REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
04-03-2015	Final	April 2011 - August 2012

4. TITLE AND SUBTITLE

Remedial Investigation Report for RVAAP-019-R-01 Landfill North of Winklepeck and RVAAP-060-R-01 Block D Igloo Munitions Response Sites, Version 1.0

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

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)

Laura O'Donnell, David Crispo, P.E.

5d. PROJECT NUMBER
136147

5e. TASK NUMBER
0300130, 0600130

5f. WORK UNIT NUMBER
N/A

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

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

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

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

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

12. DISTRIBUTION/AVAILABILITY STATEMENT
Reference distribution page.

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

14. ABSTRACT

The purpose of this Remedial Investigation (RI) Report is to present the findings and conclusions of the RI field activities conducted at RVAAP-019-R-01 Landfill North of Winklepeck MRS and RVAAP-060-R-01 Block D Igloo MRS at the former Ravenna Army Ammunition Plant under the Military Munitions Response Program. This RI Report presents a determination as to whether these MRSs warrant further response action pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act and the National Oil and Hazardous Substances Pollution Contingency Plan. More specifically, this RI Report presents the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) at each of the MRSs and subsequently provides an evaluation of the hazards and risks posed to human health and the environment by MEC and MC. Also, this RI Report presents additional data for the Feasibility Study (FS) to assist in determining if 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.

15. SUBJECT TERMS
Landfill North of Winklepeck, Block D Igloo, Remedial Investigation, Military Munitions Response Program

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			David Crispo, Project Manager
Unclassified	Unclassified	Unclassified	UU	564	19b. TELEPHONE NUMBER *(Include area code)* 781.821.3513

Reset

INSTRUCTIONS FOR COMPLETING SF 298

1. REPORT DATE. Full publication date, including day, month, if available. Must cite at least the year and be Year 2000 compliant, e.g. 30-06-1998; xx-06-1998; xx-xx-1998.

2. REPORT TYPE. State the type of report, such as final, technical, interim, memorandum, master's thesis, progress, quarterly, research, special, group study, etc.

3. DATES COVERED. Indicate the time during which the work was performed and the report was written, e.g., Jun 1997 - Jun 1998; 1-10 Jun 1996; May - Nov 1998; Nov 1998.

4. TITLE. Enter title and subtitle with volume number and part number, if applicable. On classified documents, enter the title classification in parentheses.

5a. CONTRACT NUMBER. Enter all contract numbers as they appear in the report, e.g. F33615-86-C-5169.

5b. GRANT NUMBER. Enter all grant numbers as they appear in the report, e.g. AFOSR-82-1234.

5c. PROGRAM ELEMENT NUMBER. Enter all program element numbers as they appear in the report, e.g. 61101A.

5d. PROJECT NUMBER. Enter all project numbers as they appear in the report, e.g. 1F665702D1257; ILIR.

5e. TASK NUMBER. Enter all task numbers as they appear in the report, e.g. 05; RF0330201; T4112.

5f. WORK UNIT NUMBER. Enter all work unit numbers as they appear in the report, e.g. 001; AFAPL30480105.

6. AUTHOR(S). Enter name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. The form of entry is the last name, first name, middle initial, and additional qualifiers separated by commas, e.g. Smith, Richard, J, Jr.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES). Self-explanatory.

8. PERFORMING ORGANIZATION REPORT NUMBER. Enter all unique alphanumeric report numbers assigned by the performing organization, e.g. BRL-1234; AFWL-TR-85-4017-Vol-21-PT-2.

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES). Enter the name and address of the organization(s) financially responsible for and monitoring the work.

10. SPONSOR/MONITOR'S ACRONYM(S). Enter, if available, e.g. BRL, ARDEC, NADC.

11. SPONSOR/MONITOR'S REPORT NUMBER(S). Enter report number as assigned by the sponsoring/ monitoring agency, if available, e.g. BRL-TR-829; -215.

12. DISTRIBUTION/AVAILABILITY STATEMENT. Use agency-mandated availability statements to indicate the public availability or distribution limitations of the report. If additional limitations/ restrictions or special markings are indicated, follow agency authorization procedures, e.g. RD/FRD, PROPIN, ITAR, etc. Include copyright information.

13. SUPPLEMENTARY NOTES. Enter information not included elsewhere such as: prepared in cooperation with; translation of; report supersedes; old edition number, etc.

14. ABSTRACT. A brief (approximately 200 words) factual summary of the most significant information.

15. SUBJECT TERMS. Key words or phrases identifying major concepts in the report.

16. SECURITY CLASSIFICATION. Enter security classification in accordance with security classification regulations, e.g. U, C, S, etc. If this form contains classified information, stamp classification level on the top and bottom of this page.

17. LIMITATION OF ABSTRACT. This block must be completed to assign a distribution limitation to the abstract. Enter UU (Unclassified Unlimited) or SAR (Same as Report). An entry in this block is necessary if the abstract is to be limited.

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

CB&I Federal Services LLC has completed the *Final Remedial Investigation Report for RVAAP-019-R-01 Landfill North of Winklepeck MRS and RVAAP-060-R-01 Block D Igloo MRS*. 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 technical assumptions; methods, procedures, and materials to be used; and whether the product meets customer's needs consistent with law and existing United States Army Corps of Engineers policy.

Reviewed/Approved by: _____ Date: March 4, 2015

David Crispo, P.E.
Project Manager

Reviewed/Approved by: _____ Date: March 19, 2014

Jody Perwak
Human Health Risk Assessor

Reviewed/Approved by: _____ Date: March 19, 2014

Jon Lindberg
Ecological Risk Assessor

Reviewed/Approved by: _____ Date: March 19, 2014

Maqsud Rahman
Project Chemist

Prepared/Approved by: _____ Date: March 19, 2014

Laura O'Donnell
Project Engineer

Final Remedial Investigation Report for RVAAP-019-R-01 Landfill North of Winklepeck MRS and RVAAP-060-R-01 Block D Igloo MRS
Version 1.0

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

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

Prepared for:

US Army Corps of Engineers®

U.S. Army Corps of Engineers
Baltimore District
10 S. Howard Street, Room 7000
Baltimore, Maryland 21201

Prepared by:

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

March 4, 2015

DOCUMENT DISTRIBUTION

Name/Organization	Number of Printed Copies	Number of Electronic Copies
ARNG Cleanup Program Manager	0	1
Camp Ravenna Environmental Office	1	1
CB&I Project Manager	2	2
Ohio EPA Site Coordinator	1	3
Ohio EPA–Central District Office	1	1
RVAAP Administrative Records Manager	2	2
USACE–Baltimore District	4	4

ARNG—Army National Guard
CB&I—CB&I Federal Services LLC
Ohio EPA—Ohio Environmental Protection Agency
RVAAP—Ravenna Army Ammunition Plant
USACE—U.S. Army Corps of Engineers

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

List of Figures

List of Tables

List of Appendices

Acronyms and Abbreviations

°F	degree(s) Fahrenheit
---	not available
AEDB-R	Army Environmental Database-Restoration
AMEC	AMEC Earth and Environmental
amsl	above mean sea level
AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
ARNG	Army National Guard
ASR	*Final Archival Search Report*
ASTM	American Society of Testing and Materials
B	analyte was detected in associated blank
BERA	baseline ecological risk assessment
bgs	below ground surface
BSV	background screening value
Camp Ravenna	Camp Ravenna Joint Military Training Center
CAS	Chemical Abstracts Service
CB&I	CB&I Federal Services LLC
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
cm/s	centimeters per second
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
CT Laboratories	CT Laboratories, Inc.
CTT	closed, transferring, and transferred
D	discrete
DERP	Defense Environmental Restoration Program
DMM	discarded military munitions
DoD	U.S. Department of Defense
DQO	data quality objective
e^2M	engineering-environmental Management, Inc.
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EQM	Environmental Quality Management
ERA	ecological risk assessment
ESA	Endangered Species Act
ESQD	explosive safety-quantity distance
ESV	ecological screening value
EU	exposure unit
Fe	iron

Acronyms and Abbreviations (continued)

FS	Feasibility Study
FWSAP	*Facility-Wide Sampling and Analysis Plan*
FWCUG	facility-wide cleanup goal
GPS	global positioning system
HA	hazard assessment
HE	high explosive
HHRA	human health risk assessment
HHRAM	*Facility-Wide Human Health Risk Assessor Manual*
HQ	hazard quotient
HRR	*Final Military Munitions Response Program Historical Records Review*
INRMP	*Final Integrated Natural Resources Management Plan*
IRP	Installation Restoration Program
ISM	incremental sampling method
ISO	industry standard object
lb	pound
LCS	laboratory control sample
LOD	limit of detection
mag and dig	magnetometer and dig
MC	munitions constituents
MD	munitions debris
MDAS	material determined as safe
MDL	method detection limit
MEC	munitions and explosives of concern
MFD-H	horizontal maximum fragmentation distance
mg/kg	milligrams per kilogram
MKM	MKM Engineers, Inc.
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRL	method reporting limit
MRS	Munitions Response Site
MRSPP	*Munitions Response Site Prioritization Protocol*
MS/MSD	matrix spike/matrix spike duplicate
NA	not available/not applicable
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NEW	net explosive weight
NGT	National Guard Trainee
NOAEL	no observed adverse effects level
ODNR	Ohio Department of Natural Resources
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PBA	Performance Based Acquisition

Acronyms and Abbreviations (continued)

PBT	persistent, bioaccumulative, and toxic
PRG	Preliminary Remediation Goal
QA	quality assurance
QC	quality control
R(A)	Resident Receptor (Adult)
R(C)	Resident Receptor (Child)
RCRA	*Resource Conservation and Recovery Act*
RI	Remedial Investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RSL	Regional Screening Level
RVAAP	former Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
S.U.	standard unit
Shaw	Shaw Environmental & 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
SUXOS	Senior UXO Supervisor
TBC	to be considered
TD	transferred
TOC	total organic carbon
TRV	toxicity reference value
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
USP&FO	U.S. Property and Fiscal Officer
UXO	unexploded ordnance
VSP	Visual Sample Plan®
VQ	validation qualifier

This page intentionally left blank.

EXECUTIVE SUMMARY

This *Remedial Investigation (RI) Report* documents the findings and conclusions of the RI field activities for the Landfill North of Winklepeck (RVAAP-019-R-01) and Block D Igloo (RVAAP-060-R-01) Munitions Response Sites (MRSs) 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 the Military Munitions Response Program (MMRP) Environmental Services at the facility under the *Multiple Award Military Munitions Services Performance-Based Acquisition* Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

The purpose of the RI was to determine whether the Landfill North of Winklepeck and Block D Igloo MRSs warranted further response action pursuant to the *Comprehensive Environmental Responsibility, Compensation, and Liability Act* (CERCLA) of 1980 and the *National Oil and Hazardous Substances Pollution Contingency Plan*. More specifically, the RI was intended to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the potential hazards and risks posed to likely human and ecological receptors by MEC and MC.

ES.1 MRS Descriptions

Background information related to the sites included in this RI Report was taken from the *Final Archival Search Report* (USACE, 2004), the *Final Military Munitions Response Program Historical Records Review* (HRR) (engineering-environmental Management, Inc. [e^2M], 2007), and the *Final Site Inspection Report* (Site Inspection [SI] Report) (e^2M, 2008).

Landfill North of Winklepeck MRS

The Landfill North of Winklepeck MRS is a 2.3-acre area along the northern slope of the collocated Installation Restoration Program area of concern, the Landfill North of Winklepeck Burning Grounds (RVAAP-19). The MRS is situated on top of a small bluff at the north central portion of the facility that overlooks an unnamed stream to the east. The landfill accepted general plant refuse, explosive wastes residue, and open burn waste including flares and booster cups from Winklepeck Burning Grounds. The HRR stated that there is the potential for MEC items to be present on the slope leading down to the small stream and within the stream course (e^2M, 2008). During the 2007 SI field activities, material potentially presenting an explosive hazard (MPPEH) was found at the MRS and was documented as safe (i.e., munitions debris [MD]) by unexploded ordnance (UXO)-qualified personnel. No MEC was found during the SI. MC consisting of lead and iron were detected

in surface soil samples at concentrations that exceeded the screening criteria. Although no visual evidence that would indicate potential MEC burial areas was identified during the SI, the SI Report recommended that further characterization be conducted under the MMRP to address MEC and MC concerns at the MRS (e^2M, 2008).

Current activities at the Landfill North of Winklepeck MRS include maintenance activities, environmental sampling, and natural resource management activities. The future land use for the MRS is military training (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011).

Block D Igloo Investigation Area

On March 24, 1943, Igloo 7-D-15, located at the northern portion of the facility, exploded as a result of 2,516 clusters of M-41 20-pound (lb) fragmentation bombs accidentally detonating. Based on observations, the blast created two fans. The first fan was circular and smaller in size around the vicinity of the igloo. The second larger fan extended to the east toward the Block "E" igloos. The MRS is defined as the area immediately surrounding the former igloo and all remaining documented debris locations (and areas in between) that were not investigated during the 2007 SI (e^2M, 2008). The current MRS is 340.2 acres and the areas are discontinuous. The maximum MRS boundary from the point of detonation of the explosion at Igloo 7-D-15 is approximately 10,000 feet to the east.

A boundary evaluation was performed for this RI to verify the horizontal maximum fragmentation distance (MFD-H) associated with the clusters of M-41 20 lb fragmentation bombs that exploded at the igloo. The results of the evaluation consequently reduced the size of the RI area to approximately 92.14 acres from the 340.2 acres recommended in the SI Report (e^2M, 2008). Based on the revised MFD-H, the maximum distance to be investigated from the former igloo footprint was reduced from approximately 10,000 feet to 2,389 feet. The revised MFD-H is referred to as the "Block D Igloo Investigation Area" in this RI in order to differentiate it from the current MRS boundaries. The Block D Igloo Investigation Area is the focus of this RI.

Current activities at the Block D Igloo Investigation Area include military training, maintenance, and natural resource management activities. The future land use for the Block D Igloo Investigation Area is military training (USACE, 2005).

ES.2 Summary of Remedial Investigation Activities

The preliminary conceptual site models (CSMs) for each of the MRSs were evaluated based on the historical background reviews and data needs, and the data quality objectives (DQOs) were determined as outlined in the *Final Work Plan for Military Munitions Response Program Remedial Investigation Environmental Services* (Shaw, 2011). The data needs included characterization for MEC and/or MC associated with the former activities or

incidents at each of the investigation areas. 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. The decisions rules as identified in the DQOs for each of the MRSs and the summary of the RI activities are presented below.

Landfill North of Winklepeck MRS

The DQOs for the Landfill North of Winklepeck MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform an instrument-assisted visual survey to investigate for potential MEC on the ground surface.
- Perform a geophysical investigation if MEC was identified during the visual survey.
- Collect discrete samples (surface and subsurface soil) in areas with concentrated MEC/MD to evaluate for MC.
- Process the information to evaluate whether there were unacceptable hazards/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.

The instrument-assisted visual survey at the Landfill North of Winklepeck MRS was performed over 100 percent of accessible areas at the MRS in May and September of 2011. Of the 2.32 acres that make up the MRS, 1.6 acres were investigated. The remaining portions of the MRS, which consisted of wetlands and the unnamed stream located in the northern portion of the MRS, were not investigated due to inaccessibility. The SI Report (e^2M, 2008) indicates that MEC may be present in the stream course; however, review of the HRR (e^2M, 2008) mentions that MEC/MD was only found along the slopes of the landfill leading down to the stream. It is therefore expected that any MPPEH in the stream would be found along the banks of the wetland area as a result of rolling down the slopes of the MRS and that the wetland area and stream course were not used for disposal purposes.

Block D Igloo Investigation Area

The DQOs for the Block D Igloo Investigation Area identified the following decision rules that were implemented in evaluating the MRS:

- Perform an instrument-assisted visual survey to identify the lateral extent of MEC and determine areas with the potential for buried anomalies.

- Perform a magnetometer and dig (mag and dig) investigation at selected areas identified as having surface MEC or buried anomalies.
- Collect discrete surface and subsurface soil samples in areas with concentrated MEC/MD to evaluate for MC.
- Process the information to evaluate whether there were unacceptable hazards/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.

An instrument-assisted visual survey was performed at the Block D Igloo Investigation Area between April and May 2011, to identify dispositional areas of MEC that may have resulted from the accidental explosion at Igloo 7-D-15 in 1943. The area surveyed consisted of the revised 92.14-acre investigation area and was in an east direction along the median line of the long axis of the former igloo on a 60- to 80-degree angle from the center of the former igloo. In all, 65.2 miles of instrument-assisted visual survey transects were performed at the Block D Igloo Investigation Area. Each transect consisted of a sweep width of approximately 5 feet. The total area covered was approximately 54 acres, which included the 100-foot step-outs around the MPPEH identified along the boundary of the calculated blast fan that was determined to be MD. In addition to the proposed transects, an instrument-assisted visual survey was conducted behind (west) the location of the former magazine to verify that the blast did not produce kickout in this direction.

A total of 178 MPPEH items were identified on the ground surface during the visual survey. All of the MPPEH items were documented as safe (i.e., MD) by the UXO-qualified personnel. The MD found during the visual survey consisted of bomb fragmentation sleeves and tail fin assemblies associated with the M-41 20 lb fragmentation bomb. The maximum distance of the MD found during the visual survey from the former magazine location was approximately 1,800 feet due east. No additional MD was identified from the step-outs and the investigation west of the former magazine.

A mag and dig investigation was conducted at the Block D Igloo Investigation Area following the visual survey activities between June and July, 2011. Seven 100-foot by 100-foot mag and dig grids were placed throughout the investigation area to evaluate the potential for buried MEC. The selected grid locations were biased to areas where the MD was identified during the visual survey. A total of 3,140 MPPEH items were found during the mag and dig investigation. The UXO-qualified personnel documented 3,135 of the MPPEH items as safe (i.e., MD) and 5 MPPEH items as MEC. The MD was identified to be parts associated with the M-41 20 lb fragmentation bombs. The maximum depth of the MD encountered was 0.67 feet (8 inches) below ground surface (bgs) and the total weight of the MD was 2,614 lbs.

The five MEC items were found at three of the seven mag and dig grid locations. The maximum depth of the MEC was 0.5 feet (6 inches) bgs, and all the MEC was identified as parts associated with the M-41 20 lb fragmentation bombs, with the exception of one item. This item was only a small piece of an ordnance component suspected to be a fuze of an unknown type associated with a small fragmentation bomb and was not consistent with the fuzes used in the 20 lb bombs that exploded at the Block D Igloo.

Environmental samples for MC were collected at the Block D Igloo Investigation Area following the mag and dig investigation. Three samples were collected at three of the seven 100-foot by 100-foot mag and dig grids using the incremental sampling method where the MD was well distributed on the ground surface and was found in subsurface soils. Two discrete surface soil samples were collected beneath two of the individual MEC items identified at one of the grid locations. The incremental sampling method samples were collected at each sampling unit at depths between 0 to 0.5 feet (0 to 6 inches) bgs and the discrete surface soil samples were collected at 0.5-foot (6-inch) intervals below the individual MEC items. The depths of the discrete samples ranged from 0.25 feet (3 inches) to 0.83 feet (10 inches) bgs.

ES.3 MEC Hazard Assessment

The *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (U.S. Environmental Protection Agency [EPA], 2008) addresses human health and safety concerns associated with potential exposure to MEC at a MRS under a variety of site conditions, including various cleanup scenarios and land use assumptions. However, cleanup scenarios for a MRS are not usually addressed in an RI. If an explosive hazard is identified for this RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and will provide a scoring summary for the current and future land use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns.

Landfill North of Winklepeck MRS

The Landfill North of Winklepeck MRS was an unlined landfill that may have received MEC during disposal operations. Facility personnel also reported that MEC was present on the slope leading down to the unnamed tributary (e^2M, 2007). No MEC was found during the 2007 SI or during complete coverage of the land-based areas at the MRS during the RI field activities. The results of the RI indicate that no MEC source or explosive safety hazard is present at the MRS; therefore, calculation of a MEC HA was not warranted for the Landfill North of Winklepeck MRS.

Block D Igloo Investigation Area

A potential explosive safety hazard was identified at the Block D Igloo Investigation Area during the RI field activities; therefore, an evaluation of the MEC HA was conducted (EPA, 2008). The MEC HA score for current conditions at the Block D Igloo Investigation Area was calculated to be 640, which equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The MEC HA score for future use conditions at the MRS was calculated to be 670, which also equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The slight increase in the MEC HA score is 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 Block D Igloo Investigation Area were determined for the surface soil samples collected during the RI field activities through the facility data screening process, as presented in the *Final Facility-Wide Human Health Cleanup Goals for the RVAAP* (Science Applications International Corporation, 2010). The only detected chemicals that were retained as SRCs and identified in the environmental media samples collected during the RI were antimony and iron. 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 conclusions presented below.

Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted for the surface soil samples collected at the Block D Igloo Investigation Area 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 Block D Igloo Investigation Area is military training, and the Representative Receptors are the National Guard Trainee and the Range Maintenance Soldier. The Representative Receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (Army National Guard [ARNG], 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

Iron was the only SRC identified as a COPC in the first screening step. However, weight of evidence suggests that the detected iron concentrations are not likely to pose risks to human

receptors, including the Resident Receptor (Adult and Child), and Unrestricted Land Use was achieved for MC for the Block D Investigation Area.

Ecological Risk Assessment

Both iron and antimony were identified as chemicals of potential ecological concern (COPECs) in the soil samples collected for the RI at the Block D Igloo Investigation Area. COPECs are determined in the ecological risk assessment (ERA) and may differ from COPCs. Given the conservativeness of the ERA and the low overall concentrations of antimony that was detected, the potential of exposure to iron and antimony to adversely impact populations of ecological receptors at the Block D Igloo Investigation Area is considered to be very low and not pose a concern to ecological receptors. No final COPECs are identified for surface soil and no further investigation (i.e., a Level III Baseline) or action is considered necessary at the Block D Igloo Investigation Area for ecological purposes. Therefore, there are no COPECs that require additional investigation.

ES.5 Conceptual Site Models

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

Landfill North of Winklepeck MRS

An instrument-assisted visual survey was performed at 100 percent of the accessible areas of the Landfill North of Winklepeck MRS during the RI field activities. No MEC was observed on the ground surface at the MRS during the visual survey; therefore, the MEC exposure pathway for surface soil is considered incomplete for all receptors.

Since no MEC was identified during the visual survey, a subsurface investigation was determined to be unwarranted. Based on the lack of a MEC source, an explosive safety hazard is not present in the subsurface at the Landfill North of Winklepeck MRS and the MC exposure pathway for subsurface soils is considered to be incomplete for all receptors.

There is an unnamed tributary and wetland area located at the base of the slope of the eastern portion of the MRS that was not investigated during the RI field activities due to dense vegetation and fallen trees, which prevented access. Although MEC was reported to be present along the slope down toward the unnamed stream, no MEC was identified on the ground surface during the SI or RI field activities and horizontal migration of MEC down the

slope toward the stream is not anticipated. The MEC exposure pathway for surface water is considered incomplete for all receptors given the lack of activities that could cause potential subsurface MEC to reach the surface and migrate.

As no MEC source was identified during the RI field activities at the Landfill North of Winklepeck MRS, MC sampling was not warranted at the MRS (Shaw, 2011). Based on these findings, the MC CSM was revised to reflect incomplete pathways for all receptors.

Block D Igloo Investigation Area

A total of 178 MPPEH items were encountered on the ground surface during the RI visual survey activities and were documented as safe (i.e., MD) by the UXO-qualified personnel. Although, no MEC was found on the ground surface, the presence of MEC in subsurface soils, as found during the intrusive investigations, strongly suggests that MEC most likely exists on the ground surface at uninvestigated locations. The complete MEC exposure pathway for surface soil at the Block D Igloo Investigation Area would be to handle or tread underfoot for all receptors.

During the mag and dig investigation, a total of 3,140 MPPEH items were encountered at a maximum depth of 8 inches bgs. The UXO-qualified personnel determined that five of the MPPEH items were MEC. Based on these results, the MEC exposure pathway for subsurface soil pathway (greater than 0 inches bgs) is considered complete for all receptors that may engage in intrusive activities while using the MRS.

There are several small wetlands and unnamed streams, totaling approximately 2 acres that are situated within the calculated MFD-H for the Igloo 7-D-15 accidental explosion. These areas were investigated when possible; however, thick vegetation and standing or running water restricted the ability for UXO-qualified personnel to adequately evaluate some locations. When such areas were encountered, the UXO-qualified personnel evaluated the edges of the wetland or stream for the presence of MPPEH when a visual survey transect approached them in accordance with the Work Plan (Shaw, 2011). No MPPEH was found during the evaluation of the accessible areas of the streams and wetland areas; however, the presence of buried MEC within the investigation area suggests that MEC may be present in the streams and wetlands as well. If MEC is present in these areas, receptors may become exposed by handling or treading underfoot. Therefore, the MEC exposure pathway for surface water, inclusive of the wetlands and unnamed streams, is considered potentially complete.

Antimony and iron were identified as SRCs in surface soil within the defined blast arc of the 1943 explosion at the Igloo 7-D-15. The HHRA and the ERA determined that the SRCs were not present at concentrations great enough to pose risks to likely human or ecological

receptors. As a result, the revised MC CSM for the Block D Igloo Investigation Area illustrates incomplete pathways for all receptors.

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

ES.6 Conclusions

This section presents the conclusions of the RI based on the results of the RI field activities for MEC characterization at the Landfill North of Winklepeck MRS and for MEC and MC characterization at the Block D Igloo Investigation Area.

Landfill North of Winklepeck MRS

The 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 Landfill North of Winklepeck MRS based on the results of the RI field activities:

- All accessible areas at the MRS were investigated during the RI.
- Inaccessible areas could not be investigated due to obstacles (deadfall), wetland/marshes, and thick vegetation along the edges of these areas.
- An intrusive investigation was not warranted because no physical evidence of MEC was identified on the ground surface.
- MC sampling was not warranted because no MEC was found at the MRS during the RI field activities; therefore, no further action is required for MC at this MRS.

Based on the results of the RI field work, it is concluded that the nature and extent of MEC and MC at the Landfill North of Winklepeck MRS has been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. No explosive safety hazards or potential sources of MC have been identified at the MRS. The recommended next course of action under the MMRP for the Landfill North of Winklepeck MRS will be to proceed to a No Further Action Proposed Plan.

Block D Igloo Investigation Area

The 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 Block D Igloo Investigation Area based on the results of the RI field activities:

- The maximum horizontal distance of surface MD found from the former igloo footprint (1,800 feet) supports the revised calculated MFD-H for the Igloo 7-D-15 explosion (2,389 feet).
- MPPEH documented as safe (i.e., MD) was encountered on the ground surface outside of the north and south investigation area boundaries.
- Five MEC items posing explosive safety hazards were encountered in subsurface soil in the investigation area.
- The actual MEC density was determined to be greater than the MEC density assumed for the DQOs.
- The SRCs that were evaluated as MC in surface soil do not pose risks to human or ecological receptors at the investigation area.

The RI for the Block D Igloo Investigation Area included risk assessments for explosives hazards and MC that may pose risks to likely receptors. Based on the results of the RI field work, it is concluded that nature and extent of MEC and MC at the investigation area has been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. The total area that was impacted by the explosion that occurred at Igloo 7-D-15 is approximately 101.6 acres that is considered as the revised Block D Igloo MRS. The revised MRS area maintains the calculated MFD-H of 2,389 feet from the former igloo and includes a 100-foot buffer zone beyond the bound lateral extent of MD that represents the potential for MEC at those locations as well. A Feasibility Study is recommended as the next course of action under the MMRP at the revised Block D Igloo MRS to assess possible response action alternatives for likely remaining MEC.

1.0 INTRODUCTION

This *Remedial Investigation (RI) Report* documents the finding and conclusions of the RI field activities for the Landfill North of Winklepeck (RVAAP-019-R-01) and Block D Igloo (RVAAP-060-R-01) Munitions Response Sites (MRSs) located at the former Ravenna Army Ammunition Plant (RVAAP) in Portage and Trumbull Counties, Ohio. This RI Report was prepared by CB&I Federal Services LLC (CB&I) under Delivery Order 0002 for Military Munitions Response Program (MMRP) Environmental Services at the facility under the *Multiple Award Military Munitions Services Performance-Based Acquisition* (PBA) Contract No. W912DR-09-D-0005. The Delivery Order was issued by the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District on May 27, 2009.

This report presents the results of the RI field activities that were conducted at the Landfill North of Winklepeck MRS on May 23, 2011, and September 16, 2011, and at the revised investigation area of the Block D Igloo MRS between April 28 and July 25, 2011. This report was developed in accordance with the *Final Work Plan for MMRP Remedial Investigation Environmental Services* (Shaw Environmental & Infrastructure, Inc. [Shaw], 2011) at the RVAAP, hereafter referred to as the Work Plan, and the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

1.1 Purpose

Environmental cleanup decision making under the MMRP follows the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) of 1980 prescribed sequence of RI, Feasibility Study (FS), Proposed Plan, and Record of Decision. The RI serves as the mechanism for collecting data to characterize MRS conditions, determining the nature and extent of the contamination, and assessing potential hazards/risks to human health and the environment from this contamination. While not all munitions and explosives of concern (MEC) or munitions constituents (MC) under the MMRP constitute CERCLA hazardous substances, pollutants, or contaminants, 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 Contingency Plan* (NCP).

The purpose of this RI was to determine whether the Landfill North of Winklepeck and the Block D Igloo MRSs warranted further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently identify the potential hazards and risks posed to likely human and

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

1.2 Problem Identification

This section presents a summary of the potential MEC/MC impacts to human health and the environment associated with the Landfill North of Winklepeck and Block D Igloo MRSs as identified in the *Final Site Inspection Report* (engineering-environmental Management, Inc. [e^2M], 2008), hereafter referred to as the SI Report.

1.2.1 Landfill North of Winklepeck MRS

The Landfill North of Winklepeck Burning Grounds accepted general facility refuse, explosive wastes residue, and open burn waste, which included flares and booster cups. Based on historical documentation, MEC items (i.e., booster cups, aluminum liners, etc.) may be present on the slope of the landfill towards the stream as well as within the stream (e^2M, 2008).

A meandering path magnetometer and metal-detector-assisted unexploded ordnance (UXO) survey was conducted along the hillside, creek bed, wooded area to the southeast, and downstream area of the MRS during the SI field activities. Material potentially presenting an explosive hazard (MPPEH) was found during the UXO survey and was documented as safe (i.e., munitions debris [MD]). No MEC was found during the UXO survey. Multiple, closely spaced (i.e., concentrated) subsurface anomalies were detected along the length of the hillside adjacent to the former landfill. A composite surface soil sample was collected from the location along the slope where the MD was found and MC consisting of lead and iron were detected at concentrations above the screening criteria (e^2M, 2008).

The SI Report (e^2M, 2008) recommended that the MRS footprint be reduced from 14.05 acres to 2.32 acres, and include the area adjacent and along the length of the former landfill extending down and including the unnamed stream. This reduced MRS was recommended for further characterization in the RI to address MEC and MC concerns.

1.2.2 Block D Igloo MRS

The former Block D Igloo (Igloo 7-D-15) was a storage magazine where 2,516 clusters of M-41 20-pound (lb) fragmentation bombs accidentally detonated on March 24, 1943. At the time of the 2007 SI field activities, the MRS consisted of a circle with a 3,000-foot radius around it to capture the documented debris field that resulted from the explosion.

The SI field activities included a meandering path magnetometer and metal-detector-assisted UXO survey that was conducted within and around the former igloo and at four documented locations where explosion-related debris was previously found. No MPPEH was found lying

on the ground surface within the interior of the former igloo and within a circumference of approximately 100 feet surrounding this area or at the four documented debris locations. One composite surface soil sample was collected during the SI field activities around the former igloo footprint and arsenic and lead concentrations above the screening criteria were considered as MC (e^2M, 2008).

The SI Report recommended further characterization of MC at the former igloo and further characterization of MEC at the remaining documented debris locations that were not investigated during the SI. These combined areas encompassed approximately 340.2 acres that the SI Report recommended to be the revised MRS footprint (e^2M, 2008).

During preparation of the Work Plan (Shaw, 2011), a boundary evaluation was performed to verify the horizontal maximum fragmentation distance (MFD-H) associated with the M-41 20 lb fragmentation bombs that exploded at the igloo. CB&I consulted with the USACE Support Center in Huntsville, Alabama to verify the maximum distance that the combined detonation of 20 lb bombs could have traveled. For this application, a 40 percent factor for sympathetic detonation was used. The evaluation resulted in a calculated MFD-H of 2,389 feet which represents the furthest that an M-41 20 lb fragmentation bomb, whether intact or in pieces, could have travelled as a result of the explosion. The results of the evaluation consequently reduced the size of the investigation area to 92.14 acres from the 340.2 acres recommended in the SI Report (e^2M, 2008). This approximate 92-acre area is herein referred to as the "Block D Igloo Investigation Area" in order to differentiate it from the current MRS boundaries and is the area of focus in this RI. The findings of the evaluation are presented in the *Rationale for Reduction in Investigation Area for Block D Igloo MRS (RVAAP-060-R-01)* technical memorandum to the Ohio Environmental Protection Agency (Ohio EPA) included in **Appendix A**. Ohio EPA correspondence regarding the technical memorandum is provided in **Appendix B**.

1.3 Physical Setting

This section presents the physical characteristics of the facility, the Landfill North of Winklepeck MRS, the Block D Igloo Investigation Area, and the surrounding environments that are factors in understanding fate and transport, conceptual site models (CSMs), receptors, and exposure scenarios for potential human health and ecological risks. The physiographic setting, hydrology, climate, and ecological characteristics of the facility were compiled primarily from information originally presented in (1) the SI Report (e^2M, 2008), which included the Landfill North of Winklepeck and the Block D Igloo MRSs, and (2) the *Final Integrated Natural Resources Management Plan* (AMEC Earth and Environmental, Inc. [AMEC], 2008), hereafter referred to as the INRMP, 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**).

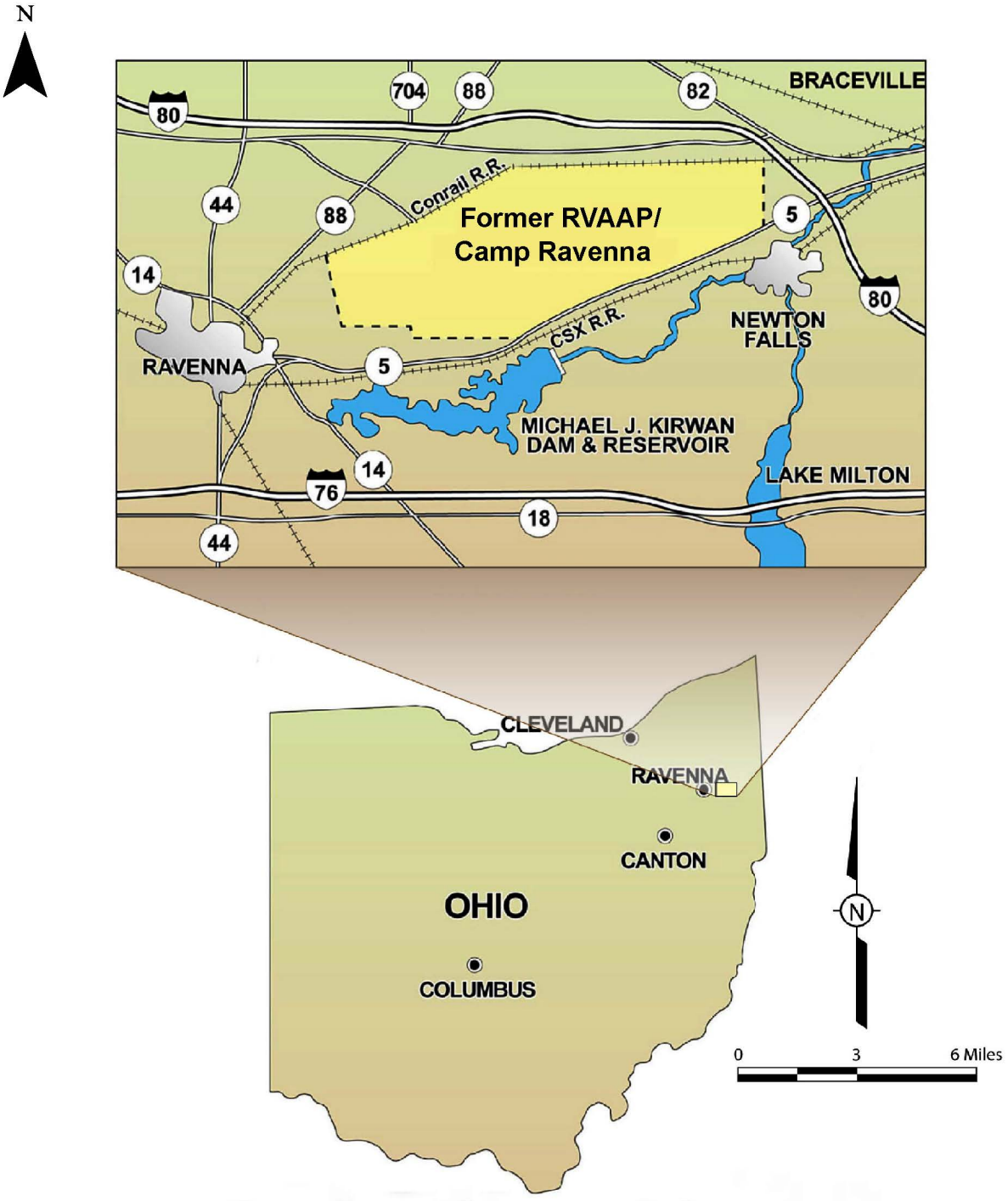
Administrative control of the 21,683-acre facility has been transferred to the U.S. Property and Fiscal Officer for Ohio and subsequently licensed to the OHARNG for use as a training site, Camp Ravenna. The restoration program involves cleanup of former production areas across the facility related to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

Both the Landfill North of Winklepeck and Block D Igloo MRSs are located on federal property that is managed by the ARNG and the OHARNG. **Table 1-1** summarizes the administrative descriptions for the Landfill North of Winklepeck and Block D Igloo MRSs. The table includes the facility Army Environmental Database-Restoration (AEDB-R) numerical designation for the MRS, the current MRS acreages, and the agency responsible for management activities for the MRS.

Table 1-1
Administrative Description Summaries for the Landfill North of Winklepeck MRS and the Block D Igloo MRS

MRS Name	AEDB-R MRS Number	MRS Area (Acres)	Property Owner	MRS Management Responsibility
Landfill North of Winklepeck	RVAAP-019-R-01	2.32	USP&FO	ARNG/OHARNG
Block D Igloo	RVAAP-060-R-01	340.2		

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



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

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS Documents\Project Maps\MMRPRIFS\RIFS BDIqloo LandfillNVink\2014 April Rev1\RVAAP LNVP BDI 001 Fig1 1 SiteLoc r1.mxd Analyst: gwt Date: 6/12/2014 2:36:29 PM

FIGURE 1-1 INSTALLATION LOCATION MAP

Although administratively, the current MRS acreage for the Block D Igloo is 340.2 acres, the focus of the RI field activities for this MRS was at the 92.14-acre investigation area calculated to be the MFD-H for the M-41 20 lb fragmentation bombs that exploded at the igloo.

1.3.2 Current and Projected Land Uses

This section presents the current and future activities for the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area. The future activities description for the Landfill North of Winklepeck MRS is based on information provided in the *RVAAP Facility-Wide Human Health Risk Assessor Manual* (USACE, 2005), which is hereafter referred to as the HHRAM. The Block D Igloo Investigation Area covers a large area due to the extent of the explosion. The future land use across the investigation area is based on information provided by the OHARNG and as presented in the Work Plan (Shaw, 2011). Since the RI was completed prior to finalization of the U.S. Army's *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant Installation Restoration Program* (ARNG, 2014), the Commercial Industrial Land Use was not evaluated for either of the MRSs. The locations of the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area at the facility are presented in **Figure 1-2**.

1.3.2.1 Landfill North of Winklepeck MRS

Current activities at the Landfill North of Winklepeck MRS include maintenance activities, environmental sampling, and natural resource management activities. Potential users associated with the current activities at the MRS include facility personnel, contractors, and occasional trespassers.

The future land use activities for the MRS will be military training. The National Guard Trainee and Range Maintenance Soldier are the Representative Receptors for the future activities (Shaw, 2011).

1.3.2.2 Block D Igloo Investigation Area

The Block D Igloo Investigation Area is located at the northern portion of the facility and reflects the maximum distance that the combined detonation of M-41 20 lb fragmentation bombs could have traveled from the former igloo. Current activities at the Block D Igloo Investigation Area include military training, maintenance, and natural resource management activities. Potential users associated with current land use at the investigation area include facility personnel, contractors, trainees, and occasional trespassers.

The future land use for the investigation area is military training. The National Guard Trainee and Range Maintenance Soldier are the Representative Receptors for the future activities (USACE, 2005).

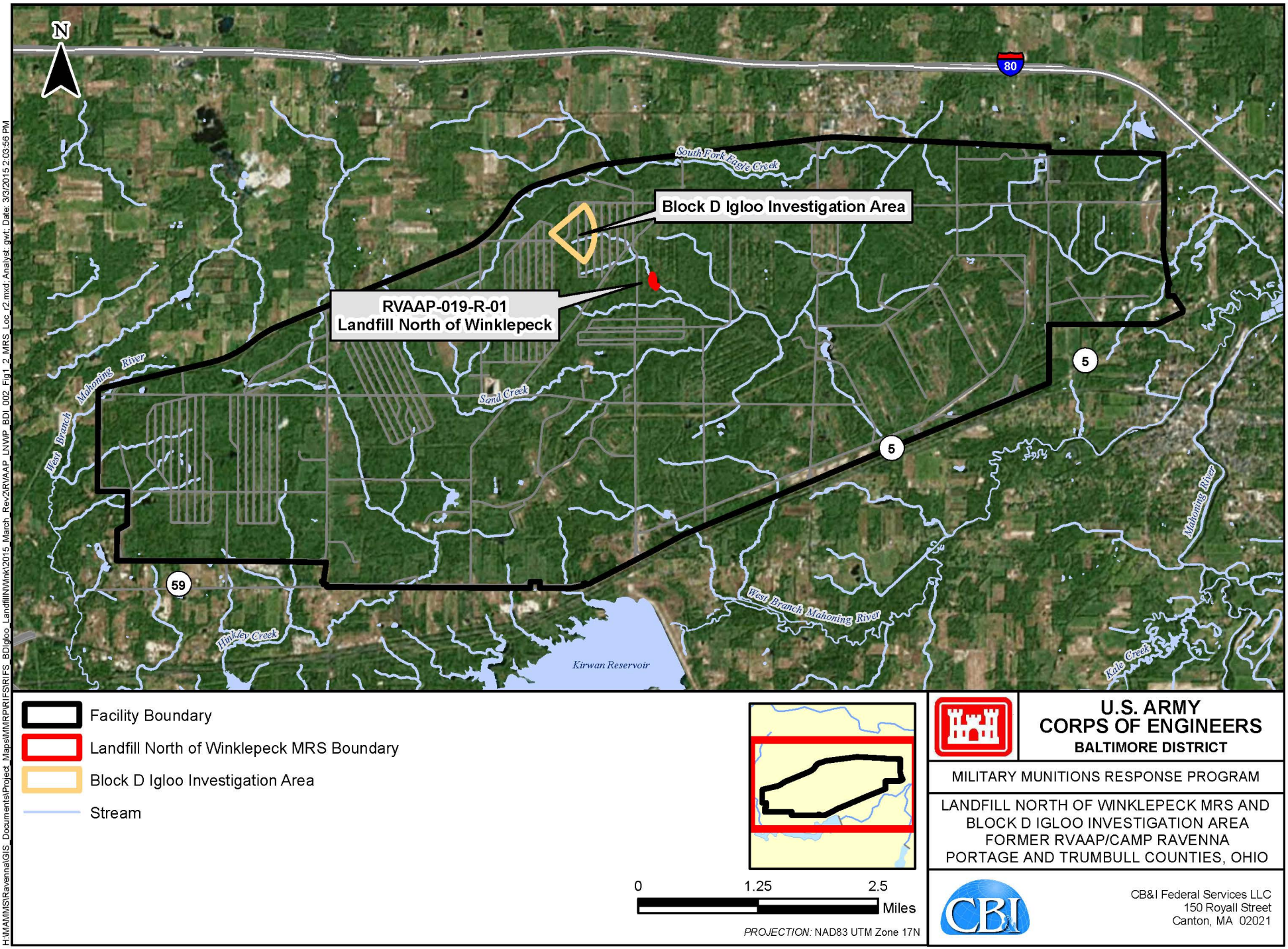


FIGURE 1-2 MRS LOCATION MAP

1.3.3 Climate

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

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

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

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

1.3.4 Topography

The facility is located within the southern New York section of the Appalachian Plateaus physiographic province. Rolling topography containing incised streams and dendritic drainage patterns is 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).

1.3.4.1 Landfill North of Winklepeck MRS Topography

The topography at the Landfill North of Winklepeck MRS slopes definitively toward the east from the top of the landfill that defines the top of the MRS to the unnamed stream which is the lowest point at the MRS. The elevations at the MRS range from approximately a topographic high of 1,138 feet above mean sea level (amsl) at the top of the slope to 1,120 feet amsl where the bottom of the slope meets the stream. The topographical features at the Landfill North of Winklepeck MRS are presented in **Figure 1-3**.

FIGURE 1-3 TOPOGRAPHY AT LANDFILL NORTH OF WINKLEPECK MRS

1.3.4.2 Block D Igloo Investigation Area Topography

Topography across the Block D Igloo Investigation Area is relatively flat with low hillocks and "pit and mound" features typical of forested sites. Based on topographical maps, the overall drainage direction for the Block D Igloo Investigation Area appears to be to the east–southeast. The lowest elevation is approximately 1,045 feet amsl at the eastern extent of the investigation area boundary. The highest elevation is approximately 1,110 feet amsl near the location of the former igloo. The topography for the Block D Igloo Investigation Area is presented in **Figure 1-4**.

1.3.5 Geology and Soils

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

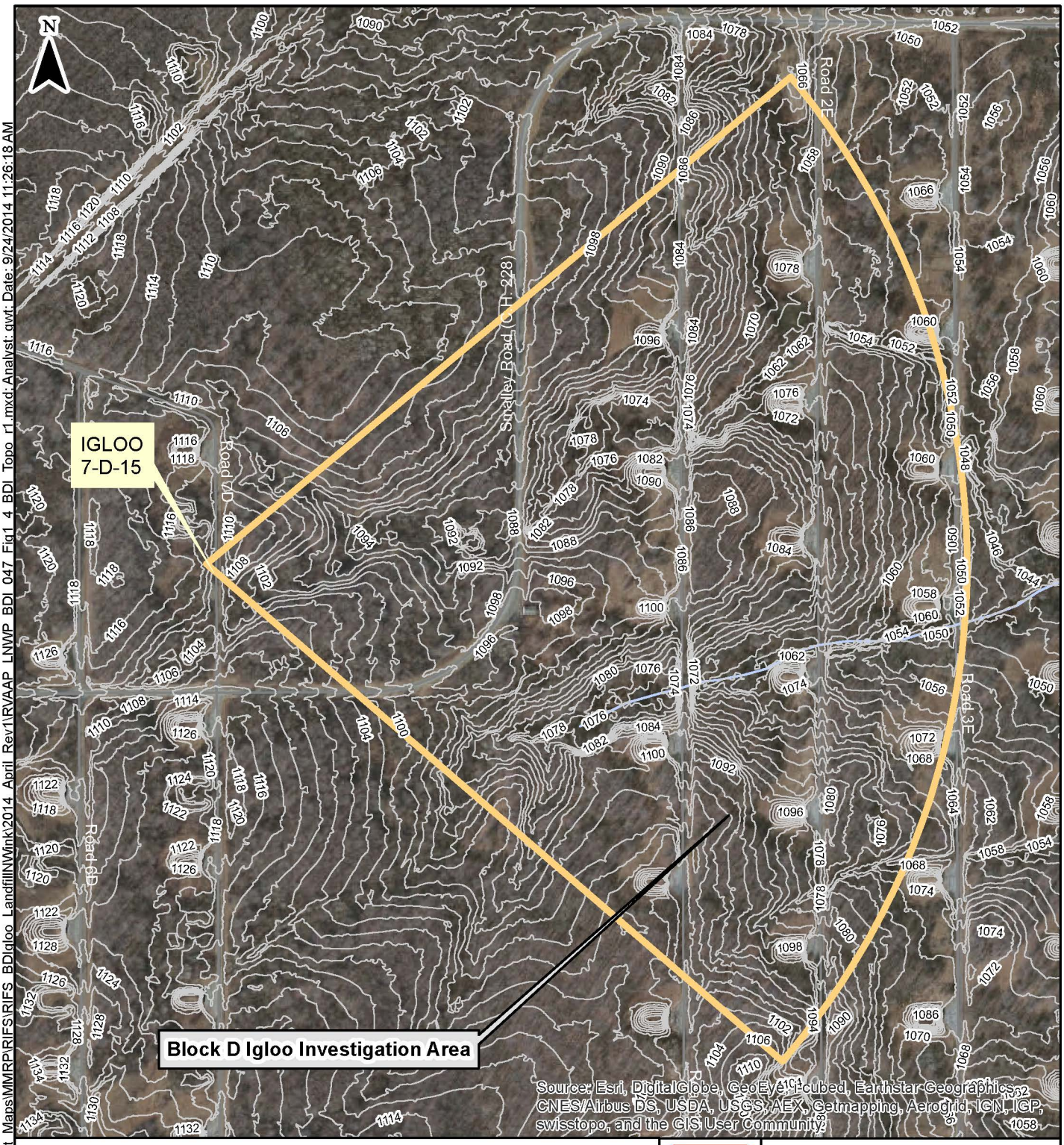
Bedrock is overlain by deposits of Wisconsin-aged Lavery Till and Hiram Till in the western and eastern portions of the facility, respectively. The thickness of the glacial deposits varies throughout the facility, ranging from ground surface in parts of the eastern portion of the facility to an estimated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

Bedrock is present near the ground surface in many locations at the facility, including Load Line 1 at the east end of the facility. Where glacial deposits are still present, their distribution and character are indicative of ground moraine origin. Laterally discontinuous groupings of yellow-brown, brown, and gray silty clays to clayey silts with sand and rock fragments are present. Glacial-age standing water body deposits may be present at the facility in the form of uniform light gray silt deposits over 50 feet thick.

At approximately 200 feet below ground surface (bgs), the Mississippian Cuyahoga Group is present throughout most of the facility. In the northeastern corner of the facility, the Meadville Shale Member of the Cuyahoga Group is present close to the surface. The Meadville Shale Member of the Cuyahoga Group is a 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 (informally referred to as the Sharon Conglomerate) is identified as a highly porous, permeable, cross-bedded, frequently fractured, and weathered quartzite sandstone, which is locally conglomeratic and has an average thickness



H:\MAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS BDIgloo LandfillINWink\2014 April Rev1\RVAAP LNWP BDI 047 Fig1 4 BDI Topo r1.mxd; Analyst: gwt; Date: 9/24/2014 11:26:18 AM

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 1-4 TOPOGRAPHY AT BLOCK D IGLOO INVESTIGATION AREA

of 100 feet. A thickness of as much as 250 feet exists in the Sharon Conglomerate where it was deposited in a broad channel cut into Mississippian rocks. In marginal areas of the channel, the conglomerate unit may thin out to approximately 20 feet or may be missing in places, owing to nondeposition on the uplands of the early Pennsylvanian erosional surface. Thin shale lenses occur intermittently within the upper part of the conglomerate unit.

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

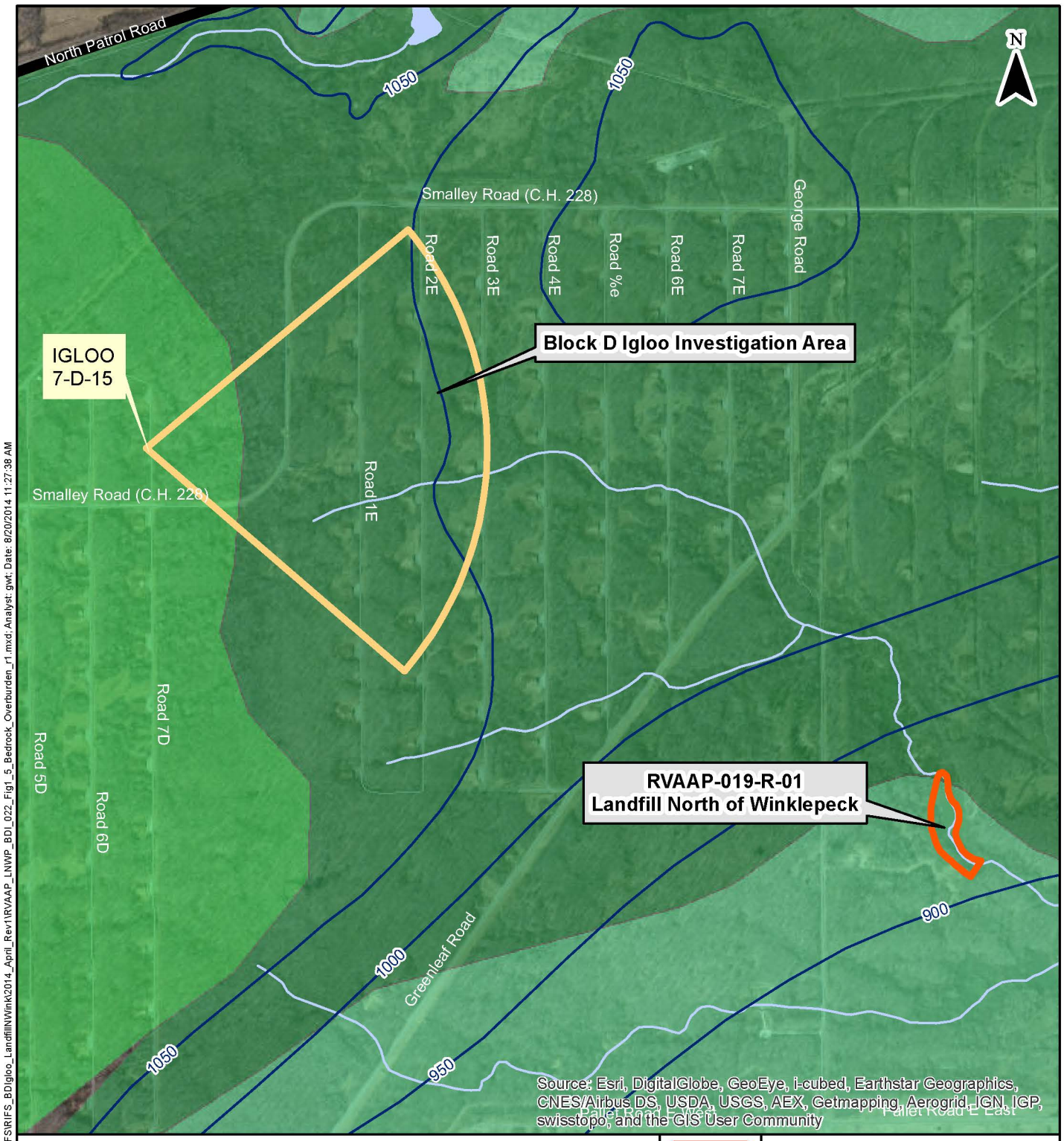
The remaining members of the Pottsville Formation overlie the Sharon Member in the western portion of the facility. Due to erosion and the land surface being above the level of deposition, the Pottsville Formation is not found in the eastern half of the facility.

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

The soils identified at the facility are generally derived from the Wisconsin-aged silty clay glacial till. The major soil types found in the high-priority MRSs are silt or clay loams, ranging in permeability from 6.0×10^{-7} to 1.4×10^{-3} centimeters per second (cm/s) (U.S. Department of Agriculture [USDA] et al, 1978). Much of the native soil at the facility was disturbed during construction activities in former production and operational areas of the facility (Science Applications International Corporation [SAIC], 2012).

1.3.5.1 Landfill North of Winklepeck MRS Geology and Soils

The Landfill North of Winklepeck MRS is located over the Sharon Sandstone Member, and the bedrock elevation ranges between approximately 910 and 940 feet amsl (AMEC, 2008). The minimum depths to bedrock in the vicinity of the MRS ranges from just below ground surface to approximately 20 feet bgs (SAIC, 2012). **Figure 1-5** illustrates the bedrock formations beneath the Landfill North of Winklepeck MRS.



Geologic Formation

- Mercer Member
- Sharon Member
- Sharon Sandstone Conglomerate Unit
- Bedrock Elevation Contour (feet above sea level)
- Stream
- Facility Boundary
- Landfill North of Winklepeck MRS Boundary
- Block D Igloo Investigation Area

0 1,000 2,000 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink\2014_April_Rev1\RVAAP_LNWP_BDI_022_Fig1_5_Bedrock_Overburden_r1.mxd: Analyst: gwt: Date: 8/20/2014 11:27:38 AM

FIGURE 1-5 BEDROCK MAP

Surface soils at the Landfill North of Winklepeck MRS have been primarily reworked due to the historical use of the MRS for landfill and disposal purposes. The naturally occurring soil type beneath the landfill and along the south east portion of the MRS consists of Ellsworth silt loam with 6 to 12 percent slopes (AMEC, 2008). The Ellsworth series consists of deep, moderately well drained, gently sloping to very steep slopes. Permeability is slow in the subsoil and the underlying glacial till with rates ranging from 4.2×10^{-5} to 1.4×10^{-3} cm/s. These soils are saturated with water for periods in the winter and spring and are slow to dry out (USDA et al, 1978). **Figure 1-6** illustrates the location and soil types located within the Landfill North of Winklepeck MRS.

1.3.5.2 Block D Igloo Investigation Area Geology and Soils

The Block D Igloo Investigation Area is situated over two bedrock types, the Mercer Member and the Sharon Member. The location of the former igloo and the western portion of the investigation area are over the Mercer Member. The eastern portion of the investigation area is located over the Sharon Member. Bedrock elevations across the investigation area are consistent at approximately 1,050 feet amsl (AMEC, 2008). Based on the ground surface topography for the investigation area, the depth to bedrock can range between 5 to 40 feet bgs. **Figure 1-5** illustrates the bedrock formations beneath the Block D Igloo Investigation Area.

Soils across the Block D Igloo Investigation Area include various soil types that consist primarily of the Mahoning silt loam with 2 to 6 percent slopes and the undulating Mahoning-Urban land complex. Other soil types found with the investigation area include the Trumbull silt loam with 0 to 2 percent slopes and the Holly silt loam along the surface water drainage paths that are frequently flooded (AMEC, 2008). **Figure 1-6** illustrates the location and soil types located within the Block D Igloo Investigation Area.

The Mahoning silt loam is located predominantly at the eastern portion of the investigation area. This soil type is characterized with medium-to-rapid runoff, severe seasonal wetness, and slow permeability. The average permeability of the Mahoning Silt Loam with a 2 to 6 percent slope is 9.1×10^{-5} cm/s (USDA et al, 1978).

The Mahoning Urban land complex is situated mostly in the central to southeast portion of the investigation area. This soil type is situated in urban or industrialized areas, and much of the natural soil type has been destroyed or covered as a result of grading and digging. Seasonal wetness is a limitation, particularly if grading has resulted in depressed or bowl-shaped areas (USDA et al, 1978).

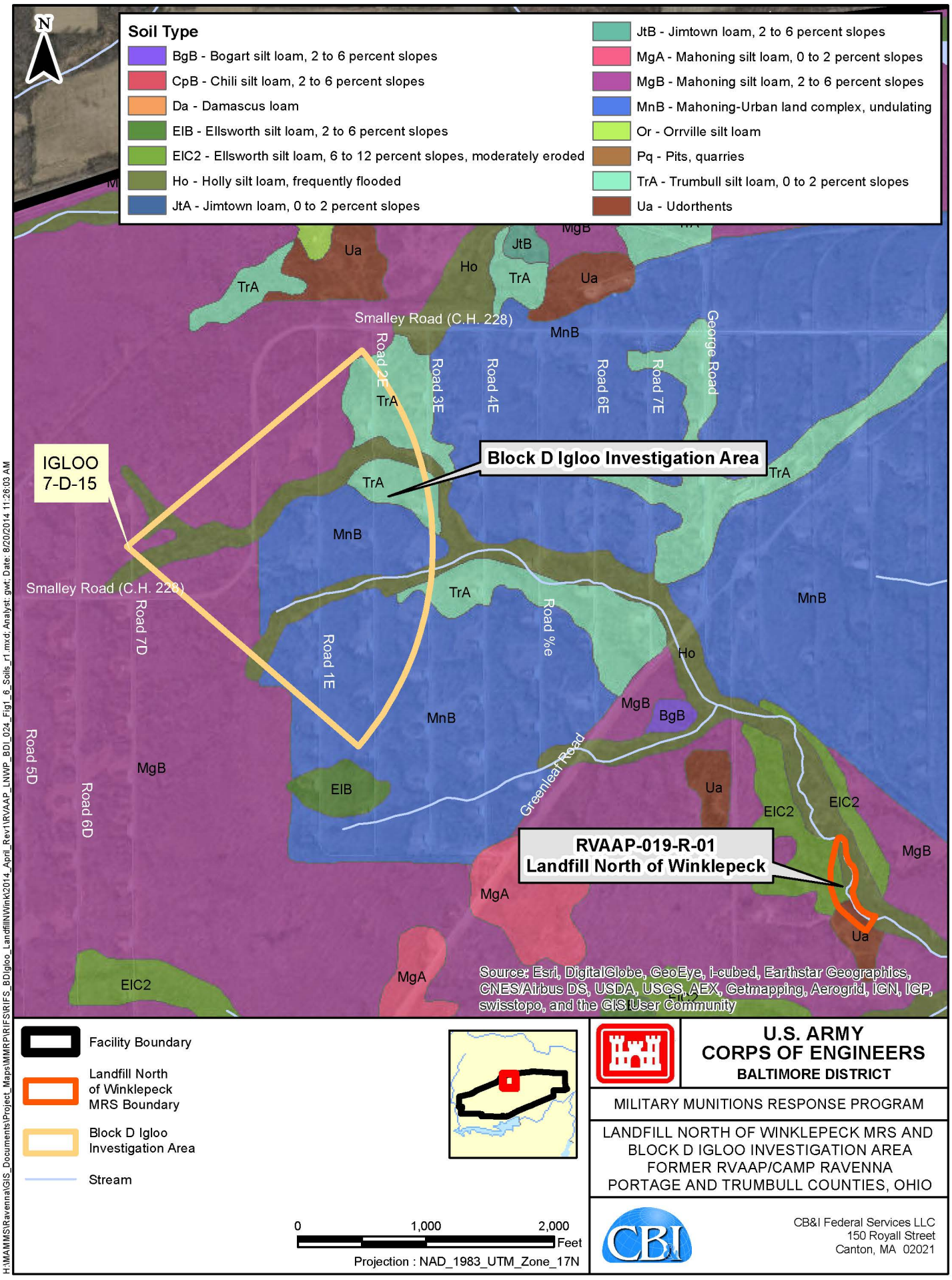


FIGURE 1-6 SOILS MAP

The Trumbull silt loam is a nearly level soil mainly along small drainage ways or in small depressions adjacent to better drained soils. Seasonal wetness and very slow permeability are limitations associated with this soil type. The average permeability rate associated with this soil type is 9.1×10^{-4} cm/s (USDA et al, 1978).

The Holly silt loam is a nearly level soil type mostly on narrow flood plains or strips on large flood plains. Runoff is slow to ponded and subjected to flooding. The average permeability rate associated with this soil type is 9.2×10^{-5} cm/s (USDA et al, 1978).

1.3.6 Surface Water

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

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

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

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

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

1.3.6.1 Landfill North of Winklepeck MRS Surface Water Features

Surface water drainage at the Landfill North of Winklepeck MRS generally flows toward the southeast following the topography. A jurisdictional delineation for wetlands has not been conducted at the MRS. A planning-level survey for wetlands was conducted at the facility, including the MRS, and identified a total area of 0.7 acres of forested wetlands at the MRS. The wetland area is situated along the eastern portion of the MRS and is associated with an unnamed tributary to Sand Creek that flows from the northwest to southeast (MKM, 2007). Sand Creek ultimately enters the downstream perennial headwater stream to the Michael J. Kirwan reservoir. The local and regional surface water features associated with the MRS are presented in **Figure 1-7**.

1.3.6.2 Block D Igloo Investigation Area Surface Water Features

A planning-level survey for wetlands was conducted for the facility, including the Block D Igloo Investigation Area, and identified a wetland at the northwest boundary of the investigation area. A 0.8-acre portion of this wetland is within the investigation area boundary. A small, 0.25-acre jurisdictional wetland is present at the central portion of the Block D Igloo Investigation Area. The wetlands present within the investigation area are either forested wetlands or wet fields (AMEC, 2008).

In general, surface water drainage for the MRS and surrounding area follows the topography toward the southeast. An unnamed tributary to Sand Creek begins approximately 1,000 feet southeast of the former igloo footprint and flows east to southeast. Sand Creek ultimately enters the downstream perennial headwater stream to the Michael J. Kirwan reservoir. The local and regional surface water features associated with the MRS are presented in **Figure 1-7**.

1.3.7 Hydrology and Hydrogeology

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

The thickness of the unconsolidated interval at the facility ranges from thin to absent in the eastern and northeastern portion of the facility to an estimated 150 feet in the south-central portion of the facility. The groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the heterogeneous nature of the unconsolidated glacial

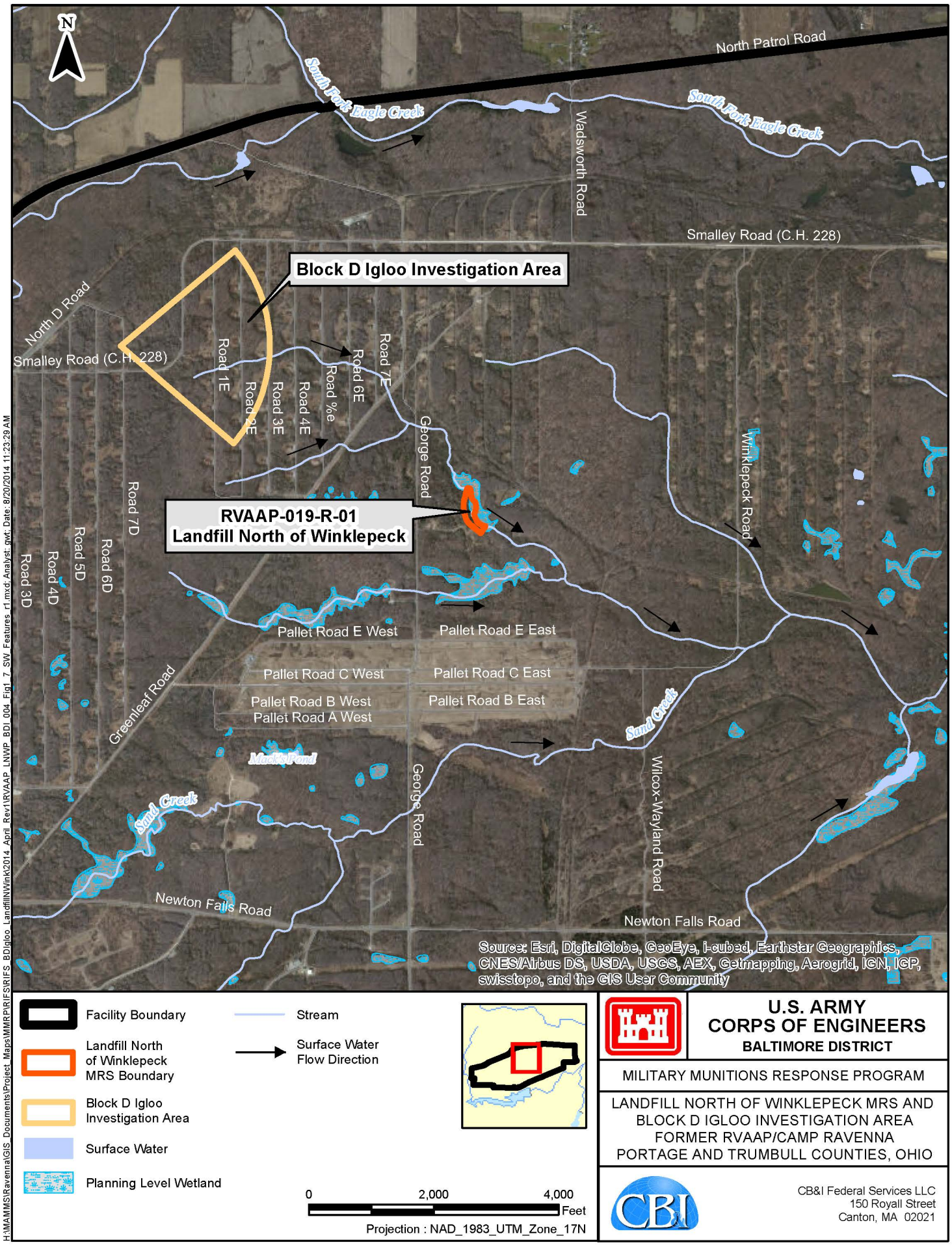


FIGURE 1-7 SURFACE WATER FEATURES

material, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones and desiccation cracks and partings within the soil column. Laterally, most groundwater flow likely follows topographic contours and stream drainage patterns, with preferential flow along pathways (i.e., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities than surrounding clay or silt-rich material (USACE, 1998).

Depending on the existence and depth of overburden, the Sharon Sandstone ranges from an unconfined to a leaky artesian aquifer. Water yields from water supply wells at the facility that were completed in the Sharon Sandstone/Conglomerate were 30 to 400 gallons per minute (gpm) (U.S. Army Toxic and Hazardous Materials Agency, 1978). Well yields of 5 to 200 gpm were reported for on-site bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer, 1982). Other local bedrock units capable of producing water include the Homewood Sandstone, which is generally thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells completed in the Connoquenessing Sandstone in Portage County have yields of 5 to 100 gpm, but are typically less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow and White, 1966).

1.3.7.1 Landfill North of Winklepeck MRS Hydrology and Hydrogeology

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

The depth to groundwater at the MRS ranges between ground surface at the unnamed tributary to Sand Creek at the most eastern portion of the MRS to approximately 17.5 feet bgs in unconsolidated sediments at the highest point of the MRS. The depth to groundwater measurements were taken from existing monitoring wells installed at the Landfill North of Winklepeck Area of Concern (AOC) under the Installation Restoration Program (IRP). Groundwater flow at the MRS is to the southeast towards the unnamed tributary (SAIC, 2012).

1.3.7.2 Block D Igloo Investigation Area Hydrology and Hydrogeology

Although groundwater recharge and discharge areas have not been delineated at the facility, it is assumed that the extensive uplands areas, located at the western portion of the facility, are regional recharge zones. Sand Creek, Hinkley Creek, and Eagle Creek are presumed to be major groundwater discharge areas (e^2M, 2008). The Block D Investigation Area is located

at the central, more level portion of the facility and is not presumed to be in a ground water recharge area.

No groundwater monitoring wells have been specifically installed for the Block D Igloo Investigation Area. Based on the facility data collected for the Facility-Wide Groundwater Monitoring Program, the groundwater elevation at the investigation area and the immediate vicinity is approximated at a potentiometric high of 1,100 feet amsl. Groundwater flow direction is towards the southeast. The approximate depth to groundwater in the unconsolidated aquifer at the Block D Igloo Investigation Area is 10 feet bgs (Environmental Quality Management [EQM], 2012).

1.3.8 Vegetation

The facility has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas. Vegetation at the facility can be grouped into three categories: (1) herb dominated, (2) shrub dominated, and (3) tree dominated. Tree-dominated areas are most abundant, covering approximately 13,000 acres on the facility. Shrub vegetation covers approximately 4,200 acres. A plant species survey identified 18 vegetation communities on the facility. The facility has seven forest formations, four shrub formations, eight herbaceous formations, and one nonvegetated formation (AMEC, 2008). **Figure 1-8** illustrates the plant communities present at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area.

1.3.8.1 Landfill North of Winklepeck MRS Vegetation

The plant communities at the Landfill North of Winklepeck MRS are predominantly characterized as the Oak Maple Tulip Tree Forest Community. The vegetation conditions for the wetland portion of the MRS are classified as Mixed Shrub Swamp and consist primarily of pondweeds, hornworts, and waterweed species (AMEC, 2008). Vegetation at the MRS has also been influenced by man-made improvements associated with the former use of the adjacent land as a landfill disposal area.

1.3.8.2 Block D Igloo Investigation Area Vegetation

The plant communities at the Block D Igloo Investigation Area primarily fall within the Red Maple Woods Community, the Oak Maple Tulip Forest Community, and the White Ash Wild Black Cherry Red Maple Woods Community. These communities are characterized by a high abundance of red maple, which sometimes occur in nearly pure stands. Green ash, white ash, black cherry, and sugar maple often are present as well, but not as dominant species (AMEC, 2008).

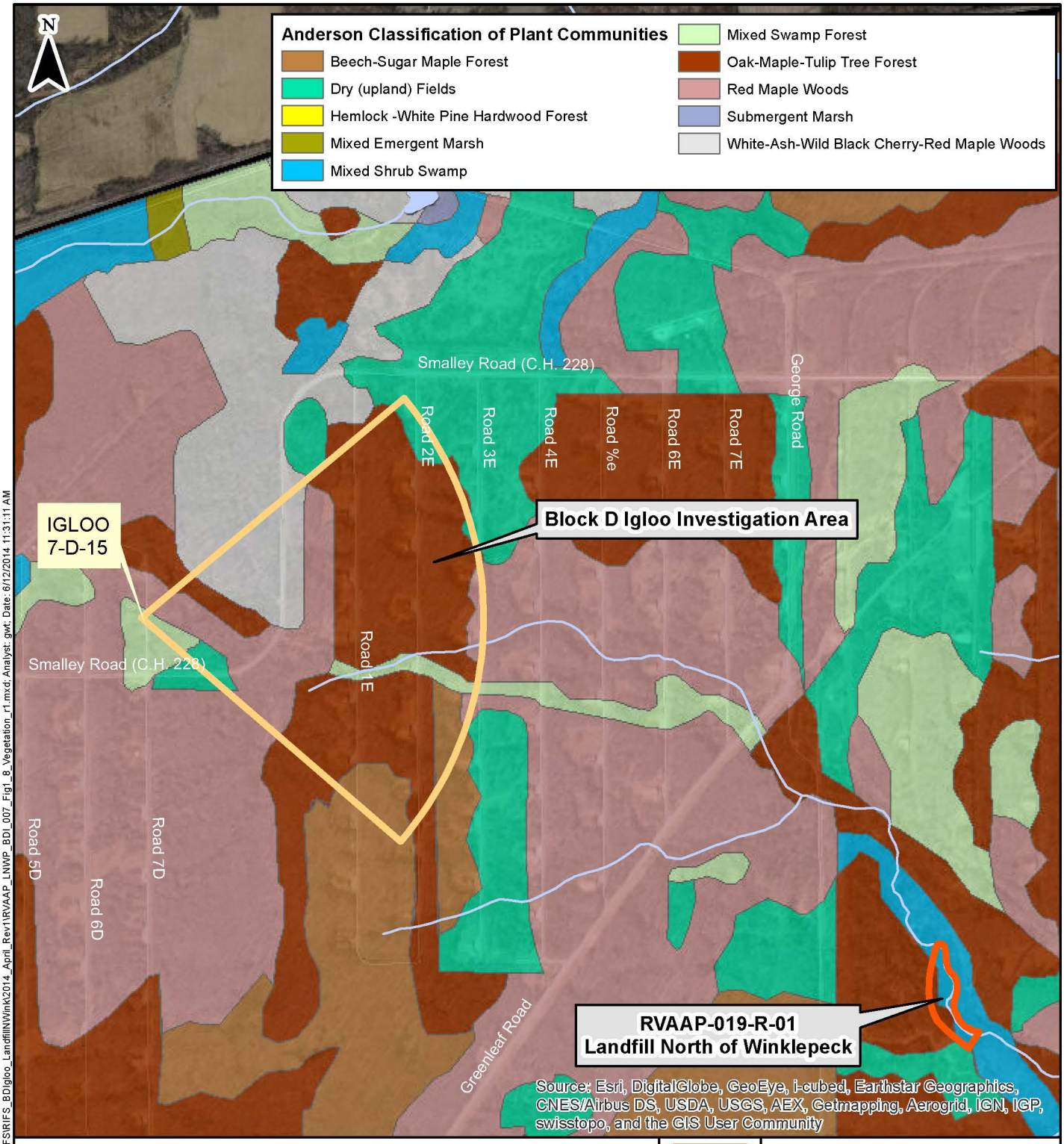


FIGURE 1-8 VEGETATION

Due to the minimal size of the combined wetlands identified in the investigation area (1.05 acres), the vegetation at these locations has not been specifically classified. However, due to the shallow depths of these wetland areas (likely less than 6 feet deep), it is likely that they are similar to other wetlands at the facility where the vegetation consists of primarily of pondweeds, hornworts, waterweed species, spatterdock, and/or white water lily (AMEC, 2008).

The area along the unnamed tributary to Sand Creek is classified as a Mixed Swamp Forest. The vegetation within this alliance consists primarily of green ash, American elm, hackberry, and red maple. Black walnut, white ash, swamp white oak, cottonwood, and black willow are also present. This vegetation is associated with flood plains near streams and rivers and other temporarily flooded areas (AMEC, 2008).

1.3.9 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). Biological inventories have occurred within the Landfill North of Winklepeck MRS and Block D Igloo Investigation Area boundaries. No confirmed sightings of state-listed species have been reported at the Landfill North of Winklepeck MRS; however, a state-listed species of concern consisting of the sharp-shinned hawk has been observed within the Block D Igloo Investigation Area (AMEC, 2008). Additionally, there is the potential for other state-listed or rare species to be within both investigation areas. Information regarding threatened and endangered 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*

Common Name	Scientific Name
Osprey	*Pandion haliaetus*
Trumpeter swan	*Cygnus buccinator*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Graceful underwing moth	*Catocala gracilis*
Tufted moisture-loving moss	*Philonotis fontana* Var. *Caespitosa*
Bobcat	*Felis rufus*
Narrow-necked Pohl's moss	*Pohlia elongata* Var. *Elongata*
Sandhill crane (probable nester)	*Grus canadensis*
Bald eagle (nesting pair)	*Haliaeetus leucocephalus*
State Threatened	
Barn owl	*Tyto alba*
Dark-eyed junco (migrant)	*Junco hyemalis*
Hermit thrush (migrant)	*Catharus guttatus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Caddisfly	*Psilotreta indecisa*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*
Lurking leskea	*Plagiothecium latebricola*
Pale sedge	*Carex pallescens*
State Potentially Threatened Plants	
Gray birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum* Var. *Roseum*
Hobblebush	*Viburnum alnifolium*
Long beech fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Large St. Johnswort	*Hypericum majus*

Common Name	Scientific Name
Water avens	*Geum rivale*
Shinning lady's tresses	*Spiranthes lucida*
Swamp oats	*Sphenopholis pensylvanica*
Arborvitae	*Thuja occidentalis*
American chestnut	*Castanea dentata*
Tufted moisture-loving moss	*Philonotis fontana* Var. *Caespitosa*
State Species of Concern	
Pygmy shrew	*Sorex hoyi*
Woodland jumping mouse	*Napaeozapus insignis*
Star-nosed mole	*Condylura cristata*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*
Cerulean warbler	*Dendroica cerulea*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chloropus*
Great egret (migrant)	*Ardea alba*
Sora	*Porzana carolina*
Virginia rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*
Mayfly	*Stenonema ithaca*
Coastal plain apamea	*Apamea mixta*
Willow peasant	*Brachylomia algens*
Sedge wren	*Cistothorus platensis*

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

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

1.3.10 Cultural and Archeological Resources

A number of archeological surveys have been conducted at the facility. Cultural and archeological resources have been identified at the facility during past surveys (AMEC, 2008). The Landfill North of Winklepeck MRS and Block D Igloo Investigation Area have 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 either area.

1.4 Facility History and Background

During operations as an ammunition plant, the RVAAP was a government-owned and contractor-operated industrial facility. Industrial operations at the RVAAP consisted of 12 munitions assembly facilities, referred to as "load lines." Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene and Composition B into large caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the "pink water" wastewater, which contained 2,4,6-trinitrotoluene and Composition B, was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. 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 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 facility include MRSs that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Other AOCs present at the facility include landfills, an aircraft fuel tank testing area, and various general industrial support and maintenance facilities (SAIC, 2011). Site-specific histories associated with the Landfill North of Winklepeck and Block D Igloo MRSs are discussed below.

1.4.1 Landfill North of Winklepeck MRS History and Background

The Landfill North of Winklepeck MRS was described in the U.S. Army Closed, Transferring, and Transferred (CTT) Range/Site Inventory as a 7.55-acre unlined landfill that accepted general facility refuse, explosive wastes residue, and open burn waste including flares and booster cups from the Winklepeck Burning Grounds. The landfill, which is collocated with an IRP AOC (Landfill North of Winklepeck Burning Grounds, AEDB-R Number RVAAP-19), is situated on top of a small bluff at the north central portion of the facility that overlooks an unnamed stream to the east.

The *Final MMRP Historical Records Review* (e^2M, 2008); herein, referred to as the HRR, includes a limited scope evaluation of the Landfill North of Winklepeck MRS and states that booster cups, aluminum liners, and other nondescript items that were identified as MEC were present on the slope leading down to the small stream and within the stream course. The stream at that time was outside of the MRS boundary as defined in the U.S. Army CTT Range/Site Inventory. The MRS boundary was subsequently revised and expanded to 14.05 acres to include the slope area and the adjacent small stream where the MEC items were reported. The landfill itself has been excluded from the MRS footprint and continues to be covered as an AOC under the IRP.

During the SI field activities, several MPPEH items (flares and 105mm projectiles) were identified on the ground surface. The MPPEH items were documented as safe (i.e., MD) by UXO-qualified personnel. The MRS boundary was revised to only include the slope area and the adjacent small unnamed tributary to Sand Creek that was approximately 2.3 acres in area (e^2M, 2008). **Figure 1-9** depicts the current boundaries and significant site features associated with the Landfill North of Winklepeck MRS.

1.4.2 Block D Igloo MRS History and Background

The "D" Block storage bunkers (igloos) at the facility are located at the north-central portion of the facility. On March 24, 1943, Igloo 7-D-15 exploded as a result of 2,516 clusters of M-41 20 lb fragmentation bombs accidentally detonating. The explosion was reported to have been caused by rough handling and the faulty design of the M-110 fuze. At the time of the detonation, the igloo was filled to 95 percent capacity. The 60-foot-long igloo was constructed of reinforced concrete with a steel door. The side walls of the igloo were sheared off at the footings during the explosion and the igloo's steel door was propelled 1,800 feet to the east. Concrete fragments were launched approximately 3,800 feet to the east of the igloo location. The slab of Igloo 7-D-15 is the only remaining part of the bunker. The igloo-shaped configuration of the bunker was designed to contain any internal explosion as best possible, and the resulting concrete fragments that were found at this distance from the igloo resulted from the impact of the detonation of the high explosives that were stored within the igloo.

Based on observations, the blast created two fans. The first fan was identified as an approximate 3,000 square foot radius around the center of the former igloo. A portion of this fan (approximately 19.25 acres) extended beyond the facility boundary, north of the explosion area, and was considered separately as a transferred MRS (RVAAP-062-R-001 Block D Igloo-TD). The second larger fan extended to the east toward the "E" Block igloos and reportedly distributed concrete fragments as far as 3,800 feet. The combined areas of the two blast fans that made up the Block D Igloo MRS footprint within the facility boundaries

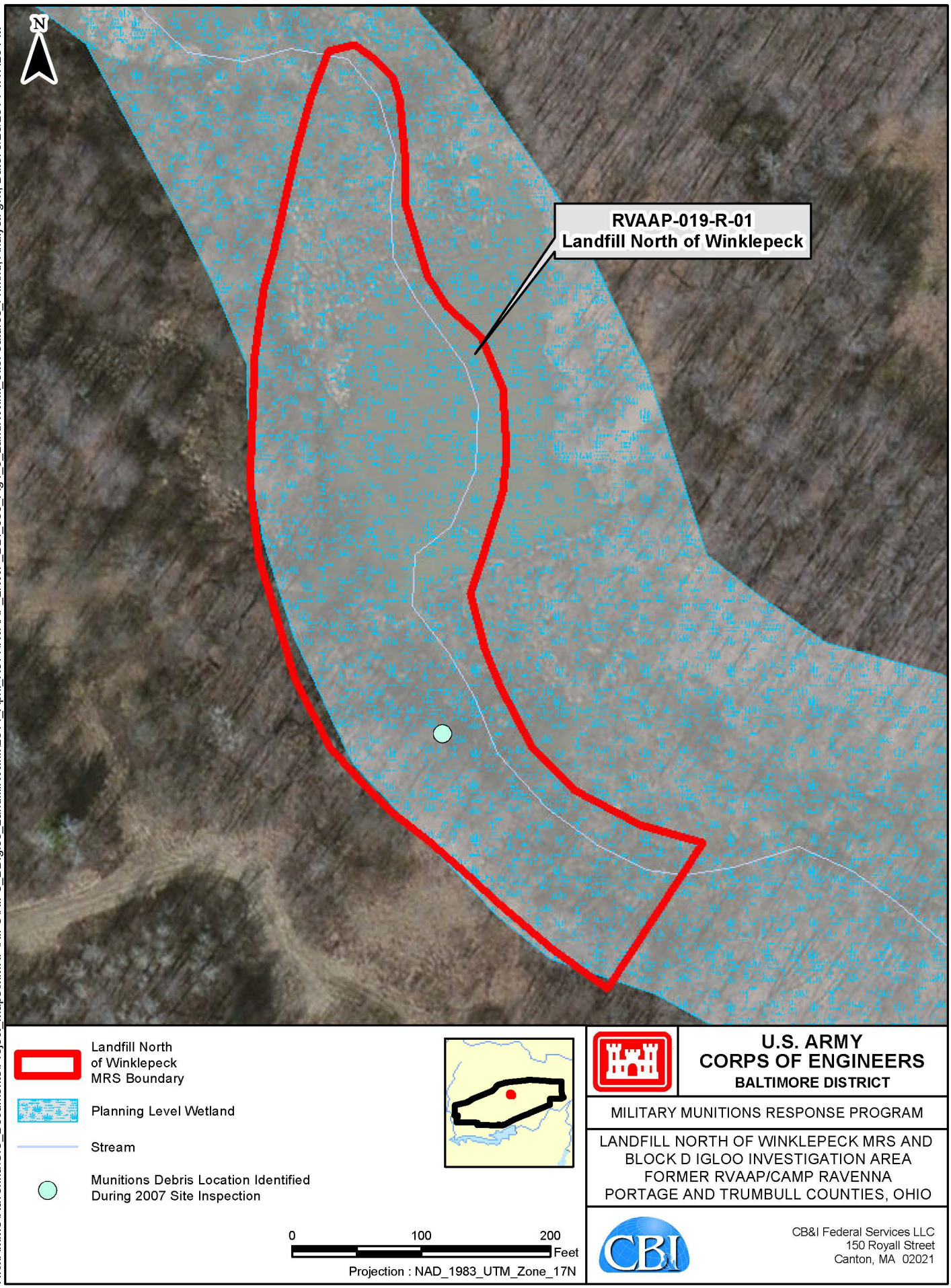


FIGURE 1-9 SITE FEATURES MAP, LANDFILL NORTH OF WINKLEPECK MRS

were originally 622.24 acres. Following the SI field work, the Block D Igloo MRS was reduced to 340.2 acres to include areas that had not been investigated as part of the SI but were considered part of the MRS in the U.S. Army CTT Range/Site Inventory and the HRR (e^2M, 2008). The 340.2 acres included the area immediately surrounding the former igloo and all remaining documented debris locations (and areas in between). Although the area of the MRS was reduced, inclusion of the documented debris locations, not previously investigated, increased the maximum distance of the MRS from the point of detonation at former Igloo 7-D-15 from 3,000 feet to nearly 10,000 feet. This resulted in noncontinous and irregular-shaped investigations areas within the MRS. **Figure 1-10** presents the revised Block D Igloo MRS boundaries and remaining cultural features as presented in the SI Report.

The recommendations that were made in the SI Report to reduce the 3,000 square foot radius around the former igloo eliminated the 19.25 acres area outside the northern portion of the facility that was the Block D Igloo-TD MRS. However, information was obtained by e^2M during the SI that indicated non-munitions related debris fragments from the 1943 explosion had been observed outside of the facility at two locations as far as 2.9 miles (15,000 feet) to the northeast. It was concluded in the SI Report that the presence of the debris fragments at these two locations (denoted as Area 1 and Area 2) also represented the potential for MEC being present outside of the facility. Area 1 and Area 2 were discontinuous areas and were located approximately 2.2 and 2.9 miles northeast of the former Igloo-7-D-15, respectively. The combined areas for Area 1 and Area 2 was 14.131 acres and were considered as the revised boundaries for the Block D Igloo-TD MRS (e^2M, 2008). **Figure 1-10** presents the revised Block D Igloo-TD MRS located outside of the facility boundaries that is based on the recommendations of the SI Report.

During preparation of the Work Plan (Shaw, 2011), a boundary evaluation was performed to verify the MFD-H associated with the M-41 20 lb fragmentation bombs that exploded at the igloo. CB&I consulted with the USACE Support Center in Huntsville, Alabama to verify the maximum distance that the combined detonation of 20 lb bombs could have traveled. For this application, a 40-percent factor for sympathetic detonation was used. The evaluation resulted in a calculated MFD-H of 2,389 feet, which represents the furthest that an M-41 20 lb fragmentation bomb, whether intact or in pieces, could have travelled as a result of the explosion. The results of the evaluation consequently reduced the size of the area to be investigated during the RI to 92.14 acres from the 340.2 acres recommended in the SI Report (e^2M, 2008). The revised Investigation Area is a continuous pie-shaped area that emanates from the center of the former igloo as opposed to the discontinuous and irregular-shaped investigation areas that were recommended in the SI Report. Furthermore, the reduction in

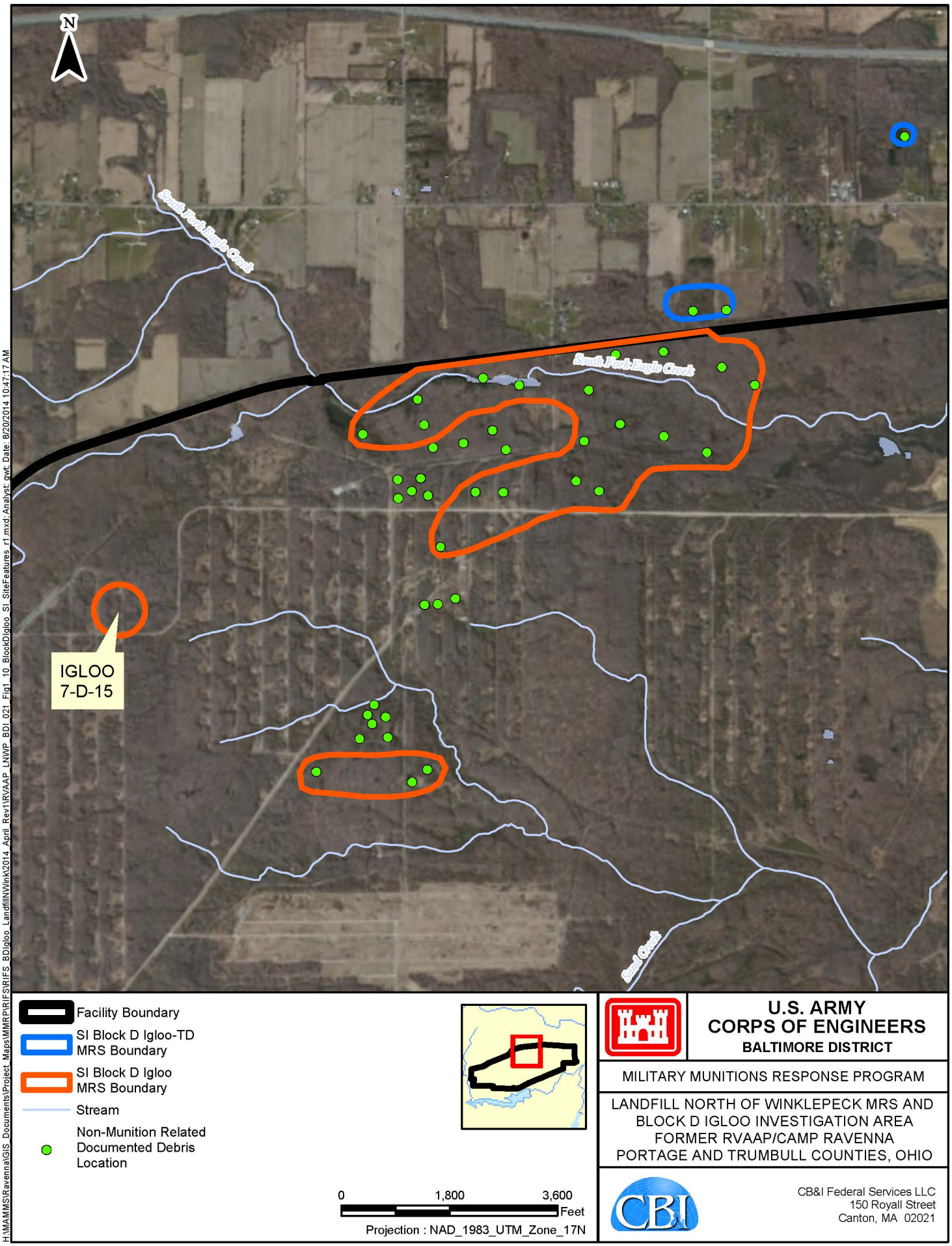


FIGURE 1-10 SITE FEATURES MAP, BLOCK D IGLOO MRS SI BOUNDARY

the calculated MFD-H eliminated the possibility that MEC may have travelled outside of the facility and the need for further investigation at the Block D Igloo-TD MRS is no longer required. The *Rationale for Reduction in Investigation Area for Block D Igloo MRS (RVAAP-060-R-01)* technical memorandum that was reviewed and approved by the Ohio EPA is presented in **Appendix A**. **Figure 1-11** depicts the Block D Igloo Investigation Area boundaries and cultural features that were evaluated in the RI.

1.5 Previous Investigations and Actions

This section briefly summarizes the investigations and actions as it pertains to the facility MRSs discussed in this RI Report. This information was obtained primarily from HRR (e^2M, 2007) and the SI Report (e^2M, 2008).

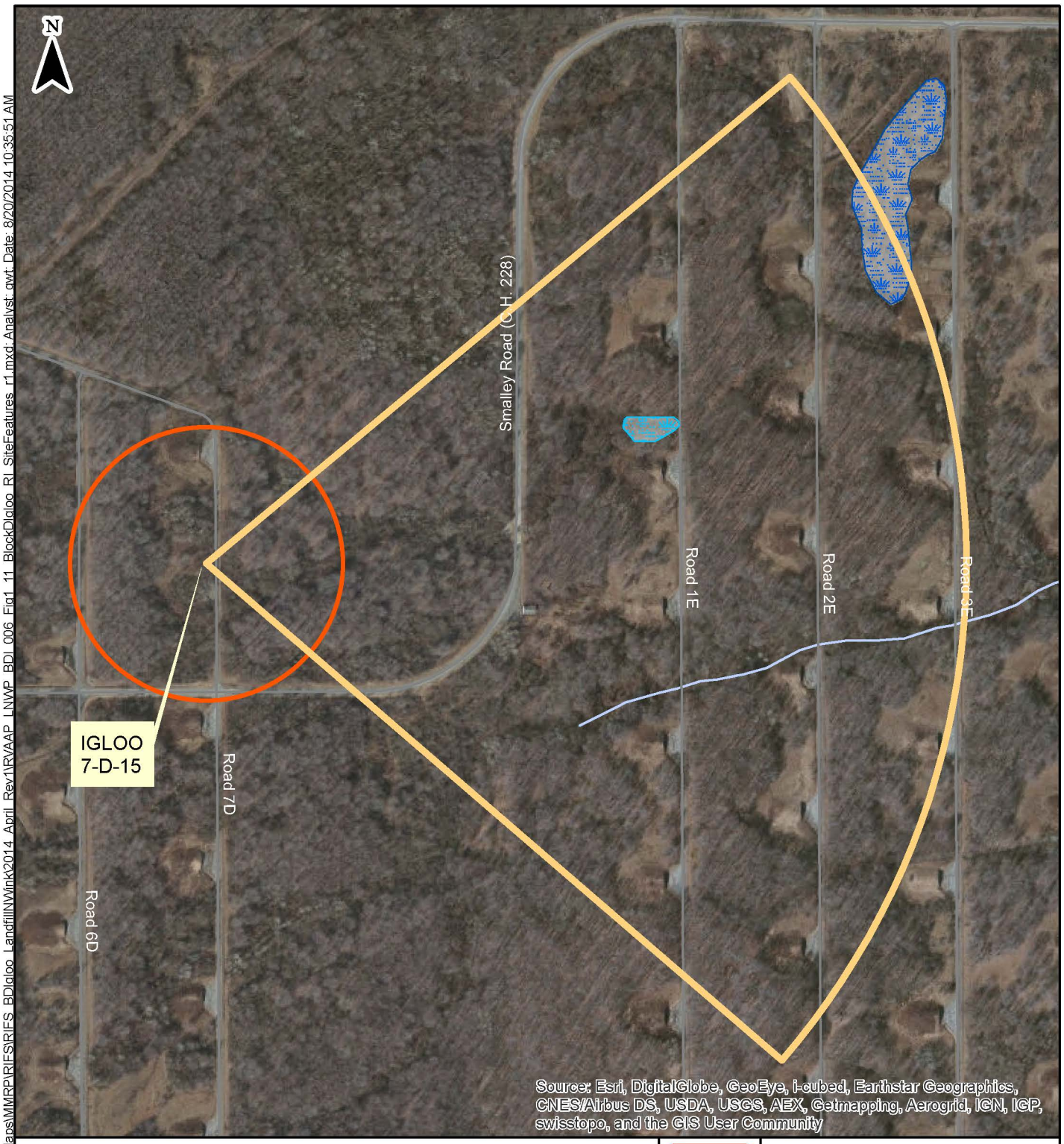
1.5.1 Archives Search Report

The USACE conducted an archives search in 2004 under the DERP as a historical records search and SI for the presence of MEC at the former RVAAP. The *Final Archives Search Report* (ASR) was prepared by the USACE in 2004 and identified 12 AOCs as well as 4 additional locations with the potential for MEC. Based on the ASR, Ramsdell Quarry Landfill, Erie Burning Grounds, Open Demolition Area #1, Load Line 12 and Dilution/Settling Pond, Building 1200 and Dilution/Settling Pond, Quarry Landfill/Former Fuze and Booster Burning Pits, 40-Millimeter 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.

1.5.2 e^2M 2007 Historical Records Review

The primary objectives of the HRR (e^2M, 2007) were 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 CTT 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 CTT 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. These 18 MRSs identified during the HRR include the following:



SI Block D Igloo MRS Boundary
Revised RI Block D Igloo Investigation Area
Planning Level Survey Wetlands
Jurisdictional Wetland
Stream

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNW\mxd\2014 April Rev1\RVAAP LNWP BDI 006 Fig1 11 BlockDigloo RI SiteFeatures r1.mxd Analyst: gwt Date: 8/20/2014 10:35:51 AM

FIGURE 1-11 SITE FEATURES MAP, BLOCK D IGLOO INVESTIGATION AREA RI BOUNDARY

- 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)
- 40-Millimeter 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 former RVAAP to 17.

1.5.2.1 Landfill North of Winklepeck MRS

The U.S. Army CTT Range/Site Inventory was reviewed during the HRR and reported that the landfill accepted general facility refuse, explosive wastes residue, and open burn waste from the Winklepeck Burning Grounds, including flares and booster cups. Facility personnel also reported that MEC in the form of booster cups and other unidentified items were present on the slope leading down to the unnamed tributary. Therefore, based on the results of the HRR it was anticipated that MEC and/or MC were present throughout the MRS. The MRS boundary was revised to 14.05 acres to include the slope and exclude the landfill AOC

included under the IRP (e^2M, 2007). **Figure 1-12** presents the U.S. Army CTT Range/Site Inventory MRS area for the Landfill North of Winklepeck and the revised MRS based on the HRR recommendations.

1.5.2.2 Block D Igloo MRS

The HRR summarized the investigation following the accidental explosion of Igloo 7-D-15 ("D" Block) on March 24, 1943, and the development of the initial MRS boundary by the USACE, Huntsville District. According to the U.S. Army CTT Range/Site Inventory, the detonation of bombs in Igloo 7-D-15 caused multiple fatalities and sent shrapnel and demolished material up to 2.9 miles away, off installation property. However, a majority of the demolished material was reported to have landed 1.3 to 2 miles to the northeast of the igloo, within installation boundaries. The material consisted of concrete fragments, parts of clothing, and an oil filter from a vehicle. The report further noted that cluster bombs may have been propelled from the igloo, as well (e^2M, 2007).

A map created by installation personnel after the explosion depicted the spread of debris from the blast. Based on the report, the MRS boundary was established by applying a 3,000-foot diameter circle ("for high explosive bombs") centered on and surrounding Igloo 7-D-15; this resulted in a total MRS acreage of approximately 622.24 acres. A portion of the circle extended beyond the installation boundary and was considered separately as a transferred site, Block D Igloo-TD (e^2M, 2007). The U.S. Army CTT Range/Site Inventory and HRR boundaries identified for the Block D Igloo MRS at the facility and Block D Igloo-TD MRS that was located outside of the facility is presented in **Figure 1-13**.

1.5.3 e^2M 2008 Site Inspection Report

In 2007, e^2M conducted an SI at each of the 17 MRSs under the MMRP. The primary objective 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 further characterization under the MMRP that included the Landfill North of Winklepeck MRS (RVAAP-019-R-01) and the Block D Igloo MRS (RVAAP-060-R-01). A summary of the SI Report (e^2M, 2008) recommendations for each of the MRSs are summarized in **Table 1-4** and discussed below.

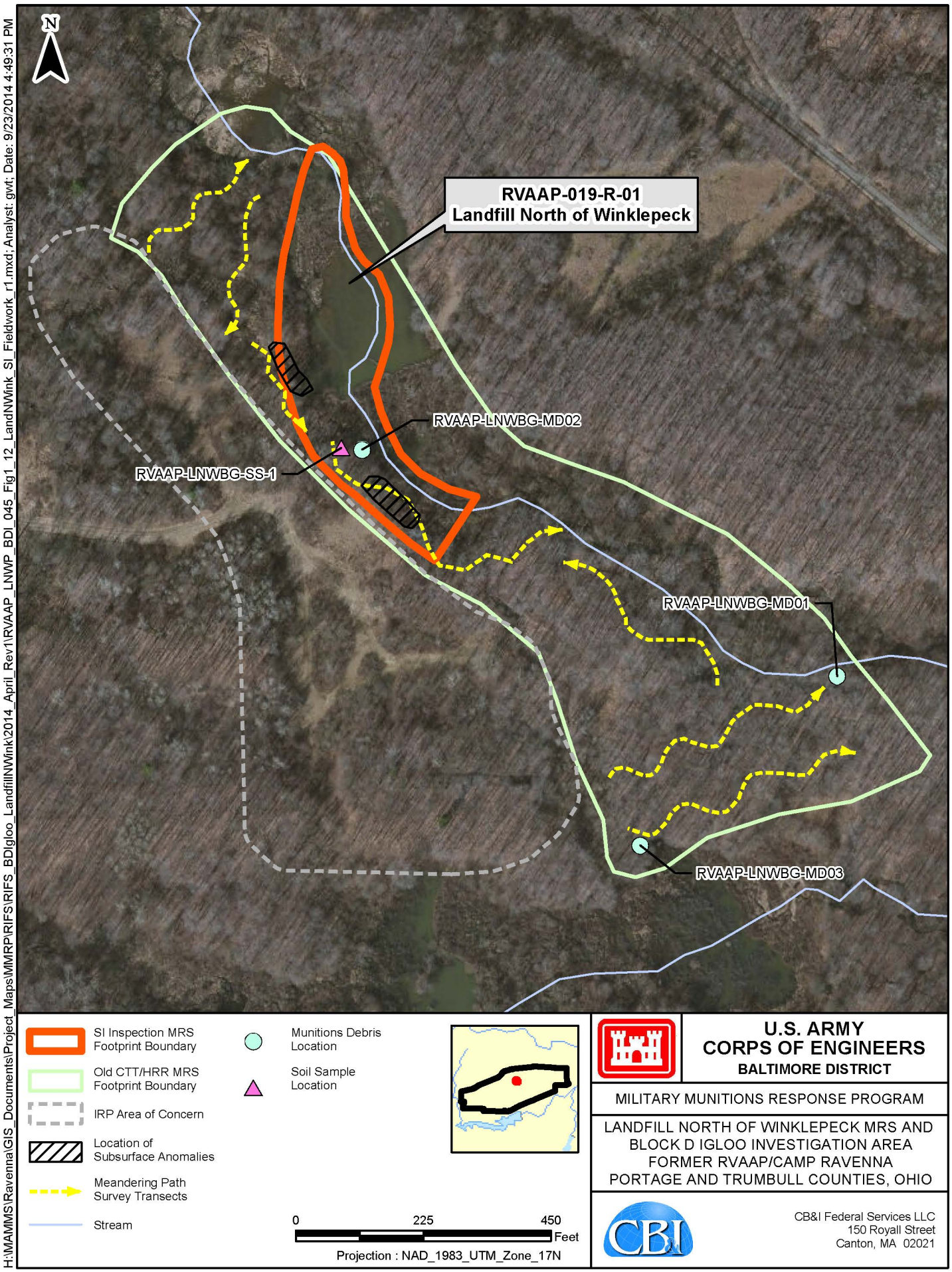


FIGURE 1-12 SI FIELDWORK AND FINDINGS, LANDFILL NORTH OF WINKLEPECK MRS

Table 1-4
Site Inspection Report Recommendation Summary

MRS	MRSPP Priority	Recommendation	Basis for Recommendation	
			MEC	MC
Landfill North of Winklepeck MRS (RVAAP-019-R-01)	5	Further characterization of MEC and MC at reduced MRS footprint	MEC potentially buried	MC detected above screening criteria
Block D Igloo MRS (RVAAP-060-R-01)	5	Further characterization of MEC and MC at reduced MRS footprint	MEC potentially present	MC detected above screening criteria

MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
MRSPP denotes Munitions Response Site Prioritization Protocol.
RVAAP denotes Ravenna Army Ammunition Plant.

The Landfill North of Winklepeck and Block D Igloo MRSs were both assigned a *Munitions Response Site Prioritization Protocol* (MRSPP) priority of 5. The MRSPP is a funding mechanism typically performed during the Preliminary Assessment/SI stage to prioritize funding for MRSs on a priority scale of 1 to 8 with a Priority 1 being the highest relative priority. Based on the MRSPP identified for the MRS in the SI Report (e^2M, 2008), the Landfill North of Winklepeck and Block D Igloo MRSs were selected for inclusion for "further characterization." The following subsections summarize the investigation activities performed at the MRSs during the 2007 SI and the conclusions and recommendations for each MRS as identified in the SI Report (e^2M, 2008).

1.5.3.1 Landfill North of Winklepeck MRS

A meandering path instrument-assisted UXO survey was performed at the Landfill North of Winklepeck MRS during the SI field activities. Several MPPEH items consisting of empty flare canisters, a partially buried fragment of an unidentified bomb casing, and one empty 105mm projectile were documented on the ground surface and were documented as safe (i.e., MD). No MEC was found during the UXO survey. In addition, multiple concentrated subsurface anomalies were detected along the length of the hillside adjacent to the former landfill. The areas investigated during the SI field activities are presented in **Figure 1-12**.

One composite surface soil sample (RVAAP-LNWBG-SS-1) was collected for the analysis of MC during the SI. The sample was collected at the location where the flare canisters were found during the UXO survey (**Figure 1-12**). Iron and lead were considered as MC and were detected at concentrations that exceeded the facility background values and one-tenth the U.S. Environmental Protection Agency (EPA) Residential Soil Preliminary Remediation

Goals (PRGs), the screening criteria used at that time. A low concentration of 2,4,6-dinitrotoluene was also detected but was below the PRGs.

No visual evidence of mounding or disturbed soil patches that would indicate potential burial areas were found during the SI field activities. The SI Report (e^2M, 2008) recommended that the MRS footprint be reduced from 14.05 acres to 2.32 acres to include the area adjacent and along the length of the former landfill extending down and including the unnamed stream (**Figure 1-12**). This area includes the location where the flare canisters and suspected booster cups were discovered and where most of the refuse from the landfill is located. This reduced MRS area was recommended for "further characterization" under the MMRP to address potential MEC and MC concerns.

1.5.3.2 Block D Igloo MRS

Meandering path instrument-assisted UXO surveys were conducted during the SI field activities around the former igloo footprint and four documented debris locations. No MPPEH was observed on the ground surface within the interior of the former igloo or within a circumference of 100 feet surrounding the area. Several subsurface anomalies were recorded within the former igloo footprint but were considered to possibly be attributed to the remnants of the former reinforced concrete floor. No subsurface anomalies were detected within 100 feet surrounding the former igloo locations that were surveyed. At the four documented debris locations, no visual evidence of MPPEH was found and very few subsurface anomalies were detected. At locations where subsurface anomalies were recorded, the findings were attributed to debris associated with the former rail lines and roadway. The portions of the MRS investigated during the SI field activities are presented in **Figure 1-13**.

One composite surface soil sample (RVAAP-BDI-SS-1) was collected from within the former igloo footprint area during the 2007 SI field activities and was analyzed for MC associated with the 20 lb fragmentation bomb (**Figure 1-13**). Lead and arsenic were considered as MC and were detected at concentrations that exceeded the facility background values and one-tenth the EPA Residential Soil PRGs.

The SI Report recommended that the MRS footprint be reduced from 622.24 acres to 340.2 acres to include the area immediately surrounding the former igloo and all remaining documented debris locations (and areas in between) that had not been investigated as part of the SI but were considered part of the MRS in the U.S. Army CTT Range/Site Inventory and the HRR (e^2M, 2008). Although the area of the MRS was reduced, inclusion of the documented debris locations, not previously investigated, increased the maximum distance of the MRS from the point of detonation at former Igloo 7-D-15 from 3,000 feet to nearly 10,000 feet. This resulted in noncontinous and irregular-shaped investigations areas within the MRS.

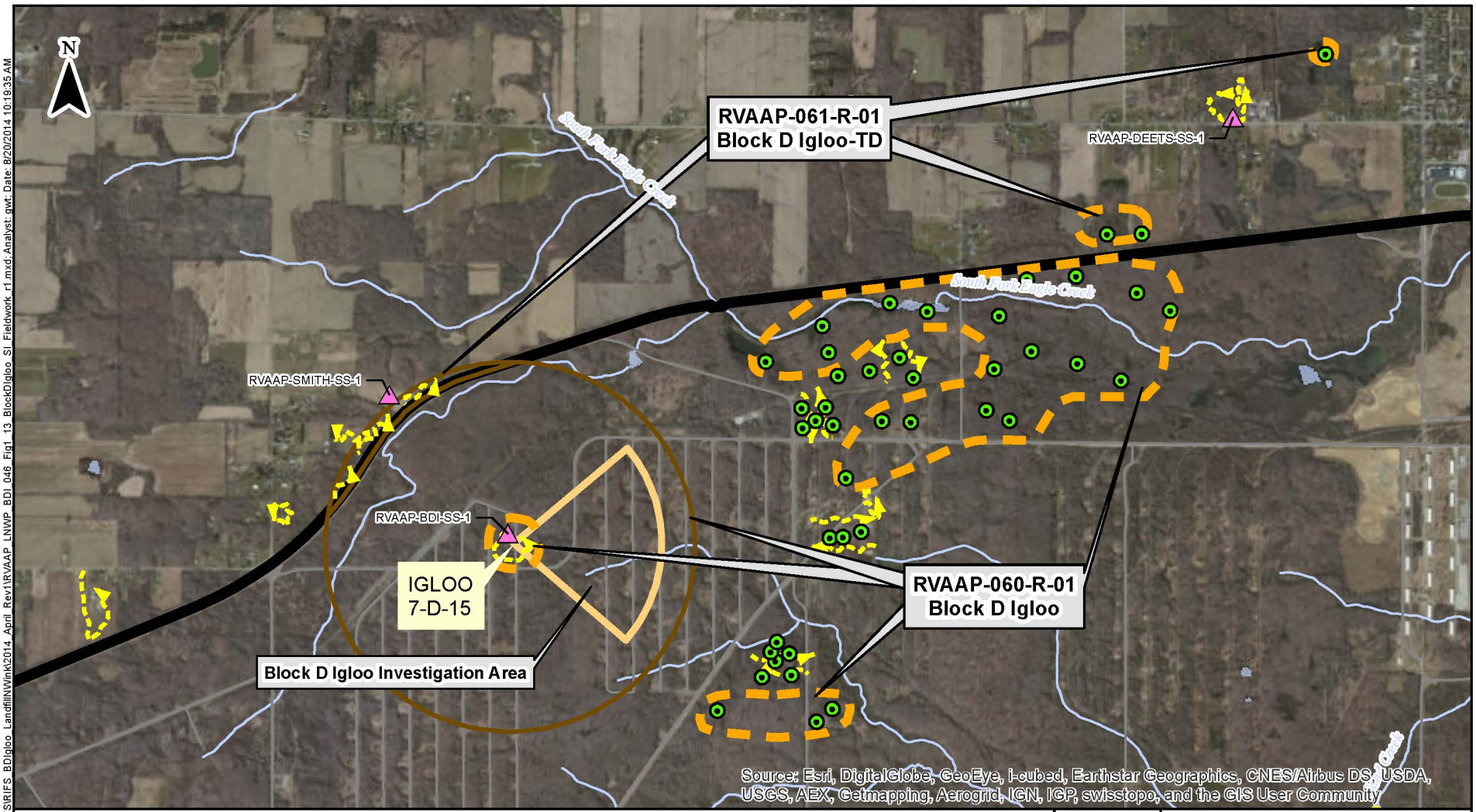


FIGURE 1-13 SI FIELDWORK AND FINDINGS, BLOCK D IGLOO MRS SI BOUNDARY

The recommendations in the SI Report to reduce the 3,000 square foot radius around the former igloo eliminated the 19.25 acres area outside the northern portion of the facility that was the Block D Igloo-TD MRS. However, information was obtained by e^2M during the SI that indicated non-munitions related debris fragments from the 1943 explosion had been observed outside of the facility at two locations as far as 2.9 miles (15,000 feet) to the northeast. It was concluded in the SI Report that the presence of the debris fragments at these two locations (Area 1 and Area 2) also represented the potential for MEC being present outside of the facility. Area 1 and Area 2 were discontinuous areas and were located approximately 2.2 and 2.9 miles northeast of the former Igloo-7-D-15, respectively. The combined areas for Area 1 and Area 2 was 14.131 acres and were considered as the revised boundaries for the Block D Igloo-TD MRS (e^2M, 2008). The Block D Igloo-TD MRS is considered separate from the Block D Igloo MRS within the facility and is not evaluated further in this RI Report.

1.6 RI Report Organization

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

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

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

- **Appendix A**—Rationale for Reduction in Investigation Area for Block D Igloo MRS
- **Appendix B—**Ohio EPA Correspondence
- **Appendix C**—Field Documentation
- **Appendix D**—Data Validation Report
- **Appendix E**—Summary of Laboratory Analytical Data
- **Appendix F**—Investigation-Derived Waste Management
- **Appendix G**—Photographic Documentation Logs
- **Appendix H**—Visual Survey and Intrusive Investigation Results
- **Appendix I**—Munitions Debris Waste Shipment and Disposal Records
- **Appendix J**—Notifications for MEC Disposal
- **Appendix K**—Munitions Data Sheets
- **Appendix L**—MEC Hazard Assessment Worksheets
- **Appendix M**—Ecological Screening Values
- **Appendix N**—Munitions Response Site Prioritization Protocol Worksheets
- **Appendix O**—Responses to Ohio EPA Comments
- **Appendix P**—Ohio EPA Approval Letters

2.0 PROJECT OBJECTIVES

This section presents the preliminary conceptual site models (CSMs) for MEC and MC for the Landfill North of Winklepeck and Block D Igloo MRSs based on historical information and identifies data gaps associated with the preliminary CSMs and the data quality objectives (DQOs) necessary to achieve the project objectives.

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

- **Sources—**Sources are those areas where MEC or MC have entered (or may enter) the physical system. A MEC source is the location where MPPEH or ordnance is situated or are expected to be found. A MC source is a location where MC has entered or may enter 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 burrowing.
- **Access—**Access is the ease with which a receptor can come into contact with a source. The presence of access controls help determine whether an exposure pathway to a receptor is complete, as fences or natural barriers can limit human access to a source area. Furthermore, the depth of MEC items in subsurface soils and associated MC may also limit access by a receptor. Ease of entry for adjacent populations (i.e., lack of fencing) can facilitate trespassing at the MRS, either intentional or accidental.

- **Receptors—**A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use and activities, as receptors are determined on that basis.

In general, the CSMs for each MRS are 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 Landfill North of Winklepeck and Block D Igloo MRSs, as presented in the SI Report (e^2M, 2008), is presented in the following section. The data collected during the RI are incorporated into these models and is discussed in Section 9.0, "Revised Conceptual Site Models."

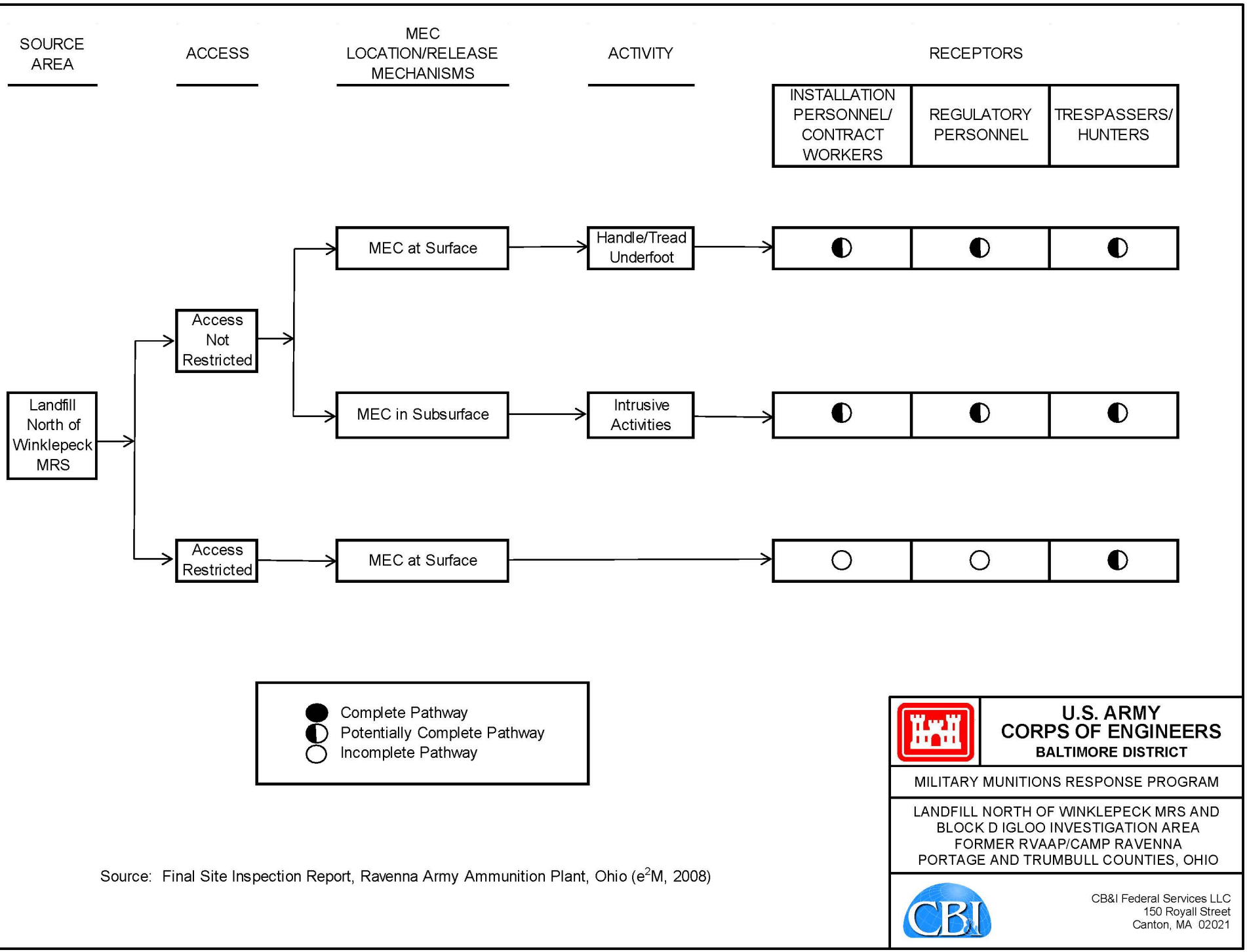
2.1 Preliminary CSM and Project Approach

The preliminary CSMs for the Landfill North of Winklepeck and Block D Igloo MRSs are based on MRS-specific data and general historical information including literature review, maps, training and technical manuals, and field observations. The CSMs were originally developed during the SI process based on guidance from USACE Engineer Manual 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects* (USACE, 2003a) and are represented by the diagrams provided as **Figures 2-1** through **2-4**.

2.1.1 Landfill North of Winklepeck MRS

This section provides a discussion of potential exposure profiles associated with MEC and MC that were identified at the Landfill North of Winklepeck MRS during the SI. A summary of each of the factors evaluated for the preliminary CSMs in the SI Report (e^2M, 2008) is as follows:

- **Sources—**Munitions-related burial or disposal activities associated with the landfill were considered the primary source of MEC at the Landfill North of Winklepeck MRS. Based on review of the archival records and available documentation; the principal sources of MEC at the Landfill North of Winklepeck MRS were booster cups and fuses from the nearby Winklepeck Burning Grounds. These activities resulted in the potential for MEC to be present on the ground surface or buried at a shallow depth (less than 2 feet bgs) in the area adjacent to the former landfill. The source of MC at the MRS was considered to be the deliberate disposal of ash, explosive plant residues, and remnants of munitions filler not completely flashed during burning operations.



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

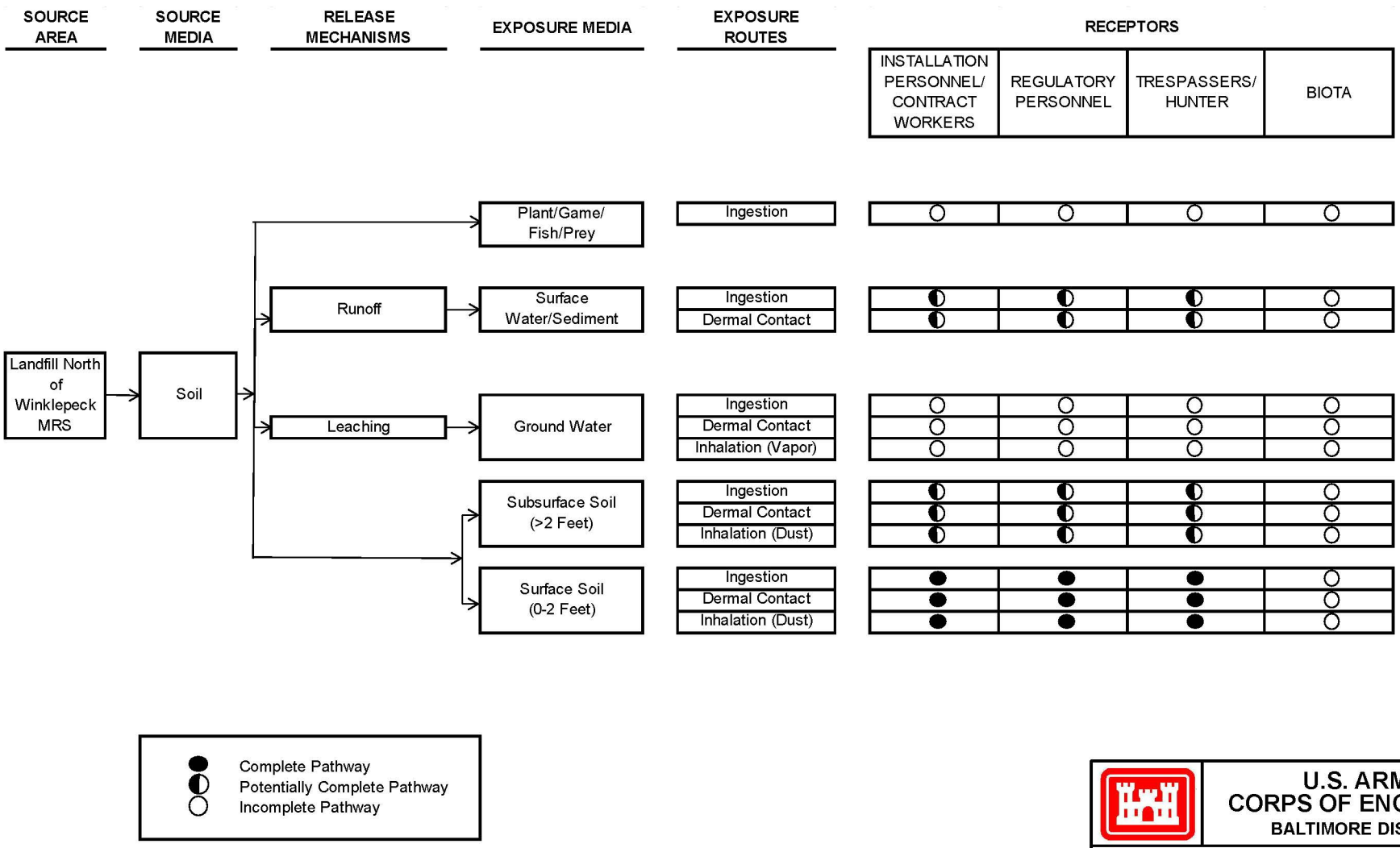
U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 2-1 PRELIMINARY MEC CONCEPTUAL SITE MODEL, LANDFILL NORTH OF WINKLEPECK MRS



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

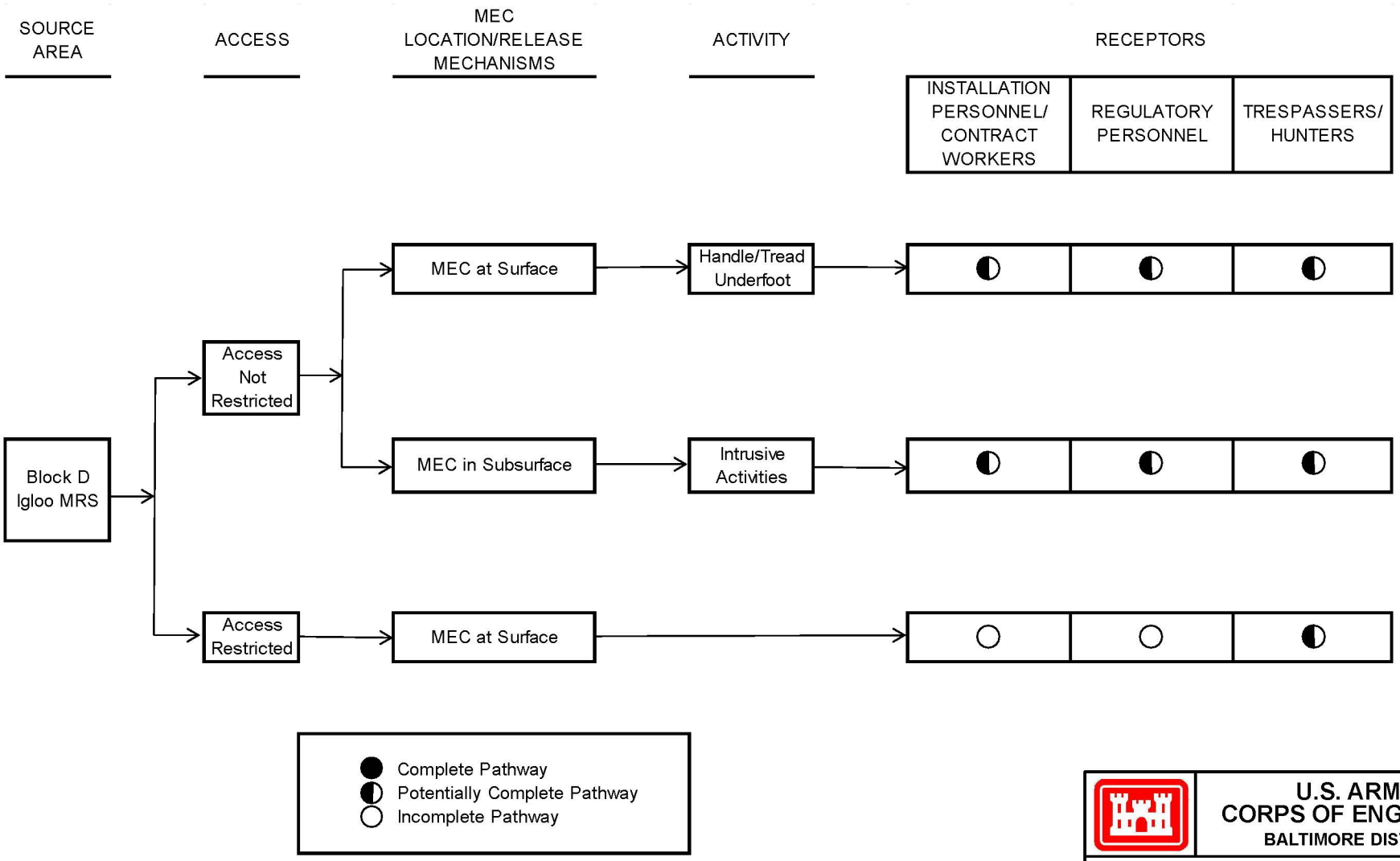
U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 2-2 PRELIMINARY MC CONCEPTUAL SITE MODEL, LANDFILL NORTH OF WINKLEPECK MRS



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

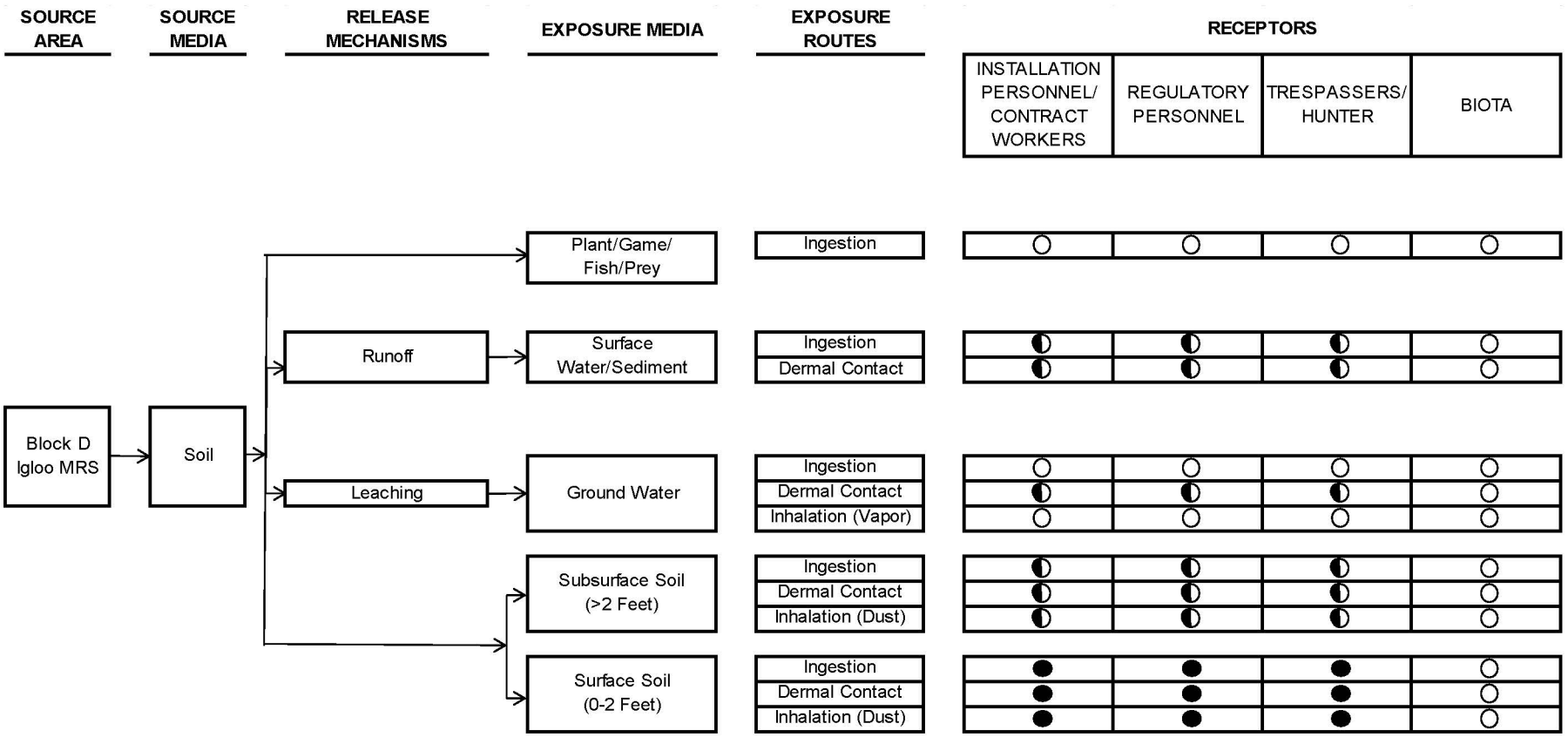
U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 2-3 PRELIMINARY MEC CONCEPTUAL SITE MODEL, BLOCK D IGLOO MRS



Source: Final Site Inspection Report, Ravenna Army Ammunition Plant, Ohio (e2M, 2008)

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 2-4 PRELIMINARY MC CONCEPTUAL SITE MODEL, BLOCK D IGLOO MRS

- **Activity—**Human activities considered for the preliminary CSMs included intermittent security patrols, natural resource management, surveying, environmental media sampling, and maintenance activities.
- **Access—**At the time of the SI, access to the area where the MRS is located was restricted by a gate (due to an adjacent operational range area). Access conditions have not changed since the SI field activities.
- **Receptors—**At the time of the SI, current receptors included facility personnel, contractors (including maintenance personnel), regulatory personnel, hunters, and trespassers. Any visits by these receptors were considered to be infrequent and at short durations. The future use of the MRS was identified to be for military training; therefore, potential future receptors were identified as installation personnel, soldiers and hunters/trappers. The SI Report (e^2M, 2008) considered biota to be state-listed species identified as being present at the facility and listed in **Table 1-3**.

The SI Report (e^2M, 2008) assumed that any MEC source at the Landfill North of Winklepeck MRS was likely located on the ground surface or potentially buried at a shallow depth in the area adjacent to the former landfill. Considering this, the primary potential exposure pathway for human receptors was contact with MEC in surface soils by handling or treading underfoot or through disturbance of the subsurface soil during environmental sampling or natural resource management. The MEC exposure pathway was found to be potentially complete for all receptors accessing the MRS.

During the SI field work, an MC source of metals (i.e., lead and iron) was found at one location within the MRS. Complete pathways for MC were considered present for surface soil and potentially complete pathways were considered present for subsurface soil and surface water/sediment. Potential exposures to MC were considered to include ingestion or dermal contact with contaminated soil, surface water, and/or sediment. The MC 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 CSMs for MEC and MC at the Landfill North of Winklepeck MRS, as presented in the SI Report (e^2M, 2008), are shown in **Figures 2-1** and **2-2**, respectively.

2.1.2 Block D Igloo MRS

This section provides a discussion of potential exposure profiles associated with MEC and/or MC that were identified at the Block D Igloo MRS during the SI. A summary of each of the factors evaluated for the preliminary CSMs in the SI Report (e^2M, 2008) follows:

- **Sources—**The identified release mechanism of MEC and MC at the Block D Igloo MRS was the March 24, 1943, accidental explosion of M-41 20 lb fragmentation bombs stored in Igloo 7-D-15. Based on the accident report of the detonation, the majority of the blast force was directed in a horizontal direction (or low trajectory). As such, MEC would have been deposited on the ground surface and minimal to no penetration would be expected.
- **Activity**—The location of former Igloo 7-D-15 is in a heavily wooded area at the northern portion of the facility and the area sits mostly as idle. The surrounding igloos are inactive and the human activities considered for the preliminary CSMs included intermittent security patrols, natural resource management, and maintenance activities.
- **Access**—Except for the igloos, the surrounding area is undeveloped. There is no fence surrounding the former igloo or the documented debris field considered as the MRS. These areas are not physically restricted and are readily accessible to personnel. Access conditions have not changed since the SI field activities.
- **Receptors**—At the time of the SI, current receptors included facility personnel, contractors (including maintenance personnel), regulatory personnel, hunters, and trespassers. Visits by these receptors were considered to be infrequent. The future use of the MRS was identified to be for military training; therefore, potential future receptors were identified as installation personnel, soldiers and hunters/trappers. The SI Report (e^2M, 2008) considered biota to be state-listed species identified as being present at the facility and listed in **Table 1-3**.

No MPPEH was discovered at the portions of the Block D Igloo MRS that were investigated during the SI field activities; however, the potential for MEC to be present in the areas within the blast fan not surveyed during the SI field work was not dismissed in the evaluation of the preliminary CSM. The SI Report (e^2M, 2008) identified that the potentially complete MEC human exposure pathways would be to handle or tread under foot and disturbance of shallow surface soil (i.e., 0–0.5 feet bgs).

During the SI field work, MC consisting of metals (arsenic and lead) was found to be present at the Block D Igloo MRS. Complete pathways for MC were considered present for surface soil and potentially complete pathways were considered present for subsurface soil. Exposure pathways for MC included dermal contact, ingestion, and inhalation of contaminated soil. The MC 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 CSMs for MEC and MC at the Block D Igloo MRS, as presented in the SI Report (e^2M, 2008), are shown in **Figures 2-3** and **2-4**, respectively.

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

Applicable or relevant and appropriate requirements (ARARs) and "to be considered" (TBC) guidance for future anticipated and reasonable remedial actions at the facility under the MMRP are currently under development. Once ARARs and/or TBC materials have been identified, preliminary remediation goals and remedial action objectives will be developed. The developed ARARs, TBCs, preliminary remediation goals and remedial action objectives will be included in the future CERCLA documents required for the MRSs.

2.3 Data Quality Objectives and Data Needs

The DQOs and data needs were determined at the planning stage and are outlined in the Work Plan (Shaw, 2011). The data needs included characterization for MEC and/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* (SAIC, 2011), herein referred to as the FWSAP, and the EPA *Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW* (2000). The DQOs developed for the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area are presented in the following tables.

Table 2-1 identifies the DQO process at the Landfill North of Winklepeck MRS as presented in the Work Plan (Shaw, 2011).

Table 2-1
Data Quality Objectives for the Landfill North of Winklepeck MRS

Step	Data Quality Objective
1. State the problem.	The Landfill North of Winklepeck accepted general facility refuse, explosive wastes residue, and open burn waste, which included flares and booster cups. The landfill itself is covered under the IRP. However, the landfill boundary has not been conclusively determined. Therefore, there is a potential for surface and subsurface MEC associated with the former landfill activities on the slope and an unnamed tributary located to the north of the IRP site. In addition, there is a potential for environmental impacts from MC at the MRS.
2. Identify the decision.	The goal of the investigation at the Landfill North of Winklepeck MRS is to identify MEC. In addition, MC sampling will be performed in order to further characterize the nature and extent of contamination associated with munitions activities at the MRS, if necessary. The information obtained during the RI field activities will be used to assess the potential risk and hazards posed to human health and the environment.
3. Identify inputs to the decision.	• Historical information • Instrument-assisted visual surveys • Discrete environmental media sampling
4. Define the study boundaries.	The RI will be performed in the Landfill North of Winklepeck MRS boundaries as defined at the conclusion of the SI Report (e^2M, 2008).
5. Develop a decision rule.	An instrument-assisted visual survey will be performed at the Landfill North of Winklepeck MRS in order to identify areas with MEC. If the visual survey identified areas with the potential for buried MEC, a geophysical investigation will be performed. If a geophysical investigation is necessary, stakeholder approval will be obtained for the agreed upon approach. Discrete samples (surface and subsurface soil) will be collected in areas with concentrated MEC/MD.
6. Specify limit of decision errors.	QC procedures are in place so that all fieldwork 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 (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Landfill North of Winklepeck MRS will be used to determine what potential risks or hazards are present at the MRS. A MEC Hazard Assessment will be prepared to identify the potential MEC hazards. An MRS-specific HHRA and ERA will be performed on analytical results of MC samples collect during the RI field event to evaluate for potential human health or ecological risks. If unacceptable risk or hazards to human health or 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.

Table 2-1 (continued)
Data Quality Objectives for the Landfill North of Winklepeck MRS

CERCLA denotes Comprehensive Environmental Response, Compensation, and Liability Act.
ERA denotes ecological risk assessment.
HHRA denotes human health risk assessment.
IRP denotes Installation Restoration Program.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
Shaw denotes Shaw Environmental & Infrastructure, Inc.
SI denotes Site Inspection.

Table 2-2 identifies the DQO process at the Block D Igloo Investigation Area as presented in the Work Plan (Shaw, 2011).

Table 2-2
Data Quality Objectives for the Block D Igloo Investigation Area

Step	Data Quality Objective
1. State the problem.	There is a potential for MEC at the Block D Igloo Investigation Area based on the 1943 accidental explosion at Igloo 7-D-15. However, the potential for MEC associated with the 1943 explosion is not limited to those areas around the former igloo. As a result of the explosion, there is a potential for MEC on the ground surface and shallow subsurface in the vicinity, in particular east of the former igloo footprint. In addition, there is a potential for environmental impacts from MC at the investigation area.
2. Identify the decision.	The goal of the investigation at the Block D Igloo Investigation Area is to identify the areas impacted by MEC from the 1943 explosion. In addition, MC sampling will be performed in order to further characterize the nature and extent of contamination associated with the accidental explosion at the investigation area. The information obtained during the RI will be used to assess the potential risk and hazards posed to human health and the environment.
3. Identify inputs to the decision.	• Historical information • Instrument-assisted visual survey • Magnetometer (mag) and dig grids • Intrusive inspection • Discrete and incremental environmental media sampling
4. Define the study boundaries.	At the conclusion of the SI (e^2M, 2008), the Block D igloo MRS boundaries were reduced to 340.2 acres. These boundaries were based on areas where documented debris fragments (i.e. concrete) from the explosion have historically been found. However, the potential for MEC associated with 1943 explosion is not limited to those areas. For the RI, the maximum fragmentation distance from the explosion was

Step	Data Quality Objective
	recalculated and the revised MFD-H associated with the M-41 20 lb fragmentation bomb was 2,389 feet to the east and included a blast arc of 92.14 acres. This is the proposed investigation area for the RI and is fan shaped with the side of the fan extending approximately 80 degrees from the former igloo location.
5. Develop a decision rule.	An instrument-assisted visual survey will be performed for the Block D Igloo Investigation Area. Visual survey transects were placed using VSP "95 percent confidence that 99 percent of transects do not contain UXO" module. After completion of the visual survey, mag and dig grids will be placed throughout the entire investigation area. The number of grids selected was based on UXO Estimator®. Due to the known MEC activities and future land use, the agreed upon UXO Estimator® inputs are 95 percent confidence and 2.0 UXO/acre. Discrete surface and subsurface soil samples will be collected in areas with concentrated MEC/MD.
6. Specify limit of decision errors.	QC procedures are in place so that all fieldwork was performed in accordance with all applicable standards. Further details on the QC process during the RI are located in Section 4.0 of the Work Plan (Shaw, 2011).
7. Optimize the design for obtaining data.	The information gathered as part of the field investigation at the Block D Igloo Investigation Area will be used to determine what risks or hazards, if any, are present. A MEC Hazard Assessment will be prepared to identify the potential MEC hazards. In addition, a MRS-specific HHRA and ERA will be performed on the analytical results. If unacceptable risks or hazards to human health and the environment are determined to exist at the MRS at the conclusion of the investigation, then the MRS will be identified for further evaluation under the CERCLA process.

CERCLA denotes Comprehensive Environmental Response, Compensation, and Liability Act.
ERA denotes ecological risk assessment.
HHRA denotes human health risk assessment.
mag and dig denotes magnetometer and dig.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
MFD-H denotes maximum fragmentation distance.
MRS denotes Munitions Response Site.
QC denotes quality control.
RI denotes Remedial Investigation.
Shaw denotes Shaw Environmental & Infrastructure, Inc.
SI denotes Site Inspection.
USACE denotes U.S. Army Corps of Engineers.
UXO denotes unexploded ordnance.
VSP denotes Visual Sample Plan®.

2.3.2 Data Needs

For MEC, data needs include determining the types, locations, condition, and number of MEC items present at the MRSs so that the potential hazard to human health can be assessed and remedial decisions can be made. The DQOs were developed in accordance with the FWSAP (SAIC, 2011), EPA guidance (*Data Quality Objectives Process for Hazardous Waste Site Investigations*, [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), that are discussed in the following sections.

For MC, data needs include sufficient information to determine the nature and extent of MC, determine the fate and transport of MC, and characterize the risk of MC to the MRS by performing a human health risk assessment (HHRA) and an ecological risk assessment (ERA). More specifically, the data needed are concentrations of MC associated with the investigation area in surface soil that pose a potential exposure risk to likely human and ecological receptors. Data quality was assessed through the evaluation of sampling activities 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 dataset, 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 the HHRA and ERA in this RI whenever possible.

2.4 Data Incorporated into the RI

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

- **Historical Records Review—**The HRR provides historical documentation for each of the MRSs and identifies the types of activities previously conducted, the types of munitions used/stored, 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 IRP at various MRSs include analytes considered to be MC associated with previous activities at the MRSs. It should be noted that not all analytes are considered as MC. The IRP data set may be incorporated with sampling data collected during the MMRP RI in order to close data gaps. IRP data is available for the Landfill North of Winklepeck MRS only. The IRP data was reviewed for this MRS and was not

included with the RI data since MEC or MD was not identified during the RI field survey and evaluation for MC was not warranted for this MRS.

- **SI Data—**The MMRP SI conducted in 2007 provides reconnaissance data for both MRSs that will be used in conjunction with historical aerial photography data to preliminarily delineate areas with munitions-related activity. MC sampling was also performed during the SI field activities and included one composite surface soil sample that was collected at each MRS. The SI data set may be incorporated with sampling data collected during the MMRP RI on a MRS-by-MRS basis in order to compare results or evaluate potential data gaps. For both MRSs, the SI data were reviewed and were not included in the RI based on the following rationale:
  - **Landfill North of Winklepeck MRS—**No MEC or MD was identified during the RI field survey; therefore, evaluation for MC is not warranted for this MRS.
  - **Block D Igloo MRS—**Samples for MC were collected during the RI using the incremental sampling method (ISM) and were taken from locations with MEC or areas concentrated with MD. The one sample collected during the SI field activities was a composite sample taken from around the location of the former igloo footprint where no evidence of MPPEH associated with the 1941 explosion was found. Therefore, comparison of samples between the two sample events is not considered relevant.

3.0 CHARACTERIZATION OF MEC AND MC

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

3.1 MEC Characterization

The following section summarizes the processes used to implement the instrument-assisted visual surveys that were performed at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area and the subsequent intrusive investigation activities that were conducted at the Block D Igloo Investigation Area only. The results of the visual surveys for each of the MRSs and intrusive investigation results for the Block D Igloo Investigation Area are discussed in Section 4.1, "MEC Investigation Results."

3.1.1 Visual Survey Activities

Visual surveys using analog geophysics (magnetometer) were proposed in areas where MEC was anticipated on or just below the ground surface. For the Landfill North of Winklepeck MRS, the locations where the visual surveys were performed were based on the historical records and documentation provided in the HRR (e^2M, 2007) and the SI Report (e^2M, 2008). The proposed visual survey areas for the Block D Igloo MRS were based on the reevaluation of the MFD-H associated with the 20 lb fragmentation bomb that was being stored at the Igloo 7-D-15 at the time of the accidental explosion (i.e., the investigation area).

The field teams consisted of at least one UXO-qualified person and one field support person to conduct the visual surveys. In most instances, the field crew consisted of three UXO-qualified personnel and one support person to guide the team using a global positioning system (GPS). The instrumentation used for detecting and logging the locations of any MPPEH identified consisted of a Schonstedt Model 52CX fluxgate magnetometer and GPS Trimble GeoXH Handheld, respectively.

3.1.1.1 Landfill North of Winklepeck MRS

The Landfill North of Winklepeck MRS consists of the slope along the north side of the landfill where subsurface anomalies were previously identified during a walkover of the MRS during the SI field activities in 2007. The RI instrument-assisted visual survey at the Landfill North of Winklepeck was conducted during two separate events performed on May 23, 2011, and September 16, 2011, to assess the presence of surface MEC associated with historical disposal activities. Due to the limited size of the MRS (2.3 acres), 100-percent

coverage of accessible areas at the MRS was proposed in the Work Plan (Shaw, 2011). Accessible areas constitute paths or locations at the MRS that are not impeded by dense vegetation or inaccessible land features such as wetlands, ponds, or very steep slopes. Since 100-percent coverage was proposed, there were no planned transects at this MRS. Instead, the GPS was configured to record position data at maximum intervals of 1 minute to track progress and ensure adequate coverage. If MPPEH was identified along the survey path, the location was to be stored in the GPS along with a brief description of the findings and a determination as to whether it was hazardous (MEC) or safe (MD). The GPS track path was uploaded to the project geographic information system to create a permanent record of the actual path followed and the area that was covered.

The actual spatial coverage of the accessible areas was calculated to be 1.6 acres following the visual survey which represents MRS coverage of nearly 70 percent. The remaining 30 percent consisted of inaccessible marsh/wetland areas associated with the unnamed tributary to Sand Creek that limited the extent of the visual surveys. The actual spatial coverage equates to a total transect distance of 2.7 miles with each transect being approximately 5 feet wide.

As part of the DQO process established in the Work Plan (Shaw, 2011), additional geophysical investigation was to be considered at the Landfill North of Winklepeck MRS in the event that the visual survey results for the MRS indicated that there was potential for subsurface MEC. If identified to be necessary, a geophysical investigation strategy would be developed, and stakeholder approval would be attained prior to implementation. The visual survey resulted in no findings of MPPEH; therefore, a geophysical investigation was not performed during the RI.

3.1.1.2 Block D Igloo Investigation Area

As part of the RI, a visual survey was performed at the Block D Igloo Investigation Area in order to determine the lateral extent of MEC. From April 28 to May 16, 2011, an instrument-assisted visual survey was performed at the Block D Igloo Investigation Area to identify dispositional areas of MEC that may have resulted from the 1943 explosion of the 2,516 clusters of M-41 20 lb fragmentation bombs that were at the igloo. The area surveyed consisted of the revised 92.14-acre investigation area as presented in the *Rationale for Reduction in Investigation Area for Block D Igloo MRS (RVAAP-060-R-01)* technical memorandum (**Appendix A**) and was in an east direction along the median line of the long axis of the former igloo on a 60- to 80-degree angle from the center of the former igloo. The visual survey transects were placed using the Visual Sample Plan® (VSP) "95-percent confidence that 99 percent of transects do not contain UXO" module. In order to meet the proposed coverage requirements, the visual survey transect was spaced from 0 to 60 feet over

the investigation area. This equates to proposed area coverage of approximately 38 acres (62 linear miles), where each transects is approximately 5 feet wide.

The planned transects for the MRS were uploaded to the GPS, and the visual sweep team navigated along the planned transects using the GPS in waypoint mode. The GPS was configured to record position data at maximum intervals of 1 minute along each transect to create a permanent record of where the visual sweep team actually walked. If an anomaly was identified along the transect path, the location was to be stored in the GPS along with a brief description of the findings and a determination as to whether it was munitions-related. In order to ensure that the lateral extent of MEC was being adequately evaluated, a 100-foot "step out" distance was proposed from any MPPEH identified along the boundary of the investigation area. The GPS track path and findings along each transect were uploaded to the project geographic information system. **Figure 3-1** presents the proposed visual survey coverage area at the Block D Igloo Investigation Area.

Although not considered to be within the MFD-H for the 20 lb fragmentation bombs, an instrument-assisted visual survey was also conducted behind (west) the location of the former magazine. This portion of the survey was not tracked with the GPS, and the purpose was to verify that the blast did not produce kickout in this direction.

The actual spatial coverage was calculated to be approximately 54 acres following the visual survey which represents MRS coverage of nearly 59 percent and exceeds the proposed investigation coverage of 38 acres presented in the Work Plan (Shaw, 2011). The actual spatial coverage equates to a total transect distance of 65.2 miles with each transect being approximately 5 feet wide. This coverage includes the 100-foot step-outs from the MPPEH considered as MD along the boundary of the calculated blast fan.

3.1.2 Magnetometer and Dig Investigations

The DQO process established in the Work Plan (Shaw, 2011) for the Block D Igloo Investigation Area specified that magnetometer and dig (mag and dig) investigations would be performed following the visual survey at locations where distribution of MPPEH was anticipated as a result of the 1943 explosion. The results of the visual survey and the proposed mag and dig investigation locations were presented to the USACE and Ohio EPA in the *Visual Survey Results and Proposed Magnetometer and Dig Locations for the Block D Igloo MRS (RVAAP-060-R-01)* technical memorandum (**Appendix C**). Ohio EPA correspondence regarding the technical memorandum is provided in **Appendix B**.

Between June 23 and July 25, 2011, seven 100-foot by 100-foot grids were investigated at the MRS based on the UXO Estimator®, Version 2.2 module inputs of "95-percent confidence and 2.0 UXO per acre" in order to distribute an appropriate number of grids

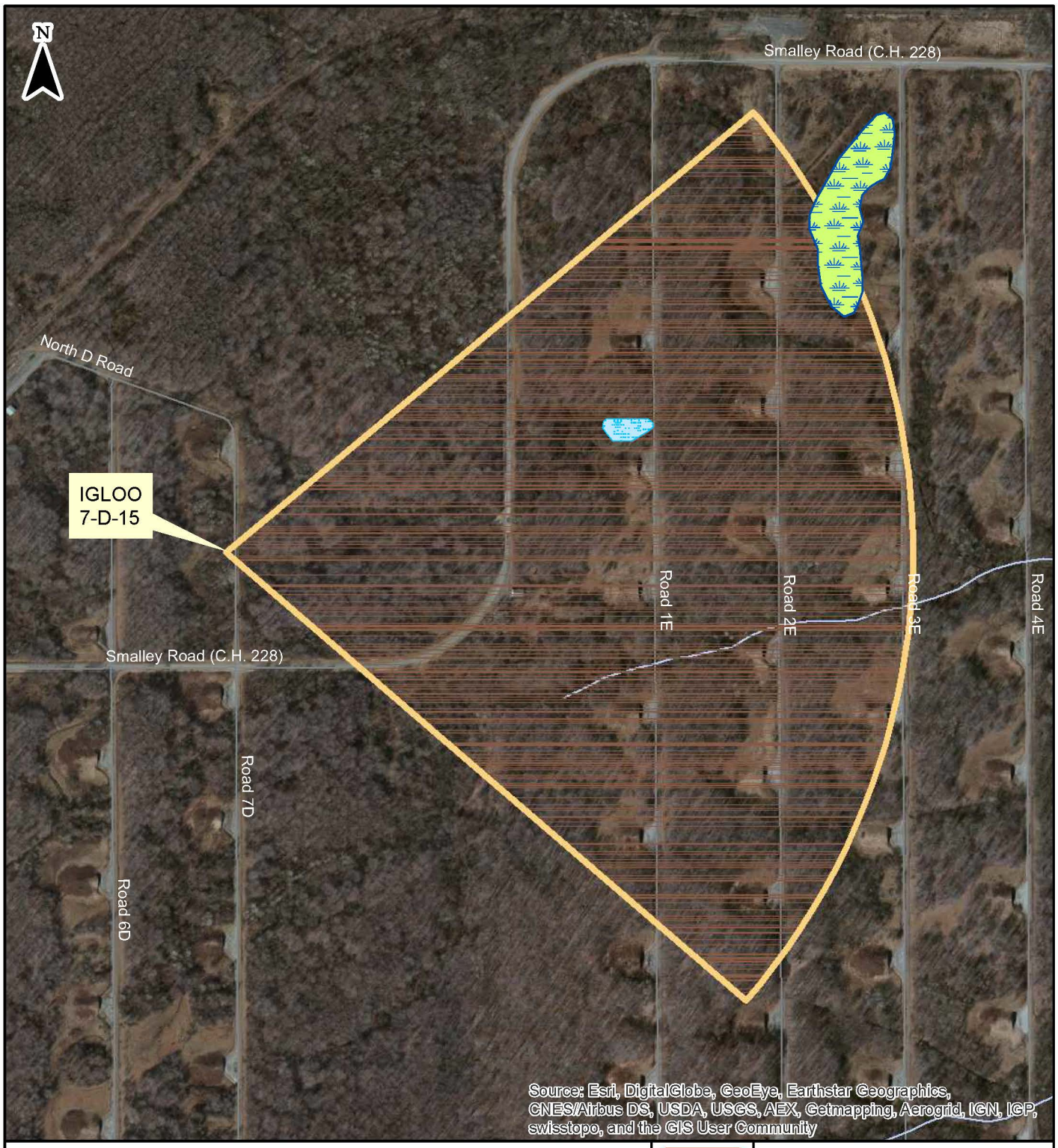
within impacted areas. The grid locations were not predetermined in the Work Plan and the majority of the proposed locations for the grids were biased towards the areas where the MD was found during the visual surveys. A summary of the rationale for selecting the locations for each of the mag and dig grids is presented in **Table 3-1** and the proposed grid locations are presented in **Figure 3-2**.

Table 3-1
Rationale for Intrusive Investigation Grid Locations at the Block D Igloo Investigation Area

Mag and Dig Grid Location	Distance and Direction from Former Igloo	Investigation Rationale
P32	875 feet southeast	Represents an area where various MD items were observed near the southern investigation boundary
S30	700 feet east	Represents the approximate midpoint of the blast area where MD items were identified within the investigation area
T25	100 feet east	Represents areas where MD was observed in the immediate vicinity in front of the former igloo
V31	700 feet east-northeast	Represents an area where various MD items were identified
V42	1,800 feet east	Represents the furthest location from the former igloo where MD was identified
X29	700 feet northeast	Represents an area where MD was observed along the northern investigation boundary
BB37	1,500 feet northeast	Represents an area in the investigation area where no MD was identified for procedural verification purposes (i.e., proves that no MPPEH exists in grids where no anomalies were identified during the visual surveys)

mag and dig denotes magnetometer and dig.
MD denotes munitions debris.
MPPEH denotes material potentially presenting an explosive hazard.

All intrusive investigations were conducted in accordance with the Work Plan (Shaw, 2011). For safety purposes, UXO-qualified personnel conducting subsurface clearances used the Schonstedt magnetometer to locate and investigate the detected ferrous anomalies. The UXO-qualified personnel used hand tools to unearth an item, and as the excavation progressed toward the anomaly source, the UXO-qualified person continued to use the Schonstedt magnetometer to determine the item location both horizontally and vertically. Once found, the item was assessed to determine if it was a munitions-related item or other metallic material. The UXO-qualified personnel were also conscious of encountering any cultural artifacts associated with historical, cultural, or archeological resources. Once the



Block D Igloo Investigation Area
Jurisdictional Wetland
Planning Level Survey Wetlands
Planned Visual Transects (~62.5 mi.)
Stream

0 500 1,000 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

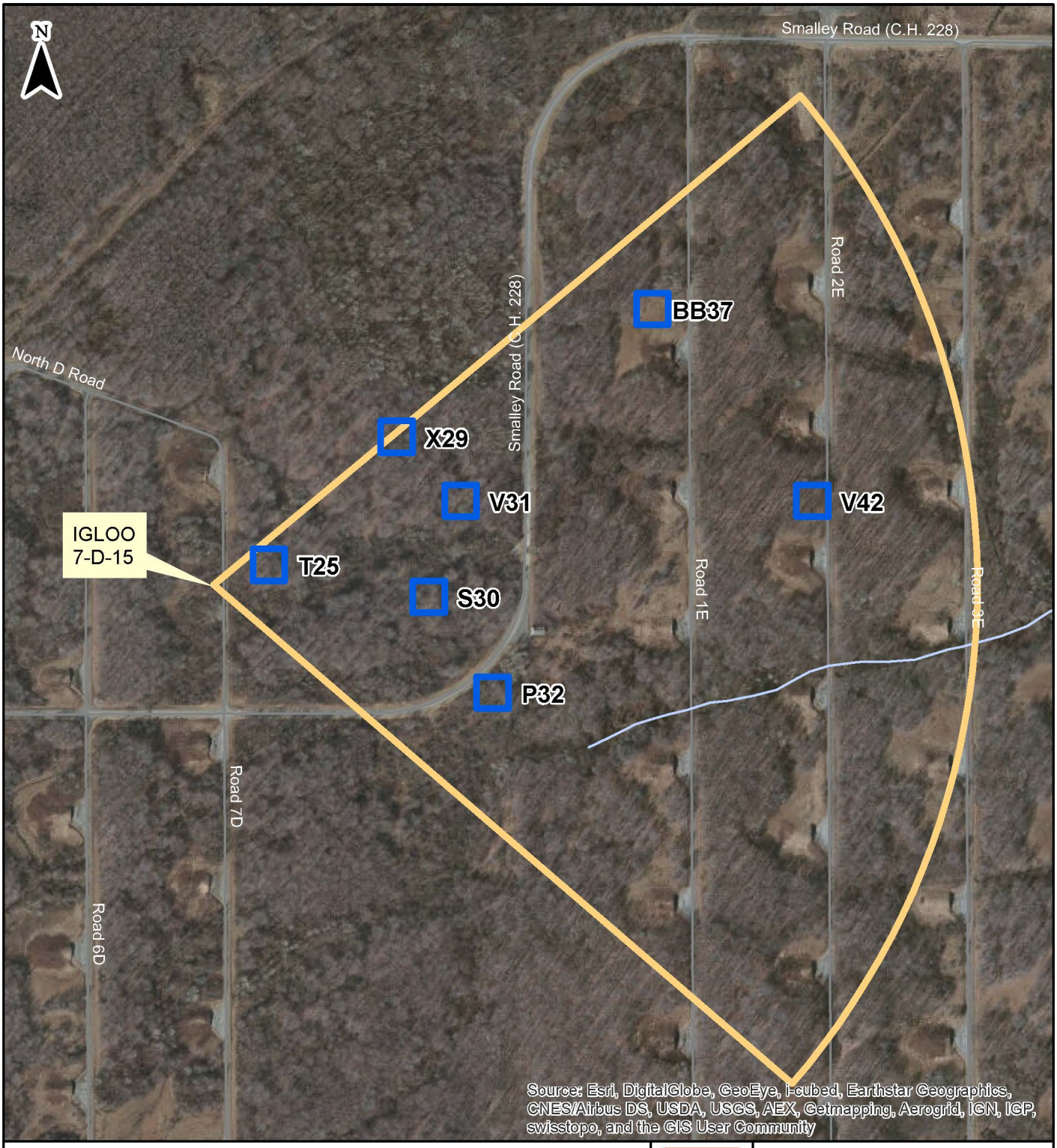
MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWinkl\2015_March_Rev2\RVAAP_LNWP_BDI_009_Fig3_1_BlockDIgloo_PropAnalogTrans_r2.mxd: Analyst: gwt: Date: 3/4/2015 11:09:47 AM

FIGURE 3-1 PLANNED VISUAL TRANSECTS, BLOCK D IGLOO INVESTIGATION AREA



Block D Igloo Investigation Area

Magnetometer and Dig Grid Location

Stream

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink\2014_April_Rev1\RVAAP_LNWP_BDI_008_Fig3_2_BlockDIgloo_PropMag_DigGridLocs_r1.mxd; Analyst: gwt; Date: 9/23/2014 5:05:02 PM

FIGURE 3-2 MAGNETOMETER AND DIG GRID LOCATIONS, BLOCK D IGLOO INVESTIGATION AREA

anomaly was identified, the UXO-qualified personnel used the Schonstedt magnetometer to confirm that the location was free of ferrous materials. All anomalies identified during the intrusive investigation and anomaly reacquisition activities were logged and recorded in accordance with Data Item Description MMRP-09-004, *Geophysics* (USACE, 2009a). The intrusive investigation results are discussed in Section 4.1.2, "Block D Igloo Investigation Area Visual Survey Results."

3.1.3 Field Instrument Quality Control

Prior to the detector-aided visual survey operations at the Landfill North of Winklepeck MRS and Block D Igloo Investigation Area and the subsequent mag and dig investigation at the Block D Igloo Investigation Area, a brief test program was performed at an analog test strip established at the facility for field instrument quality control (QC) measures. The test strip consisted of industry standard objects (ISOs) buried at the depth and orientation indicated and separated along the analog test strip at intervals of approximately 5 to 10 feet. The ISOs consisted of 1-inch by 4-inch (small), 2-inch by-8 inch (medium), and 4-inch by 12 -inch (large) pipe nipples made from Schedule 40 black carbon steel from McMaster Carr Hardware (or equivalent). After burial of the inert seed items, the UXO QC Specialist conducted a test program using experienced operators, whereby the handheld detector settings were optimized and documented for the soil conditions and reliable detection of the seed items.

The objectives of the test program were to validate that the Schonstedt magnetometer handheld sensor meets the project objectives, ensure the instrument settings and survey parameters were optimized and that the sensor was functioning properly on a daily basis, and certify the sweep personnel performing the mag and dig and detector-aided visual survey tasks. This ensured that consistent data of known quality were being collected.

For the mag and dig activities at the Block D Igloo Investigation Area, each grid was seeded with three large QC ISOs at 2.5 feet bgs, three medium QC ISOs at 0.33 feet bgs, and six surface QC ISOs in accordance with Section 3.3.1 of the Work Plan (Shaw, 2011). Each grid was investigated by the UXO-qualified personnel using a Schonstedt magnetometer to detect and excavate by hand any positive detection for metal.

3.1.4 UXO Estimator® Analysis

Following completion of the intrusive investigation activities at the Block D Igloo Investigation Area, the UXO Estimator® "Analyze Field Data" module was then used to calculate the UXO density. The data incorporated into the module for this exercise included the size of the investigation area (92.14 acres), the actual area investigated (approximately 1.6 acres), the number of MEC items identified during the investigation, the UXO Target

Density (2.0 UXO/acre), and a 95 percent confidence level. The results of the digital geophysical mapping investigation and the UXO Estimator® calculation are discussed in Section 4.1.3, "Block D Igloo Investigation Area Intrusive Investigation Results."

3.2 MC Characterization

This section summarizes the MC characterization activities and decision-making process at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area. The determination as to whether MC characterization was required at each of the sites was made based on historical evidence and the results of the MEC investigations. In accordance with the Work Plan (Shaw, 2011), soil samples were proposed to be collected at both of the sites in areas identified with concentrated MEC/MD. All MC samples were collected in accordance with the *Final Sampling and Analysis Plan and Quality Assurance Project Plan for Military Munitions Response Program Remedial Investigation Environmental Services* included in Appendix D of the Work Plan (Shaw, 2011), herein referred to as the SAP. The results of the MC sampling activities are presented in Section 4.3, "Nature and Extent of SRCs."

3.2.1 Landfill North of Winklepeck MRS

Discrete surface and subsurface soil samples were proposed to be collected at the Landfill North of Winklepeck MRS in areas identified with concentrated MEC/MD. An instrument-assisted visual survey was performed over 100 percent of the accessible areas at the MRS, and no MPPEH was found on the ground surface. Subsurface anomalies were detected at the MRS during the visual survey, in particular along the slope areas at the southwest portion of the MRS; however, the surface of the slope was littered with metal debris, and any buried anomalies were assumed to be consistent with the surface debris. Since no MPPEH was identified, MC sampling was not performed at the Landfill North of Winklepeck MRS.

3.2.2 Block D Igloo Investigation Area

Discrete surface and subsurface soil samples were proposed to be collected within the Block D Igloo Investigation Area at locations with concentrated MEC/MD. During the mag and dig investigation, grid locations were identified that contained MD that was well distributed in surface soils throughout the investigation area. In addition, individual MEC items were identified during the intrusive investigation. Based on the investigation findings, MC sampling was performed at the Block D Igloo Investigation Area. The following sections discuss the sampling locations, collection methods, and the required analyses for the RI sampling activities at the Block D Igloo Investigation Area.

3.2.2.1 Surface Soil Sample Collection

The types of samples that were collected at the Block D Igloo Investigation Area deviated slightly from the Work Plan (Shaw, 2011), which specified that only discrete surface and subsurface soil samples would be collected at areas with concentrated MEC/MD. Based on the distribution of the MD across the grid locations, surface soil samples were collected using ISM and were considered to be the more appropriate approach to adequately assess potential MC contamination over a widespread area. The ISM samples were collected over the 100-foot by 100-foot mag and dig grids, considered the sampling units, where MD was well distributed across or just beneath the ground surface. In addition, discrete surface soil samples were collected beneath individual MEC items identified in the investigation area. The increments for the ISM soil samples were collected at depths between 0 to 0.5 feet (0 to 6 inches) bgs, and the discrete surface soil samples were collected at 0.5-foot (6-inch) bgs intervals below the individual MEC items. 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 depth of the discrete samples ranged from 0.25 to 0.83 feet (4 to 10 inches) bgs. No soil samples were collected at a depth greater than 0.83 feet bgs.

Surface soil samples were collected using the ISM at three sampling unit locations, and discrete samples were collected at two individual locations. The ISM sampling units were biased toward areas with significant MD, and the discrete samples were biased toward locations beneath identified MEC items to determine whether or not there was unacceptable risk associated with the most likely contaminated areas within the Block D Igloo Investigation Area. **Table 3-2** summarizes the sample locations and types of samples collected for the RI and the rationale for the sample strategy.

Table 3-2
Summary and Rationale for Surface Soil Sampling at the Block D Igloo Investigation Area

Medium	Sample Type	Sample Depth	Number of Samples[1]	Rationale
Surface Soil	ISM	0–0.5 feet bgs	3	To characterize for MC in surface soils within 100-foot by 100-foot area grids identified to contain MD during the visual survey
Surface Soil	D	0–0.5 feet bgs below MEC item	2	To characterize the potential release of MC in soils surrounding point source MEC items identified during the intrusive (mag and dig) investigation

Table 3-2 (continued)
Summary and Rationale for Surface Soil Sampling at the Block D Igloo Investigation Area

[1] The number of samples does not include duplicate or other QC samples.
bgs denotes below ground surface.
D denotes discrete.
ISM denotes incremental sampling method.
mag and dig denotes magnetometer and dig.
MC denotes munitions constituents.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
QC denotes quality control.

The methods used for the collection of surface soil samples during the RI are summarized below. Detailed presentation of the procedures used to collect ISM samples are presented in the SAP (Shaw, 2011). The collection methodology for ISM samples is presented in the SAP and is based on the procedures presented in the *Interim Guidance 09-02, Implementation of Incremental Sampling of Soil for the Military Munitions Response Program* (USACE, 2009b).

3.2.2.2 Incremental Surface Soil Sample Collection

The purpose of collecting, preparing, and analyzing an ISM sample is to provide an estimate of the mean analyte concentration within a previously defined sample area or sampling unit (USACE, 2009b). The combined sampling units are considered the decision unit and are the area for which a decision regarding MC in surface soil will be made for the Block D Igloo Investigation Area. Sufficient amount of sample material must be collected from each of the sampling units to account for compositional heterogeneity and additionally, a sufficient number of increments utilizing a systematic random methodology must be taken to account for distributional heterogeneity. For the purposes of the RI, the estimates of the mean analyte concentrations derived from each of the ISM samples was used to evaluate exposure point concentration within human health or ecological risk assessments and the delineation of the nature and extent of the contamination.

Four ISM surface soil samples (BDISS-001(I)-0001-SS, BDI-002(I)-0001-SS, BDISS-003(I)-0001-SS, and BDI-004(I)-0001-SS), including a field duplicate QC sample, were collected on August 22, 2011, at selected grid locations (Grids T25, X29, and V42) in the investigation area. The ISM samples were biased to characterize the potential for residual MC in surface soils at areas with the most concentrated MD. Each ISM sample consisted of 30 increments collected from the sampling units selected in a systematic random pattern at sample depths of 0 to 0.5 feet (0 to 6 inches) bgs throughout the designated sampling unit area (i.e., decision unit). 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

rationale for the ISM sampling unit sizes was based on the criteria presented in the SAP (Shaw, 2011), which included the following; (1) all of the sampling units were situated within the potential contaminant release area associated with the accidental explosion at Igloo 7-D-15, and (2) the sampling units were all within the area for equally probable use and potential receptor exposure.

The key steps for the collection of a systematic random sample were the following: (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 (USACE, 2009b).

The sampling units were established by placing pin flags at the corners of each sampling 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 and 2 kilograms.

QC samples included one field duplicate sample and one matrix spike/matrix spike duplicate (MS/MSD) sample. The collection of the QC samples required similar portions of soil as the original sample. Therefore, at each ISM sample location where a QC sample was required, additional ISM samples were collected from within the same sampling unit consisting of at least 30 increments of soil each. The field duplicate was labeled with a different sample number (BDISS-002(I)-0001-SS) and submitted to the laboratory for processing as a blind field duplicate. Due to sufficient soil volume, additional collection of soil for the MS/MSD was not required and the original sample (BDISS-001(I)-0001-SS) was designated as the MS/MSD on the chain of custody prior to shipment.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix C**. The surface soil ISM sampling units are presented in **Figure 3-3**. Additional details regarding the ISM samples collected at each of the sampling units are provided in **Figures 3-4**, **3-5**, and **3-6**.

3.2.2.3 Discrete Surface Soil Sample Collection

Three discrete soil samples (BDISS-005(D)-0001-SS, BDISS-006(I)-0001-SS, and BDISS-007(I)-0001-SS), including a field duplicate QC sample, were collected during the RI field activities on August 22, 2011. The intent of the discrete samples was to evaluate for point source concentrations from identified MEC items that may have leached directly to surrounding soil. The discrete samples were collected directly beneath two of the five

Block D Igloo Investigation Area
ISM Sampling Unit Location
Stream
Discrete Soil Sample Location

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

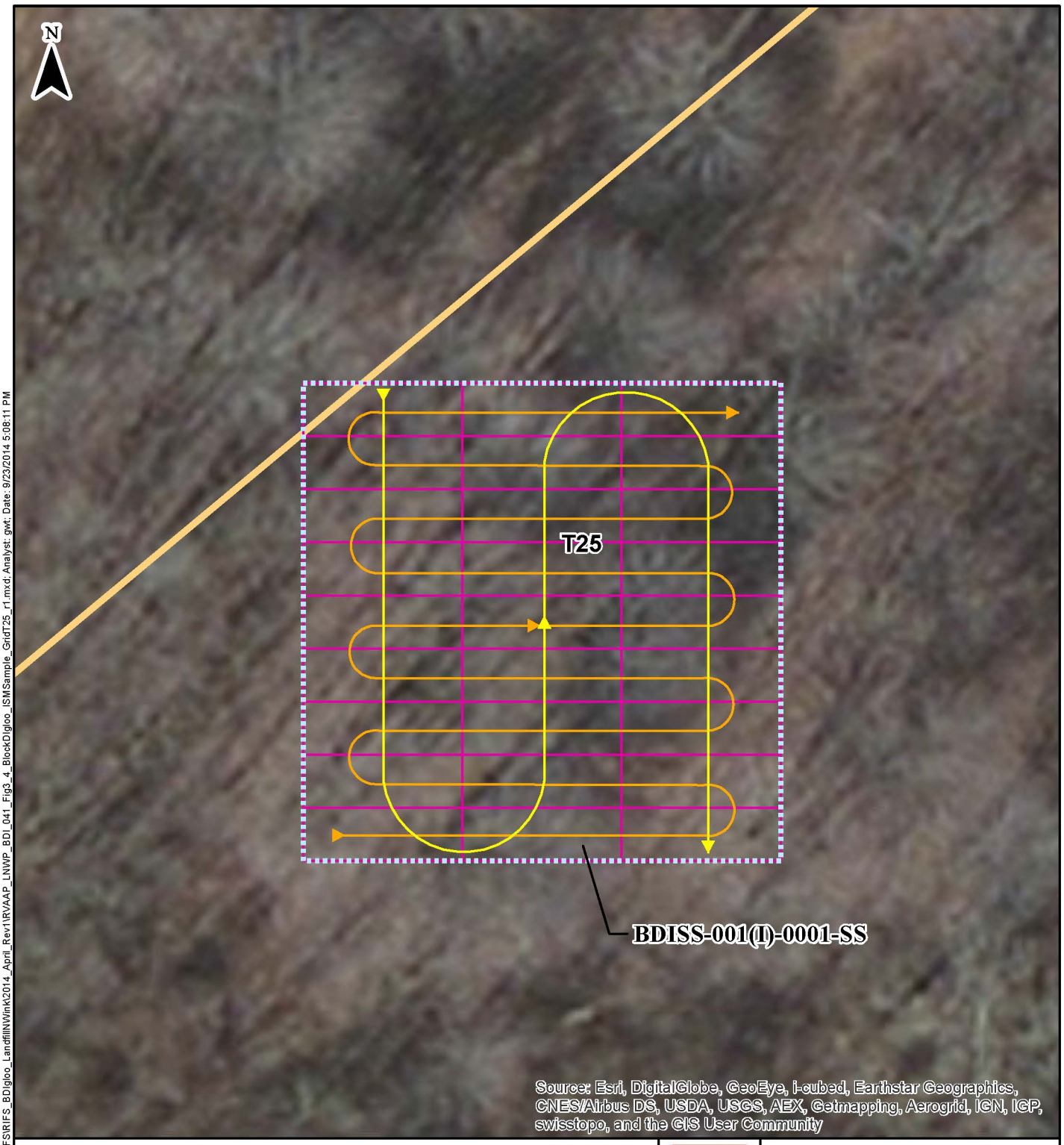
MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink2014_April_Rev1\RVAAP_LNWP_BDI_035_Fig3_3_BlockDIgloo_SampleLocs_r1.mxd; Analyst: gwt; Date: 9/23/2014 5:06:16 PM

FIGURE 3-3 SURFACE SOIL SAMPLE LOCATIONS, BLOCK D IGLOO INVESTIGATION AREA



Block D Igloo Investigation Area Boundary
ISM Soil Sampling Unit
Increment Sample Grid
ISM Sample Path
Duplicate Sample Path

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink2014_April_Rev1\RVAAP_LNWP_BDI_041_Fig3_4_BlockDIgloo_ISMSample_GridT25_r1.mxd; Analyst: gwt; Date: 9/23/2014 5:08:11 PM

FIGURE 3-4 ISM SOIL SAMPLE AT GRID T25, BLOCK D IGLOO INVESTIGATION AREA

Block D Igloo
Investigation Area Boundary
ISM Soil Sampling Unit
Increment Sample Grid
ISM Sample Path

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWink2014_April_Rev1\RVAAP_LNWP_BDI_042_Fig3_5_BlockDIgloo_ISMSample_GridX29_r1.mxd: Analyst: gwt: Date: 9/24/2014 9:24:17 AM

FIGURE 3-5 ISM SOIL SAMPLE AT GRID X29, BLOCK D IGLOO INVESTIGATION AREA

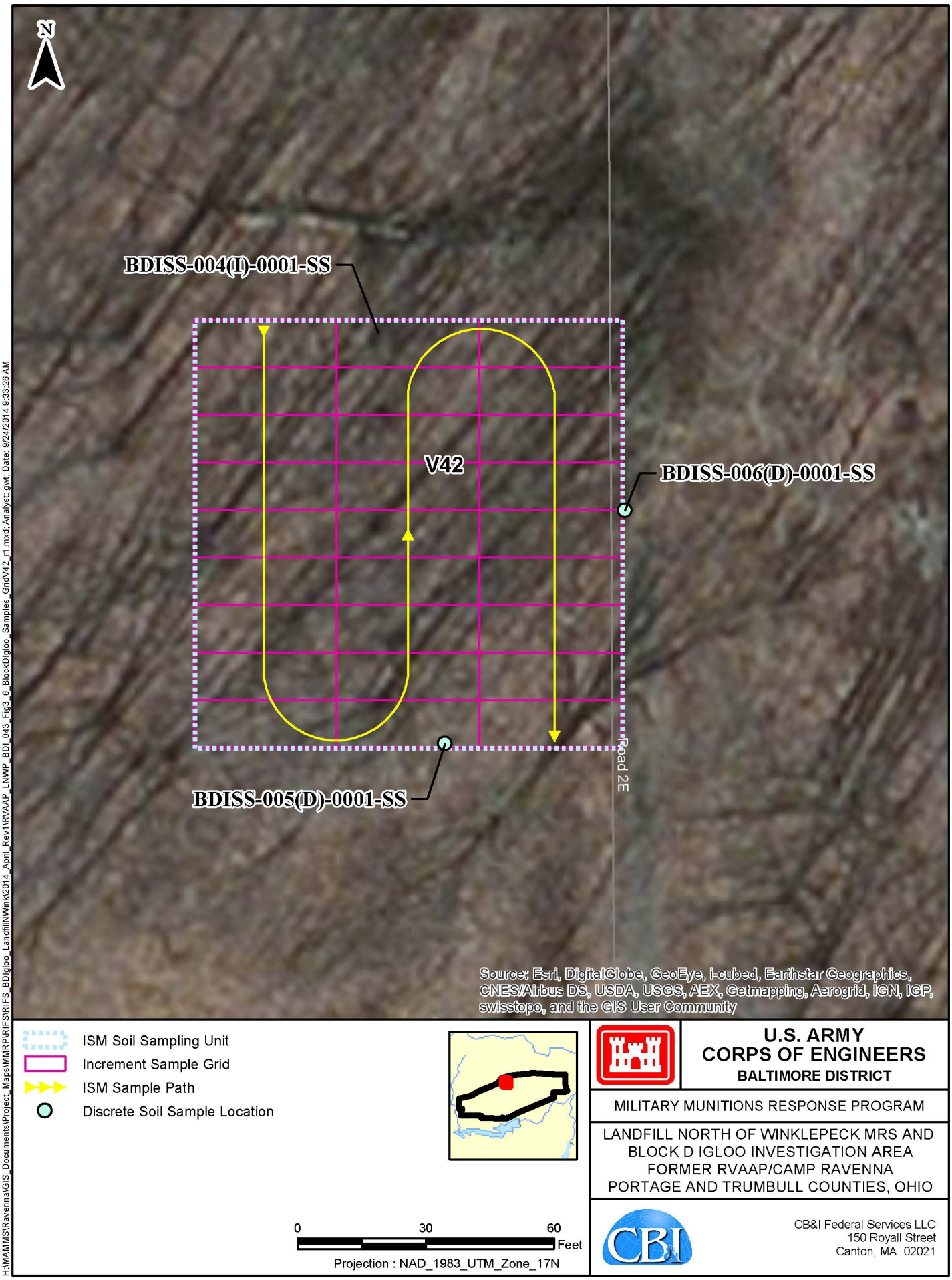


FIGURE 3-6 ISM AND DISCRETE SOILS SAMPLES AT GRID V42, BLOCK D IGLOO INVESTIGATION AREA

locations where MEC items were identified to evaluate if MC associated with the MEC had impacted surrounding soils. Discrete sample BDISS-005(D)-0001-SS was collected at target anomaly location 31 where an M-41 20 lb bomb fragment consisting of a base plate with high explosive (HE) residue present was uncovered at a depth of 0.33 feet (4 inches) bgs. Discrete sample BDISS-005(D)-0001-SS was collected at target anomaly location 16 where an AN-M110A1 nose fuze to an M-41 20 lb fragmentation bomb was found at a depth of 0.25 feet (3 inches) bgs.

The sample interval was from 0 to 0.5 feet bgs beneath the MEC items. The trowel/spoon method was used to collect the discrete soil samples, and disposable sample equipment was used. The trowel was used to manually dig into the subsurface material to the required depth designated for the sampling location. Enough soil was collected at that depth to fill the applicable jar for that analysis.

QC samples for the discrete soil samples included one field duplicate sample. The duplicate sample required the same volume of soil as the original sample from the same location. The field duplicate was labeled with a different sample number (BDISS-007(I)-0001-SS) and was submitted to the laboratory for processing as a blind field duplicate.

The sampling field logs where all data and observations at the sample locations were recorded and the chain-of-custody forms for the samples submitted to the contracted laboratory are included in **Appendix C**. The discrete sample locations are presented in **Figure 3-3**. Additional details regarding the discrete surface soil samples are provided in **Figures 3-4**, **3-5**, and **3-6**.

3.2.2.4 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 EPA publication SW846 entitled *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007) provides test procedures and guidance which are recommended for use in conducting the evaluations and measurements needed to comply with the *Resource Conservation and Recovery Act* (RCRA). These methods are accepted by the EPA for obtaining data to satisfy the requirements of 40 Code of Federal Regulations (CFR), Parts 122 through 270, promulgated under RCRA, as amended, and are commonly used on CERCLA sites for contamination evaluation. Test methods are approved procedures for measuring the presence and concentration of physical and chemical pollutants, evaluating properties such as toxic properties of chemical substances, or measure the effects of substances under various conditions. The selection of chemical analyses for the Block D Igloo Investigation Area was based on the types of

munitions historically identified at the MRS and the potential MC associated with those munitions. The munitions identified at the Block D Igloo Investigation Area were the M-41 20 lb fragmentation bombs that detonated at Igloo 7-D-15. Based on this information, the proposed SW846 analytical suites and methods were presented in the MC Sampling Rationale in the SAP (Shaw, 2011) and included the following:

- Metals (aluminum, iron, lead, and antimony), Method EPA SW846 6010B
- Explosives, Method EPA SW846 8330B
- Nitrocellulose, Method EPA SW846 9056M
- Total organic carbon (TOC), Lloyd Kahn Method
- pH, Method EPA SW846 9045D

In addition to the above analyses, the surface soil samples were also analyzed for geochemical parameters via EPA Method 6010B in order to potentially evaluate naturally high inorganic concentrations and distinguish them from potential contamination. The geochemical parameters analyzed for the Block D Igloo included calcium, magnesium, and manganese.

Each 1- to 2-kilogram sample was submitted to the contracted laboratory, CT Laboratories, 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 grounded using a puck mill to reduce the particle size, as sampling splitting and particle size reduction is necessary to reduce fundamental error. The final reduced portions of the ISM field samples were analyzed for metals (aluminum, iron, lead, and antimony), geochemical parameters (calcium, magnesium, and manganese), explosives, and nitrocellulose. The ISM field samples were analyzed for the TOC and pH parameters following processing of the sample and prior to grinding.

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

A summary of the samples collected and parameters analyzed is presented in **Table 3-3**.

Table 3-3
Summary of Field Samples Collected and Required Analytical Parameters for the Block D Igloo Investigation Area

Grid Location	Sample Name	Sample Type	Depth (feet bgs)	Analytical Parameters	Original Sample	Field Duplicate
T25	BDISS-001(I)-0001-SS BDISS-002(I)-0001-SS	ISM	0–0.5	Metals[1], Explosives, Nitrocellulose, Geochemical parameters[2], TOC, pH	1	1
X29	BDISS-003(I)-0001-SS				1	
V42	BDISS-004(I)-0001-SS				1	
V42	BDISS-005(D)-0001-SS	D	0.33–0.83		1	
V42	BDISS-006(D)-0001-SS BDISS-007(D)-0001-SS		0.25–0.75		1	1

[1] Metals include analysis for aluminum, iron, lead, and antimony.

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

bgs denotes below ground surface.

D denotes discrete.

ISM denotes incremental sampling method.

MEC denotes munitions and explosives of concern.

TOC denotes total organic carbon.

3.2.3 Laboratory Analyses

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

Strict adherence to the requirements set forth in the FWSAP (SAIC, 2011) and the SAP (Shaw, 2011) was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (EPA, 2007), *Methods for Chemical Analysis of Water and Wastes* (EPA, 1983), or as specified in the FWSAP. SW-846 chemical analytical procedures were followed for the analyses of metals, explosives, nitrocellulose, and pH. TOC was analyzed in accordance with

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. A field blank consisting of an equipment rinsate sample was submitted for analysis, along with field duplicate samples, to provide a means to assess the quality of the data resulting from the field sampling program. **Table 3-4** presents a summary of QA/QC samples utilized during the RI field activities for the Block D Igloo Investigation Area.

Table 3-4
Summary of Quality Assurance/Quality Control Samples for the Block D Igloo Investigation Area

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
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 to 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 retains all original raw data in a secure area under the custody of the laboratory project manager.

CT Laboratories performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing 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 in the SAP (Shaw, 2011). Data reduction, review, and reporting by the laboratory were conducted as follows:

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

Data were then delivered to 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 disc), 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, initial and continuing calibration verifications of standards and blanks, method blanks, and LCS information

3.2.4 Data Validation

A systematic process for data validation on all surface soil samples collected from Block D Igloo Investigation Area (including field duplicates and QC samples) was performed by CB&I 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 a primary sample and a field duplicate sample.

The data validation process 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. Samples were identified through implementation of “definitive” analytical methods. These definitive data were then verified through the review process outlined in the SAP (Shaw, 2011).

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 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
- "B"—Analyte was detected in associated blank
- "J"—The reported result is an estimated value

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 D**.

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 the 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 project specifications and the data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the SAP (Shaw, 2011), FWSAP (SAIC, 2011), the *DoD Quality Systems Manual for Environmental Laboratories Version 4.2* (DoD, 2010), and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance. DQOs were developed concurrently with the Work Plan (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 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; 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 D**.

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

- **General Review—**The EPA guidance, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) Interim Final* (EPA, 1989), states that the data qualified during the validation process as estimated "J" or "UJ" may be included in quantitative assessments indicating the associated numerical value is an estimated quantity, i.e., the guidance states to "use J-qualified concentrations the same way as positive data that do not have this qualifier." In review of analytical information, the sample results qualified as "J" (i.e., estimated or nondetect estimated values) during the validation process are considered usable

data points (EPA, 1989), and are included in the data summary tables of this report. The majority of the "J" qualified samples were the result of analytical column confirmation or accuracy recoveries outside criteria. The explosives detections did not pass method confirmation criteria for samples BDISS-001(I)-0001-SS (nitroguanidine), BDISS-002(I)-0001-SS (nitroguanidine) and BDI-008-RB (tetryl); therefore, they were qualified estimated "J" based upon these outliers. Although these results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). There was no data rejections (i.e., R-flagged results) resultant from the data validation reviews. Further discussion is provided in the *Data Validation Report* in **Appendix D**.

- **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 laboratories duplicates and MSD pairs were within RPD criteria limits; and therefore, did not warrant further qualification. Blind field duplicate sample pairs were collected for the ISM soil samples (BDISS-001(I)-0001-SS/BDISS-002(I)-0001-SS) and the discrete (BDISS-006(D)-0000-SS/BDISS-007(D)-0000-SS) soil samples for all parameter groups. For the field duplicate pair, explosive compound nitroguanidine was detected at low levels in the parent sample and nondetect in the associated duplicate pair. For all other parameter groups, all criteria were met for the field duplicate. Although these results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion is provided in the *Data Validation Report* in **Appendix D**.

- **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.

  The MS/MSD recoveries for spiked sample BDISS-00(1)-0001-SS exceeded recovery limits for antimony, iron, aluminum, and manganese. The serial dilutions for this sample exceeded percent difference limits for iron, aluminum, and

manganese while the post-digestion spike for this sample had unacceptable recoveries for iron, manganese, and aluminum. These elements (iron, aluminum, and manganese) were qualified estimated "J" flag in the parent sample based upon these outliers. All other MS/MSD recoveries were within criteria.

All LCS and surrogate recoveries were within criteria limits for all parameter groups; therefore, they did not warrant qualification. As a result, no further actions were required. Although some data results have been qualified as estimated due to the outliers noted, the data are still considered useable (EPA, 1989). Further discussion is presented in the *Data Validation Report* in **Appendix D**.

- **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 "B" and considered nondetect at the limit of detection (LOD) or level of contamination, whichever was greater. From the EPA guidance *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final* (EPA, 1989), the definitions of the 5 times and 10 times rules are as follows:

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

  In review of the field and laboratory blanks, antimony, iron, and tetryl were detected at trace levels and aluminum was detected above the LOD for the rinsate blank (BDI-008-RB). For the method blanks, lead and magnesium were detected above the LOD, and aluminum, calcium, iron, and manganese were detected at trace levels. Aluminum was detected above the LOD in the initial and continuing calibration blanks. All other target analytes were nondetect for the QC blanks. For the associated surface and subsurface soil samples collected on August 2011, aluminum was qualified "B" based upon these outliers. The associated soil sample concentrations for aluminum were well above the amount detected in the associated blank sample (i.e. greater than the "five times" rule); therefore, there

were no resultant significant impacts based upon this qualification. As a result, no further actions were required. Further discussion is provided in the *Data Validation Report* in **Appendix D**.

- **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 event, the sample collection was performed using CB&I standard operating procedures (SOPs) and the sampling procedure requirements specified in the FWSAP (SAIC, 2011). 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 (Shaw, 2011). The audit was activity-based and covered ISM surface soil sample collection conducted at the Group 8 MRS in February 2012. Although the audit was not conducted at the Block D Igloo Investigation Area, the QC audit is directly applicable to the ISM surface soil samples collected at the MRS because the sampling conducted at both the Group 8 MRS and Block D Igloo Investigation Area was performed using the same procedures as outlined in the Work Plan and the samples were collected by many

of the same individuals at both sites. The QC field audit is presented along with the field documentation in **Appendix C**.

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

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

- **Completeness—**Completeness is a measure of the amount of information that must be collected during the field investigation to allow for successful achievement of the objectives of the program and valid conclusions. Completeness is defined as the percentage of measurements which are judged to be usable. The percent completeness criterion is 90 percent. In this data validation review, three categories of completeness quotients are calculated, including the overall sampling completeness, overall analytical completeness, and analytical completeness by parameter 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. Three discrete surface soil samples (including one field duplicate), four ISM surface soil samples (including one field duplicate sample), and one rinsate blank were collected and

sent to the laboratory for analyses. Three discrete surface soil samples (including one field duplicate), four ISM surface soil samples (including one field duplicate sample), and one rinsate blank were proposed for this sampling event following the RI visual survey and intrusive investigation. Excluding rinsate blanks, the overall sampling completeness was 100 percent (or 7 surface soil samples collected divided by 7 planned surface 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 resulted in 196 useable data points of possible 196 data points, resulting in an overall analytical completeness quotient of 100 percent for all parameter groups. The completeness statistics were computed as follows:

– 196 represents the total number of accepted analytes as usable data points (no analytes were rejected).

– 196 represents the number of analyzed inputs, which is equal to the total number of analytes for all field samples.

There were no rejected data points for any of the parameters for explosives, metals, 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 D**.

- **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 CT Laboratories, Inc., an ELAP-accredited laboratory, in accordance with the approved SAP (Shaw, 2011) using cited EPA methodology. Where applicable, the EPA-approved methods and *DoD Quality Systems Manual* provided the QC criteria guidelines for the analytical methods and the ELAP accrediting body provided the QA oversight (DoD, 2010). The laboratory adapted its processes accordingly into an applicable working SOP specific to its 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 bodies. Furthermore, laboratory data were validated in accordance with established SOPs, and the validation qualifiers were applied when QC nonconformances were

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

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

- **Sensitivity—**The sensitivities are dependent on the analytical method, the sample volumes, and percent moistures (solid matrix) used in laboratory determinative analysis. For each analyte, the method sensitivities (i.e., MDLs, LODs, MRLs, etc.) and analyte detections presented in the analytical data 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 AAP MRSs* of the Work Plan (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.

The Block D Igloo Investigation Area analytical data were determined to be of sufficient quality to make informed decisions for the surface soil samples collected. Further discussions of data qualifications are provided in the *Data Validation Report* in **Appendix D**.

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. All sampling decontamination procedures were performed at Building 1036, the facility contractors' building. In summary, the decontamination procedures consisted of the following:

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

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

Following the equipment decontamination process, an equipment rinsate sample was collected by running distilled water through the sampling equipment for the identical analytical parameters as the environmental samples. The purpose of the equipment rinsate sample 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 supported 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." Summaries of results of the equipment rinsate sample are presented in **Appendix E**.

3.4 Investigation-Derived Waste

The investigation-derived waste generated during the field activities at the Block D Igloo Investigation Area consisted of solid waste that included expendable waste debris (personal protective equipment), disposable sample equipment, and equipment decontamination materials. Due to the minimal number of sampling equipment pieces 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 disposable sample equipment (plastic scoops) were disposed as solid waste. The expendable waste debris and equipment decontamination materials generated were containerized along with similar materials generated from other MRSs and were staged at Building 1036. A description of the waste characterization analyses performed, waste

characterization screening, and investigation-derived waste transport and disposal are presented in **Appendix F**.

4.0 REMEDIAL INVESTIGATION RESULTS

This section presents a discussion of the results of the RI data that were collected at the Landfill North of Winklepeck MRS and Block D Igloo Investigation Area 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 at both sites, associated MC (at the Block D Igloo Investigation Area only), and subsequently determine the potential hazards and risks posed to likely human and ecological receptors. Once the hazards/risks are determined, they will then be integrated into the preliminary CSMs for each of the MRSs that were developed during the SI (e^2M, 2008) and presented in Section 2.0, "Project Objectives." Photographs of the RI activities are presented in **Appendix G**.

4.1 MEC Investigation Results

The following sections present the results of the RI field efforts for MEC that were performed to achieve the DQOs defined in Section 2.3.1, "Data Quality Objectives," and define the nature and extent of MEC at the Landfill North of Winklepeck MRS and Block D Igloo Investigation Area. These efforts consisted of an instrument-assisted visual survey at both locations and a subsequent intrusive investigation at the Block D Igloo Investigation Area only.

4.1.1 Landfill North of Winklepeck MRS Visual Survey Results

The instrument-assisted visual survey at the Landfill North of Winklepeck MRS was performed over 100 percent of the accessible areas at the MRS. Of the 2.3 acres that make up the MRS, 1.6 acres were investigated. The remaining 0.7 acres of the MRS that were not investigated were located on the eastern side of the MRS at the base of the slope and were determined to be inaccessible due to the presence of wetlands and the unnamed stream. No MEC was found on the ground or in shallow surface soil at the areas investigated along the northern slope of the landfill. **Figure 4-1** illustrates the area of actual visual survey coverage at the Landfill North of Winklepeck MRS.

Subsurface anomalies were detected at the MRS during the instrument-assisted visual survey, in particular along the slope areas at the southwest portion of the MRS; however, the surface of the slope was littered with metal debris that included a 55-gallon drum and rusted pails and cans, and any buried anomalies were assumed to be consistent with the surface debris. As a result, performing intrusive investigations were determined to be unwarranted based on the lack of MEC on the surface.

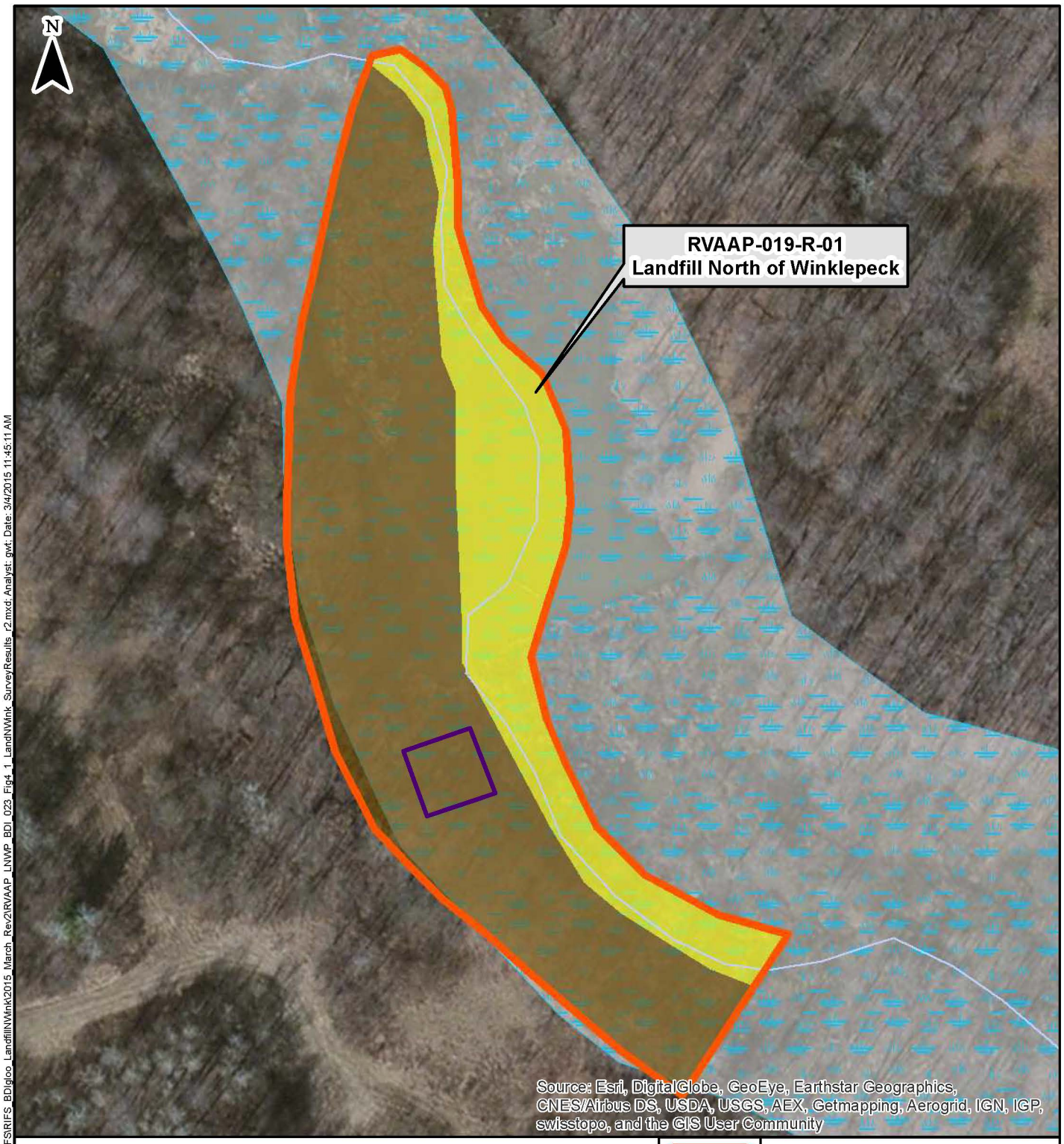


FIGURE 4-1 VISUAL SURVEY RESULTS, LANDFILL NORTH OF WINKLEPECK MRS

4.1.2 Block D Igloo Investigation Area Visual Survey Results

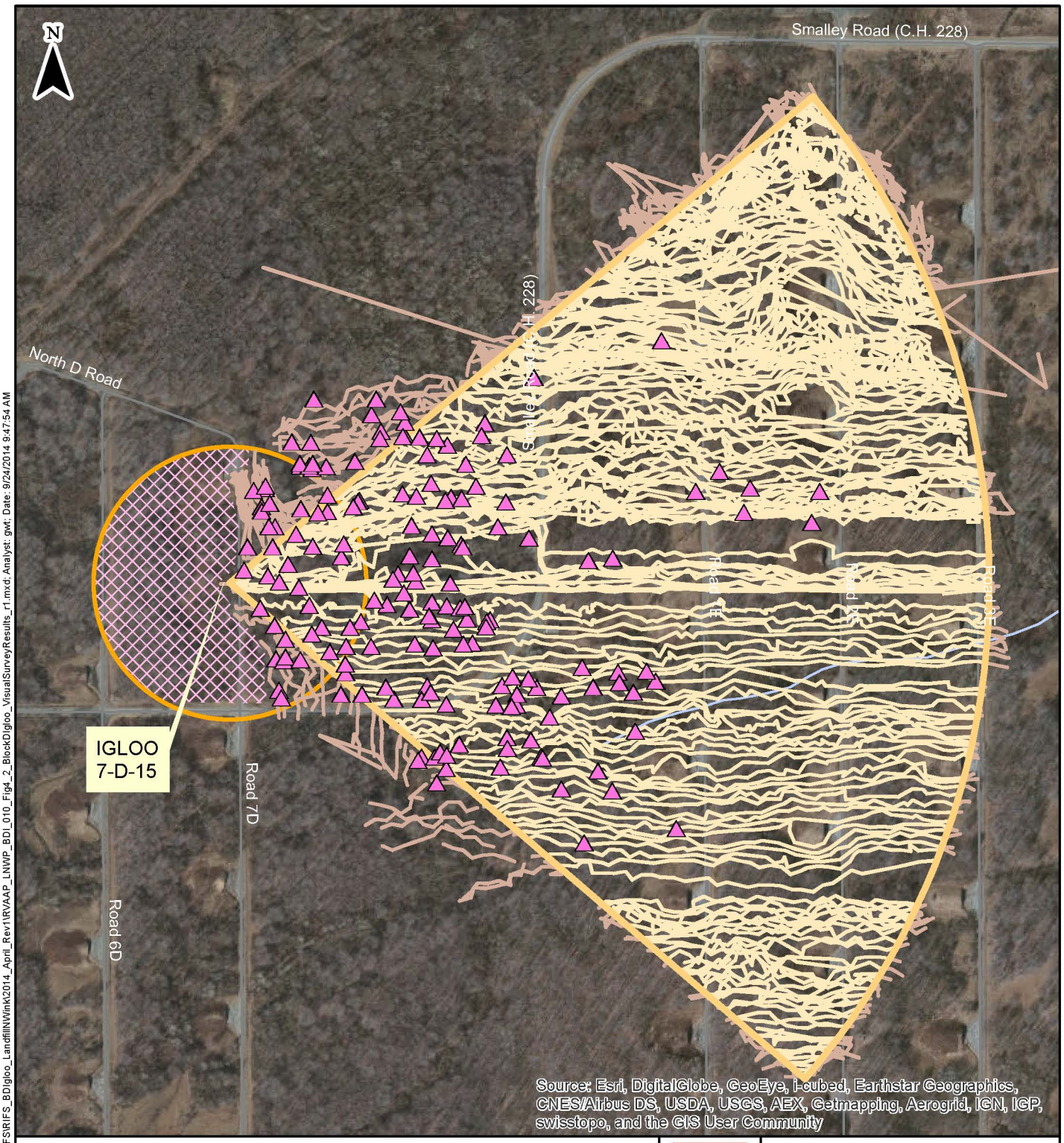
A total of 65.2 miles of instrument-assisted visual survey transects were performed at the Block D Igloo Investigation Area. Each transect consisted of a sweep width of approximately 5 feet. The total area covered was approximately 54 acres including the 100-foot step-outs around the MPPEH identified along the boundary of the calculated blast fan. Additionally, an instrument-assisted visual survey was also conducted behind (west) the former magazine to verify that the blast did not produce kickout in this direction. This portion of the survey was considered part of the calculated MFD-H associated with the M-41 20 lb fragmentation bomb and was not tracked with a GPS since it was for verification purposes only. **Figure 4-2** illustrates the area of actual visual survey coverage at the Block D Igloo Investigation Area.

A total of 178 MPPEH items were identified on the ground surface during the visual survey. All of the MPPEH items were documented as safe (i.e., MD) by the UXO-qualified personnel. The MD found during the visual survey consisted of bomb fragmentation sleeves and tail fin assemblies associated with the M-41 20 lb fragmentation bomb. The maximum distance of the MD found during the visual survey from the former magazine location was approximately 1,800 feet due east within Grid V42; however, most of the MD were found within 1,300 feet east of the former igloo. No additional MD were identified from the step-outs and the investigation west of the former magazine. **Appendix H** presents a summary of the locations and descriptions of MD identified during the visual survey activities.

4.1.3 Block D Igloo Investigation Area Intrusive Investigation Results

A mag and dig investigation was conducted at the Block D Igloo Investigation Area following the RI visual survey activities. The expected nature of MEC at the investigation area was M-41 20 lb fragmentation bomb components in subsurface soils to a maximum depth of 1 foot. Seven 100-foot by 100-foot mag and dig grids were placed throughout the investigation area to evaluate the potential for subsurface MEC. The seven selected grid locations (P32, S30, T25, V32, V42, X29, and BB37) were biased based on the amount of MD identified during the visual survey. The seven grid locations are presented in **Figure 3-2**.

A total of 3,140 MPPEH items were found during the mag and dig investigation. The UXO-qualified personnel documented 3,135 of the MPPEH items as safe (i.e., MD) and 5 MPPEH items as MEC. The MD items were identified to be parts associated with the M-41 20 lb fragmentation bombs. The maximum depth of the MD items encountered was 0.67 feet (8 inches) bgs, and the total weight of the MD was 2,614 lbs.



MRS Boundary at Conclusion of 2007 SI

RI Investigation Area (92.14 acres)

Actual Visual Transects (~53.9 ac./ 65.2 mi.)

Step-Out Transects

Muitions Debris Items (178 Items)

Instrument-Assisted Visual Survey Behind (West) Igloo

Stream

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_010_Fig4_2_BlockDIgloo_VisualSurveyResults_r1.mxd: Analyst: gwt: Date: 9/24/2014 9:47:54 AM

FIGURE 4-2 VISUAL SURVEY RESULTS, BLOCK D IGLOO INVESTIGATION AREA

The five MEC items were found at three of the seven mag and dig grid locations. Two MEC items were each found in Grid T25 and Grid V42 and one MEC item was found in Grid X29. Only the MEC found in Grid V42 contained visible HE residue. The depth of the MEC ranged from just below top soil in Grid T25 to a maximum depth of 0.5 feet (6 inches) bgs in Grid X29. All of the MEC items were identified as parts associated with the M-41 20 lb fragmentation bombs, with the exception of one item (Anomaly No. 17) that was found less than 200 feet east of the former igloo location in Grid T25. This item was only a small piece of an ordnance component suspected to be a fuze of an unknown type associated with a small fragmentation bomb and was not consistent with the fuzes used in the 20 lb bombs that exploded at Block D Igloo.

Figures 4-3 through **4-9** present the items found for the grids that were intrusively investigated. **Table 4-1** presents the descriptions of the MEC items identified and the grid locations where they were found.

Table 4-1
MEC Items Identified at the Block D Igloo Investigation Area

Grid Location (Anomaly ID)	MEC Item Description	Depth (feet bgs)	Quantity (each)	NEW (lbs)
T25 (16)	Fuze, Nose, 20 lb Fragmentation Bomb, M-41 (partial)	0.08	1	0.1
T25 (17)	Ordnance Components (Fuze, Type Unknown, Small Fragmentation Bomb Type) (partial)	0.08	1	0.1
V42 (16)	Bomb, Fuze, Nose, AN-M110A1 (partial)	0.25	1	0.1
V42 (31)	Bomb, Fragmentation, 20 lb, M-41, Base Plate with HE Residue (partial)	0.33	1	0.1
X29 (31)	Bomb, Fragmentation, 20 lb, M-41 (partial)	0.5	1	0.1
		Total:	**5**	**0.5**

bgs denotes below ground surface.
HE denotes high explosive.
ID denotes identification.
lb denotes pound.
MEC denotes munitions and explosives of concern.
NEW denotes net explosive weight.

4.1.3.1 UXO Estimator® Analysis Results

The UXO Estimator® module (USACE, 2003b) was used to analyze the data collected during the mag and dig investigation. A total of 1.607 acres of the 92.14-acre Investigation Area were investigated and 5 MEC items were found. The results of the mag and dig investigation confirmed that the MEC density was greater than the DQO UXO Estimator® input of 2.0

Mag/Dig Grid BB37
Munitions Debris Quantity = 9 Items
Munitions Debris Weight = 2.1 Pounds
Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWinK2014_April_Rev1\RVAAP_LNWP_BDI_011_Fig4_3_BlockDIgloo_MagDig_GridBB37_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:12:47 AM

FIGURE 4-3 GRID BB37 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA

Mag/Dig Grid P32
Munitions Debris Quantity = 249 Items
Munitions Debris Weight = 161 Pounds

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

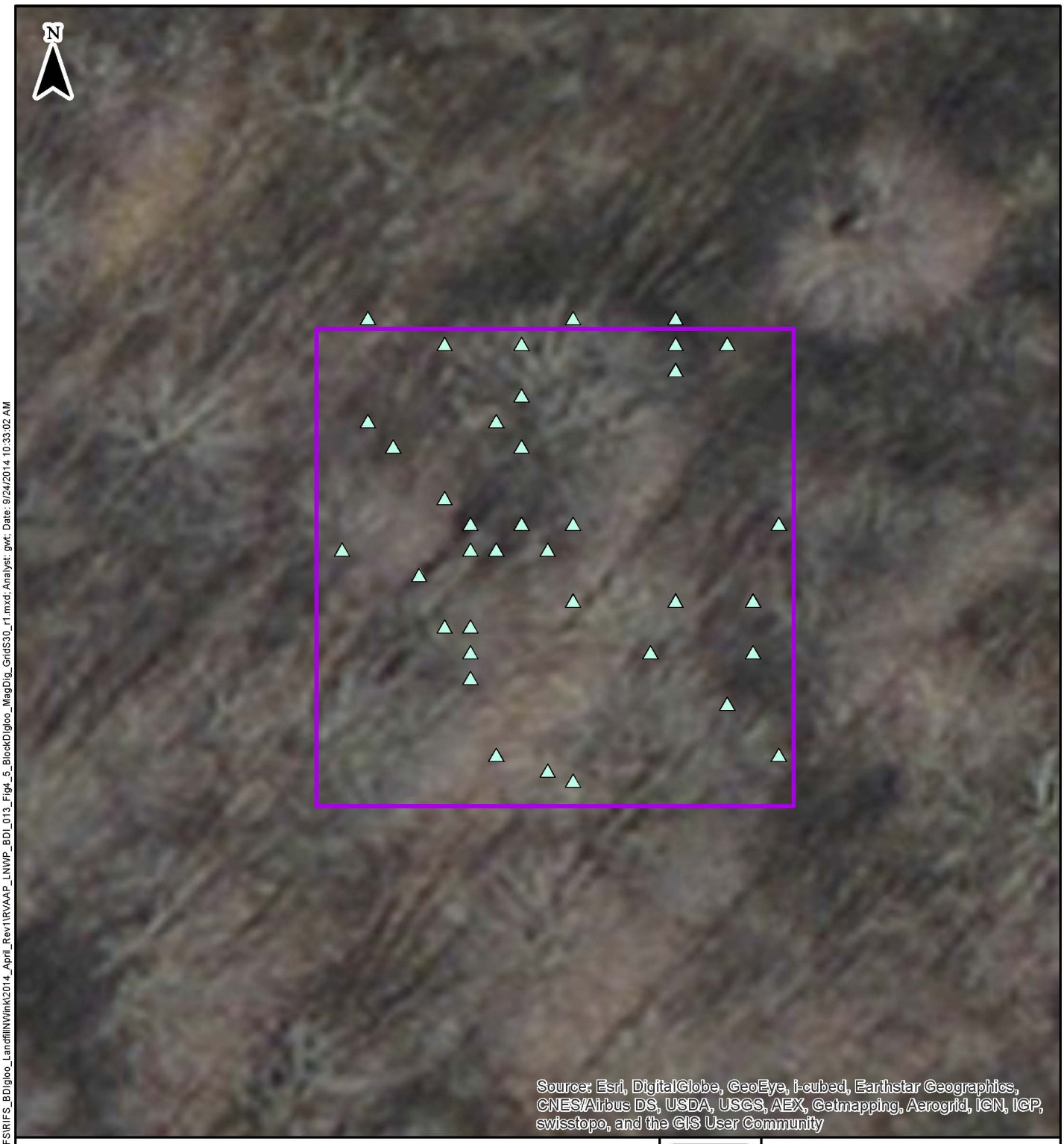
MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRP\RIFS\RIFS_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_012_Fig4_4_BlockDIgloo_MagDig_GridP32_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:18:31 AM

FIGURE 4-4 GRID P32 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA



Mag/Dig Grid V31
Munitions Debris Quantity = 1,489 Items
Munitions Debris Weight = 848.5 Pounds

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWinK2014_April_Rev1\RVAAP_LNWP_BDI_013_Fig4_5_BlockDIgloo_MagDig_GridS30_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:33:02 AM

FIGURE 4-5 GRID S30 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA

Block D Igloo
Investigation Area

Mag/Dig Grid T25
Munitions Debris Quantity = 1,289 Items
Munitions Debris Weight = 760.3 Pounds

Material Potentially Presenting Explosive Hazard Item

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_014_Fig4_6_BlockDIgloo_MagDig_GridT25_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:36:25 AM

FIGURE 4-6 GRID T25 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA

Mag/Dig Grid V31
Munitions Debris Quantity = 22 Items
Munitions Debris Weight = 321.5 Pounds

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_015_Fig4_7_BlockDIgloo_MagDig_GridV31_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:41:29 AM

FIGURE 4-7 GRID V31 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA

Mag/Dig Grid V42
Munitions Debris Quantity = 24 Items
Munitions Debris Weight = 9.9 Pounds

Material Potentially Presenting Explosive Hazard Item

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

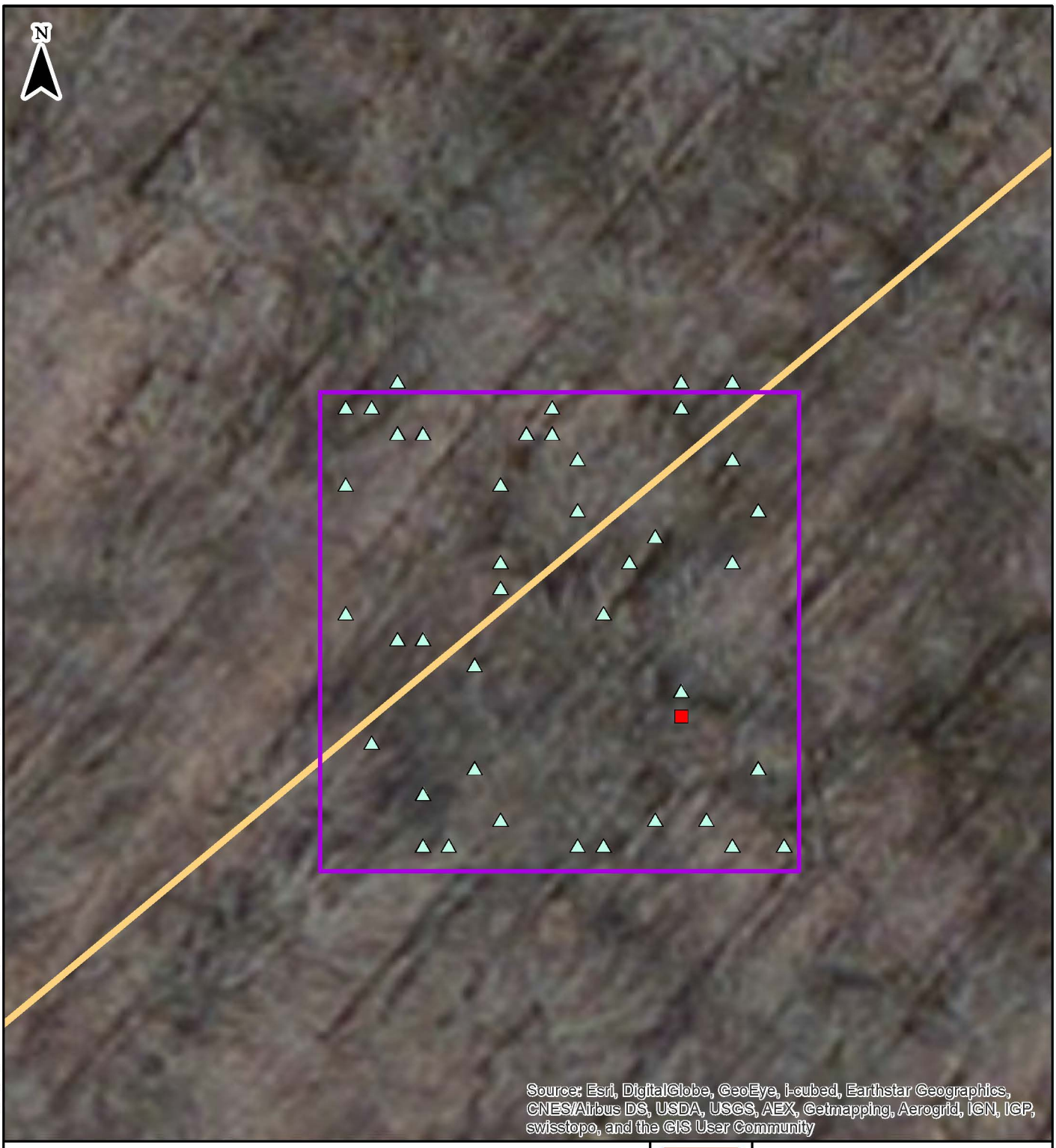
MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_016_Fig4_8_BlockDIgloo_MagDig_GridV42_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:44:13 AM

FIGURE 4-8 GRID V42 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA



Block D Igloo
Investigation Area

Mag/Dig Grid X29
Munitions Debris Quantity = 53 Items
Munitions Debris Weight = 475.5 Pounds

Material Potentially Presenting Explosive Hazard Item

Munitions Debris Item

0 30 60 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMRMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWinK2014_April_Rev1\RVAAP_LNWP_BDI_017_Fig4_9_BlockDIgloo_MagDig_GridX29_r1.mxd: Analyst: gwt: Date: 9/24/2014 10:48:33 AM

FIGURE 4-9 GRID X29 MAG/DIG RESULTS, BLOCK D IGLOO INVESTIGATION AREA

UXO/acre assuming a 95 percent confidence level. According to UXO Estimator® Version 2.2[1], the average MEC density is approximately 3.723 MEC per acre based on the field results. The actual density at the 95 percent confidence level is 6.512 MEC per acre. As such, it can be estimated that between 343 and 600 MEC items may be present within the investigation area, assuming densities between 3.723 and 6.512 MEC per acre, respectively.

4.1.4 Management and Disposal of MEC and MD

This section presents the management and disposal practices for the MEC and MD items that were collected during the RI field work at the Block D Igloo Investigation Area. In all, less than 10 lbs of MEC items containing approximately 0.5 lbs net explosive weight and nearly 2,597 lbs of MD were generated during the visual survey and mag and dig investigations at the Block D Igloo Investigation Area. The MEC and MD items were managed and disposed in accordance with the *Explosives Management Plan* in Section 5.0 of the Work Plan (Shaw, 2011).

Once an MPPEH item was determined to be MD by the UXO-qualified personnel during the intrusive investigations, it was removed from the MRS and placed into a 55-gallon steel drum. The drums were verified as material documented as safe (MDAS) and were transported to a designated area at the Open Demolition Area #2 MRS for temporary storage. The drums of MD were shipped off site on September 8, 2011, for demilitarization at Demil Metals, Inc. in Glencoe, Illinois. 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 Block D Igloo Investigation Area and other facility MRSs investigated under the MMRP as of September 8, 2011.

As each MPPEH item was identified, it was evaluated by the CB&I Senior UXO Supervisor (SUXOS) as to whether an explosive hazard was present. If no explosive hazard was identified, the item was determined to be MDAS or MD and no longer considered MPPEH. If the SUXOS could not conclude that an item was free of explosives, the item was considered as MEC and required destruction. The MEC item was evaluated to determine whether it was safe to move or required to be blown in place. All MEC items found at the mag and dig locations were transported to the temporary magazines established at Building 1501 at the Open Demolition Area #2. The MEC items were destroyed at the Operational Open Demolition Area at the Open Demolition Area #2 on July 29, 2011, along with MEC items found at other MRSs investigated by CB&I at the facility under the MMRP. The *Pre-Demolition MEC Notification* and *Post-Demolition MEC Notification* information submitted to the Ohio EPA for notice of the demolition activities on July 29, 2011, are provided in **Appendix J**.

[1] The underlying assumption in UXO Estimator® Version 2.2 is that MEC in the area of interest are uniformly distributed.

4.2 MC Data Evaluation

This section presents the results of the RI data screening process for MC that may be indicative of impacts from historical munitions events, which have occurred at the Block D Igloo Investigation Area, and to evaluate the occurrence and distribution of MCs in surface soil. No samples were collected for MC at the Landfill North of Winklepeck MRS since no MEC was found during the RI. The data evaluated in this section is inclusive of the results of the RI sampling event only. Analytical data from previous samples collected during the 2007 SI field activities were not included in this evaluation since comparison of samples between the two sample events is not considered relevant, as summarized 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) established for this RI Report are also presented below. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix E**.

4.2.1 Data Evaluation Methods

The data evaluation methods for the Block D Igloo Investigation Area are consistent with those established in the *Final Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (SAIC, 2010), herein referred to as the FWCUG Guidance, and the *Ravenna Army Ammunition Plant Position Paper for the Application and Use of Facility-Wide Cleanup Goals* (USACE, 2012); herein referred to as the Position Paper. These methods consist of three general steps: (1) definition of data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

4.2.1.1 Definition of Aggregates

The sample aggregate at the Block D Igloo Investigation Area consisted of surface soils that were collected using both ISM and discrete sampling methods. The ISM samples were collected at multiple same-sized sampling units at similar depths within the 92.14-acre Investigation Area that is considered the decision unit and encompassed only areas of equally probable anticipated use by potential receptors. The discrete samples were collected at biased locations within the investigation area where MEC was encountered and were collected at the same sample intervals as the ISM samples but at varying depths due to the different depths at which MEC was encountered. A summary of the surface soil aggregate and use in evaluating the nature and extent of contamination at the Block D Igloo Investigation area is as follows:

- **Surface Soil (0 to 0.83 feet bgs)**: This medium is evaluated over the entire surface soil aggregate for the Block D Igloo Investigation Area. Both ISM and discrete sample data are available for this media, but because it not appropriate to combine ISM and discrete sample data, these two sample types are evaluated separately. Typically, the exposure unit (EU) depth of surface soil used for the evaluation of site-related chemicals (SRCs) at the facility for human receptors is considered to be 0 to 1 foot for the Residential Farmer or 0 to 4 feet for the National Guard Trainee. However, the maximum depth of the ISM surface soil samples was 0.5 feet (6 inches) and the maximum depth of the discrete samples was 0.83 feet (10 inches) bgs. The EU depths for the ISM samples were selected based on the anticipated maximum depth that MC from MEC or MD on the ground surface would be expected to vertically migrate in the soil column. The EU depths for the discrete samples were based on the same expected 0.5-foot vertical migration below an encountered MEC item.

The ISM and discrete samples collected for the surface soil aggregate were further used to define human and ecological risk exposure to likely receptors in the risk assessments, as discussed in Section 7.0, "Human Health Risk Assessment" and Section 8.0, "Ecological Risk Assessment."

4.2.1.2 Data Validation

Data validation was performed on all surface soil ISM and discrete samples collected from Block D Igloo Investigation Area (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" of this report.

4.2.1.3 Data Reduction and Screening

The data reduction process employed to identify MC as 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 for each compound. Following data reduction, the data were screened to identify SRCs using the processes outlined in the following sections. **Figure 4-10** shows the facility data screening process to identify SRCs and chemicals of potential concern (COPCs)

and perform selection for chemicals of concern (COCs) in accordance with the FWCUG Guidance (SAIC, 2010).

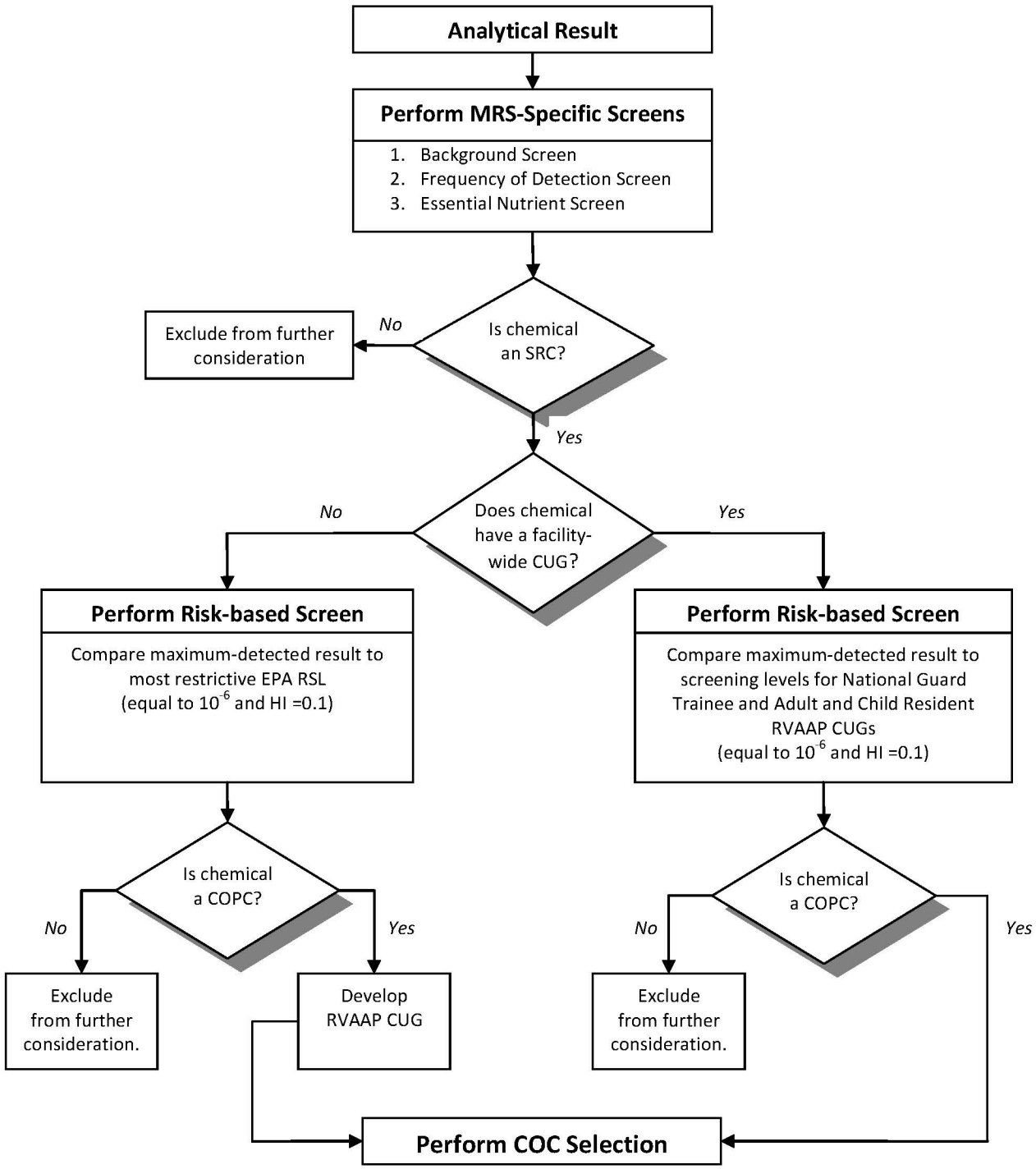
Frequency of Detection

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 a frequency of detection of less than 5 percent, a weight of evidence approach may be used to determine if the chemical is MRS related. Surface samples were collected at only five locations (three ISM and two discrete samples); therefore, frequency of detection was not utilized to support a weight of evidence approach for the Block D Igloo Investigation Area data set.

Facility-Wide Background Screen

For each inorganic constituent, concentrations were compared against established facility-wide BSVs. For inorganic constituents, if the detected value 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 MRSs being investigated under the MMRP, analyses were conducted for calcium, magnesium, and manganese to be potentially used for geochemical analysis. Aluminum was analyzed for geochemical purposes in certain MRSs where aluminum is not considered an MC related to munitions; however, aluminum is considered to be an MC associated with the Block D Igloo Investigation Area and was not analyzed as a geochemical metal for this MRS. Geochemical analysis is typically used when metals are found to be only slightly elevated above background levels and a risk assessment identifies potential to receptors due to metals. A geochemical analysis is then used to determine if MEC metals are background related or actually elevated due to site history. Use of the geochemical evaluation in this manner requires approval from the USACE and Ohio EPA prior to implementing geochemical evaluation results as a comparison tool for background results. A geochemical analysis was not required for Block D Igloo Investigation Area based on the evaluation of the metal results in Section 4.0, “Remedial Investigation Results,” and the HHRA and ERA conclusions in Section 7.0 and Section 8.0, respectively.



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 COPCs is for human health evaluation only.

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
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_BDIgloo_LandfillNWinkl2014_April_Rev1\RVAAP_LNWP_BDI_036_Fig4_10_Process_Chem_of_Concern_r1.mxd: Analyst: gwt: Date: 6/12/2014 2:48:47 PM

FIGURE 4-10 RVAAP DATA SCREENING PROCESS

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). Recommended daily allowance and recommended daily intake values are available for most of the metals identified as essential nutrients (USACE, 2005).

For the RI field effort, analyses were conducted for calcium, magnesium, and manganese to be used for geochemical analysis. Although geochemical analysis was not performed, these constituents were eliminated as SRCs in the environmental media since they are not considered as an MC associated with the munitions (M-41 20 lb fragmentation bombs) that accidentally detonated at the Block D Igloo Investigation Area (Shaw, 2011). Iron is considered as an MC associated with the M-41 20 lb fragmentation bomb and is not evaluated as an essential nutrient.

4.2.1.4 Data Presentation

Data use summary statistics and screening results for SRCs in the surface soil samples collected at the Block D Igloo Investigation Area are presented in the following sections. Designation of the intended use of the samples for evaluation of fate and transport, human health risk, and ecological risk are presented in **Table 4-2**. A summary of the laboratory analytical results for the ISM and the discrete surface soil samples are presented in **Table 4-3** and **Table 4-4**, respectively. The identification of SRCs following the facility screening process is presented in **Table 4-5** and **Table 4-6** for the ISM and discrete surface soil samples, respectively. The SRCs identified for the investigation area are presented by sample location in **Figure 4-11**. A summary of the complete laboratory analytical results for the data collected during the RI field work is presented in **Appendix E**.

4.2.2 Data Use Evaluation

During the RI field effort, both discrete and ISM surface soil samples were collected at locations that were biased based on the results of MEC and MD found during the visual survey and mag and dig investigations. Available sample data were evaluated to determine suitability for use in the various key RI data screens that include evaluation of nature and extent of contamination, fate and transport, and human and ecological risk assessments. Evaluation of data suitability for use in this RI Report involved two primary considerations: (1) representativeness with respect to current MRS conditions, and (2) sample collection methods (i.e., discrete sample versus ISM).

Table 4-2
Data Use Summary and Collection Rationale for the Block D Igloo Investigation Area

Sample ID	Date	Depth (feet bgs)	Sample Type	Data Use Type	Sampling Rationale
Surface Soil					
BDISS-001(I)-0001-SS	8/22/11	0–0.5	ISM	N&E, F&T, R	Collected from Grid T25. Two MEC items and 69 MD items recovered from grid.
BDISS-003(I)-0001-SS	8/22/11	0–0.5	ISM	N&E, F&T, R	Collected from Grid X29. One MEC item and 47 MD items recovered from grid.
BDISS-004(I)-0001-SS	8/22/11	0–0.5	ISM	N&E, F&T, R	Collected from Grid V42. Two MEC items and 21 MD items recovered from grid.
BDISS-005(D)-0001-SS	8/22/11	0.33–0.83	D	N&E, F&T, R	Collected from Grid V42, Anomaly ID 31. Collected beneath MEC item (Bomb, Fragmentation, 20 lb, AN-M41, Base Plate with HE Residue) recovered from grid.
BDISS-006(D)-0001-SS	8/22/11	0.25–0.75	D	N&E, F&T, R	Collected from Grid V42, Anomaly ID 16. Collected beneath MEC item (Bomb, Fuze, Nose, AN-M110A1) recovered from grid.

bgs denotes below ground surface.
D denotes discrete.
F&T denotes fate and transport evaluation.
HE denotes high explosive.
ID denotes identification.
ISM denotes incremental sampling method.
MD denotes munitions debris.
MEC denotes munitions and explosives of concern.
N&E denotes nature and extent evaluation.
R denotes human and ecological risk assessment evaluation.

Table 4-3
Summary of ISM Surface Soil Results

		Location ID:	BDISS-001		BDISS-003		BDISS-004	
		Sample ID:	BDISS-001(I)-0001-SS		BDISS-003(I)-0001-SS		BDISS-004(I)-0001-SS	
		Sample Date:	22-Aug-11		22-Aug-11		22-Aug-11	
		Depth (feet bgs):	0–0.5		0–0.5		0–0.5	
Analyte	**Units**	**BSV[1]**	**Result**	**VQ**	**Result**	**VQ**	**Result**	**VQ**
Metals								
Aluminum	mg/kg	*17,700*	12,000	J	12,500		9,760	
Antimony	mg/kg	*0.96*	**1.1**		**1.8**		**1.5**	
Calcium	mg/kg	*15,800*	444		183		313	
Iron	mg/kg	*23,100*	**35,200**	**J**	**23,600**		15,500	
Lead	mg/kg	*26.1*	17.9		15.4		14.6	
Magnesium	mg/kg	*3,030*	1,940		1,650		1,540	
Manganese	mg/kg	*1,450*	543	J	792		1,040	
Explosives and Propellants								
1,3,5-Trinitrobenzene	mg/kg	*NA*	<0.25	U	<0.25	U	<0.25	U
1,3-Dinitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
2,4,6-Trinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
2,4-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	<0.25	U
2,6-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
3,5-Dinitroaniline	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U

Analyte	Units	Location ID:	BDISS-001		BDISS-003		BDISS-004	
		Sample ID:	BDISS-001(I)-0001-SS		BDISS-003(I)-0001-SS		BDISS-004(I)-0001-SS	
		Sample Date:	22-Aug-11		22-Aug-11		22-Aug-11	
		Depth (feet bgs):	0–0.5		0–0.5		0–0.5	
		BSV[1]	Result	VQ	Result	VQ	Result	VQ
4-Amino-2,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
HMX	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
m-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
Nitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
Nitroglycerin	mg/kg	*NA*	<1	U	<1	U	<1	U
Nitroguanidine	mg/kg	*NA*	**0.52**	J	<0.125	U	**0.29**	
o-Nitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U	<0.25	U
PETN	mg/kg	*NA*	<1	U	<1	U	<1	U
p-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
RDX	mg/kg	*NA*	<0.25	U	<0.25	U	<0.25	U
Tetryl	mg/kg	*NA*	<0.2	U	<0.2	U	<0.2	U
General Chemistry								
Nitrocellulose	mg/kg	*NA*	<50	U	<50	U	<50	U
Total organic carbon	mg/kg	*NA*	19,000		16,000		28,000	
pH	S.U.	*NA*	5.33		5.23		5.13	
Percent Solids	%	*NA*	98.6		98.2		98.4	

Table 4-3 (continued)
Summary of ISM Surface Soil Results

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).
For metals bold numbering indicates concentration is greater than the RVAAP background value. For organics, bold numbering indicates a detected value.
< denotes less than.
bgs denotes below ground surface.
BSV denotes background screening value.
ID denotes identification.
mg/kg denotes milligrams per kilogram.
NA denotes that a BSV is not available.
S.U. denotes standard unit.
VQ denotes validation qualifier.

Validation Qualifier:
J denotes the result is reported as an estimated value.
U denotes result is not detected or the concentration is below the detection limit.

Table 4-4
Summary of Discrete Surface Soil Results

Analyte	Units	Location ID:	BDISS-005		BDISS-006	
		Sample ID:	BDISS-005(D)-0001-SS		BDISS-006(D)-0001-SS	
		Sample Date:	22-Aug-11		22-Aug-11	
		Depth (feet bgs):	0.33–0.83		0.25–0.75	
		BSV[1]	Result	VQ	Result	VQ
Metals						
Aluminum	mg/kg	*17,700*	5,920		5,700	
Antimony	mg/kg	*0.96*	0.49	U	0.455	U
Calcium	mg/kg	*15,800*	141		106	
Iron	mg/kg	*23,100*	9,660		9,550	
Lead	mg/kg	*26.1*	8.6		8	
Magnesium	mg/kg	*3,030*	1,050		998	
Manganese	mg/kg	*1,450*	334		320	
Explosives and Propellants						
1,3,5-Trinitrobenzene	mg/kg	*NA*	<0.25	U	<0.25	U
1,3-Dinitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U
2,4,6-Trinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U
2,4-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U
2,6-Dinitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U
2-Amino-4,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U
3,5-Dinitroaniline	mg/kg	*NA*	<0.2	U	<0.2	U

Analyte	Units	Location ID:	BDISS-005		BDISS-006	
		Sample ID:	BDISS-005(D)-0001-SS		BDISS-006(D)-0001-SS	
		Sample Date:	22-Aug-11		22-Aug-11	
		Depth (feet bgs):	0.33–0.83		0.25–0.75	
		BSV[1]	Result	VQ	Result	VQ
4-Amino-2,6-Dinitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U
HMX	mg/kg	*NA*	<0.2	U	<0.2	U
m-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U
Nitrobenzene	mg/kg	*NA*	<0.2	U	<0.2	U
Nitroglycerin	mg/kg	*NA*	<1	U	<1	U
Nitroguanidine	mg/kg	*NA*	**0.18**		**0.14**	
o-Nitrotoluene	mg/kg	*NA*	<0.25	U	<0.25	U
PETN	mg/kg	*NA*	<1	U	<1	U
p-Nitrotoluene	mg/kg	*NA*	<0.2	U	<0.2	U
RDX	mg/kg	*NA*	<0.25	U	<0.25	U
Tetryl	mg/kg	*NA*	<0.2	U	<0.2	U
General Chemistry						
Nitrocellulose	mg/kg	*NA*	<50	U	<50	U
Total organic carbon	mg/kg	*NA*	16,000		12,000	
pH	S.U.	*NA*	4.82		5.13	
Percent Solids	%	*NA*	81.5		88.2	

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

[1] Background values as presented in the Final Facility-Wide Human Health Cleanup Goals at the RVAAP, Ravenna, Ohio (SAIC, 2010).
For metals bold numbering indicates concentration is greater than the RVAAP background value. For organics, bold numbering indicates a detected value.
< denotes less than.
bgs denotes below ground surface.
BSV denotes background screening value.
ID denotes identification.
mg/kg denotes milligrams per kilogram.
NA denotes that a BSV is not available.
S.U. denotes standard unit.
VQ denotes validation qualifier.

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

Table 4-5
SRC Screening Summary for the Block D Igloo Investigation Area ISM Surface Soil Samples (0 to 0.5 feet bgs)

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV (mg/kg)	SRC?	SRC Justification
			Result (mg/kg)	VQ	Result (mg/kg)	VQ				
Explosives and Propellants										
Nitroguanidine	556-88-7	2/3	0.29		0.52	J	0.31	---	No	Not an MC
Metals										
Aluminum	7429-90-5	3/3	9,760		12,500		11,420	77,700	No	Below BSV
Antimony	7440-36-0	3/3	1.1		1.8		1.5	0.96	Yes	Above BSV
Iron	7439-89-6	3/3	15,500		35,200	J	24,766.7	23,100	Yes	Above BSV
Lead	7439-92-1	3/3	14.6		17.9		16.0	26.1	No	Below BSV

--- denotes not available.
BSV denotes background screening value.
CAS denotes Chemical Abstracts Service.
J denotes reported result is an estimated value.
MC denotes munitions constituents associated with an M-41 20 lb fragmentation bomb.
mg/kg denotes milligrams per kilogram.
SRC denotes site-related chemical.
VQ denotes validation qualifier.

Validation Qualifier:
J denotes the result is reported as an estimated value.

Table 4-6
SRC Screening Summary for the Block D Igloo Investigation Area Discrete Surface Soil Samples (0.25 to 0.83 feet bgs)

Analyte	CAS Number	Frequency of Detection	Minimum Detect		Maximum Detect		Mean Result (mg/kg)	BSV (mg/kg)	SRC?	SRC Justification
			Results (mg/kg)	VQ	Result (mg/kg)	VQ				
Nitroguanidine	556-88-7	2/2	0.14		0.18		0.16	---	No	Not an MC
Aluminum	7429-90-5	2/2	5,700		5,920		5,810	77,700	No	Below BSV
Antimony	7440-36-0	0/2	---		---		---	0.96	No	Below BSV
Iron	7439-89-6	2/2	9,550		9,660		9,605	23,100	No	Below BSV
Lead	7439-92-1	2/2	8.0		8.6		8.3	26.1	No	Below BSV

--- denotes not available.

BSV denotes background screening value.

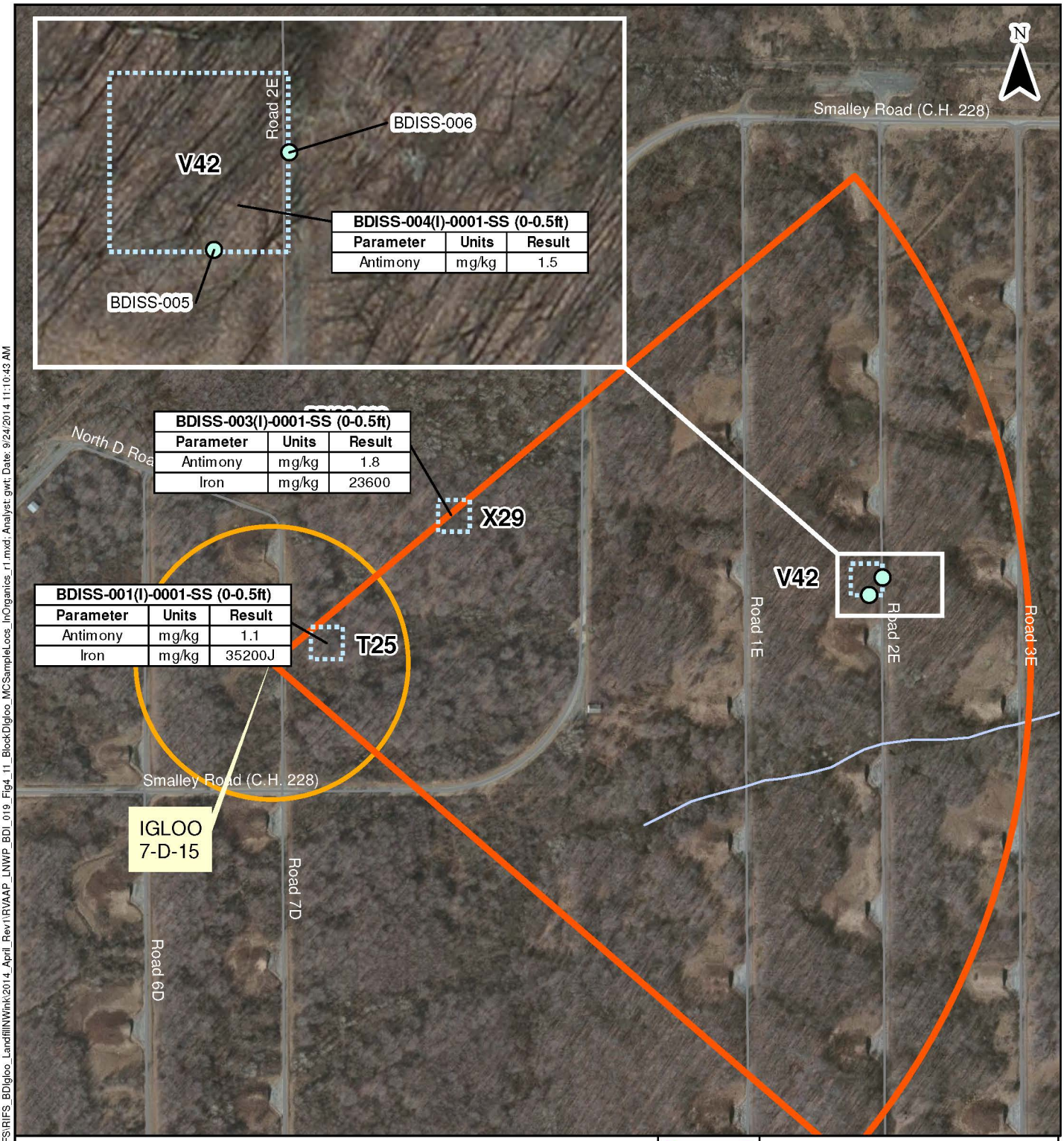
CAS denotes Chemical Abstracts Service.

MC denotes munitions constituents associated with an M-41 20 lb fragmentation bomb.

mg/kg denotes milligrams per kilogram.

SRC denotes site-related chemical.

VQ denotes validation qualifier.



Block D Igloo MRS Boundary at Conclusion of 2007 SI

Block D Igloo Investigation Area

ISM Soil Sample Location

Discrete Soil Sample Location

Stream

Notes:
1) mg/kg = milligrams per kilogram
2) J = the reported result is an estimated concentration
3) ft = foot

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MAMMS\Ravenna\GIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink\2014_April_Rev1\RVAAP_LNWP_BDI_019_Fig4_11_BlockDIgloo_MCSampleLocs_InOrganics_r1.mxd: Analyst: gwt: Date: 9/24/2014 11:10:43 AM

FIGURE 4-11 SRCS IN SURFACE SOIL, BLOCK D IGLOO INVESTIGATION AREA

All data from the previous investigation performed at the MRS during the 2007 SI field activities were evaluated, and it was determined that there was no applicable data to be incorporated into the RI data set as discussed in Section 2.4, "Data Incorporated into the RI." Therefore, only the samples collected during the RI field effort were screened for SRCs and carried forward into the risk assessment for human health and ecological receptors.

4.3 Nature and Extent of SRCs

This section presents a summary of the nature and extent of SRCs identified in the ISM and discrete surface soil samples collected during the RI field activities at the Block D Igloo Investigation Area following the facility data evaluation process.

4.3.1 Explosives and Propellants

The propellant nitroguanidine was analyzed in the analytical suite for explosives and was detected at two of the three ISM sampling unit locations and at both discrete sample locations. The maximum concentration detected in the ISM soil samples was 0.52 J milligrams per kilogram (mg/kg) at sampling unit location BDISS-001. The "J"-flagged data are estimated, are considered as the approximate concentration in the samples, and are retained as detected values. This sample was collected at Grid T25, which is located 100 feet east of the former igloo and is the closest grid to the former igloo out of the three sampling units. The discrete sample with the highest nitroguanidine result (0.18 mg/kg) was at sample location BDISS-005 that was collected beneath the M-41 20 lb bomb fragment found in Grid T42. This grid is located approximately 1,800 feet from the former igloo.

The explosive filler in the M-41 20 lb fragmentation bomb consisted of 2,4,6-trinitrotoluene, and the M-110 fuze was a tetryl booster. Nitroguanidine is used as an explosive propellant in triple-base propellant that was not used in the manufacture of the 20 lb bomb. Therefore, the detected nitroguanidine is not an MC associated with the M-41 20 lb fragmentation bomb and is removed from further considered as an SRC at the Block D Igloo Investigation Area. Munitions data sheets associated with the M-41 20 lb fragmentation bomb are presented in **Appendix K**.

4.3.2 Metals

The four MEC metals, aluminum, antimony, iron, and lead, were detected at all three ISM sampling unit locations. Antimony exceeded the BSV of 0.96 mg/kg in all ISM samples. The maximum antimony concentration (1.8 mg/kg) detected was at sampling unit location BDISS-003 collected from Grid X29, located approximately 675 feet northeast of the former igloo footprint. Iron concentrations exceeded the BSV of 23,100 mg/kg at sampling unit locations BDISS-001 and BDISS-003. The maximum iron concentration (35,200 J mg/kg) was estimated and was detected at sampling unit location BDISS-001 collected at Grid T25, located approximately 150 feet northeast of the former igloo footprint. Since the

concentrations for antimony and iron exceeded their respective BSVs, they were retained as SRCs for further evaluation.

Aluminum, iron, and lead were detected in the discrete surface samples collected below the MEC items in Grid V42. This grid is located approximately 1,800 feet east of the former igloo footprint. None of the inorganic concentrations in the discrete samples exceeded the BSVs and no SRCs were identified in the discrete surface soil samples.

4.3.3 Summary of MC Data Evaluation

A total of two inorganic SRCs were identified in surface soils collected at the Block D Igloo Investigation Area. These SRCs include antimony and iron and were identified in the ISM samples only that were collected at a maximum depth of 0.5 feet (6 inches) bgs. Nitroguanidine was detected at two of the three ISM sampling unit locations and at both discrete sample locations, but is not an MC associated with the M-41 20 lb fragmentation bomb and is removed from further considered as an SRC at the Block D Igloo Investigation Area.

5.0 FATE AND TRANSPORT

This section describes the fate of chemicals detected 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 of MEC and/or MC to the environment. Contaminant transport refers to migration mechanisms of MEC and/or MC away from the MEC source area or the location where MC was deposited as a result of low-order detonation. Section 5.1 and Section 5.2 discuss fate and transport associated with MEC and MC, respectively.

5.1 Fate and Transport of MEC

No MEC was found during the visual surveys performed at the Landfill North of Winklepeck MRS; therefore, evaluation for fate and transport of MEC is not considered further for this MRS. MEC was found in the subsurface soils at the Block D Igloo Investigation Area during the intrusive investigation activities. Thus, the following discussion regarding fate and transport of MEC is applicable for the Block D Igloo Investigation Area.

Transport of MEC is generally not anticipated to be significant at an MRS containing MEC; however, the facility does receive significant precipitation due to snowfall accumulations and heavy seasonal rainfall events that can result in 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 Block D Igloo Investigation Area. Significant overland migration from a source area is not expected since the facility has very little difficulty with erosion because slope is 5 percent or less (AMEC, 2008). In addition, the investigation area is heavily forested, which most likely mitigates the potential to be impacted by the aforementioned natural processes.

Human activities may also result in subsurface MEC becoming exposed to the surface. On land, these may include construction activities that involved excavation or recontouring land. As future land use at the Block D Igloo Investigation Area is military training, these activities could expose subsurface MEC that was not previously identified. The result of the action 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. Locations where MEC may be redistributed as a result of human activities become the points of potential direct contact exposure to people engaged in various future land use activities.

In addition, weather and climate will play an important role in the life of the MEC material and degradation rate. MEC items that may be present at the MRS may corrode or degrade based on weather and climate conditions and thereby release harmful MC into the

environment that may affect the soil and water or pose a threat to health and safety from MC. At the Block D Igloo Investigation Area, the MEC 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 released from MEC enters an environmental medium, the fate and transport of MC are dependent on a wide variety of factors. Migration pathways often include air, water, soil, and the interfaces between the phases of the contaminant (i.e., solid, liquid, or gas). The fate and transport of 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.

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 SRC Sources

This section presents a discussion of the detected SRCs in the environmental media at the Block D Igloo Investigation Area. Analytes identified as SRCs at the Block D Igloo Investigation Area include the metals antimony and iron that are considered chemical constituents associated with the M-41 20 lb fragmentation bomb, as is presented in the munitions data sheets in **Appendix K**. These SRCs were identified in surface soil only at a maximum depth of 0.5 feet (6 inches) bgs. No investigation of soils greater than 10 inches bgs, sediment, surface water, or groundwater was conducted during the RI. The physical and chemical properties and potential release mechanisms and routes of migration for each of these SRCs are discussed below.

- **Antimony—**The primer located in the fuse of the M-41 20 lb fragmentation bomb contained small quantities of antimony sulfide (**Appendix K**). Antimony is also alloyed with lead and tin to improve the properties of the alloys that are used in munitions; therefore, antimony may be present in low concentrations in the metallic components of M-41 20 lb fragmentation bombs that accidentally detonated at Igloo 7-D-15. Antimony's 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 aerobic surface soils, oxidation generally occurs (Agency for Toxic Substances and Disease Registry, 1992). In water, antimony has the capability to undergo photochemical reactions. However, these reactions do not appear to have a significant effect on its aquatic fate (Callahan et al., 1979).
- **Iron—**Iron is typically used in the case composition of munitions made from steel. For the M-41 20 lb fragmentation bomb, iron would most likely have been used in the manufacture of the fragmentation shell casing (**Appendix K**). The oxidation/reduction (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 reduced species of anions such as sulfide. The precipitation of iron sulfide minerals limits the mobility of ferrous iron; however, if conditions become oxidizing, the precipitated ferrous iron is released and may be subject to reprecipitation (as ferric iron oxides or hydroxides) (Kabata-Pendias, 2001).

5.2.2 Summary of Fate and Transport of MC

Based on the current soil conditions at the Block D Igloo Investigation Area, which consist primarily of silty clay loam with low permeability and moderate pH of approximately 5.2, it is expected that iron and antimony associated with the M-41 20 lb fragmentation bombs that accidentally detonated at Igloo 7-D-15 would tend to bind to the soil and are considered relatively immobile. In addition, iron is a major element that is naturally occurring in soils, present as iron oxide minerals, and is incorporated in the structure of other minerals. Since antimony and iron are naturally occurring, it is expected that these elements would be found throughout the soil horizon and that only additional antimony and iron deposited as a result of the accidental explosion would be present in the top several inches.

One of the principal migration pathways at the Block D Igloo Investigation Area may be infiltration through the unsaturated soil to groundwater. The approximate depth to groundwater in the unconsolidated aquifer at the Block D Igloo Investigation Area is 10 feet bgs (EQM, 2012). The soil type at the Block D Igloo Investigation Area consists primarily of the Mahoning silt loam and the undulating Mahoning Urban land complex that are somewhat poorly drained to moderately well-drained (USDA et al, 1978). Based on the local topography, some of the precipitation falling as rainfall and snow likely leaves the investigation area as surface runoff to the wetlands and unnamed streams that drain towards Sand Creek. The precipitation that does not leave the investigation area 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 investigation area. Based on the aforementioned soil conditions and that antimony and iron are expected to remain in the top several inches of soil where they were deposited, subsurface soils or groundwater conditions have most likely not be impacted.

6.0 MEC HAZARD ASSESSMENT

This section presents an evaluation of the MEC hazards that may be associated with an MRS in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008). 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; however, cleanup scenarios are not usually addressed in an RI. The MEC HA was developed through a collaborative, consensus approach to promote consistent evaluation of potential explosive hazards at MRSs (EPA, 2008). The MEC HA methodology addresses human health and safety concerns associated with the 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. The Landfill North of Winklepeck MRS was an unlined landfill that may have received MEC during disposal operations. Facility personnel also reported that MEC was present on the slope leading down to the unnamed tributary (e^2M, 2007). No MEC was found during the 2007 SI or during complete coverage of the land-based areas at the MRS during the RI field activities. The results of the RI indicate that no MEC source or explosive safety hazard is present at the MRS; therefore, calculation of a MEC HA was not warranted for the Landfill North of Winklepeck MRS.

MEC was identified at the Block D Igloo Investigation Area during the RI field activities. The presence of MEC represents a potential explosive safety hazard; therefore, an evaluation of the MEC HA was conducted for the investigation area (EPA, 2008).

6.1 Components of the MEC HA

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 hazard levels. For the RI, hazard levels are generated for the current and future land use activities only, since remediation alternatives have not been generated for the investigation area at this time. **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 Methodology Hazard Levels

Hazard Level	Maximum MEC HA Score	Minimum MEC HA Score	Description
1	1,000	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.

Descriptions for each of the three MEC HA components (severity, accessibility, and sensitivity) and the required input factors that are evaluated to determine the hazard levels for the current and future activities at the Block D Igloo Investigation Area are presented below:

- **Severity—**This component is defined in the MEC HA guidance (EPA, 2008) 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 investigation area. 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.
- **Accessibility**—The accessibility component is defined in the MEC HA guidance (EPA, 2008) 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 investigation area.
    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 investigation area 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 investigation area. This input factor is assessed by determining the type of munitions activities that took place at the investigation area (some of the categories are target area, open burning/open detonation, 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).

- **Sensitivity**—The sensitivity component is defined in the MEC HA guidance (EPA, 2008) 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).

The MEC HA workbook for the Block D Igloo Investigation Area that evaluates the aforementioned components and input factors to generate hazard levels for the current and future activities is presented in **Appendix L**. The following sections discuss the individual components that comprise the MEC HA and provide rationale for the input factors chosen.

6.2 Severity

The two input factors for the "severity" component of the MEC HA, *Energetic Material Type* and *Location of Human Receptors*, are presented below for the Block D Igloo Investigation Area.

6.2.1 Energetic Material Type

The presence of HE-filled bombs (M-41 20 lb fragmentation bombs) was confirmed during the field activities at the Block D Igloo Investigation Area. Based on this information; the input factor for the "energetic material type" is determined to be "High Explosives." This input would not change for a future use scenario.

6.2.2 Location of Human Receptors

Unintentional detonation of a MEC item could result in injury or death to the individual initiating the detonation and 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) arc. The ESQD arc was determined to be 1,634 feet based on the calculated MFD-H for the M-41 20 lb fragmentation bomb (**Figure 6-1**).

Under current conditions, there are no specific areas within the ESQD arc where facility personnel/trespassers would congregate; however, current activities within the Block D Igloo Investigation Area do include military training. These areas within the investigation area will continue to be used for training activities in the future and may include the construction of military complexes for ranges and multipurpose training areas that will likely increase or change the location of human receptors. Therefore, there is the potential for human receptors to be located within the investigation area or the ESQD arc.

6.3 Accessibility

The five input factors for "accessibility" component of the MEC HA (Site Accessibility, Potential Contact Hours, Amount of MEC, Minimum MEC Depth Relative to the Maximum Receptor Intrusive Depth, and Migration Potential) are presented below for the Block D Igloo Investigation Area.

6.3.1 Site Accessibility

The 92.14-acre Investigation Area is located in the northern portion of the facility and is within the installation fence line. However, once on the facility property, there are no additional barriers preventing access to the investigation area. The input factor for "site accessibility" is determined to be "full accessibility," which indicates that there are few or no physical barriers to entry. This input would not change for the future land use scenario.

6.3.2 Potential Contact Hours

The areas where MEC associated with the former Igloo 7-D-15 accidental explosion is present are available to facility personnel, contractors, and potential trespassers. The following types of activities, receptors, and hours were assumed for current use activities at the investigation area and were based on input provided by the USACE and the OHARNG during the preparation of this RI Report:

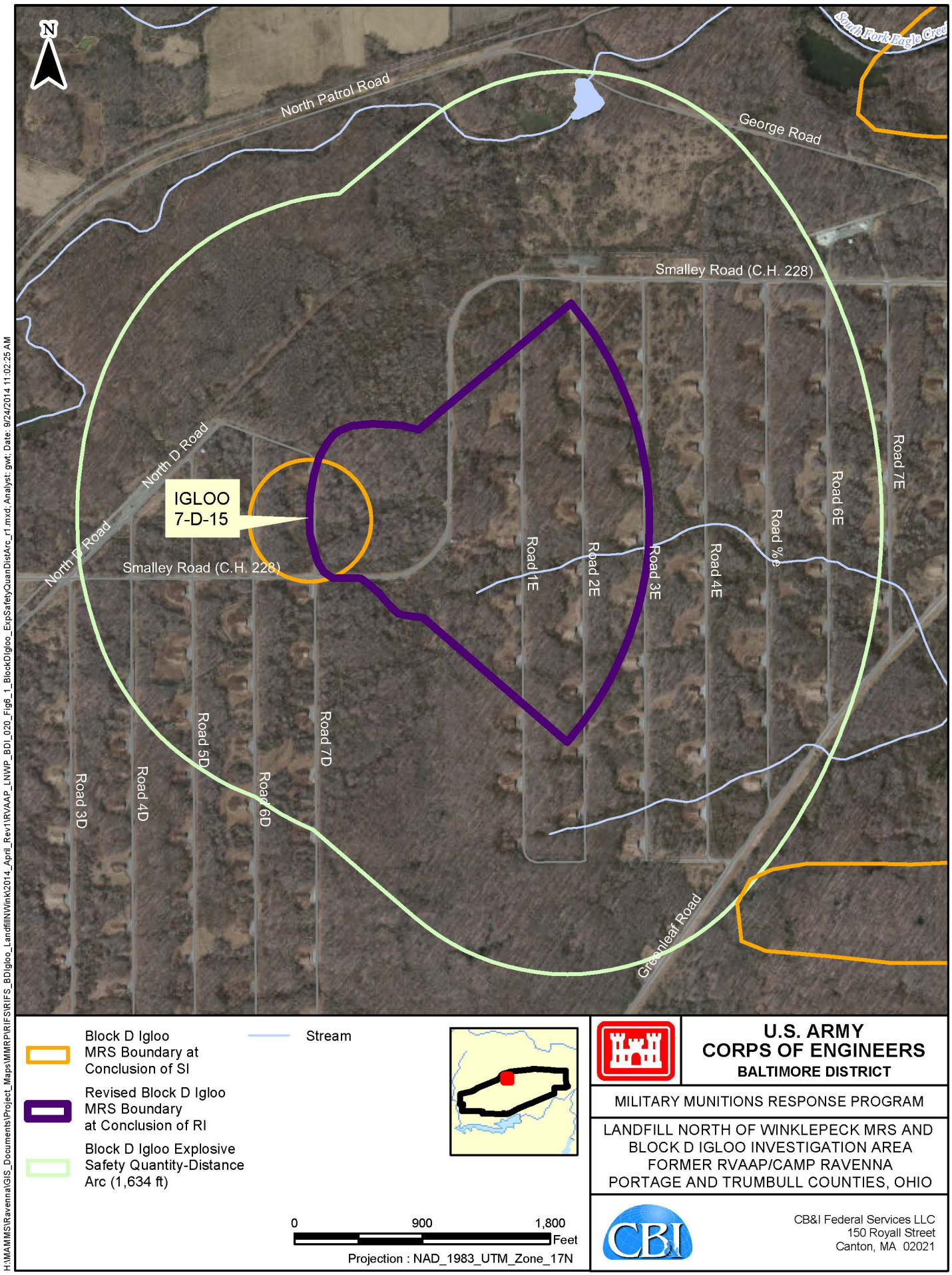


FIGURE 6-1 EXPLOSIVE SAFETY QUANTITY-DISTANCE ARC, BLOCK D IGLOO INVESTIGATION AREA

- National Guard Trainee—20 people per year × 28 days per year × 24 hours per day = 13,440 receptor hours per year
- Security Guard/Maintenance Worker—1 hour per day × 250 days per year = 250 receptor hours per year
- Natural Resources Management—2 people per year × 1 hour per week × 52 weeks = 104 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 investigation area were also calculated, and the following types of activities, receptors, and hours were developed with the USACE and the OHARNG:

- National Guard Trainee—276 people per year × 39 days per person × 24 hours per day = 258,336 receptor hours per year
- Range Maintenance Soldier—3 people per year × 85 days per person × 6 hours per day = 1,530 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 per year)
2. Some hours (100,000 to 999,999 receptor hours per year)
3. Few hours (10,000 to 99,999 receptor hours per year)
4. Very few hours (less than 10,000 receptor hours per 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 14,044 resulting in a category of “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 15 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 land use scenario, the number of receptor hours per year increases to 259,866 and the resulting category would increase to “some hours” and is the category used in the MEC HA scoring.

6.3.3 Amount of MEC

The amount of MEC input factor has nine categories to classify an MRS as follows:

1. Target Area

2. Open Burn/Open Detonation Areas
3. Function Test Range
4. Burial Pit
5. Maneuver Areas
6. Firing Points
7. Safety Buffer Areas
8. Storage
9. Explosives-related Industrial Facility

The MEC source at the Block D Igloo Investigation Area (accidental explosion) does not specifically fall into any of these categories; however, each category was evaluated and the category that best represented the MEC source was selected. Igloos within the Block D Igloo Investigation Area were used for munitions storage; therefore, "Storage" was selected as the most appropriate category for the MEC HA. "Storage" is defined as "any facility used for the storage of military munitions, such as earth-covered magazines, above-ground magazines, and open-air storage areas" (EPA, 2008).

6.3.4 Minimum MEC Depth Relative to Maximum Receptor Intrusive Depth

MEC items were found in subsurface soil at a maximum depth of 0.5 feet bgs during the RI field activities. Based on the RI findings, the minimum depth of munitions was assumed to be 0 feet bgs, since there is a potential for MEC to be present in the surface and subsurface soil.

Intrusive activities are not currently restricted at the investigation area and intrusive activities may occur at the investigation area for the future land use. The maximum depth associated with the future land use receptors is disturbance to 7 feet bgs (SAIC, 2010). Because the shallowest minimum MEC depth is less than or equal to the deepest intrusive depth, the intrusive depth overlaps. Therefore, the category for this input factor is "Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC." For future activities, the shallowest minimum MEC depth is less than or equal to the deepest intrusive depth, the intrusive depth overlaps. Therefore, the category for this input factor is "Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC." Only baseline conditions are considered for current and future land use activities.

6.3.5 Migration Potential

The Investigation Area is potentially susceptible to frost heave due to seasonally wet soil and poor drainage associated with the soil types; however, the facility has very little difficulty with erosion since slope is 5 percent or less (AMEC, 2008). In addition, the investigation area is located in a heavily forested location at the facility. Therefore, although vertical migration of MEC in the soil may occur, significant migration once on the ground surface is considered to be minimal.

6.4 Sensitivity

The two input factors for the "sensitivity" component of the MEC HA, *MEC Classification* and *MEC Size*, are presented below for the Block D Igloo Investigation Area.

6.4.1 MEC Classification

The MEC HA guidance 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

The category selected for the MEC classification was "Fuzed DMM." The term "DMM" per 10 USC 2710(e)(2) is defined as "military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations." This is supported by the presence of only unarmed munitions in the Block D Igloo Investigation Area. This input would not change for the future land use scenario.

6.4.2 MEC Size

The MEC HA indicates that if "any of the items" weigh less than 90 lbs, then the category "small" must be used as the input. The subject fragmentation bombs that accidentally detonated at Igloo 7-D-15 weighed 20 lbs each and the category used in the MEC HA was "small."

6.5 MEC HA Results

The input factors for the components that comprise the MEC HA were discussed in this section and an explosive hazard level determination has been generated for both the current and future land use activities at the Block D Igloo Investigation Area. The MEC HA workbook is an automatically generated report that provides the calculated explosive hazard level determinations based on the inputs discussed in this section and is presented in **Appendix L.**

Based on current conditions and land use at the investigation area, evaluation of the MEC HA resulted in a score of 640. This equates with a Hazard Level of 3 (moderate potential explosive hazard condition).

Evaluation of the MEC HA for the investigation area based on the future land use resulted in a score of 670. Similar to the MEC HA score based on current land use, the MEC HA score based on future land use equates with a Hazard Level of 3 (moderate potential explosive hazard condition). The slight increase in the MEC HA score is solely the result of the increase in the receptors hours for the future land use scenario.

This page intentionally left blank.

7.0 HUMAN HEALTH RISK ASSESSMENT

This section discusses the HHRA approach and conclusions for the SRCs detected in environmental samples collected at the Block D Igloo Investigation Area. No MEC was observed at the Landfill North of Winklepeck MRS during the RI visual survey, and further investigation for MC was not warranted. An HHRA was not required for this MRS and no further discussion regarding evaluation for human health risk at the Landfill North of Winklepeck MRS is presented in this section.

The purpose of this HHRA is to document whether the SRCs detected at the Block D Igloo Investigation Area pose risks to current or future human receptors and to identify which, if any, conditions at the investigation area need to be addressed further in the CERCLA process. This HHRA has been prepared in accordance with the Work Plan (Shaw, 2011) using the streamlined approach to risk decision-making, as described in the FWCUG Guidance (SAIC, 2010). The Position Paper (USACE, 2012) describes the applicability and use of the final FWCUGs in the following steps:

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

This HHRA was initiated before the finalization of the U.S. Army's 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 Block D Igloo Investigation Area during the RI field activities.

7.1 Data Used in the HHRA

The MC investigation for the RI was based on the results of the MEC evaluation. Surface soil samples were collected at three sampling units at 0–0.5 feet bgs using the ISM. Two

discrete samples were collected at a 0.5-foot interval beneath the anomaly excavations where MEC items were identified. The maximum depth of the discrete samples was 0.83 feet (10 inches) bgs. The ISM soil samples were collected in 100-square-foot sampling units at the mag and dig grids where MD was well distributed on the ground surface and in subsurface soils. Discrete samples were collected beneath individual MEC items identified during the intrusive investigation activities. Samples included in the HHRA data set are identified in **Table 7-1**.

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

Sample Location ID	Sample Location ID	Date	Depth (feet bgs)	Sample Type	Analysis
BDISS-001	BDISS-001(I)-0001-SS	8/22/11	0–0.5	ISM	Metals[1] Explosives Nitrocellulose TOC pH
BDISS-003	BDISS-003(I)-0001-SS	8/22/11	0–0.5	ISM	
BDISS-004	BDISS-004(I)-0001-SS	8/22/11	0–0.5	ISM	
BDISS-005	BDISS-005(D)-0001-SS	8/22/11	0.33–0.83	D	
BDISS-006	BDISS-006(D)-0001-SS	8/22/11	0.25–0.75	D	

[1] *Metals include analysis for aluminum, iron, lead, and antimony.*

bgs denotes below ground surface.

D denotes discrete.

ID denotes identification.

ISM denotes incremental sampling method.

MEC denotes munitions and explosives of concern.

TOC denotes total organic carbon.

7.2 Human Receptors and Exposure Scenarios

The future land use for the Block D Igloo Investigation Area is military training, and the OHARNG receptors are the National Guard Trainee and the Range Maintenance Soldier. The OHARNG receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005).

The facility has defined exposure depths scenarios for the identified receptors. They are presented in the FWCUG Guidance (SAIC, 2010); however the defined exposure depths may not necessarily correlate to the actual sample depths collected at the investigation area during the RI field activities. Sampling for MC under the MMRP is selective in general to evaluate identified munitions-related source areas and the potential that MC may have been released from the source areas. The data used in the HHRA is used to evaluate for the receptors at the

depths that the samples were collected; however, the data is not intended to evaluate for predefined exposure depth scenarios, as is typically performed under the IRP. The standard approach for investigating sites under the MMRP is, to a certain degree, adapted to address MEC; however, the HHRA is valuable in identifying potential releases of MC from the source areas and if the MC poses risks to likely human receptors (U.S. Army, 2009).

At the facility, surface soil for the Resident Receptor (Adult and Child) is defined as 0 to 1 foot bgs, and surface soil for the OHARNG receptors is 0 to 4 feet bgs (SAIC, 2010). For the RI field activities, the ISM surface soil samples were collected at three sampling units at 0 to 0.5 feet bgs, the surface soil decision unit. Additionally, two discrete surface soil samples were collected at 0.5-foot (6 inches) beneath MEC items that were encountered within the sampling units. The surface soil decision unit is the portion of the investigation area in which a decision regarding MC will be made and is the EU for the evaluation of the human receptors in surface soil at the investigation area as well. The sample data for the surface soil EU is considered suitable for comparison against the established facility HHRA screening criteria (SAIC, 2010).

The ISM and discrete surface soil samples were collected at 0.5-foot (6-inch) increments, since this is the depth that MC associated with any MEC or MD on the ground surface or buried would be expected to vertically migrate from the source in the soil column. This sampling methodology is consistent with the sampling depths for MC as recommended in the *Military Munitions Response Program, Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009). Therefore, for the RI, surface soil for the Resident Receptor (Adult and Child) and the OHARNG receptors are evaluated as 0 to 10 inches, the range of the sample depths that the ISM and discrete surface soil samples were collected at the investigation area.

7.3 COPC Identification

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

Two inorganic SRCs were identified in surface soils collected at the Block D Igloo Investigation Area. These SRCs include antimony and iron and were identified in the ISM samples only that were collected at a maximum depth of 0.5 feet (6 inches) bgs. To establish COPCs, all SRCs that have not been eliminated to this point were evaluated using the following steps:

- The final FWCUGs developed for the Resident Receptor (Adult and Child) and the National Guard Trainee for each chemical were used. If there are no final FWCUGs developed for a particular chemical, then the RSLs for residential exposure (EPA, 2012) were used. If neither a final FWCUG nor an RSL is available, then a cleanup goal can be developed in concurrence with the USACE and the Ohio EPA. The final FWCUGs or RSLs were available for all chemicals not previously eliminated. The final FWCUGs are currently presented in the FWCUG Guidance (SAIC, 2010).
- The final FWCUGs at the 1×10^{-6} (one in a million) excess cancer risk level and noncarcinogenic risk HQ using the 0.1 risk value for each of the receptors will be selected.
- A comparison of the selected final FWCUG to the exposure point concentration (EPC) will be completed. The EPCs for the Block D Igloo Investigation Area data are the maximum detected concentration, since the number of samples does not allow statistical representation.
- The chemical is retained as a COPC if the EPC exceeds the most stringent risk value for the Resident Receptor (Adult and Child) or the National Guard Trainee for either one of the 1×10^{-6} excess carcinogenic values, and the noncarcinogenic HQ using the 0.1 risk value.

The Work Plan (Shaw, 2011) specifies that in addition to screening the final FWCUGs for the Resident Receptor (Adult and Child) and the National Guard Trainee, evaluation will also be made against the remaining OHARNG receptors in order to ensure that the most stringent receptor is identified. For the chemicals detected at the Block D Igloo Investigation Area, the final FWCUGs for the Resident Receptor (Adult and Child) or National Guard Trainee FWCUGs were lower 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 E**.

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

	Range of Values, mg/kg											
	Detected Concentrations				Reporting Limits							
Site-Related Chemical	Minimum	VQ	Maximum	VQ	Minimum	Maximum	Location of MDC	R(A) FWCUG[1] (mg/kg)	R(C) FWCUG[1] (mg/kg)	NGT FWCUG[1] (mg/kg)	COPC?	COPC Justification
Antimony	1.1		1.8		0.81	0.98	BDISS-003(I)-0001-SS	13.6	2.82	175	No	Below risk screening criteria
Iron	15,550		35,200	J	1.8	18	BDISS-001(I)-0001-SS	19,010	2,313	184,370	Yes	Above risk screening criteria

[1] FWCUG is lower of noncarcinogenic FWCUG at HQ of 0.1 and carcinogenic FWCUG at risk of 10^{-6}. All FWCUGs shown are based on noncancer hazard, as none are considered carcinogens.
bgs denotes below ground surface.
COPC denotes chemical of potential concern.
FWCUG denotes Facility-Wide Cleanup Goal per the Final Facility-Wide Human Health Cleanup Goals for the RVAAP (SAIC, 2010).
HQ denotes hazard quotient.
MDC denotes maximum detected concentration.
mg/kg denotes milligrams per kilogram.
NGT denotes National Guard Trainee.
R(A) denotes Resident Receptor (Adult).
R(C) denotes Resident Receptor (Child).
SAIC denotes Science Applications International Corporation.
VQ denotes validation qualifier.

Validation Qualifier:
J denotes the reported result is an estimated value.

This page intentionally left blank.

Table 7-2 presents 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). This table includes the final FWCUGs that are based on the lower of the 1×10^{-6} (one in a million) excess cancer risk level and an HQ of 0.1 for noncancer effect values. If a chemical was detected for which there was no final FWCUG, the RSLs for residential exposure in soils (EPA, 2012) would be used; however, final FWCUGs were available for both SRCs and inclusion of the RSLs were not necessary.

COPC Evaluation in Surface Soil

The COPCs are identified by comparing the maximum detected concentrations to the applicable screening criteria. The SRCs for which the maximum detected concentration is greater than the lowest final FWCUG, or the RSL if no final FWCUGs are available, are considered COPCs. Iron was the only SRC identified as a COPC in surface soil for the Resident Receptor (Adult and Child). No SRCs were identified as COPCs for the National Guard Trainee.

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 7.3 and are typically chemicals that should be addressed in the FS following the RI. The determination of COCs was conducted in accordance with the Position Paper (USACE, 2012) as follows:

- Select final FWCUG values for the Resident Receptor (Adult and Child) as well as the OHARNG receptors evaluated in the HHRA. The OHARNG receptors for the Block D Igloo MRS are the National Guard Trainee and Range Maintenance Soldier.
- The final FWCUGs are selected using the 1×10^{-5} (one in one hundred thousand) excess cancer risk value and HQ of 1 for noncancer hazard. Critical effects and target organs are provided from noncancer hazard values.
- A comparison of the final FWCUGs to the EPC was conducted. The EPC for iron was the maximum detected concentration.
- For carcinogens and noncarcinogens, the EPCs were compared to the target risk final FWCUGs using the Sum of Ratios approach 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 Adult Resident Receptor or the Child Resident Receptor that are evaluated for Unrestricted land Use, or the OHARNG receptors evaluated

for the Military Training land Use, considering the 1×10^{-5} (one in one hundred thousand) carcinogenic value and the noncarcinogenic risk value termed HQ using the 1.0 risk value, and/or (2) the sum of ratios for all carcinogens or all noncarcinogens that may affect the same organ is greater than 1, and the chemical contributes 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. Since iron was identified as the only COPC in surface soil, consideration of exposure to multiple chemicals in the COC evaluation is not required.

7.4.1 Final FWCUG Identification

Final FWCUGs are needed that reflect the planned future land use of the Block D Igloo Investigation Area by the OHARNG. For military training, the OHARNG receptors include the National Guard Trainee and the Range Maintenance Soldier; however, the final FWCUGs for the National Guard Trainee are more stringent and are therefore protective of the Range Maintenance Soldier. The final FWCUGs used for identification of COCs also include the Residential Receptor (Adult and Child).

The final 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 final FWCUGs for the identified COCs are provided in **Tables 7-3** and **7-4** for the Resident Receptor (Adult and Child) and the National Guard Trainee, respectively.

7.4.2 Comparison of EPCs to Final FWCUGs

The EPCs are compared to the final FWCUGs for cancer and noncancerous effects through the development of a ratio (USACE, 2012). These ratios are summed to account for potential cumulative effects and are shown in **Tables 7-3** and **7-4** for the Resident Receptor (Adult and Child) and the National Guard Trainee, respectively. COCs are identified if one of the following occurs:

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

The EPC for iron is the maximum detected concentration, which is from an ISM sample (**Table 7-2**). Iron is identified as a COC for the Resident Receptor (Adult and Child), since the noncancerous ratio for this COPC is greater than 1 (**Table 7-3**). No COCs are identified for the National Guard Trainee (**Table 7-4**).

Table 7-3
Summary of Screening Results for COCs in Surface Soil (0–0.5 feet bgs) for the Resident Receptor

		Cancer Evaluation			Noncancer Evaluation				
COPC	**EPC (mg/kg)**	**R(A) FWCUG[1] (mg/kg)**	**Ratio of EPC to R(A) FWCUG**	**% Contribution to the Total Sum**	**R(C) FWCUG[2] (mg/kg)**	**Ratio of EPC to R(C) FWCUG**	**% Contribution to the Total Sum**	**COC?**	**COC Justification**
Iron	35,200	NA	NA	NA	23,125	1.52	100	Yes	Sum of ratios >1
	Sum of Ratios:		**0**			**1.52**			

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

[2] FWCUG is noncarcinogenic FWCUG at HQ of 1; only child FWCUG is shown, as this is lower than adult for noncancer effects.

bgs denotes below ground surface.

COC denotes chemical of concern.

COPC denotes chemical of potential 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 quotient.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable, as chemical is not considered a potential carcinogen.

R(A) denotes Resident Receptor (Adult).

R(C) denotes Resident Receptor (Child).

SAIC denotes Science Applications International Corporation.

Table 7-4
Summary of Screening Results for COCs in Surface Soil (0–0.5 feet bgs) for the National Guard Trainee

		Cancer Evaluation			Noncancer Evaluation				
COPC	**EPC (mg/kg)**	**NGT FWCUG[1] (mg/kg)**	**Ratio of EPC to NGT FWCUG**	**% Contribution to the Total Sum**	**NGT FWCUG[2] (mg/kg)**	**Ratio of EPC to NGT FWCUG**	**% Contribution to the Total Sum**	**COC?**	**COC Justification**
Iron	35,200	NA	NA	NA	1,000,000	0.04	100	No	Sum of ratios <1
	Sum of Ratios:		**0**			**0.04**			

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

[2] FWCUG is noncarcinogenic FWCUG at HQ of 1.

bgs denotes below ground surface.

COC denotes chemical of concern.

COPC denotes chemical of potential 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 quotient.

mg/kg denotes milligrams per kilogram.

NA denotes not applicable, as chemical is not considered a potential carcinogen.

NGT denotes National Guard Trainee.

7.5 Weight of Evidence Discussion for COCs

This section provides a weight of evidence discussion for the iron concentration that was identified as a COC at two ISM surface soil locations based on concentrations above the final FWCUG for the Resident Receptor (Adult and Child) and the BSV.

Four ISM samples, including a field duplicate, were collected at the Block D Igloo Investigation Area. Iron was detected above the final FWCUG assuming an HQ of 1 for the Resident Receptor (Adult and Child) and the BSV at ISM sample locations BDISS-001(I)-0001-SS (35,200 mg/kg) and BDISS-003(I)-0001-SS (23,600 mg/kg).

The ISM surface soil sample BDI-002(I)-0001-SS was collected in the sampling unit at Grid T25, located approximately 100 feet east of the former igloo footprint, as a blind field duplicate for ISM sample BDISS-001(I)-0001-SS. The result of the duplicate sample exhibited an iron concentration of 21,500 mg/kg that is less than the final FWCUGs assuming an HQ of 1. Comparison of the results of the two samples indicates that elevated iron concentrations do not appear to be ubiquitous even in relatively small areas such as the 100-foot by 100-foot sampling units.

The ISM surface soil sample BDISS-003(I)-0001-SS was collected at the sampling unit at Grid X29, located approximately 700 feet northeast of the former igloo footprint. The iron result of 23,600 mg/kg for this sample is well within an order of magnitude of the BSV of 23,100 mg/kg and is most likely representative of existing background conditions.

7.6 COC Identification

This section presents the COC evaluation process for the receptors presented in the HHRA. The COCs are identified through additional screening of the COPCs identified in Section 7.3 and are typically chemicals that should be addressed in the FS following the RI. The determination of COCs was conducted in accordance with the Position Paper (USACE, 2012).

While iron is identified as a COC based on the consideration of the two ISM surface soil results above the screening criteria, the consideration of this analyte as a COC for the FS is not recommended. The field duplicate sample collocated with sample BDISS-001(I)-0001-SS was not able to replicate the elevated concentration detected in the original sample, and the BDISS-003(I)-0001-SS sample results was just above the BSV. In addition, the grinding of the samples for ISM analysis may overestimate the exposure scenario under soil contact conditions, and the iron concentrations detected are unlikely to pose risks to the Resident Receptor (Adult and Child).

7.7 Conclusions of the HHRA

Iron was the only SRC identified as a COC in surface soil; however, weight of evidence suggests that the detected concentrations are unlikely to pose risks to any of the receptors evaluated in the HHRA. Additionally, no other MC-related SRCs were determined to pose risks to likely human receptors, including the Resident Receptor (Adult and Child), in the evaluated potential exposure pathways of surface soil at the investigation area. Based on the results of the HHRA, Unrestricted Land Use at the investigation area is achieved.

7.8 Uncertainty Analysis

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

Uncertainty can arise from sampling techniques or approaches. In this assessment, surface soil was sampled using ISM and discrete techniques. The ISM provides a good representation of average concentrations over the area sampled. While it may not identify small areas of higher concentrations, this approach is useful for estimating exposure, which is expected to occur over an area and not discrete locations. Discrete samples were used to evaluate a localized area where MEC items were identified. As discussed in Section 3.2, "MC Characterization," samples for analytical testing were identified based on historical evidence and the results of the MEC investigations. The MC samples consisted of surface soil samples collected at a maximum depth of 0.83 feet (10 inches) beneath or within the vicinity of MEC items that were encountered during the intrusive investigation activities. Thus, the sampling was biased to the areas of highest possible contamination.

The selection of the maximum detected concentration as the EPC provides a conservative evaluation of potential exposures at the Block D Igloo Investigation Area and may overestimate exposure and risk for the entire location that is defined as the exposure area. The selection of receptors also represents an uncertainty to the risk assessment. The evaluation of COPCs and COCs for Unrestricted Land Use is required in accordance with CERCLA and represents a conservative evaluation of possible future exposures. In addition, the National Guard Trainee, which is considered to be the most stringent of the OHARNG receptors, is used to evaluate for military training. Therefore, the most stringent OHARNG

receptors are evaluated against the most stringent exposure scenarios, and risks are not expected to be underestimated for the other OHARNG receptors.

This page intentionally left blank.

8.0 ECOLOGICAL RISK ASSESSMENT

This section discusses the ERA approach and conclusions for the SRCs detected in environmental samples collected at the Block D Igloo Investigation Area. No MEC or MD was observed at the Landfill North of Winklepeck MRS during the RI visual survey, and further investigation for MC was not warranted. An ERA was not warranted for this MRS, and no further discussion regarding evaluation for ecological risk at the Landfill North of Winklepeck MRS is presented in this section.

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

Consistent with the facility Unified Approach for performing ERAs, a screening-level ERA (SLERA) was performed for the Block D Igloo Investigation Area. The SLERA is an initial screening step in the ERA 8-step approach as described in EPA Guidance (1997). 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 Screening, 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 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 the Block D Igloo Investigation Area, 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 the SRCs identified for an 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 wildlife, threatened and endangered species, and wetlands or other sensitive habitats associated with the MRS.

The objective of this SLERA was to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from the accidental explosion at former Igloo 7-D-15. The results of the SLERA would contribute to the overall characterization of the Block D Igloo Investigation Area and are used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives.

The SLERA used site-specific analyte concentration data for environmental samples that were collected under the MMRP. 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 potentially pose adverse effects to ecological receptors. Following the determination of COPECs, an ecological CSM was developed that describes the selection of receptors, exposure pathways, and assessment and measurement endpoints and accounts for cumulative effects.

8.2 Level I Scoping

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

8.2.1 Site Description and Land Use

The Block D Igloo Investigation Area is 92.14 acres and represents the calculated MFD-H associated with the clusters of M-41 20 lb fragmentation bombs that exploded at Igloo 7-D-15 in 1943. Based on the revised MFD-H, the maximum distance that MEC or MD is expected is 2,389 feet to the east of the former igloo.

Current activities at the Block D Igloo Investigation Area include military training, maintenance, and natural resource management activities. The future land use at the Block D Igloo Investigation Area is military training (Shaw, 2011).

8.2.2 Ecological Significance

The ecological features of the Block D Igloo Investigation Area 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).

Topography across the Block D Igloo Investigation is relatively flat with low hillocks and "pit and mound" features typical of forested sites. Based on topographical maps, the overall drainage direction for Block D Igloo Investigation Area appears to be to the east–southeast. The lowest elevation is approximately 1,045 feet amsl at the eastern extent of the investigation area boundary. The highest elevation is approximately 1,110 feet amsl near the location of the former igloo (e^2M, 2008).

An unnamed tributary to Sand Creek begins approximately 1,000 feet southeast of the former igloo footprint and flows east–southeast as well. In general, surface water drainage for the Block D Igloo Investigation Area and surrounding area follows the topography toward the southeast.

A planning-level survey wetland is located at the northwest boundary of the investigation area. The portion of this wetland within the investigation area boundary is 0.8 acre. A small 0.25-acre jurisdictional wetland is present at the central portion of the Block D Igloo Investigation Area. The wetlands present within the investigation area are either forested wetlands or wet fields (AMEC, 2008).

The plant communities at the Block D Igloo Investigation Area primarily fall within the Red Maple Woods Community, the Oak Maple Tulip Forest Community and the White Ash Wild Black Cherry Red Maple Woods Community. These communities are characterized by a high abundance of red maple, which sometimes occurs in nearly pure stands. Green ash, white ash, black cherry, and sugar maple often are present as well, but not as dominant species (AMEC, 2008).

Due to the minimal size of the combined wetlands identified in the investigation area (1.05 acres), the vegetation at these locations has not been specifically classified. However, due to the shallow depths of these wetland areas (likely less than 6 feet deep), it is likely that they are similar to other wetlands at the facility where the vegetation consists of primarily of pondweeds, hornworts, waterweed species, spatterdock, and/or white water lily (AMEC, 2008).

The area along the unnamed tributary to Sand Creek is classified as a Mixed Swamp Forest. The vegetation within this alliance consists primarily of green ash, American elm, hackberry, and red maple. Black walnut, white ash, swamp white oak, cottonwood, and black willow are also present. This vegetation is associated with flood plains near streams and rivers and other temporarily flooded areas (AMEC, 2008).

8.2.3 Facility Management Goals

The INRMP (AMEC, 2008) was developed for the OHARNG as the primary guidance document and tool for managing natural resources at the facility. Several of these management goals have relevance to maintaining the ecological resources at the MRS. Therefore, they are pertinent to the SLERA because they articulate overarching objectives regarding ecological resources that should be considered when identifying whether adverse impacts associated with a release have occurred. Specifically, the following goals listed in the INRMP are pertinent to the Block D Igloo Investigation Area SLERA:

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

8.2.4 Terrestrial Resources

This section summarizes the terrestrial resources identified for the Block D Igloo Investigation Area that are evaluated in the ERA.

8.2.4.1 Special Interest Areas

Special interest areas are ecosystems that are not federally protected and have no legal standing, but are areas that host state-listed species, are representative of historic ecosystems, or are otherwise noteworthy. No special interest areas have been identified at the Block D Igloo Investigation Area during a search of natural heritage data; however, an area along the northern fence of the facility boundary near the Block D Igloo Investigation Area has been identified as a Camp Ravenna Special Interest Area. This Special Interest Area encompasses approximately 145 acres and contains a large number of rare plants and a mature stand of Mixed Swamp Forest (AMEC, 2008).

8.2.4.2 Wetlands

A planning-level survey (i.e., desktop review of wetlands data and resources [National Wetlands Inventory maps, aerials, etc.]) for wetlands was conducted for the entire facility, including the investigation area. A small wetlands area was identified during the planning-level survey of wetlands at the northwest corner of the investigation area. Approximately 0.8 acres of the planning-level wetland is located within the boundaries of the investigation area. Additionally, a jurisdictional wetlands delineation has been conducted within the investigation area and a small 0.25-acre jurisdictional wetland was been identified at the central portion of the investigation area (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 length of streams at the facility is 212 linear miles. Approximately 153 acres of ponds are found on the facility. These ponds generally provide valuable wildlife habitats. The ponds generally support wood ducks, hooded mergansers, mallards, Canada geese, and many other birds and wildlife species. Some ponds have been stocked with fish and are used for fishing and hunting. Wetlands are abundant and prevalent throughout the facility and are present at the investigation area. These wetland areas include seasonal wetlands, wet fields, and forested wetlands. Most of the wetland areas at the facility are the result of natural

drainage and beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas (AMEC, 2008).

The plant communities within the area of the Block D Igloo Investigation Area also provide habitats that support several species of animals. Nearly the entire Investigation Area is covered by successional or mature forest habitats. Common bird species that could be expected to use the forest/riparian habitat include the veery (*Catharus fuscescens*), red-eyed vireo (*Vireo olivaceus*), and eastern wood pewee (*Contopus virens*). Common large mammals include the white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and woodchuck (*Marmota monax*), while the eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), and short-tailed shrew (*Blarina brevicauda*) are common small mammals present at the installation (ODNR, 1997) that may use the habitat present at the Block D Igloo Investigation Area.

8.2.4.4 Threatened, Endangered, and Other Rare Species Information

The relative isolation of the facility that helps to protect habitat at the facility has created an important area of refuge for a number of plant and animal species considered rare by the State of Ohio. Biological inventories have been performed across the facility, and to date, 77 state-listed species are confirmed to be on the facility and are listed in **Table 1-3**. Biological inventories have occurred within the Block D Igloo Investigation Area boundaries and confirmed sightings of a state-listed species of concern consisting of the sharp-shinned hawk (*Accipiter striatus*) has been observed within the investigation area (AMEC, 2008).

8.2.5 Level I Conclusions

Based on the presence of ecological resources, including a state-listed species of concern at the investigation area, and the presence of detected SRCs associated with the munitions that accidentally exploded at former Igloo 7-D-15 that could adversely affect these resources, proceeding to the Level II Screening step is recommended for this SLERA. This Level II Screening is presented in the Section 8.3.

8.3 Level II Screening

A Level II Screening was performed for Block D Igloo Investigation Area to compare site-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 were identified based on the CSM to describe ecological features targeted for protection. Then, a COPEC identification step was performed to determine what chemicals,

if any, potentially represent a threat to the ecological receptors present at the investigation area.

8.3.1 Ecological Conceptual Site Model

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

8.3.1.1 Contamination Source

The contamination source includes potential releases of MC from the accidental explosion of 2,516 clusters of M-41 20 lb fragmentation bombs that occurred at Igloo 7-D-15 in 1943.

8.3.1.2 Source Medium

The source medium at the Block D Igloo Investigation Area is surface soil. Although surface soil at the facility is defined as 0 to 1 foot bgs, the ISM surface soil samples used in this SLERA and collected under the MMRP were for the 0- to 0.5-foot (0- to 6-inch) bgs sample depth. The discrete samples were collected at 0.5-foot (6-inch) bgs sample intervals beneath MEC items at sample intervals ranging from 0.25 to 0.83 feet (3 to 10 inches) bgs. The samples were collected at 0.5-foot intervals since MC that may have been released from the explosion at the igloo or MC associated with a MEC source resulting from the explosion would have mostly collected in the top several inches of soil.

8.3.1.3 Transport Mechanisms

Potential transport mechanisms at the investigation area include volatilization into the air, biota uptake, erosion to surface water and sediment, and leaching to groundwater. Biota uptake is a transport mechanism because the SRCs are known to accumulate in biota, which may act as a vehicle to spatially disperse contaminants. Biota also represents a secondary exposure medium for upper trophic level receptors that prey on it.

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 animals that come in contact with these media. Potential exposure media include air, surface soil, and the food chain. For the

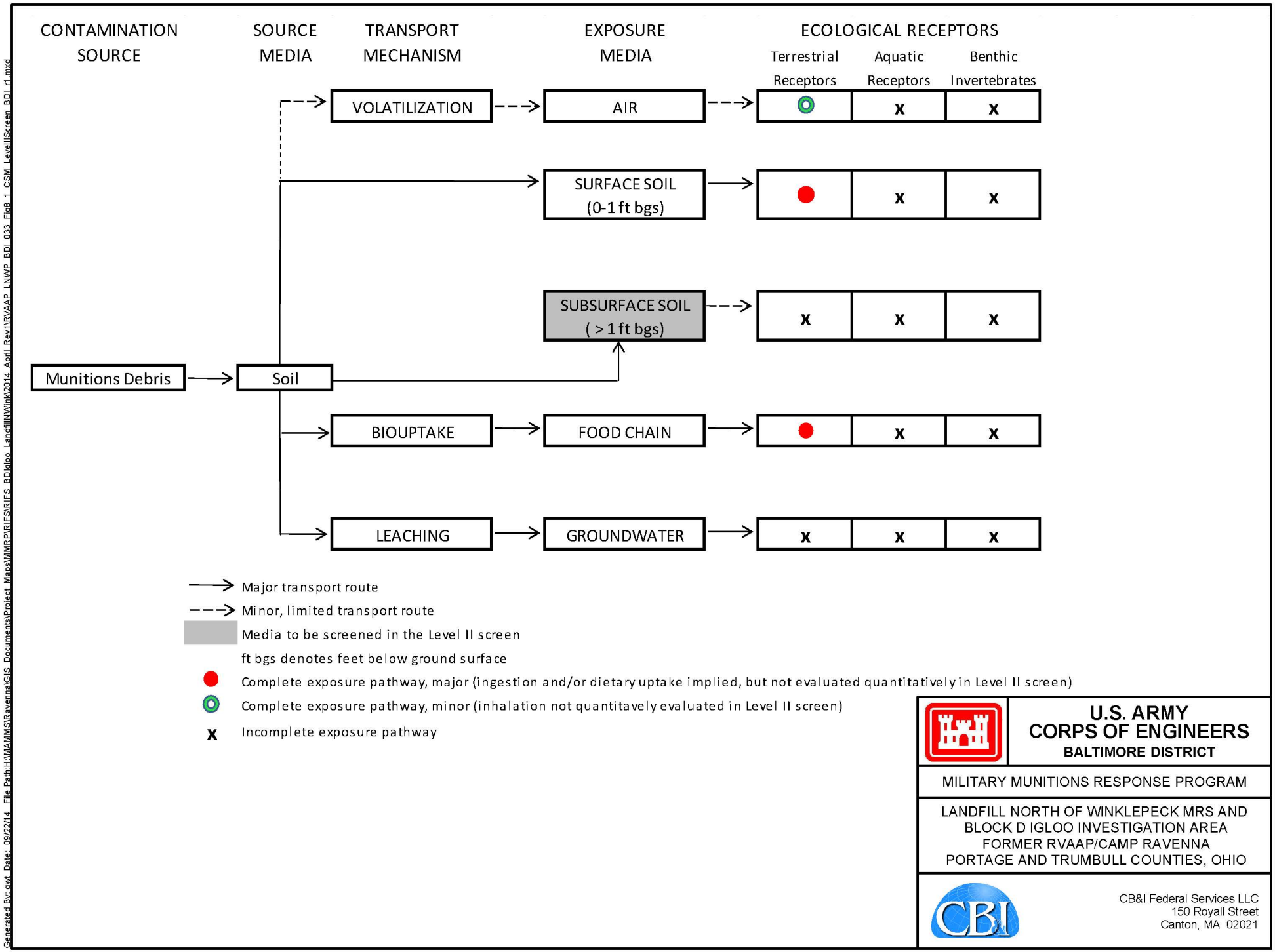
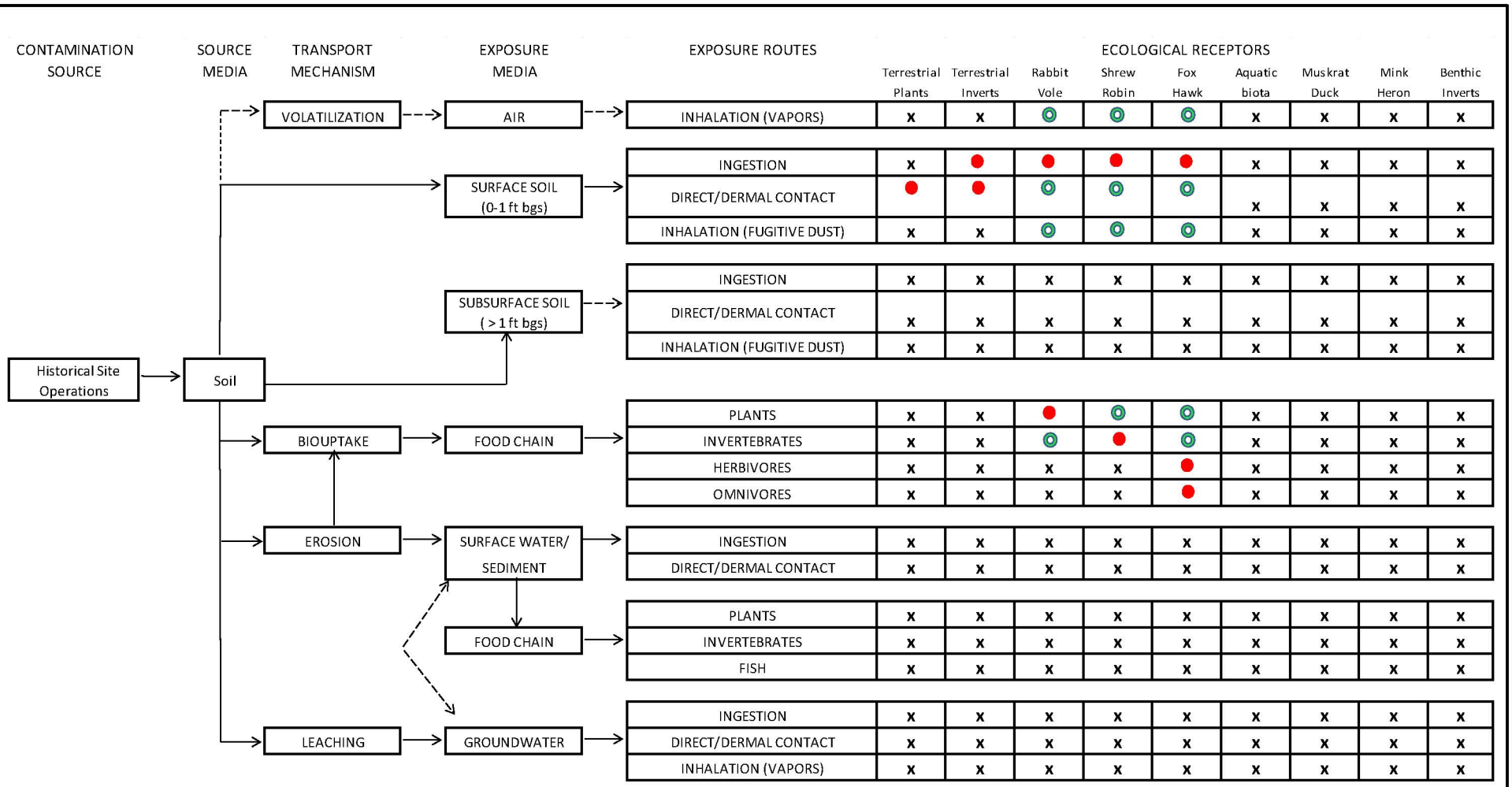


FIGURE 8-1 ECOLOGICAL CSM FOR LEVEL II SCREEN, BLOCK D IGLOO INVESTIGATION AREA



U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 8-2 ECOLOGICAL CSM FOR LEVEL III SCREEN, BLOCK D IGLOO INVESTIGATION AREA

purposes of this ecological discussion, subsurface soil is soil at depths greater than 1 foot that ecological receptors typically do not come into contact with, and is not being evaluated at the Block D Igloo Investigation Area. 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 principal exposure media for the Block D Igloo Investigation Area.

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 MRSs 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, whether the organism is mobile or immobile; local or migratory; burrowing or aboveground; or 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 comparison of maximum detected concentrations of chemicals in the exposure media against 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 to ecological receptors.

The major exposure routes for chemical toxicity from surface soil include ingestion (for terrestrial invertebrates, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial invertebrates). The ingestion exposure routes for voles, shrews, robins, foxes, and hawks include soil as well as plant and/or animal food items (i.e., food chain transfer) that were also 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. At sites where groundwater outcrops via seeps or springs into wetlands or ditches, it becomes part of the surface water and would be evaluated as surface water.

8.3.1.6 Ecological Receptors

For the Level II Screening, specific ecological receptors were not identified, but rather, terrestrial biota was considered as a whole. However, for the Level III Baseline evaluation, specific terrestrial ecological receptors were identified as part of the ecological CSM (**Figure 8-2**). The terrestrial receptors include terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003c). 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 investigation area-specific analysis screen was based on animal species that are likely to occur in the terrestrial habitats that make up the majority of the habitats at the investigated portions of the investigation area. Three criteria were used to identify the investigation area-specific receptors (USACE, 2003c) as follows:

1. **Ecological Relevance**—The receptor has or represents a role in an important function such as nutrient cycling (i.e., earthworms), and population regulation (i.e., hawks). Receptor species were chosen to include representatives of all applicable trophic levels identified by the ecological CSM for the investigation area. 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 investigation area, 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 investigation area'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 former RVAAP (AMEC, 2008).

At the Block D Igloo Investigation Area, the following types of ecological receptors are likely to be present: terrestrial invertebrates, meadow voles (*Microtus pennsylvanicus*), short-tailed shrews (*Blarina brevicauda*), American robins (*Turdus migratoris*), red foxes (*Vulpes vulpes*), red-tailed hawks (*Buteo jamaicensis*), and sharp-shinned hawks (*Accipiter striatus*). Each of these receptors is described in the following paragraphs.

Terrestrial Invertebrate Exposure to Soil

Terrestrial invertebrate exposure to soil is applicable to soils for the Block D Igloo Investigation Area. Earthworms represent the receptor for the terrestrial invertebrate class, and there is sufficient habitat present for them at the investigation area. Earthworms have ecological relevance because they are important for decomposition of detritus, for energy, for nutrient cycling in soil (Efroymson et al., 1997a), 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., 1997a). Although specific 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 Block D Igloo Investigation Area.

Mammalian Herbivore Exposure to Soil

Mammalian herbivore exposure to soil is applicable to the Block D Igloo Investigation Area. Cottontail rabbits and meadow voles represent mammalian herbivore receptors, and there is suitable habitat present for them at the investigation area. 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 regulatory statutes for rabbits because they are an upland small game species protected under Ohio hunting regulations. There are no specific regulatory statutes for meadow voles at the Block D Igloo Investigation Area. The meadow vole has a smaller home range than the rabbit, which makes it potentially more susceptible to localized contamination. Therefore, it is a more conservative selection as a representative mammalian herbivore than the rabbit and is selected as a representative receptor for this foraging guild at the Block D Igloo Investigation Area.

Insectivorous Mammal and Bird Exposure to Soil

Insectivorous mammal and bird exposure to soil is applicable to the Block D Igloo Investigation Area. Short-tailed shrews and American robins represent the receptors for the insectivorous mammal and bird terrestrial exposure class, respectively. There is sufficient, suitable habitat present at the investigation area for these receptors. Both species have ecological relevance because they help to control the aboveground 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 invertebrates. Insectivorous mammals such as short-tailed shrews and birds such as American robins are primarily exposed by ingestion of contaminated prey (i.e., earthworms, insect larvae, and slugs) as well as ingestion of soil. In addition, shrews ingest a small amount of leafy vegetation, and the robin's diet consists of 50 percent each of seeds and fruit. Dietary toxicity benchmarks are available for mammals and birds (Sample et al., 1996). Both species are recommended as receptors because there can be different toxicological sensitivity between mammals and birds exposed to the same contaminants. There are regulatory statutes for robins because they are federally protected under the *Migratory Bird Treaty Act of 1993*, as amended, and are consistent with the INRMP (AMEC, 2008) polices and management goals. There are no specific regulatory statutes for shrews at the investigation area. Based on the regulatory statutes for the robin plus the susceptibility to contamination and ecological relevance for both species, there is sufficient justification to warrant the shrew and the robin as representative receptors for the Block D Igloo Investigation Area.

Terrestrial Top Predators

Exposure of terrestrial top predators is applicable to the Block D Igloo Investigation Area. Red foxes, red-tailed hawks, and sharp-shinned hawks represent the mammal and bird receptors for the terrestrial top predator exposure class. There is a limited amount of suitable habitat available for them at the investigation area. All three species have ecological relevance; as representatives of the top of the food chain for the terrestrial EUs, they control populations of prey animals such as small mammals and birds.

All three species 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 investigation area. 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 both the *Mammalia* and *Aves* classes. Red foxes are primarily carnivorous, but consume some plant material. The red-

tailed hawk and the sharp-shinned hawk consume only animal prey. The fox may incidentally consume soil. There are regulatory statutes for all three species. Laws (Ohio trapping season regulations for foxes and federal protection of raptors under the *Migratory Bird Treaty Act of 1993*, as amended) and the INRMP (AMEC, 2008) policies and management goals also protect these species. Additionally, the sharp-shinned hawk is a state-listed species of concern that has the potential to become threatened under continued or increased stress (AMEC, 2008). These species are susceptible to contamination and have ecological relevance as top predators in the terrestrial ecosystem. Based on this justification, these two species were selected as representative receptors for the Block D Igloo Investigation Area.

8.3.1.8 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at the Block D Igloo Investigation Area were described in Section 8.3. As previously discussed, there are relevant and complete exposure pathways for various ecological receptors including terrestrial invertebrates and terrestrial herbivores, insectivores, and carnivores. Thus, these types of receptors could be exposed to COPECs in surface soil at the investigation area.

8.3.2 Ecological Endpoint (Assessment and Measurement) Identification

The protection of ecological resources, such as habitats and species of animals, is a primary motivation for conducting SLERAs. Key aspects of ecological protection are presented as general management goals. These are 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., CERCLA and the NCP). Other legislation includes the ESA (16 USC § 1531-1544, et seq., 1993, as amended) and the *Migratory Bird Treaty Act of 1993*, as amended (16 USC § 703-711, as amended). Specific management goals for the MRS pertaining to natural resources management goals for the facility are presented in Section 8.2, "Level I Scoping." Based on these facility management goals, one general management goal was identified for the Block D Igloo Investigation Area SLERA based upon the CSM. This identified general management goal is the following:

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

To evaluate whether the general management goal has been met, assessment endpoints, measures of effects, and decision rules were formulated. An ecological assessment endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor (i.e., COPEC). Assessment endpoints are "explicit expressions of the actual environmental

value that is to be protected" (EPA, 1992). Assessment endpoints often reflect environmental values that are protected by law, provide critical resources, or provide an ecological function that would be significantly impaired if the resource was altered. Unlike the HHRA process, which focuses on individual receptors, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. Population responses are also better defined and predictable than community and ecosystem responses (USACE, 2010). 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 investigation area, potential impacts to populations are the appropriate criteria for consideration.

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

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

Table 8-1 shows the general management goal 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 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 general management goal. Assessment endpoints 1 through 4 entail the growth, survival, and reproduction of terrestrial receptors such as terrestrial invertebrates, herbivorous mammals, worm-eating/insectivorous mammals and birds, and carnivorous top predator mammals and birds, respectively.

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

This page intentionally left blank.

Table 8-1
General Management Goal, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified During the Level II Screening at the Block D Igloo Investigation Area

General Management Goal	Assessment Endpoint	Measures of Effect	Decision Rule
General Management Goal 1: The protection of terrestrial populations, communities, and ecosystems	**Assessment Endpoint 1:** Growth, survival, and reproduction of soil invertebrate communities and low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk Receptors: earthworms	**Measures of Effect 1:** Earthworm soil toxicity benchmarks and measured RME concentrations of constituents in soil	**Decision Rule for Assessment Endpoint 1:** If HQs, defined as the ratios of COPEC RME concentrations in surface soil to soil toxicity benchmarks for adverse effects on soil invertebrates, are less than or equal to 1, then Assessment Endpoint 1 has been met and soil-dwelling invertebrates are not at risk. If 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
	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 Decision Rule for Assessment Endpoint 4.
	Assessment Endpoint 4: Growth, survival, and reproduction of carnivorous mammal and bird populations Receptors: red-tailed hawk, sharp-shinned 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

COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.
NOAEL denotes no observed adverse effects level.
RME denotes reasonable maximum exposure.
SMDP denotes scientific management decision point.
TRV denotes toxicity reference value.

This page intentionally left blank.

composition. Measurement endpoints should be selected so as to provide insights related to the specific assessment endpoint (USACE, 2010). 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 consisted of the comparison of the maximum detected concentrations of each contaminant in soil to ESV benchmarks. Measurement endpoints for the Level III Baseline would include the comparison of estimated doses of chemicals in various receptor animals (such as voles, shrews, and American robins) to TRVs.

In the Level II Screening, maximum detected concentrations in soil were used as the EPC for comparison to generic soil or sediment 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.

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 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 hazard index 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 surface soil samples collected at the Block D Igloo Investigation Area. After the Level II Screening is complete,

any COPECs identified are discussed in greater detail, and a recommendation is made as to whether the ERA should proceed to a Level III Baseline or Level IV Field Baseline.

8.3.3.1 Data Used in the SLERA

Historical sampling activities at the Block D Igloo MRS include the collection of one composite sample within the footprint of the former Igloo 7-D-15 during the SI field activities (**Figure 1-12**). This sample is not included in this SLERA, since the sample was not collected consistent with the sample methods used during the RI. Furthermore, the RI soil samples were collected at locations where MEC or MD was observed, whereas the sample collected during the SI was collected at a location where no MEC or MD was found.

The MC investigation for the RI was based on the results of the MEC evaluation. Surface soil samples were collected at three sampling units at 0–0.5 feet bgs using the ISM. Two discrete samples were collected at a 0.5-foot interval beneath the anomaly excavations where MEC items were identified. The maximum depth of the discrete samples was 0.83 feet (10 inches) bgs. The ISM soil samples were collected in 100-square-foot sampling units at the mag and dig grids where MD was well distributed on the ground surface and in subsurface soils. Discrete samples were collected beneath individual MEC items identified during the intrusive investigation activities. Samples included in the ERA data set are identified in **Table 8-2**.

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

Sample Location ID	Sample Location ID	Date	Depth (feet bgs)	Sample Type	Analysis
BDISS-001	BDISS-001(I)-0001-SS	8/22/11	0–0.5	ISM	Metals[1] Explosives Nitrocellulose TOC pH
BDISS-003	BDISS-003(I)-0001-SS	8/22/11	0–0.5	ISM	
BDISS-004	BDISS-004(I)-0001-SS	8/22/11	0–0.5	ISM	
BDISS-005	BDISS-005(D)-0001-SS	8/22/11	0.33–0.83	D	
BDISS-006	BDISS-006(D)-0001-SS	8/22/11	0.25–0.75	D	

[1] Metals analysis includes aluminum, antimony, iron, and lead.
bgs denotes below ground surface.
D denotes discrete.
ID denotes identification.
ISM denotes incremental sampling method.
MEC denotes munitions and explosives of concern.
TOC denotes total organic carbon.

Surface soil samples that ranged in depths between 0 and 0.83 feet (10 inches bgs) at three ISM sampling units and two discrete sample locations was identified as the only medium of

concern at the Block D Igloo Investigation Area. The ISM data are considered relevant for estimating ecological exposure because they provide good representation of current conditions and because the ISM approach provides an accurate estimate of average concentrations that receptors would be exposed to at the investigation area. Discrete samples provide additional information for specific areas where MEC items were identified. Data from the ISM and discrete samples were analyzed separately. Only surface soil samples (0 to 0.83 feet) were used in the SLERA because potential contamination from the igloo explosion is likely limited to the ground surface and shallow subsurface and because most ecological exposure occurs within the top 1 foot of soil. Therefore, the 0- to 0.83-foot interval is assumed to represent the ecological EU for most ecological receptors.

The MC analytical data were reviewed and evaluated for quality, usefulness, and uncertainty, as described in Section 4.2, "MC Data Evaluation." A COPEC selection process was performed for the identified SRCs 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. Note that with the exceptions noted below, all detected chemicals are included in the COPEC screening step, but the screen incorporates the same criteria described in Section 4.2.1.3 to eliminate chemicals that are not SRCs (i.e., infrequently detected chemicals, background comparisons, essential nutrients, and chemicals that are not MC-related).

Some chemicals were analyzed for a specific purpose other than for identifying MC (i.e., the collection of magnesium concentrations for the purposes of performing a geochemical analysis on chemical concentration ratio data), and are not known or suspected SRCs at the MRS. Information for these chemicals is presented in the data summary tables but is not carried forward as MC in the SLERA.

Two inorganic SRCs were identified in surface soils collected at the Block D Igloo Investigation Area. These SRCs include antimony and iron and were identified in the ISM samples only that were collected at a maximum depth of 0.5 feet (6 inches) bgs.

8.3.3.3 Comparison to Ecological Screening Values

For surface soils, the maximum detected concentration of each SRC was compared to ESVs. The SRCs that exceed the ESVs, or for which no ESVs are available, were retained as COPECs. The hierarchy of sources of soil screening values, in order of preference, was as follows and is in accordance with the Work Plan (Shaw, 2011):

- *Guidance for Developing Ecological Soil Screening Levels* (EPA, 2010) online updates from http://www.epa.gov/ecotox/ecossl/
- Oak Ridge National Laboratory: Efroymson, et al, 1997b. *Preliminary Remediation Goals for Ecological Endpoints*, ES/ER/TM-162/R2
- *Region 5 RCRA Ecological Screening Levels*, (EPA, 2003)
- Los Alamos National Laboratory: *ECORISK Database,* Release 2.3, November 2010
- Talmage et al., 1999. *Nitroaromatic Munitions Compounds: Environmental Effects and Screening Value*s, Rev. Environ. Contamin. Toxicol., 161:1–156

The ESVs used in the evaluation for this SLERA are presented in **Appendix M**.

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 not to be harmful to ecological receptors when present in environmental media. Iron is considered to be an MC associated with historical activities at the Block D Igloo Investigation Area is; therefore, it is not eliminated as an essential nutrient.

8.3.4 Summary of COPEC Selection

The results of the COPEC screening for SRCs detected in surface soil are presented in **Table 8-3**. The data is presented for the ISM samples only since this was the only sample type where the SRCs were detected. The table presents the following information for the ISM surface soil samples:

- SRCs (as identified in Section 4.2.1.3)
- Range of detected concentrations
- Range of detection limits
- BSV
- ESV
- HQ

Table 8-3
Summary of COPEC Evaluation in Surface Soil (0–0.5 feet bgs)

Site-Related Chemical	Range of Values (mg/kg)						BSV (mg/kg)	ESV[1] (mg/kg)	Below ESV?	HQ	PBT?[1]	COPEC?[2]
	Detected Concentrations				Reporting Limits							
	Minimum	VQ	Maximum	VQ	Minimum	Maximum						
Antimony	1.1		1.8		0.81	0.81	0.96	0.27	No	6.7	No	Yes
Iron	15,500		35,200	J	1.8	18	23,100	NA	NA	NA	No	Yes

[1] *See Appendix M.*

[2] *Selection of COPECs:*

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

No (a) denotes chemical is not site-related (MDC is less than BSV).

No (b) denotes the MDC is less than the ESV, and chemical is not a PBT or the ESV is protective of food chain effects.

bgs denotes below ground surface.

BSV denotes background screening value.

COPEC denotes chemical of potential ecological concern.

ESV denotes ecological screening value.

HQ denotes hazard quotient and is based on the MDC.

MDC denotes maximum detected concentration.

mg/kg denotes milligrams per kilogram.

NA denotes value is not applicable/available.

PBT denotes persistent, bioaccumulative, and toxic.

VQ denotes validation qualifier.

Validation Qualifier:

J denotes the reported result is an estimated value.

This page intentionally left blank.

- Determination as to whether the chemical is a persistent, bioaccumulative, or toxic (PBT) compound.
- 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 screening value is not protective of food chain effects. A description and summary of the COPECs identified in surface soil are presented in the following section.

Soil Sample COPEC Selection

Initial evaluation of the SRCs antimony and iron in **Table 8-3** indicates that both metals are considered to be COPECs. The minimum and maximum detected concentrations for antimony exceeds the ESV and the HQ for antimony, based on the maximum detected concentration, is greater than 1 (0.67). Therefore, antimony is automatically retained as a COPEC for further evaluation. Iron is retained as a COPEC, since the maximum detected concentration exceeds the BSV.

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 EPA Process (USACE, 2011) 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 integrated 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 the following section to support final recommendations for this stage of the ERA process.

8.3.6 Weight of Evidence Discussion for ISM Soil Samples

As presented in Section 8.3.4, "Summary of COPEC Selection," both antimony and iron were identified as COPECs in the ISM surface soil samples. This section presents a weight of evidence discussion for each of the COPECs.

Iron was identified as a COPEC, since the maximum detected concentration exceeded its BSV. Iron would typically be excluded from further evaluation due to its status as an essential nutrient. An ESV is not available for iron because iron's bioavailability to plants and resulting toxicity are dependent upon site-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. Additionally, the EPA (2008) recommends "no further action" for iron in soils with a pH of 5 or greater. The pH for the three ISM samples ranged from 5.13 to 5.33. Therefore, iron is not expected to pose a threat to ecological receptors and is not retained as a COPEC for further evaluation at the investigation area.

Antimony was present in all three ISM soil samples at concentrations that exceeded its ESV; however, the HQs for antimony were below 10, which indicate that the potential for impacts is expected to be low. Furthermore, detected concentrations of antimony only exceed naturally occurring background levels by a factor of 2. Antimony is not bioaccumulative, and ingestion of contaminated prey items is not expected to be a significant exposure pathway. **Table 8-4** summarizes the antimony results at each of the sampling units and **Table 8-5** presents the HQs associated with antimony at each of the sampling units.

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

			Sample Location ID:	**BDISS-001**		**BDISS-003**		**BDISS-004**	
			Sample Number ID:	**BDISS-001(I)-0001-SS**		**BDISS-003(I)-0001-SS**		**BDISS-004(I)-0001-SS**	
			Sample Date:	**22-August-11**		**22-August-11**		**22-August-11**	
			Sample Depth (feet bgs):	**0–0.5**		**0–0.5**		**0–0.5**	
COPEC	**BSV**	**ESV**	**Units**	**Result[1]**	**VQ**	**Result[1]**	**VQ**	**Result[1]**	**VQ**
Antimony	0.96	0.27	mg/kg	***1.1***		***1.8***		***1.5***	

[1] *Detects in bold exceed the ESV if an ESV is available; detects in italic exceed the BSV or indicate that a BSV isn't available.*

bgs denotes feet below ground surface.

BSV denotes background screening value.

COPEC denotes chemical of potential ecological concern.

ESV denotes ecological screening value.

ID denotes identification.

mg/kg denotes milligram per kilogram.

VQ denotes validated qualifier.

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

Sample Location ID:	BDISS-001	BDISS-003	BDISS-004
Sample Number ID:	BDISS-001(I)-0001-SS	BDISS-003(I)-0001-SS	BDISS-004(I)-0001-SS
Sample Date:	22-August-11	22-August-11	22-August-11
Sample Depth (feet bgs):	0–0.5	0–0.5	0–0.5
COPEC	HQ	HQ	HQ
Antimony	4.1	6.7	5.6

bgs denotes below ground surface.
COPEC denotes chemical of potential ecological concern.
HQ denotes hazard quotient.
ID denotes identification.

Slightly elevated concentrations of antimony were detected in surface soil at the Block D Igloo Investigation Area, and the potential for localized ecological impacts cannot be completely discounted. However, the appropriate assessment endpoints for this MRS (see **Table 8-1**) stipulate the protection of populations of ecological receptors at the Block D Igloo Investigation Area. Given the conservativeness of the Level II Screening and the low overall concentrations of antimony detected, the potential of exposure to antimony to adversely impact populations of ecological receptors at the Block D Igloo Investigation Area is considered to be very low. Therefore, antimony is not retained as a COPEC for further evaluation at the investigation area.

8.4 Level II Screening Recommendations

Both antimony and iron were identified as COPECs in surface soil at the Block D Igloo Investigation Area during the Level II Screening. As discussed in Section 8.3.6, weight of evidence indicates that the detected concentrations of antimony and iron do not pose threats to ecological receptors, and antimony and iron are not retained as a COPECs for further evaluation.

No final COPECs are identified for surface soil and no further investigation (i.e., a Level III Baseline) or action is considered necessary at the Block D Igloo Investigation Area for ecological purposes. Therefore, there are no COPECs that require additional investigation.

9.0 REVISED CONCEPTUAL SITE MODELS

This section presents the revised CSMs for MEC and MC at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area based on the results of the data collected for the RIs for each of these sites and 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, "Project Objectives," and the summary of the RI results were presented in Section 4.0, "Remedial Investigation Results." Potential human health and environmental risks for the Block D Igloo Investigation Area only were evaluated in Section 7.0, "Human Health Risk Assessment," and Section 8.0, "Ecological Risk Assessment," respectively. Following the integration of the RI results into the CSMs for MEC and MC, the MRSPP evaluations for each MRS was reevaluated to include the results of the RIs and are discussed at the end this section.

9.1 MEC Exposure Analysis

This section summarizes the RI data for the MEC exposure pathway analyses for the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area. 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. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. A pathway is considered potentially complete when a source has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in some activity which results in contact with the source. Lastly, an incomplete pathway is any case where one of the four components (source, activity, access, or receptors) is missing from the MRS.

9.1.1 Landfill North of Winklepeck MRS

A discussion of the MEC exposure pathway analysis for the Landfill North of Winklepeck MRS is presented below.

9.1.1.1 Source

The Landfill North of Winklepeck was an unlined landfill that may have received MEC during disposal operations. Facility personnel also reported that MEC was present on the slope leading down to the unnamed tributary. Based on the historical activities and reported observations, there is the potential for MEC items to be present on the slope leading down to the small unnamed tributary and within the stream course. The SI field activities conducted in 2007 documented the presence of MD on the hillside adjacent to the former landfill that

included a partially buried fragment from an unidentified bomb casing and empty 105mm projectiles. Based on historical activities, the source of any MEC would be expected to be found on the surface and/or subsurface soils.

During the RI, a full coverage visual survey was performed in all accessible areas. No MEC was identified within the MRS boundary. A subsurface investigation was not conducted at the MRS as buried anomalies were assumed to be consistent with surface debris and a MEC source/explosive hazard is not anticipated to be present at the MRS.

9.1.1.2 Activity

Current activities at the Landfill North of Winklepeck MRS include maintenance activities, environmental sampling, and natural resource management activities. These activities mainly involve foot traffic and minor ground disturbance. The future land use for the MRS is military training (Shaw, 2011).

9.1.1.3 Access

The MRS is located adjacent to an operational range complex and current access to the MRS is through a locked gate. Future access to this MRS should be similar to current access, as the area will be utilized as part of a range complex that will require gate access.

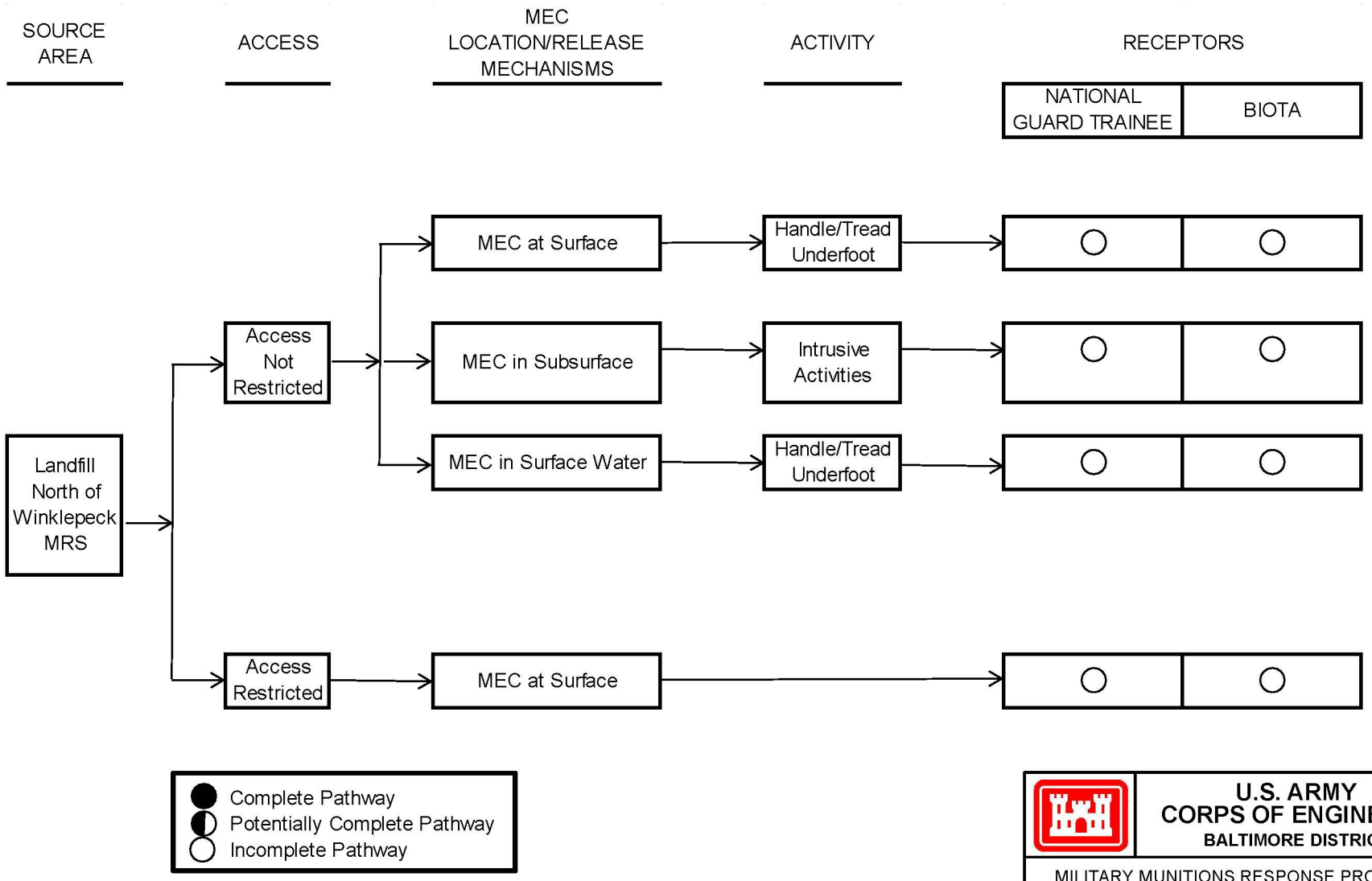
9.1.1.4 Receptors

Potential users associated with current activities at the MRS include facility personnel, contractors, and occasional trespassers. The National Guard Trainee and Range Maintenance Soldier are the Representative Receptors for the future land use at the MRS (Shaw, 2011). The National Guard Trainee is the more sensitive of the current and future receptors that may become exposed to any potentially remaining MEC.

Ecological receptors (biota) are based on animal and aquatic species that are likely to occur in the terrestrial and aquatic habitats at the MRS. The primary MRS-specific biota identified for the MRS include aquatic biota, terrestrial invertebrates (earthworms), voles, shrews, rabbits, robins, foxes, hawks, muskrats, ducks, minks, and benthic invertebrates (insect larvae, crayfish, snails, clams, and bivalves) (USACE, 2003c).

9.1.1.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Landfill North of Winklepeck 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 Exposure Pathway Analysis for the Landfill North of Winklepeck MRS is presented in **Figure 9-1**.



U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

Generated By: owt Date: 09/22/14 File Path:H:\MMMS\Ravenna\GIS Documents\Project Maps\MMRP\RIFS\RIFS BDIgloo LandfillNWWink\2014 April Rev1\RVAAP LNWP BDI 029 Fig9 1 RevMECCSM LNW r1.mxd

FIGURE 9-1 REVISED MEC CONCEPTUAL SITE MODEL, LANDFILL NORTH OF WINKLEPECK MRS

An instrument-assisted visual survey was performed at 100 percent of the accessible areas of the Landfill North of Winklepeck MRS during the RI field activities. No MEC was observed on the ground surface at the MRS during the visual survey; therefore, the MEC exposure pathway for surface soil is considered incomplete for all receptors.

Since no MEC was identified during the visual survey, a subsurface investigation was determined to be unwarranted. Based on the lack of a MEC source, an explosive hazard is not present in the subsurface at the Landfill North of Winklepeck MRS and the MC exposure pathway is considered to be incomplete for all receptors.

There is an unnamed tributary and wetland area located at the base of the slope of the eastern portion of the MRS that was not investigated during the RI field activities due to dense vegetation and fallen trees which prevented access. Although MEC was reported to be present along the slope down toward the unnamed stream, no MEC was identified on the ground surface during the SI or RI field activities and horizontal migration of MEC down the slope toward the stream is not anticipated. The MEC exposure pathway for surface water is considered incomplete for all receptors given the lack of activities which could cause potential subsurface MEC to reach the surface and migrate.

9.1.2 Block D Igloo Investigation Area

A discussion of the MEC exposure pathway analysis for the Block D Igloo Investigation Area is presented below.

9.1.2.1 Source

At the Block D Igloo Investigation Area, the source of MEC is the M-41 20 lb fragmentation bombs associated with the 1943 explosion at Igloo 7-D-15. During the RI visual survey, 178 MPPEH items were observed on the ground surface within and outside the boundaries of the 92.14-acre Investigation Area. All of the MPPEH was documented as safe (i.e., MD) by the UXO-qualified personnel in the field. During the mag and dig investigation, a total of 3,140 MPPEH items were encountered at a maximum depth of 8 inches bgs. The UXO-qualified determined that 3,135 of the MPPEH items were safe (i.e., MD) and 5 of the MPPEH items were MEC. The maximum depth of the MD found during the mag and dig investigation was 0.67 feet (8 inches) bgs. The MEC was found at a maximum depth of 0.5 feet (6 inches) bgs. Based on the amount of MD found during the visual survey and mag and dig investigation and that the presence of buried MEC was confirmed during the RI field work, surface and subsurface MEC likely remains at the Block D Igloo Investigation Area.

9.1.2.2 Activity

The location of former Igloo 7-D-15 is in a heavily wooded area at the northern portion of the facility, and the area sits mostly as idle. Current activities at the Block D Igloo

Investigation Area include military training, maintenance, and natural resource management activities which primarily involve foot traffic only. Biota activities at the MRS may include foot traffic or burrowing activities. The future land use for the Block D Igloo Investigation Area is military training (Shaw, 2011).

9.1.2.3 Access

Except for the igloos, the surrounding area is undeveloped. There is no fence surrounding the former igloo or the Investigation Area where MEC/MD was found during the RI field activities. These areas are not physically restricted and are readily accessible to all likely receptors.

9.1.2.4 Receptors

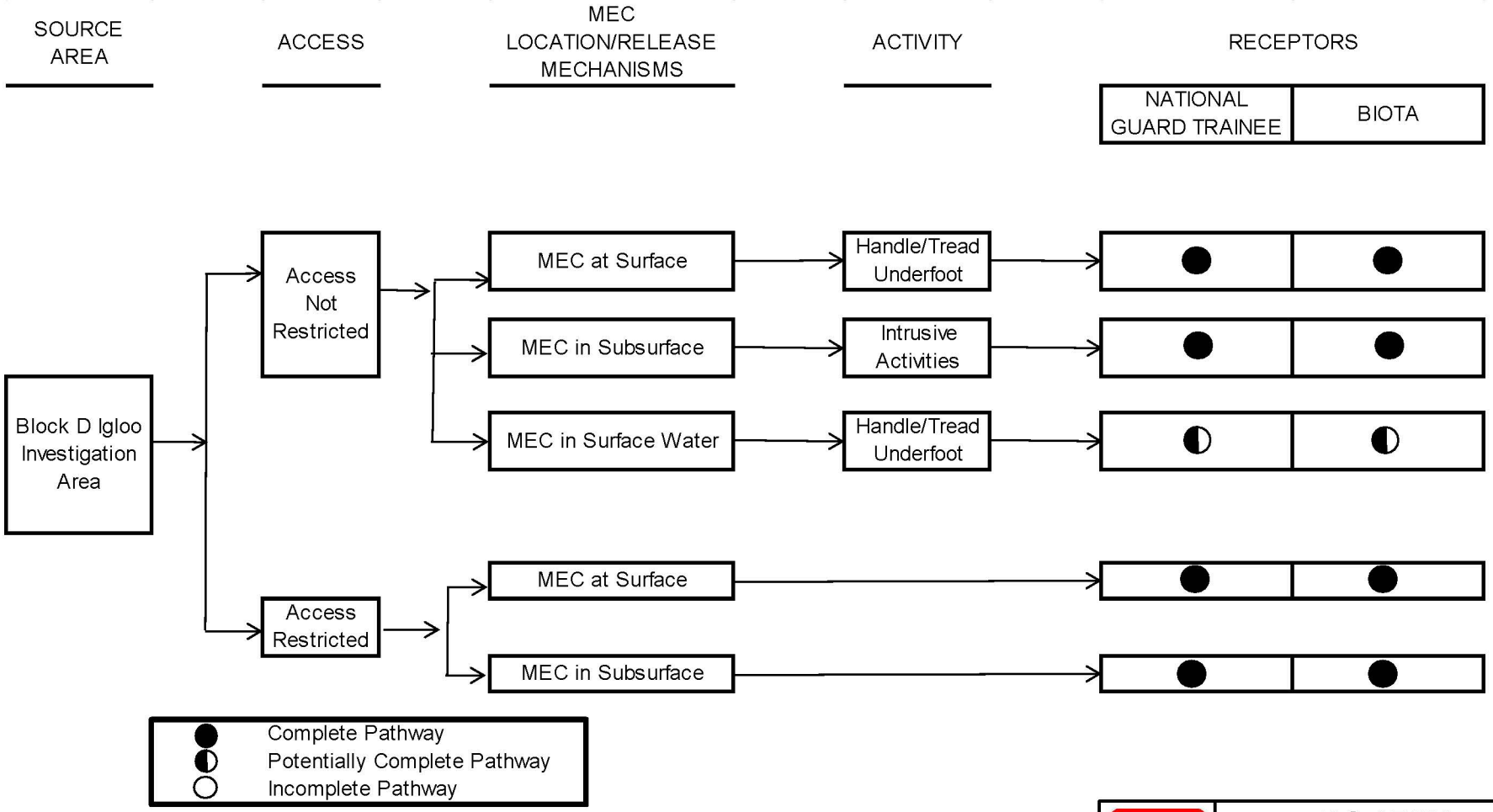
Potential users associated with current activities at the investigation area include facility personnel, contractors, trainees, and occasional trespassers. The National Guard Trainee and Range Maintenance Soldier have been identified as Representative Receptors for the future land use (Shaw, 2011). The National Guard Trainee is the most sensitive of the current and future receptors that may become exposed to any potentially remaining MEC at the Block D Igloo Investigation Area.

Ecological receptors (biota) are based on mammals and birds known to be present at the facility and, based on the physical setting, are reasonably anticipated to be present on either a permanent or transient basis at the terrestrial habitats at the Block D Igloo Investigation Area. The biota identified for the investigation area includes terrestrial invertebrates (earthworms), voles, shrews, robins, foxes, and hawks (USACE, 2003c).

9.1.2.5 MEC Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Block D Igloo Investigation Area 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 Exposure Pathway Analysis is presented on **Figure 9-2**.

A total of 178 MPPEH items were encountered on the ground surface during the RI visual survey activities and were documented as safe (i.e., MD) by the UXO-qualified personnel. Although no MEC was found on the ground surface, the presence of MEC in subsurface soils, as found during the intrusive investigations, strongly suggests that MEC most likely exists on the ground surface at uninvestigated locations. The complete MEC exposure pathway for surface soil at the Block D Igloo Investigation Area would be to handle or tread underfoot for all receptors.



ft bgs denotes feet below ground surface

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 9-2 REVISED MEC CONCEPTUAL SITE MODEL, BLOCK D IGLOO INVESTIGATION AREA

During the mag and dig investigation, a total of 3,140 MPPEH items were encountered at a maximum depth of 8 inches bgs. The UXO-qualified personnel determined that five of the MPPEH items were MEC. Based on these results, the MEC exposure pathway for subsurface soil pathway (greater than 0 inches bgs) is considered complete for all receptors that may engage in intrusive activities while using the MRS.

There are several small wetlands and unnamed streams totaling approximately 2 acres that are situated within the calculated MFD-H for the Igloo 7-D-15 accidental explosion. These areas were investigated when possible; however, thick vegetation and standing or running water restricted the ability for UXO-qualified personnel to adequately evaluate some locations. When such areas were encountered, the UXO-qualified personnel evaluated the edges of the wetland or stream for the presence of MPPEH when a visual survey transect approached them in accordance with the Work Plan (Shaw, 2011). No MPPEH was found during the evaluation of the accessible areas of the streams and wetland areas; however, the presence of buried MEC within the investigation area suggests that MEC may be present in the streams and wetlands as well. If MEC is present in these areas, receptors may become exposed by handling or treading underfoot. Therefore, the MEC exposure pathway for surface water, inclusive of the wetlands and unnamed streams, is considered potentially complete.

9.2 MC Exposure Analysis

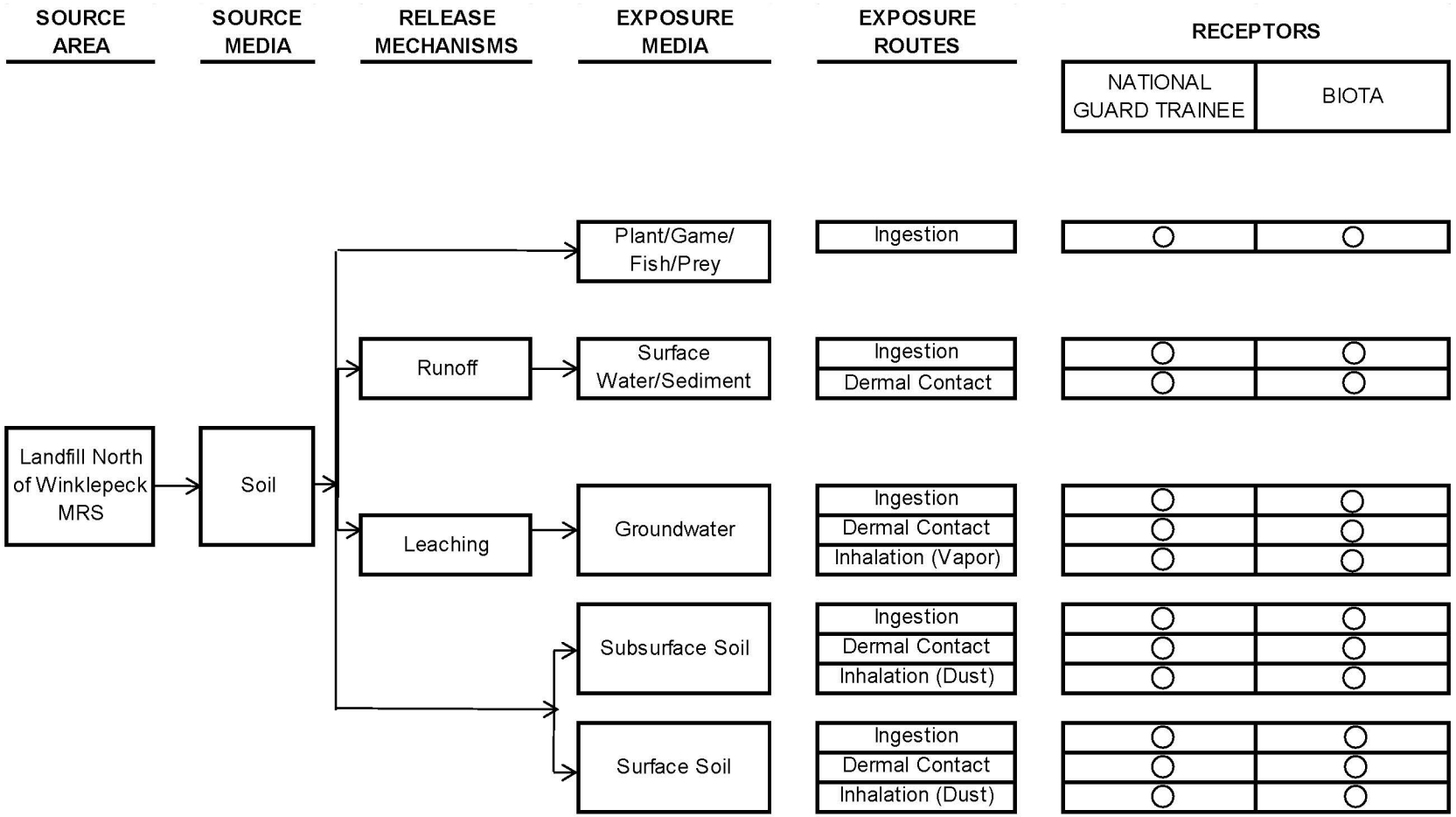
An MC is defined as any material originating from MPPEH or munitions, or other military munitions including explosive and nonexplosive materiel, and emission degradation, or breakdown elements of such ordnance and munitions (10 USC 2710(e)(4)). The information collected during the RI was used to update the CSMs 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.

9.2.1 Landfill North of Winklepeck MRS

As no MEC source was identified during the RI field activities at the Landfill North of Winklepeck MRS, sampling for MC was not warranted at the MRS. The MC CSM has been revised to reflect incomplete pathways for all receptors The revised MC Exposure Pathway Analysis for the Landfill North of Winklepeck MRS is presented in **Figure 9-3**.

9.2.2 Block D Igloo Investigation Area

An MC source is an area where MC has entered (or may enter) the environment. The MC contamination may result from a corrosion of munitions or from low-order detonation, the latter of which occurred at the Igloo 7-D-15 in 1943. Additionally, MC that is found at concentrations high enough to pose an explosive hazard is considered MEC. The revised MC



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

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 9-3 REVISED MC CONCEPTUAL SITE MODEL, LANDFILL NORTH OF WINKLEPECK MRS

Exposure Pathway Analysis for the Block D Igloo Investigation Area is presented in **Figure 9-4**.

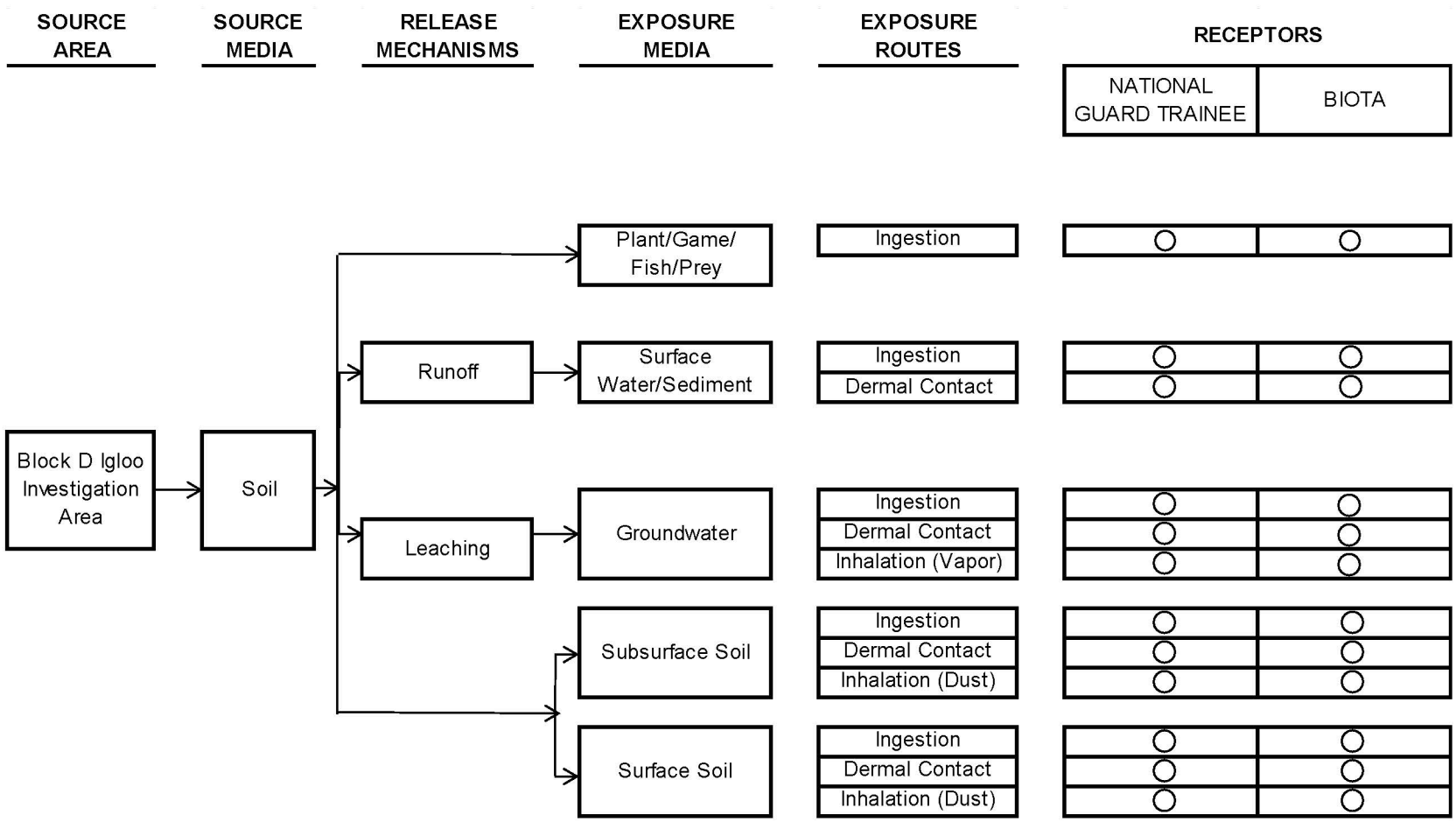
Sampling for MC was performed at the Block D Igloo Investigation Area at concentrated areas of MD and beneath individual MEC items identified during the RI field activities. The SRCs identified were antimony and iron that were detected in surface soils to a maximum depth of 0.5 feet (6 inches) bgs. However, none of the detected SRCs were determined to pose risks to likely human or ecological receptors. The MC CSM has been updated to reflect incomplete pathways for the receptors in the terrestrial environments.

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

Several small wetlands and the flood plain along the unnamed tributary to Sand Creek are present within the Block D Igloo Investigation Area. These areas were not investigated as part of the RI; however, the SRCs detected in the surrounding terrestrial environments were low and were determined not to pose risks to likely human or ecological receptors. Therefore, the aquatic environments, including surface water and sediment, are considered incomplete MC exposure pathways for the receptors.

Sufficient time has elapsed for contaminants in the surface soil to have migrated to potential exposure media, resulting in possible exposure of plants, fish and animals that come into contact with these media. The major exposure routes to ecological receptors for chemical toxicity from surface soil include ingestion for invertebrates and direct contact for plants. The SRCs in surface soil were determined to be low and the MC exposure pathway for plant/game/fish/prey is considered incomplete for all receptors.

Groundwater beneath the facility is evaluated on a facility-wide basis and MRS-specific sampling was not intended for an MRS being investigated under the MMRP unless there is a likely impact from a MEC source. Although SRCs were detected during the RI field work, the concentrations were considered low and it is unlikely that groundwater has been impacted. No groundwater samples were collected at the Block D Igloo Investigation Area during the RI field work and the MC exposure pathway for groundwater is considered incomplete.



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

ft bgs denotes feet below ground surface

U.S. ARMY
CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

LANDFILL NORTH OF WINKLEPECK MRS AND
BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

FIGURE 9-4 REVISED MC CONCEPTUAL SITE MODEL, BLOCK D IGLOO INVESTIGATION AREA

9.3 Uncertainties

The purpose of the DQO process is to adequately characterize and define the hazards/risks posed by the MRS; however, the RI/FS process does not remove all uncertainty associated with the MRS. There are minimal levels of uncertainties associated with the MEC and MC characterization results at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area that are presented in this section.

9.3.1 Landfill North of Winklepeck MRS

The primary uncertainty related to the evaluation of the RI results at the Landfill North of Winklepeck MRS is associated with the incomplete record of historical disposal operations. The HRR (e^2M, 2008) identified the landfill operations as trench and fill, and approximately 0.25 acres of the landfill AOC is collocated with the southwest corner of the MRS. However, the exact depth of burial activities along the slope of the MRS is not known. Uncertainty exists if the current debris and the MEC that was reportedly previously found at the MRS were dumped down the surface of the slope during normal landfill operations and were not actually buried or were the result of erosion of the landfill cover. No MEC was found on the slopes, inclusive of the collocated portion of the AOC and MRS during the RI field activities, and the potential risk posed by the presence of MEC within the MRS may be overstated if burial activities are considered in comparison to a one-time accidental release where munitions-related items have already been retrieved from the surface.

Secondary uncertainty is associated with the RI field investigation data where 100 percent of the accessible area was investigated, whereby the 0.7 acres of inaccessible (dense vegetation and surface water) area at the base of the slope were not able to be investigated for the potential presence of surface MEC. However, as no MEC was identified in the remaining 1.6 acres closest to the landfill boundary, it is unlikely that MEC is present at the base of the slope.

9.3.2 Block D Igloo Investigation Area

There are uncertainties and limitations associated with the delineation of the Block D Igloo Investigation Area based solely on the visual survey results of the RI. The visual survey encompassed 54 acres including 100-foot step-outs from most MD located along the investigation boundaries and beyond. A total of 178 MD items were identified on the ground surface. The intrusive investigation activities were conducted over an area that is less than 2 percent of the investigation area and a total of 3,135 buried MD and 5 buried MEC items were found. The subsurface MEC items found during the intrusive investigation were observed near surface MD items since this was the basis for the grid selections for mag and dig activities. The majority of the intrusive investigation activities was conducted in the investigation area; however, limited mag and dig activities were conducted outside of the

investigation area boundary at Grid X29 (**Figure 4-9**) and no buried MEC was found. Although remaining MEC is likely to be present where MD was found; the presence of surface MD is not necessarily an indicator of buried MEC. It is then possible that the lateral extent of buried MEC for the Block D Igloo Investigation Area is underestimated and may extend beyond the area of surface MD identified during the visual survey; however the limited intrusive investigation outside of the investigation area with no MPPEH findings reduces this uncertainty.

The mag and dig grids for the intrusive investigation activities at the Block D Igloo Investigation Area were designed based on the UXO Estimator® program that at a 95 percent confidence level, a minimum MEC density of 2.0 MEC per acre was expected to be found. Based on the five MEC items found, the average density is calculated to be 3.723 MEC per acre and actual density at a 95 percent confidence level is calculated to be 6.512 MEC per acre. Therefore, it is statistically possible that between 350 and 600 MEC items may be present at the investigation area, assuming that uniform distribution occurred as a result of the explosion. Based on the RI results, the DQO UXO Estimator® inputs were exceeded and there is a high degree of certainty that the existing MEC density at the investigation area is much greater than originally anticipated.

9.4 Munitions Response Site Prioritization Protocol

The DoD proposed the MRSPP (32 CFR Part 179) to assign a relative risk priority to each defense MRS in the MMRP Inventory for response activities. These response activities are to be based on the overall conditions at each location and taking into consideration various factors related to explosive safety and environmental hazards (68 Federal Regulations 50900 [32 CFR 179.3]). The revised MRSPP documents for the Landfill North of Winklepeck MRS and recommended revised MRS for the Block D Igloo are included in **Appendix N** for reference only. The MRSPP tables were updated or created in accordance with the *Munitions Response Site Prioritization Protocol Primer* (DoD, 2007).

10.0 SUMMARY AND CONCLUSIONS

This section summarizes the results of the RI field activities conducted at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area. The purpose of the RI was to determine whether the Landfill North of Winklepeck MRS and Block D Igloo Investigation Area warranted further response action pursuant to CERCLA and the NCP. More specifically, the RI was intended to determine the nature and extent of MEC and MC and subsequently determine the hazards and risks posed to likely human and ecological receptors by MEC and MC. Additional data are also presented in this RI Report to assist in the identification and evaluation of alternative 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

Investigation Area	Proposed Investigation Area (Acres)	Actual Investigation Area (Acres)	Were DQOs Met?	MEC Found?	MC Detected?	MC Risk Analysis
Landfill North of Winklepeck MRS	2.3	1.6	Yes	No	NA	NA
Block D Igloo Investigation Area	38	54	Yes	Yes	Yes	No further action

DQO denotes data quality objective.
MC denotes munitions constituents.
MEC denotes munitions and explosives of concern.
MRS denotes Munitions Response Site.
NA denotes not applicable.

10.1 Summary of Remedial Investigation Activities

Information available for the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area relating to the potential presence of MEC and associated MC is compiled and evaluated in this RI. The sources of this information were obtained from previous investigations and historical records, including the ASR (USACE, 2004), the HRR (e^2M, 2008), and the SI Report (e^2M, 2008).

The preliminary CSMs for each of the MRSs were evaluated based on the historical background reviews and data needs, and the DQOs were determined as outlined in the Work Plan (Shaw, 2011). The data needs included characterization for MEC and/or MC associated with the former activities or incidents at each of the investigation areas. 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. The decisions rules as identified in the DQOs for each of the MRSs and the summary of the RI activities are presented below.

10.1.1 Landfill North of Winklepeck MRS

The DQOs for the Landfill North of Winklepeck MRS identified the following decision rules that were implemented in evaluating the MRS:

- Perform an instrument-assisted visual survey to investigate for potential MEC on the ground surface.
- Perform a geophysical investigation if MEC was identified during the visual survey.
- Collect discrete samples (surface and subsurface soil) in areas with concentrated MEC/MD to evaluate for MC.
- Process the information to evaluate whether there were unacceptable hazards/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.

As part of the RI, an instrument-assisted visual survey at the Landfill North of Winklepeck MRS was performed over 100 percent of accessible areas at the MRS in May and September of 2011. Of the 2.32 acres that make up the MRS, 1.6 acres were investigated. The remaining portions of the MRS were inaccessible due to wetlands and the unnamed stream at the north portion of the MRS. No MEC was found during the RI field activities. Based on these results, a subsurface geophysical investigation or sampling for MC was not warranted at the MRS.

10.1.2 Block D Igloo Investigation Area

The DQOs for the Block D Igloo Investigation Area identified the following decision rules that were implemented in evaluating the MRS:

- Perform an instrument-assisted visual survey to identify the lateral extent of MEC and determine areas with the potential for buried anomalies.
- Perform a mag and dig investigation at selected areas identified as having surface MEC or buried anomalies.
- Collect discrete surface and subsurface soil samples in areas with concentrated MEC/MD to evaluate for MC.

- Process the information to evaluate whether there were unacceptable hazards/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.

An instrument-assisted visual survey was performed at the Block D Igloo Investigation Area between April and May 2011 to identify dispositional areas of MEC that may have resulted from the accidental explosion at Igloo 7-D-15 in 1943. The area surveyed consisted of the revised 92.14-acre investigation area and was in an east direction along the median line of the long axis of the former igloo on a 60- to 80-degree angle from the center of the former igloo. In all, 65.2 miles of instrument-assisted visual survey transects were performed at the Block D Igloo Investigation Area. Each transect consisted of a sweep width of approximately 5 feet. The total area covered was approximately 54 acres, which included the 100-foot step-outs around the MPPEH identified along the boundary of the calculated blast fan that was determined to be MD. In addition to the proposed transects, an instrument-assisted visual survey was conducted behind (west of) the location of the former magazine to verify that the blast did not produce kickout in this direction.

A total of 178 MPPEH items were identified on the ground surface during the visual survey. All of the MPPEH items were documented as safe (i.e., MD) by the UXO-qualified personnel. The MD found during the visual survey consisted of bomb fragmentation sleeves and tail fin assemblies. The maximum distance of the MD found during the visual survey from the former magazine location was approximately 1,800 feet due east. No additional MD were identified from the step-outs and the investigation west of the former magazine.

A mag and dig investigation was conducted at the Block D Igloo Investigation Area following the visual survey activities between June and July 2011. Seven 100-foot by 100-foot mag and dig grids were placed throughout the investigation area to evaluate the potential for buried MEC. The selected grid locations were biased to areas where the MD was identified during the visual survey. A total of 3,140 MPPEH items were found during the mag and dig investigation. The UXO-qualified personnel documented 3,135 of the MPPEH items as safe (i.e., MD) and 5 MPPEH items as MEC. The MD were identified to be parts associated with the M-41 20 lb fragmentation bombs. The maximum depth of the MD encountered was 0.67 feet (8 inches) bgs, and the total weight of the MD was 2,614 lbs.

The five MEC items were found at three of the seven mag and dig grid locations. The maximum depth of the MEC was 0.5 feet (6 inches) bgs, and all the MEC were identified as parts associated with the M-41 20 lb fragmentation bombs, with the exception of one item. This item was only a small piece of an ordnance component suspected to be a fuze of an unknown type associated with a small fragmentation bomb and was not consistent with the fuzes used in the 20 lb bombs that exploded at the Block D Igloo.

Following the MEC investigation, environmental samples were collected for MC analysis at the Block D Igloo Investigation Area. Three ISM surface soil samples were collected at sampling units at that consisted of three of the seven 100-foot by 100-foot mag and dig grids where the MD was well distributed on the ground surface and encountered in the subsurface. In addition, two discrete surface soil samples were collected beneath two of the individual MEC items identified at the grid locations.

10.2 Nature and Extent of SRCs

The SRCs for the Block D Igloo Investigation Area were determined for the surface soil samples collected during the RI field activities through the facility data screening process, as presented in the FWCUG Guidance (SAIC, 2010). Antimony and iron exceeded the facility BSV in all three ISM surface soil samples collected for the RI and were retained as SRCs. No SRCs were identified in the discrete surface soil samples. The maximum depth of the detected SRCs was 0.5 feet (6 inches) bgs in the ISM surface soil samples.

10.3 Fate and Transport

Five MEC items were encountered at the Block D Igloo Investigation Area during the mag and dig investigation activities. Transport of MEC is generally not anticipated to be significant at an MRS containing MEC; however, the facility does receive significant precipitation due to snowfall accumulations and heavy seasonal rain fall events that can result in 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 Block D Igloo Investigation Area, especially since the facility has very little difficulty with erosion since slope is 5 percent or less (AMEC, 2008). In addition, the investigation area is heavily forested, which most likely mitigates the potential to be impacted by the aforementioned natural processes.

Based on the current soil conditions at the investigation area, which consist primarily of silty clay loam types with low permeability and moderate pH of approximately 5.2, it is expected that iron and antimony would tend to bind to the soil and are considered relatively immobile. In addition, iron is a major element that is naturally occurring in soils, present as iron oxide minerals, and is incorporated in the structure of other minerals. The trace element antimony is also naturally occurring and has an affinity to adsorb on the surfaces of iron oxides. Therefore, these SRCs would be expected to be found in the top several inches where they were deposited as a result of the accidental detonation and subsurface or groundwater conditions have mostly likely not been impacted.

10.4 MEC Hazard Assessment

The *Interim MEC HA Methodology* (EPA, 2008) addresses human health and safety concerns associated with potential exposure to MEC at a MRS under a variety of site conditions, including various cleanup scenarios and land use assumptions. However, cleanup scenarios for a MRS are not usually addressed in an RI. If an explosive hazard is identified for this RI, the MEC HA evaluation will include the information available for the MRS up to and including the RI field activities and will provide a scoring summary for the current and future land use activities. If no explosive hazard is found at the MRS, then there is no need to calculate a MEC HA score, since there are no human health safety concerns.

10.4.1 Landfill North of Winklepeck MRS

The Landfill North of Winklepeck MRS was an unlined landfill that may have received MEC during disposal operations. Facility personnel also reported that MEC was present on the slope leading down to the unnamed tributary (e^2M, 2007). No MEC was found during the 2007 SI or during complete coverage of the land-based areas at the MRS during the RI field activities. The results of the RI indicate that no MEC source or explosive safety hazard is present at the MRS; therefore, calculation of a MEC HA was not warranted for the Landfill North of Winklepeck MRS.

10.4.2 Block D Igloo Investigation Area

A potential explosive safety hazard was identified at the Block D Igloo Investigation Area during the RI field activities; therefore, an evaluation of the MEC HA was conducted (EPA, 2008). The MEC HA score for current conditions at the Block D Igloo Investigation Area was calculated to be 640, which equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The MEC HA score for the future land use conditions at the MRS was calculated to be 670, which also equates to a Hazard Level of 3 (moderate potential explosive hazard condition). The slight increase in the MEC HA score is 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 (antimony and iron) at the Block D Igloo Investigation Area through the facility data screening process, the SRCs were then carried through the human health and ecological risk assessments process to evaluate for potential receptors. The risk assessments resulted in the following conclusions.

10.5.1 Protection of Human Health

An HHRA was conducted for surface soil samples collected at the Block D Igloo Investigation Area 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 Block D Igloo Investigation

Area is military training, and the Representative Receptors are the National Guard Trainee and the Range Maintenance Soldier. The Representative Receptors for military training, in conjunction with the evaluation of the Resident Receptor (Adult and Child) for Unrestricted Land Use, form the basis for identifying COCs in the RI. Evaluation for Unrestricted Land Use is performed to assess for baseline conditions and the no action alternative under CERCLA, and as outlined in the HHRAM (USACE, 2005). Since the RI was initiated before the finalization of the U.S. Army's technical memorandum (ARNG, 2014), the Commercial Industrial Land Use using the Industrial Receptor was not included.

Iron was the only SRC identified as a COPC in the first screening step. However, weight of evidence suggests that the detected iron concentrations are not likely to pose risks to human receptors. Since no COCs were identified for the Resident Receptor (Adult and Child), Unrestricted Land Use was achieved for MC.

10.5.2 Protection of Ecological Receptors

Both iron and antimony were identified as COPECs in the soil samples collected for the RI at the Block D Igloo Investigation Area. COPECs are determined in the ERA and may differ from COPCs. Given the conservativeness of the ERA and the low overall concentrations of antimony that was detected, the potential of exposure to iron and antimony to adversely impact populations of ecological receptors at the Block D Igloo Investigation Area is considered to be very low and not pose a concern to ecological receptors. No final COPECs are identified for surface soil and no further investigation (i.e., a Level III Baseline) or action is considered necessary at the Block D Igloo Investigation Area for ecological purposes. Therefore, there are no COPECs that require additional investigation.

10.6 Conceptual Site Models

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

10.6.1 Landfill North of Winklepeck MRS

An instrument-assisted visual survey was performed at 100 percent of the accessible areas of the Landfill North of Winklepeck MRS during the RI field activities. No MEC was observed on the ground surface at the MRS during the visual survey; therefore, the MEC exposure pathway for surface soil is considered incomplete for all receptors.

Since no MEC was identified during the visual survey, a subsurface investigation was determined to be unwarranted. Based on the lack of MEC source, an explosive hazard is not present in the subsurface at the Landfill North of Winklepeck MRS and the MEC exposure pathway for subsurface soil is considered to be incomplete.

There is an unnamed tributary and wetland area located at the base of the slope of the eastern portion of the MRS that was not investigated during the RI field activities due to dense vegetation and fallen trees, which prevented access. Although MEC was reported to be present along the slope down toward the unnamed stream, no MEC was identified on the ground surface during the SI or RI field activities and horizontal migration of MEC down the slope toward the stream is not anticipated. The MEC exposure pathway for surface water is considered incomplete for all receptors given the lack of activities which could cause potential subsurface MEC to reach the surface and migrate.

As no MEC source was identified during the RI field activities at the Landfill North of Winklepeck MRS, sampling for MC was not warranted at the MRS. The MC CSM has been revised to reflect incomplete pathways for all receptors.

10.6.2 Block D Igloo Investigation Area

A total of 178 MPPEH items were encountered on the ground surface during the RI visual survey activities and were documented as safe (i.e., MD) by the UXO-qualified personnel. Although no MEC was found on the ground surface, the presence of MEC in subsurface soils, as found during the intrusive investigations, strongly suggests that MEC most likely exists on the ground surface at uninvestigated locations. The complete MEC exposure pathway for surface soil at the Block D Igloo Investigation Area would be to handle or tread underfoot for all receptors.

During the mag and dig investigation, a total of 3,140 MPPEH items were encountered at a maximum depth of 8 inches bgs. The UXO-qualified personnel determined that five of the MPPEH items were MEC. Based on these results, the MEC exposure pathway for subsurface soil pathway (greater than 0 inches bgs) is considered complete for all receptors that may engage in intrusive activities while using the MRS.

There are several small wetlands and unnamed streams totaling approximately 2 acres that are situated within the calculated MFD-H for the Igloo 7-D-15 accidental explosion. These areas were investigated when possible; however, thick vegetation and standing or running water restricted the ability for the UXO-qualified personnel to adequately evaluate some locations. When such areas were encountered, the UXO-qualified personnel evaluated the edges of the wetland or stream for the presence of MPPEH when a visual survey transect approached them in accordance with the Work Plan (Shaw, 2011). No MPPEH was found

during the evaluation of the accessible areas of the streams and wetland areas; however, the presence of buried MEC within the investigation area suggests that MEC may be present in the streams and wetlands as well. If MEC is present in these areas, receptors may become exposed by handling or treading underfoot. Therefore, the MEC exposure pathway for surface water, inclusive of the wetlands and unnamed streams, is considered potentially complete for all receptors.

Antimony and iron were identified as SRCs in surface soil within the defined blast arc of the 1943 explosion at the Igloo 7-D-15. The HHRA and the ERA determined that the SRCs were not present at concentrations great enough to pose risks to likely human or ecological receptors. As a result, the revised MC CSM for the Block D Igloo Investigation Area identifies incomplete pathways for all receptors.

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

10.7 Uncertainties

There are minimal levels of uncertainties associated with the MEC and MC characterization results at the Landfill North of Winklepeck MRS and the Block D Igloo Investigation Area.

10.7.1 Landfill North of Winklepeck MRS

The primary uncertainty related to the evaluation of the RI results at the Landfill North of Winklepeck MRS is associated with the incomplete record of historical disposal operations. The HRR (e^2M, 2008) identified the landfill operations as trench and fill, and approximately 0.25 acres of the landfill AOC is collocated with the southwest corner of the MRS. However, the exact depth of burial activities along the slope of the MRS is not known. Uncertainty exists if the current debris and the MEC that was reportedly previously found at the MRS were dumped down the surface of the slope during normal landfill operations and were not actually buried or were the result of erosion of the landfill cover. No MEC was found on the slopes, inclusive of the collocated portion of the AOC and MRS during the RI field activities, and the potential risk posed by the presence of MEC within the MRS may be overstated if burial activities are considered in comparison to a one-time accidental release where munitions-related items have already been retrieved from the surface.

Secondary uncertainty is associated with the RI field investigation data where 100 percent of the accessible area was investigated, whereby the 0.7 acres of inaccessible (dense vegetation and surface water) area at the base of the slope were not able to be investigated for the

potential presence of surface MEC. However, as no MEC was identified in the remaining 1.6 acres closest to the landfill boundary, it is unlikely that MEC is present at the base of the slope.

10.7.2 Block D Igloo Investigation Area

There are uncertainties and limitations associated with the delineation of the Block D Igloo Investigation Area based solely on the visual survey results of the RI. The visual survey encompassed 54 acres including 100-foot step-outs from most MD located along the investigation boundaries and beyond. A total of 178 MD items were identified on the ground surface. The intrusive investigation activities were conducted over an area that is less than 2 percent of the investigation area, and a total of 3,135 buried MD and 5 buried MEC items were found. The subsurface MEC items found during the intrusive investigation were observed near surface MD items since this was the basis for the grid selections for mag and dig activities. The majority of the intrusive investigation activities was conducted in the investigation area; however, limited mag and dig activities were conducted outside of the investigation area boundary at Grid X29 and no buried MEC was found. Although remaining MEC is likely to be present where MD was found, the presence of surface MD is not necessarily an indicator of buried MEC. It is then possible that the lateral extent of buried MEC for the Block D Igloo Investigation Area is underestimated and may extend beyond the area of surface MD identified during the visual survey; however, the limited intrusive investigation outside of the investigation area with no MPPEH findings reduces this uncertainty.

The mag and dig grids for the intrusive investigation activities at the Block D Igloo Investigation Area were designed based on the UXO Estimator® program that at a 95 percent confidence level, a minimum MEC density of 2.0 MEC per acre was expected to be found. Based on the five MEC items found, the average density is calculated to be 3.723 MEC per acre and actual density at a 95 percent confidence level is calculated to be 6.512 MEC per acre. Therefore, it is statistically possible that between 350 and 600 MEC items may be present at the investigation area, assuming that uniform distribution occurred as a result of the explosion. Based on the RI results, the DQO UXO Estimator® inputs were exceeded and there is a high degree of certainty that the existing MEC density at the investigation area is much greater than originally anticipated.

10.8 Conclusions

This section presents the conclusions of the RI based on the results of the RI field activities for MEC characterization at the Landfill North of Winklepeck MRS and MEC and MC characterization at the Block D Igloo Investigation Area.

10.8.1 Landfill North of Winklepeck MRS

The 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 Landfill North of Winklepeck MRS based on the results of the RI field activities:

- All accessible areas at the MRS were investigated during the RI.
- Inaccessible areas could not be investigated due to obstacles (deadfall), wetland/marshes, and thick vegetation along the edges of these areas.
- An intrusive investigation was not warranted because no physical evidence of MEC was identified on the ground surface.
- MC sampling was not warranted because no MEC was found at the MRS during the RI field activities; therefore, no further action is required for MC at this MRS.

Based on the results of the RI field work, it is concluded that the nature and extent of MEC and MC at the Landfill North of Winklepeck MRS have been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. No explosive safety hazards or potential sources of MC have been identified at the MRS. The recommended next course of action under the MMRP for the Landfill North of Winklepeck MRS will be to proceed to a No Further Action Proposed Plan.

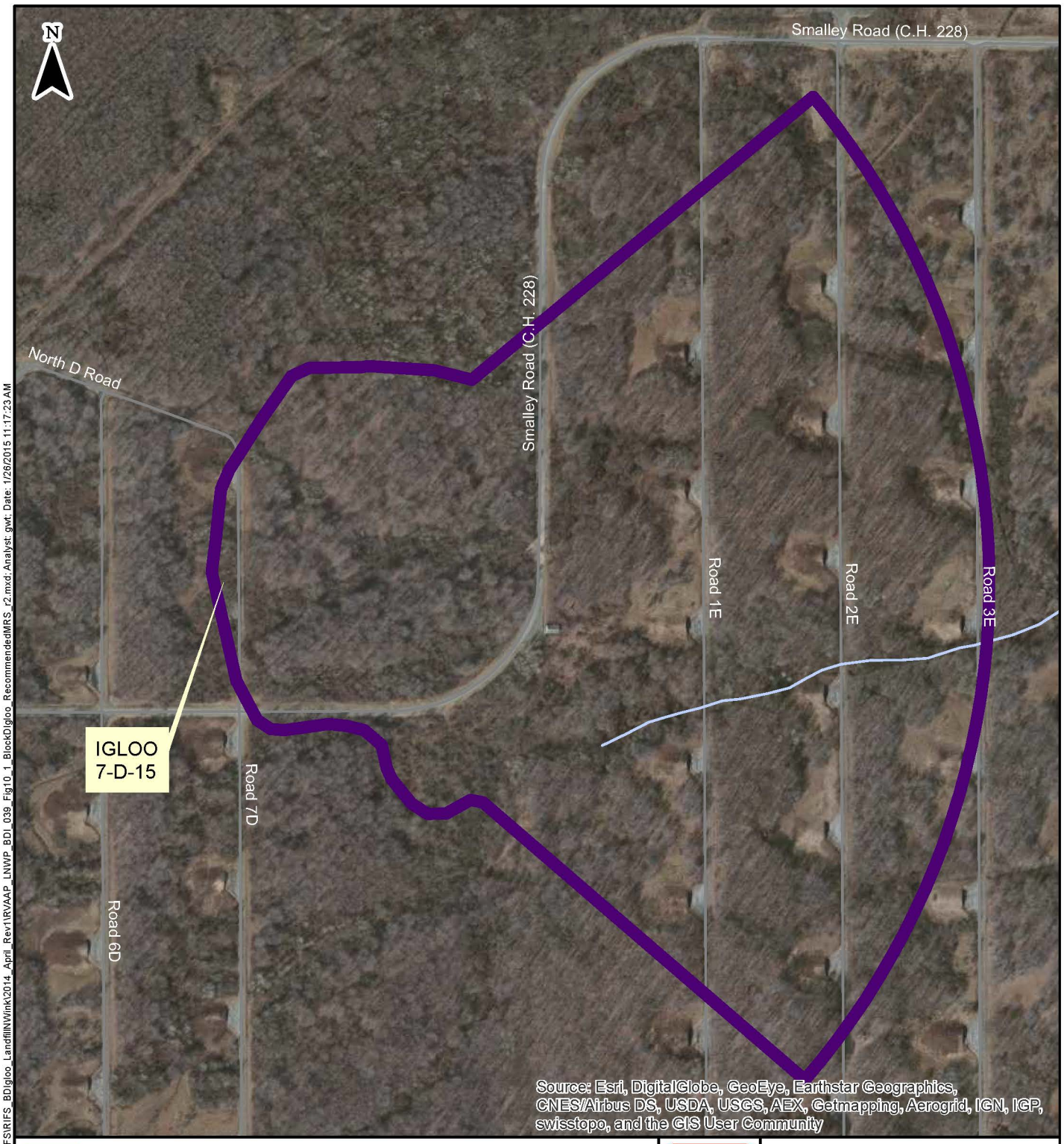
10.8.2 Block D Igloo Investigation Area

The 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 Block D Igloo Investigation Area based on the results of the RI field activities:

- The maximum horizontal distance of surface MD found from the former igloo footprint (1,800 feet) supports the revised calculated MFD-H for the Igloo 7-D-15 explosion (2,389 feet).
- MPPEH documented as safe (i.e., MD) was encountered on the ground surface outside of the north and south investigation area boundaries.
- Five MEC items posing explosive safety hazards were encountered in subsurface soil in the investigation area.
- The actual MEC density was determined to be greater than the MEC density assumed for the DQOs.

- The SRCs that were evaluated as MC in surface soil do not pose hazards to likely human or ecological receptors at the investigation area.

The RI for the Block D Igloo Investigation Area included risk assessments for explosives hazards and MC that may pose risks to likely receptors. Based on the results of the RI field work, it is concluded that the nature and extent of MEC and MC at the investigation area have been adequately characterized and the DQOs presented in the Work Plan (Shaw, 2011) have been satisfied. The total area that was impacted by the explosion that occurred at Igloo 7-D-15 is approximately 101.6 acres that is considered as the revised Block D Igloo MRS. The revised MRS area maintains the calculated MFD-H of 2,389 feet from the former igloo and includes a 100-foot buffer zone beyond the bound lateral extent of MD that represent the potential for MEC at those locations as well. A FS is recommended as the next course of action under the MMRP at the revised Block D Igloo MRS to assess possible response action alternatives for likely remaining MEC. The revised boundary for the Block D Igloo MRS is presented on **Figure 10-1**.



Revised Block D Igloo MRS Boundary

Stream

0 450 900 Feet

Projection : NAD_1983_UTM_Zone_17N

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

MILITARY MUNITIONS RESPONSE PROGRAM

BLOCK D IGLOO INVESTIGATION AREA
FORMER RVAAP/CAMP RAVENNA
PORTAGE AND TRUMBULL COUNTIES, OHIO

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

H:\MMAMMS\RavennaIGIS_Documents\Project_Maps\MMRP\RIFS\RIFS_BDIgloo_LandfillNWink2014_April_Rev1\RVAAP_LNWP_BDI_039_Fig10_1_BlockDIgloo_RecommendedMRS_r2.mxd; Analyst: gwt; Date: 1/26/2015 11:17:23 AM

FIGURE 10-1 REVISED BLOCK D IGLOO MRS

11.0 REFERENCES

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

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

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

Army National Guard-ILE Cleanup, U.S. Army (ARNG), 2014. *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the Ravenna Army Ammunition Plant (RVAAP) Installation Restoration Program, Portage /Trumbull Counties, Ohio (Tech Memo).* Memorandum between ARNG-ILE Cleanup and the Ohio Environmental Protection Agency, dated February 4.

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

Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Fowler, J.R. Freed, P. Jennings, R.L. Durfee, F.C. Whitmore, B. Maestri, W.R. Mabey, B.R. Holt, and C. Gould (Callahan, et al.), 1979. *Water-Related Environmental Fate of 129 Priority Pollutants*, Volume 1, EPA-440/4-79-029a, pp. 5-1–5-8.

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

Department of Defense (DoD) Office of the Deputy Under Secretary of Defense (Installations & Environment) Office of Environmental Management, 2007. *Munitions Response Site Prioritization Protocol Primer*, April.

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

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

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

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

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

Environmental Quality Management, Inc. (EQM), 2012. *Final Facility-Wide Groundwater Monitoring Program, RVAAP-66 Facility-Wide Groundwater Report on the January 2012 Sampling Event, Ravenna Army Ammunition Plant, Ravenna, Ohio,* July 18.

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

Kabata-Pendias, A., 2001. *Trace Elements in Soils and Plants*, Third Edition, CRC Press.

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

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

Langmuir, D., P. Chrostowski, B. Vigneault, and R. Chaney (Langmuir, et al.), 2004. *Issue Paper on the Environmental Chemistry of Metals*, U.S. Environmental Protection Agency Risk Assessment Forum, Washington, D.C.

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

MKM Engineers, Inc. (MKM), 2007. *Final Characterization of 14 AOCs at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* March.

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

Ohio Environmental Protection Agency (Ohio EPA), 2004. *Directors Final Findings and Orders*, Division of Emergency and Remedial Response, Columbus, Ohio, June.

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

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

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

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

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

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

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

SAIC, 2012. *Draft Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-19 Landfill North of Winklepeck Burning Ground, Ravenna Army Ammunition Plant, Ohio.* February 17.

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

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

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

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

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

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

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

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

USACE, 2003b. *Unexploded Ordnance (UXO) Estimator®, Version 2.2*, Licensed to U.S. Army Corps of Engineers Engineering and Support Center, Huntsville, Alabama.

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

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

USACE, 2005. *RVAAP Facility-Wide Human Health Risk Assessor Manual*.

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

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

USACE, 2010. *Risk Assessment Handbook Volume II: Environmental Evaluation,* Engineer Manual 200-1-4, December 31.

USACE, 2011. *Final PBA08 Unified Ecological Risk Assessment Report Outline, List of Possible Evaluation Factors, and List of Important Ecological Places*, August 26.

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

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

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

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

U.S. Environmental Protection Agency (EPA), 1983. *Methods for Chemical Analysis of Water and Wastes*, EPA/600479020, March.

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

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

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

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

EPA, 2003. *U.S. EPA Region 5 RCRA Ecological Screening Levels, August 22*, <http://www.epa.gov/reg5rcra/ca/edql.htm>.

EPA, 2007. EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols*.

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

EPA, 2010. *Guidance for Developing Ecological Soil Screening Levels*, Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C., <http://epa.gov/ecotox/ecossl/index.html>.

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

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

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

This page intentionally left blank.

Appendix A
Rationale for Reduction in Investigation Area for Block D Igloo MRS

Appendix B
Ohio EPA Correspondence

Appendix C
Field Documentation

Appendix D
Data Validation Report

Appendix E
Summary of Laboratory Analytical Data

Note: Data submitted on compact disc.

Appendix F
Investigation-Derived Waste Management

Appendix G
Photographic Documentation Logs

Appendix H
Visual Survey and Intrusive Investigation Results

Appendix I
Munitions Debris Waste Shipment and Disposal Records

Appendix J
Notifications for MEC Disposal

Appendix K
Munitions Data Sheets

Appendix L
MEC Hazard Assessment Worksheets

Appendix M
Ecological Screening Values

Appendix N
Munitions Response Site Prioritization Protocol Worksheets

Appendix O
Responses to Ohio EPA Comments

Appendix P
Ohio EPA Approval Letter

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