F I N A L

R E M E D I A L I N V E S T I G A T I O N R E P O R T

CROW'S NEST IMPACT AREA
MILITARY MUNITIONS RESPONSE PROGRAM
MUNITIONS RESPONSE SITE WSTPT-023-R-01

WEST POINT MILITARY RESERVATION
WEST POINT, NEW YORK

Prepared for

U.S. Army Corps of Engineers
10 South Howard Street
Baltimore, MD 21201-1715
Contract No. W912DR-12-D-0011/DO 0001

December 2016

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Tables

Figures

Appendices (on CD)

ºF	degrees Fahrenheit
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
ALM	Adult Lead Methodology
ARAR	applicable or relevant and appropriate requirements
Army	U.S. Army
AVS	Acid Volatile Sulfide
BERA	Baseline ecological risk assessment
BKSF	biometric slope factor
CENAB	U.S. Army Corps of Engineers Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CHE	Chemical Warfare Material Hazard Evaluation
CMUA	concentrated munitions use area
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
DGM	digital geophysical mapping
DMM	discarded military munitions
DNT	dinitrotoluene
DO	delivery order
DoD	U.S. Department of Defense
DQO	data quality objective
DU	decision unit
EE/CA	Engineering Evaluation / Cost Analysis
EHE	Explosive Hazard Evaluation
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency
ESP	Explosives Site Plan
ESQD	Explosive Safety Quantity Distance
EZ	exclusion zone
FUDS	Formerly Used Defense Site

GNSS	Global Navigation Satellite System
GPS	global positioning system
HA	hazard assessment
HE	high explosives
HFD	hazardous fragment distance
HHE	Health Hazard Evaluation
HHRA	human health risk assessment
HQ	hazard quotient
ID	identification
IS	incremental sampling
ISM	incremental sampling methodology
ITS	instrument test strip
LCS	laboratory control spike
LOD	limit of detection
LOQ	limit of quantification
MC	munitions constituents
MCOC	munitions constituents of concern
MD	munitions debris
MDAS	material documented as safe
MDC	maximum detection concentration
MDEH	material documented as an explosive hazard
MDL	method detection limit
MEC	munitions and explosives of concern
MFD	maximum fragment distance
mg/kg	milligram per kilogram
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRS	munitions response site
MRSPP	munitions response site prioritization protocol
MS/MSD	matrix spike/matrix spike duplicate
MSD	Minimum separation distance
NAD83	North American Datum of 1983

NCMUA	non-concentrated munitions use area
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
PbB	lead blood concentration
PTTF	powder train time fuze
QA	quality assurance
QC	quality control
QL	quantitation limit
RA	removal action
RAGS	Risk Assessment Guidance for Superfund
RI	remedial investigation
RPD	relative percent difference
RSD	relative standard deviation
RSL	Regional Screening Levels
SEM	Simultaneously Extracted Metals
SI	Site Inspection
SLERA	Screening level ecological risk assessment
SOP	standard operating procedure
SU	sampling unit
SUXOS	Senior Unexploded Ordnance Supervisor
TCRA	Time Critical Removal Action
TNT	trinitrotoluene
TOC	Total Organic Carbon
TP	technical paper
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
VSP	Visual Sampling Plan

Under the Military Munitions Response Program (MMRP), a remedial investigation (RI) was completed at the Crow's Nest Impact Area Munitions Response Site (MRS), WSTPT-023-R-01, at the West Point Military Reservation (referred to as the Installation). The MRS also includes former Training Areas G1, G2, and J1.

The purpose of the MMRP RI was to determine whether further remedial response is required pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the National Oil and Hazardous Substances Pollution Contingency Plan. The overall objective of the RI is to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and evaluate the explosive hazards and assess the potential risks to human health and the environment.

The Installation is located approximately 50 miles north of New York City and 90 miles east of Scranton, PA. It is divided into two main areas: the Main Post and the Military Reservation. The Crow's Nest MRS is part of the Military Reservation, outside of the cantonment area to the north of the Main Post. It is located entirely within Orange County. The Crow's Nest MRS is approximately 615 acres and consists of the historical Crow's Nest Impact Area and former Training Areas G1, G2, and J1.

The Crow's Nest MRS is associated with former artillery training and testing ranges used from the early 1800s to the early 1930s at the Installation. Eight artillery range fans were oriented toward the former Crow's Nest Impact Area and overlie Training Areas G1, G2, and J1. They included Artillery Firing Ranges (Adolphs Pond, Silver Depository, and Sacred Heart Cemetery), Fort Clinton, Lusk Reservoir, Redoubt No. 2, Siege Battery, and West Point Foundry (testing range).

RI field activities were conducted between August and November 2015. Analog mag and dig geophysical surveys were performed and data were collected for 32.2 miles (39.1 acres) of transects across the Crow's Nest MRS. Of this total, 6.4 miles (7.8 acres) were not intrusively investigated within a planned 239-foot safety buffer along roadways.

Sixty unexploded ordnance (UXO) and material potentially presenting an explosive hazard (MPPEH) (11 types of munitions or munitions-components) items were recovered from the Crow's Nest Impact Area and included 75 mm projectiles (shrapnel and high explosive [HE]) and associated fuzes, 6-inch common HE, 4.7-inch HE, 155 mm MK1 HE, boosters, and fuzes. No MEC were identified within Training Areas G1, G2, or J1. A total of 2,693 munitions debris (MD) items were recovered from the MRS. Approximately 227 anomalies were detected within the safety buffer across the MRS but not investigated. Upon evaluation of the MEC/MD anomaly data, two separate concentrated munitions use areas (CMUAs) were identified, one in the Crow's Nest Impact Area and the other in Training Area G2. The Crow's Nest Impact Area CMUA is approximately 116 acres and has an average MEC density of 0.52 MEC/acre. No MEC were found in the Training Area G2 CMUA.

Incremental sampling (IS) and discrete sampling methodologies were used to characterize MC in soil and sediment when 1) potential MEC releases were identified during geophysical surveys (i.e., CMUA), or 2) MEC item locations (single or multiple items) where soil staining or visible evidence of a potential MC release was observed (e.g., cracked, leaking, or partially filled munitions; staining of soil or sediment under munitions; evidence of low-order detonations).

The IS design was based on CMUA locations. Discrete samples were collected in relation to a low-order detonated 155 mm HE projectile and a large pile of UXO/MPPEH. Samples were analyzed for explosives—trinitrotoluene (TNT) and its breakdown products 2,4-dinitrotoluene (DNT), 2,6-DNT, 2-Amino (Am)-DNT, and 4-Am-DNT (soil only)—as well as metals—lead (soil and sediment).

TNT and DNT breakdown products were detected at trace levels in surface soil but did not exceed human health or ecological screening criteria. Lead was detected in surface soil and sediment above human health and ecological screening criteria.

The associated risks of lead to human health and the environment were evaluated through a human health risk assessment (HHRA) and a screening level ecological risk assessment (SLERA). The results of the HHRA show no unacceptable risk to current and future human receptors. The results of the SLERA indicate that, given the large size of DU-01 and colocation of DU-02, species that have a limited home range and could potentially spend all or most of their lives at the site, such as small insectivorous mammals and birds, have the greatest likelihood to be adversely affected by contaminants at the site.

An MEC Hazard Analysis was performed, which resulted in a Hazard Level 1 (HE hazard condition) designation for the Crow's Nest MRS for current land use and future land use assuming public use.

Data collected during the RI meet the data quality objectives and are sufficient to adequately characterize the nature and extent of MEC and MC at the Crow's Nest MRS. The distribution of MEC/MD confirms the summit of the mountain (Crow's Nest) was the main artillery target, and the types of munitions identified are consistent with the types of artillery reportedly used at the former ranges. In addition, the data show a target/impact area on the lower eastern portion of the mountain within Training Area G2. No MEC were found in this area during the RI. The types of MD recovered are consistent with the testing range at the West Point Foundry (Parrott rounds), Siege Battery, and Fort Clinton ranges (cannonballs/mortars). Based on the data, the following conclusions have been made for the Crow's Nest MRS:

- MEC hazards are present in the former Crow's Nest Impact Area.
- No MEC were identified within the three training areas. Significant MD was identified in Training Area G2, and MEC could be present.
- Based on the MRSPP, a Priority of 3 is assigned to the MRS.
- No unacceptable risk from MC to current or future human receptors in soil or sediment was determined.
- SLERA results indicate there is a potential for adverse effects to ecological receptors as a result of lead concentrations in soil and sediment. However, the results are highly conservative by design and there are many uncertainties inherently associated with screening level assessments. The risk assessment results represent potential risks to single individual organisms, not to a population or community. As such, what, if any, effect the concentrations of lead found within the MRS have on ecological communities as a whole is not known.

- A baseline ecological risk assessment (BERA) is not necessary since the SLERA results are based on a refinement of contaminants of concern and further characterization of ecological effects (food chain modeling). In addition to the SLERA, a refined screening was conducted where less conservative (average) estimates were used; the refined screening provides an insight regarding the likely results of a BERA.

A Feasibility Study is recommended to further evaluate future remedial action for MEC at the Crow's Nest Impact Area MRS (WSTPT-023-R-01).

SECTION ONE: INTRODUCTION

URS Group, Inc. (URS), a wholly owned subsidiary of AECOM, performed munitions response and environmental services at the Crow's Nest Impact Area and Training Areas G1, G2, and J1, Munitions Response Site (MRS) Number WSTPT-023-R-01 (herein collectively referred to as the Crow's Nest MRS) under the Military Munitions Response Program (MMRP). The Crow's Nest MRS is located at the U.S. West Point Military Reservation (herein referred to as the Installation) in West Point, NY (**Figure 1-1**).

1.1 PROJECT AUTHORIZATION

URS performed this remedial investigation (RI) at the Crow's Nest MRS at the request of the U.S. Army Corps of Engineers (USACE), Baltimore District (CENAB), under Contract Number W912DR-12-D-0011, Delivery Order (DO) 0001, issued on 29 September 2014. The RI was performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986; the National Oil and Hazardous Substances Pollution Contingency Plan (Title 40 of the Code of Federal Regulations [CFR] Part 300), and applicable provisions of 29 CFR Section 1910.120, hazardous waste operations and emergency response.

The lead agency for this RI is the U.S. Army with support from the New York State Department of Environmental Conservation (NYSDEC). This document was prepared using applicable components of the *Final Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) and in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988).

1.2 PURPOSE AND SCOPE

The U.S. Department of Defense (DoD) established the MMRP under the Defense Environmental Restoration Program to address unexploded ordnance (UXO), discarded military munitions (DMM), munitions constituents (MC) in sufficiently high concentrations to pose an explosives hazard (collectively known as munitions and explosives of concern [MEC]), and MC in media (residual metals and explosives) located on current and former defense sites. Sites that are eligible under the MMRP are non-operational ranges where MEC are known or suspected to be present. Sites that are classified as operational military ranges, permitted munitions disposal facilities, or operating munitions storage facilities are not eligible for the MMRP. **Figure 1-1** shows current operational range areas at the Installation. Other MRSs eligible under the MMRP at the Installation that previously underwent RI activities are shown on **Figure 1-2**.

The 2015 Site Inspection (SI) Report (URS, 2015a) recommended an RI for both MEC and MC, based on the confirmed presence of MEC and the potentially complete MC exposure pathways that exist in association with MEC.

1.3 MUNITIONS RESPONSE SITE DESCRIPTION AND PROBLEM IDENTIFICATION

The Installation is located in Orange and Putnam Counties and is approximately 50 miles north of New York City and 90 miles east of Scranton, PA. It is divided into two main areas: the Main Post and the Military Reservation. The Main Post covers approximately 2,530 acres and contains

the majority of the U.S. Military Academy, residential housing, and athletic and support facilities. An additional 13,444 acres comprises the Military Reservation, which is largely undeveloped and contains operational training facilities, ranges, and bivouac areas where cadets are trained and housed.

The Crow's Nest MRS is part of the Military Reservation, outside of the cantonment area to the north of the Main Post (**Figure 1-1**). It is located entirely within Orange County. The Crow's Nest MRS is approximately 615 acres and consists of the historical Crow's Nest Impact Area and former Training Areas G1, G2, and J1. It is bounded to the east by the Hudson River, to the west by Black Rock Forest Preserve, to the north by Storm King State Park, and to the south by the Main Post. Training Areas G1, G2, and J1 are located to the west, east, and southwest of the former Crow's Nest Impact Area, respectively. **Figure 1-2** presents the locations of the individual areas composing the Crow's Nest MRS and **Table 1-1** summarizes the location and background of each former training area.

Table 1-1: Crow's Nest MRS Areas

Area	Acreage	Location/Background
Crow's Nest Impact Area	350	Located on northern boundary of the Installation and encompasses the Crow's Nest Mountain. This area is a historical impact area for several former artillery ranges used from the early 1800s through the 1930s. MEC have been recovered over the years in this area. In 2001, a UXO survey was completed in support of a gas line being installed across the area. Approximately 0.64 acres were surveyed. One MEC was discovered.
Training Area G1	102	Located west-southwest of the Crow's Nest Impact Area. Specific historical use of the training area is unknown but was likely limited given the steep terrain and small size. During a 1994 UXO survey, munitions debris (MD) was identified along the western edge of the training area. In 2001, a UXO survey was completed in support of a gas line being installed across the area. Approximately 0.2 acres were surveyed. Only MD was recovered.
Training Area G2	33	Located east of the Crow's Nest Impact Area and adjacent to the Hudson River. Specific historical use of the area for training is unknown but given the very steep terrain and small size this area was not likely used for munitions training. No previous investigations or surveys were conducted.
Training Area J1	130	Located south-southwest of the Crow's Nest Impact Area. Specific historical use of the area for training is unknown but given the very steep terrain and small size this area was not likely used for munitions training. In 2001, a UXO survey was completed in support of a gas line installation. Approximately 0.44 acres were surveyed. Only MD was recovered.

The usability of the former Training Areas G1, G2, and J1 for military training was limited because of their small size and very steep terrain. In 2013, these three training areas were approved for closure by a Department of Army Memorandum dated 09 January 2013 and were subsequently included with the Crow's Nest Impact Area to ensure that all potential contamination associated with the use of Crow's Nest Mountain as a historical target could be addressed under the MMRP.

1.3.1 Historical Use

Based on findings presented in the MMRP Historical Records Review (Tech Law, Inc., 2006) and the 2007 SI Report (TLI Solutions, Inc., 2007) for the former ranges that targeted the Crow's Nest Mountain (the former Crow's Nest Impact Area), the Installation was the principal testing ground for ordnance in the 19th century. Batteries were first constructed and used for artillery training at the Installation during the Revolutionary War; additional batteries and ranges were established and used until World War II. As a result, a wide array of munitions was fired toward Crow's Nest Mountain, north of the Main Post, over which the Crow's Nest MRS lies.

The Crow's Nest MRS is associated with former artillery training that occurred from the early 1800s to the early 1930s. Eight artillery range fans, including a testing range that originated on the east side of the Hudson River (West Point Foundry), were oriented toward the former Crow's Nest Impact Area and overlie Training Areas G1, G2, and J1. **Figure 1-3** shows the orientation of the former artillery range fans associated with the Crow's Nest MRS. **Table 1-2** lists the potential types of artillery used and periods of their use.

Table 1-2: Former Ranges Targeting the Crow's Nest MRS

Range	Types of Artillery[1]	Period of Use
Artillery Firing Ranges: Adolphs Pond, Silver Depository, and Sacred Heart Cemetery	• 2.95-inch howitzer • 75 mm guns • 6-inch high-capacity gun • 15-inch and 16-inch mortar	1906 – late 1930s
Fort Clinton	• brass 4-pounder • brass mortars • iron 12-pounder or 18-pounder • 75 mm guns	1830s – 1927
Lusk Reservoir	• 2.95-inch howitzer • 75 mm guns • 6-inch high-capacity gun • 15-inch and 16-inch mortar	1909 – 1916
Redoubt No. 2	• 2.95-inch howitzer • 75 mm guns • 6-inch high-capacity gun • 15-inch and 16-inch mortar	1915 – 1916
Siege Battery	• 4½-inch rifled gun • 30-pound Parrott gun • 8-inch and 10-inch smooth bore siege mortars • 3.2-inch field guns • 5-inch steel breech-loading gun • 7-inch steel breech-loading howitzers • 7-inch breech-loading mortars	1845 – 1910
West Point Foundry (Artillery Testing)	• 8-inch Parrott gun • 32-42-pounder cannon • 36-32-pounder cannon • 10-pounder (2.9-inch rifle) • 100-pounder • 300-pounder (10-inch rifle)	1820s – 1870s

[1] Explosive fillers used were mainly black powder and trinitrotoluene (TNT).

1.3.2 Previous Investigations / Surveys / Removal Actions

The following summarizes the findings of investigations, UXO surveys, and removal actions (RAs) previously conducted within the Crow's Nest MRS as well on the Main Post of the Installation, south of the MRS, and in the Storm King State Park Formerly Used Defense Site (FUDS), north of the MRS boundary (**Figures 1-1** and **1-2**). The firing points and range floors of the former ranges located on the Main Post of the Installation and associated with the Crow's Nest MRS were investigated under the MMRP in 2011.

Table 1-3 summarizes the MEC reported/recovered during these investigations/actions.

Table 1-3: Summary of MEC Reported/Recovered From Previous Investigations

Source Report	MEC	Location/Area
1994 UXO Site Survey Finds (475 MEC/MD items)	• 75 mm shrapnel and HE projectiles • 8-inch projectile • 6.5-inch projectile • 2.94-inch Absterdam Subpattern II (3-inch rifle) • 120 mm projectile • 7-inch projectile	Crow's Nest Impact Area and north and west of boundary
2000 Time Critical Removal Action (TCRA) (23 MEC/86 MD items)	• 75 mm HE projectile • M1907 powder-train time fuze (PTTF) • 3-, 4-, 5-, 6-, and 8-inch projectiles	Storm King Site (Palisades Park and the New York Central Railroad easement along the Park's eastern boundary)
2001 UXO Clearance for Utility Installation (1 MEC/10 MD items)	• 115 mm shrapnel projectile • 75 mm projectile	Crow's Nest Impact Area, Training Areas G1 and J1, and Main Post
2002 Engineering Evaluation / Cost Analysis (EE/CA) (10 MEC/476 MD items)	• 75 mm projectile • 75 mm HE projectiles, fuzed and unfuzed • 6-inch MK 34 projectile • M1907 PTTF, inert	Storm King State Park FUDS (north of Crow Nest MRS)
2006 RA[1] (520 MEC items)	• 75 mm MK1 Shrapnel projectile • M1907 PTTF • 75 mm HE • Booster/fuze	
2011 Remedial Investigation	• 8-inch Parrott Projectile • 8-inch Butler Projectile • MK II Hand Grenade (unfuzed) • 90 mm APC-T	Main Post of the Installation (south of Crow's Nest MRS)

[1] MEC recovered from area located north of the Crow's Nest MRS

1.3.2.1 2015 Site Inspection Report, Crow's Nest Impact Area and Training Areas G1, G2, and J1, Military Munitions Response Program, West Point Military Reservation, West Point, NY

Available historical information was reviewed and reported in the 2015 SI Report for the Crow's Nest MRS (URS, 2015a). The SI conclusion, as approved by CENAB and stakeholders, is that the strength of the historical information available is sufficient to reasonably determine that additional investigation is required because of the known presence of MEC and the lack of MC

sampling at the Crow's Nest MRS. As a result, the SI recommends that the Crow's Nest MRS proceed to the RI phase for MEC and MC.

1.3.2.2 2014 and 2015 Final Remedial Investigation Reports Associated with the Former Range Fans

RIs were conducted for the portion of the former range fans targeting the Crow's Nest Impact Area (Crow's Nest Mountain) located on the Main Post of the Installation. Weston Solutions, Inc. investigated MRSs that included the firing points and range fan danger areas in front of the impact area between April and August of 2011 (see **Figure 1-2**). Digital geophysical mapping (DGM) and "mag and dig" surveys were performed to locate surface and subsurface anomalies for investigation along transects and grids within each MRS. Focused sampling for MC in soil was also conducted at firing points and where evidence of munitions-related impacts were recorded during the geophysical investigations. A summary of RI results are presented below. Additional details of the RIs conducted for each range fan are provided in the referenced RI reports listed in **Table 1-4.**

Table 1-4: RI Reports Associated with Crow's Nest Former Range Fans

Former Range (MRS)	RI Report Reference
Artillery Firing Ranges: (Adolph's Pond, Silver Depository, and Sacred Heart Cemetery) (WSTPT-001-R-01); Artillery Firing Range North (WSTPT-001-R-02); and Artillery Firing Range South (WSTPT-001-R-03)	Weston, 2015. *Final Remedial Investigation Report for Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range Munitions Response Sites*. U.S. Army Garrison West Point, West Point, NY. March 2015.
Fort Clinton (WSTPT-008-R-01)	
Lusk Reservoir (WSTPT-019-R-01)	
Siege Battery (WSTPT-015-R-01)	
Redoubt No. 2 (WSTPT-020-R-01)	Weston, 2014. *Final Remedial Investigation Report for Redoubt No. 2 Munitions Response Sites*. U.S. Army Garrison West Point, West Point, NY. October 2014.

Artillery Firing Range – No MEC were recovered during the RI. Fifty-eight MD items were recovered from the MRS. The MRS boundary was revised to encompass the 7 acres of the firing point area. No MEC or MD were recovered within the revised MRS. Approximately 42 acres was associated with the former Crow's Nest Impact Area and transferred to Artillery Firing Range North MRS (WSTPT-001-R-02). Another 123.4 acres was delineated as a separate MRS, Artillery Firing Range South MRS (WSTPT-001-R-03). MC pathways were determined to be incomplete for all MRSs associated with the Artillery Firing Ranges.

Fort Clinton West (WSTPT-008-R-01) – Three subsurface UXO and 32 MD items were recovered from the northwestern area of the Fort Clinton MRS during the RI. UXO identified included MKII hand grenades (two) and an 8-inch Butler projectile. The MRS boundary was revised to encompass 1.7 acres. No MEC or MD were recovered within the revised MRS and 12.7 acres of the northwestern portion of Fort Clinton West was transferred to Artillery Firing

Range North MRS (WSTPT-001-R-02) because of its association with the former Crow's Nest Impact Area. MC pathways were determined to be incomplete for both MRSs.

Lusk Reservoir (WSTPT-019-R-01) – No MEC were recovered during the RI. Thirteen MD items were recovered. The MRS boundary was revised to encompass 74.4 acres, and 8.8 acres was transferred to Artillery Firing Range North MRS (WSTPT-001-R-02) because of its association with the former Crow's Nest Impact Area. MC pathways were determined to be incomplete for both MRSs.

Siege Battery (WSTPT-015-R-01) – No MEC were recovered during the RI. Six hundred forty-six MD items were recovered. The MRS boundary was revised to encompass 48.8 acres within the Main Post, and 66.3 acres in the northwestern portion of the Siege Battery MRS was transferred to Artillery Firing Range North MRS (WSTPT-001-R-02) because of its association with the former Crow's Nest Impact Area. Another 52 acres was delineated as the Siege Battery Constitution Island MRS (WSTPT-015-R-02), located east of the Hudson River on Constitution Island. MC pathways were determined to be incomplete for all MRSs.

Redoubt No. 2 (WSTPT-020-R-01) – No MEC or MD were recovered. MC pathways were determined to be incomplete.

1.3.2.3 2013 Final Operational Range Assessment Program Phase II Quantitative Assessment Report, U.S. Army Garrison, West Point, NY

The Phase II Operational Range Assessment was completed in May 2013. The report presents the findings of field activities completed April 2012 and August/September 2012 on several *Inconclusive* ranges on West Point, including the Crow's Nest MRS 1 month prior to the Crow's Nest range area being officially closed (EA, 2013). The activities included wet and dry season surface water, sediment, and benthic macroinvertebrate sampling to identify potential seasonal variations. Surface water and sediment samples were collected from seven locations at the Installation: five locations downstream of potential munitions constituents of concern (MCOC) source areas and two reference locations upstream. One of the sample locations was on the Crow's Nest Brook and is thus relevant to the RI sampling design. Surface water samples were analyzed for explosives, perchlorate, metals (i.e., antimony, copper, lead, zinc, and tungsten), and water quality parameters. Sediment samples were analyzed for explosives and metals. No explosives or perchlorate were detected in surface water or sediment samples at concentrations that exceeded potable (surface water) or freshwater (surface water and sediment) screening levels. For the downstream sampling location on Crow's Nest Brook, the 95 percent upper confidence limit of the mean for metals (copper, lead, and zinc) in sediment exceeded freshwater screening levels and average downstream concentrations were statistically greater than average reference concentrations. However, after a screening level ecological risk assessment (SLERA) was conducted to further evaluate risk, the Phase II Report concludes that no MCOC are migrating from operational ranges at concentrations that pose an unacceptable risk to off-range human and ecological receptors. The 95 percent upper confidence limit of the mean for copper in surface water exceeded site-specific screening levels but was not statistically greater than average reference concentrations; whereas, the reciprocal was true for lead and antimony. The operational ranges at the Installation were re-categorized as *Unlikely* and were placed into a periodic review program.

1.3.2.4 2006 Final Removal Action Report, Military Response Program for Storm King, Orange County, New York, NY

The 2006 RA was conducted by American Technologies for the Army Engineering and Support Center, Huntsville (American Technologies Inc., 2006). The RA objective was to find, identify, and dispose of MEC found in the Storm King State Park FUDS. The RA covered 1,901 acres and recovered 520 MEC from within 1,000 feet of the northern boundary of the Crow's Nest MRS.

1.3.2.5 2002 Draft Final Engineering Evaluation / Cost Analysis Storm King Site, Orange County, New York, NY

The 2002 EE/CA was prepared for the USACE New York District and the USACE Huntsville Center. The July 2002 EE/CA was performed by Parsons for the Storm King Site, which encompasses the Storm King State Park / Palisades Park north of the Installation and a New York Central Railroad easement to the east (Parsons, 2002). The scope of the EE/CA was to characterize the type, location, and distribution of MEC present in Storm King / Palisades Park FUDS (located to the north and west of the Crow's Nest MRS). The EE/CA summarizes the findings from previous MEC studies conducted in Storm King State Park and surrounding areas. During the EE/CA, a geophysical survey identified 7,165 anomalies that were investigated at the Storm King FUDS. Of these anomalies, nine 75 mm projectiles (HE and shrapnel) and one 6-inch MK 34 projectile were recovered and 476 MD items were recovered. An RA was recommended and subsequently conducted in 2006.

1.3.2.6 2000 Time Critical Removal Action

A TCRA was performed by Environmental Hazards Specialists International, Inc. for the Army Engineering and Support Center, Huntsville in 2000. The goal of the TCRA was to locate and remove MEC in the Storm King State FUDS. During this investigation, 23 MEC (75 mm projectiles and M1907 PTTFs) and 86 pieces of MD were recovered. The MEC were destroyed on site. The results indicated that the density of items increased toward the south, closer to the northern boundary of the Crow's Nest MRS.

1.3.2.7 2001 Final Report UXO Clearance at United States Military Academy, West Point, NY

In September/October 2001, Explosive Ordnance Technologies Incorporated was contracted by Noresco Corporation to conduct UXO clearance in support of a gas pipeline installation. A surface sweep was performed for approximately a 12,000-foot by 50-foot site where pipe existed. The UXO clearance was conducted where the new pipeline would be installed, along the northern Training Area J1 boundary on the western edge of the Crow's Nest Impact Area boundary and then bisecting Training Area G1 to the west. In total, 10 inert items, one live projectile, and 15 small arms rounds were recovered. Exact locations of these recovered items are unknown.

1.3.2.8 1994 Unexploded Ordnance Site Survey Report for Crow's Nest

In 1994, a UXO survey was conducted by Human Factors Applications, Inc.to identify the types and the extent of MEC present in the Crow's Nest Impact Area. The survey also sought to

determine whether the presence of MEC extended beyond the Installation property boundaries. Because of the difficult terrain, the site was broken into four survey areas: Area A (Training Area G1), Area B (Storm King State Park), and Areas C and D (Crow's Nest Impact Area). During this survey, MEC were recorded and left in place.

The following UXO were identified during the survey: 3-inch Absterdam, 75 mm projectile, 4.5-inch projectile, 120 mm projectile, 6.5-inch projectile, and 8-inch projectile. MD identified during the survey included a 2.25-inch projectile, 75 mm projectile, 4.5-inch projectile, 8-inch projectile, M1907 PTTF, base fuzes, brass and lead rotating bands, and fragmentation.

Most of the UXO identified was discovered in Storm King State Park (Area B of the report and just north of the MRS) and was predominantly 75 mm projectiles and expended M1907 PTTFs. Only M1907 PTTFs and fragmented items were located in Training Area G1 (Area A of the report), including a Civil War era cannon ball (10-inch) and mortar (15-inch shell). A 2.94-inch Absterdam, 4.5-inch projectile, 6-inch solid shot (Civil War cannon ball), 6.5 inch projectile, 8-inch projectile, 75 mm projectiles, and expended M1907 PTTFs were identified in the Crow's Nest Impact Area (Areas C and D of the report). These areas are shown in **Figure 1-4.**

1.3.3 Environmental Setting

Site-specific environmental investigations have not been conducted at the Crow's Nest MRS; therefore, site-specific information is not available for many characteristics. For the purposes of assessing the environmental setting of the site, where site-specific information was not available, regional data were utilized for the RI.

1.3.3.1 Climate

The regional area surrounding West Point is characterized as a humid, continental climate. Summers are warm with periods of high humidity. The semi-permanent Bermuda High brings south-to-southwest warm and humid air to the area. July is the hottest month, with a mean temperature of 86 degrees Fahrenheit (ºF). Winters are cold with extended periods of snow cover and are influenced by the cold Hudson Bay air masses that are brought into the area. The coldest month of the year is January, which has a mean temperature of 27 ºF. Most winters are characterized by one or more warm periods when soils nearly or completely thaw (Tetra Tech, 2011).

Another weather pattern that influences the climate of West Point is an air mass that flows inland from the North Atlantic Ocean bringing cool, cloudy, and damp weather to the region. Prevailing winds are generally westerly.

Thunderstorms occur approximately 20 times per year; tornadoes occur 3 to 4 times a year in the region, although no significant tornadoes have occurred at West Point for over 20 years. Total annual precipitation is 49.5 inches, with the least amount of precipitation occurring in January and February (3.5 inches each month) and the most occurring in May (4.9 inches) (Tetra Tech, 2011).

1.3.3.2 Topography

The topography of West Point is best described as having moderately steep hills and numerous escarpments as a result of glaciation and the weathering of ancient rock. The highest elevation

(1,433 feet) on the Reservation occurs at Burke Mountain and the lowest elevation (near sea level) occurs at the Hudson River. Slopes from 10 to 60 percent are common on the Installation. The topography of the surrounding region is undulating and rugged (Tetra Tech, 2011).

The topography of the Crow's Nest MRS is characterized by a very steep summit sloping toward the Hudson River to the east. The Crow's Nest Mountain has an approximately 1,400-foot elevation range from base to summit with the lowest elevation at the Hudson River.

1.3.3.3 Geology

West Point lies within the Hudson Highlands hill formation, which is characterized as a low, rugged mountain range. They form a zone of folded and faulted metamorphic and igneous rocks, which are subjected to extensive weathering and erosion. Shallow bedrock characterizes the Crow's Nest MRS. The predominant rock type within the bedrock is granite and is typically medium-grained and composed of quartz, feldspar, and mica. Rock outcrops of gneiss and schist (highly metamorphosed igneous and sedimentary rocks) are visible on hillsides and along stream banks (Tetra Tech, 2011).

The MRS contains exposed bedrock and shallow excessively- to well-drained soils consisting of glacial till and alluvium from glacially transported sediment overlying crystalline bedrock (NRCS, 2011). The predominant soil series is Rock-outcrop-Hollis complex, moderately steep and very steep. These soil types are characterized as shallow in depth to bedrock, with excessive droughtiness and high to very-high erosion potential, and exhibit slopes ranging from 15 percent to 60 percent grade (Tetra Tech, 2011).

1.3.3.4 Groundwater

Two connected aquifers exist at the Installation: an unconsolidated aquifer consisting of alluvial deposits and a consolidated bedrock aquifer. They have low well yields and a limited extent, making them incapable of being used for municipal supply. Stratified sand and gravel deposits are the most prolific sources of groundwater on the Installation. These deposits are relatively thin and cannot be used for domestic supply because of the fairly small well yields averaging 151 liters per minute. Recharge to this aquifer is primarily by local precipitation, although some upward seepage from bedrock does occur in the lowland areas (Tetra Tech, 2011).

Groundwater has not been assessed at the Crow's Nest MRS; however, it is unlikely to be present in significant quantities based on the prevalence of exposed/shallow granitic bedrock within the MRS.

1.3.3.5 Surface Water

The major drainage network within the MRS is the Crow's Nest Brook. Crow's Nest Brook and an unnamed tributary to Crow's Nest Brook both flow through the central portion of the MRS toward the Main Post of the Installation; ultimately discharging to the Hudson River. A tributary to Highland Brook also flows adjacent to the MRS at the southern edge of former Training Area J1. Eighteen wetland and vernal pool areas exist within the Crow's Nest MRS. **Figure 1-2** shows the locations of surface water bodies within the MRS.

Portions of minor drainage networks and an unnamed intermittent natural drainage channel are located in the far northern area of the Crow's Nest MRS. However, based on data from the U.S.

Geological Survey National Hydrography Dataset (U.S. Geological Survey, 2015), perennial surface water does not flow through this area within the MRS.

1.3.3.6 Vegetation

The majority of the Crow's Nest MRS is covered by mature hardwood forest with successional hardwoods surrounding the summit following fire disturbance. Highland areas of the MRS are composed of the following communities: Oak Hickory, Chestnut Oak, Rich Rocky Woodland, and Pitch Pine-Oak-Heath Rocky Summit. Lower elevation area communities are predominantly composed of Tulip Poplar and Maple Beech. Dense underbrush exists over the majority of the Crow's Nest MRS with vegetation consisting of small saplings, sweet-fern, mountain laurel, blueberry, briers, and vines (Tetra Tech, 2011).

According to the Installation's current Integrated Natural Resources Management Plan and rare plant management plan, no federally listed plant species are found or likely to be found on the property (Tetra Tech, 2011). The only federally listed threatened or endangered plant species that may occur within the MRS is the small whorled pogonia; the following plant species are listed by the NYSDEC: Small Whorled Pogonia (*Isotria medeoloides*), Clustered Sedge (*Carex cumulata*), Gypsy-wort (*Lycopus rubellus*), Weak Rush (*Juncus debilis*), Reflexed Sedge (*Carex retroflexa*), Black-edge Sedge (*Carex nigromarginata*), Virginia Snakeroot (*Endodeca serpentaria*), and historically Michaux's Blue-eyed-grass (*Sisyrinchium mucronatum*).

1.3.3.7 Wildlife

Numerous aquatic and terrestrial vertebrate and invertebrate species have been observed and/or documented at the Installation. A complete list documented species at the Installation is provided in the *Integrated Natural Resources Management Plan for the United States Army Garrison – West Point* (Tetra Tech, 2011). Several of the species that occur within the Crow's Nest MRS are State- and/or federally listed as threatened or endangered.

State- and federally listed species that have the potential to occur within the Crow's Nest MRS are provided in **Table 1-5**. This targeted list was identified in consultation with the NYSDEC Natural Heritage Division and the U.S. Fish and Wildlife Service's Information, Planning, and Conservation decision support system.

Table 1-5: Potential Federally and State-Listed Species

Scientific Name	Common Name	Taxonomy	State Status	Federal Status
Myotis sodalis	Indiana bat	Mammal	E	E
Myotis septentrionalis	Northern long-eared bat	Mammal	NL	T
Haliaeetus leucocephalus	Bald eagle	Bird	T	NL
Clemmys muhlenbergii	Bog turtle	Reptile	E	T
Crotalus horridus	Timber rattlesnake	Reptile	T	NL

Table 1-5: Potential Federally and State-Listed Species

Scientific Name	Common Name	Taxonomy	State Status	Federal Status
Acipenser brevirostrum	Shortnose sturgeon	Fish	E	E
Acipenser oxyrinchus	Atlantic sturgeon	Fish	NOS	E; New York Bight DPS
Alasmidonta heterodon	Dwarf wedge mussel	Mussel	E	E
Isotria medeoloides	Small whorled pogonia	Plant	NL	T
Carex cumulata	Clustered sedge	Plant	T	NL
Lycopus rubellus	Gypsy-wort	Plant	E	NL
Juncus debilis	Weak rush	Plant	E	NL
Carex retroflexa	Reflexed sedge	Plant	T	NL
Carex nigromarginata	Black-edge sedge	Plant	T	NL
Endodeca serpentaria	Virginia snakeroot	Plant	T	NL
Sisyrinchium mucronatum	Michaux's blue-eyed-grass	Plant	E	NL

Status: E = Endangered, T = Threatened, PE = Proposed Endangered, NOS = No Open Season, NL = Not Listed, DPS = Distinct Population Segment

1.3.3.8 Cultural Resources

Numerous cultural, archaeological, and historical resources exist at the Installation as it is one of the oldest intact training grounds in the United States. Historic resources have been identified at the Installation, including an Early to Middle Woodland component at the Crow's Nest Rockshelter within the Crow's Nest MRS (Geo-Marine, Inc., 2001).

1.3.4 Current and Future Land Uses

The entirety of the land composing the Crow's Nest MRS is undeveloped, forested land. Access to the land is currently restricted from public use as Installation property. However, trespassers routinely hike into the area from the surrounding park and preserve areas to camp and relic hunt illegally. Installation personnel and contractors occasionally access the site to perform maintenance activities to roads and subsurface utilities.

Given the topography of the area, the land within the Crow's Nest MRS is expected to remain undeveloped, forested land. However, use of the land may change and could include public recreational use for hiking and hunting purposes.

1.4 PROJECT REMEDIAL RESPONSE OBJECTIVES

The overall objectives of the RI were to collect sufficient information to characterize the nature and extent of MEC and MC resulting from former military activities and to evaluate the associated risks to human health and the environment. The Crow's Nest MRS was investigated using a combination of geophysical and intrusive investigative techniques to delineate the nature and extent of MEC and MC. Geophysical surveys were implemented using analog methods. MC sampling was performed using incremental and discrete sampling methods. The information collected during the RI was also used to update the conceptual site model (CSM) and Munitions Response Site Prioritization Protocol (MRSPP) to support informed risk management decisions for future remedial actions.

1.4.1 Preliminary Conceptual Site Model

A CSM is used to conceptualize the relationship between MEC/MC and receptors through consideration of potential or actual migration and exposure pathways. It presents the current understanding of the MRS and previous investigations. Preliminary CSMs for MEC and MC were used in the development of a technical approach for the RI. Information contributing to understanding the site includes the following characterization profiles:

- *Physical*: Describes elements that may affect the release, transport, or fate of MEC and/or MC
- *Land Use and Exposure*: Summarizes information used to identify and evaluate relevant exposure scenarios and the location of receptors
- *Ecological*: Presents the environmental setting of the site, potential ecological receptors, and areas of potential cultural or historical significance
- *Release*: Relates the extent of MEC/MC release and transport in the environment

Numerous munitions are associated with the Crow's Nest MRS (**Table 1-3**), and MEC have been previously identified and removed from within and north of the MRS boundary (**Figure 1-4**). Thus, the likelihood of MEC being present in the MRS is high and the exposure pathway for human receptors to come in direct contact with it is complete. The primary exposure mechanism for human receptors to MEC at the surface is through handling/direct contact (e.g., treading underfoot) with MEC. A subsurface pathway may be potentially complete for human receptor exposure to MEC during intrusive activities (e.g., installation of subsurface utility lines, digging to remove cultural artifacts, including Civil War–era munitions). **Figure 1-4** presents the preliminary graphical CSM for MEC. **Figure 1-5** illustrates the preliminary MEC pathway analysis as a wire diagram.

For MC, incomplete pathways are anticipated for surface water based on the findings of the 2013 Phase II Operational Range Assessment findings for Crow's Nest Brook (EA, 2013). Furthermore, groundwater pathways are considered incomplete because of the shallow granitic bedrock underlying the MRS and low mobility of the potential MC. Biotic uptake of MC through food chain pathways is also considered incomplete.

Potentially complete pathways exist for MC in surface and shallow subsurface soil for both human and ecological receptors. Intrusive activities (e.g., installation of subsurface utilities, relic

hunting, burrowing) may result in direct contact with soil and inhalation of soil dust by human and ecological receptors. However, the inhalation of vapors from soil is incomplete because no volatile soil MC were identified. Sediment within wetland and/or vernal pool areas is a potentially complete pathway for ecological receptors only. Human exposure to sediment within wetlands and/or vernal pools is unlikely based on restricted access to the MRS and little recreational value of such areas and is, therefore, considered incomplete. **Figure 1-6** illustrates the preliminary MC pathway analysis as a wire diagram.

Both MEC and MC CSMs are updated as new data and information become available. The data collected during the RI were used to revise the preliminary CSMs. Revised CSMs for MEC and MC are presented in **Section 6.1.4** and **Section 6.2.4** respectively.

1.4.2 Data Quality Objectives

Data needs and data quality objectives (DQOs) were determined during the planning stages following the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) (EPA, 2006) and are discussed in detail within Section 3.2 of the *Final Crow's Nest MRS RI Work Plan* (URS, 2015b). The data needs include characterization of the nature and extent of MEC and MC at the Crow's Nest MRS. The DQOs were developed to ensure the reliability of field sampling, chemical and physical analyses; the collection of sufficient data; the acceptable quality of the data generated; and the ability to infer valid assessments from the data.

The DQO process includes the following seven steps:

1. **State the Problem:** Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem.
2. **Identify the Goals of the Study:** Identify what questions the study will attempt to resolve and what actions may result.
3. **Identify Information Inputs:** Identify the information that needs to be obtained and the measurements that need to be taken to address the goals of the study.
4. **Define the Boundaries of the Study:** Specify the time periods and spatial area to which information and decisions will apply. Determine when and where data should be collected.
5. **Develop the Analytic Approach:** Define the statistical parameter of interest, specify the action level, and develop the logic for drawing conclusions from findings.
6. **Specify Performance or Acceptance Criteria:** Define the decision-maker's tolerable error rates based on a consideration of the consequences of making an incorrect decision.
7. **Develop the Design:** Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets DQOs.

Table 1-6 provides a summary of the DQOs and a crosswalk to relevant sections of this report that support each DQO.

Table 1-6: Data Quality Objective Crosswalk

Data Quality Objective	DQO Crosswalk
1. State the Problem Historical use of the former Crow's Nest Impact Area as an artillery target likely resulted in the Crow's Nest MRS containing MEC. The distribution and density of MEC (e.g., concentrated munitions use area [CMUA]) within the MRS, or outside the MRS boundary to the west in Black Rock Preserve, are not known. It is unknown if an MC release associated with CMUAs or single/multiple (piles) MEC exists.	Section 1.3
2. Identify the Goals of the Study The decision statements are: a. Determine whether the nature (type), density, and extent (vertical and horizontal distribution) of MEC are sufficiently defined that an informed risk management decision for potential remedial actions can be made. b. Determine whether the nature and extent of MC, if present, are sufficiently defined that an informed risk management decision for potential remedial actions can be made. c. Determine whether data results support MRS footprint reduction. d. Determine whether data indicate MEC and/or MC extend into Black Rock Forest Preserve that would warrant an Army response.	a. Sections 4.1, 4.2, and 5.1 b. Sections 4.3 and 5.2 c. Section 7.3 d. Section 4.1
3. Identify Information Inputs To meet the goals of the project, a field investigation was required to collect sufficient data from the MRS. The field investigation will use an analog mag and dig geophysical data collection approach across the MRS to identify and delineate areas defined as CMUAs from non-concentrated munitions use areas (NCMUAs). In addition, focused investigations at the base of slopes and rock faces are required to determine whether MEC accumulated. MC sampling may be triggered if an MEC release is identified. Based on site characteristics, only soil and sediment sampling is necessary for data collection. The analytical program was developed based on the historical information presented in Section 1. Based on the potential MC associated with the types of munitions used, the likelihood of their presence, and the availability of laboratory analysis, soil and sediment will be analyzed for potential lead, TNT, and 2,4-dinitrotoluene (DNT) contamination.	Sections 2.0 and 3.0
4. Define the Boundaries of the Study The MRS is approximately 615 acres. The MRS is bounded to the south by Route 218 and the Main Post, to the north by Storm King State Park, to the west by Black Rock Forest Preserve, and to the east by railroad tracks directly adjacent to the Hudson River. The Storm King State Park area directly north of the MRS boundary is currently being addressed under the FUDS Program. The RI did not address potential MEC/MC contamination beyond the study boundaries described above except for up to 180 feet beyond the western boundary into Black Rock Forest Preserve. Decision units (DUs) will be determined based on the sizes of identified CMUAs, which will be defined following the geophysical survey. Practical constraints during MEC/MC sampling will include extreme rocky terrain, steep slopes greater than a degree that can be safely accessed, public roadways, sensitive hibernaculum, and exposed bedrock (lack of soil within the DU). Field activities (MEC and MC) will not be performed during the winter months.	Sections 1.3 and 3.1.1
5. Develop the Analytic Approach If excessive gaps in transect spacing are identified, then additional transects may be completed unless terrain prevents infill. Additional transect coverage requirements will be determined by the Visual Sampling Plan's (VSP's) post-sampling analysis module. If anomalies are identified on transects within the 239-foot hazardous fragment distance (HFD) from Route 9W and 218, they will be flagged and the data used to extrapolate MEC	Sections 2.0, 3.0 and 3.3

Table 1-6: Data Quality Objective Crosswalk

Data Quality Objective	DQO Crosswalk
densities based on the intrusive data collected throughout the MRS. If a CMUA is identified but not fully defined, then additional transect or DGM (contingency up to 2 acres) data will be collected. If the initial transect data collected within defined NCMUAs do not meet the minimum statistical coverage required, then additional random transect or grid data will be collected. If a CMUA or discrete MEC item is identified along the western Training Area G1 boundary, then the investigation will extend beyond the current boundary, as needed, to encompass a 180-foot buffer around the outermost extent of the westernmost MEC/MD discovery. If an MEC release is identified (CMUA or a single/multiple MEC that appears to be a low-order detonation, cracked, or leaking), then soil and or sediment will be sampled for MC (lead, TNT, and DNT) and compared to project action limits. If MCOCs are below the screening values, no further sampling will be required. For discrete samples, if MCOCs are above the screening values, then discrete step-out sampling will be conducted at 2-foot intervals in horizontal and vertical directions (not to exceed a 10-foot radius) to delineate the extent of the contamination. For incremental samples, if MCOCs are above the screening values, then additional sampling unit (SUs) surrounding the CMUA, in each cardinal direction, will be defined and sampled incrementally to determine whether the contamination extends beyond the DU.	
6. Specify Performance or Acceptance Criteria The proposed spacing will be honored where possible (i.e., safety concerns will have primacy). A conservative upper limit on transect spacing, where terrain does not permit safe collection of data along the proposed transect spacing, is 440 feet. Data gaps will be considered "significant" if transect spacing exceeds 440 feet along transects. A minimum of 6 acres of transect or grid data is required to meet the sample design and achieve a 95 percent confidence that there is no more than 0.5 UXO per acre in NCMUAs within the MRS. The baseline condition (i.e., null hypothesis) for MC sampling is that an MCOC is present. The false negative decision error would be deciding that an MCOC is not present when it actually is or deciding that the extent of an MCOC has been defined when it actually has not. This type of decision error is controlled by having a high degree of confidence that the sample locations selected will identify an MCOC if present, and that the analysis selected is sufficient to detect selected analytes in the sampled media, the detection limits are adequate to ensure an accurate quantification of the MCOC, and there is a high degree of confidence that the dataset is of sufficient quality and completeness.	Sections 2.2, 3.14, and 3.2.1
7. Develop the Design The occurrence and distribution of MEC will be assessed by collecting analog mag and dig survey data. Approximately 28 miles (34 acres) of transect coverage is planned to characterize the MRS. This value exceeds the recommendation prescribed in Engineer Manual (EM) 200-1-15, *Technical Guidance for Military Munitions Response Actions* (USACE, 2015). All anomalies will be intrusively investigated by UXO technicians and results evaluated to determine the approximate MEC density. Detailed information on recovered MEC will be documented. All MEC will be destroyed on site. If CMUAs are identified in a widespread area covering 0.25 acres or more, IS protocol will be implemented for MC sampling. Note: Contingency DGM was included in the design but never implemented and instances have been removed from the DQO text.	Sections 2.0 and 3.0

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CLIENT	USACE - Baltimore District		
PROJ	Crow's Nest MRS Remedial Investigation		
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Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagerysourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LAP	06/17/2016

N

Legend

- Crow's Nest MRS
- Operational Range
- Installation Boundary
- Storm King State Park FUDS

TITLE

Installation Location

URS 12420 Milestone Center Drive Germantown, MD 20876

West Point, NY

FIGURE 1-1

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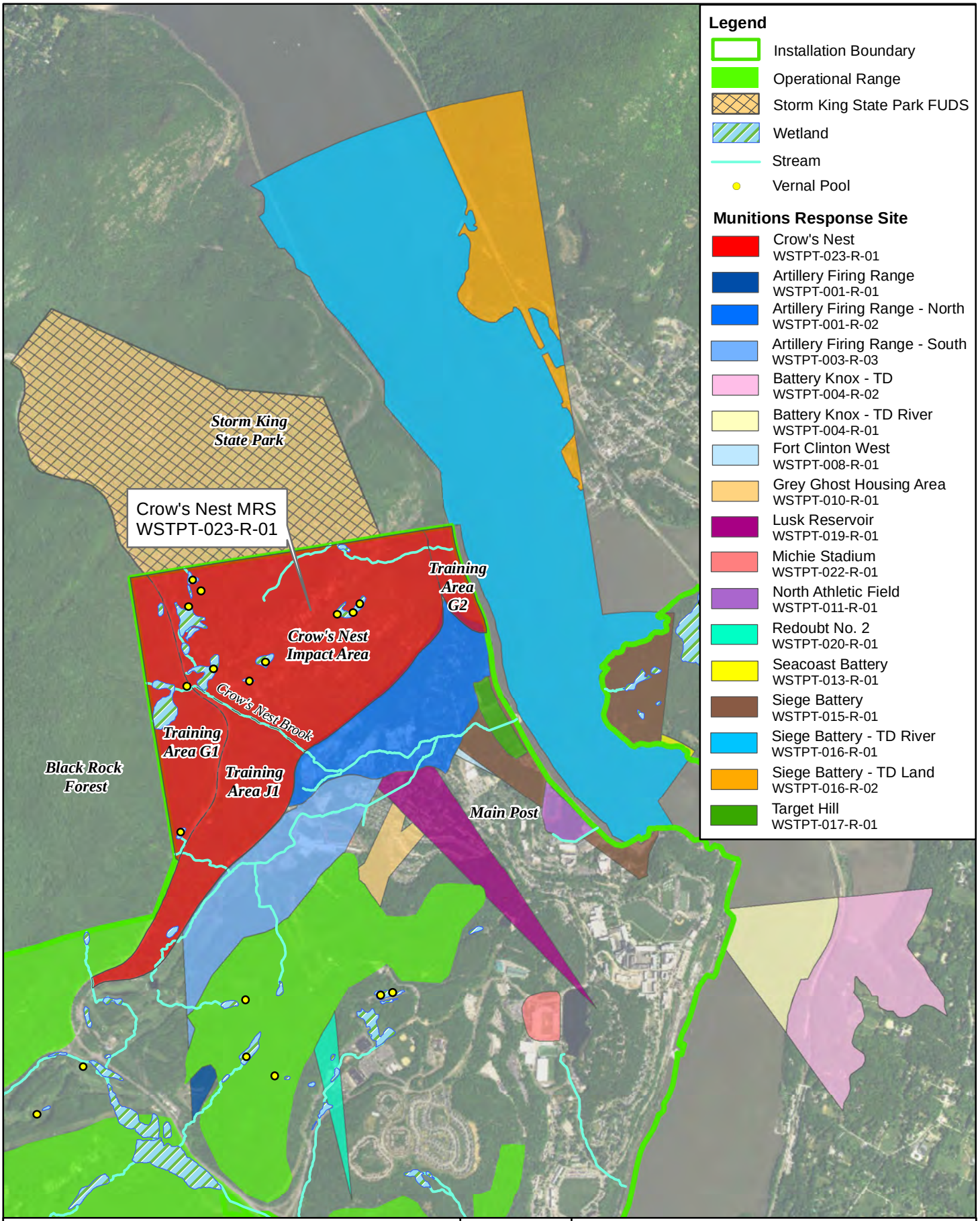

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N

TITLE **MRS Locations**

URS 12420 Milestone Center Drive Germantown, MD 20876

West Point, NY

FIGURE 1-2

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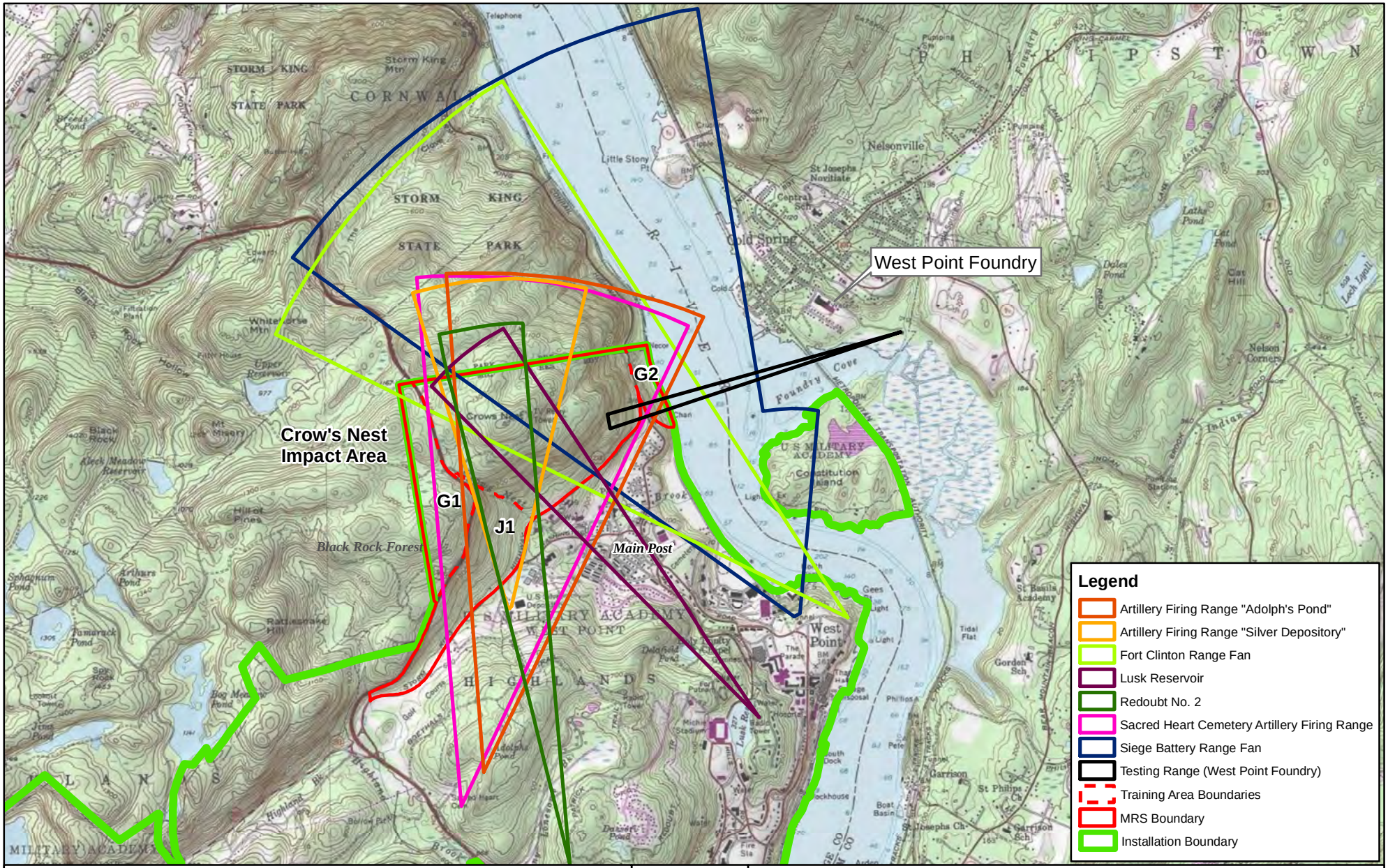

CLIENT	USACE - Baltimore District
PROJECT	Crow's Nest MRS Remedial Investigation

0 1,650 3,300 6,600 Feet

N

TITLE **Former Artillery Range Fans**

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Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LAP	06/30/2016

URS
12420 Milestone Center Drive
Germantown, MD 20876

West Point, NY

FIGURE **1-3**

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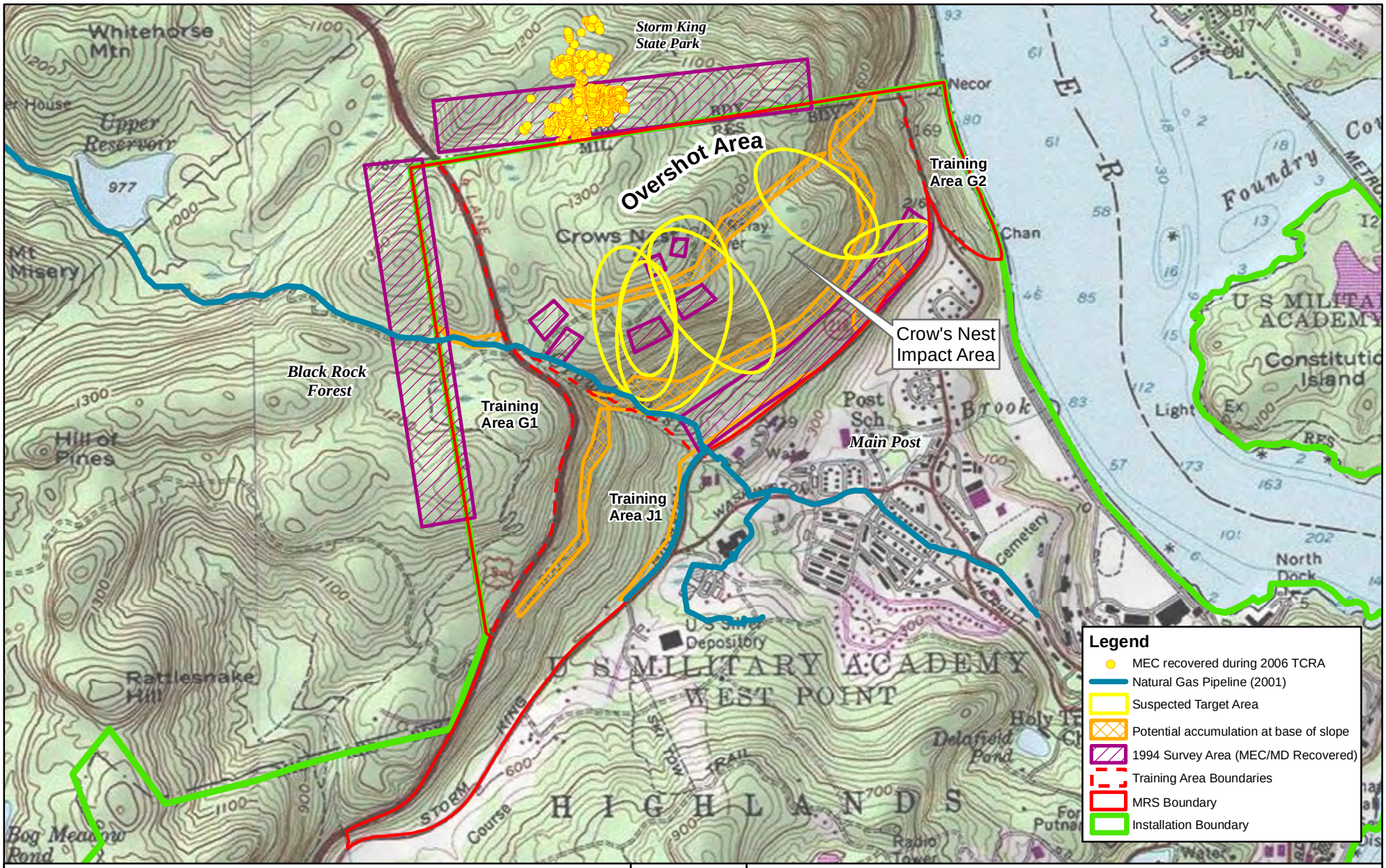

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PROJECT	Crow's Nest MRS Remedial Investigation			
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Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LAP	04/29/2016

N

TITLE **Preliminary Graphical MEC CSM**

URS
12420 Milestone Center Drive
Germantown, MD 20876

West Point, NY

FIGURE 1-4

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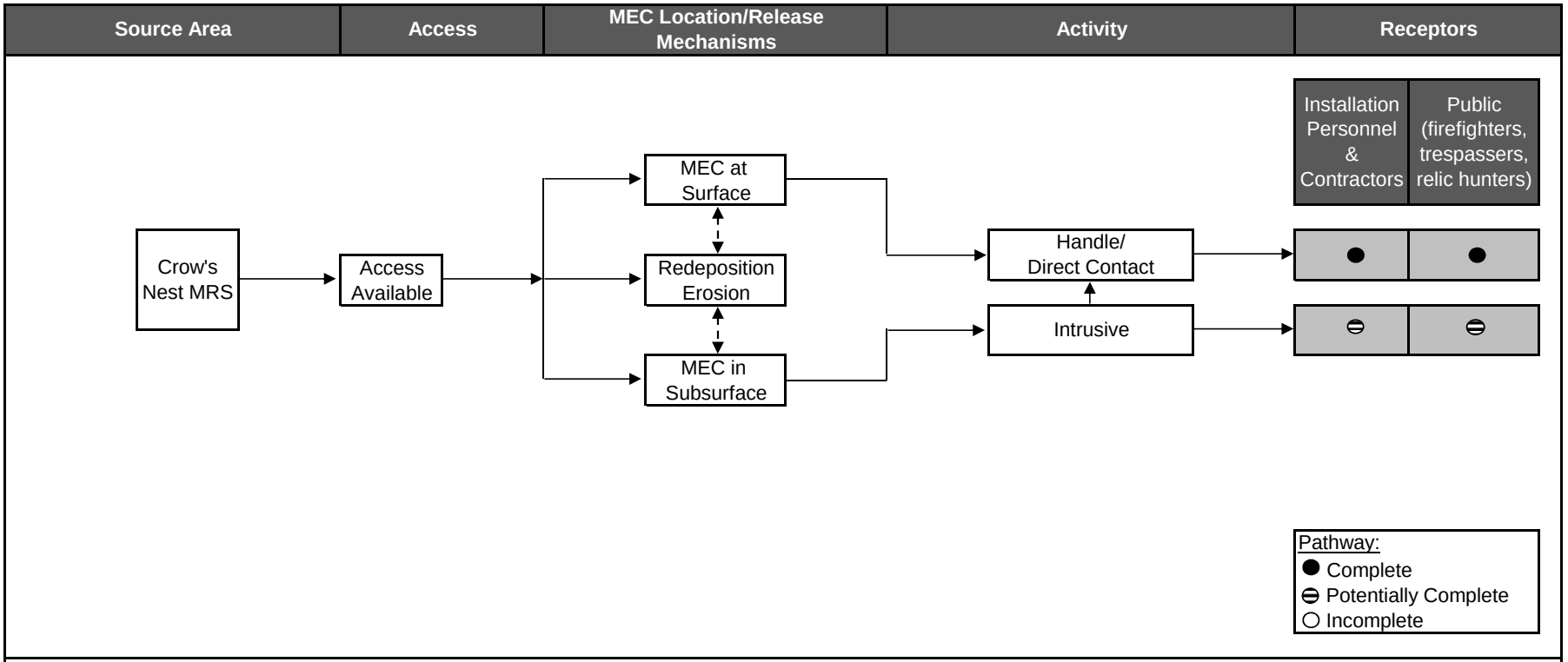

Figure 1-5
Preliminary MEC Pathway Analysis
Crow's Nest MRS Remedial Investigation
West Point, New York

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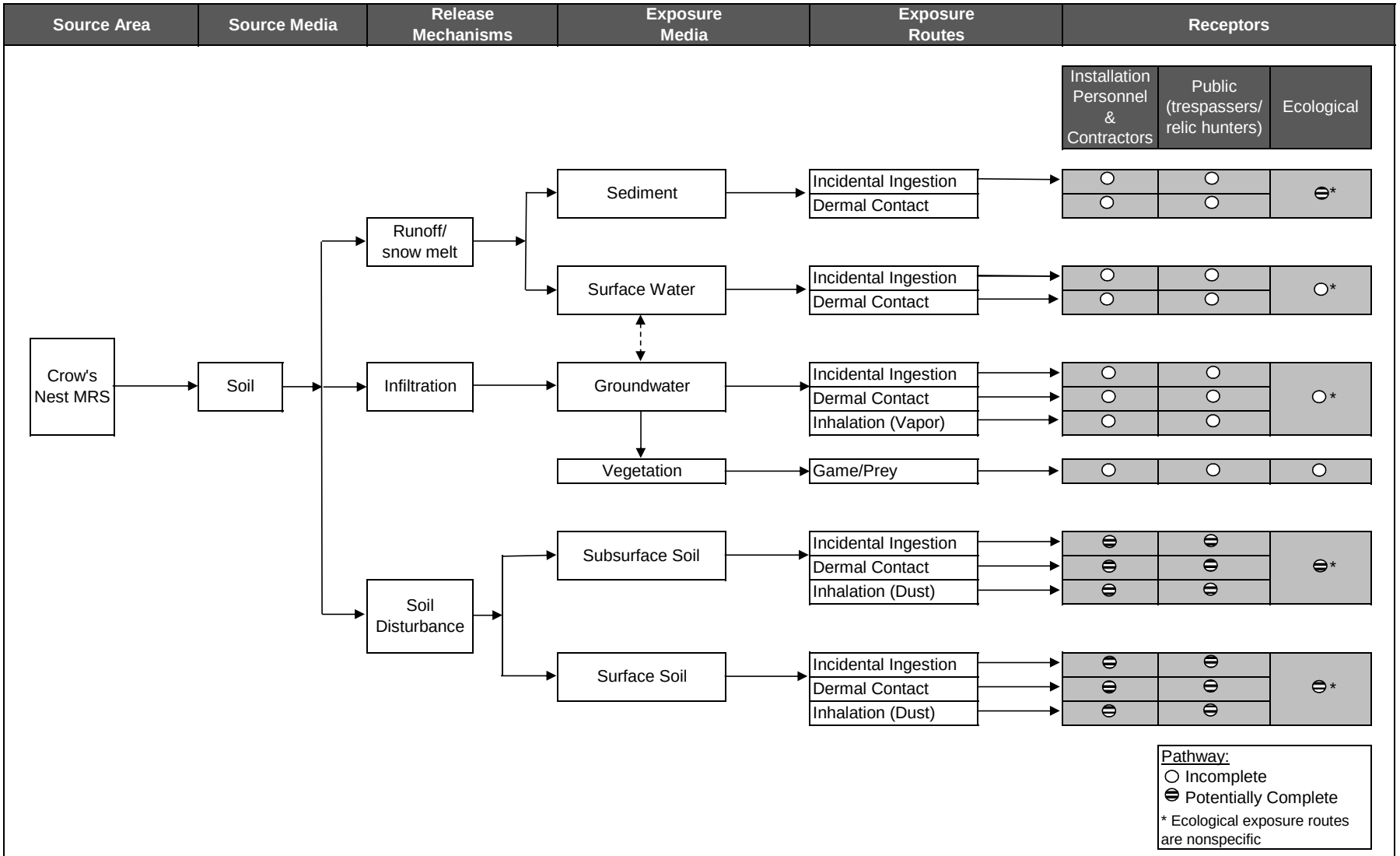

Figure 1-6
Preliminary MC Pathway Analysis
Crow's Nest MRS Remedial Investigation
West Point, New York

SECTION TWO: CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

This section presents the field investigation approach, methods, and operational procedures used to characterize the nature and extent of MEC within the Crow's Nest MRS. **Table 2-1** presents the timeframe field tasks were performed. Section 3 presents the details of the MC characterization.

Table 2-1: RI Field Schedule

Field Activity	Dates
Mobilization	8/24/2016
Installation of Control Points	8/24/2016
Mag and Dig Operations	9/1/2016 – 10/27/2016
Demolition Operations	10/30/2016
MC Sampling	10/27/2016 – 11/9/2016
Demobilization	11/9/2016

2.1 MEC CHARACTERIZATION: GEOPHYSICAL METHODOLOGY

The primary investigative approach relied on analog "mag and dig" geophysical transects to detect and delineate CMUAs and NCMUAs.[1] A DGM approach was included in the project work plan if needed, but as a result of safety concerns associated with the steeply sloping terrain at the MRS, DGM was not performed during the field effort. EM 200-1-15, *Technical Guidance for Military Munitions Response Actions* (USACE, 2015) and statistical software tools, including VSP Version 7.4 (VSP Development Team, 2016) and the USACE UXO Estimator (USACE, 2003), were used to determine the required coverage at the MRS.

2.1.1 MEC Investigation Coverage Requirements

In accordance with guidance in EM 200-1-15 (USACE, 2015), VSP was used to identify an appropriate transect spacing for the RI. This guidance recommends as the most conservative estimate that one-half of the maximum fragment distance (MFD) of the applicable munitions type be used to determine the target radius when evaluating transect separation. A 95 percent confidence level was used to determine the recommended transect spacing to detect a CMUA of a specific size. The most common munitions type expected within the MRS is the 75 mm MKI

[1] CMUAs are areas with significant amounts of MEC or MD and fragmentation. EM 200-1-15 defines a CMUA as an MRS or areas within an MRS(s) where there is a high likelihood of finding UXO or DMM and that have a high amount of MD within them as a result of historical munitions use and fragmentation. CMUAs were defined following data collection and determined with VSP's geostatistical analysis module.

NCMUAs are areas that do not contain significant amounts of MEC or MD and fragmentation as defined following VSP geostatistical analysis.

shrapnel projectile, and the theoretical calculated fragmentation distances for this munition were used as the basis for determining the sampling requirements for the MRS. However, using the MFD for the 75 mm MKI returns a recommended transect separation of approximately 745 feet, which may not have provided sufficient data to fully characterize the site. Instead, a more conservative approach using the HFD of the 75 mm MKI projectile was used to determine the statistical sampling requirements. The 75 mm MKI HFD target radius of 121 feet was used to obtain a VSP-recommended transect spacing of approximately 180 feet. Given the mountainous terrain at the site, this more conservative transect spacing was preferred because it would yield a higher probability of identifying CMUAs within the MRS.

UXO Estimator was used to determine the amount of transect coverage required to achieve a 95 percent confidence that there is no more than 0.5 UXO per acre in the NCMUAs within the MRS. That is, analog transect data collected outside of CMUAs (determined by actual survey results) will yield a statistically estimated MEC density per acre in NCMUAs. The actual confidence level associated with the assumed MEC density varied based on survey results. The initial input assumption of 0.5 UXO per acre was chosen based on the software module guidance for sites where public usage is moderate (e.g., a hiking or hunting area, large subdivision). Based on this analysis, UXO Estimator recommended that approximately 6 acres of coverage be collected in NCMUAs to meet the design objectives.

Transect spacing was expected to vary as a result of the steep irregular terrain of the MRS. Furthermore, field teams were encouraged to actively seek out locations where gravitational accumulation of MEC/MD was possible (i.e., at the base of steep slopes or rock outcrops) for further investigation. The actual transect paths deviated as necessary to assist with characterization goals and to ensure safety of field personnel. The results of the analog survey were evaluated daily by the onsite data manager to evaluate gaps that may have required additional survey and, upon completion, with VSP to assist with delineation of potential CMUAs.

2.1.2 MEC Data Collection and Site Coverage

To achieve the planned transect coverage, analog mag and dig geophysical surveys were performed along pre-planned transects across the Crow's Nest MRS. Terrain conditions and vegetation at the MRS limited the safe, efficient collection of DGM data; therefore, mag and dig transects were used to characterize the extent of MEC at the site. A "mag and flag" approach was used in areas of transects located within a 239-foot buffer that was established to avoid closures of US-9W and State Route 218 during intrusive operations. The buffer is based on the minimum safety distance established in the Explosives Site Plan (ESP) and uses the HFD of the 75mm HE projectile. **Figure 2-1** shows the planned transect locations following site condition adjustments.

In total, 32.2 miles (39.1 acres) were surveyed at the Crow's Nest MRS, which exceeded the amount of coverage required based on the initial UXO Estimator calculation. Two additional transects were investigated outside of the western boundary of the MRS within Black Rock Forest Preserve to verify the absence of MEC along the western border of Training Area G1. The following sections detail the geophysical investigations performed as part of the RI.

2.1.2.1 Mag and Dig Survey

UXO teams traversed 25.8 miles of mag and dig transects using hand-held Trimble® Global Navigation Satellite System (GNSS) receivers equipped with Floodlight™ satellite shadow reduction technology to navigate and record positional and attribute data. Transects encompassed a 10-foot-wide swath of analog coverage, equating to a total of 31.3 acres of mag and dig survey. Field teams determined actual transect paths based on site conditions. Adjustments to transect location and spacing were assessed as work progressed daily to ensure data gaps were minimized.

UXO technicians used analog instrumentation (White's XLT all-metals detectors) to detect anomalies. Anomalies identified during analog surveys were intrusively investigated as they were discovered. Intrusive activities were performed in accordance with EM 385-1-97, *Explosives Safety and Health Requirements Manual* (USACE, 2008), and DoD manual 6055.09-M, *Ammunition and Explosive Safety Standards* (2010), by qualified UXO technicians meeting or exceeding Department of Defense Explosives Safety Board TP-18, *Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel* (DoD, 2004) requirements.

2.1.2.2 Mag and Flag Survey

A total of 6.4 miles (7.8 acres) of mag and flag transects was surveyed. The same methodologies used for mag and dig operations were used for mag and flag operations with the exception that no intrusive activities were performed. Subsurface anomalies identified within the buffer were flagged; their locations were recorded in GNSS units and left in place. Surficial anomalies encountered were logged and removed from the site.

2.2 GEOPHYSICAL SYSTEM VERIFICATION

Inspection and surveillance of all analog geophysical activities were performed by the UXO Quality Control Supervisor (UXOQCS) to monitor the quality of field activities. Adherence to the quality control (QC) program has provided confidence in the site characterization processes and results and has ensured that:

- Data products are of known and documented quality and suitable for their intended use; and
- Data collection processes meet the stated requirements.

An instrument test strip (ITS) was used to monitor analog equipment and personnel on a daily basis to verify that instruments were functioning properly and that the operator detected all seed items. An ITS was installed near the project storage container along State Route 218 and seeded with three medium industry standard objects. Item depths and orientation were blind to sweep personnel and reconfigured periodically. The ITS results were documented in the Daily Quality Control Reports (**Appendix A**). Proper instrument settings and sweep technique were verified by the UXOQCS and/or Team Leaders.

The accuracy of hand-held GNSS units was verified by the project geophysicist / data manager each day of production activities. Three temporary control points were established to ensure field teams had ready access to daily positional QC locations. Control points were established by Badey & Watson Surveying & Engineering, P.C., a New York–licensed surveyor. Horizontal

control was referenced to the North American Datum of 1983 Transverse Mercator New York State Plane East Zone, U.S. Survey Feet. Vertical control was recorded in feet and referenced to the North American Vertical Datum of 1988. The control point locations used during RI survey activities are provided on **Figure 2-2**. The results of the daily accuracy checks were monitored daily by the UXOQCS to confirm system configuration and operator compliance with QC standards.

2.3 INTRUSIVE INVESTIGATION ACTIVITIES

Intrusive investigations were conducted at the locations of 1,536 anomalies identified during survey activities in accordance with the procedures outlined in the Final RI Work Plan (URS, 2015b) to determine the nature of identified anomalies.

Prior to the start of intrusive activities, the Senior Unexploded Ordnance Supervisor (SUXOS) and UXO Safety Officer (UXOSO) verified that the exclusion zone (EZ) for the work area was established and secure. The EZ was based on the K40 minimum separation distance provided in the ESP and maintained for each work area during MEC activities.

Manual excavation methods (e.g., shovel, hand trowel) were used to investigate any detected anomaly in accordance with EM 385-1-97 (USACE, 2008). Excavations ranged in depth from 0.3 inches to 18 inches below ground surface (bgs). For each investigated anomaly, the following information was recorded in the GNSS and uploaded to the project's database (**Appendix F**).

- Date/time
- Transect ID
- Target ID
- Anomaly type
- Categorization as geology, cultural, MEC / material potentially presenting an explosive hazard (MPPEH), or MD
- Item description
- Mark/model/nomenclature
- Condition of MEC/MPPEH (e.g., fuzed, unfuzed)
- Quantity
- Depth recovered
- Approximate weight
- Location coordinates using GNSS
- Digital photograph taken of each MEC item, significant cultural items, or unusual items (**Appendix B**)

Excavations were rechecked following anomaly acquisition with a hand-held magnetometer to verify anomaly resolution (i.e., that the initial anomaly was not masking additional anomalies). Excavations were carefully backfilled with the removed soil in accordance with the Work Plan.

The SUXOS and UXOSO conducted oversight of all work activities; daily QC inspections of intrusively investigated transects were performed by the UXOQCS. The Daily Site Reports, Daily Site Safety Reports, and Daily Quality Control Reports are provided in **Appendix A.**

The results of the intrusive investigation are presented in **Section 4.1**. The results of the survey (i.e., locations of MEC/MD) were used to define CMUAs and NCMUAs within the MRS using VSP's geostatistical analysis module.

2.4 INSPECTION AND MANAGEMENT OF MPPEH

During intrusive operations, munitions/munitions-related items were considered MPPEH upon discovery until inspected and verified either as either material documented as safe (MDAS) or material documented as an explosive hazard (MDEH). In accordance with USACE EM 385-1-97 (USACE, 2008) and Department of Defense Instruction 4140.62, *Material Potentially Presenting an Explosive Hazard Instruction* (2014), munitions-related items were initially inspected by a UXO Technician II upon acquisition followed by an independent re-inspection by a UXO Technician III. Items were again inspected and certified by the SUXOS with verification conducted by the UXOQCS prior to disposal. All recovered material was classified either as MDEH or MDAS.

2.5 DISPOSITION OF MDEH AND MDAS

MDEH was disposed of by detonation. All MDEH items were positively identified prior to disposal operations. No items of unknown filler or potential chemical warfare materiel were discovered. Items determined to be acceptable-to-move by the SUXOS and UXOSO were consolidated for disposal within the MRS in accordance with the ESP. No blown-in-place operations were required. To protect public safety, all items determined to be MDEH were guarded until disposal by detonation. Overnight security of MDEH items was provided by Atlas Security Inc.

Disposal operations were conducted in accordance with the project's work plan and ESP. Donor explosives were provided using an on-call delivery service. Explosives accountability documentation is provided in **Appendix C**.

A post-shot inspection was conducted following disposal operations to confirm that all explosives had been consumed. Any remaining material underwent inspection and certification as MDAS. MDAS was stored in sealed, locked containers to maintain custody. Prior to release/transfer, the SUXOS and UXOQCS signed DoD Form 1348-1A to certify and verify that the material has been 100 percent inspected and, to the best of their knowledge and belief, does not present an explosive hazard or contain explosives (**Appendix D**). MDAS was subsequently released to JFR Salvage Inc. for recycling under chain-of-custody.

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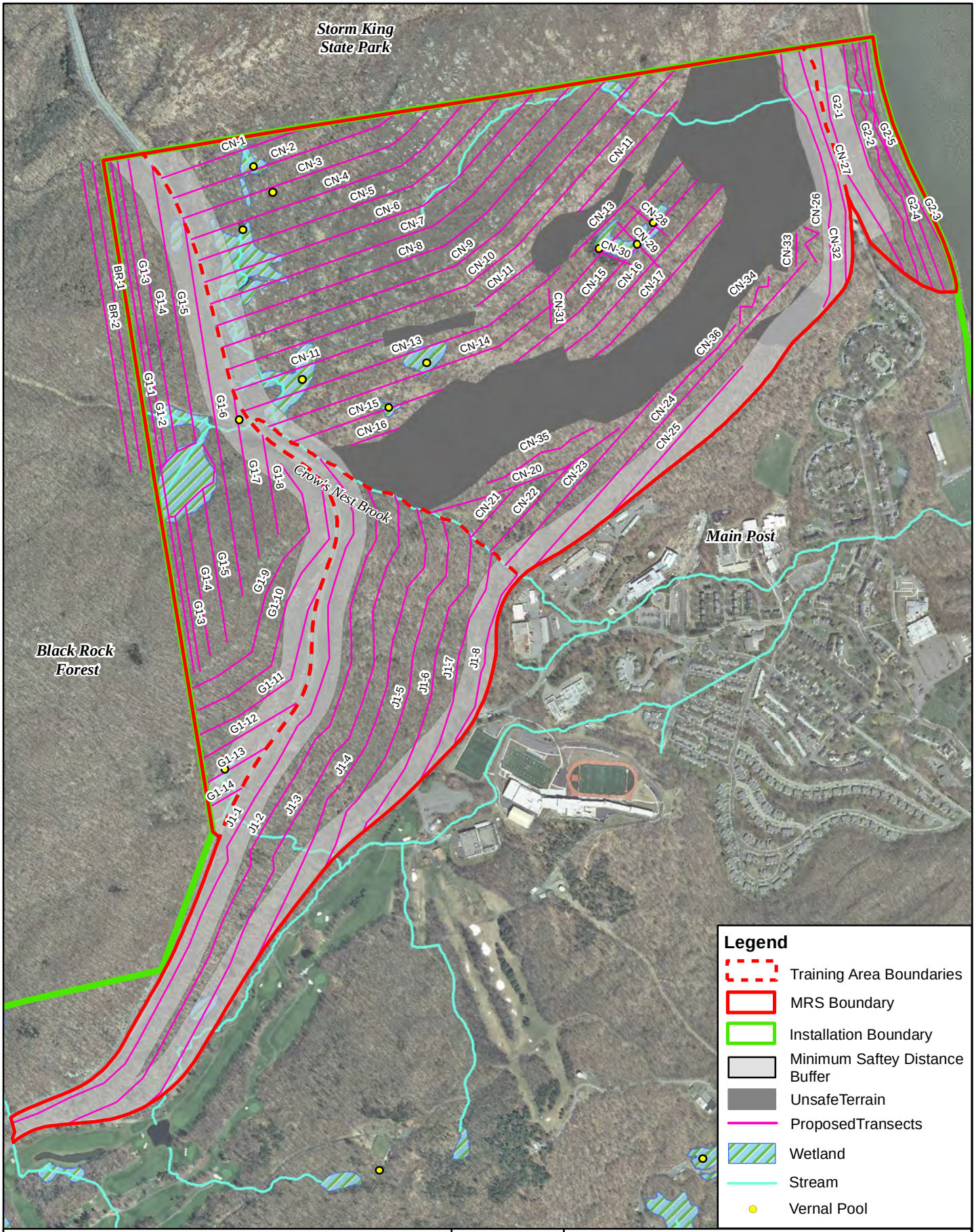

CLIENT	USACE - Baltimore District			
PROJECT	Crow's Nest MRS Remedial Investigation			
0 625 1,250 2,500 Feet				
SCALE	1:12,500	DES BY	MS	06/30/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	JL	06/30/2016

N

TITLE **Planned Transcripts**

URS 12420 Milestone Center Drive Germantown, MD 20876

West Point, NY

FIGURE 2-1

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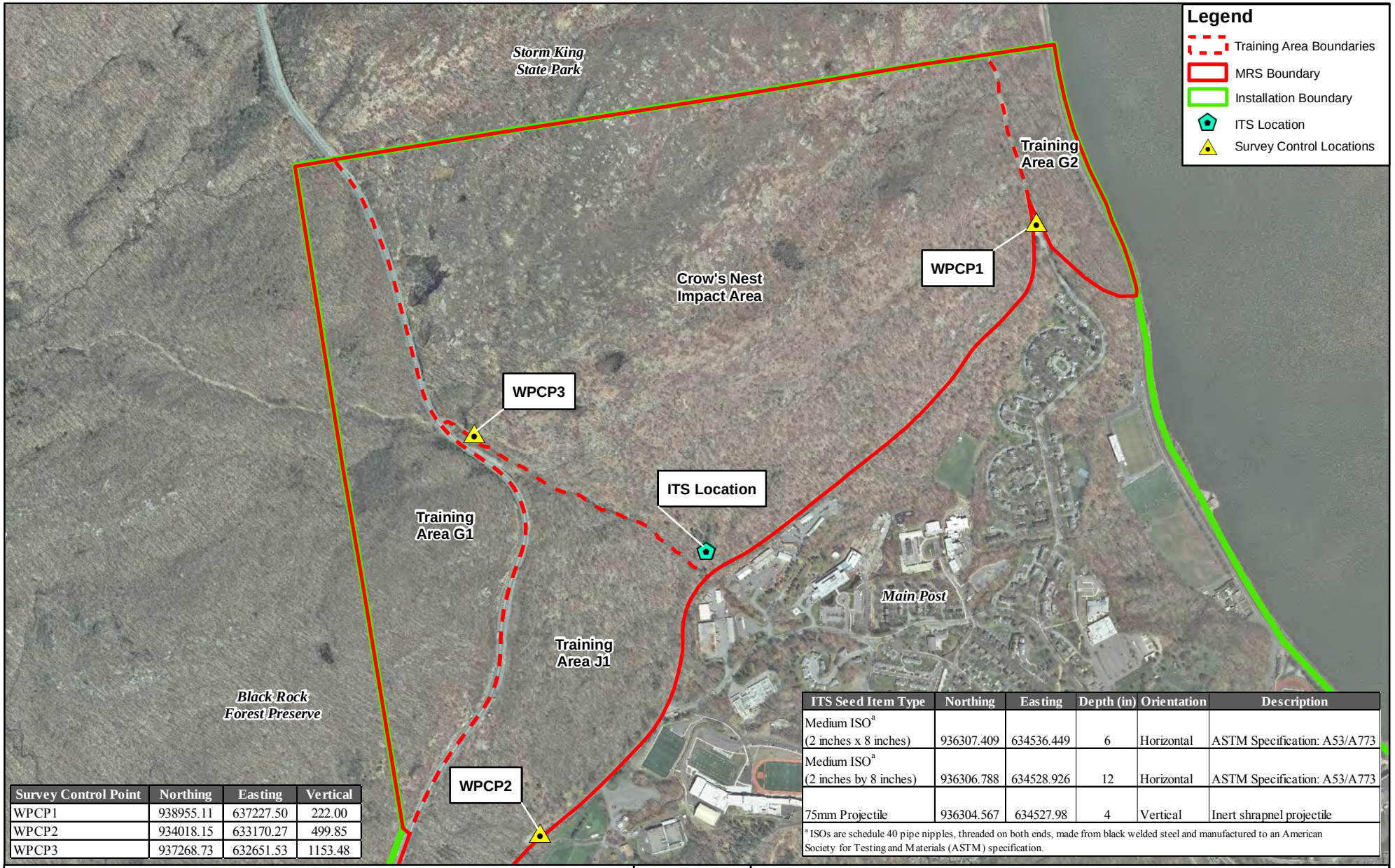

Survey Control Point	Northing	Easting	Vertical
WPCP1	938955.11	637227.50	222.00
WPCP2	934018.15	633170.27	499.85
WPCP3	937268.73	632651.53	1153.48

ITS Seed Item Type	Northing	Easting	Depth (in)	Orientation	Description
Medium ISO[a] (2 inches x 8 inches)	936307.409	634536.449	6	Horizontal	ASTM Specification: A53/A773
Medium ISO[a] (2 inches by 8 inches)	936306.788	634528.926	12	Horizontal	ASTM Specification: A53/A773
75mm Projectile	936304.567	634527.98	4	Vertical	Inert shrapnel projectile

[a] ISOs are schedule 40 pipe nipples, threaded on both ends, made from black welded steel and manufactured to an American Society for Testing and Materials (ASTM) specification.

CLIENT: USACE - Baltimore District

PROJECT: Crow's Nest MRS Remedial Investigation

0 500 1,000 2,000 Feet

SCALE: 1:13,103 | DES BY: MS | 05/04/2016

Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services

CHK BY: JL | 05/04/2016

N

TITLE

ITS and Survey Control Locations

URS
12420 Milestone Center Drive
Germantown, MD 20876

West Point, NY

FIGURE 2-2

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SECTION THREE: CHARACTERIZATION OF MUNITIONS CONSTITUENTS OF CONCERN

This section presents the field investigation approach, methods, and operational procedures used to characterize the nature and extent of MC within soil and sediment within the Crow's Nest MRS. MC sampling field activities were conducted between 27 October and 9 November 2015.

3.1 MC CHARACTERIZATION: MC SAMPLING METHODOLOGY

MC characterization activities were performed in accordance with the procedures outlined in the Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP), as appended to the Final RI Work Plan (URS, 2015b). As prescribed in these planning documents, MC sampling was conducted based on the results of the geophysical survey and geostatistical definition of CMUAs within the Crow's Nest MRS. The MC investigation was initiated when the following criteria were met:

- Potential MEC releases identified during geophysical surveys (i.e., MEC and MD are determined to be concentrated in a definable CMUA)
- MEC item locations (single or multiple items) where soil staining or visible evidence of a potential MC release is observed (e.g., cracked, leaking, or partially filled munitions; staining of soil or sediment under munitions; evidence of low-order detonations)

Based on the preliminary CSM discussed in **Section 1.4.1**, soil and sediment (from wetland/vernal pool areas) was sampled using either incremental or discrete sampling methodologies as discussed in **Sections 3.1.1 and 3.1.2**. MC sampling activities were supported by a UXO Technician II implementing MEC avoidance.

An extensive review of the historical munitions used at the former artillery ranges associated with the Crow's Nest MRS was performed to determine potential MC associated with the MEC anticipated and to determine the analytical program required to characterize the MRS for MC. The review included identification of the fillers associated with each of the munitions as well as the composition of each component (e.g., bursting charges, fuzes). A memorandum was prepared and submitted to project stakeholders for concurrence with the sampling approach. The following MCOC were sampled and analyzed during this RI:

- Explosives: TNT, and its breakdown products: 2,4-DNT, 2,6-DNT, 2-Amino (Am)-DNT, and 4-Am-DNT (soil only)
- Metals: Lead (soil and sediment)

The detailed rational for selecting these MC is provided within the MC Sampling Rationale Memorandum included as Appendix H of the Final RI Work Plan (URS, 2015b).

3.1.1 Incremental Sampling

IS methodology (ISM) was used to characterize the nature and extent of MC in soil and sediment associated with CMUAs identified following the characterization of MEC. DU's were defined as distinct CMUAs identified within the Crow's Nest MRS. CMUAs were defined as areas where the density of MEC and MD was ≥ 50 MEC/MD anomalies per acre. A discussion of how the

CMUAs were statistically determined is provided in **Section 4.1.2.** Where a wetland area was encompassed by a CMUA; the wetland was defined as a separate DU because the media (sediment) and habitat/receptors are different from the surrounding area. Three separate DUs were identified within the MRS and are shown on **Figure 3-1.**

Table 3-1 summarizes each DU's location and size, and the SUs located within each. DUs larger than 2.0 acres were broken up into multiple, smaller SUs for the purposes of IS. The location and size of each SU was determined based on topographic limitations and preliminary analysis of MEC survey data. All SUs were 1 acre and were sampled in accordance with the UFP-QAPP as 50-increment samples. SU's larger than 1 acre would require the relocation of many increment sample locations in order to safely traverse and sample the SU. The location of SUs, within a DU, was chosen to appropriately characterize the entirety of the DU (a CMUA) in a representative manner based on preliminary analysis of MEC survey data. SUs were placed equally in areas of higher and lower estimated anomaly density within a DU, as presented in **Figure 3-1**, to capture the conditions present throughout the DU. Areas of unsafe terrain and steep topography were avoided during the placement of SUs out of safety concerns. The pre-planned locations of all SUs were achieved in the field with the exception of WPIS01SK01-03. Approximately 1/2 of WPIS01SK01-03 was positioned over unsafe, steep terrain; because of this, its location was adjusted approximately 150 feet south (1 acre area was maintained). The locations of the SUs are presented in **Figure 3-1** and summarized in **Table 3-2**.

In addition to soil and sediment samples collected from within CMUAs, background ISM soil and sediment samples were collected from 1 acre areas as 50-increment samples in a location of very low anomaly density within Training Area G1 using the methodologies described below.

Table 3-1: Incremental Sampling Summary

Decision Unit	DU Size (Acres)	Location/Description	Sampling Unit IDs	Analysis
DU-01	147	Within the northwest area of the former Crow's Nest Impact Area. Predominant vegetation consisted of mature and successional hardwoods (following previous fire disturbance) with dense woody underbrush, vines, and grassy vegetation in areas of open canopy. Soil is shallow throughout the DU and comprises silty deposits and humus rich topsoil.	11 total SUs (soil): WPIS01SA01 WPIS01SB01 WPIS01SC01 WPIS01SD01 WPIS01SE01 WPIS01SF01 WPIS01SG01 WPIS01SH01 WPIS01SI01 WPIS01SJ01 WPIS01SK01	Target Metals and Explosives

Table 3-1: Incremental Sampling Summary

Decision Unit	DU Size (Acres)	Location/Description	Sampling Unit IDs	Analysis
DU-02	1.3	Wetland located within the central southern portion of DU-1 in a very high anomaly density area of the CMUA. Water depth is shallow (ranging 1-2 feet) with deeper areas not exceeding approximately 3 feet. The wetland appears to be lined by bedrock. Contains organic-rich silty black sediment and is densely vegetated by the reed *Phragmites australis*.	1 Sample (sediment): WPIS02SA01	Target Metals
DU-03	16	Within the southern half of Training Area G2. Predominantly covered by mature hardwoods with little underbrush. Terrain comprises steeply graded, exposed, medium to large-sized cobbles and boulders. Shallow topsoil is silty and rich in humus.	2 total SUs (soil): WPIS03SA01 WPIS03SB01	Target Metals and Explosives
BG (DU-00)	NA	Background location within Training Area G1 where no evidence of MEC/MD was identified. Vegetation throughout the area is predominantly mature hardwoods with moderate to sparse amounts of woody underbrush. Soil is silty and rich in humus. The wetland portion contains silty, organic-rich sediment with dense woody underbrush and vines emerging from raised areas. Depth of water was shallow (approximately 1 foot depth) with deeper pockets exceeding 2 feet.	2 total SUs: WPIS00SA01 (sediment) WPIS00SB01 (soil)	Target Metals and Explosives

Note: all SUs were 1 acre in size and collected as 50-increment samples

ISM samples were collected using a systematic random approach and in accordance with the applicable procedures outlined within the standard operating procedures (SOPs) appended to the Final RI Work Plan (URS, 2015b). All incremental samples were collected in 100 percent triplicate following the technical guidance outlined in the 2012 *Incremental Sampling Methodology* by the Interstate Technology & Regulatory Council (ITRC) Incremental Sampling Methodology Team (2012).

Primary increments were separated by approximately 30 feet and were located in the field by navigating to waypoints using a hand-held global positioning system (GPS) unit. The location of

duplicate and triplicate increments were selected in relation to the primary location by a random number generator and navigated to via compass and measuring tape.

A UXO Technician II performed anomaly avoidance using a metal detector at each increment prior to sample collection. If the location of an increment was deemed unsafe or not feasible to sample because of anomalies or naturally occurring obstructions (i.e., rocks or tree roots), the location was moved to the nearest possible available location and sampled. There were no instances where an increment could not be collected.

Individual increments were collected from the first 6 inches of soil or sediment encountered. Using a 5/8-inch diameter soil probe, an equal volume of approximately 37 grams of soil/sediment per increment was collected, resulting in an approximate 1.9 kilogram ISM sample per SU. Increments were composited into a single sample in plastic re-sealable bags. Sampling equipment was decontaminated at the sampling location with a phosphate-free detergent and deionized water. The volume of water used for decontamination is not sufficient to generate surface runoff or affect potential groundwater, and thus was discharged on site at the point of sample collection. No investigation derived waste was generated.

3.1.2 Discrete Sampling

Focused sampling was conducted for MEC locations (single or multiple items) where soil staining or visible evidence of a potential MC release was observed (e.g., cracked, leaking, or partially filled munitions; staining of soil or sediment under munitions; evidence of low-order detonations). Discrete samples were collected in proximity to the item or at the location of observed staining using disposable plastic scoops. Two discrete sampling locations were identified during the MEC characterization (**Figure 3-1**); the first location was a single munitions item and the second location was where a munitions pile was discovered.

At the first location, coarse fragments of a 155 mm HE projectile that experienced a low-order detonation were observed and removed from the excavation. This item was located within the central portion of the Crow's Nest Impact Area and designated as discrete sample (DS)-01. A discrete soil sample was collected directly from beneath the projectile (discovered approximately 12 inches bgs) after it was removed.

The second discrete sampling location, designated DS-02, was from beneath a MEC/MPPEH pile discovered within the central-western area of the Crow's Nest Impact Area. After the pile was removed, a soil sample was collected at 0 to 6 inches bgs from approximately the center of where the pile was located.

Additional step-out samples were collected from DS-01 and DS-02 to delineate the lateral and vertical extent of MC contamination. Step-out samples were collected at a distance of 5 feet from the primary location, in each cardinal direction, at two separate depth intervals. The step-out samples for DS-01 were collected from depths of 12 inches bgs (corresponding to the depth at which the item was found) and approximately 12 to 18 inches bgs. An additional deeper sample was also collected from the primary location at an approximate depth interval of 12 to 18 inches bgs. Step-out samples for DS-02 were collected from 0 to 6 inches bgs and 6 to 12 inches bgs. An additional deeper sample was also collected from the primary location at a depth interval of 6 to 12 inches bgs.

Table 3-2 summarizes the discrete samples collected. Shallow bedrock restricted soil collection from depths greater than 18 inches at both locations. All discrete soil samples were analyzed for explosives and lead. Step-out samples were placed on hold at the laboratory pending the results of the initial primary sample. Results of the primary and step-out discrete samples are presented in **Section 4.3.2**.

Discrete background soil samples were not collected because preexisting discrete data exists for New York soils (*Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey,* Appendix D [NYSDEC, 2005]).

Table 3-2: Discrete Sampling Summary

Discrete Sample	Sample ID	Primary/Step-Out	Sample Direction	Depth (in feet bgs)
DS-01 (Low-order detonation 155mm HE projectile)	WPDS01SA01	Primary	Primary	12
	WPDS01SB01	Step-Out (with duplicate)	Primary	12–18
	WPDS01SC01	Step-Out	North	12
	WPDS01SD01	Step-Out	North	12–18
	WPDS01SG01	Step-Out	East	12
	WPDS01SH01	Step-Out	East	12–18
	WPDS01SK01	Step-Out	South	12
	WPDS01SL01	Step-Out	South	12–18
	WPDS01SO01	Step-Out	West	12
	WPDS01SP01	Step-Out	West	12–18
DS-02 (Munitions Pile)	WPDS02SA01	Primary (with duplicate)	Primary	0–6
	WPDS02SB01	Primary	Primary	6–12
	WPDS02SC01	Step-Out	North	0–6
	WPDS02SD01	Step-Out	North	6–12
	WPDS02SG01	Step-Out	East	0–6
	WPDS02SH01	Step-Out	East	6–12
	WPDS02SK01	Step-Out	South	0–6
	WPDS02SL01	Step-Out	South	6–12
	WPDS02SO01	Step-Out	West	0–6
	WPDS02SP01	Step-Out	West	6–12

3.1.3 Sample Identification

Soil and sediment samples collected at the Installation were identified using the procedures detailed in the UFP-QAPP (URS, 2015b). Using indelible ink, each sample was labeled with an eight-character sampling code and a two-digit identification number. The sampling code consisted of a two-character installation identifier, two-character sampling method code, two-

character DU number, two-character location code, and two-digit identification number. Each component of the sample code as shown in **Tables 3-1** and **3-2** is described in the two examples below:

WPIS01SA01and WPDS02SB02

Where:

WP = Two-character installation identifier for the Installation

IS = Two-character sampling method code for Incrementally Sampled

DS = Two-character sampling method code for Discretely Sampled

= Two-character DU number

SA = Sequential (SA, SB, etc.) location code

= Unique sequential identification number

Unique sequential identification numbers began with 01 (primary sample). QC samples (e.g., duplicates, equipment blanks) received unique sequential identification numbers at the end of the sampling code and were not identified as QC samples on the laboratory chain-of-custody (custody form) form. The samples collected used the following unique sequential identification numbers:

- 01 = Primary Sample
- 02 = Duplicate Sample
- 03 = Triplicate Sample
- 04 = Equipment Blank

3.1.4 MC Quality Assurance Quality Control

Quality Assurance (QA) / Quality Control (QC) samples were collected to evaluate the field collection methods and the laboratory analytical techniques for soil and sediment samples. The QA/QC samples consisted of duplicate samples, matrix spike / matrix spike duplicate (MS/MSD) samples, and equipment blanks.

3.1.4.1 Duplicates

Duplicate samples were collected at a rate of at least 1 per 10 samples. Duplicate samples were collected simultaneously from the same source under identical conditions, submitted to the laboratory as indistinguishable samples, and labeled accordingly. Because IS samples were collected in triplicate, duplicate QA/QC samples were unnecessary.

3.1.4.2 MS/MSD

MS/MSD samples were collected at a rate of once per mobilization. Sub-samples were pulled from the parent sample by the analytical laboratory for IS samples. Additional volume was

collected for discrete soil and sediment samples from the same location as the parent sample. Labels for the extra volume were the same as the parent sample.

3.1.4.3 Equipment Blanks

Equipment blanks were collected at rate of 10 percent per mobilization. Equipment blanks were collected by passing analyte-free deionized water over a decontaminated soil probe into sampling containers.

3.2 LABORATORY ANALYTICAL METHODS

Soil and sediment samples were submitted to a DoD Environmental Laboratory Approval Program-certified laboratory (Katahdin Analytical Services) for all chemical analyses. For all sampling matrices and analyses, each sample was labeled and secured in a shipping cooler filled with ice. Each sample was entered on the custody form with the required analyses. The custody forms are included in **Appendix E**. Each cooler was sealed with the custody form inside. Custody seals were signed, dated, and placed on opposite corners of the cooler. The coolers were shipped overnight to the analytical laboratory.

The following analytical methods were used for media-specific analyses:

Soil was analyzed for:

- Lead by EPA Method 6020A
- Explosives by EPA Method 8330B

Sediment was analyzed for:

- Lead EPA Method 6020A
- Total Organic Carbon (TOC) by Lloyd Kahn Method
- Acid Volatile Sulfide (AVS) / Simultaneously Extracted Metals (SEM) by EPA Method 821/R-91-100

These analytical methods achieve the project quantitation limits of at least one-third and, in most cases, one-tenth the project action limits. Therefore, in the evaluation of analytical data in **Section 4**, statements about analytes that are "not detected" mean that a chemical was not detected above the laboratory detection limit.

3.2.1 Data Validation

A Tier III Data Validation Report was prepared for each Sample Delivery Group as assigned by the laboratory. The procedure used information from the UFP-QAPP, and *DoD Quality Systems Manual (QMS)* Version 5.0 (DoD, 2013) to define the method quality objectives. Data were qualified according to the protocols defined in the EPA Region II SOPs HW-36A Revision 0 SOM02.2, *Pesticide Data Validation* (EPA, 2015a), and HW-2b Revision 15, *ICP-MS Data Validation* (EPA, 2012).

Issues identified during the data validation resulted in the application of letter qualifiers to the data to ensure reported concentrations were accurately represented. Inclusion or exclusion of

data for further analysis was based on review of analytical qualifiers and performed in accordance with guidelines noted above:

- Analytical results bearing the U qualifier (indicating that the analyte was not detected at the given reporting limit) were retained in the data set and considered non-detects. U qualifiers were also assigned to sample concentrations less than five times the concentrations observed in associated laboratory and field blanks. When samples were U qualified based on blank contamination and the concentration was less than the limit of detection (LOD), the detected concentration was elevated to the LOD. When samples were U qualified based on blank contamination and the detected concentration was greater than the LOD, the detected concentration became the new LOD. If the LOD was elevated above the limit of quantitation (LOQ), the LOQ was also elevated.
- Analytical results bearing the J qualifier (indicating that the reported value was estimated because of minor anomalies with the method quality objectives) were retained at the measured concentration.
- Analytical results bearing the UJ qualifier (indicating that the analyte was analyzed, but not detected, and the associated LOD is an estimate and may be inaccurate or imprecise) were retained at the measured concentration.
- Analytical results bearing the NJ qualifier (indicating the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration) were retained at the measured concentration.
- Analytical results bearing the R qualifier (indicating the sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria; the presence or absence of the analyte cannot be verified) were retained at the estimated concentration as a conservative measure within the calculation (see **Section 4.2.3.2** for discussion).

3.2.2 Data Analysis

Each sample result was compared directly to the screening criteria (**Section 3.3**) for all MCOC parameters examined. The weight-of-evidence approach used in the assessment helped control decision errors. MCOC concentrations from all sample results and site conditions were considered to ensure additional information did not provide indications that MCOC conclusions may be in error.

3.3 MC RISK SCREENING CRITERIA

MC results were compared to Federal human health and ecological risk screening criteria for both soil and sediment. Screening values were chosen based on EPA-published screening levels for the protection of ecological receptors and human health as follows in **Table 3-3**.

Table 3-3: MC Screening Criteria

Analyte	Human Health Soil Screening Value (mg/kg) [1]	Ecological Soil Screening Value (mg/kg) [2]	Ecological Sediment Screening Value (mg/kg) [3]
Metals			
Lead	400	11	35.8
Explosives			
2,4,6-TNT	3.6	7.6	--
2,4-DNT	1.7	1.28	--
2,6-DNT	0.36	0.0328	--
2-Am-4,6-DNT	15	15	--
4-Am-2,6-DNT	15	12	--

"--": analyte is not an MCOC for sediment
[1] EPA Residential Soil Regional Screening Level Value (November 2015), protective of a target hazard quotient of 0.1 and a target cancer risk of $1x10^{-6}$
[2] Ecological Soil Screening Values selected following this hierarchy: EPA EcoSSL, EPA Region V Ecological Screening Levels for soil (August 2003), Oak Ridge National Laboratory Screening Benchmark, Los Alamos National Laboratory Ecological Screening Levels (R3.3; October 2015)
[3] EPA Region III Biological Technical Assistance Group Freshwater

Where MC results exceeded their respective criteria, listed in **Table 3-3**, a human health and/or ecological risk assessment was initiated to determine whether the concentrations of MCOC in soil and/or sediment pose a risk for adverse effects to a potential receptor.

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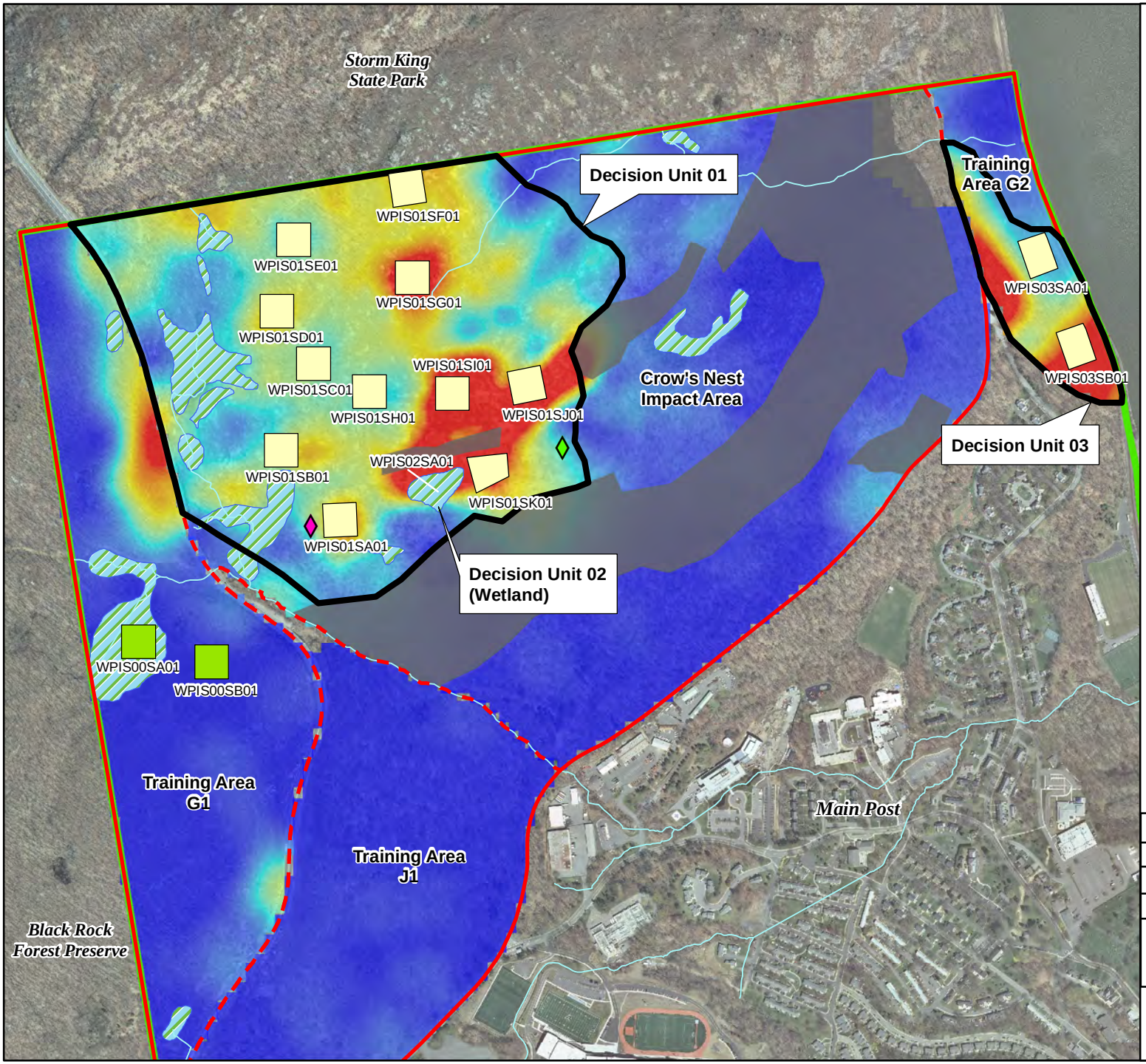


Legend

- Training Area Boundaries
- MRS Boundary
- Installation Boundary
- Decision Unit (50 anomalies/acre)
- Unsafe Terrain
- Wetland
- Stream

MC Sampling Location

- Incremental Sampling Location
- Background Incremental Sampling Location
- Discrete Sampling Location Munitions Pile
- Discrete Sampling Location Single Item

Estimated Anomaly Density (Kriged)
(anomalies/acre)

>200, 190, 180, 170, 160, 150, 140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0

N

0 400 800 1,600 Feet

Coordinate System: NAD 1983
UTM Zone 18N

CLIENT	USACE - Baltimore District	
PROJ	Crow's Nest MRS Remedial Investigation	
DES BY	JL	05/04/2016
CHK BY	LAP	05/04/2016

URS
12420 Milestone Center Drive
Germantown, MD 20876

Figure 3-1
MC Sampling Locations

Q:\Projects\ENV\GEARS\GEO\MAES 2012 Unrestricted\West Point\J. GIS\0_Final RI GIS Files\Fig 3-1_MC Sampling Locations.mxd 10/27/2016

SECTION FOUR: REMEDIAL INVESTIGATION RESULTS

This section presents the results of the MEC characterization (**Section 2**) and MC characterization (**Section 3**). Data usability assessments for MEC and MC data are presented within **Sections 4.1.5 and 4.2.3**, respectively.

4.1 MEC CHARACTERIZATION RESULTS

Characterization of MEC at the Crow's Nest MRS consisted of the following tasks:

- Analog survey (mag and dig approach)
- Analog survey (non-intrusive mag and flag approach)
- Intrusive investigation and identification of anomalies

A total of 39.1 acres of transects was surveyed during the RI. As described in **Sections 2.1.2.1 and 2.1.2.2**, of that acreage, 31.3 acres was investigated by mag and dig and 7.8 acres by mag and flag within the 239-foot buffer where intrusive investigation was not performed. Intrusive investigations were performed on 1,221 anomalies. There were 102 anomalies identified at ground surface and 224 anomalies detected within the 239-foot safety buffer along US-9W and State Route 218. A single anomaly was detected within the additional transects (step-outs) surveyed within Black Rock Forest Preserve, which was subsequently identified as an old utility.

Of the anomalies investigated, 263 were classified as either geologic or cultural in nature (utilities or refuse not of archaeological significance). MD was distributed across the MRS but was concentrated within the former Crow's Nest Impact Area of the MRS. The majority of MD recovered in this area was related to the 75 mm projectile (shrapnel and HE). A small amount of MD was identified within Training Area J1. The majority of MD recovered from Training Area G1 was small fragments that were distributed mainly in the northern portion of the Training Area. A high concentration of MD was recovered within the southern portion of Training Area G2. The types of munitions from which MD originated consisted mainly of cannon balls, mortar rounds, and Parrott and Hotchkiss projectiles. UXO/MPPEH was identified only within the former Crow's Nest Impact Area. **Table 4-1** summarizes the results of the investigation, including subsurface anomalies that were not investigated, and **Figure 4-1** shows the characterization results. **Appendix F** contains the RI results database.

Table 4-1: Analog Geophysical Survey Results

Category	Quantity	Weight (lbs)	Depth Range (in)
Crow's Nest Impact Area			
MD	2,310	8,484	0–18
UXO/MPPEH	60	511	0–12
Anomalies (not investigated)	57	NA	NA
Training Area G1			
MD	21	14.75	0–7
UXO/MPPEH	0	NA	NA

Table 4-1: Analog Geophysical Survey Results

Category	Quantity	Weight (lbs)	Depth Range (in)
Anomalies (not investigated)	83	NA	NA
Training Area G2			
MD	354	964.25	0–12
UXO/MPPEH	0	NA	NA
Anomalies (not investigated)	67	NA	NA
Training Area J1			
MD	8	29.25	0–8
UXO/MPPEH	0	NA	NA
Anomalies (not investigated)	20	NA	NA

Note: Anomalies that were not investigated were located within the 239-foot safety buffer along the public roadways.

A munitions pile, spread out approximately 20 feet long and 5 feet wide, was discovered off of proposed transect CN-13 within the former Crow's Nest Impact Area. Within this pile, 475 MD items (75 mm MK1 Shrapnel rounds) and 16 UXO/MPPEH (14 – 75 mm MK1 Shrapnel and 2 – 75 mm M48 HE) were recovered at ground surface and removed as part of RI activities. Additionally, during the MC investigation, a suspected munitions pile was found during UXO avoidance activities within SU-H. The location of this second pile was recorded but not investigated because intrusive investigation operations had been completed. **Figure 4-1** shows the locations of the piles.

4.1.1 MEC and MPPEH Recovered and Identified

MEC recovered from the MRS were identified as UXO. No DMM or bulk explosives were identified. The most predominant munitions type recovered during the RI is the 75 mm projectile (shrapnel and HE). **Table 4-2** lists the number of UXO/MPPEH recovered, which were only in the former Crow's Nest Impact Area. No MEC/MPPEH were discovered in any of the training areas during the RI. **Figure 4-1** presents the locations of UXO/MPPEH. A complete inventory of all items recovered is presented in the project database, located in **Appendix F**. The types of munitions identified are consistent with the types of munitions anticipated (**Table 1-3**). **Appendix G** contains data sheets associated with the UXO/MPPEH recovered and provides details about the munitions.

Table 4-2: UXO/MPPEH Recovered

Crow's Nest Impact Area	
Type	**Number Recovered**
75 mm MK 1 shrapnel	43
75 mm M48 HE	7
M1907 PTTF	2
M3 PD Fuze	1

Table 4-2: UXO/MPPEH Recovered

Crow's Nest Impact Area	
Type	**Number Recovered**
M48 HE Fuze	1
Parrott base fuze	1
M4 HE booster	1
Unknown booster	1
6-inch common HE	1
4.7-inch projectile HE	1
155 mm MK 1 HE	1

4.1.2 Identification of CMUAs (Impact Areas)

Approximately 170,356 linear feet (32.3 miles) of transect data was collected in support of field activities at the MRS. Approximately 33,885 linear feet (6.4 miles) of data was collected in the buffer adjoining US-9W and State Route-218 (**Figure 2-1**).

VSP was used to determine the CMUA boundaries (Impact Areas). VSP was used during the analysis to generate a continuous estimate of anomaly density for the entire MRS based on the transect data collected during the analog survey. Locations of all MEC and MD identified during the field effort were used as the primary kriging analysis input. Histogram analysis of the kriging results guided the CMUA delineation process. High-density delineation was evaluated for anomaly densities of 25, 50, 100, and 140 anomalies per acre; however, the 100 and 140 anomalies per acre boundaries were rejected because they failed to encompass much of the area impacted by MEC and MD. The 25-anomaly-per-acre boundary was rejected because it encompassed only more MD, not MEC. Two CMUA boundaries were chosen to represent the kriged estimate of 50 anomalies per acre. **Figure 4-2** presents the kriged density results and chosen CMUA boundaries within the Crow's Nest Impact Area and Training Area G2. The CMUA within the Crow's Nest Impact Area captures approximately 91 percent of all MEC/MD detected and encompasses approximately 116 acres. The boundary was modified slightly to eliminate locations of higher uncertainty associated with impassable terrain that was inaccessible to field teams and to capture a few MEC located on the edge of this terrain. The CMUA boundary within Training Area G2 is approximately 12 acres and captures approximately 93 percent of MD detected. No MEC were detected in this area. **Figures 4-3** and **4-4** provide a closer aerial view of each CMUA.

4.1.3 Identification of NCMUA (Non-Impact-Area)

Those portions within the MRS designated as NCMUA (non-impact area) are less likely to contain material associated with munitions training. Areas designated as NCMUA were analyzed with Module 2 (Analyze Field Data) of UXO Estimator. The inputs to Module 2 are the acreage of the NCMUA, the number of acres actually investigated (i.e., the acreage of the analog transects), the number of UXO found within the NCMUA during field work (zero), the target density assumed for the sampling effort (i.e., 0.5 UXO per acre), and the confidence level (i.e.,

95 percent). The Module 2 results include the density (in UXO per acre) indicated by the field sampling data at the 95 percent confidence level, and this result is accompanied by a statement that the density level is within the assumed target UXO density. The second result gives the actual confidence for the field data at the target UXO density value. The third result is the average UXO density expected in the NCMUA. The results of the Module 2 evaluation are presented in **Figure 4-2.**

The total acreage of NCMUAs (i.e., outside the former Crow's Nest Impact Area and Training Area G2 CMUA) is approximately 464 acres. The transect/anomaly data from the NCMUA were analyzed in UXO Estimator. Approximately 22.7 miles of transects, equivalent to approximately 27.5 acres, were evaluated. The UXO Estimator results state that sampling was adequate to be 95 percent confident there is less than 0.1 UXO per acre within the NCMUA, and that we can be 100 percent confident there is less than 0.5 UXO per acre (original input assumption) within the NCMUA. **Figure 4-5** shows the NCMUA in blue.

4.1.4 MEC Density

Figure 4-5 presents the calculated MEC density (MEC/acre) within the MRS. The Crow's Nest Impact Area CMUA is 0.52 MEC/acre. When contouring only the MEC located within the CMUA, there is a 1.0 MEC/acre density. No MEC were found in the Training Area G2 CMUA, so the MEC/acre is zero. The remaining MEC density within the NCMUA is calculated as less than 0.1 MEC/acre based on UXO Estimator (discussed in **Section 4.1.3**).

4.1.5 MEC Data Usability Assessment

All DQOs respecting data collection metrics were in compliance with the RI Work Plan (URS, 2015b) and satisfied the requirements of both VSP and UXO Estimator recommendations utilized for planning. Deviation (i.e., unable to complete proposed transect coverage) from planned field sampling occurred where safety concerns limited access. Data were collected in sufficient quantity and frequency to enable evaluation by statistical planning/evaluation software as stated above.

4.2 MC CHARACTERIZATION RESULTS

Incremental and discrete soil and sediment samples were collected and analyzed for MCOC. Following completion of the analog geophysical survey, an initial geostatistical estimation of anomaly density was performed. Two CMUAs were identified resulting in the classification of three separate DUs for IS (**Section 3.1.1**). The results of the IS effort are presented in **Section 4.2.1**. Discrete samples were also collected at two locations identified during survey activities (**Section 3.1.2**). The discrete sample results are presented in **Section 4.2.2**. MC sample locations are shown in **Figure 3-1**. Data tables are presented at the end of this section. All soil samples were analyzed for lead and TNT and its breakdown products: 2,4-DNT, 2,6-DNT, 2-Amino-DNT, and 4-Amino-DNT. Sediment was analyzed for lead and AVS/SEM and TOC to determine the bioavailability of metals to aquatic organisms.

All data were validated using the procedures outlined in **Section 3.2.1**. The data validation report and analytical data package, including a glossary of laboratory data qualifiers/flags, are included in **Appendix H**. A Data Usability Assessment is provided in **Section 4.2.3**.

4.2.1 Incremental Sampling Results

IS provides a reasonably unbiased estimate of mean contaminant concentrations in a targeted unit volume. For this RI, lead and target explosives MC were characterized in DU soil and sediment using IS methodologies (**Section 3.1.1**). Only lead was detected at concentrations that exceeded either human health or ecological screening criteria. The aggregate arithmetic mean of lead in incremental samples was calculated for each DU as the point of comparison to screening criteria and background reference values (**Table 4-3**).

Background Sampling

Incremental soil and sediment samples were collected as background reference from accessible locations of the MRS that were not impacted by MEC or MD. Based on the MEC RI results, the middle and southern portion of Training Area G1 was determined to not have been impacted by any live fire activities and was chosen as an appropriate background location (**Figure 3-1**). The incremental soil and sediment samples were collected as 50-increment samples, each in triplicate, from representative 1 acre areas within Training Area G1.

The average background concentration of lead in soil was calculated as the arithmetic average of triplicate samples (WPIS00SB01-03); the average background lead concentration in soil was 86.7 milligrams per kilogram (mg/kg) (**Table 4-4**). This concentration is consistent with the range of 3 mg/kg to 112 mg/kg of lead that is reported for New York rural soils in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table 6b, August 2005 (NYSDEC, 2005).

Although explosives do not naturally occur, target explosives (TNT and its breakdown products) were analyzed in background soil samples to confirm the representativeness of the sampling locations and to show that no bias exists because the sampling locations were within the footprint of the Crow's Nest MRS. Target explosives were reported below detection limits in background soil samples WPIS00SB01-03 (**Table 4-4**).

The average background concentration of lead in triplicate sediment samples (WPIS00SA01-03) was 74.53 mg/kg. A summary of all soil and sediment background data is provided in **Table 4-4** and presented on **Figures 4-6** and **4-7**.

Decision Unit 01

IS soil samples were collected from 11 SUs within DU-01 to characterize lead and explosives MC within the former Crow's Nest Impact Area CMUA. Each SU was sampled in triplicate as 50-increment samples. All soil samples were analyzed for lead and target explosives (TNT and its DNT breakdown products).

Elevated concentrations of lead were detected in DU-01 soil. The mean lead concentration in DU-01 was 690.8 mg/kg which exceeds both the human health and ecological screening criteria for lead (400 mg/kg and 11 mg/kg, respectively) and is an order of magnitude higher than the background reference concentration (86.7 mg/kg) (**Table 4-3** and **4-5**). **Figure 4-6** presents the findings for lead at the MRS. **Table 4-5** presents the analytical results for MC in DU-01 soil.

Trace levels of explosives were also detected within DU-01 soil. However, no human health or ecological benchmarks were exceeded for TNT or any of its DNT breakdown products. **Figure 4-7** presents the findings for target explosives in DU-01 soil. **Table 4-5** presents the analytical results for MC in DU-01 soil.

Decision Unit 02

Sediment was collected from the wetland located within the highest expected density of MEC, within the footprint of DU-01, and defined as a separate DU. Sediment was incrementally collected from the 1.3-acre wetland as 50-increment samples using the same methodologies as IS soil sample collection (**Section 3.1.1**). All sediment samples were analyzed for lead, AVS, SEM, and TOC.

The average concentration of lead within DU-02 sediment was 3,433 mg/kg (**Table 4-3**). This concentration is two orders of magnitude higher than the average background sediment concentration of 74.5 mg/kg. Both human health and ecological screening criteria (400 mg/kg and 35.8 mg/kg, respectively) are exceeded. **Figure 4-6** presents the findings for lead at the MRS. **Table 4-6** presents the analytical results for MC in DU-02 sediment.

AVS was positively reported as an average of 0.92 micromoles (µmol) per gram of sediment. For the most part, SEM were positively or tentatively identified in all samples with the exception of mercury. Mercury was not detected above the LOD in the primary and duplicate samples (WPIS02SA01 and WPIS02SA02) and the data were subsequently rejected as a result of an MS/MSD percent recovery anomaly. These rejected mercury data were retained in the calculation of ΣSEM, at their LOD, as a conservative estimate in the assessment of ∑SEM/AVS. Relatively high concentrations of TOC were observed in DU-02 sediment (average 53 percent organic carbon).

The bioavailability of some cationic metals in most anoxic sediments can be predicted by measuring the 1:1 relationship (in µmol) between AVS and SEM (∑SEM = sum of cadmium, copper, lead, nickel, mercury, and zinc). The resulting ratio of ∑SEM/AVS is useful for predicting metals bioavailability and toxicity (or lack thereof) to benthic organisms in sediments (ITRC, 2011). Ratios less than 1 indicate low potential for metals bioavailability; while ratios above 1 indicate greater potential for metals bioavailability. The ratio of ∑SEM/AVS for DU-02 sediment is above 1 indicating there is insufficient AVS present to completely form insoluble metal sulfides.

Organic carbon in sediment can also bind free metals and reduce their availability to aquatic organisms. When ∑SEM-AVS is normalized to the fraction of organic carbon (f_{oc}) in sediment, the resulting ratio is an indication of the potential for metals in sediment to be toxic to benthic invertebrates. Sediment samples are predicted to be non-toxic with ratio values less than or equal to 130 µmol/g (gram) organic carbon. The results of this calculation indicate there is a low potential for metal toxicity to benthic invertebrates (calculated average of 13.5) (USEPA, 2005).

All analytical results as well as the calculation of the average ΣSEM/AVS and (ΣSEM – AVS) / f_{oc} for DU-02 sediment are provided in **Table 4-6**.

Decision Unit 03

IS soil samples were collected from two SUs within DU-03 to characterize lead and explosives MCOC within Training Area G2. Each SU was collected in triplicate as 50-increment samples (**Section 3.1.1**). All soil samples were analyzed for lead and target explosives (TNT and its DNT breakdown products).

The average concentration of lead in DU-03 was 73.73 mg/kg. The human health screening criterion was not exceeded. The ecological screening criterion of 11 mg/kg was exceeded; however, the average DU-03 lead concentration was below the average background reference concentration of 86.7 mg/kg (**Table 4-3**). **Table 4-7** and **Figure 4-6** present the analytical results for lead at DU-03.

Neither TNT nor any of its DNT breakdown products were found above their detection limits within DU-03. **Table 4-7** and **Figure 4-7** present the analytical results for target explosives at DU-03.

4.2.2 Discrete Sampling Results

Background Concentration

Published data for lead in rural New York soils were used as background reference for discrete samples. Based on the published data in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table 6b, August 2005 (NYSDEC, 2005), lead in rural New York soils ranges from 3 mg/kg to 112 mg/kg (95th percentile of 63 mg/kg). Explosives are not naturally occurring; therefore, no background value exists.

Single Item: DS-01

Discrete soil samples were collected from both primary and step-out locations at two different depths for 10 sampling locations. Shallow subsurface samples were collected at 12 inches bgs (the depth of discovery); subsurface samples were collected in the following 12 to 18 inches bgs. All soil samples were analyzed for lead and TNT and its breakdown products.

Lead was detected in all sample locations at varying magnitudes ranging from 30.4 mg/kg in subsurface sample WPDS01SL01 to 881 mg/kg in shallow subsurface sample WPDS01SA01 (B-flagged). The maximum lead concentration observed is consistent with that found in soil within the surrounding area (see ISM samples WPIS01SK01-03 and WPIS01SJ01-03; **Figure 4-6**). The human health screening level for lead of 400 mg/kg was exceeded only in primary shallow subsurface (881 mg/kg, B-flagged) and subsurface (755 mg/kg) samples (WPDS01SA01 and WPDS01SB01, respectively).

Explosives were detected in 8 out of 10 sample locations. TNT was detected in 7 out of 10 sample locations with concentrations ranging from 0.017 mg/kg in sample WPDS01SK01 (JJ-flagged) to 20 mg/kg in sample WPDS01SA01. The human health screening level for TNT (3.6 mg/kg) was exceeded only in primary shallow subsurface (20 mg/kg at WPDS01SA01) and subsurface (6.7 mg/kg at WPDS01SB01) samples. Trace amounts of TNT breakdown products were observed; however, none exceeded their respective screening levels.

Table 4-8 presents the analytical results for both lead and explosives for the discretely collected samples from the Single Item location.

Munitions Pile: DS-02

Discrete soil samples were collected from both primary and step-out locations at two different depths for 10 sampling locations. Shallow samples were collected from the first 0 to 6 inches bgs; shallow subsurface samples were collected in the following 6 to 12 inches bgs. All soil samples were analyzed for lead and TNT and its breakdown products.

Lead was detected at all 10 sampling locations at concentrations ranging from 10.7 mg/kg, in shallow subsurface sample WPDS02SD01, to 557 mg/kg (B-flagged), in duplicate surface sample WPDS02SB02. These concentrations are consistent with, or below, the concentration of lead observed in soil within the surrounding area (see ISM samples WPIS01SA01-03 and WPIS01SB01-03; **Figure 4-6**). The human health screening level for lead of 400 mg/kg was exceeded only in duplicate primary shallow sample WPDS02SB02 (557 mg/kg, B-flagged) and the shallow sample collected to the east of the primary location, WPDS02SG01 (407 mg/kg). No exceedances were found in shallow subsurface samples.

Explosives were detected only within the primary sample location, at both depths. Primary shallow sample WPDS02SA01 and WPDS02SA02 (duplicate) contained 18 mg/kg (MM-flagged) and 55 mg/kg of TNT, respectively; primary shallow subsurface sample WPDS02SB01 contained only 1.4 mg/kg of TNT. The human health screening level for TNT (3.6 mg/kg) was exceeded only in the primary shallow sample location. Trace amounts of TNT breakdown products were observed; however, none exceeded their respective screening levels.

Table 4-9 presents the analytical results for both lead and explosives for the discretely collected samples from the munitions pile location.

4.2.3 MC Data Usability Assessment

Although the RI MC data are considered reliable, some degree of uncertainty is unavoidable. Specific factors that may contribute to the uncertainty of the data evaluation are described below. The following Data Quality Indicators (Precision, Accuracy, Representativeness, Comparability, Completeness and Sensitivity) are important components in assessing data usability. When evaluated using these parameters, the data is shown to be of high quality. The data validation report (**Appendix H**) presents explanations for all qualified data in greater detail. As stated in the data validation report, all data are usable as qualified, except for the data that were flagged "R" by the data validator.

4.2.3.1 Precision

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected as close as possible in time and place. Field sampling precision is measured with the field duplicate relative percent differences (RPDs); laboratory precision is measured with calibration verification, laboratory control spike (LCS) and matrix spike duplicate RPDs, dual column precision analysis, and serial dilution percent differences.

Calibration verifications are performed routinely to ensure that instrument responses for all calibrated analytes are within established control criteria. Two calibration verifications displayed percent differences greater than the quality control limit of ±20 percent for 2,4,6-TNT and 2,6-DNT. The associated field sample results were qualified due to a linear range exceedance and these field samples were reanalyzed by the laboratory with results that were used in risk assessment.

LCS pairs are prepared by addition of known concentrations of each analyte in a matrix-free media known to be free of target analytes. LCS pairs were analyzed for every analytical batch to demonstrate the ability of the laboratory to detect similar concentrations of a known quantity in matrix-free media. All LCS pairs met the RPD precision outlined in the UFP-QAPP.

For the explosives analysis, a positive detection on one analytical column is confirmed by a second signal. Several positive field sample results displayed a RPD greater than the control limit of 40 percent, resulting in 10 retained field sample results being flagged "J," and three retained field sample results being flagged "NJ" for an RPD greater than 70 percent. The "J" flag means that the sample concentration reported is an approximation, and the bias is unknown, while "NJ" indicates the presence of an analyte that has been "tentatively identified" and the concentration reported is an approximation. These flagged data were retained as useable in the RI as conservative estimates for the calculation of risk. A summary of these anomalies is displayed in **Table 4-9** below:

Table 4-10: Relative Percent Difference Summary

Field Sample	Analyte	RPD (%)
WPDS01SA01	2,4-DNT	40.7
WPDS02SA01	4-Am-2,6-DNT	49.3
WPDS02SA02	4-Am-2,6-DNT	53.3
WPIS01SI02		99.4
WPIS01SE03	2,4,6-TNT	60.6
WPIS01SJ03		42.7
WPIS01SF01		41.5
WPIS01SK01	2-Am-4,6-DNT	53.3
	2,4-DNT	66.4
WPIS01SK02	4-Am-2,6-DNT	42.1
WPIS01SK03		44.1
WPIS01SD04	2-Am-4,6-DNT	73.9
	2,4-DNT	75.9
WPDS02SB01	4-Am-2,6-DNT	100.5
WPDS01SK01	2,4,6-TNT	42.8
	4-Am-2,6-DNT	97.6
WPDS01SP01	2,4-DNT	64.7

A matrix spike pair is prepared, analyzed, and reported for all preparation batches. Matrix spikes demonstrate that the analytical system was in control for the matrix being tested. Matrix spike pairs were analyzed for every analytical batch to demonstrate the ability of the laboratory to detect similar concentrations of a known quantity in site matrix media. The matrix spike pairs performed on field sample WPIS02SA01 displayed a RPD greater than the laboratory control limit of 30 percent for copper at 48.5 percent and mercury at 54.0 percent. This anomaly is considered minor based on EPA Region 2 Evaluation of Metals Data for the Contract Laboratory Program Data Assessment and Contract Compliance Review, and the associated field sample results were qualified due to matrix spike percent recovery anomalies. The matrix spike imprecision is likely due to matrix interference, considering the laboratory control spike pairs displayed RPD within control limits.

Field duplicate pairs and field triplicate sets were collected to assess the overall sampling and measurement error for this sampling effort. The field duplicate sample was analyzed for the same analytes as the primary field sample. An RPD of 35 percent was used to evaluate the field duplicate precision and a relative standard deviation (RSD) of 50 percent was used to evaluate the field triplicate precision for all results that displayed concentrations greater than the LOD in accordance with the UFP-QAPP. If one result of the pair or set was greater than the LOD, a control limit of less than three times the limit of quantitation (LOQ) was used. The field duplicate pairs performed on field samples WPDS02SA01 and WPDS01SB01 displayed anomalies for lead, 2-amino-4,6-DNT and 2,4,6-TNT that resulted in eight field sample results being flagged "J," while the field triplicate sets associated with WPIS01SG01, WPIS01SF01, and WPIS01SC01 displayed anomalies for lead that resulted in nine field samples being flagged "J," The "J" flag means that the associated numerical results are considered approximations of the actual sample concentrations.

Results qualified "J" (estimated) are considered positive detections in accordance with EPA/540/1-89/002, *Risk Assessment Guidance for Superfund*, Volume I (1989). These estimated concentrations introduce a small amount of uncertainty into the precision of the data, the direction of which is unknown. However, the inherent heterogeneity of soil coupled with topographic effects of localized weathering and settling of contaminated soil into depressions and crevices likely contributes to the elevated RPD/RSD. This heterogeneity is a reflection of the actual conditions encountered throughout the MRS and the resulting uncertainty in concentration does not warrant rejection of the data. For the incremental sample RSD anomalies specifically, nine out of the 342 incremental sample results were flagged due to RSD anomalies. Sampling design was adequate to control the effects of distributional and compositional heterogeneity, as evidenced by 2.6% of the data points having to be flagged for this imprecision, all of them lead. Laboratory processing procedures were adequate to control the effects of the site heterogeneity, as evidenced by the explosives laboratory replicates being within control limits. A summary of the RPD/RSD anomalies is displayed below in **Table 4-10**:

Table 4-11: RPD/RSD Anomaly Summary

Primary Sample	Analyte	RSD (%)	RPD (%)	Δ>3x LOQ
WPIS01SG01	Lead, Total	63.0	-	-
WPIS01SF01		55.1	-	-

Table 4-11: RPD/RSD Anomaly Summary

Primary Sample	Analyte	RSD (%)	RPD (%)	Δ>3x LOQ
WPIS02SA01	Copper (SEM)	58.1	-	-
WPIS01SC01	Lead, Total	52.4	-	-
WPDS02SA01	Lead, Total	-	42.4	-
	2.4.6-TNT	-	101.4	-
	2-Amino-4,6-DNT	-	-	Yes
WPDS01SB01	Lead, Total	-	47.3	-
	2.4.6-TNT	-	101.1	-

A serial dilution is prepared by the laboratory after digestion for the metals analyses for each preparation batch by creating a 1:5 dilution of a digestate in water. The serial dilution result should be within 10 percent of the neat digest. A serial dilution displayed a percent difference greater than 10 percent for lead at 10.8 percent. Two field sample results were qualified "J." The "J" flag means that the associated numerical results are considered approximations of the actual sample concentrations.

4.2.3.2 Accuracy

Accuracy is a measure of confidence in a measurement. The smaller the difference between the measurement of a parameter and its "true" or expected value, the more accurate the measurement. The more precise or reproducible the result, the more reliable or accurate the result. Accuracy is measured through percent recoveries in the LCSs, the matrix spike pairs, and surrogates.

LCS are prepared by addition of known concentrations of each analyte in a matrix-free media known to be free of target analytes. LCSs were analyzed for every analytical batch to demonstrate that the analytical system was in control during sample preparation and analysis. Two LCS pairs displayed percent recoveries greater than the upper quality control limit of 117 percent for 2,4-DNT. The associated field sample results were non-detect and no data were qualified based on these anomalies.

A matrix spike pair is prepared, analyzed, and reported for all preparation batches. Matrix spikes demonstrate that the analytical system was in control for the matrix being tested. Matrix spike pairs were analyzed for every analytical batch to demonstrate the ability of the laboratory to recover a concentration of a known quantity in site matrix media. The matrix spike performed on field sample WPIS01E01 displayed percent recoveries greater than the upper control limit for 2,6-DNT. The associated field sample results were non-detect and no data were qualified based on these anomalies. The matrix spike performed on field sample WPIS02SA01 displayed percent recoveries less than 10 percent for copper and mercury and a percent recovery greater than the upper control limit for nickel. The positive field sample results associated with the positive bias were qualified with a "J" and the concentrations reported may be biased high. The positive field sample results associated with the negative biases were qualified "J," and the concentrations reported may be biased low. The two non-detect field sample results associated with the negative biases were qualified "R," indicating that for two associated mercury results, the absence of the

analyte cannot be verified. However, the rejected mercury data were retained in the calculation of ΣSEM, at mercury's LOD, as a conservative estimate in calculations. Utilizing the rejected mercury data, at mercury's LOD, in the assessment of metals bioavailability in sediment results in a more conservative estimate of the ability of AVS and/or TOC to bind metals in sediment and thereby reduce their availability to aquatic organisms.

The surrogate compound 1,2-dinitrobenzene was added to all field samples and QC samples during sample preparation. Surrogate compounds are substances with properties that mimic the analytes of interest. Surrogate compounds are unlikely to be found in field samples and are added to demonstrate the laboratory's ability to detect a similar compound at a known concentration. Several field samples displayed surrogate percent recoveries less than the lower control limit of 78 percent with 14 field sample results being retained in the data set. The positive field sample results were qualified "J," and the concentrations reported may be biased low. The non-detect field sample results were qualified "UJ," indicating that the reported quantitation limit is approximate and may or may not represent the actual LOQ necessary to accurately and precisely measure the analyte in the sample.

4.2.3.3 Representativeness

Representativeness qualitatively expresses the degree to which data accurately reflect site conditions. Factors that affect the representativeness of analytical data include appropriate sample population definitions, proper sample collection and preservation techniques, analytical holding times, use of standard analytical methods, and determination of matrix or analyte interferences.

Field sample collection, preservation and shipping were performed in accordance with the UFP-QAPP and URS SOPs. No quality issues were observed by the Sample Team Lead during field activities (see Daily Quality Reports presented in **Appendix A**). Each SU was located at the time of collection using a GPS. These locations were plotted on a site map and accurately correspond with the planned GIS locations. Thus, the sampled soil and sediment is known to be located within the CMUA and background area.

One SU within DU-01 (WPIS01SK) had to be shifted south approximately 150 feet as a result of unsafe, steep terrain. The size of the sampling unit was maintained (1 acre). The expected anomaly density covered by the relocated WPIS01SK is the same as the pre-planned location. Shifting the SU within the same expected anomaly density has no predictable effect on representativeness.

As described in **Section 3.1.1**, the MC sampling design was fundamentally biased high to target CMUAs within the MRS that reflect a higher expected degree of potential contamination based on the presence of MEC and/or MD. As such, uniform distribution of MC across the MRS was considered unlikely and targeting CMUAs (DUs) within the MRS appropriate. The data resulting from the characterization of MC within respective DUs is considered conservative. DU and SU location and sampling density were established following the preliminary results of the RI MEC survey and based on professional judgment in accordance with the UFP-QAPP.

The location of duplicate and triplicate IS samples was randomized with respect to the primary location. Heterogeneity observed between duplicate and triplicate samples is likely the result of the heterogeneous nature of soil, the dispersion of munitions-related source material, and

topographic erosional effects. Overtime, intense weathering likely caused localized migration of MC-contaminated soil into depressions and crevices resulting in higher concentrations within "pockets" of the SUs and DUs as a whole. In the instances where an RSD greater than the control limit of 50% was encountered, it should be noted that high RSDs are very likely to overestimate the mean, so the average value of the triplicate set would be a more conservative concentration for lead. According to ITRC guidance on Skewness and Dispersion, the RSD (or coefficient of variation) value is still considered to have low variability and dispersion (http://itrcweb.org/ism-1/4_1_1_Skewness_and_Dispersion.html#Table_4_1). Samples from within each SU are considered both representative of their SUs and, as a whole, representative of the entire DU. Additionally, samples collected from the background area are considered representative of baseline conditions because the area was found to not have been impacted by any live fire activities and covers a terrain and soil/sediment types similar to that of the DUs.

Use of a standard soil probe sampler at each location ensured representativeness of the medium being sampled (surface soil and sediment) because it allows standardizing grab sample sizes, reliably achieving the targeted sample depth (i.e., material within the top 6 inches), and is easy to decontaminate thus minimizing the potential for cross contaminating samples. Each incremental aliquot was identical in size and volume and was thus equally represented within each SU sample.

Field QC samples were collected to assess the representativeness of the data collected. All ISM samples were collected in triplicate for all analyses conducted. Field duplicates were collected at a rate of 10 percent for all discrete samples. All preservation techniques were followed by the field staff and all technical and analytical holding times were met by the laboratory. The laboratory used approved standard methods as outlined in the UFP-QAPP for all analyses.

Equipment blanks were also collected for ISM samples. Trace amounts of lead were detected in equipment blanks WPIS01SD04 at 0.12 micrograms per liter (µg/L) J-flagged and WPIS01SE04 at 0.10 µg/L J-flagged (**Table 4-12**, located at the end of this section), both of which are below the LOD of 0.5 µg/L. The acceptance criteria for an equipment blank is that no analytes are detected greater than the LOD (per the RI UFP-QAPP). The detections for lead in the equipment blanks did not display a bias above this threshold and were not used as outliers during data validation. No impact on the data is anticipated as a result of carryover from the soil probe following the decontamination process because the amount of lead is very low. Furthermore, given the magnitude of lead concentrations found at each DU, the concentrations of lead observed in equipment blanks is negligible by comparison. The degree to which any given DU exceeded or was below human health or ecological screening criteria for lead was more than three orders a magnitude greater than the maximum equipment blank concentration observed. As such, all data are useable in the assessment of human health and ecological risk. Overall, the data are usable for evaluating the nature and extent of MC at the MRS. Sufficient usable data were obtained for each DU to meet the objectives of the RI and to complete the risk assessment.

4.2.3.4 Comparability

Comparability is the extent to which data from one study can be compared directly to either past data from the current project or data from another study. Using standardized sampling and analytical methods, units of reporting, and site selection procedures helps ensure comparability. Standard field sampling and typical laboratory protocols were used in this investigation.

Data comparability between the background and DU sampling data is necessary to accurately screen DU MC concentrations against the background average. Comparability was achieved by implementing identical sampling and analytical procedures in both the background area and DU. The background area is located in a portion of the MRS found to not have been impacted by any live fire activities and covers a terrain, soil types, and similar wetland area to that of the DUs.

Samples were collected over a period of approximately 2 weeks. Sample collection dates therefore varied by up to a week between samples from a particular DU. However, the temporal difference is negligible considering that the sampling program is assessing possible effects from artillery training that occurred over a century ago.

Following EPA (2010) guidance, the aggregate arithmetic mean of lead in incremental samples was calculated for each DU as the point of comparison to screening criteria and background reference values so that decisions would be based on the overall data distribution for the DU and not a single value (such as a maximum detected concentration). No target explosives MC were detected in any samples above human or ecological screening criteria.

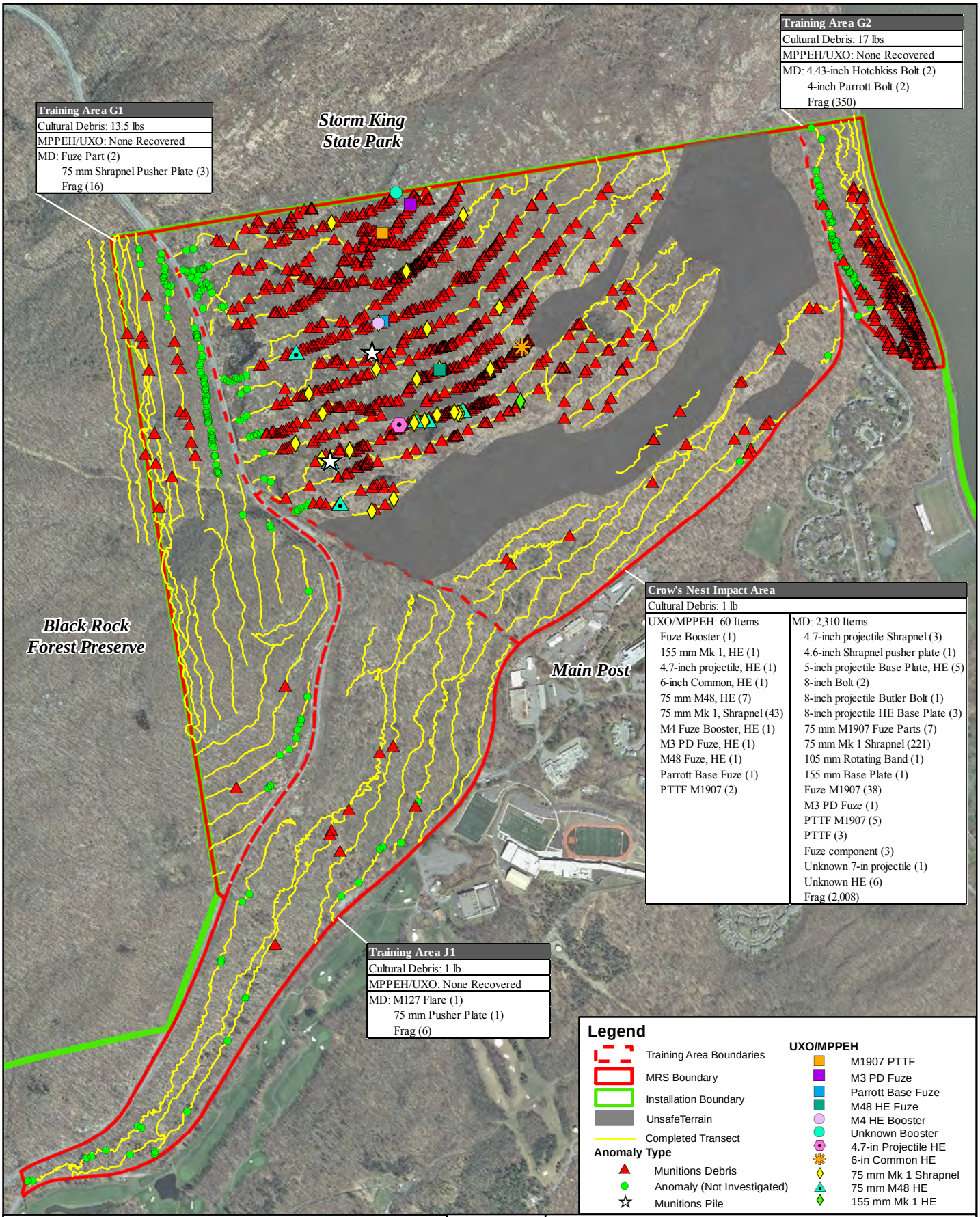
4.2.3.5 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount of data expected under normal conditions. It is expected that laboratories will provide data meeting system QC acceptance criteria for all samples tested. Project completeness is determined by evaluating the planned versus actual quantities of data. Percent completeness per soil parameter is as follows:

- Explosives by SW-846 8330B at 100 percent
- Total Lead by SW-846 6010C/6020A/7470A at 97.7 percent
- TOC by Llyod Khan at 100 percent

4.2.3.6 Sensitivity

Sensitivity is the capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. Examples of QC measures for determining sensitivity include laboratory fortified blanks, a method detection limit (MDL) study, and calibration standards at the quantitation limit (QL). To meet the needs of the data users, project data must meet the measurement performance criteria for sensitivity and project QLs specified in the UFP-QAPP. The laboratory provided the requested MDL studies and provided applicable calibration standards at the QL. To achieve the DQOs for sensitivity outlined in the UFP-QAPP, the laboratory reported all field sample results at the lowest possible dilution. No non-detect field sample results were retained in the data set; all dilutions were performed appropriately and correctly.



CLIENT	USACE - Baltimore District			
PROJ	Crow's Nest MRS Remedial Investigation			
	0 500 1,000 2,000 Feet			
SCALE	1:12,940	DES BY	MS	05/03/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagery sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	JL	05/03/2016

N

TITLE

MEC Characterization Results

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FIGURE 4-1

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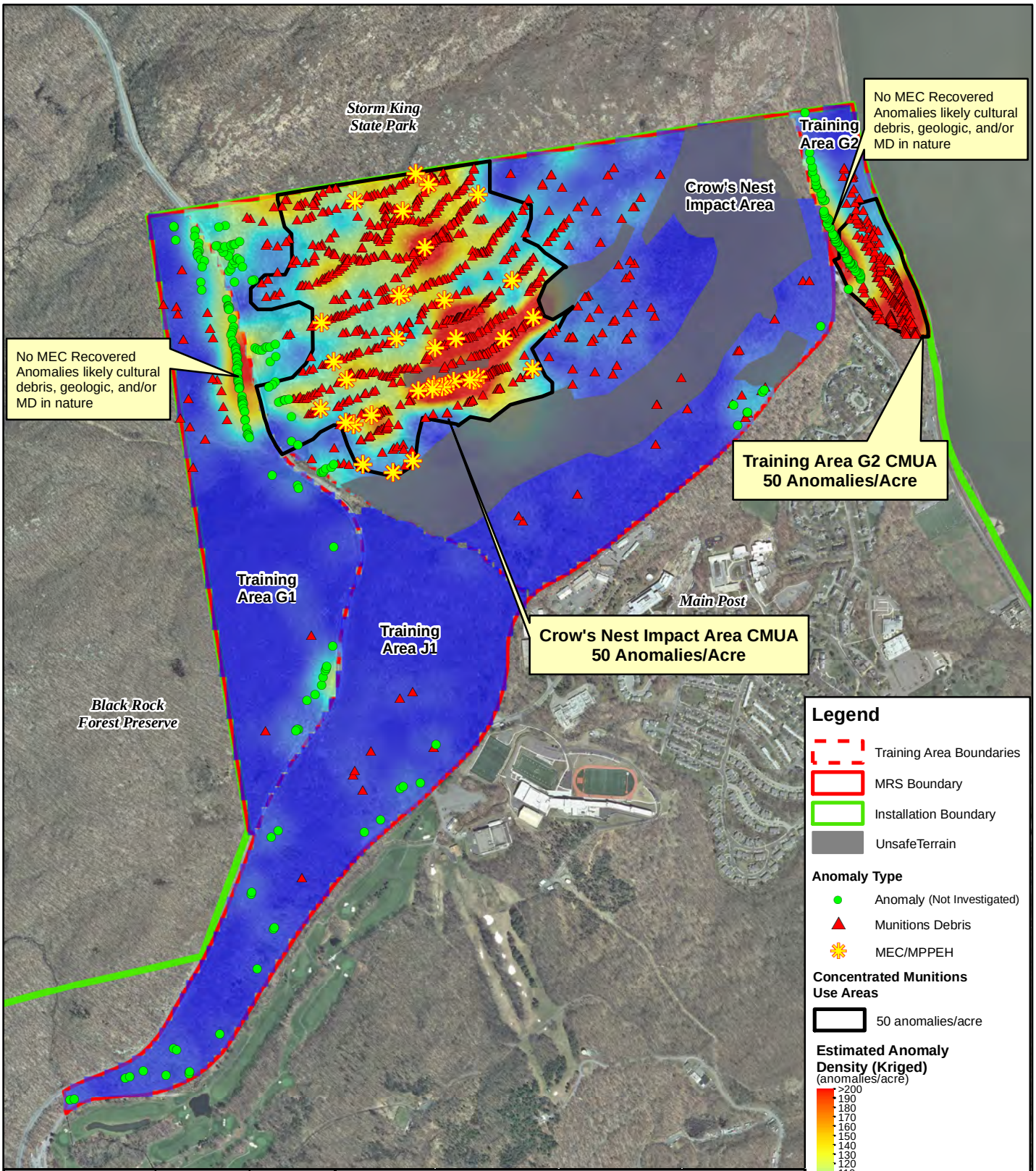

Only MEC & MD used to generate boundary delineation	Crow's Nest Impact Area CMUA (acres)	Training Area G2 CMUA (acres)	Complete MRS			
			NCMUA (acres)	NCMUA Transect Area (acres)	Total number of MEC in CMUA	Total number of MEC in NCMUA
50	115.94	12.25	477.02	29.52	60	0

CLIENT	USACE - Baltimore District		
PROJ	Crow's Nest MRS Remedial Investigation		
0 600 1,200 2,400 Feet			
SCALE	1:14,621	DES BY	JL	06/20/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagery sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LP	06/20/2016

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TITLE

CMUAs - Impact Areas

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FIGURE 4-2

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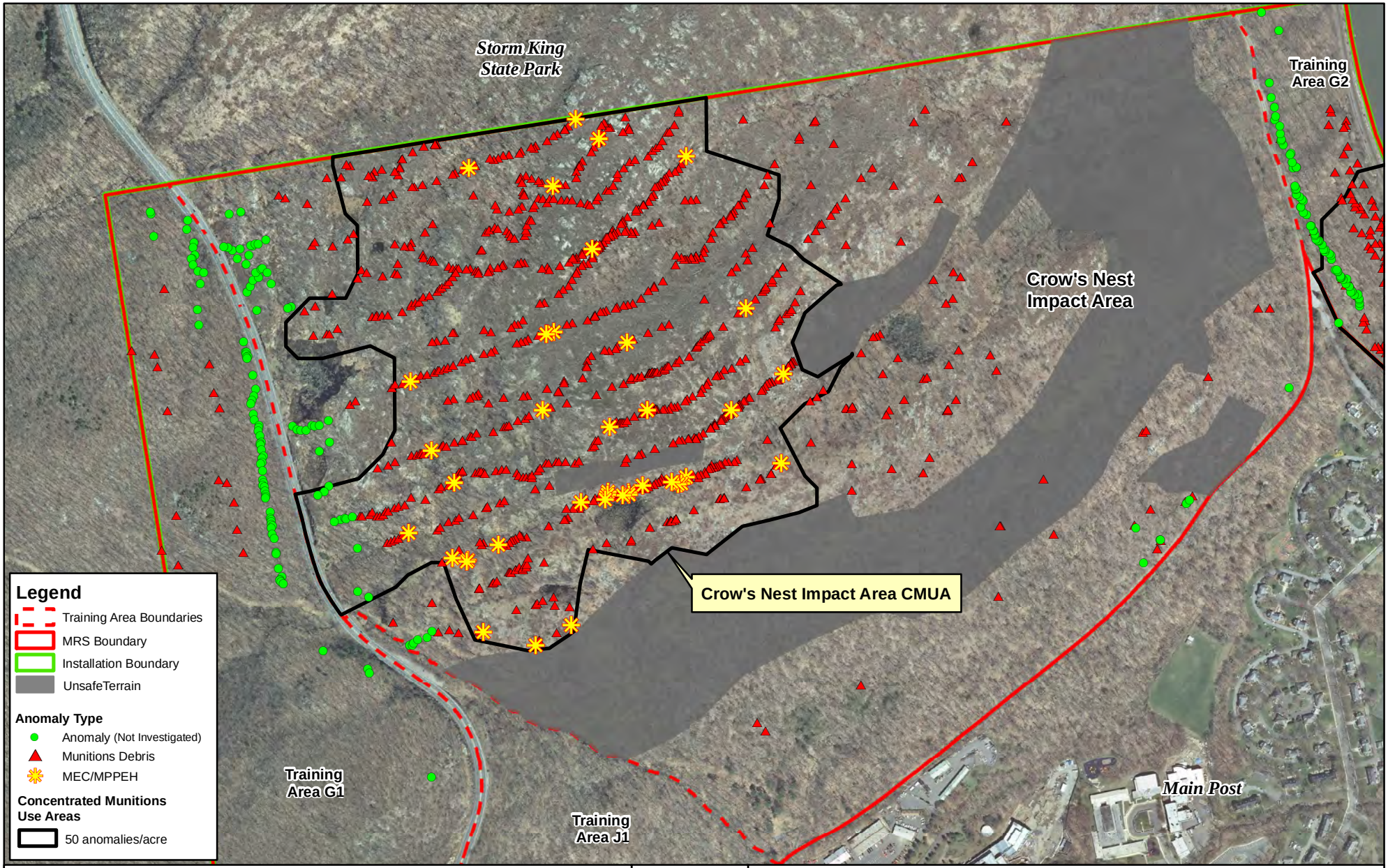

CLIENT	USACE - Baltimore District
PROJECT	Crow's Nest MRS Remedial Investigation

0 335 670 1,340 Feet

N

TITLE **Crow's Nest Impact Area CMUA Results**

SCALE	1:8,000	DES BY	JL	07/05/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LAP	07/05/2016

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FIGURE 4-3

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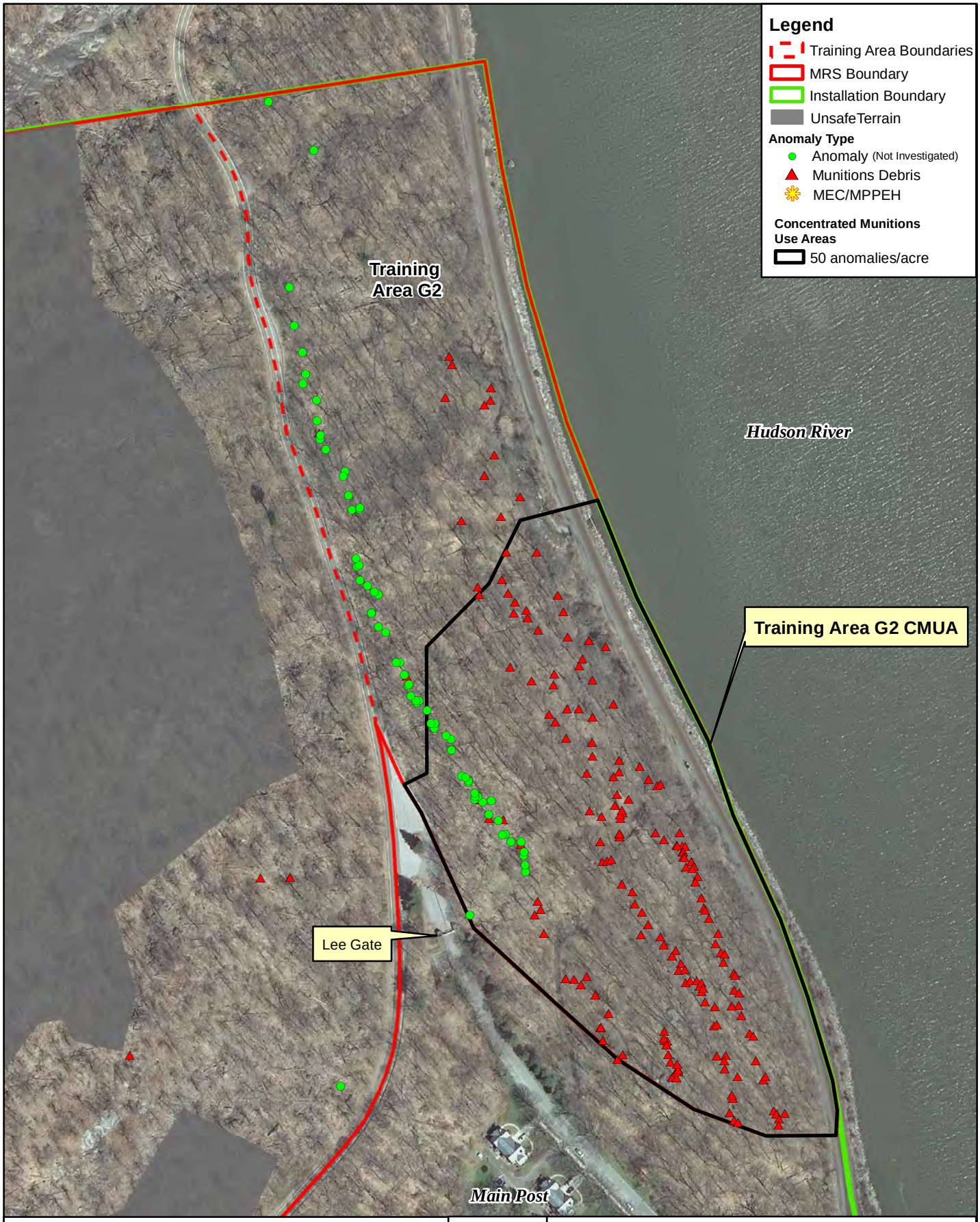

CLIENT	USACE - Baltimore District			
PROJ	Crow's Nest MRS Remedial Investigation			
	0 125 250 500 Feet			
SCALE	1:3,000	DES BY	JL	04/06/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagery sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LP	04/06/2016

N

TITLE

Training Area G2 CMUA Results

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FIGURE 4-4

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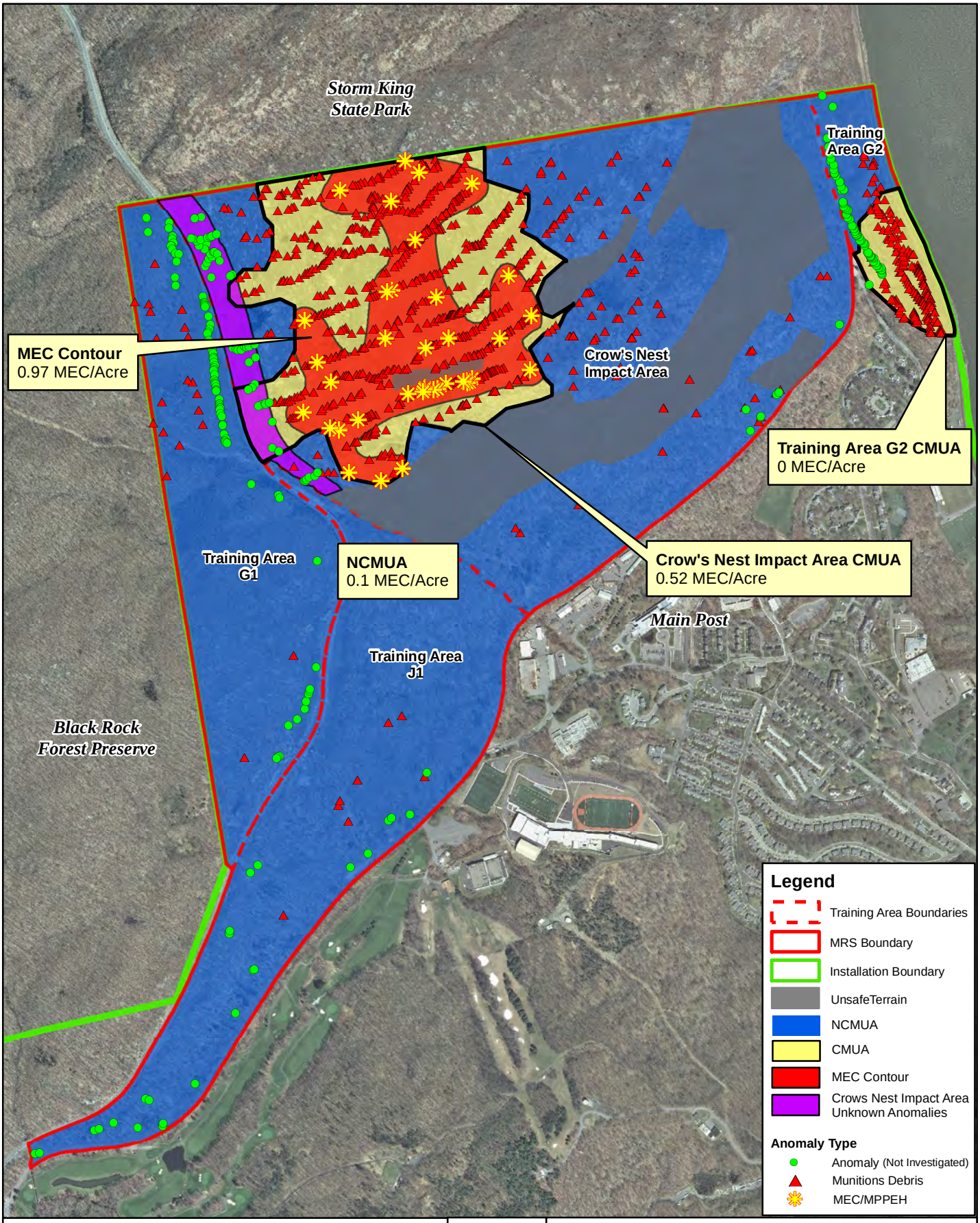

CLIENT	USACE - Baltimore District			
PROJ	Crow's Nest MRS Remedial Investigation			
	0 500 1,000 2,000 Feet			
SCALE	1:12,909	DES BY	MS	06/29/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagery sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LP	06/29/2016

N

TITLE

MEC Density

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FIGURE 4-5

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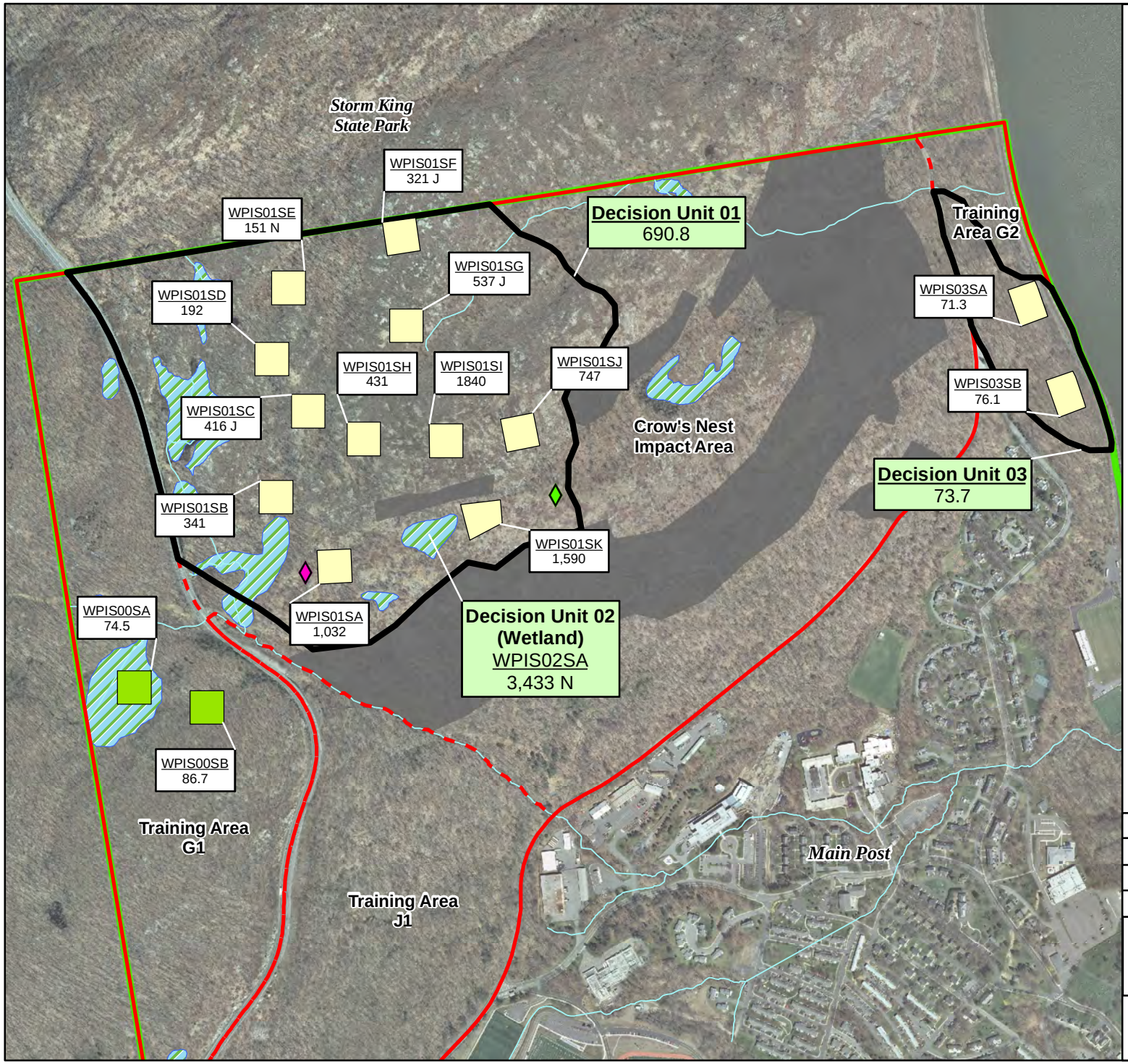

Legend

- Training Area Boundaries
- MRS Boundary
- Installation Boundary
- Decision Unit (50 anomalies/acre)
- Unsafe Terrain
- Wetland
- Stream

MC Sampling Location

- Incremental Sampling Location
- Background Incremental Sampling Location
- Discrete Sampling Location Munitions Pile
- Discrete Sampling Location Single Item

All Lead Results in mg/kg

WPIS01SE 151 N — Sampling Unit - Average Triplicate Concentration

Decision Unit 01 690.8 — Decision Unit - Average Total Concentration

N

0 400 800 1,600 Feet

Coordinate System: NAD 1983 UTM Zone 18N

CLIENT	USACE - Baltimore District	
PROJ	Crow's Nest MRS Remedial Investigation	
DES BY	JL	06/18/2016
CHK BY	LAP	06/18/2016

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Figure 4-6
MC IS Results - Lead

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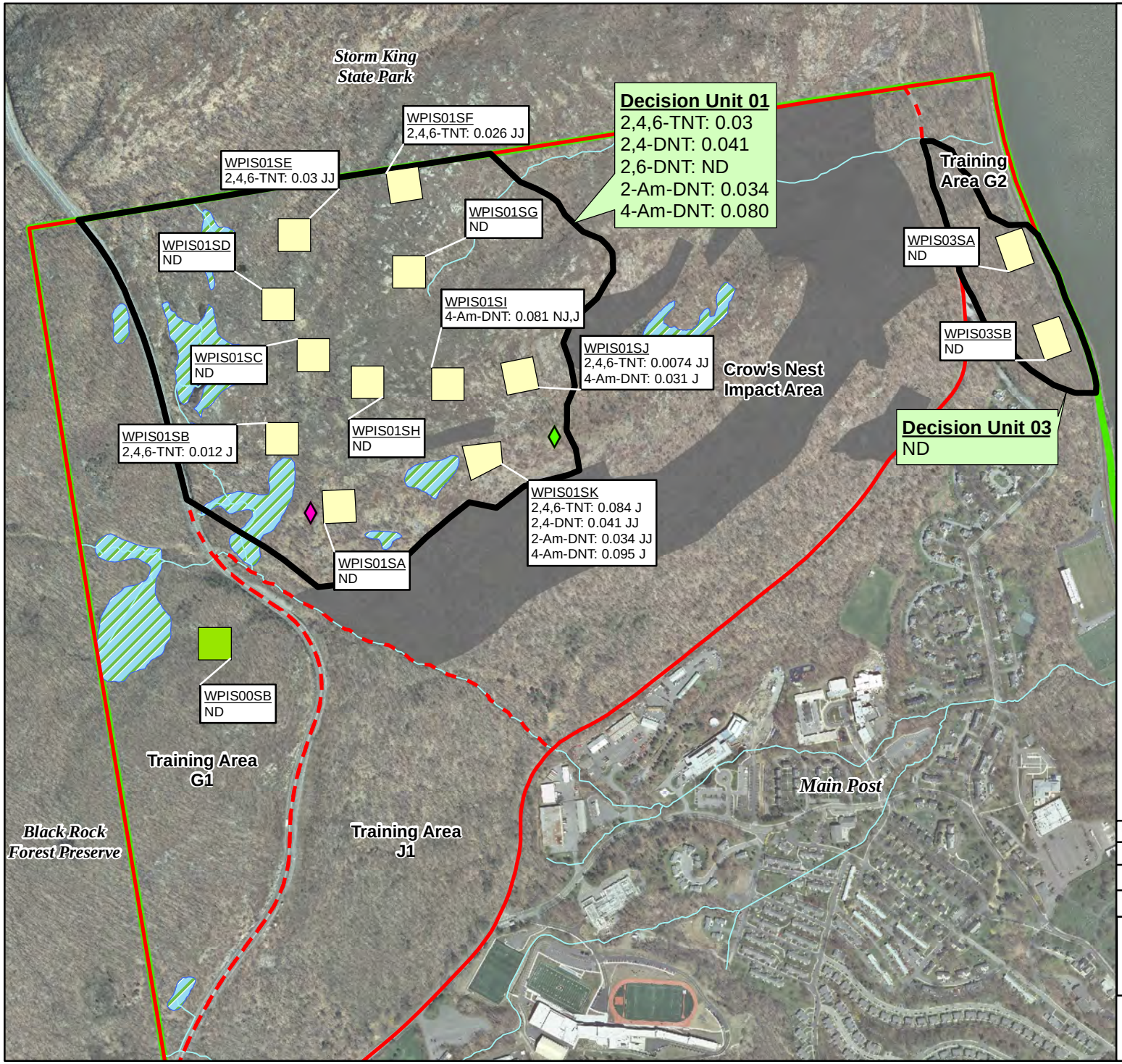

Legend

- Training Area Boundaries
- MRS Boundary
- Installation Boundary
- Decision Unit (50 anomalies/acre)
- Unsafe Terrain
- Wetland
- Stream

MC Sampling Location

- Incremental Sampling Location
- Background Incremental Sampling Location
- Discrete Sampling Location Munitions Pile
- Discrete Sampling Location Single Item

All Explosives Results in mg/kg

WPIS01SE ND — Sampling Unit - Average Triplicate Concentration

Decision Unit 01 ND — Decision Unit - Average Total Concentration

N

0 410 820 1,640 Feet

Coordinate System: NAD 1983
UTM Zone 18N

CLIENT	USACE - Baltimore District	
PROJ	Crow's Nest MRS Remedial Investigation	
DES BY	JL	06/17/2016
CHK BY	LAP	06/17/2016

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Figure 4-7
MC IS Results - Explosives

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Table 4-3: Incremental MC Results

Location:				Decision Unit 01		Decision Unit 02		Decision Unit 03	
Explosives (mg/Kg dry wt)	Average Background	Human SL	Ecological SL	Average Concentration	Data Flag	Average Concentration	Data Flag	Average Concentration	Data Flag
2,4,6-Trinitrotoluene	--	3.6	7.6	0.032	J, JJ	-		ND	
2,4-Dinitrotoluene	--	1.7	1.28	0.041	JJ	-		ND	
2,6-Dinitrotoluene	--	0.36	0.0328	ND		-		ND	
2-Am-DNT	--	15	14	0.034	JJ	-		ND	
4-Am-DNT	--	15	12	0.069	NJ, J	-		ND	
Lead (mg/Kg)	Average Background (soil/sediment)	Human Health Screening Criteria (mg/kg) Soil & Sediment	Ecological Screening Criteria (mg/kg) Soil / Sediment	Average Concentration	Data Flag	Average Concentration	Data Flag	Average Concentration	Data Flag
Lead	86.7 / 74.5	400	11 / 35.8	**690.8**	N, J	**3433**	N	**73.73**	

Data Flags Used

J	Estimated Value
N	Tenatively Identified Compound; presumptive evidence of a compound based on mass spectral library search.
NJ	Tentatively Identified. Associated numerical value represents its approximate concentration.

Multiple flags of the same value indicates a repeat of the same anomaly

Notes:

ND	Analyte not detected above limit of detection
-	Not tested
--	Not Applicable
	Value exceeds Human Health Screening Level
Bold	Value exceeds Ecological Screening Level
Red Text	Value exceeds Background concentration

Table 4-4: Incremental Background Soil and Sediment Results

Sample ID:	WPIS00SA01				WPIS00SA02				WPIS00SA03				WPIS00SB01				WPIS00SB02				WPIS00SB03			
Laboratory Sample ID:	SI9083-1				SI9083-2				SI9083-3				SI9083-4				SI9083-5				SI9083-6			
Sample Matrix:	Sediment				Sediment				Sediment				Soil				Soil				Soil			
Sample Date:	11/9/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015			
Location:	Training Area G1 Background				Training Area G1 Background				Training Area G1 Background				Training Area G1 Background				Training Area G1 Background				Training Area G1 Background			
Comments:	Primary Sample				Field Duplicate of WPIS00SA01				Field Triplicate of WPIS00SA01				Primary Sample				Field Duplicate of WPIS00SB01				Field Triplicate of WPIS00SB01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	-				-				-				0.052	U			0.047	U			0.046	U		
2,4-Dinitrotoluene	-				-				-				0.052	U			0.047	U			0.046	U		
2,6-Dinitrotoluene	-				-				-				0.052	U			0.047	U			0.046	U		
2-Am-DNT	-				-				-				0.052	U			0.047	U			0.046	U		
4-Am-DNT	-				-				-				0.052	U			0.047	U			0.046	U		
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	76.6				78.6				68.4				77.1				90.6				92.4			

Laboratory Qualifiers Used

U Analyte not detected

Notes:

SL Screening Level

LQ Laboratory Qualifier

VQ Validation Qualifier

RC Reason Code

- Not tested

-- Not Applicable

Table 4-5: Incremental DU-01 Soil Results

Sample ID:	WPIS01SA01				WPIS01SA02				WPIS01SA03				WPIS01SB01				WPIS01SB02				WPIS01SB03			
Laboratory Sample ID:	SI9083-7				SI9083-8				SI9083-9				SI8935-19				SI8935-20				SI8935-21			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/9/2015				11/9/2015				11/9/2015				11/5/2015				11/5/2015				11/5/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SA01				Field Triplicate of WPIS01SA01				Primary Sample				Field Duplicate of WPIS01SB01				Field Triplicate of WPIS01SB01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.052	U			0.05	U			0.051	U			0.042	U			0.054	U			0.012	J		
2,4-Dinitrotoluene	0.052	U			0.05	U			0.051	U			0.042	U			0.054	U			0.051	U		
2,6-Dinitrotoluene	0.052	U			0.05	U			0.051	U			0.042	U			0.054	UL			0.051	U		
2-Am-DNT	0.052	U			0.05	U			0.051	U			0.042	U			0.054	U			0.051	U		
4-Am-DNT	0.052	U			0.05	U			0.051	U			0.042	U			0.054	U			0.051	U		
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	1010				895				1190				298				364				362			

Sample ID:	WPIS01SC01				WPIS01SC02				WPIS01SC03				WPIS01SD01				WPIS01SD02				WPIS01SD03			
Laboratory Sample ID:	SI8935-13				SI8935-14				SI8935-15				SI8935-16				SI8935-17				SI8935-18			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/5/2015				11/5/2015				11/5/2015				11/5/2015				11/5/2015				11/5/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SC01				Field Triplicate of WPIS01SC01				Primary Sample				Field Duplicate of WPIS01SD01				Field Triplicate of WPIS01SD01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.049	U			0.051	U			0.05	U			0.049	U			0.053	U			0.047	U	UJ	s
2,4-Dinitrotoluene	0.049	U			0.051	U			0.05	U			0.049	U			0.053	U			0.047	U	UJ	s
2,6-Dinitrotoluene	0.049	U			0.051	U			0.05	U			0.049	U			0.053	U			0.047	U	UJ	s
2-Am-DNT	0.049	U			0.051	U			0.05	U			0.049	U			0.053	U			0.047	U	UJ	s
4-Am-DNT	0.049	U			0.051	U			0.05	U			0.049	U			0.053	U			0.047	U	UJ	s
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	668		J	f	296		J	f	285		J	f	197				178				202			

Laboratory Qualifiers Used

J Estimated Value

L Indicates corresponding LCS and/or LCSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria

M Indicates corresponding MS and/or MSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria

N Tenatively Identified Compound; presumptive evidence of a compound based on mass spectral library search.

U Analyte not detected

Multiple flags of the same value indicates a repeat of the same anomaly

Notes:

SL Screening Level

LQ Laboratory Qualifier

VQ Validation Qualifier

RC Reason Code

-- Not Applicable

Data Validation Flags Used

J Analyte present. Reported value may not be accurate or precise

NJ Tentatively Identified. Associated numerical value represents its approximate concentration.

UJ Analyte not detected significantly greater than method blank

Reason Codes Used

f Field Duplicate Imprecision

g Method Blank Detection

s Surrogate Percent Recovery Anomaly

Table 4-5 Incremental DU-01 Soil Results (cont.)

Sample ID:	WPIS01SE01				WPIS01SE02				WPIS01SE03				WPIS01SF01				WPIS01SF02				WPIS01SF03			
Laboratory Sample ID:	SI8810-7				SI8810-8				SI8810-9				SI8810-13				SI8810-14				SI8810-15			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/3/2015				11/3/2015				11/3/2015				11/3/2015				11/3/2015				11/3/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SE01				Field Triplicate of WPIS01SE01				Primary Sample				Field Duplicate of WPIS01SF01				Field Triplicate of WPIS01SF01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.052	U			0.05	U			0.03	JJ	J	g	0.026	JJ	J	g	0.044	U			0.05	U		
2,4-Dinitrotoluene	0.052	U			0.05	U			0.052	U			0.051	U			0.044	U			0.05	U		
2,6-Dinitrotoluene	0.052	ULLM			0.05	ULL			0.052	U			0.051	U			0.044	U			0.05	U		
2-Am-DNT	0.052	U			0.05	U			0.052	U			0.051	U			0.044	U			0.05	U		
4-Am-DNT	0.052	U			0.05	U			0.052	U			0.051	U			0.044	U			0.05	U		
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	141	N			113				198				254		J	f	187		J	f	521		J	f

Sample ID:	WPIS01SG01				WPIS01SG02				WPIS01SG03				WPIS01SH01				WPIS01SH02				WPIS01SH03			
Laboratory Sample ID:	SI8810-1				SI8810-2				SI8810-3				SI8810-16				SI8810-17				SI8810-18			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/3/2015				11/3/2015				11/3/2015				11/2/2015				11/2/2015				11/2/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SG01				Field Triplicate of WPIS01SG01				Primary Sample				Field Duplicate of WPIS01SH01				Field Triplicate of WPIS01SH01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.051	U			0.052	U			0.052	U			0.049	U			0.052	U			0.046	U		
2,4-Dinitrotoluene	0.051	U			0.052	U			0.052	U			0.049	U			0.052	U			0.046	U		
2,6-Dinitrotoluene	0.051	U			0.052	U			0.052	ULL			0.049	U			0.052	U			0.046	U		
2-Am-DNT	0.051	U			0.052	U			0.052	U			0.049	U			0.052	U			0.046	U		
4-Am-DNT	0.051	U			0.052	U			0.052	U			0.049	U			0.052	U			0.046	U		
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	330		J	f	353		J	f	927		J	f	440				352				502			

Table 4-5: Incremental DU-01 Soil Results (cont.)

Sample ID:	WPIS01SI01				WPIS01SI02				WPIS01SI03				WPIS01SJ01				WPIS01SJ02				WPIS01SJ03			
Laboratory Sample ID:	SI8810-4				SI8810-5				SI8810-6				SI8810-10				SI8810-11				SI8810-12			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/2/2015				11/2/2015				11/2/2015				11/2/2015				11/2/2015				11/2/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SI01				Field Triplicate of WPIS01SI01				Primary Sample				Field Duplicate of WPIS01SJ01				Field Triplicate of WPIS01SJ01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.051	U			0.051	U			0.053	U			0.052	U			0.049	U			0.0074	JJ	J	g
2,4-Dinitrotoluene	0.051	U			0.051	U			0.053	U			0.052	U			0.049	U			0.05	U		
2,6-Dinitrotoluene	0.051	ULL			0.051	ULL			0.053	ULL			0.052	U			0.049	U			0.05	U		
2-Am-DNT	0.051	U			0.051	U			0.053	U			0.052	U			0.049	U			0.05	U		
4-Am-DNT	0.051	U			0.096	JJ	NJ	g	0.066	J			0.052	U			0.049	U			0.031	J		
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	1280				2020				2220				787				689				766			

Sample ID:	WPIS01SK01				WPIS01SK02				WPIS01SK03			
Laboratory Sample ID:	SI8935-10				SI8935-11				SI8935-12			
Sample Matrix:	Soil				Soil				Soil			
Sample Date:	11/4/2015				11/4/2015				11/4/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Comments:	Primary Sample				Field Duplicate of WPIS01SK01				Field Triplicate of WPIS01SK01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.045	U			0.053	U			0.084	J		
2,4-Dinitrotoluene	0.041	JJ	J	g	0.053	U			0.052	U		
2,6-Dinitrotoluene	0.045	U			0.053	U			0.052	U		
2-Am-DNT	0.034	JJ	J	g	0.053	U			0.052	U		
4-Am-DNT	0.066	J			0.12	J	J	g	0.1	J	J	g
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	1480				1760				1530			

Table 4-6: Incremental DU-02 Sediment Results

Sample ID:	Average of DU-02 Triplicate Samples	WPIS02SA01				WPIS02SA02				WPIS02SA03			
Laboratory Sample ID:		SI8935-1				SI8935-4				SI8935-7			
Sample Matrix:		Sediment				Sediment				Sediment			
Sample Date:		11/4/2015				11/4/2015				11/4/2015			
Location:		Crow's Nest Impact Area Decision Unit - 02				Crow's Nest Impact Area Decision Unit - 02				Crow's Nest Impact Area Decision Unit - 02			
Comments:		Primary Sample				Field Duplicate of WPIS02SA01				Field Triplicate of WPIS02SA01			
Lead (mg/Kg)	**Average Results**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	3433	4470	N			2250				3580			
SEM (umole/g)	**Average Results**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Cadmium	0.012	0.0128	J			0.0118	J			0.0116	J		
Copper	1.11	1.84	N*	J	m	0.83		J	m	0.647		J	m
Lead	4.16	3.66	N*E	J	q	3.79		J	s	5.04		J	s
Nickel	0.11	0.118	N	J	m	0.0918		J	m	0.113		J	m
Mercury	0.00006	0.00008	UN	R	m	0.00007	U	R	m	0.00003	J	J	m
Zinc	2.69	2.84				2.71				2.52			
[1]Σ SEM	8.08	8.47				7.43				8.33			
AVS (umole/g)	**Average Results**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Acid Volatile Sulfide	0.92	1.7				0.42	J			0.65	J		
[1]Σ SEM / AVS	8.7	5.0				18				13			
TOC	**Average Results**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
TOC (ug/g dry wt)	530000	470000				580000				540000			
f_{OC} (g/g dry wt)	0.53	0.47				0.58				0.54			
TOC %	53%	47%				58%				54%			
([1]Σ SEM - AVS) / (f_{oc})	13.5	14				12				14			
Total Solids (%)	**Average Results**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
% Total Solids	13.7	11				15				15			

Laboratory Qualifiers Used

J	Estimated Value
E	Concentration Exceeded the Linear Range
N	Tenatively Identified Compound; presumptive evidence of a compound based on mass spectral library search.
U	Analyte not detected
*	Relative percent difference was outside of quality control limits

Multiple flags of the same value indicates a repeat of the same anomaly

Data Validation Flags Used

J	Analyte present. Reported value may not be accurate or precise
R	The sample results are rejected and the data point is unusable

Reason Codes Used

m	MS/MSD Percent Recovery Anomaly
q	Concentration Exceeded the Linear Range
s	Surrogate Percent Recovery Anomaly

Notes:

SL	Screening Level
LQ	Laboratory Qualifier
VQ	Validation Qualifier
RC	Reason Code
1	When the laboratory reported a non-detect value for an SEM metal or AVS, the LOD concentration was used, including where rejected, as a conservative estimate
f_{OC}	Fraction of organic carbon
--	Not Applicable

Table 4-7: Incremental DU-03 Soil Results

Sample ID:	WPIS03SA01				WPIS03SA02				WPIS03SA03				WPIS03SB01				WPIS03SB02				WPIS03SB03			
Laboratory Sample ID:	SI8990-1				SI8990-2				SI8990-3				SI8990-4				SI8990-5				SI8990-6			
Sample Matrix:	Soil				Soil				Soil				Soil				Soil				Soil			
Sample Date:	11/6/2015				11/6/2015				11/6/2015				11/6/2015				11/6/2015				11/6/2015			
Location:	Training Area G2 Decision Unit - 03				Training Area G2 Decision Unit - 03				Training Area G2 Decision Unit - 03				Training Area G2 Decision Unit - 03				Training Area G2 Decision Unit - 03				Training Area G2 Decision Unit - 03			
Comments:	Primary Sample				Field Duplicate of WPIS03SA01				Field Triplicate of WPIS03SA01				Primary Sample of WPIS03SB				Field Duplicate of WPIS03SB01				Field Triplicate of WPIS03SB01			
Explosives (mg/Kg dry wt)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.05	U			0.049	U			0.05	U			0.051	U			0.04	U			0.051	U	UJ	s
2,4-Dinitrotoluene	0.05	U			0.049	U			0.05	U			0.051	U			0.04	U			0.051	U	UJ	s
2,6-Dinitrotoluene	0.05	UL			0.049	UL			0.05	UL			0.051	UL			0.04	UL			0.051	UL	UJ	s
2-Am-DNT	0.05	U			0.049	U			0.05	U			0.051	U			0.04	U			0.051	U	UJ	s
4-Am-DNT	0.05	U			0.049	U			0.05	U			0.051	U			0.04	U			0.051	U	UJ	s
Lead (mg/Kg)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	77.5				67.5				69				73.7				64.1				90.6			

Laboratory Qualifiers Used

L Indicates corresponding LCS and/or LCSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria

U Analyte not detected

Multiple flags of the same value indicates a repeat of the same anomaly

Notes:

SL Screening Level

LQ Laboratory Qualifier

VQ Validation Qualifier

RC Reason Code

-- Not Applicable

Data Validation Flags Used

UJ Analyte not detected significantly greater than method blank

Reason Codes Used

s Surrogate Percent Recovery Anomaly

Table 4-8: Discrete Sample Results - Single Item - DS-01

	Sample ID:	WPDS01SA01						WPDS01SB01				WPDS01SB02				WPDS01SC01				WPDS01SD01				WPDS01SG01				WPDS01SH01			
	Laboratory Sample ID:	SI8562-1						SI9084-20				SI9084-21				SI9084-22				SI9084-23				SI9084-26				SI9084-27			
	Sample Matrix:	Soil						Soil				Soil				Soil				Soil				Soil				Soil			
	Sample Depth (in bgs):	@ 12						12-18				12-18				@ 12				12-18				@ 12				12-18			
	Sample Date:	10/27/2015						11/9/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015			
	Location:	Crow's Nest Impact Area Single Item						Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item			
	Comments:	Primary						Primary				Field Duplicate of Primary (WPDS01SB01)				North of Primary				North of Primary				East of Primary				East of Primary			
Explosives (mg/Kg dry wt)	Background Reference	Human SL	Ecological SL	Result	LQ	VF	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
2,4,6-Trinitrotoluene	--	3.6	7.6	20				6.7		J	s	2.2				0.039	J			0.065	U			0.68				0.54			
2,4-Dinitrotoluene	--	1.7	1.28	0.46	J	J	g	0.77		J	s	0.62				0.075	U			0.065	U			0.074	U			0.066	U		
2,6-Dinitrotoluene	--	0.36	0.032	0.053	ULL			0.062	U			0.062	U			0.075	ULL			0.065	U			0.074	U			0.066	U		
2-Am-DNT	--	15	14	7.8				5.4		J	s	4.6				0.16				0.065	U			0.26				0.12	J		
4-Am-DNT	--	15	12	7.8				6		J	s	5.1				0.21				0.065	J			0.41				0.24			
Lead (mg/Kg)	Background Reference (soil)*	Human SL	Ecological SL	Result	LQ	VF	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
Lead	63	400	11	881	B			755		J	f	466		J	f	292				75.7				101				45.8			

	Sample ID:	WPDS01SK01						WPDS01SL01				WPDS01SO01				WPDS01SP01			
	Laboratory Sample ID:	SI9084-30						SI9084-31				SI9084-34				SI9084-35			
	Sample Matrix:	Soil						Soil				Soil				Soil			
	Sample Depth (in bgs):	@ 12						12-18				@ 12				12-18			
	Sample Date:	11/9/2015						11/9/2015				11/9/2015				11/9/2015			
	Location:	Crow's Nest Impact Area Single Item						Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item				Crow's Nest Impact Area Single Item			
	Comments:	South of Primary						South of Primary				West of Primary				West of Primary			
Explosives (mg/Kg dry wt)	Background Reference	Human SL	Ecological SL	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
2,4,6-Trinitrotoluene	--	3.6	7.6	0.017	JJ	J	g	0.064	U			0.075	U			0.066	U		
2,4-Dinitrotoluene	--	1.7	1.28	0.074	U			0.064	U			0.075	U			0.059	JJ	J	g
2,6-Dinitrotoluene	--	0.36	0.032	0.074	U			0.064	U			0.075	U			0.066	U		
2-Am-DNT	--	15	14	0.074	U			0.064	U			0.075	U			0.066	U		
4-Am-DNT	--	15	12	0.1	JJ	NJ	g	0.064	U			0.075	U			0.066	U		
Lead (mg/Kg)	Background Reference (soil)*	Human SL	Ecological SL	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
Lead	63	400	11	195				30.4				137				53.8			

Laboratory Qualifiers Used

B	Indicates the Analyte was detected in the laboratory method blank analyzed concurrently with Sample
J	Estimated Value
N	Tentatively Identified.
U	Analyte not detected
L	Indicates corresponding LCS and/or LCSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria
M	Indicates corresponding MS and/or MSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria
	Multiple flags of the same value indicates a repeat of the same anomaly

Data Validation Flags Used

J	Analyte present. Reported value may not be accurate or precise
NJ	Tentatively Identified. Associated numerical value represents its approximate concentration.
UJ	Analyte not detected significantly greater than method blank

Reason Codes Used

f	Field Duplicate Imprecision
g	Method Blank Detection
s	Surrogate Percent Recovery Anomaly

Notes:

LQ	Laboratory Qualifier	RC	Reason Code
VQ	Validation Qualifier	SL	Screening Level
--	Not Applicable		
	Value exceeds Human Health Screening Level		
Bold	Value exceeds Ecological Screening Level		
Red Text	Value exceeds Background concentration		

* Background Reference Value is 95th Percentile Reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D, Table 6b, August 2005 (NYSDEC, 2005)*

Table 4-9: Discrete Sample Results - Munitions Pile - DS-02

Sample ID:	WPDS02SA01			WPDS02SA02				WPDS02SB01				WPDS02SC01				WPDS02SD01				WPDS02SG01				WPDS02SH01			
Laboratory Sample ID:	SI8562-3			SI8562-5				SI9084-1				SI9084-2				SI9084-4				SI9084-8				SI9084-9			
Sample Matrix:	Soil			Soil				Soil				Soil				Soil				Soil				Soil			
Sample Depth (in bgs):	0-6			0-6				6-12				0-6				6-12				0-6				6-12			
Sample Date:	10/27/2015			10/27/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015				11/9/2015			
Location:	Crow's Nest Impact Area Munitions Pile			Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile			
Comments:	Primary			Field Duplicate of Primary (WPDS02SA01)				Primary				North of Primary				North of Primary				East of Primary				East of Primary			
Explosives (mg/Kg dry wt)	Background Reference	Human SL	Ecological SL	Result	LQ	VF	RC	Result	LQ	VF	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
2,4,6-Trinitrotoluene	--	3.6	7.6	18	MM	J	f	55		J	f	1.4				0.063	U			0.059	U			0.071	U			0.067	U		
2,4-Dinitrotoluene	--	1.7	1.28	0.056	U			0.088	J			0.064	U			0.063	U			0.059	U			0.071	U			0.067	U		
2,6-Dinitrotoluene	--	0.36	0.032	0.056	ULLM			0.053	ULL			0.064	U			0.063	U			0.059	U			0.071	U			0.067	U		
2-Am-DNT	--	15	14	0.29		J	f	0.98		J	f	0.13	J			0.063	U			0.059	U			0.071	U			0.067	U		
4-Am-DNT	--	15	12	0.37	J			1.3	J			0.43	J	NJ	g	0.063	U			0.059	U			0.071	U			0.067	U		
Lead (mg/Kg)	Background Reference (soil)*	Human SL	Ecological SL	Result	LQ	VF	RC	Result	LQ	VF	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
Lead	63	400	11	362	N*B	J	f	557	B	J	f	163				63.8	N*A			10.7				407				256			

Sample ID:	WPDS02SK01			WPDS02SL01				WPDS02SO01				WPDS02SP01			
Laboratory Sample ID:	SI9084-12			SI9084-13				SI9084-16				SI9084-17			
Sample Matrix:	Soil			Soil				Soil				Soil			
Sample Depth (in bgs):	0-6			6-12				0-6				6-12			
Sample Date:	11/9/2015			11/9/2015				11/9/2015				11/9/2015			
Location:	Crow's Nest Impact Area Munitions Pile			Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile				Crow's Nest Impact Area Munitions Pile			
Comments:	South of Primary			South of Primary				West of Primary				West of Primary			
Explosives (mg/Kg dry wt)	Background Reference	Human SL	Ecological SL	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
2,4,6-Trinitrotoluene	--	3.6	7.6	0.062	U			0.061	U			0.057	U			0.063	U		
2,4-Dinitrotoluene	--	1.7	1.28	0.062	U			0.061	U			0.057	U			0.063	U		
2,6-Dinitrotoluene	--	0.36	0.032	0.062	U			0.061	U			0.057	U			0.063	U		
2-Am-DNT	--	15	14	0.062	U			0.061	U			0.057	U			0.063	U		
4-Am-DNT	--	15	12	0.062	U			0.061	U			0.057	U			0.063	U		
Lead (mg/Kg)	Background Reference (soil)*	Human SL	Ecological SL	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC	Result	LQ	VQ	RC
Lead	86.7	400	11	107				38.2				142				30.9			

Laboratory Qualifiers Used

B	Indicates the Analyte was detected in the laboratory method blank analyzed concurrently with Sample
J	Estimated Value
N	Tentatively Identified
U	Analyte not detected
L	Indicates corresponding LCS and/or LCSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria
M	Indicates corresponding MS and/or MSD prepared and/or analyzed concurrently with sample did not meet DoD Criteria
*	Relative percent difference was outside of quality control limits
A	Tentatively Identified, suspected aldol-condensation product
	Multiple flags of the same value indicates a repeat of the same anomaly

Data Validation Flags Used

J	Analyte present. Reported value may not be accurate or precise
NJ	Tentatively Identified. Associated numerical value represents its approximate concentration.
UJ	Analyte not detected significantly greater than method blank

Reason Codes Used

f	Field Duplicate Imprecision
g	Method Blank Detection
s	Surrogate Percent Recovery Anomaly

Notes:

LQ	Laboratory Qualifier	RC	Reason Code
VQ	Validation Qualifier	SL	Screening Level
--	Not Applicable		
	Value exceeds Human Health Screening Level		
Bold	Value exceeds Ecological Screening Level		
Red Text	Value exceeds Background concentration		

* Background Reference Value is 95th Percentile Reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D, Table 6b, August 2005 (NYSDEC, 2005)*

Table 4-12: Equipment Blanks

Sample ID:	WPIS01SD04				WPIS01SE04			
Laboratory Sample ID:	SI8935-22				SI8810-19			
Sample Date:	11/5/2015				11/3/2015			
Location:	Crow's Nest Impact Area Decision Unit - 01				Crow's Nest Impact Area Decision Unit - 01			
Explosives (ug/L)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
2,4,6-Trinitrotoluene	0.12	U			0.12	U		
2,4-Dinitrotoluene	0.12	U			0.12	U		
2,6-Dinitrotoluene	0.12	U			0.12	U		
2-Am-DNT	0.12	U			0.12	U		
4-Am-DNT	0.12	U			0.12	U		
Lead (ug/L)	**Result**	**LQ**	**VQ**	**RC**	**Result**	**LQ**	**VQ**	**RC**
Lead	0.12	J			0.10	J		

Laboratory Qualifiers Used

LQ	Laboratory Qualifier
VQ	Validation Qualifier
RC	Reason Code
J	Estimated Value
U	Analyte not detected

SECTION FIVE: MEC HAZARD ASSESSMENT AND MC RISK ASSESSMENT

This section presents the methodology and results of the MEC hazard assessment (HA) and the MC risk assessments completed for the DUs at the Crow's Nest MRS. **Section 5.1** presents the methods and results of the MEC HA. **Appendix I** present the MEC HA worksheets. **Appendix J** is the human health risk assessment (HHRA) conducted for the DUs; **Section 5.2.1** presents HHRA information. **Appendix K** is the SLERA for the Crow's Nest MRS DUs; **Section 5.2.2** summarizes the results of the SLERA.

5.1 MEC HAZARD ASSESSMENT

A MEC HA was performed based on the results of the RI field activities to evaluate the potential hazards associated with MEC encountered at the MRS. The MEC HA follows the guidelines presented in the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (EPA, 2008). The MEC HA worksheets, model assumptions, and output are included in **Appendix I**.

5.1.1 Presence and Source of MEC

Primary factors affecting risk associated with a MEC source are the quantity and density of MEC. As MEC density increases, so does the likelihood of interaction with a receptor. Additionally, the following factors must also be taken into consideration: munitions type (HE, shrapnel, solid shot (bolt), or practice), fuzed/unfuzed items, low order / incomplete detonations, and UXO items.

MEC identified during the RI are described in **Section 4.1.1** and **Figure 4-1**. UXO was identified within the former Crow's Nest Impact Area of the MRS at both the surface and shallow subsurface (up to 18 inches bgs). No MEC were found within Training Areas J1, G1, and G2.

5.1.2 MEC Exposure Receptors

MEC exposure receptors were considered by weighing the exposure media and accessibility against the range of potential activities and uses that are likely to occur at the MRS. Potential receptors include both current and future Installation personnel, contractors, trespassers, recreational hikers, relic hunters, and wild game hunters.

5.1.3 MEC HA Results

Utilizing the input information presented below, **Table 5-1** presents the Hazard Level assigned for current and future land use.

- **Summary Information:** The information in the MEC HA is drawn from this RI report and other project-related referenced documents.
- **Munitions, Bulk Explosives:** Types of MEC identified during survey activities were input in the model.
- **Current and Future Activities:** The Crow's Nest MRS is currently undeveloped, forested land with restricted public access. However, trespassers routinely hike into the area from the surrounding park and preserve areas for illegal relic hunting. Installation personnel and

contractors occasionally access the MRS for road or subsurface utility maintenance. Potential future use may include public recreational use for hiking and hunting purposes.

- **Input Factors:**
  - *Energetic Material Type:* Several MEC fall under the HE category, which is the most hazardous energetic material type.
  - *Location of Additional Human Receptors:* The HFD of 239 feet, calculated for the 75 mm MK1 HE projectile, was used for the Explosive Safety Quantity Distance (ESQD). The Crow's Nest Tower is within the MRS and people would congregate to this feature. Within the ESQD arc, there are public roads, hiking trailheads, parking areas, and buildings.
  - *Site Accessibility:* The accessibility of the MRS is moderate. The rough mountainous terrain provides some barrier to accessing the MRS.
  - *Potential Contact Hours:* Current human receptors include Installation personnel and contractors, relic hunters, and trespassers; potential future human receptors also include wild game hunters, hikers, and campers. Potential total contact time is determined at 3,216 receptor hours per year.
  - *Amount of MEC:* The assumption for the amount of MEC is based on classification of the MRS as a "Target Area." The amount, depth, size, and classification of MEC are concluded from the intrusive investigation results.
  - *Migration Potential:* There is a potential for MEC to migrate within and from the MRS through erosion of soil and direct human contact with MEC moving the item.
  - *MEC Classification:* MEC were classified as "UXO Special Case" because of the presence of high explosive-filled fuzes.
  - *MEC Size:* MEC are determined to be "small" due to the presence of small fuzes.

Table 5-1: MEC HA Hazard Level Determination

Evaluation Scenario	Hazard Level Category	Score
Current Use Activities	1	870
Future Use Activities	1	840

5.2 RISK ASSESSMENTS FOR MC

This section presents the HHRA and SLERA information for the Crow's Nest MRS. Full risk assessment reports for the HHRA and SLERA are presented in **Appendices J** and **K**, respectively. The HHRA and SLERA address MC risk using the incremental soil sampling results from DU-01 and DU-03, and the incremental sediment sampling results of DU-02. DU-02 is primarily a heavily vegetated wetland area; DU-01 and DU-03 are also vegetated, but are more easily accessed via trails and roadways.

The IS results for MC from background sediment (WPIS00SA01-03) and soil (WPIS00SB01-03) are also used as lines of evidence in both risk assessments. For the SLERA, an assessment of the bioavailability of metals in sediment to benthic invertebrates was also evaluated using SEM, AVS, and TOC analysis.

5.2.1 Human Health Evaluation

A HHRA was prepared pursuant to the EPA *Risk Assessment Guidance for Superfund* (RAGS), Part A (EPA, 1989) and subsequent RAGS guidance (Parts B through F) where applicable. The HHRA report is presented in **Appendix J**. The risk-based screening results identified lead as the soil and sediment constituent of potential concern (COPC) at DU-01 and DU-02, respectively. Explosives were eliminated from further evaluation. The risk-based screening results and background evaluation eliminated DU-03 from further evaluation.

5.2.1.1 Risk-Based Screening Results

Table 5-2 presents the maximum detected concentrations (MDCs) in soil and sediment that were compared to the EPA's residential soil regional screening levels (RSLs). The residential soil RSLs are protective of a target cancer risk of 1×10^{-6} and a hazard quotient (HQ) of 0.1 (EPA, 2015b). Residential RSLs were selected for the risk-based screening because they are protective of any type of public receptors that may access the MRS. If a constituent's MDC exceeded the residential soil RSL, then it was carried forward as a COPC in the HHRA.

The risk-based screening results in **Table 5-2** indicate that explosives were eliminated from further evaluation for all the DUs. However, lead was identified as a soil COPC at DU-01 and DU-02. The risk-based screening results and background evaluation eliminated DU-03 from further evaluation.

Table 5-2: Human Health Risk-Base Screening Results

Detected Constituent	CAS No	Maximum Detection (mg/kg)	Maximum Sample Location	EPA Residential Soil RSL[(1)] (mg/kg)	COPC? (Yes/No)	Lead Mean (mg/kg)	Mean Exceeds Action Level?
Decision Unit 1 (DU-01)							
Lead	7439-92-1	2220	WPIS01SI03	400	Yes	690.8	Yes
2-Am-DNT	35572-78-2	0.034	WPIS01SK01	15	no	-	-
2,4-Dinitrotoluene	121-14-2	0.041	WPIS01SK01	1.7	no	-	-
2,4,6-Trinitrotoluene	118-96-7	0.084	WPIS01SK03	3.6	no	-	-
4-Am-DNT	19406-51-0	0.12	WPIS01SK02	15	no	-	-
Decision Unit 2 (DU-02)							
Lead	7439-92-1	4470	WPIS02SA01	400	Yes	3433	Yes
Decision Unit 3 (DU-03)							
Lead	7439-92-1	90.6	WPIS03SB03	400	no	-	-
Background Sediment							
Lead	7439-92-1	78.6	WPIS00SA02	400	no	-	-

Table 5-2: Human Health Risk-Base Screening Results

Detected Constituent	CAS No	Maximum Detection (mg/kg)	Maximum Sample Location	EPA Residential Soil RSL(1) (mg/kg)	COPC? (Yes/No)	Lead Mean (mg/kg)	Mean Exceeds Action Level?
Background Soil							
Lead	7439-92-1	92.4	WPIS00SB03	400	no	-	-

Notes:
- = no value; Am = amino; BG = background; COPC = constituent of potential concern; DNT = dinitrotoluene; DU = decision unit; mg/kg = milligrams per kilogram; RSL = regional screening level
(1) EPA, 2015b. Residential Soil Regional Screening Level (RSL) Table, Dated November 2015. Protective of a target cancer risk of 1×10^{-6} and hazard quotient of 0.1.

5.2.1.2 Exposure Assessment

The HHRA identifies the following current and/or future exposed populations or scenarios for the MRS: Installation personnel and contractors, and the public (i.e., trespassers, relic hunters, wild game hunters, hikers, campers).

- The current and future installation personnel and contractors are adults who visit the MRS periodically to conduct outdoor inspections, maintenance activities, and/or environmental studies.
- The current and future trespasser and relic hunter are likely to be adults and/or teens who dig up relics or play at the MRS.
- The future wild game hunter and hiker are likely to be an older teen or adult who likes to go hunting or hiking at the MRS. The wild game food consumption pathway for the hunter scenario is not quantitatively evaluated because biomagnification of lead is not expected to occur with terrestrial food chains (ATSDR, 2007).
- The future recreational camper is a young teen or an adult that spends his/her family vacation camping at the MRS.

For the HHRA, a young child (less than 6 years old) is assumed to be unlikely to frequently visit the MRS because of its heavy vegetation and steep slopes.

Habitat within the MRS is inhabited by invertebrates, birds, and mammals and is contiguous to other large areas of excellent habitat.

5.2.1.3 Toxicity Assessment

Toxicity assessments provide the basis for evaluating what is acceptable exposure and what level of exposure may adversely affect human health. A toxicity assessment involves:

- Determining whether exposures to a constituent can increase the incidence of a specific adverse effect (e.g., cancer, kidney damage) in humans
- Characterizing the nature and strength of evidence of causation

- Quantifying the relationship between the dose of the constituent and the incidence of adverse health effects in the exposed population

The increase in lead blood concentration (PbB) at the MRS for each receptor is estimated using a linear biokinetic slope factor (BKSF). EPA guidance recommends using a BKSF of 0.4 micrograms per deciliter (µg/dL) per µg/day for the adult lead methodology (ALM) (EPA, 2003). The estimated lead uptake is multiplied by the BKSF to determine the MRS related increase in PbBs for each receptor.

5.2.1.4 Risk Characterizations

Risk characterization summarizes the nature and magnitude of the potential for occurrence of adverse health effects under a specific set of conditions. The Exposure Assessment and the Toxicity Assessment are integrated into quantitative estimates of health risks to potential receptors.

The ALM model uses the exposure parameter described in the Exposure Assessment of the HHRA (Section 4.0 of **Appendix J**) to estimate lead uptake which is multiplied by the BKSF presented in the Toxicity Assessment (Section 5.0 of **Appendix J**) to estimate risk from exposure to lead for each receptor.

EPA's target threshold for lead is to limit the risk to no more than a 5 percent chance fetuses exposed to lead would exceed a PbB of 10 µg/dL (EPA, 2010). Tables 6-1 through 6-9 of **Appendix J** summarize the ALM results and model runs for each receptor at DU-01 and DU-02.

The ALM results for all scenarios at DU-01 and DU-02 are below EPA's target PbB for the fetus threshold of 10 µg/dL and the probability threshold of 5 percent.

5.2.1.5 HHRA Conclusions

The HHRA identified lead as the primary COPC at DU-01 and DU-02. The risk-based screening results and background evaluation eliminated DU-03 from further evaluation.

EPA's ALM model was used to estimate risk from exposure to lead in soil at DU-01 and sediment at DU-02. Per EPA (2003) guidance, lead's mean concentration was used as the exposure point concentration for DU-01 (690.8 mg/kg) and DU-02 (3,433 mg/kg). The following non-residential exposure scenarios were evaluated:

- Current and future Installation personnel and contractor
- Current and future relic hunter and trespasser
- Future recreational wild game hunter and hiker
- Future recreational camper

EPA's target threshold for lead is to limit the risk to no more than a 5 percent chance of fetuses exposed to lead would exceed a PbB of 10 µg/dL (EPA, 2010). The ALM results for all scenarios were below the target PbB and probability thresholds. The HHRA indicates no unacceptable risk to human receptors if the MRS is converted to recreational use.

5.2.2 Environmental Evaluation

The SLERA used the soil and sediment IS results collected in November 2015 at the Crow's Nest MRS to assess the potential for adverse effects to ecological receptors. The SLERA Report is presented in **Appendix K**.

5.2.2.1 Benchmark Comparison

Conservative ecological screening values were used to screen soil and sediment data to determine contaminants of concern (COC) for each DU, as presented in **Tables 5-3** through **5-5**.

Table 5-3: Selection of Ecological COCs: DU-01 – Surface Soil

Surface Soil							
	Maximum	Invertebrate		Mammal		Avian	
Analyte	Concentration	Screening Level	COC?	Screening Level	COC?	Screening Level	COC?
2,4,6-Trinitrotoluene	0.03	32 [a]	No	96 [a]	No	7.6 [a]	No
2,4-Dinitrotoluene	0.041	18 [a]	No	13 [a]	No	13 [a,c]	No
2,6-Dinitrotoluene	ND	30 [a]	No	7.1 [a]	No	52 [a]	No
2-Amino-Dinitrotoluene	0.034	43 [a]	No	15 [a]	No	15 [a,c]	No
4-Amino-Dinitrotoluene	0.12	18 [a]	No	12 [a]	No	12 [a,c]	No
Lead	2,220	1700 [b]	Yes	56 [b]	Yes	11 [b]	Yes

Notes:
All concentrations are milligrams per kilogram (mg/kg)
ND: analyte not detected; NV: no value reported for receptor
a) Los Alamos National Laboratory Ecological Screening Levels (R3.3, October 2015)
b) USEPA Eco-SSL Soil Screening Benchmark
c) No value exists for avian receptors, therefore the lowest screening level presented will be utilized

Table 5-4: Selection of Ecological COCs: DU-02 – Sediment

Wetland Sediment							
	Maximum	Invertebrate		Mammal		Avian	
Analyte	Concentration	Screening Level	COC?	Screening Level	COC?	Screening Level	COC?
Lead	4,470	35.8 [a]	Yes	35.8[a]	Yes	35.8 [a]	Yes

Notes:
All concentrations are mg/kg
a) USEPA Region 3 Biological Technical Assistance Group Freshwater Sediment Screening Benchmarks

Table 5-5: Selection of Ecological COCs: DU-03 – Surface Soil

Surface Soil							
	Maximum	Invertebrate		Mammal		Avian	
Analyte	Concentration	Screening Level	COC?	Screening Level	COC?	Screening Level	COC?
2,4,6-Trinitrotoluene	ND	32 [a]	No	96 [a]	No	7.6 [a]	No
2,4-Dinitrotoluene	ND	18 [a]	No	13 [a]	No	13 [a,c]	No
2,6-Dinitrotoluene	ND	30 [a]	No	7.1 [a]	No	52 [a]	No
2-Amino-Dinitrotoluene	ND	43 [a]	No	15 [a]	No	15 [a,c]	No
4-Amino-Dinitrotoluene	ND	18 [a]	No	12 [a]	No	12 [a,c]	No
Lead	90.6	1700 [b]	No	56 [b]	No *	11 [b]	No *

Notes:
All concentrations are mg/kg
ND: analyte not detected
* Background lead concentrations range from 77.1 - 92.4 mg/kg; since the maximum concentration of lead in Decision Unit 3 is below background, it is not carried through as a COC.
a) Los Alamos National Laboratory Ecological Screening Levels (R3.3, October 2015)
b) USEPA Eco-SSL Soil Screening Benchmark
c) No value exists for avian receptors, therefore the lowest screening level presented will be utilized

5.2.2.2 Background Comparison

RI field activities included collection of incremental samples from two background locations: WPIS00SA01-03 (sediment) and WPIS00SB01-03 (soil). The background incremental sampling results are used to distinguish lead concentrations related to past munitions use at the MRS from those that are naturally occurring at the MRS. When the MDC and the calculated mean concentration are close values, it indicates that the high number of increments collected for each replicate produced a homogeneous aliquot and is a representative concentration. As shown below in **Table 5-6**, the background sample data has representative concentrations.

Table 5-6: Background Lead Results

Background Sample	Lead MDC (mg/kg)	Lead Mean (mg/kg)
WPIS00SA01 (Sediment)	78.6	74.5
WPIS00SB01 (Soil)	92.4	86.7

The soil MDC and mean concentrations of lead in DU-01 and DU-03 are compared with the corresponding lead concentrations in background soil to determine whether lead concentrations are likely associated with MC releases or attributed to background in **Table 5-7**.

Table 5-7: Site to Background Lead in Soil Comparison

Decision Unit	Lead MDC (mg/kg)	Lead Mean (mg/kg)	Background Soil Lead MDC (mg/kg)	Background Soil Lead Mean (mg/kg)
DU-01	2,220	690.8	92.4	86.7
DU-03	90.6	73.7		

The DU-01 concentrations of lead are higher than the background lead concentrations indicating that site-related activities have contributed to lead concentrations in surface soil. DU-03 lead concentrations are similar to the background concentrations indicating that the presence of lead at DU-03 surface soil may be attributed to background.

For DU-02, the sediment MDC and mean concentrations for lead are higher than the sediment MDC and mean concentrations for background sediment (**Table 5-8**). The lead concentrations at DU-02 are likely attributed to a MC release rather than background.

Table 5-8: Site to Background Lead in Sediment Comparison

Decision Unit	Lead MDC (mg/kg)	Lead Mean (mg/kg)	Background Sediment Lead MDC (mg/kg)	Background Sediment Lead Mean (mg/kg)
DU-02	4,470	3,433	78.6	74.5

Lead is carried forward as a COC at DU-01 and DU-02 following the background evaluation. No COCs were identified for DU-03.

5.2.2.3 Potential Receptors

The Crow's Nest MRS contains favorable habitat for a variety of terrestrial ecological receptors because of the variety of vegetative cover types and limited human activity. The quality of the habitat is enhanced because it is contiguous to other large tracts of undeveloped land, which allows the potential for wildlife migration over an extended area. Currently, the MRS is covered by mature hardwood forest with successional hardwoods surrounding the summit following previous fire disturbance.

A varied invertebrate community is present, which is important for nutrient cycling and as a source of food (and potentially contaminants) for upper trophic-level organisms. Mammals are also present across the less mountainous, forested habitat of the MRS. Small mammals that feed on plants and invertebrates are present, and larger omnivorous mammals, such as Red Fox and black bear, also inhabit this area. During field activities at the site, numerous mammals, including squirrels, deer, and black bear were observed. Bird species typical of the terrestrial habitat present in the area include insectivorous birds, which feed on invertebrates, as well as larger carnivorous birds, which feed on small mammals. Bird species most frequently observed at the site during field activities included turkeys and hawks.

Terrestrial plants are potential receptors exposed to COCs at the MRS, but it is unlikely that the adverse effects to plant communities would be significant. During RI field activities, no signs of contaminant-stressed vegetation were observed. Although the plant communities present at the

site contribute to favorable habitat for animals, no unique or sensitive plant communities have been identified within DU-01 or DU-02. Potential adverse effects to plants were not evaluated quantitatively in the SLERA.

The following indicator species were used in the SLERA:

- Terrestrial invertebrates – DU-01
- Benthic Invertebrates – DU-02
- Small insectivorous mammals – Short-Tailed Shrew (*Blarina brevicauda*) – DU-01 and DU-02
- Omnivorous mammals – Red Fox (*Vulpes vulpes*) – DU-01 and DU-02
- Insectivorous birds – American Robin (*Turdus migratorius*) – DU-01
- Insectivorous birds – Marsh Wren (*Cistothorus palustris*) – DU-2
- Carnivorous birds – Red-Tailed Hawk (*Buteo jamaicensis*) – DU-01 and DU-02

5.2.2.4 Complete Exposure Pathways

Based on the physical characteristics of the DUs and surrounding areas, the COCs present at the site, and the ecological receptors likely to be present in habitats at and near the site, the following potential exposure pathways have been identified:

- Direct exposure to surface soil and/or sediment (invertebrate);
- Ingestion of soil (insectivorous mammal or bird, omnivorous mammal); and
- Ingestion of food items (insectivorous mammal or bird, omnivorous mammal, carnivorous bird)

Surface soil and sediment (first 0-6 inches bgs) were used for the SLERA because most biological activity occurs within this shallow stratum.

5.2.2.5 Assessment of Exposure and Risk

Food-chain modeling was used to estimate risk from exposure to lead in soil at DU-01 and sediment at DU-02. For the screening level assessment, the maximum detected concentration of lead within each DU (DU-01: 2,220 mg/kg; DU-02: 4,470 mg/kg) as well as highly conservative exposure parameters (i.e., minimum body weight, maximum food ingestion rate, and 100 percent dietary composition of the most contaminated food item) were used in the modeling. Following the screening level assessment, a refined assessment was conducted utilizing the mean concentration of lead within each DU (DU-01: 690.8 mg/kg; DU-02: 3,433 mg/kg) as well as less-conservative exposure parameters (i.e., average body weight, average food ingestion rate, and dietary fractions of individual food items).

The following assessment endpoints were evaluated for both the screening level and refined screening level assessment:

- Assessment Endpoint No. 1: Terrestrial and/or benthic invertebrates
- Assessment Endpoint No. 2: Small insectivorous mammal – Short tailed shrew

- Assessment Endpoint No. 3: Insectivorous birds – American robin / marsh wren
- Assessment Endpoint No. 4: Omnivorous mammals – Red fox
- Assessment Endpoint No. 5: Carnivorous birds – Red-tailed hawk

DU-02 sediment was also analyzed for lead, AVS, SEM, and TOC (results in **Section 4.2.1**). Organic carbon in sediment can bind free metals and reduce their availability to aquatic organisms. When ∑SEM-AVS is normalized to the f_{oc} in sediment, the resulting ratio is an indication of the potential for metals in sediment to be toxic to benthic invertebrates. The results of this calculation indicate there is a low potential for metal toxicity to benthic invertebrates (calculated average of 13.5).

5.2.2.6 SLERA Results

At the screening level, the results indicate that lead levels in DU-01 surface soil and DU-02 sediment may result in potential adverse effects to all assessment endpoints evaluated except for the carnivorous bird in DU-01 and benthic invertebrates in DU-02.

For the refined screening level assessment, the results indicate that lead levels in DU-01 surface soil and DU-2 sediment may result in adverse effects to insectivorous mammals and birds. The relatively high concentration of TOC found within DU-02 sediment has the ability to bind free metals and reduce their availability to benthic organisms.

The results of this SLERA indicate that, given the large size of DU-01 and colocation of DU-02, species that have a limited home range and could potentially spend all or most of their lives at the DU, such as small insectivorous mammals and birds, have the greatest likelihood to be adversely affected by contaminants at the site.

SECTION SIX: CONTAMINANT FATE AND TRANSPORT

This section discusses routes of migration, migration, and contaminant persistence for MEC and MC that have the potential to occur at the Crow's Nest MRS.

6.1 MUNITIONS AND EXPLOSIVES OF CONCERN

UXO, as well as MPPEH was identified within the former Crow's Nest Impact Area of the MRS. **Table 4-2** lists the munition types that were positively identified as UXO or MPPEH within the MRS, discovered both at the surface and in the subsurface up to 18 inches bgs.

6.1.1 Routes of MEC Migration

Route of migration include physical processes that may result in the movement or relocation of MEC from its original placement. The MRS is composed of a mountain with steep slopes and sheer rock faces, and is subject to storm water runoff, snowmelt, erosion of soil and land/rock-slides. UXO/MPPEH can migrate in the MRS in gullies, or with movement of soil and rock by these physical processes. State Route 218, located downslope to the east and south of the MRS, is periodically closed to traffic during heavy rain storms and snowfall due to land/rock-slides.

6.1.2 MEC Persistence

UXO/MPPEH at the Crow's Nest MRS is made of heavy steel and will remain in environmental media until physically removed or destroyed (e.g., deliberate removal or from a wild fire that may detonate items). Munitions recovered were fired in the early 1800s (Civil War era) to mid-1930s.

6.1.3 Migration of MEC

UXO/MPPEH at the MRS can become exposed, migrate, be transported, or become further buried as a result of erosion via wind, runoff, and/or frost heave. UXO/MPPEH at the surface can migrate into the subsurface by soil erosion and re-deposition. UXO/MPPEH at the surface can migrate to downgradient areas of the MRS by soil erosion, runoff, and snowmelt and transport down steep slopes and gullies. As a result of below freezing winter temperatures and heavy annual snowfall in the area, it is possible for UXO/MPPEH to migrate from the subsurface to the surface by frost heave. UXO/MPPEH can be exposed from the subsurface by direct human contact (e.g., relic hunters) and subsequently moved within the MRS. During the investigation, several munitions items were placed deliberately on exposed rocks indicating humans move items within the MRS.

6.1.4 Revised MEC Conceptual Site Model

Complete exposure pathways exist between both human and ecological receptors and MEC. **Figure 6-1** presents the revised graphical MEC CSM following RI activities. **Figure 6-2** presents a three-dimensional view of the revised MEC CSM. **Figure 6-3** presents the revised MEC pathway analysis wire diagram. UXO/MPPEH and significant amounts of MD were recovered within the former Crow's Nest Impact Area from both the surface and subsurface. No MEC were discovered within Training Area J1, G1, or G2. A small amount of MD was recovered from

Training Area G1 and J1. A significant amount of MD (small fragments) was recovered from the southern portion of Training Area G2.

Although access to the MRS is currently restricted from public use as Installation property, trespassers routinely hike into the area from the surrounding park and preserve areas to camp and relic hunt illegally. Evidence of trespassers was observed during RI field activities. Installation personnel and contractors also occasionally access the MRS to perform maintenance activities to roads and subsurface utilities. Future recreational use would increase the likelihood of receptors interacting with MEC/MPPEH.

Based on the removal of UXO/MPPEH within the former Crow's Nest Impact Area of the MRS and the potential for human receptors to interact with MEC/MPPEH, an explosives hazard exists at the MRS.

6.2 MUNITIONS CONSTITUENTS

MC associated with munitions used at the MRS was confirmed to exist at elevated levels in soil and wetland sediment within the former Crow's Nest Impact Area (DU-01 and DU-02). Both lead and trace levels of TNT and its breakdown products, 2,4-DNT, 2-Am-DNT, and 4-Am-DNT, were detected in surface soil. **Section 4.2** presents the MC data for the Crow's Nest MRS.

6.2.1 Routes of MC Migration

The MRS contains steep terrain, sheer rock faces, and shallow soil that is subject to natural erosive processes due to storm water runoff, snowmelt, and land/rock-slides. This is evident by the periodic closure of State Route 218, located downslope of the mountain to the east and south of the former Crow's Nest Impact Area, during heavy rain and snow storms because of land/rock-slides. Furthermore, areas of exposed rock and soil were observed throughout the MRS during field activities, which indicates erosion is actively occurring. MC sorbed to soil particles, can be transported via these natural erosional processes to low-lying, downgradient areas, such as gullies, and areas of natural drainage, such as wetlands or vernal pools.

6.2.2 MC Persistence

The persistence of lead in soil is reliant on other environmental factors. Adsorption of lead to soil particles is highly dependent on soil pH, where rising pH levels favor adsorption. The predominant soil series within the MRS is Rock-outcrop-Hollis complex, which has a pH of 5.3 (NRCS, 2011), indicating a potentially moderate likelihood of adsorption. Lead also has the ability to adsorb strongly to ferric oxides (NAVFAC, 2015). Soils within the MRS are known to have a high, naturally occurring, iron content (NYSM, 1970). As such, there is a high likelihood that lead is adsorbed to soil particles within the MRS and thus persists. This is evident by the high lead concentrations in soil found within areas of high estimated munitions density during the RI compared to the time period of initial release. Furthermore, the source of MC (i.e., MEC and MD) is still present within the MRS and may be continuing to act as a source to this day.

Adsorption processes also affect the persistence of lead in sediment. Although AVS is not present within DU-02 sediment at sufficient quantities to form insoluble metals sulfides, relatively high levels of organic carbon (average 53 percent TOC; **Table 4-6**), which can bind

free metals (**Section 4.2.1**), are present. As such, there is a high likelihood that lead is bound to the organic rich sediment within DU-02 and therefore persists.

Explosive MC can degrade within the environment via both chemical (i.e., photolysis) and biological (i.e., microbial decomposition) degradation processes. However, explosive MC, such as TNT and its DNT breakdown products, are anticipated to persist so long as point sources exist (i.e., cracked, leaking, or low-order detonation MEC) within the MRS.

6.2.3 Migration of MC

MC migrates and is transported with soil within DU-01 as a result of erosion. Although the MRS is predominantly vegetated, erosion is evident in areas of steep topography. Localized flooding during unusual precipitation events likely results in overland runoff of storm water and snow melt, which can contribute to erosion and result in surface soil being transported to downgradient low-lying areas, such as gullies and natural depressions (i.e., wetland and/or vernal pools). This is evident by higher observed concentrations of lead within DU-02 sediment compared to the surrounding soil of DU-01 (**Figure 4-6**).

Migration of MC-contaminated sediment within DU-02 is unlikely. DU-02 is a wetland/vernal pool located within a natural depression immediately downgradient of the summit of the Crow's Nest Mountain and does not discharge to any adjacent bodies of water. Additionally, because of the relatively high organic carbon content of DU-02 sediment, lead MC is likely bound to sediment particles (**Section 4.2.1**). Because there is no active drainage network leading from DU-02, sediment is not likely to be carried to out of the wetland/vernal pool.

6.2.4 Revised MC Conceptual Site Model

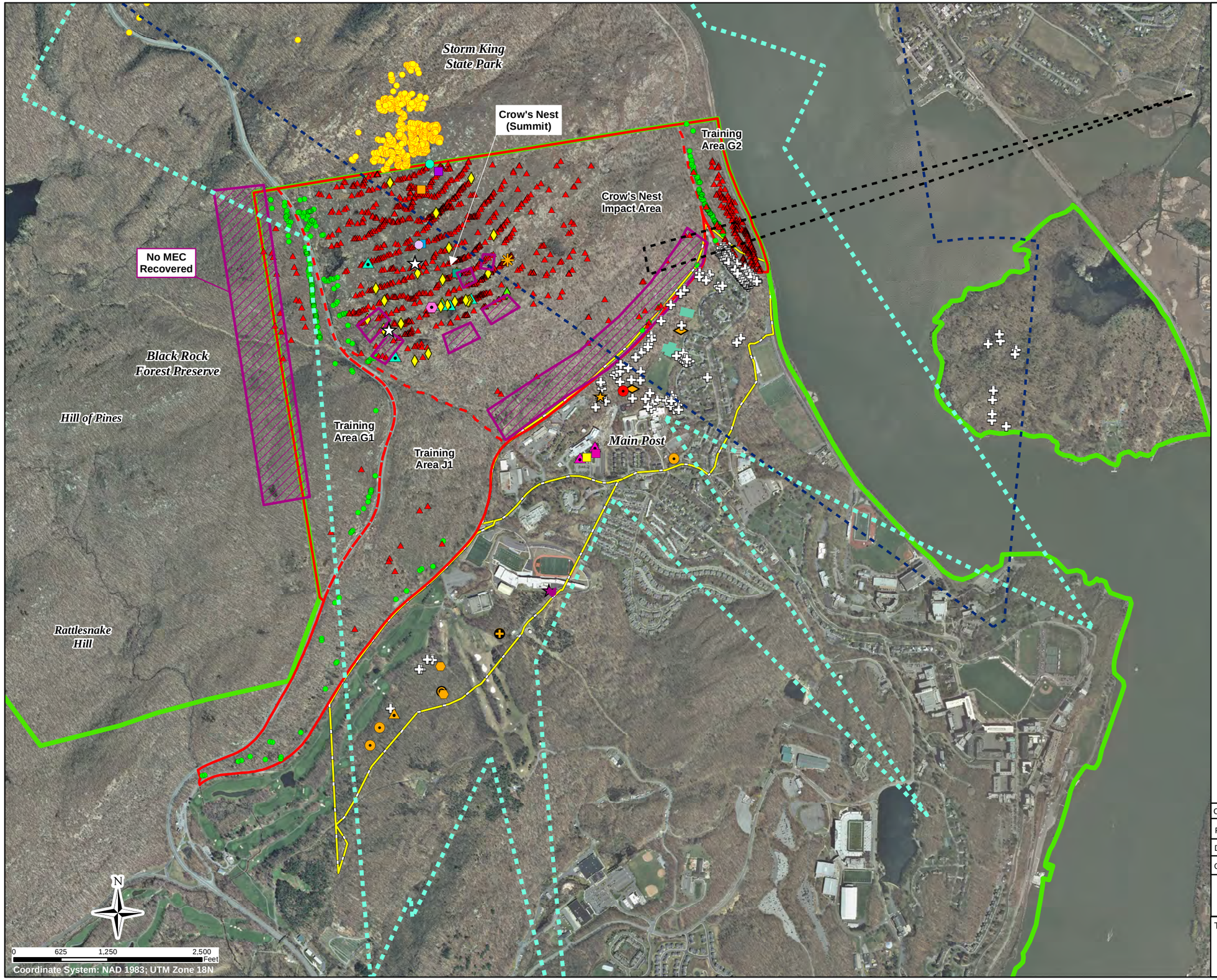
Complete exposure pathways exist between both human and ecological receptors and MC in soil and sediment within in the MRS. **Figure 6-4** presents the revised MC CSM following RI activities.

Significant concentrations of lead in surface soil and sediment (first 0 to 6 inches) were observed within DU-01 and DU-02 of the Crow's Nest MRS. The source of lead is most likely from lead shot used as shrapnel within the 75 mm MK 1 shrapnel round, which was the most common munitions type found within the MRS during the intrusive investigation. Trace levels of TNT and its DNT breakdown products were also detected within DU-01 surface soil. The source of explosives MC is likely MEC present within DU-01.

Although access to the MRS is currently restricted from public use as Installation property, trespassers routinely hike into the area from the surrounding park and preserve areas to camp and relic hunt illegally. Evidence of trespassers was observed during RI field activities. Installation personnel and contractors also occasionally access the MRS to perform maintenance activities to roads and subsurface utilities. Opening the area for recreational use in the future would further increase the likelihood of human receptors being exposed to MC in soil and/or sediment.

The presence of MC within the MRS and the potential for interaction between human receptors and contaminated media confirms that there is a complete pathway for human receptors to interact with MC-contaminated surface soil and sediment. However, the HHRA (**Section 5.2.1** and **Appendix J)** indicates that there is no unacceptable risk to either current or future human receptors from exposure to MC-contaminated media if the MRS is converted to recreational use.

Both DU-01 and DU-02 are attractive habitats for insects, birds, and mammals; this appeal is enhanced by the presence of large, contiguous areas of undeveloped land adjacent to the MRS. As such, complete pathways between MC in both surface soil and sediment and ecological receptors exist. Specifically, the SLERA (**Section 5.2.2** and **Appendix K**) indicates lead levels in DU-01 surface soil and DU-02 sediment may result in potential adverse effects to all ecological receptors evaluated except for the carnivorous bird in DU-01 and benthic invertebrates in DU-02. There is no unacceptable risk to ecological receptors from exposure to explosives MC at the concentrations observed within the MRS.



Legend

- Installation Boundary
- Crow's Nest MRS Training Area Boundaries
- Crow's Nest WSTPT-023-R-01
- Artillery Firing Range - North & South
- Siege Battery RangeFan
- Testing Range Fan (West Point Foundry)
- Combined Artillery Range Fans
- 1994 Survey Area
- MEC recovered during 2006 TCRA

RI Anomaly Type

- Munitions Debris
- Anomaly (Not Investigated)
- Munitions Pile

UXO/MPPEH

- M1907 PTTF
- M3 PD Fuze
- Parrott Base Fuze
- M48 HE Fuze
- M4 HE Booster
- Unknown Booster
- 4.7-in Projectile HE
- 6-in Common HE
- 75 mm Mk 1 Shrapnel
- 75 mm M48 HE
- 155 mm Mk 1 HE

Main Post RI Results

Munitions Debris

- 3-in Stokes Mortar (unfuzed)
- 4.6-in Parrott Round (Empty)
- 8-in Projectile (circa 1851)
- 8-in Butler Projectile
- M18A1 Rifle Grenade (illumination)
- MD 69 practice grenade
- MKII Practice Grenade
- Slap Flare
- 8-in Butler Projectile (concrete filled) (found during construction support
- Rifle Grenade (illumination)
- Frag

MEC

- 8-in Butler Projectile
- 8-in Butler Projectile (found during construction support
- 8-in Parrott Shell (unfuzed) (found during construction support

CLIENT	USACE - Baltimore District	
PROJ	Crow's Nest MRS Remedial Investigation	
DES BY	JL	05/09/2016
CHK BY	LP	05/09/2016

URS
12420 Milestone Center Drive
Germantown, MD 20876

TITLE

Revised MEC CSM (Graphical View)

FIGURE 6-1

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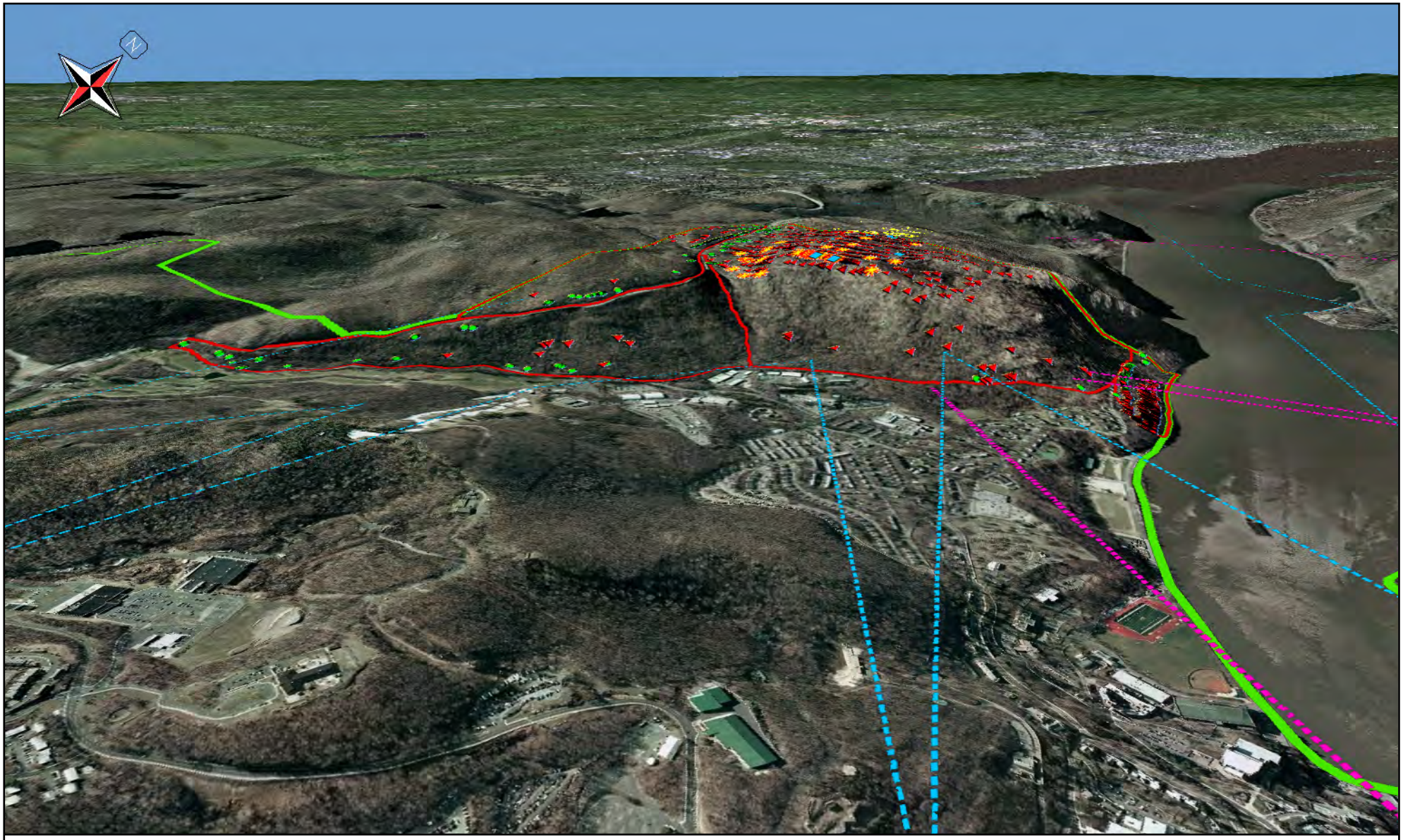

Legend

- MEC recovered during 2006 TCRA
- UXO
- MPPEH
- Munitions Debris
- Anomaly (Not Investigated)
- Munitions Pile
- Installation Boundary
- Crow's Nest MRS Boundary
- Siege Battery Range Fan
- Testing Range Fan (West Point Foundry)
- Combined Artillery Range Fans

CLIENT	USACE - Baltimore District
PROJECT	Crow's Nest MRS Remedial Investigation

Data projected in NAD 1983, UTM Zone 18N, Basemap World Topo Map sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services

DES BY	MS	5/12/2016
CHK BY	LAP	5/12/2016

TITLE

Revised MEC CSM (3D View)

URS
12420 Milestone Center Drive
Germantown, MD 20876

West Point, NY

FIGURE

6-2

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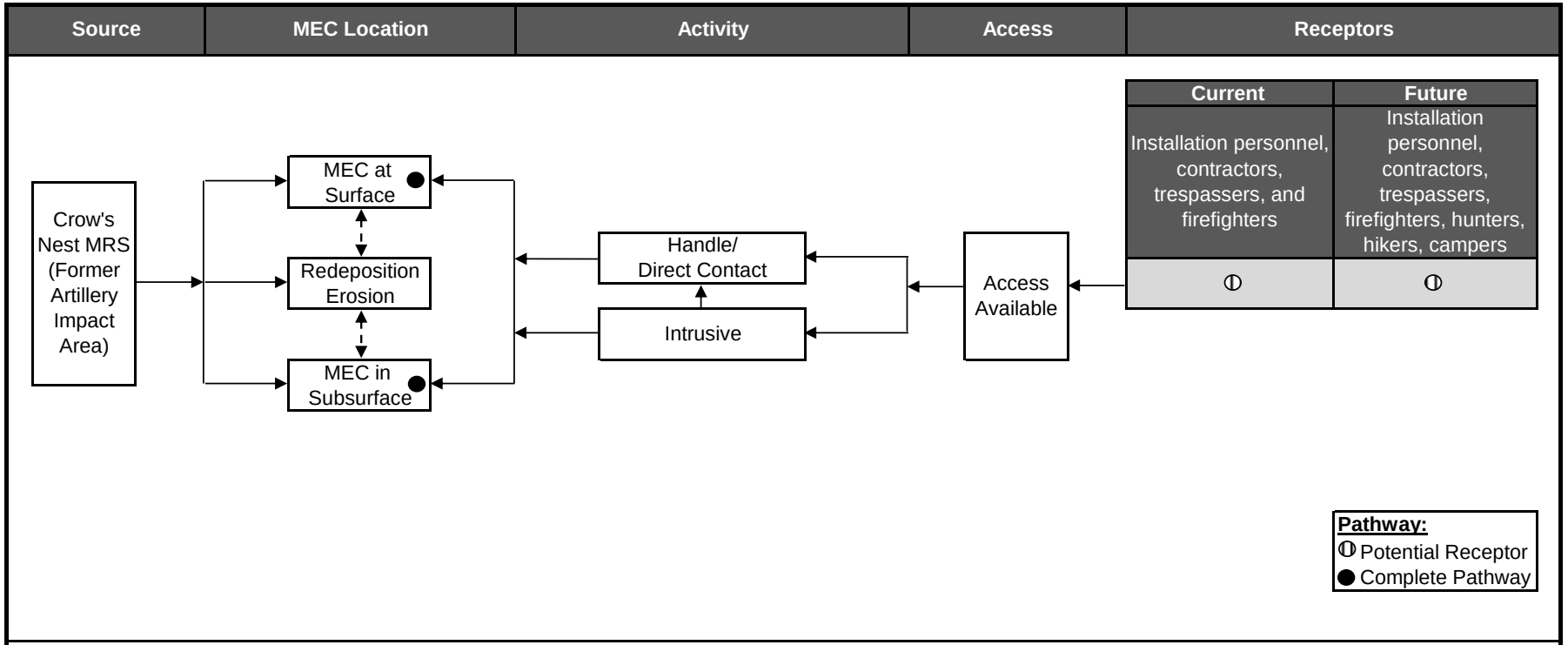

Figure 6-3

Revised MEC Exposure Pathway Analysis

Crow's Nest MRS Remedial Investigation

West Point, New York

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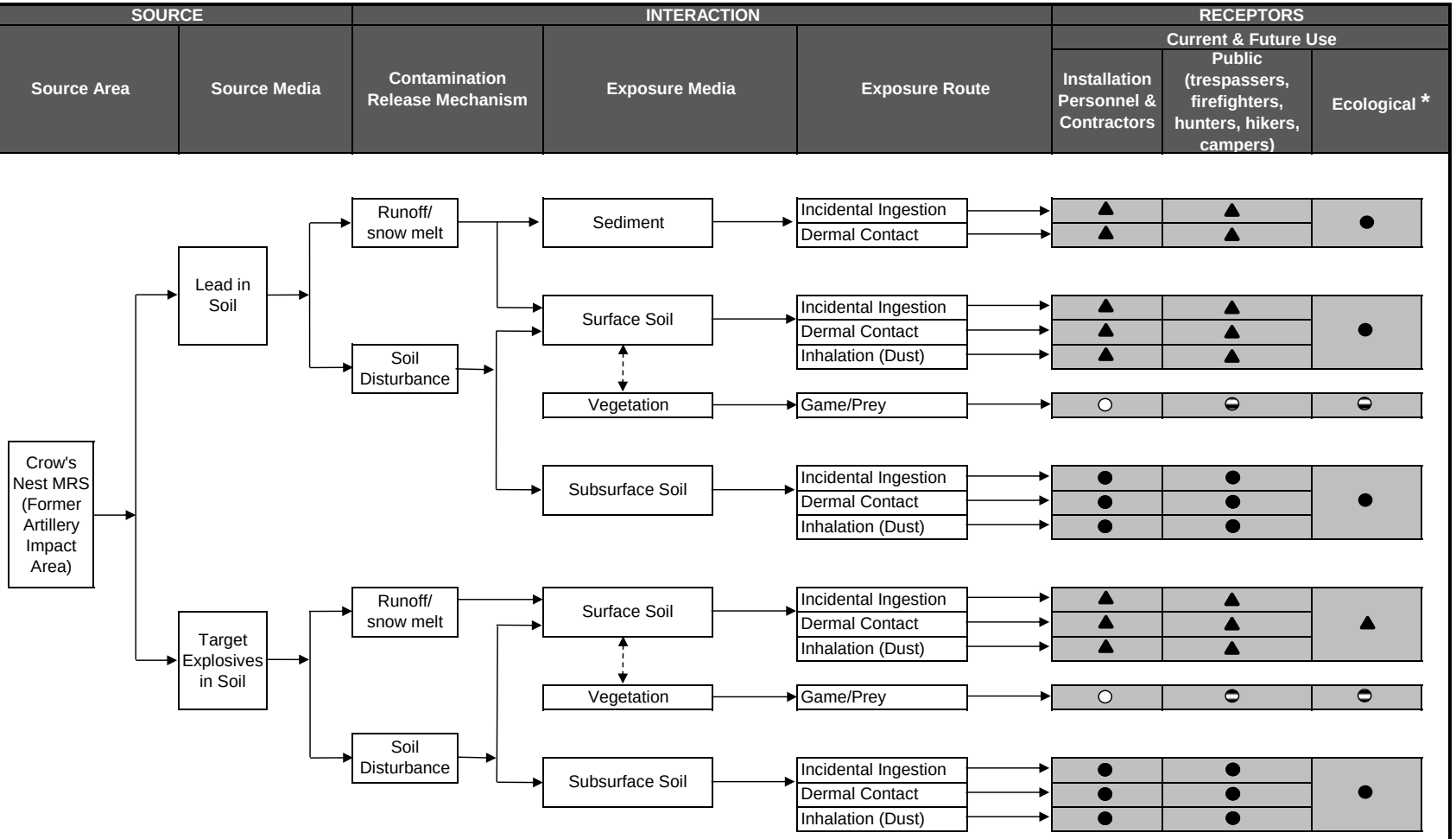


Figure 6-4

Revised MC Exposure Pathway Analysis

Crow's Nest MRS Remedial Investigation

West Point, New York

SECTION SEVEN: MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

During the SI (URS, 2015a), the MRSPP was applied in accordance with 32 CFR Part 179 and the guidance provided in the DoD MRSPP Primer (DoD, 2007). Using the information gained during the RI, the MRSPP worksheet tables were reviewed and updated, as appropriate.

During the SI, the MRS was assigned an MRSPP Priority of 3 (range is from 1 to 8). Priority 1 indicates the highest potential hazard and Priority 8 indicates the lowest potential hazard. Only a site with a potential Chemical Warfare Hazard can receive a Priority of 1. The priority is determined by selecting the highest rating from among the Explosive Hazard Evaluation (EHE), Chemical Warfare Material Hazard Evaluation (CHE), and Health Hazard Evaluation (HHE) Modules. For example, if the EHE rating is 2, the CHE rating is 7, and the HHE rating is 4, the priority assigned would be 2. The priority will be used to determine the future funding sequence of MRSs for further munitions response action.

The MRS Priority assigned to the EHE, CHE and HHE modules are based on the MRSPP worksheet tables and is presented in **Table 7-1**. No revisions were made to the EHE module as the munitions recovered during the RI were the same type of munitions already captured in the module. No known or suspected chemical warfare material or MC hazard was assigned to the CHE and HHE modules, respectively. The overall MRS Priority assigned for the Crow's Nest MRS is 3. The MRSPP scoring worksheets for the Crow's Nest MRS are presented in **Appendix L**.

Table 7-1: MRS Priority

EHE Rating	Priority	CHE Rating	Priority	HHE Rating	Priority
B	3	No Known or Suspected CWM Hazard		No Known or Suspected MC Hazard	

SECTION EIGHT: SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Crow's Nest MRS (WSTPT-023-R-01). The RI was completed by collecting sufficient data to determine the nature and extent of MEC and MC resulting from historical use of the Crow's Nest Mountain as a former artillery impact area and to evaluate the associated risks and hazards to human health and the environment.

8.1 SUMMARY OF REMEDIAL INVESTIGATION RESULTS

The RI resulted in the collection, evaluation, and analysis of a large amount of data to characterize the Crow's Nest MRS by determining the nature and extent of MEC and MC resulting from the historical use of the Crow's Nest Mountain as an artillery target. In summary:

- A total of 170,355.80 linear feet (32.2 miles, 39.1 acres) were surveyed during the RI.
- Sixty UXO/MPPEH items were identified within the former Crow's Nest Impact Area.
- No MEC were identified in Training Areas G1, G2, and J1.
- Two CMUAs were identified by performing geostatistical analysis of MEC/MD anomaly data: one in the Crow's Nest Impact Area, which is approximately 116 acres, and the other in Training Area G2, which is approximately 12 acres.
- An MEC density of approximately 0.52 MEC per acre was determined within the Crow's Nest Impact Area CMUA. No MEC were recovered from within the Training Area G2 CMUA. Within the Crow's Nest Impact Area, there are approximately 64 acres where MEC were delineated, yielding an average MEC density of 0.95 MEC per acre.
- The 75 mm projectile (both shrapnel and HE rounds) and their associated fuzes (M1907 PTTF, M48 fuze) were the most prevalent UXO/MPPEH items identified. A total of 2,693 MD items were detected and removed from the MRS.
- MC were detected in surface soil, discrete shallow subsurface soil, and sediment in the Crow's Nest Impact Area.
- TNT and DNT breakdown products were detected at trace levels in surface soil, but did not exceed human health or ecological screening criteria. Detections above human health and ecological screening criteria were also discretely observed at MC point source areas in both surface and shallow subsurface soil.
- Lead was detected in surface soil and sediment at concentrations above human health and ecological screening criteria. Detections above human health and ecological screening criteria were also discretely observed at MC point source areas in shallow subsurface soil.
- For Training Area G2, lead concentrations were detected in surface soil below human health screening criteria, but exceeded ecological screening criteria. However, concentrations were below background concentrations. TNT and DNT breakdown products were not detected. MC were not evaluated in Training Areas G1 and J1 because evidence of a MEC release was not identified within these areas.

- A MEC HA was performed, which resulted in a Hazard Level 1 (highest explosives hazard condition) designation for the Crow's Nest MRS for current and future land use.
- Using the RI results to update the MRSPP, a Priority of 3 was assigned to the MRS.
- Associated risks of lead to human health and the environment were evaluated through a HHRA. The results of the HHRA show no unacceptable risk to current and future human receptors (**Section 5.2.1**).
- Associated risks of lead to the environment were evaluated through a SLERA. The results of the SLERA indicate that species that have a limited home range and could potentially spend all or most of their lives at the MRS, such as small insectivorous mammals and birds, have the greatest likelihood to be adversely affected by contaminants at the site (**Section 5.2.2**).

8.2 UNCERTAINTIES

Anomalies detected within the 239-foot safety buffer used along US 9W and State Route 218 during the RI are unknown and allow for a certain degree of uncertainty (see **Figure 4-1**). At the request of the Installation, the technical approach was designed to allow detection of anomalies within this buffer, but not allow intrusive investigation of the anomalies so that shutdown of public roads would be avoided. However, by using the overall MRS characterization information and interpolating the intrusive data collected from the Crow's Nest Impact Area and Training Areas G1, G2, and J1, we can postulate the likelihood of MEC. Because MEC were recovered in the Crow's Nest Impact Area, MEC are likely present in the uninvestigated area between State Route 9W and the Crow's Nest CMUA. The uninvestigated anomalies within the Training Areas G1, G2, and J1 are less likely to be MEC because no MEC were identified within the training areas. In Training Area G1, the uninvestigated transect is in close proximity to US 9W. Hot rock and debris (e.g., roadside garbage) were visible at the surface along transect G1-3. In addition, the location of the majority of MD identified falls outside the original former artillery range boundary (**Figure 6-1**). Furthermore, the construction of US 9W, which included blasting the mountain after the former ranges were closed, could have contributed to the relocation of MD into Training Area G1. Similarly, transect G2-1 in Training Area G2 parallels the Lee Gate turn off and State Route 218. Debris (garbage) was prevalent in this area at the surface and, therefore, the uninvestigated anomalies within Training Area G2 are likely also cultural-related debris.

There is some uncertainty regarding the original distribution of MEC/MD within the Crow's Nest Impact Area. Determining the CMUA and delineation of MEC (MEC contouring) within the Crow's Nest Impact Area relies on the distribution and density of MEC recovered (**Figure 4-5)**. Two large munitions piles were discovered in the Crow's Nest Impact Area. One of the piles was removed during the RI; approximately 500 munitions items were recovered, 16 of which were identified as UXO/MPPEH. The other pile discovered during the MC sampling was not investigated and any potential MEC/MD existing in the pile is not included in CMUA or MEC density calculations. During a MEC clearance in 1997, MEC were recovered from their original locations and placed into these piles. Based on this report, at least three additional piles may exist within the Crow's Nest Impact Area. Because the original locations of MEC recovered from the piles are unknown, there is some uncertainty in the distribution of MEC/MD.

8.3 CONCLUSIONS

Data collected during the RI meet the DQOs and are sufficient to adequately characterize the nature and extent of MEC and MC at the Crow's Nest MRS. A CMUA, or impact area, was confirmed within the Crow's Nest Impact Area and results indicate the summit of the mountain (Crow's Nest) was the main artillery target. The types of munitions identified are consistent with the types of artillery reportedly used at the former ranges. In addition, the data show a target/impact area on the lower eastern portion of the mountain within Training Area G2. The types of MD recovered, specifically Parrott rounds, cannonballs, and mortars, are consistent with the testing range at the West Point Foundry, Siege Battery, and Fort Clinton ranges.

Based on the data, the following conclusions have been made for the Crow's Nest MRS:

- MEC hazards are present in the former Crow's Nest Impact Area.
- No MEC were identified within the three training areas. Significant MD was identified in Training Area G2, and MEC could be present.
- Based on the MRSPP, a Priority of 3 is assigned to the MRS.
- No unacceptable risk from MC to current or future human receptors in soil or sediment was determined.
- SLERA results indicate there is a potential for adverse effects to ecological receptors as a result of lead concentrations in soil and sediment. However, the results are highly conservative by design and there are many uncertainties inherently associated with screening level assessments (**Appendix K**). The risk assessment results represent potential risks to single individual organisms, not to a population or community. As such, what, if any, effect the concentrations of lead found within the MRS have on ecological communities as a whole is not known.
- A baseline ecological risk assessment (BERA) is not necessary since the SLERA results are based on a refinement of COCs and further characterization of ecological effects (food chain modeling). In addition to the SLERA, a refined screening was conducted where less conservative (average) estimates were used; the refined screening provides an insight regarding the likely results of a BERA.

8.4 RECOMMENDATIONS AND REMEDIAL ACTION OBJECTIVES

A Feasibility Study is recommended to further evaluate future response actions for MEC at the Crow's Nest Impact Area MRS (WSTPT-023-R-01).

Preliminary remedial action objectives for the MRS are:

- Reduce the explosive hazards from UXO and MPPEH within the Crow's Nest MRS at the surface to address the likelihood of exposure to Installation personnel/contractors, trespassers and recreational users (hunters, hikers) via direct contact such that the likelihood of encountering is negligible.
- Reduce the explosive hazards from UXO and MPPEH within the Crow's Nest MRS to a maximum depth of 24 inches (2 ft) bgs in the subsurface soil to address the likelihood of

exposure to Installation personnel/contractors, trespassers (relic hunters), and firefighters via direct contact such that the likelihood of encountering is negligible.

Because no MEC were found in the Training Areas G1, G2, and J1, it is recommended that the MRS be subdivided into two areas for assessing explosive hazards (using the MEC HA) and evaluating remedial alternatives for future action. **Figure 8-1** shows the two areas. The first area is approximately 143 acres and combines the Crow's Nest Impact Area CMUA and unknown anomalies to the west of the area. The second area includes the accessible remaining portions of the MRS where no MEC were identified during the RI. This area is approximately 462 acres.

8.5 PRELIMINARY IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) are defined at 40 CFR Section 300.5 as: "cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under Federal environmental, State environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (defined as being applicable) or that "address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (defined as relevant and appropriate). Only the State standards that are more stringent than Federal requirements may supersede Federal requirements.

Substantive requirements may include numerical cleanup standards, required technology, and discharge limitations, among others. Administrative requirements, procedures, and guidance such as permits, reporting, and recordkeeping are not considered ARARs; however, they may be considered criteria for determining the necessary level of cleanup for human safety and protection of the environment if no other regulatory statute applies.

ARARs that may apply to the Crow's Nest MRS and that support the determination of remedial action objectives were identified by assessing the following criteria. The standard/requirement must:

- Be promulgated – related to an environmental law or facility siting law
- Be substantive – not administrative or procedural
- Apply directly to or be sufficiently similar to be relevant AND appropriate to the site
- Be a cleanup standard, standard of control, or requirement that specifically addresses a site pollutant or contaminant, remedial action, or remedial location

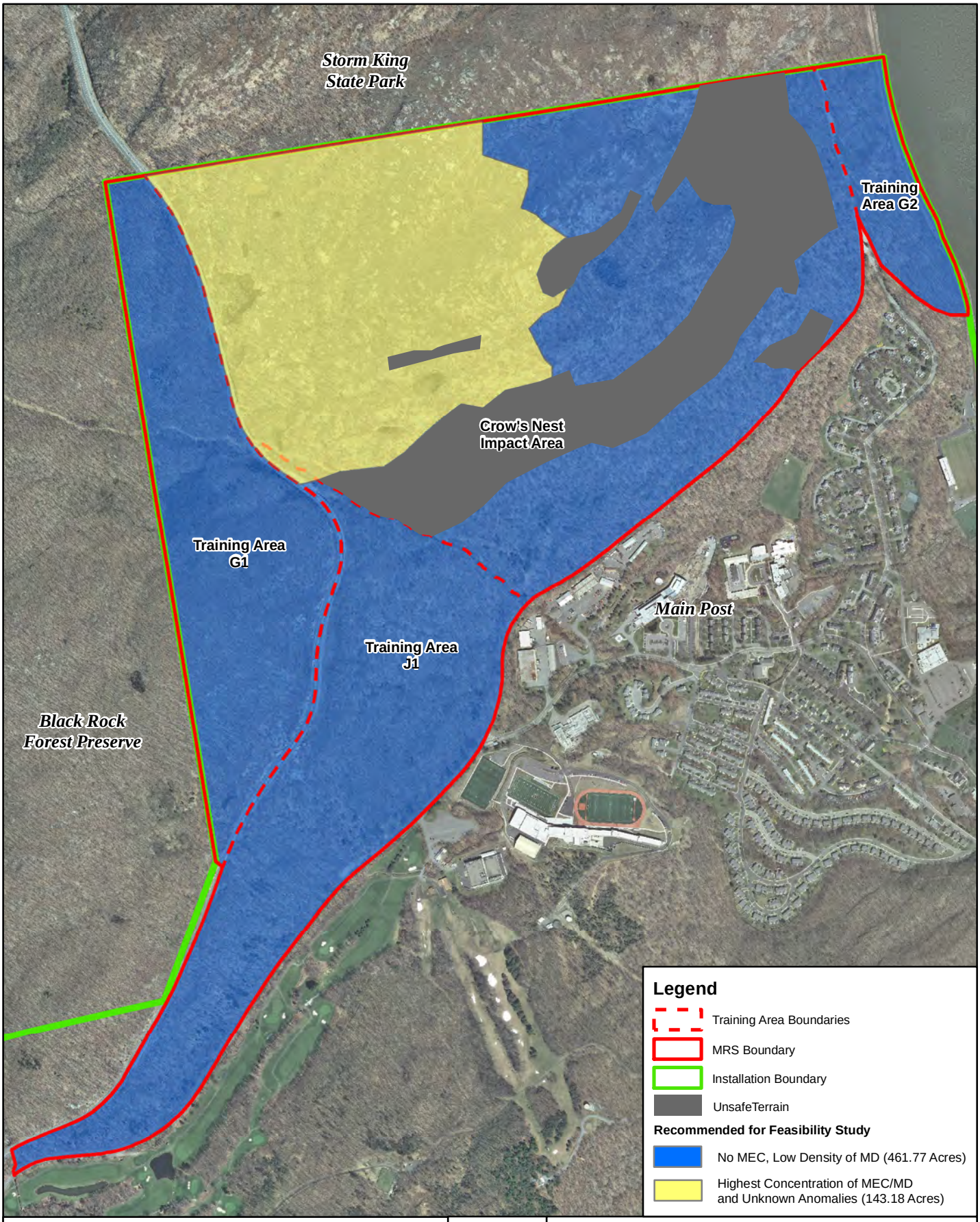
An initial evaluation has been performed and statues or regulations in **Table 8-1** may be considered potential ARARs if remedial action objectives include removal of soil/sediment in the MRS. The determination of ARARs for the MRS is an iterative process conducted by the Army, NYSDEC and USEPA through consultation and collective decision-making. ARARs will not be finalized until the Decision Document is signed.

Location-specific ARARs were identified for the Crow's Nest MRS and provide certain restrictions on conducting activities to prevent damage to unique or sensitive areas, such as wetlands and sensitive ecosystems or habitats. Because no unacceptable risk was determined for human health or the environment, chemical-specific ARARs have not been carried forward.

Table 8-1: Potential ARARs

Statute or Regulation	Citation	Description of Requirement	Comments
Endangered and Threatened Species of Fish and Wildlife Species of Special Concern	6 NYCRR Part 182	Requires action to conserve endangered or threatened species and their critical habitats.	*Location Specific* Timber Rattlesnakes are NYSDEC listed as a threatened species and known to inhabit the MRS.
NYSDEC Division of Water – Freshwater Wetlands Regulations	6 NYCRR Parts 662 – 665	Regulates uses of freshwater wetlands and areas adjacent to ensure use is compatible with the preservation, protection, and enhancement of the wetlands' present and potential values.	*Location Specific* Eighteen freshwater wetland and vernal pool areas exist within the MRS.

NYCRR = New York Codes, Rules and Regulations



CLIENT	USACE - Baltimore District			
PROJ	Crow's Nest MRS Remedial Investigation			
	0 500 1,000 2,000 Feet			
SCALE	1:12,500	DES BY	MS	06/29/2016
Data projected in NAD 1983, UTM Zone 18N, Basemap World Imagery sourced from ArcGIS Online; http://services.arcgisonline.com/ArcGIS/services		CHK BY	LP	06/29/2016

N

TITLE

Recommended Areas For Feasibility Study

URS 12420 Milestone Center Drive Germantown, MD 20876

West Point, NY

FIGURE 8-1

Q:\Projects\ENV\GEARS\GEO\MAES 2012 Unrestricted\West Point\J. GIS\0_Final RI GIS Files\Fig 8-1_Recommended_Areas_FS.mxd 10/27/2016

SECTION NINE: REFERENCES

American Technologies, Inc. 2006. *Final Removal Action Report*, Military Munitions Response Program for Storm King Orange County, New York. January 2006.

ATSDR (Agency for Toxic Substances and Disease Registry). 2007. *Toxicological Profile for Lead*, U.S. Department of Health and Human Services. August 2007.

DoD (U.S. Department of Defense). 2004. Technical Paper (TP) 18, *Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel*. December 2004.

DoD. 2007. *Munitions Response Site Prioritization Protocol (MRSPP) Primer*. June 2007.

DoD. 2010. 6055.09-M, *Ammunition and Explosive Safety Standards*. March 2012.

DoD. 2013. *DoD Quality Systems Manual (QSM) Version 5.0.* July 2013.

DoD. 2014. 4140.62, *Material Potentially Presenting an Explosive Hazard Instruction*. February 2014.

EA (EA Engineering, Science, and Technology, Inc.). 2013. *Final Operational Range Assessment Program Phase II Quantitative Assessment Report United States Army Garrison – West Point*, West Point, New York, 2013.

Environmental Hazards Specialists International, Inc. 2000. *Site Specific Final Report, Time Critical Removal Action and OE Construction Support, Crow's Nest Area/Palisades Park/FUDS/Cold Springs, Near USMA*, West Point, New York. December 2000.

EPA (U.S. Environmental Protection Agency). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004. October 1988.

EPA. 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A)* Interim Final. Office of Emergency and Remedial Response. Washington DC 20460. EPA/540/1-89/002. December 1989.

EPA, 2003. *Human Health Toxicity Values in Superfund Risk Assessments*. OSWER Directive 9285.7-53, December 5, 2003. http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf

EPA. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4). February 2006.

EPA. 2008. EPA 505-B-08-001, *Interim Munitions and Explosives of Concern Hazard Assessment Methodology*.

EPA. 2009. *Calculations of Blood Lead Concentrations (PbBs)*, U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee, Version 6/21/09. http://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

EPA. 2010. *Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM)*. March. http://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-adult-lead-methodology.

EPA. 2012. EPA Hazardous Waste Support Section, SOP NO. HW-2b Revision 15. ICP-MS *Data Validation*.

EPA. 2015a. EPA Hazardous Waste Support Section, SOP No. HW-36A Revision 0 SOM02.2. *Pesticide Data Validation*.

EPA, 2015b. *Regional Screening Level (RSL) Table and User's Guide*, Dated November 2015. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-November-2015

Explosives Ordnance Technologies Incorporated. 2001. *Final Report UXO Clearance at United States Military Academy West Point, NY*.

Geo-Marine, Inc. 2001. *U.S. Military Academy, West Point, Integrated Cultural Resources Management Plan, Final.* On file at the United States Military Academy, West Point, NY.

Human Factors Applications, Inc. 1994. *Unexploded Ordnance Site Survey Report for Crow's Nest*. Prepared for the U.S. Army Engineering and Support Center, Huntsville, 1994.

Interstate Technology and Regulatory Council (ITRC) Incremental Sampling Methodology Team, 2012. *Incremental Sampling Methodology,* Incremental Sampling Methodology Team, February 2012.

ITRC. 2011. *Incorporating Bioavailability Considerations into the Evaluation of Contaminated Sediment Sites,* February.

Los Alamos National Laboratory (LANL), 2015 (October). ECORISK Database (Release 3.3). Environmental Restoration Project, Los Alamos National Laboratory, Los Alamos, NM.

NAVFAC (Naval Facilities Engineering Command). 2015. "Attenuation Pathways for Munitions Constituents in Soils and Groundwater." TR-NAVFAC EXWC-EV-1503. January 2015.

NRCS (Natural Resources Conservation Service). 2011. *Physical Soil Properties*. Soil Data Mart. United States Department of Agriculture, Natural Resources Conservation Service. http://soildatamart.USDA/NRCS.usda.gov/

NYSDEC (New York State Department of Environmental Conservation).2005. *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey.* Appendix D. New York State Departments of Environmental Conservation and Health. August 2005.

NYSM (New York State Museum). 1970. *Geologic Map of New York*. United States Geologic Survey and the University of the State of New York. Reprinted 1995.

Parsons. 2002. *Engineering Evaluation/Cost Analysis, Storm King Site,* Orange County, New York. July 2002.

Tech Law, Inc. 2006. *Final Historical Records Review*, United States Military Academy, West Point, NY, 2006.

Tetra Tech. 2011. *Integrated Natural Resources Management Plan for the United States Army Garrison-West Point*. 2011.

TLI Solutions, Inc. 2007. *Final Site Inspection Report*, United States West Point, 2007.

URS Group, Inc. (URS). 2015a. *Final Site Inspection Report, Crow's Nest Impact Area and Training Areas G1, G2, and J1, Munitions Response Site WSTPT-023-R-01*. Military Munitions Response Program, West Point Military Reservation, West Point, NY. September 2015.

URS Group, Inc. (URS). 2015b. *Final Remedial Investigation Work Plan, Crow's Nest Impact Area and Training Areas G1, G2, and J1, Munitions Response Site WSTPT-023-R-01*. Military Munitions Response Program, West Point Military Reservation, West Point, NY. September 2015.

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

USACE. 2003. *Unexploded Ordnance (UXO) Estimator Version 2.2* [Computer Software]. http://www.hnd.usace.army.mil/oew/CX_PTR.aspx

USACE. 2008. EM 385-1-97, *Explosives Safety and Health Requirements Manual*. September 15, 2008.

USACE. 2015. Engineer Manual (EM) 200-1-15, *Technical Guidance for Military Munitions Response Actions*. October 2015.

U.S. Geological Survey, 2015. Geological Survey National Hydrography Dataset. Retrieved from http://nhd.usgs.gov/. Accessed June 2015.

Weston Solutions, Inc., 2014. *Final Remedial Investigation Report, Redoubt No. 2 MRS*, U.S. Army Garrison, West Point, New York. October 2014.

Weston Solutions, Inc., 2015. *Final Remedial Investigation Report for Fort Clinton West MRS, Siege Battery MRS, Lusk Reservoir MRS and Artillery Firing Range MRS*, U.S. Army Garrison, West Point, New York. March, 2015.

Appendices on CD

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Appendix B	Photographic Log
Appendix C	Explosives Accountability
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Appendix E	Analytical Chain of Custody Forms
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