayesian statistical approach is warranted instead of a classical statistical approach. The Bayesian approach is applicable, as it uses the information from the sampled anomaly population in conjunction with previous knowledge regarding the occurrence of MEC to predict the occurrence of MEC in the unsampled population of anomalies. For the investigation at the Group 8 Munitions Response Site (MRS), an assumption was made that the percentage of MEC items is between 1 and 0.1 percent (i.e., between 1 in 100 and 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 Group 8 MRS during the intrusive investigation activities. In total, 1,641 individual target anomalies were identified using digital geophysical mapping. Using the hypergeometrics statistics module, 248 of these were anomalies originally randomly selected for intrusive investigation. An additional 24 anomalies were biased based on recommendations provided by the Ohio Environmental Protection Agency and were recommended for intrusive investigation as well. In all, a total of 272 individual target anomalies were originally proposed for intrusive investigation; however, only 264 individual target anomalies were successfully reaquired as is discussed in the Remedial Investigation Report.

For comparative purposes, the mean value of the MEC among the 264 individual target anomalies reacquired was estimated to be 1 percent, 2.5 percent, 4 percent, or 50 percent before any intrusive information was acquired. The assumption that 2.5 percent, 4 percent, or 50 percent of the anomalies at the MRS are MEC is intended to provide information that errs on the side of conservatism. **Table H-1** presents a summary of the Bayesian approach and estimations used to predict the probability of MEC at unsampled anomalies at the Group 8 MRS.

If the mean MEC population at the MRS is estimated to be 1 percent, 2.5 percent, and 4 percent, then the predicted probability that there is no MEC in the remaining 1,377 samples using the actual intrusive results is 99, 95, and 92 percent, respectively. In the case where the mean MEC population is estimated to be 50 percent, there is only a 15 percent prediction probability that there is no MEC in the remaining 1,377 anomalies based on the intrusive results. In this scenario, 1,555 of the 1,641 anomalies would need to be sampled to obtain a prediction probability of 95 percent that there is no MEC in the remaining 94 samples. Based on the results of the intrusive investigation as well as previous investigations, a priori that MEC was at 1 percent or less was assumed.

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 H-1
Probabilities of Remaining MEC for Unsampled Anomalies

Estimated Mean Population of MEC	Probability that there is no MEC in Remaining 1,377 Unsampled Anomalies	95th Percentile of Prediction Distribution for Count of MEC in Remaining 1,377 Unsampled Anomalies	99th Percentile of Prediction Distribution for Count of MEC in Remaining 1,377 Unsampled Anomalies
1%	0.99	0	0
2.5 %	0.95	0	3
4%	0.92	1	4
50%	0.15	17	25

MEC denotes munitions and explosives of concern.

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Appendix I
Waste Shipment and Disposal Records for Munitions Debris

Appendix J
MEC Hazard Assessment Workbook

Appendix K
Ecological Screening Values

Appendix L
SLERA Risk Characterization Worksheets

Appendix M
Munitions Response Site Prioritization Protocol Worksheets

Appendix N
Responses to Ohio EPA Comments

Appendix O
Ohio EPA Approval Letter

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