Final

REMEDIAL INVESTIGATION REPORT

MILITARY MUNITIONS RESPONSE PROGRAM
REMEDIAL INVESTIGATION

PICATINNY ARSENAL
MORRIS COUNTY, NEW JERSEY

Contract No.: W912DR-09-D-0006
Delivery Order No.: 0002

SEPTEMBER 2014

Prepared For:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
Baltimore, MD 21201

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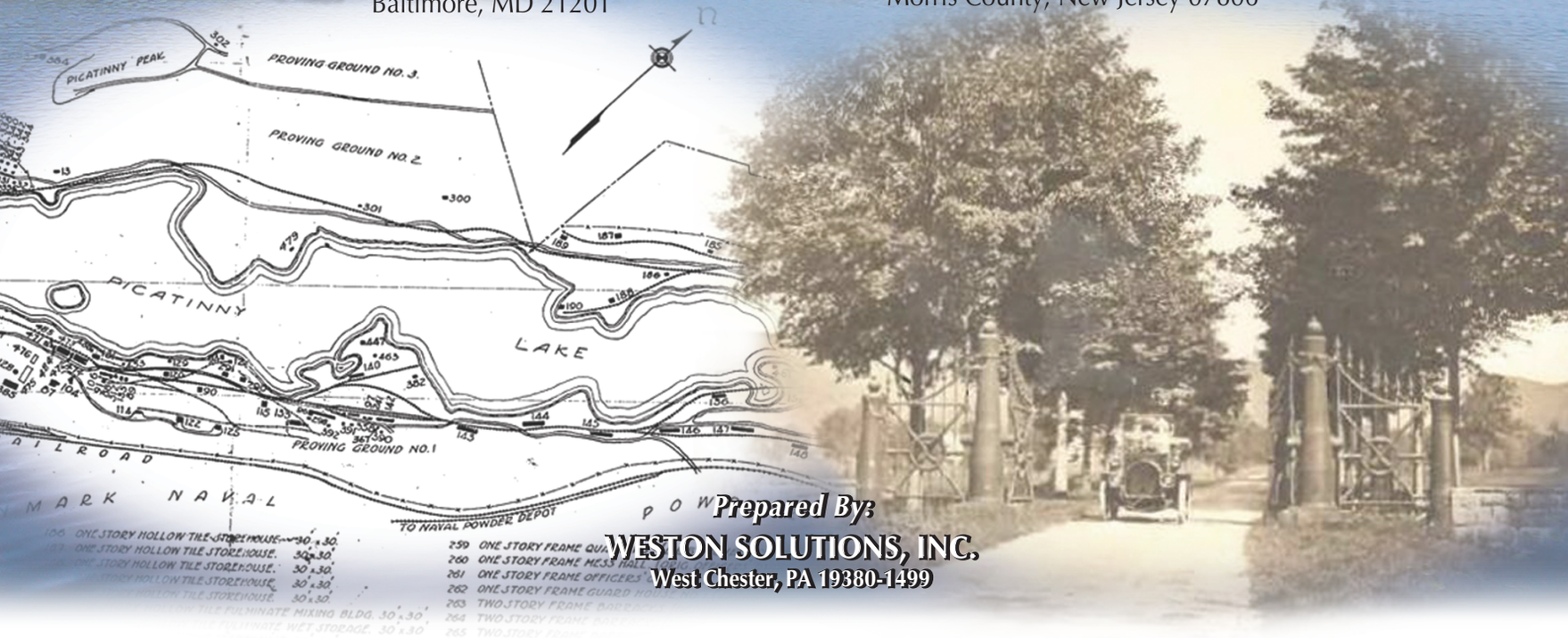

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Final

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September 2014

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REMEDIAL INVESTIGATIONS
PICATINNY ARSENAL
MORRIS COUNTY, NEW JERSEY

CONTRACT NO.: W912DR-09-D-0006
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LIST OF ACRONYMS

µg	micrograms
1,3-DNB	1,3-dinitrobenzene
AGI	Advanced Geosciences, Inc.
AMC	U.S. Army Materiel Command
amsl	above mean sea level
AOI	Area of Interest
AF	adherence factor
AP	armor-piercing
ARARs	applicable or relevant and appropriate requirements
ARDEC	Armament Research, Development and Engineering Center
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	area use factor
BAF	Bioaccumulation Factor
BD	base detonating
bgs	below ground surface
BIP	blown-in-place
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, xylene
Ca	outdoor air
CalEPA	California Environmental Protection Agency
CDC	Childcare Development Center
CDI	chronic daily intake
CENAB	U.S. Army Corps of Engineers, Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	contaminant of concern
COPC	constituent of potential concern
COPEC	constituents of potential ecological concern
CSF	cancer potency slope factor
CSM	conceptual site model
CTE	central tendency exposure
CWA	Clean Water Act
DAD	dermally absorbed doses
DA_{event}	final absorbed dose
DAI	Direct Action Impact
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DMM	discarded military munitions

LIST OF ACRONYMS (CONTINUED)

DoD	Department of Defense
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DSERTS	Defense Sites Environmental Restoration Tracking System
EC	exposure concentrations
Eco-SSL	Ecological Soil Screening Level
ED	exposure duration
EE/CA	Engineering Evaluation/Cost Analysis
EF	exposure frequency
EM	Engineering Manual
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentrations
ER	Electrical resistivity
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERF	Electromagnetic Research Facility
ESL	ecological screening level
ESP	explosive safety plan
ESRI	Environmental Systems Research Institute®
ESV	ecological screening values
EZ	Exclusion Zone
F	Fahrenheit
FS	Feasibility Study
GIS	Geographic Information System
GPS	Global Positioning System
GSV	geophysical system verification
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
HFD	hazardous fragment distance
HHRA	human health risk assessment
H_0	null hypothesis
HQ_{loael}	HQ calculated based on LOAEL
HQ_{noael}	HQs calculated based on NOAEL
HRR	Historical Records Review
IAP	Installation Action Plan
ICM	improved conventional munitions

LIST OF ACRONYMS (CONTINUED)

IC	Institutional Control
INRMP	Installation Natural Resources Management Plan
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
ISO	industry standard object
IVS	instrument verification strip
LANL	Los Alamos National Laboratory
LOAEL	lowest observed adverse effect level
LOQ	limit of quantitation
LUCs	land use controls
m^3	cubic meter
MAMMS	Multiple Award Military Munitions Services
MBTEX	methyl, benzene, toluene, ethylbenzene, xylene
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MDEH	material documented as an explosive hazard
MEC	munitions and explosives of concern
MGFD	munition with the greatest fragmentation distance
mm	millimeter
MMRP	Military Munitions Response Program
MPPEH	material potentially presenting an explosive hazard
MRA	munitions response area
MRS	Munitions Response Site
MSD	minimum separation distance
mV	orientation response
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	no further action
NHPA	National Historic Preservation Act
NJ	New Jersey
NJHPO	New Jersey Historic Preservation Office
NOAEL	no observed adverse effect level
NRWQC	National Recommended Water Quality Criteria
NWI	National Wetlands Inventory
OESS	Ordnance and Explosive Safety Specialist

LIST OF ACRONYMS (CONTINUED)

ORNL	Oak Ridge National Laboratory
PAH	polychlorinated biphenyls
PCB	levels of polychlorinated biphenyls
PD	Point Detonating
PEF	particulate emission factor
PHS&T	Packaging, Handling, Storage, and Transportation Center
PPRTV	Peer-Reviewed Toxicity Values
PSE&G	Public Service Electric and Gas Company
PTA	The Picatinny Arsenal
QA	Quality Assurance
QC	quality control
QSM	Quality Systems Manual
R	rejected
R&D	research and development
RAGS	Risk Assessment Guidance for Superfund
RDX	cyclotrimethylenetrinitramine
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
RSL	Regional Screening Levels
RTI	Radiation Technology, Inc.
RTK	Real Time Kinematic
SARA	Superfund Amendments and Reauthorization Act of 1986
SDD	single deployment distance
SDZ	surface danger zone
SI	Site Inspection
SLERA	screening level ecological risk assessment
SQL	sample quantitation limit
SRS	Soil Remediation Standard
SUXOS	Senior UXO Supervisor
TACOM	Tank Automotive and Armaments Command
TBC	to-be-considered
TCE	trichloroethylene
Tilcon	Tilcon, New York, Inc.
TNT	2,4,6-trinitrotoluene

LIST OF ACRONYMS (CONTINUED)

TPH	total petroleum hydrocarbon
TRV	toxicity reference value
TSD	team separation distance
U.S.	United States
UCL	upper confidence limit
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
URF	unit risk factor
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
UXOQCS	unexploded ordnance quality control specialist
VSP	Visual Sample Plan
WESTON®	Weston Solutions, Inc.
WP	white phosphorus
WWI	World War I
WWII	World War II

ES EXECUTIVE SUMMARY

A remedial investigation (RI) was completed for nine munitions response sites (MRSs) located at United States Army Garrison, Picatinny Arsenal, Morris County, New Jersey (NJ) in support of the Military Munitions Response Program (MMRP). The overall goal of the RI was to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC) and subsequently determine the potential hazards and risks posed to human health and the environment by MEC and MC. The nine MRSs characterized as part of the RI are listed in **Table ES-1**.

Table ES-1 Munitions Response Sites

MRS	AEDB-R ID
1926 Explosion Radius	PICA-003-R-01
1926 Explosion Radius – Off-Post	PICA-004-R-01
Shell Burial Grounds	PICA-010-R-01
Green Pond	PICA-005-R-01
Former Operational Areas	PICA-006-R-01
Lakes	PICA-008-R-01
Lake Denmark – Off-Post	PICA-012-R-01
Inactive Munitions Waste Pit	PICA-013-R-01
Inactive Munitions Waste Pit – Off-Post	PICA-014-R-01

Geophysical surveys, intrusive investigations and environmental sampling were performed in accordance with the final RI work plan and approved minor field changes. More than 6,900 anomalies were detected and investigated as part of the RI fieldwork. MEC was recovered at the 1926 Explosion Radius MRS, Former Operational Areas MRS, and Lakes MRS. A summary of the geophysical survey coverage and intrusive investigation results for each MRS is listed in **Table ES-2**.

Table ES-2 RI Results Summary

MRS	Geophysical Survey Coverage						Anomalies Investigated	Quantity of MEC	Quantity of MD
	Transect Approach				Grid Approach				
	Mag & Dig (ft)	DGM (ft)	Analog Detection Density (ft)	ER (ft)	Mag & Dig	DGM			
1926 Explosion Radius and 1926 Explosion Radius - Off-Post	-	-	13,844	-	93 grids/ 5.33 acres	39 grids/ 2.23 acres	2,928	14	973
Shell Burial Grounds	-	15,313	-	4,660	-	-	0	0	0
Green Pond Brook	2,160	2,703	-	-	-	-	562	0	58
Former Operational Area	218,910	70,650	13,443	-	1 grid/ 0.05 acres	7 grids/ 0.4 acres	3,194	75	444
Lakes	78,837	31,439	-	-	-	2 grids/ 0.82 acres	268	2	44
Inactive Munitions Waste Pit	830	6,163	3,020	-	1 grid/ 0.05 acres	-	14	0	1
Inactive Munitions Waste Pit - Off-Post	6,780	-	-	-	-	-	6	0	4
Lake Denmark - Off-Post	-	-	30,817	-	-	-	0	0	0
Project Total	**307,517 ft or 58 miles**	**126,268 ft or 24 miles**	**61,124 ft or 11 miles**	**4,660 ft or 0.9 miles**	**95 grids/ 5.43 acres**	**48 grids/ 3.45 acres**	**6,972**	**91**	**1,524**

DGM = digital geophysical mapping
ER = electrical resistivity
MD = munitions debris

MC sampling was completed at the Former Operational Areas MRS and Inactive Munitions Waste Pit MRS. Based on geophysical survey, intrusive investigation findings and MC being addressed under co-located Installation Restoration Program (IRP) sites, MC sampling was not warranted at the remaining MRSs. A summary of the MC sampling results for each MRS is listed in **Table ES-3**. Baseline risk assessments were performed for MRSs where complete exposure pathways to MC were identified. The MC exposure pathway analysis and risk assessment results for each MRS are presented in **Table ES-3**.

Table ES-3 MC Sampling and Risk Assessment Results

MRS	MC Characterization	MC Results
1926 Explosion Radius	MC sampling was not warranted based on intrusive investigation results.	Exposure pathways for MC are incomplete.
Fuze Area	MC sampling was not warranted based on intrusive investigation results.	Exposure pathways for MC are incomplete.
1926 Explosion Radius – Off-Post	MC sampling was not warranted based on intrusive investigation results.	Exposure pathways for MC are incomplete.
Shell Burial Grounds	MC is covered under the IRP.	No MC risk analyses performed
Former Operational Areas	Systematic and step-out sampling was performed in accordance with the final work plan.	No human health or ecological risk indicated based on risk assessment.
Former Operational Areas – Mortar Range	MC is covered under the IRP and systematic and step-out sampling performed for the Former Operational Area MRS overlapped into the new MRS.	No human health or ecological risk indicated based on risk assessment for the surrounding Former Operational Area MRS.
Lakes	MC sampling on land was not warranted based on intrusive investigation results. MC for the water portions of the MRS is covered under the IRP.	Land exposure pathways for MC are incomplete. No MC risk analyses performed for water portion..
Lake Denmark – Off-Post	MC sampling was not warranted based on intrusive investigation results.	Exposure pathways for MC are incomplete.
Inactive Munitions Waste Pit	Biased MC sampling was performed.	Risk assessment indicated exposure pathways incomplete due to lack of a confirmed release/source.
Inactive Munitions Waste Pit – Off-Post	MC sampling was not warranted based on intrusive investigation results.	Exposure pathways for MC are incomplete.

The RI fieldwork results were assessed to update the conceptual site models (CSMs) for each MRS. Human and ecological receptor exposure pathways to MEC were also evaluated for each MRS. A MEC Hazard Assessment (MEC HA) was performed for MRSs where complete exposure pathways to MEC were identified. The purpose of the MEC HA is to evaluate the potential explosive hazard associated with conventional MEC present at an MRS. A MEC probability assessment was performed for the Shell Burial Grounds MRS since MEC, although not confirmed, is believed to be present based on historical accounts. MEC exposure pathway analysis and MEC hazard or probability assessments for each MRS is presented in **Table ES-4**.

Table ES-4 MEC Characterization & Hazard Assessment Results

MRS	MEC Characterization	MEC HA Results
1926 Explosion Radius/ 1926 Explosion Radius – Off-Post	There is a 95% confidence level that less than or equal to 0.159 MEC/acre remains within the Outer Radius Decision Unit of the MRS. There is a 95% confidence level that less than or equal to 1.577 MEC/acre remains within the Inner Radius Decision Unit. A new Fuze Area Decision Unit was delineated within the 1926 Explosion Radius MRS during RI fieldwork. The Fuze Area is 1.63 acres in size and exhibited a different CSM than the surrounding 1926 Explosion Radius MRS therefore it is being split into a separate Fuze Area MRS. Complete exposure pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRS. The Green Pond MRS was incorporated into the 1926 Explosion Radius MRS.	1926 Explosion Radius MEC HA Hazard Level: 1. Highest potential explosive hazard condition. 1926 Explosion Radius – Off-Post MEC HA Hazard Level: 3. Moderate potential explosive hazard condition.
Fuze Area	There is 95% confidence that less than or equal to 173.006 MEC/acre within the Fuze Area MRS. Complete exposure pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRS.	MEC HA Hazard Level: 2. High potential explosive hazard condition.
Shell Burial Grounds	No MEC or MD was observed during geophysical surveys. The lateral and vertical extents of each burial area were delineated. Incomplete exposure pathways for MEC were identified for surface soil. Complete exposure pathways for MEC were identified for subsurface soil.	Moderate to high probability of encountering MEC based on MEC Probability Assessment.
Green Pond MRS	The Green Pond MRS was incorporated into the 1926 Explosion Radius MRS because of similar CSMs.	NA
Former Operational Areas	MEC and MD were recovered at the MRS. A MEC impact area was detected and delineated as an approximately 183-acre mortar range. The Mortar Range exhibited a different CSM than the surrounding Former Operational Area MRS therefore it is being split into a separate Former Operational Areas – Mortar Range MRS. The horizontal extent of the subsurface material at the AOIs was	MEC HA Hazard Level: 1. Highest potential explosive hazard condition

MRS	MEC Characterization	MEC HA Results
	determined to be within the current AOI boundaries. Complete MEC pathways were identified for surface and subsurface soils for all receptors having access to the MRS. Complete MC pathways were identified for human and ecological receptors that may contact surface soil. Pathways for subsurface soil are incomplete.	
Former Operational Areas – Mortar Range	The Former Operational Area –Mortar Range MRS is 183 acres with a MEC density of approximately 2 MEC per acre. Complete exposure pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRS.	MEC HA Hazard Level: 1. Highest potential explosive hazard condition
Lakes	MEC and MD were recovered at the MRS. Complete exposure pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRS.	MEC HA Hazard Level: 1. Highest potential explosive hazard condition.
Lake Denmark – Off-Post	No MEC or MD observed. Incomplete exposure pathways for MEC were identified for surface and subsurface soil.	A MEC HA was not warranted based on fieldwork findings.
Inactive Munitions Waste Pit	MEC and MD were recovered at the MRS during an Installation Restoration Program investigation. A burial pit feature was confirmed to be present based on DGM performed at ground surface extending over 0.24 acre laterally within the MRS boundary. Incomplete exposure pathways for MEC were identified for surface soil. Complete exposure pathways for MEC were identified for subsurface soil. Incomplete exposure pathways for MC were identified for surface and subsurface soil.	MEC HA Hazard Level: 3. Moderate potential explosive hazard condition.
Inactive Munitions Waste Pit – Off-Post	No MEC or MD observed. Incomplete exposure pathways for MEC were identified for surface and subsurface soil.	A MEC HA was not warranted based on fieldwork findings.

It has been determined that DQOs for each MRS have been satisfied and the nature and extent of MEC and MC has been adequately characterized. The MEC hazards and MC risks for each MRS have been assessed. In addition the Munitions Response Site Prioritization Protocol (MRSPP) tool was used for each MRS to aid in prioritizing potential actions at MRSs for national funding and responses. The resultant recommendations and MRSPP priority or alternative rating for each MRS are presented in **Table ES-5**.

Table ES-5 RI Recommendations and MRSPP Score

MRS	Recommendations	MRSPP Score
1926 Explosion Radius	It is recommended the Green Pond MRS be incorporated into the 1926 Explosion Radius MRS because the CSMs for both MRSs are similar. It is recommended that the new Fuze Area Decision Unit be separated from the 1926 Explosion Radius MRS, and be known as the1.63 acre Fuze Area MRS. The 1926 Explosion Radius MRS is now 1,543.9 acres in size based on the addition of the Green Pond MRS and the delineation of the new Fuze Area MRS. It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	3
1926 Explosion Radius – Off-Post	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	2
Fuze Area	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	3
Shell Burial Grounds	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	5
Green Pond	This MRS has been incorporated into the 1926 Explosion Radius MRS.	NA
Former Operational Areas	It is recommended that the approximately 183-acre impact area be separated from the Former Operational Areas MRS, and be known as the Former Operational Areas - Mortar Range MRS. The Former Operational Areas MRS is now 1,689.5 acres in size based on the delineation of the new Former Operational Areas - Mortar Range MRS. It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	3
Former Operational Areas – Mortar Range	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	3
Lakes	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	4
Lake Denmark – Off-Post	It is recommended that the MRS be further evaluated in an FS to assess a No Further Action response alternative.	No Known or Suspected MEC, CWM, or MC Hazard
Inactive Munitions Waste Pit	It is recommended that the MRS be further evaluated in an FS for potential action to address potential explosive hazards due to the presence of MEC.	4
Inactive Munitions Waste Pit – Off-Post	It is recommended that the MRS be further evaluated in an FS to assess a No Further Action response alternative	No Known or Suspected MEC, CWM, or MC Hazard

1. INTRODUCTION

The Picatinny Arsenal (PTA) Remedial Investigation (RI) Report documents the findings, conclusions, and recommendations following RI activities conducted at various Munitions Response Sites (MRSs) located at PTA, Morris County, New Jersey (NJ) (listed on **Table 1-1**).

Weston Solutions, Inc. (WESTON®) was authorized to perform the RI under the United States Army Corps of Engineers (USACE), Baltimore District (CENAB) Multiple Award Military Munitions Services (MAMMS) Contract W912DR-09-D-0006, Delivery Order 0002. The RI was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). In accordance with Executive Order 12580, the United States (U.S.) Army is the lead agency with support from the New Jersey Department of Environmental Protection (NJDEP). The U.S. Environmental Protection Agency (EPA) is the lead regulatory reviewer and has signed an agreement with the Army on the cleanup of Picatinny Arsenal. The RI Report is consistent with the U.S. Army Military Munitions Response Program (MMRP) document, *Final Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009), and EPA October 1988 document, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under* CERCLA (EPA, 1988). There are areas within several MRSs that required investigation methods that differed from the majority of the encompassing MRS because of variations in release mechanisms and strategies employed for characterization. These areas, called sub-sites in the Work Plan, were designated Areas of Interest (AOIs). **Table 1-1** provides the acreages for each MRS and the associated AOI within each MRS.

1.1 PURPOSE

The U.S. Congress established the MMRP under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC), including unexploded ordnance (UXO), discarded military munitions (DMM), and munitions constituents (MC) located on current and former defense sites. MMRP-eligible sites include locations other than operational ranges where UXO, DMM, or MC is known or suspected and where the release occurred prior to 30 September 2002. Properties classified as operational military ranges, permitted munitions disposal facilities, or operating munitions storage facilities are not eligible for the MMRP. The

DERP, including the MMRP, follows the environmental cleanup decision-making process provided by CERCLA and NCP.

Table 1-1 MRS Acreages

MRS	Total MRS Acreage[1]	AOI/Acreage[2]	
1926 Explosion Radius (PICA-003-R-01)	**1,544**	Code 300 Area[3]	91.3
1926 Explosion Radius – TD[4] (PICA-004-R-01)	**838**		
Shell Burial Grounds (PICA-010-R-01)	**5.7**		
Green Pond (PICA-005-R-01)	**1.1**		
Former Operational Areas (PICA-006-R-01)	**1,880**	Code 300 Area[3]	56.8
		Site 20/24	28
		Waste Burial Area	8.5
		Former Sanitary Landfill and Dredge Pile	13
Lakes (PICA-008-R-01)	**741**		
Lake Denmark – Off-Post (PICA-012-R-01)	**113**		
Inactive Munitions Waste Pit (PICA-013-R-01)	**21**	Code 300 Area[3]	14.1
Inactive Munitions Waste Pit – Off-Post (PICA-014-R-01)	**39**		

Notes:

1 MRS acreage does not include the current operational areas acreage; therefore, the MRS acreage does not equal the total PTA acreage.

2 AOI acreage is included in the associated MRS acreage but does not necessarily equal the total MRS acreage.

3 The Code 300 Area overlaps three separate MRSs, the 1926 Explosion Radius MRS, Former Operational Areas MRS, and Inactive Munitions Waste Pit MRS. The Code 300 Area analysis and results are discussed with the 1926 Explosion Radius MRS because the majority of the AOI is within 1926 Explosion Radius MRS. Supporting details are included in the Former Operational Areas MRS and Inactive Munitions Waste Pit MRS results sections.

4 The name of the MRS is presented in this table exactly as listed in the Army Environmental Database-Restoration (AEDB-R); however, to be consistent with the Final Site Inspection (SI) Report (Malcolm Pirnie, 2008) and the Final Work Plan (WESTON, 2012), the 1926 Explosion Radius - TD is referred to as the 1926 Explosion Radius - Off-Post throughout this report.

The purpose of the RI conducted at PTA was to determine whether further response action pursuant to CERCLA and the NCP is warranted at each of the nine MRSs. The overall goal of the RI was to determine the nature and extent of MEC and MC and subsequently to determine the hazards and potential risks posed to human health and the environment by MEC and MC. The project objectives are listed below:

- Characterize the type (nature), density and/or distribution (extent) of MEC on the surface and in the subsurface at each MRS.

- Characterize the nature and extent of MC in soil at applicable MRSs.
- Perform a hazard assessment for MEC, if recovered.
- Perform a baseline risk assessment for MC, as appropriate.
- Evaluate the MRS boundaries based on the RI results.

1.2 PLANNING PROCESSES

1.2.1 Technical project Planning

Prior to the initiation of RI field activities, representatives and stakeholders from USACE, PTA, EPA, NJDEP, WESTON, and ARCADIS participated in two technical project planning (TPP) meetings. TPP 1 was conducted on 10 November 2010. At this meeting, the MRS summary and RI approach, objectives, planning documentation, and field investigation and reporting requirements were discussed.

TPP 2 was conducted on 28 July 2011. The project stakeholders reviewed the RI Work Plan and identified and discussed project goals and Data Quality Objectives (DQOs). Details regarding the implementation of the MMRP RI were presented and discussed among the group. Based on the results of the second meeting, specific details of the investigation approach for the MRS including coverage area, survey type (grid versus transect), and quantities were determined. The TPP meeting minutes are included as **Appendix A**.

1.2.2 Pathways Analysis Report

A detailed risk assessment work plan, termed a Pathways Analysis Report (PAR), was prepared for the Former Operational Areas MRS, which was the only MRS where a detailed human health risk assessment (HHRA) or screening level ecological risk assessment (SLERA) was warranted. The PAR included Risk Assessment Guidance for Superfund (RAGS) Part D (EPA, 2001) Tables 1 to 6 and served as a predecessor to the HHRA and/or SLERA. Comments to the PAR were discussed via teleconference and all resolved comments were incorporated directly into the HHRA and/or SLERA since a revised PAR was not developed.

1.3 PROPERTY DESCRIPTION AND PROBLEM IDENTIFICATION

PTA is an active military installation that consists of 5,801 acres that house government-operated munitions research and development (R&D) facilities; operational ranges for munitions testing[1]; residential housing; and recreational facilities, including a golf course and water park (**Figure 1-1)**. Ten MRSs were initially identified in the SI Report (Malcolm Pirnie, 2008). In 2010, PICA-001-R-01 (Former Munitions and Propellant Test Area) was designated as an operational range and, therefore, is not MMRP-eligible and was not included in the RI. The nine remaining MRSs are associated with former ranges, historical testing areas, an explosion of munitions storage magazines in 1926, or specific locations where munitions have been reportedly recovered. Three MRSs consisting of 990 acres are not located on PTA (off-post). The land use of the off-post MRSs are varied: recreational, industrial and a wildlife management area. The locations of each of the nine MRSs are shown on **Figure 1-2**. AOIs within each MRS are demarcated on MRS-specific figures (**Figures 1-3** and **1-5** through **1-15**). The Code 300 Area is shown on its own figure (**Figure 1-4**) because it overlaps three separate MRSs.

In addition to the MRSs, almost 200 Installation Restoration Program (IRP) sites are present across PTA with many of the IRP sites located within MRS boundaries. Several IRP sites are also co-located (share boundaries) with MRSs and some environmental media have already been investigated and addressed at individual MRSs. For example at the Shell Burial Grounds MRS, groundwater will be addressed by the MidValley Groundwater Site (PICA 204) and MEC will be addressed by the MMRP RI. MRS-specific information is addressed in later sections. Refer to **Appendix B** for the IRP site locations, Army Environmental Database Restoration (AEDB-R) numbers, and site descriptions.

The Army has two restoration programs under DERP at active/operating Army installations, the IRP and the MMRP. The IRP is a comprehensive program to identify, investigate, and clean up hazardous substances, pollutants, and contaminants at active/operating Army installations. The MMRP was described in Section 1.1.

The following subsections present a brief description and problem identification for each MRS.

[1] Active operational range areas are located within MRS footprints but are not MMRP-eligible and are not included in the RI. These operational range areas are shown as dark green areas on RI Report figures.

1.3.1 1926 Explosion Radius MRS

The 1926 Explosion Radius MRS (PICA-003-R-01) consists of 1,544 acres on PTA that are within a 1-mile radius of the 1926 Lake Denmark Naval Ammunition Depot explosions (except for the Shell Burial Grounds MRS, which includes the explosion centers). **Figure 1-3** presents the location of the 1926 Explosion Radius MRS. The majority of the 1926 Explosion Radius MRS is located in the center of PTA, is developed, and includes portions of eastern "downtown" PTA and the golf course. In addition, approximately 40 IRP sites are partially or wholly located within the 1926 Explosion Radius MRS.

Historically, MEC and munitions debris (MD) have been identified and recovered within the 1926 Explosion Radius MRS.

The results of the SI (Malcolm Pirnie, 2008) indicated that the 1926 Explosion Radius MRS required further action through an MMRP RI/FS focused on MEC.

Several water bodies, including the majority of Picatinny Lake, EOD Pond, a portion of Green Pond Brook, Fisher's Pond, North Basin, and South Basin, are located within the 1926 Explosion Radius MRS. With the exception of Green Pond Brook and Picatinny Lake addressed below, EOD Pond, Fisher's Pond, North Basin, and South Basin water bodies were not investigated as part of the RI.

Three other MRSs are defined within the boundary of the 1926 Explosion Radius MRS, as shown on **Figure 1-2**. They include the Green Pond MRS (PICA-005-R-01), the Picatinny Lake portion of the Lakes MRS (PICA-008-R-01), and the Shell Burial Grounds MRS (PICA-010-R-01). These MRSs were investigated and are reported on separately in the RI Report as a result of differences in the preliminary conceptual site models (CSMs) and strategies employed for characterization.

1.3.1.1 Code 300 Area

The majority of the historical Code 300 Area is located in the northwestern portion of the 1926 Explosion Radius MRS (with some acreage within northwestern portions of the Former Operational Areas MRS and the Inactive Munitions Waste Pit MRS). The Code 300 Area (shown in **Figure 1-4**) consists of approximately 975 acres. According to a PTA Survey Report (Department of Defense (DoD), 1973), the historical Code 300 Area was used as a former

artillery firing and fragmentation pattern testing area for munitions as large as 155 millimeter (mm) projectiles. As a result of several operational ranges overlapping the historical Code 300 Area boundary, approximately 162.2 of the total 975 acres were included as an AOI in the RI.

1.3.2 1926 Explosion Radius – Off-Post MRS

The 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01), is 838 acres in size, and consists of a portion of the 1-mile radius of the 1926 Lake Denmark Naval Ammunition Depot explosion centers that are outside the PTA boundary. The 1926 Explosion Radius – Off-Post MRS, which has eight privately owned land parcels with six property owners, consists of vacant land and commercial property. Mount Hope Quarry, owned and operated by Tilcon, New York, Inc. (Tilcon), covers approximately 80% of the 1926 Explosion Radius – Off-Post MRS. The additional property owners are Ilac Reality, LLC; K. Doland; Rockaway Township; Morris County; and SMC-DAG, Inc. **Figure 1-5** presents the location of the 1926 Explosion Radius – Off-Post MRS. Historically, both MEC and MD have been discovered in the 1926 Explosion Radius – Off-Post MRS and as a result response actions have been completed for MEC.

The results of the SI (Malcolm Pirnie, 2008) indicated that the 1926 Explosion Radius – Off-Post MRS required further action through an MMRP RI/FS focused on MEC.

1.3.3 Shell Burial Grounds MRS

The Shell Burial Grounds MRS (PICA-010-R-01) consists of two large burial areas where three craters were formed from the 1926 Lake Denmark Naval Ammunition Depot explosion. Two of the three craters are so close they are considered a single site named the Shell Burial Grounds – West.[2] This larger burial ground covers approximately 4.2 acres and is located in the southern half of PTA near Building 3100. The third crater, referred to as the Shell Burial Grounds – East, covers approximately 1.5 acres and is located near Building 3150. **Figure 1-6** presents the location of the Shell Burial Grounds MRS. It was estimated that 2.4 million pounds of explosives and munitions detonated in the explosion, burning and/or destroying almost everything within a 3,000-foot radius of the explosion centers (Picatinny Arsenal, 1931). Unexploded munitions have

[2] The SI report refers to the two burial areas as the Northern Shell Burial Area and the Southern Shell Burial Area. To be more accurate geographically, the Northern Burial Area (near Building 3100) is now referred to as the Shell Burial Grounds MRS – West; the Southern Burial Area (near Building 3150) is now referred to Shell Burial Grounds MRS – East.

been recovered up to ¾ of a mile from the explosion center, and MD relating to the explosion were recovered up to 1 mile away (basis for the 1926 Explosion Radius MRS and 1926 Explosion Radius-Off Post MRS). Initially, the craters were used to dispose of approximately 25 tons of explosives and/or munitions released during the 1926 explosion. Subsequently, the Navy disposed of material in the craters until 1945, after which the craters were backfilled/covered with fill material.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Shell Burial Grounds MRS required further action through an MMRP RI/FS focused on MEC. It was determined that the IRP program RI will sufficiently address potential MC at the Shell Burial Grounds MRS.

1.3.4 Green Pond MRS and Former DRMO Yard

The Green Pond MRS (PICA-005-R-01) consists of 1.1 acres of the Green Pond Brook channel beginning south of the 9th Street Bridge and extending to the eastern edge of the Former Defense Reutilization and Marketing Office (DRMO) Yard. The Green Pond MRS includes a 15-foot buffer area on either side of the Green Pond Brook channel banks. Historically, MEC has been discovered protruding from the banks of Green Pond Brook, although the source of the MEC is unknown (Malcolm Pirnie, 2008).

The Green Pond MRS and Former DRMO Yard are located within the 1926 Explosion Radius MRS. Because of their proximity and similar MEC release mechanisms, which are discussed in Section 4, the Green Pond MRS and Former DRMO Yard were investigated as one site and are reported together in the RI Report. During the HRR the Former DRMO Yard was designated as an MRS (PICA-007-R-01); however, during the SI the Former DRMO Yard MRS was consolidated with the 1926 Explosion Radius (PICA-003-R-01). The Green Pond MRS was not consolidated and remained a separate MRS. **Figure 1-7** shows the location of the Green Pond MRS and adjacent Former DRMO Yard.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Green Pond MRS required further action through an MMRP RI/FS focused on MEC. It was determined that the IRP program will sufficiently address potential MC within the Green Pond MRS and adjacent Former DRMO Yard.

1.3.5 Former Operational Areas MRS

The Former Operational Areas MRS (PICA-006-R-01) consists of 1,880 acres across PTA southwest of Lake Denmark to the southern boundary of PTA, excluding operational ranges and other RI MRS footprints. **Figure 1-8** presents the location of the Former Operational Areas MRS. The boundary for the Former Operational Areas MRS was established based on the discovery of a map in the PTA Safety Office following the Historical Records Review (HRR) and prior to the SI phase of investigation. This map (referred to as the "UXO Finds" map) documents the numerous munition-related items recovered throughout PTA between 1986 and 1998 (see Section 2.1.2.1 for more detailed map information). In addition, a PTA Survey report, dated 1973, documents an original 2,036 acres[3] as being allocated for former R&D activities that included approximately 51 acres of testing areas (Malcolm Pirnie, 2008). The munition locations present on the UXO Finds map and the R&D areas in the 1973 Survey Report, which were not included within other MRS boundaries, were incorporated into the Former Operational Areas MRS.

In 2011, several active operational areas within the footprint of Former Operational Areas MRS were designated non-operational MMRP eligible and are included in the Former Operational Areas MRS total acreage.

In the southern portion of the Former Operational Areas MRS, are several AOIs that required investigation methods that differed from the overall Former Operational Areas MRS characterization approach during the RI. A description of these AOIs is presented in the following subsections and the locations are shown on **Figure 1-8**.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Former Operational Areas MRS required further action through an MMRP RI/FS focused on MEC.

1.3.5.1 AOI Code 300 Area

Only a small portion of the AOI Code 300 Area is within Former Operational Areas MRS, the majority of the AOI Code 300 Area is located in the northwestern portion of the 1926 Explosion

[3] The Former Operational Areas MRS acreage does not equate to the original acreage reported in the 1973 PTA Survey report because portions of the former R&D designated areas either are within current operational range areas or are located outside the MRS (e.g., AOI Code 300 Area).

Radius MRS and a small portion in the Inactive Munitions Waste Pit MRS. The AOI Code 300 Area (shown in **Figure 1-4**) consists of approximately 975 acres. According to a PTA Survey Report (Department of Defense (DoD), 1973), the Code 300 Area was used as a former artillery firing and fragmentation pattern testing area for munitions as large as 155 millimeter (mm) projectiles.

1.3.5.2 AOI Former Sanitary Landfill and Dredge Pile

The AOI Former Sanitary Landfill and Dredge Pile consists of a 13-acre former landfill (PICA-067/068) located in the southern portion of PTA (between Parker Road and Spicer Avenue). During an interview conducted for the HRR, it was reported that during excavation of a utility line in the southwest corner of the landfill, MEC might have been identified. No additional information is available regarding these items. It was also stated during the same interview that MEC might have been disposed of in the landfill but this has not been independently confirmed (Malcolm Pirnie, 2006). In addition, a large soil pile (also referred to as the dredge pile) from former Green Pond Brook dredging activities resides on top of the former landfill cap approximately 12 to 15 feet (ft) above the surrounding grade.

1.3.5.3 AOI Waste Burial Area

The AOI Waste Burial Area consists of an 8.5-acre unregulated waste burial area (IRP Site PICA-093) located near the former burning ground in the southern portion of PTA. In 1998, MD and potential UXO consisting of 40mm grenades were recovered from the AOI during IRP activities (IT Corporation, 2000a).

1.3.5.4 AOI Site 20/24

The AOI Site 20/24 covers approximately 28 acres and is located in the southwestern corner of PTA between Phipps Road and Green Pond Brook. The AOI Site 20/24 (IRP Site PICA-063/066), which consists of cleared, reclaimed/filled wetlands, is a former pyrotechnic testing area and includes a portion of a former mortar training area. A one-acre shallow pond in the central portion of AOI Site 20/24, called Landfill Pond, was used for dumping of miscellaneous waste and debris from the early 1960s through 1972 (IT Corporation, 2000b).

1.3.6 Lakes MRS

The Lakes MRS (PICA-008-R-01) consists of Picatinny Lake and Lake Denmark. The locations of the two non-contiguous portions of the Lakes MRS are presented on **Figure 1-9**.

Picatinny Lake is an approximately 108-acre manmade lake that is centrally located on PTA. Approximately 17 acres of shoreline surrounding Picatinny Lake are included in the Lakes MRS. The majority of Picatinny Lake lies within the 1926 Explosion Radius MRS. A former 3-inch projectile Barbette gun range extended across the lake; in addition, Flare Island, a manmade peninsula in the southwestern portion of Picatinny Lake, was used for pyrotechnic testing. **Figure 1-10** presents the location of the Picatinny Lake portion of the Lakes MRS.

The Lake Denmark Area consists of approximately 516 acres: 263 acres of open water and 353 acres of land. Lake Denmark is located in the northern portion of PTA and is presented in **Figure 1-11.** The Lake Denmark Area boundary coincides with overlapping safety fans from former 60mm, 81mm, and 4.2-inch mortar ranges as well as a 20mm cannon range. The layout of the former range and firing points (both abandoned and relocated firing points for the mortar range) is presented in **Figure 1-12.** In addition, a Sagger Missile Range and two observation points were identified during an interview with ex-PTA personnel conducted on 30 April, 2013 (included in **Appendix C)**. This additional range and observation points are also shown on **Figure 1-12.** The Lake Denmark Area excludes the northeasternmost extent of the lake because it is outside the boundary of the mortar range safety fans.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Lakes MRS required further action through an MMRP RI/FS focused on MEC. It was determined that the IRP program RI will sufficiently address potential MC within the water of the Lakes MRS.

1.3.7 Lake Denmark - Off-Post MRS

The Lake Denmark – Off-Post MRS (PICA-012-R-01), depicted on **Figure 1-13**, consists of 113 acres. The Lake Denmark – Off-Post MRS is the northeasternmost surface danger zone (SDZ) portion of the former mortar range located on PTA that is being addressed under the Lake Denmark portion of the Lakes MRS. This portion of the former mortar range has been designated as the Lake Denmark – Off-Post MRS because it is located outside the PTA boundary and the majority of the Lake Denmark – Off-Post MRS is within the adjacent Radiation Technologies, Inc. (RTI) Superfund site[4]. The remainder of the Lake Denmark – Off-Post MRS is owned by Rockaway Township. Previous industrial activities at RTI included testing and development of

[4] Right-of-entry was granted through a joint agreement with EPA and RTI for only non-intrusive visual surveys.

rocket engines and propellants. Perchlorate, a contaminant of concern (COC) associated with RTI, has been found in groundwater. Sterigenics, a gamma facility that provides sterilization and ionization services for the healthcare, food safety, and advance application industries, currently leases the RTI facility. To date, no positive confirmations of MEC or MD have been noted within the Lake Denmark – Off-Post MRS.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Lake Denmark – Off-Post MRS required further action through an MMRP RI/FS focused on MEC, including MC.

1.3.8 Inactive Munitions Waste Pit MRS

The Inactive Munitions Waste Pit MRS (PICA-013-R-01) consists of 21 acres, defined by part of a 1,250-foot SDZ centered on an area reportedly used as a former munitions test area and waste pit. Anecdotal evidence and a review of historical aerial photography included in the HRR indicate that up to 12 feet of fill material has been placed over the former munitions test area since the 1980s and 1990s (Malcolm Pirnie, 2006 and 2008). The Inactive Munitions Waste Pit MRS is located on Green Pond Mountain and is bordered by the PTA boundary to the northwest and operational ranges to the south and east. **Figure 1-14** presents the location of the Inactive Munitions Waste Pit MRS.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Inactive Munitions Waste Pit MRS required further action through an MMRP RI/FS focused on MEC, including MC.

1.3.8.1 AOI Code 300 Area

Only a small portion of the AOI Code 300 Area is within Inactive Munitions Waste Pit MRS, the majority of the AOI Code 300 Area is located in the northwestern portion of the 1926 Explosion Radius MRS and a small portion in the Former Operational Areas MRS. The AOI Code 300 Area (shown in **Figure 1-4**) consists of approximately 975 acres. According to a PTA Survey Report (Department of Defense (DoD), 1973), the Code 300 Area was used as a former artillery firing and fragmentation pattern testing area for munitions as large as 155 millimeter (mm) projectiles.

1.3.9 Inactive Munitions Waste Pit – Off-Post MRS

The Inactive Munitions Waste Pit – Off-Post MRS consists of 39 acres of the 1,250-foot SDZ that is outside the PTA boundary and located in Jefferson Township. **Figure 1-15** presents the location of the Inactive Munitions Waste Pit – Off-Post MRS. The Inactive Munitions Waste Pit – Off-Post MRS is located on Green Pond Mountain and is bordered by the PTA boundary to the southeast and a steep mountain slope to the northwest.

The results of the SI (Malcolm Pirnie, 2008) indicated that the Inactive Munitions Waste Pit – Off-Post MRS required further action through an MMRP RI/FS focused on MEC, including MC.

1.4 REMEDIAL INVESTIGATION REPORT ORGANIZATION

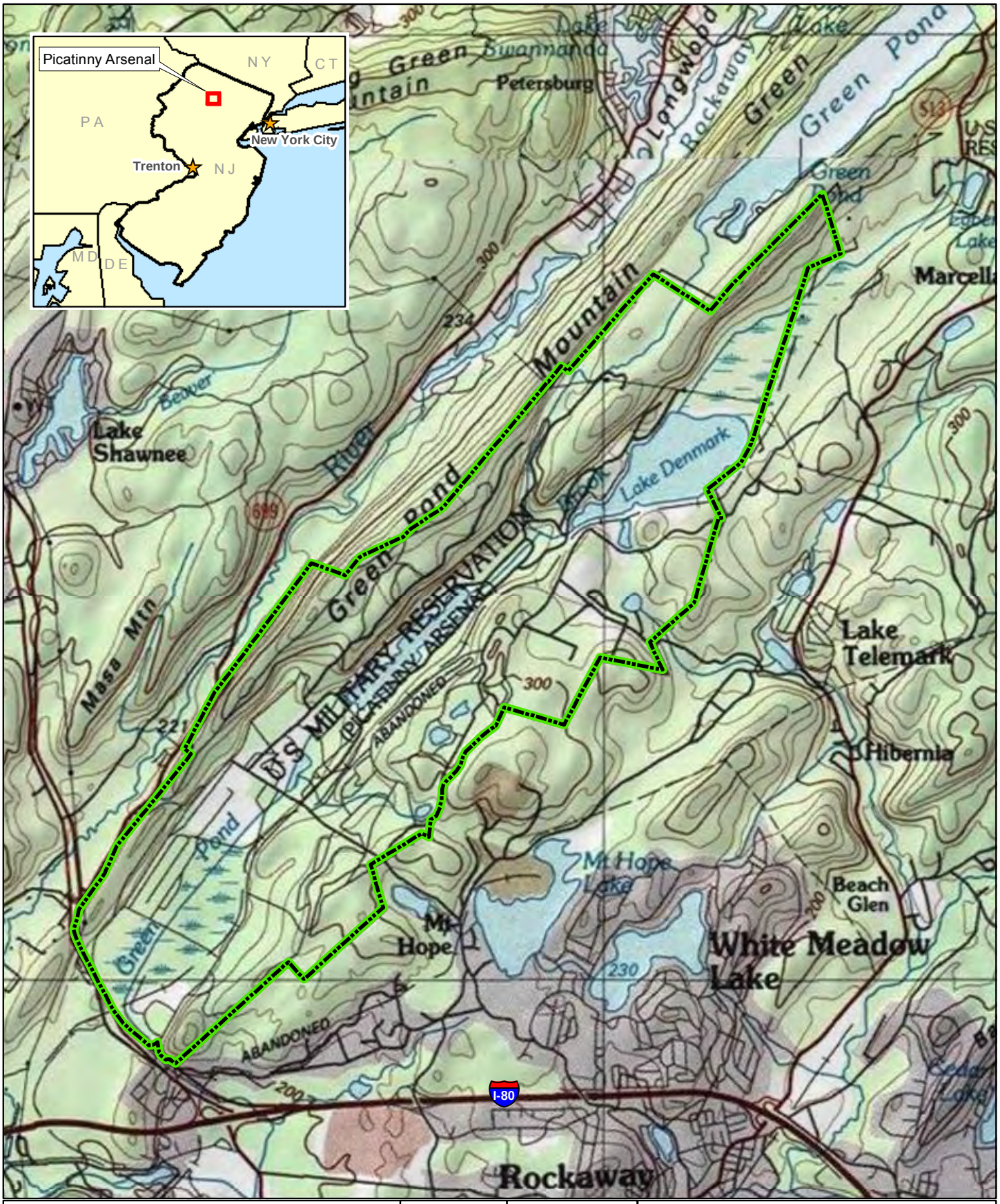
The RI Report is organized as follows:

- **Section 1.0: Introduction** – Presents the purpose of the project and report with a description of work authorization, an overview of the MRSs being addressed, and content of the report.
- **Section 2.0: Site Background –** Presents PTA and MRS historical information and a summary of previous investigations.
- **Section 3.0: Physical Setting –** Presents PTA and MRS-specific physical characteristics.
- **Section 4.0: Remedial Response Objectives –** Presents a discussion of the preliminary CSMs, project approach, preliminary remediation goals, data needs, and DQOs used to develop the RI.
- **Section 5.0: Characterization of Munitions and Explosives of Concern and Munitions Constituents –** Provides details on the approach, methods, and procedures used to characterize MEC and MC.
- **Section 6.0: Remedial Investigation Results and Revised Conceptual Site Models –** Presents the results of the RI and the updated CSM based on the additional information gathered during the RI**.**
- **Section 7.0: Munitions and Explosives of Concern Hazard Assessment and Munitions Response Site Prioritization Protocol –** Presents the assessment of human health and ecological hazards as a result of presence or potential presence of MEC.
- **Section 8.0: Contaminant Fate and Transport –** Presents a discussion of the fate and transport of MEC/MC in the environment.
- **Section 9.0: Risk Assessment for Munitions Constituents –** Presents the assessment of human health and ecological risks as a result of the presence of MC.

- **Section 10.0: Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements –** Presents a discussion of the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs).
- **Section 11.0: Summary and Conclusions–** Presents the RI summary and conclusions.
- **Section 12.0: References and Bibliography** – Provides a list of references used in preparing the RI Report.

Appendices included after the above sections are as follows:

- **Appendix A:** TPP and PAR Meeting Minutes
- **Appendix B:** IRP Site Locations and UXO Finds Maps
- **Appendix C:** Interviews
- **Appendix D:** Inactive Munitions Waste Pit MRS White Paper
- **Appendix E:** Soil Unit Descriptions
- **Appendix F:** DGM Data
- **Appendix G:** DGM Equipment and Procedures
- **Appendix H:** Dig Lists
- **Appendix I:** Photograph Log
- **Appendix J:** Munitions Debris DD Form 1348-1A
- **Appendix K:** Daily Reports
- **Appendix L:** CENAB Form 948
- **Appendix M:** MC Data
- **Appendix N:** SBG Technical Memo
- **Appendix O:** MEC HA
- **Appendix P:** MRSPP
- **Appendix Q:** Risk Assessment Supporting Tables



Legend

Installation Boundary

Data Source: ESRI, USGS Map Service
Coordinate System: UTM Zone 18N
Datum: NAD 83
Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N
0 3,000 Feet
0 590 1,180 1,770 Meters

Figure 1-1
Picatinny Arsenal Location
Morris County, New Jersey

6/5/2013

Contract # W912DR-09-D-0006
DO 0002

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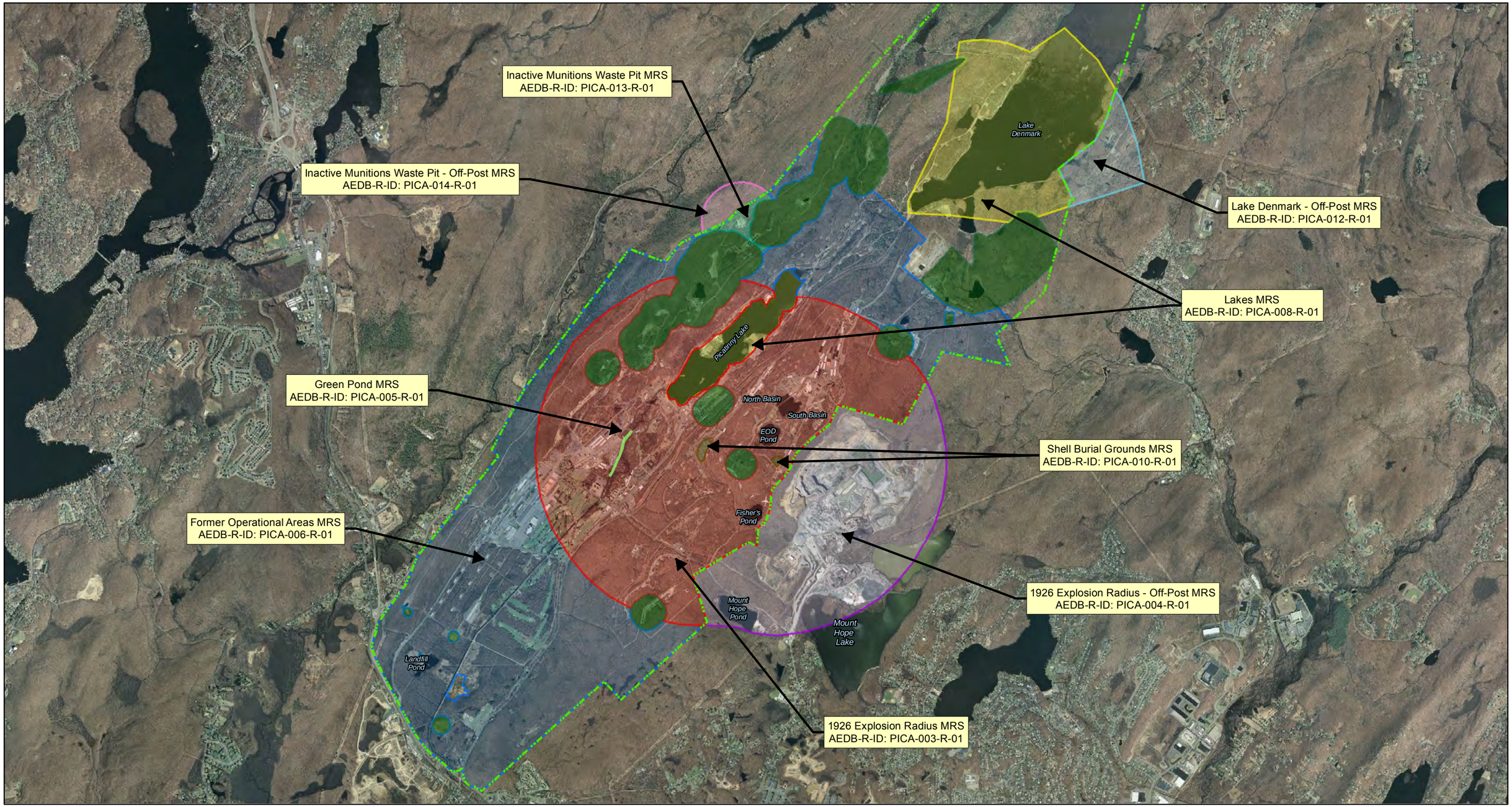

Legend

- Installation Boundary
- Operational Range Areas

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-2
Location of Munitions Response Sites

10/14/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\MRS_Loc.mxd

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- 1926 Explosion Radius MRS
- 2008 EE/CA Footprint
- Inner Radius Decision Unit
- Outer Radius Decision Unit

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 1,300 2,600 Feet

0 320 640 960 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-3
1926 Explosion Radius MRS
PICA-003-R-01

10/16/2013

Contract # W912DR-09-D-0006
DO 0002

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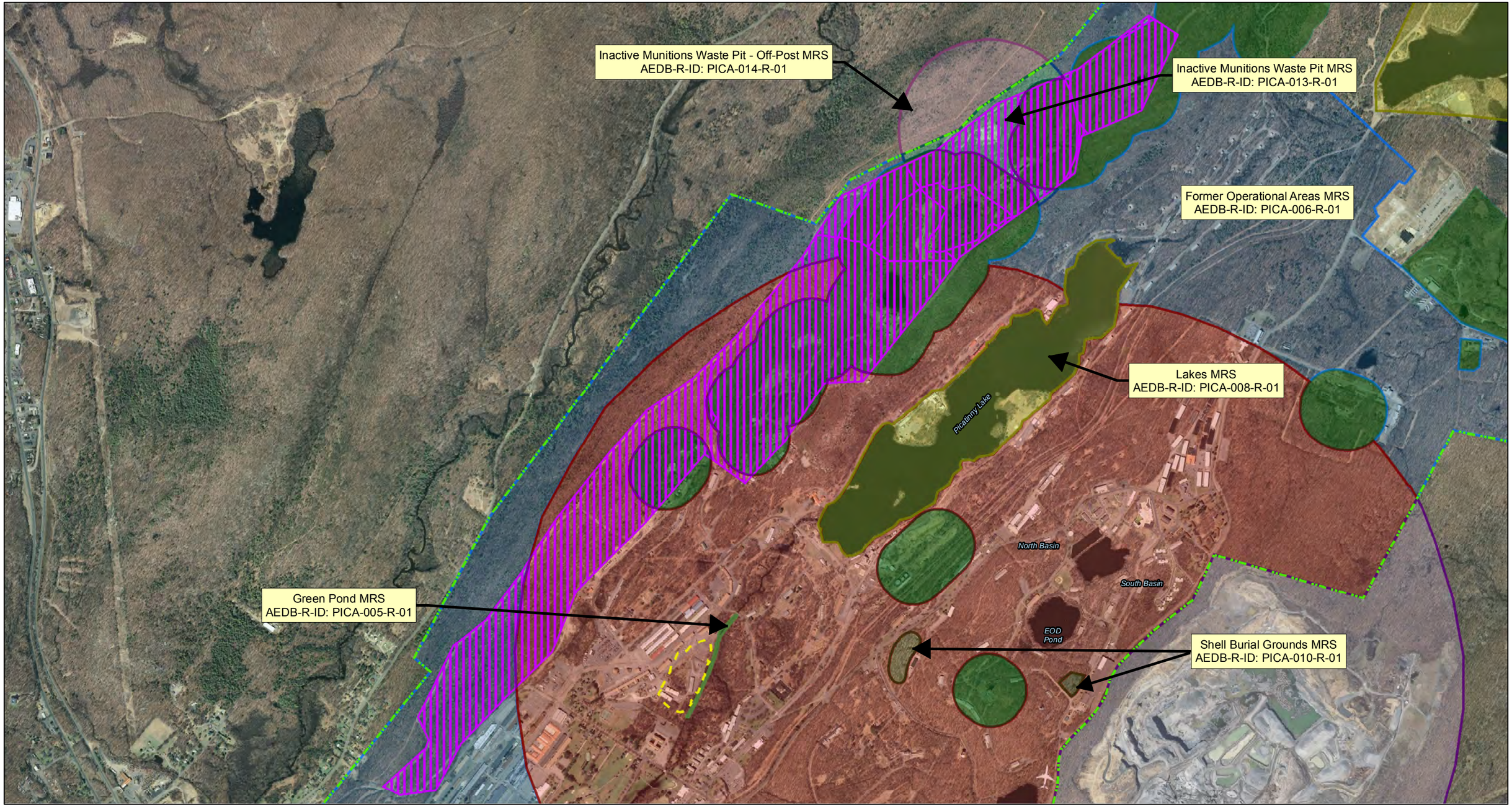


Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard
- Code 300 Area

Munitions Response Sites
- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 Feet

0 320 640 960 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-4
Location of the Code 300 Area

10/14/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Code300.mxd

Lakes MRS
Former Projectile Range
Picatinny Lake
Navy Hill Housing
Packing, Handling, Storage and Transportation Center
North Basin
South Basin
Ilac Realty, LLC
Green Pond MRS
Childcare Development Center
EOD Pond
Former DRMO Yard
Farley Avenue Housing
Green Pond Brook
Shell Burial Grounds MRS
Mount Hope Rock Products
Fisher's Pond
1926 Explosion Radius MRS
Fishers Pond Housing
K. Doland
1926 Explosion Radius - Off-Post MRS
AEDB-R-ID: PICA-004-R-01
Golf Course
Golf Course
Rockaway Township
Mount Hope Pond
Ilac Realty, LLC
Rockaway Township
Mount Hope Lake
Former Operational Areas MRS
Morris County
SMC-DAG, Inc.

Legend

- Installation Boundary
- Operational Range Areas
- Military Response Sites
- Munitions Response Site Boundaries
- 1926 Explosion Radius - Off-Post
- TCRA Boundary
- SI Survey
- Current Property Boundaries
- Inner Radius Decision Unit
- Outer Radius Decision Unit

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,300 2,600 Feet

0 320 640 960 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-5
1926 Explosion Radius - Off Post MRS
PICA-004-R-01

10/16/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\1926_explosion_radius_offpost.mxd

EOD Pond

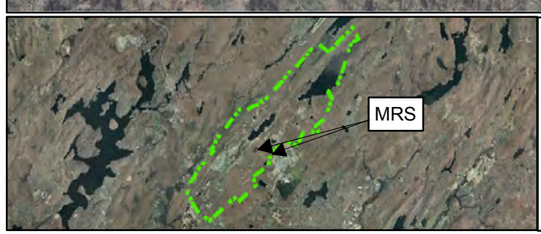
Bldg 3100

Bldg 3150

1926 Explosion Radius MRS

Shell Burial Grounds MRS
AEDB-R-ID: PICA-010-R-01

1926 Explosion Radius - Off-Post MRS



Legend

- Installation Boundary
- Operational Range Areas
- Shell Burial Grounds MRS

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 250 500 Feet

0 60 120 180 Meters

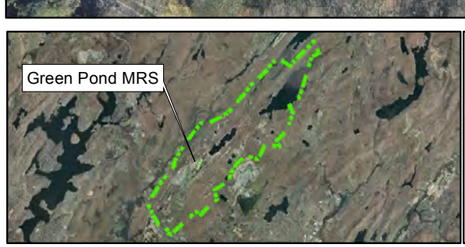
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-6
Shell Burial Grounds MRS
PICA-010-R-01

10/16/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds.mxd



Legend

- Installation Boundary
- Green Pond MRS
- Former DRMO Yard
- Asphalt Cover
- Time Critical Removal Action Footprint
- Soil Cover

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 200 400 Feet

0 70 140 Meters

Created By: CLR

Verified By: NAS

Approved By: RSS

Figure 1-7
Green Pond MRS
PICA-005-R-01

10/16/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Greenpond_DRMO_Yard.mxd

Lakes MRS

Lake Denmark

Lake Denmark - Off-Post MRS

Inactive Munitions Waste Pit MRS

Inactive Munitions Waste Pit - Off-Post MRS

Former Operational Areas MRS
AEDB-R-ID: PICA-006-R-01

Lakes MRS

Picatinny Lake

Green Pond MRS

North Basin

South Basin

EOD Pond

Shell Burial Grounds MRS

Fisher's Pond

Former Operational Areas MRS
AEDB-R-ID: PICA-006-R-01

1926 Explosion Radius MRS

1926 Explosion Radius - Off-Post MRS

Mount Hope Pond

Mount Hope Lake

Site 20/24

Historical Pyrotechnic Hazard Area

Waste Burial Area

Historical Flare Hazard Area

Dredge Piles

Former Sanitary Landfill

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest
- Former DRMO Yard
- Historical Range Fan
- Firing Point

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR

Verified By: NAS

Approved By: RSS

Figure 1-8
Former Operational Areas MRS
PICA-006-R-01

11/15/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA.mxd

Lakes MRS
AEDB-R-ID: PICA-008-R-01

Mortar Range
Impact Area

Lake
Denmark

Inactive Munitions Waste Pit MRS

Inactive Munitions Waste Pit -
Off-Post MRS

Lake Denmark - Off-Post MRS

Former Operational Areas MRS

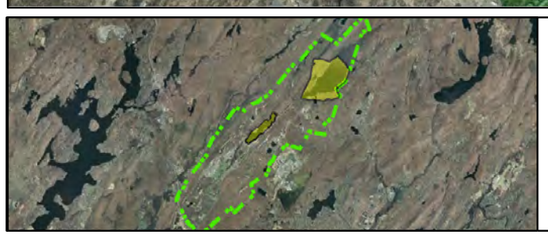
Lakes MRS
AEDB-R-ID: PICA-008-R-01

Picatinny Lake

1926 Explosion Radius MRS

North Basin

South Basin



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 1-9
Lakes MRS
PICA-008-R-01

N

0 750 1,500 2,250 3,000 Feet

0 520 1,040 Meters

Created By: CLR

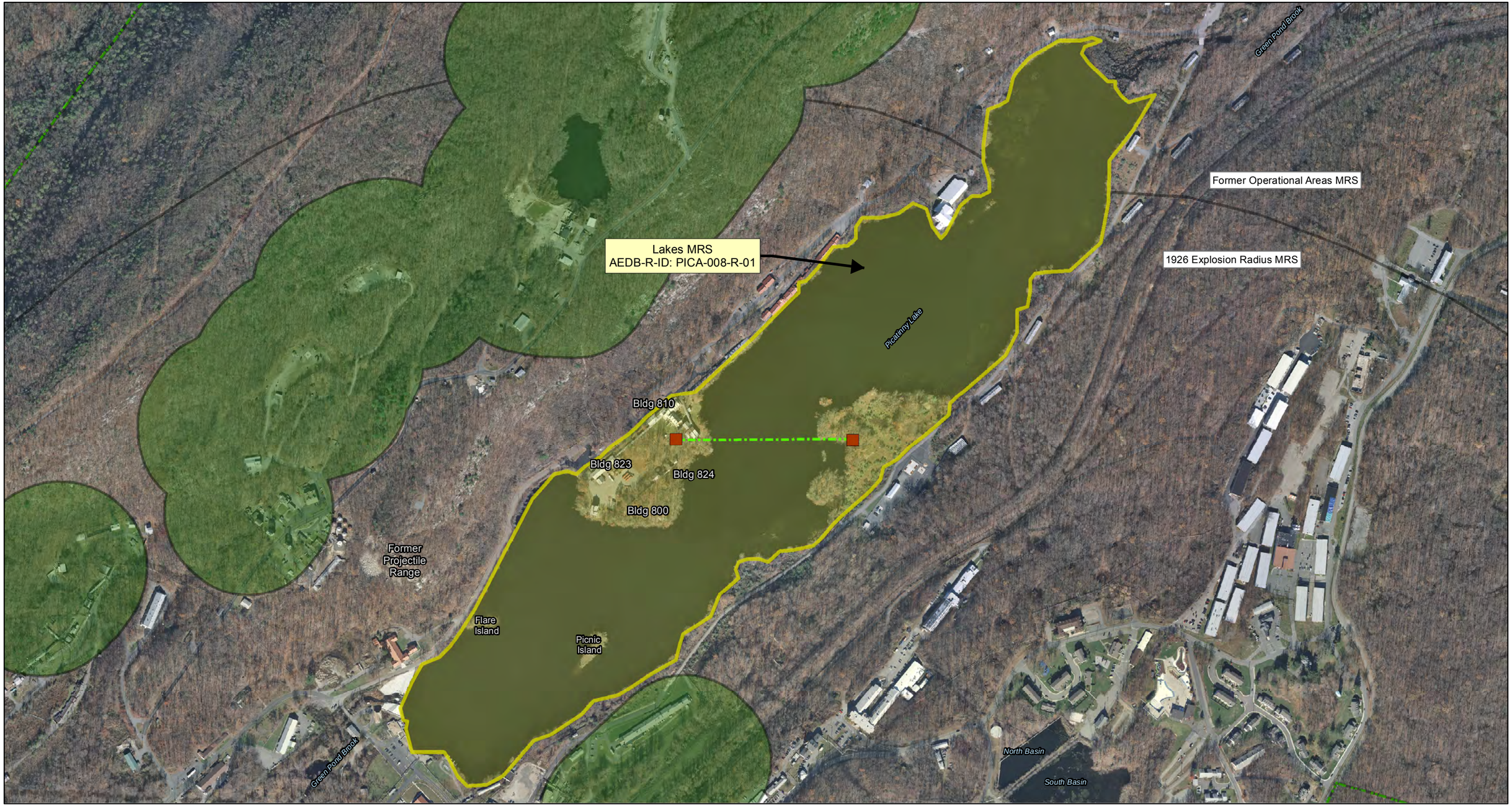
Verified By: NAS

Approved By: RSS

Date: 10/14/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lakes.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- 3-inch Barbette Gun Range
- Firing Point and Slug Butt

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 550 1,100 Feet

0 130 260 390 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

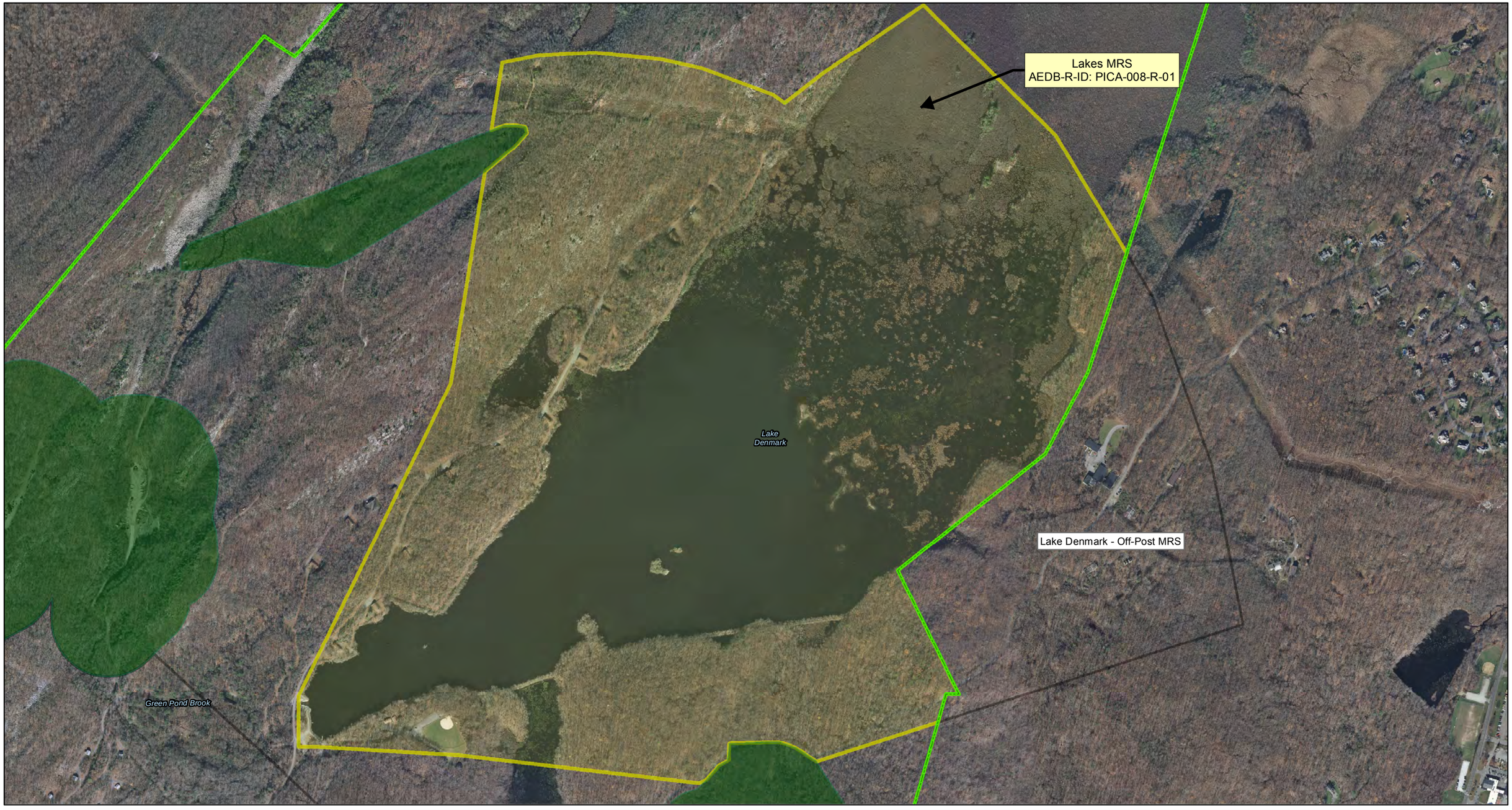
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-10
Lakes MRS -
Picatinny Lake Portion
PICA-008-R-01

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Picatinny_Lake.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 1-11
Lakes MRS -
Lake Denmark Portion
PICA-008-R-01

N

0 750 1,500 Feet

0 260 520 Meters

Created By: CLR

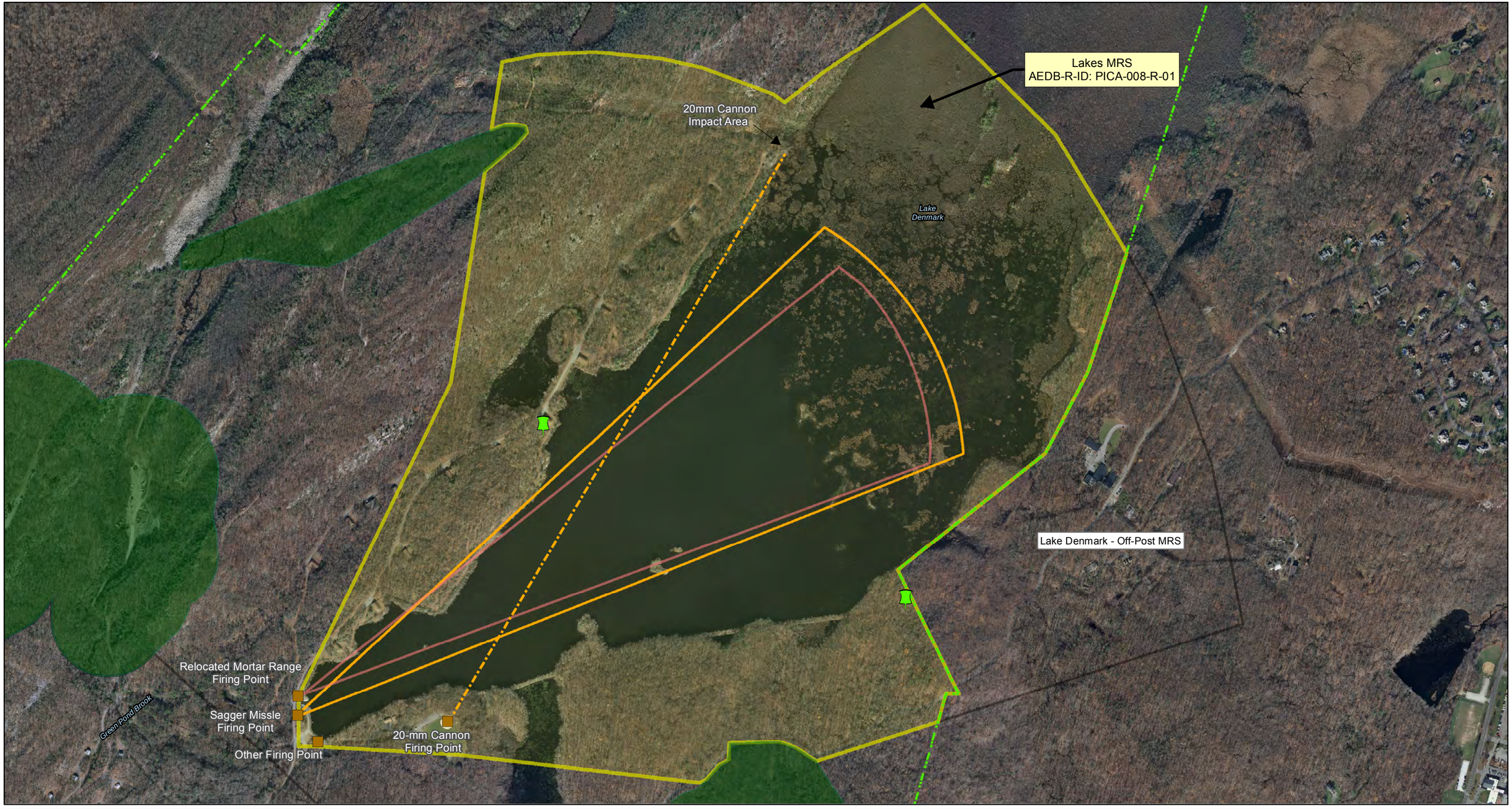
Verified By: NAS

Approved By: RSS

10/17/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Former Mortar Range Impact Area
- Sagger Missile Range Impact Area
- Firing Points
- Observation Points

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 750 1,500 Feet

0 260 520 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

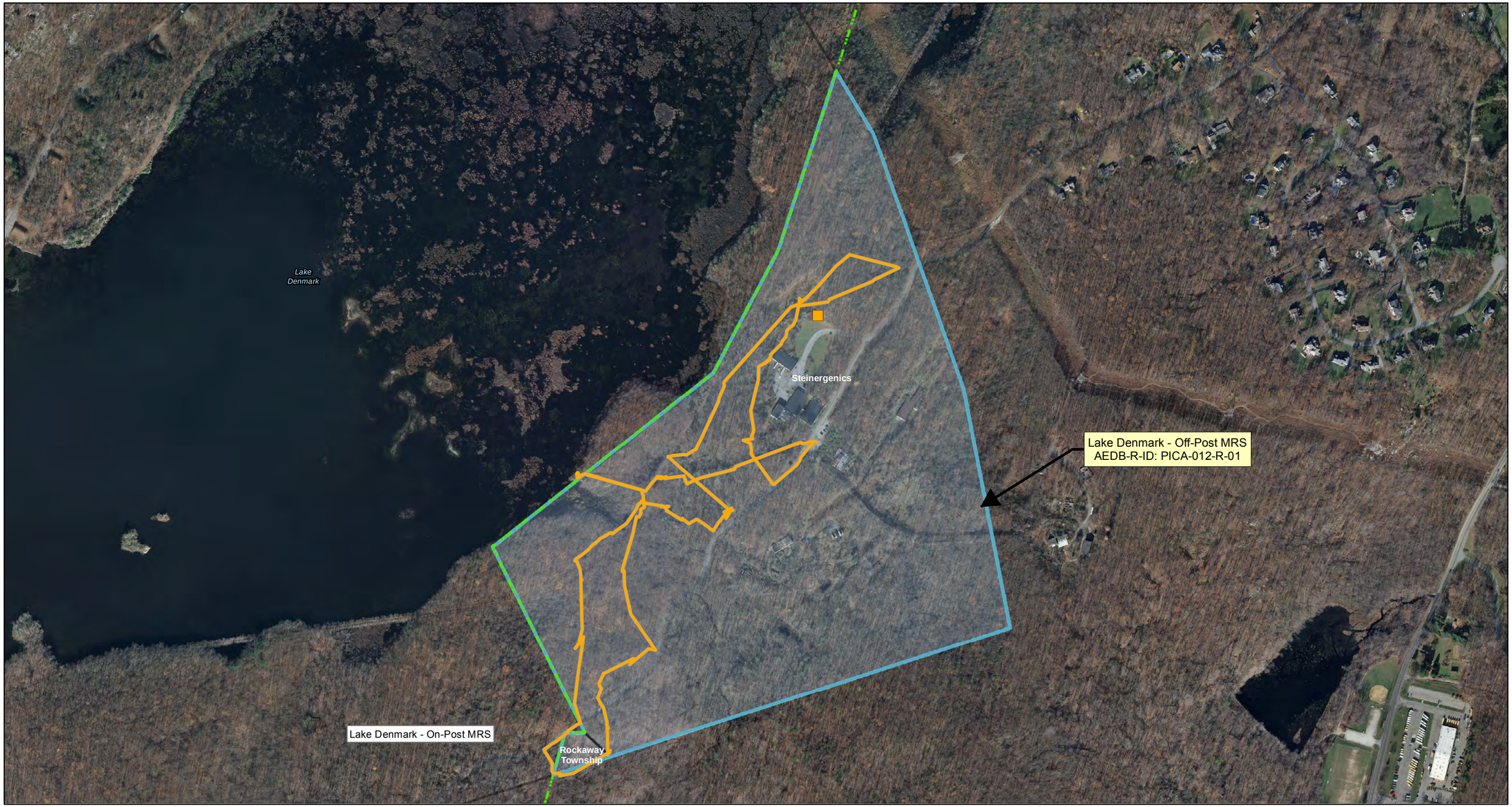
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-12
Lake Denmark Mortar Range
PICA-008-R-01

10/14/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_mortar_range.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lake Denmark Off-Post MRS
- Current Property Boundaries
- SI Survey
- Approximate location of a former drum disposal area

SOURCE:
Base Imagery: NJ 2010 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 500 1,000 Feet

0 175 350 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

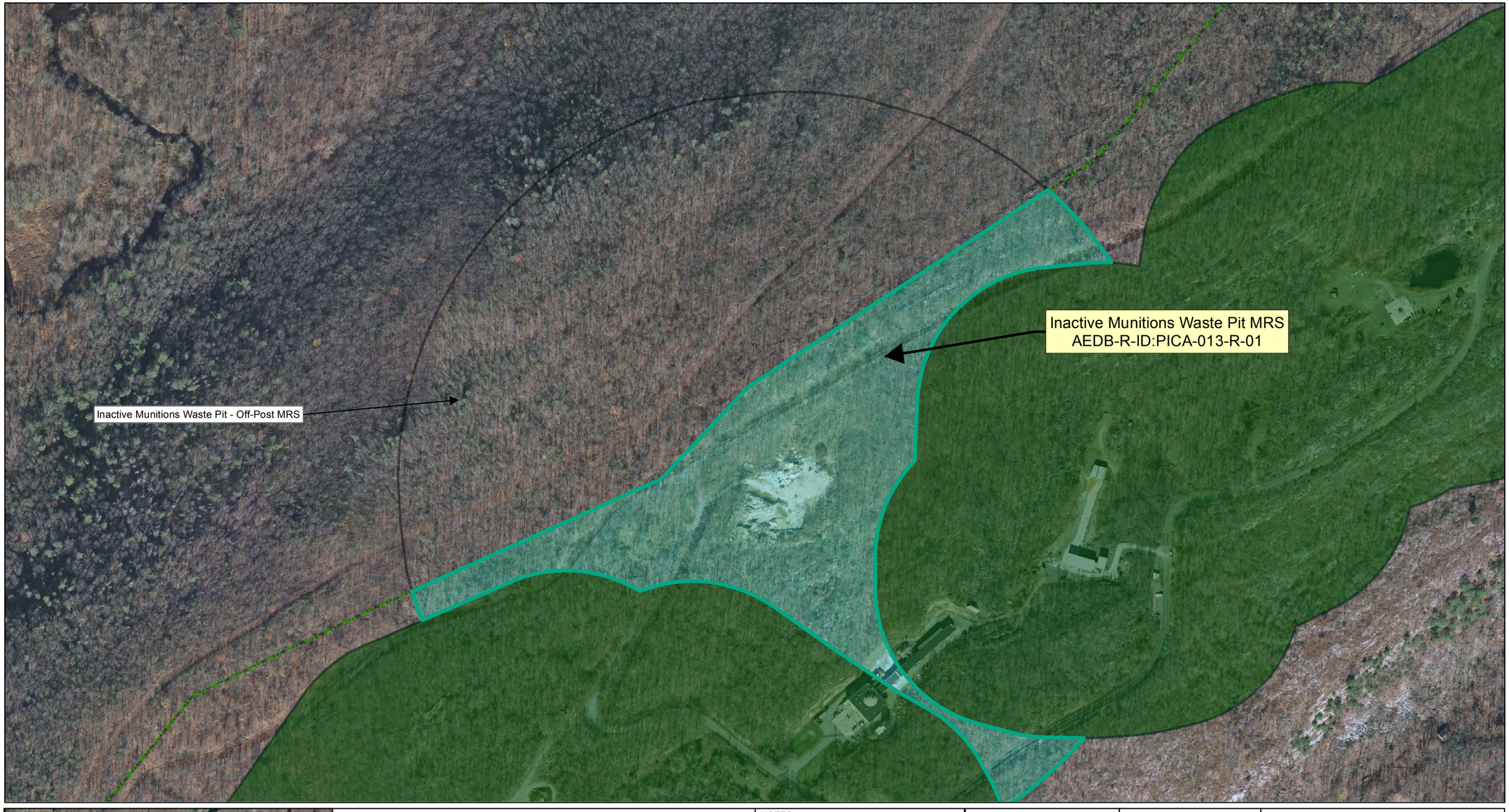
Figure 1-13
Lake Denmark - Off-Post MRS
PICA-012-R-01

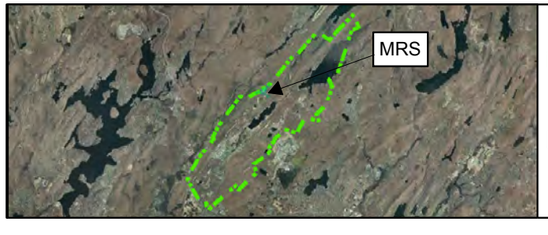
Created By: CLR
Verified By: NAS
Approved By: RSS

Date: 10/17/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_offpost.mxd





Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Inactive Munitions Waste Pit

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 300 600 Feet

0 70 140 210 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

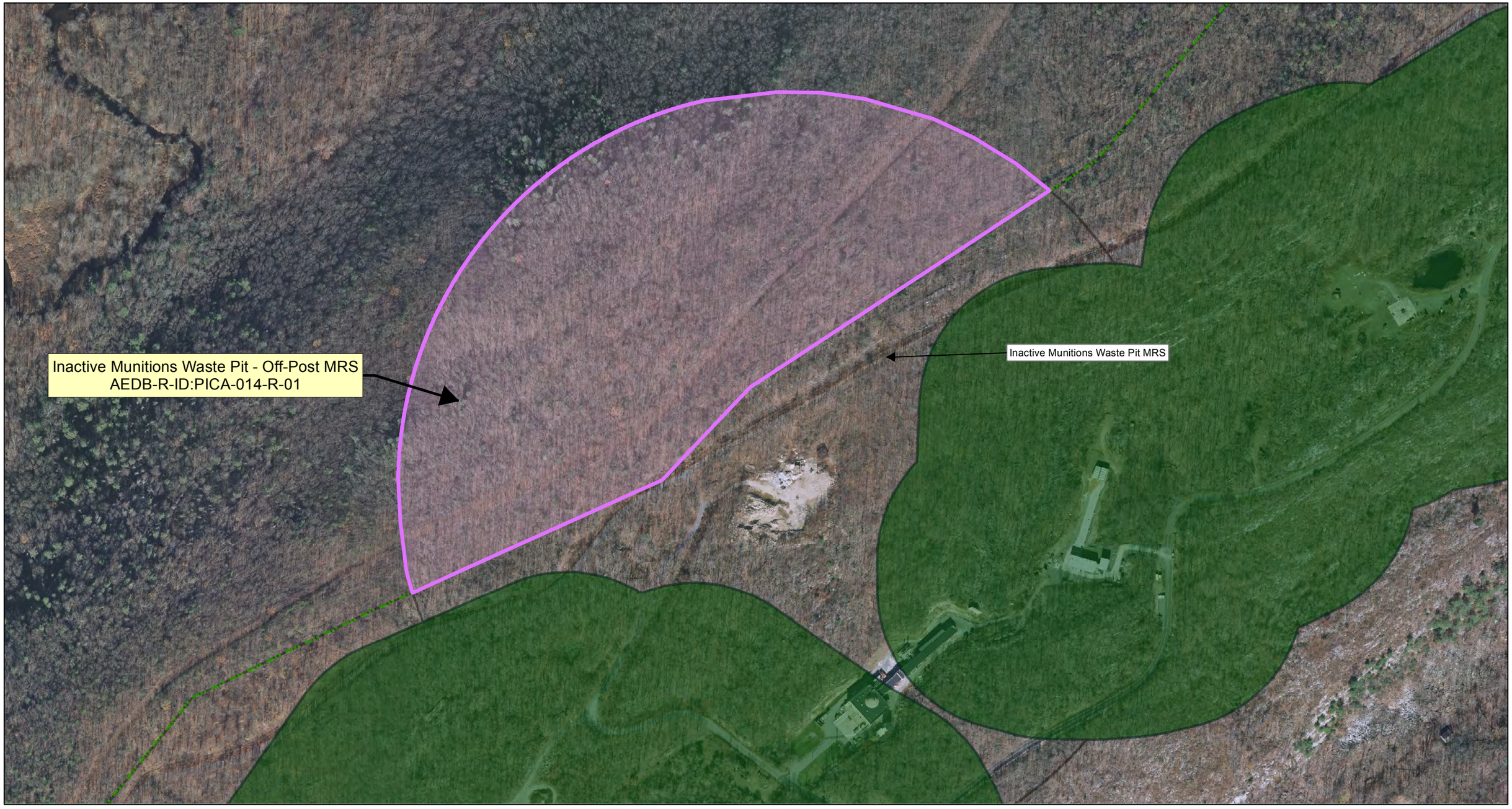
Figure 1-14
Inactive Munitions Waste Pit MRS
PICA-013-R-01

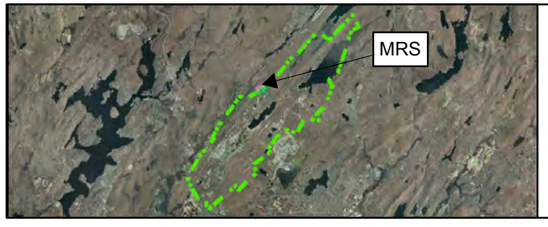
Created By: CLR
Verified By: NAS
Approved By: RSS

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP.mxd





Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Inactive Munitions Waste Pit - Off-Post

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 300 600 Feet

0 70 140 210 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 1-15
Inactive Munitions Waste Pit - Off-post MRS
PICA-014-R-01

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP_offpost.mxd

2. SITE BACKGROUND

Section 2 presents a brief discussion of the operational history of PTA and each MRS as well as any relevant previous investigations and removal actions conducted in each MRS.

2.1 PICATINNY ARSENAL

2.1.1 Historical Information

Around 1750, two iron forges that manufactured ordnance items for the continental Army were located at the lakes. Historical records indicate that in 1773 the continental congress contracted with the forges to produce materials for the Army, including iron cannonballs and other munitions. In 1880, what is known today as Picatinny Arsenal was established as Picatinny Powder Depot. Assembly of powder charges for cannons to support the Spanish-American War began by the 1890s. Also during this time, the Navy established the Lake Denmark Powder Depot, later known as Lake Denmark Naval Ammunition Depot, adjacent to the Picatinny Powder Depot. The Navy used the property for storage of explosives, powder, and projectiles from the 1880s to 1960. In 1907, the Army changed the name of Powder Depot to Picatinny Arsenal and began to expand its role from that of storage facility to include the manufacture of smokeless powder and propellants. Manufacturing continued and at the height of World War I (WWI), storage and manufacturing facilities were added. Melt-loading projectiles were produced, 2,4,6-trinitrotoluene (TNT) was loaded into bombs, and the experimental manufacture of high explosive (HE) fuzes and metal components was begun.

In 1926, lightning set off a series of storage magazine explosions at the Lake Denmark Naval Ammunition Depot that destroyed most of the depot and adjacent PTA and killed 18 people. Approximately 2.4 million pounds of explosives were detonated or burned. Unexploded shells and shell fragments were recovered up to ¾ mile to 1 mile away from the two explosion centers. PTA was rebuilt and by World War II (WWII), pyrotechnics and smokeless powder were being manufactured and loaded, bombs and projectiles were being loaded, and fixed ammunition larger than .50-caliber was being assembled. During WWII, PTA was the only facility in the U. S. capable of producing large amounts of explosives, bombs, and ammunition for the war. After WWII, PTA focused primarily on research and engineering of new munitions; however, production of munitions and explosives continued through the Korean and Vietnam Wars.

Between the Korean and Vietnam Wars, PTA contributed to the development of some nuclear weapons, including artillery shells and the "Davy Crockett Weapon System." PTA was also involved in the design of several different warheads.

The Army reacquired the Lake Denmark Naval Ammunition Depot land from the Navy in 1960, and the land was added to PTA's boundary.

Following the Vietnam War, R&D work on nuclear and non-nuclear weapons continued at PTA. R&D applications included artillery, infantry, vehicle, and aircraft weapons; demolition munitions; mines; bombs; grenades; pyrotechnic systems; rocket-assisted projectiles; flares; chemical systems and/or materials; and fuzes.

2.1.2 Previous Investigations and Removal Actions

Since 2003, several investigations and/or actions have been conducted under the MMRP at PTA and are discussed in the following applicable MRS subsections. Under the MMRP, an SI was conducted at PTA from 2007 through 2008 (Malcolm Pirnie, 2008). The SI provided recommendations for each MRS as to whether further investigation or studies for MEC and MC was warranted under CERCLA.

Numerous investigations and remedial activities to address non-munitions-related hazards under the IRP have been conducted and are ongoing across PTA. Relevant details from IRP activities that impact the MRSs are also discussed in this report although they are not the focus of RI activities being conducted at MRSs under the MMRP.

2.1.2.1 Ongoing Munitions Response and UXO Finds Map

Response to potential munitions-related material on PTA and off PTA (e.g., Mount Hope Quarry owned by Tilcon within the 1926 Explosion Radius – Off-Post MRS) has been handled by Explosive Ordnance Disposal (EOD) personnel. Additionally the PTA Safety Office maintained records and created a map of on-post recovered munitions-related material from 1986 through 1998. This map was designated as the "UXO Finds" map. The information from the UXO Finds map (which was discovered during the SI), usable data from EOD Incident Reports from 1998 through January 2013, data on or information about MEC recovered during TCRAs and EE/CAs and MEC identified during the RI have been compiled and are presented in **Appendix B**.

Originally historical finds were classified as UXO; however, after an analysis of the information provided for each find, many items were determined to actually be MD not UXO. These items were classified as "UXO Finds" to differentiate them from MEC identified during the RI, TCRAs and EE/CAs, and EOD incident reports). These changes are reflected on the map provided in **Appendix B.**

In addition to the EOD incident reports are the items identified in the Site Specific Final Report for the construction support conducted over a period ranging from April 2009 to December 2012. Four items (3 MEC items and 1 inert mortar) were located and turned over to PTA EOD for final disposition. Two MD items were located and turned over to the Life Cycle Supportability Division of PTA. One additional UXO item was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD (PIKA, 2014). The items identified during construction support are discussed further in the appropriate MRS sections and include the following items:

Item	Quantity	Date Identified	MRS
8-inch Projectile (DMM)	1	7/16/10	1926 Explosion Radius
81mm Mortar (Inert)	1	10/11/10	1926 Explosion Radius
60mm Mortar with Fuze (UXO)	1	12/8/10	Lake Denmark: Lakes MRS
60mm Mortar Fuze with Booster (UXO)	1	12/8/10	Lake Denmark: Lakes MRS
3-inch Brass Ball Empty (MD)	1	5/9/11	Lake Picatinny: Lakes MRS
75mm Cartridge Case M51A1 (MD)	1	10/10/11	Lake Picatinny: Lakes MRS
M302A1 60mm WP mortar and M527B1 fuze and WP filler (UXO)	1	6/13/11	Lake Denmark: Lakes MRS

2.2 1926 EXPLOSION RADIUS MRS

2.2.1 Historical Information

The Lake Denmark Naval Ammunition Depot, which was located on what is currently the eastern portion of PTA near Picatinny Lake, was used by the Navy from the late 1800s to the 1960s, mainly for storage of materials such as HEs, smokeless powder, black powder, and projectiles. Reportedly, the Navy property had between 160 and 200 buildings, and 40 to 50 of these were used for explosives storage. On July 10, 1926, during an electrical storm, lightning struck Temporary Magazine No. 8, then several minutes after the magazine exploded, Temporary Store House

No. 9 (approximately 150 feet in the clear) exploded, and a third explosion occurred at Shell Store House No. 22. According to a historical report, it was estimated that 2.4 million pounds of the following explosives detonated in the explosion[1]:

- TNT
- 25-pound Navy Mark I bombs, loaded, and plugged
- Mark II, III, IV, and V bombs, each loaded with TNT
- Bomb accessories (e.g., fins, tails)
- Aerial bombs, TNT center section
- 14-inch Class "B," loaded and fuzed
- 14-inch armor-piercing (AP) projectiles, loaded, and fuzed
- 8-inch shells, loaded, and fuzed
- 5-inch shells, loaded, and fuzed

In addition, explosive D (ammonium picrate or Dunnite) burned but did not detonate (Malcolm Pirnie, 2006; 2008). Nearly everything within a 3,000-foot radius of the explosion centers was burned or otherwise destroyed. Many of the buildings within the next 1,000 feet of the explosion centers were significantly damaged. Some minor damage, such as broken windows and bulging roofs, was also reported for buildings farther than 4,000 feet from the explosion centers. Unexploded shells were found up to ¾ mile from the explosion centers, and shell fragments were found up to 1 mile away (Picatinny Arsenal, 1931). Therefore, the explosion radius has been divided into an inner and outer radius (shown on **Figure 1-3** and **1-5**). The inner radius covers the area within 0.5 mile of the explosion centers. The outer radius encompasses the area from 0.5 to 1 mile of the explosion centers. Three large craters, two near the central portion of PTA and one near the eastern PTA boundary, were created in the explosion and were considered the explosion centers. The three craters are discussed in this RI report as the Shell Burial Grounds MRS (PICA-010-R-01).

In addition to the explosion, a separate potential MEC release mechanism is present for the Code 300 Area. According to DoD, *Executive Order 11508 Installation Survey Report, Picatinny Arsenal, Dover, New Jersey,* January 1973, in 1973 PTA had 975 acres of land on the northwestern portion of PTA used for the artillery firing of shells up to 155mm, as well as for fragmentation pattern testing. Although a large portion of the Code 300 Area is located within operational ranges, portions of it fall within the 1926 Explosion Radius MRS, Inactive Munitions

[1] Although not listed in the historical documents, 3-, 4-, and 6-inch common projectiles are also associated with the 1926 explosion. These MEC have been found off-post at Mount Hope Quarry either by the quarry workers during quarry operations or during time-critical removal actions (TCRAs) conducted at the Mount Hope Quarry.

Waste Pit MRS, and the Former Operational Areas MRS. The firing point and target area are not discussed in the 1973 report, and no other information is currently available regarding this area.

2.2.2 Previous Investigations and Response Actions

2.2.2.1 Site Inspection

SI field work was not performed within the pre-SI configuration of the 1926 Explosion Radius MRS as the presence of MEC had already been documented through a variety of sources and historical information, including data from IRP sites that overlap the boundary of this MRS, were determined sufficient to confirm the presence of potential MC hazards. However, a former projectile range was identified as a stand-alone MRS as a result of the HRR and incorporated into the 1926 Explosion Radius MRS during the SI. The former projectile range was less than 1 acre in size and consisted of a covered firing point and a slug butt. Although no information is available to indicate the specific types of munitions used on the former projectile range, based on the size and configuration of the range (i.e., it is a short range with a stationary firing point and target), it is assumed that the range was used only to conduct impact testing of 20mm, 37mm, and 40mm inert projectiles. A visual survey of the former projectile range was planned, the range was inaccessible during the SI and the field crew conducted the survey around the perimeter of the range instead. A visual survey for MEC was conducted over approximately 0.45 acres around the perimeter of the former range. During the survey, no MEC was identified; however, MD, including expended trip flares, flare brackets, and flare levers (spoons), were observed at two locations (Malcolm Pirnie, 2008). It was later determined that the MD found were not associated with the 1926 explosion.

During the SI within the 1926 Explosion Radius MRS, two composite and two grab soil samples were collected from biased locations adjacent to the MD and analyzed for copper, lead, iron, zinc, and explosives. Biased samples are collected from the area that is most likely to have the highest levels of MC contamination. Therefore, one discrete soil sample was collected immediately under, or adjacent to MEC, where contamination was likely (e.g., visual staining, near crack/corrosion). The four metals were found at levels that exceeded site-specific background levels and screening levels.[2] No explosives were detected at concentrations greater

[2] For the SI, the screening levels used included New Jersey Department of Environmental Protection (NJDEP) Residential Soil Cleanup Criteria and Region 3 Non-Industrial Risk Based Criteria.

than laboratory reporting limits. Because the four soil samples were collected adjacent to MD that is not associated with the 1926 explosion, the sample results might not be representative of conditions in the 1926 Explosion Radius MRS.

Based on the results of the SI, it was recommended that an MMRP RI/FS for MEC and MC be conducted for the 1926 Explosion Radius MRS (inclusive of the former projectile range and former DRMO yard). As a result of overlapping IRP sites within the boundary of this MRS, IRP sites are included under the MMRP for MEC only. Refer to **Appendix B** for the locations of the IRP sites.

2.2.2.2 Engineering Evaluation/Cost Analysis

In 2008, an Engineering Evaluation/Cost Analysis (EE/CA) investigation and subsequent intrusive portion of the investigation for MEC, munitions potentially presenting an explosive hazard (MPPEH), and MD were conducted at six areas within the 1926 Explosion Radius MRS. This work was conducted because of the potential presence of MEC in construction area footprints. The six areas described below include three parcels within the construction footprint for the RCI Military Housing Project properties (Navy Hill, Fisher's Pond, and Farley Avenue) and the construction footprints for the Childcare Development Center (CDC), Electromagnetic Research Facility (ERF), and the Packaging, Handling, Storage, and Transportation Center (PHS&T):

- RCI Properties:
  - Navy Hill—Consists of approximately 45 acres and is located in the northeast portion of the MRS. At the time of the EE/CA, all three housing properties included residential and recreational areas.
  - Fisher's Pond—Consists of approximately 0.1 acre and is located in the southern portion of the MRS.
  - Farley Avenue—Consists of approximately 14 acres and is located in the western portion of the MRS.
- CDC—Was undeveloped land at the time of the EE/CA and consists of 5.2 acres near the center of the MRS.
- ERF—Was an asphalted parking lot and consists of approximately 0.22 acre in the eastern portion of the MRS.
- PHS&T—Consists of approximately 6 acres just south of Picatinny Lake near the center of the MRS. The PHS&T property was mainly an undeveloped grassy and wooded area; however, several buildings were present within the construction footprint.

As shown in **Table 2-1**, a total of 45 MEC items were found in four of the six areas included in the EE/CA and removal actions. MEC recovered included the following:

- MK 13 primer
- MK 10 base ignition fuze
- 3-inch MK 3 MOD 7 common projectile
- 6-inch MK 20 MOD 0 common projectile
- 5-inch MK 15 MOD 12 common projectile
- MK 3 base detonating (BD) fuze
- No. 45 P Direct Action Impact (DAI) fuze
- Practice BLU 36
- T46E4 bomb adapter booster

The majority of MEC found (43 of 45 items, or 96%) was determined to be associated with the 1926 explosion; however, two items, practice BLU 36 and T46E4 bomb adapter booster, were not associated with the 1926 explosion. MEC was recovered within 2 feet below ground surface (bgs), with the majority of items located within the top foot. In addition, approximately 6,380 pounds of MD and approximately 25,500 pounds of non-munitions related metal waste were also recovered. A limited number of pre- and post-blown-in-place (BIP) soil samples were collected from areas where MEC was found; no explosives were detected at concentrations greater than the laboratory detection limits (Malcolm Pirnie, 2010).

Table 2-1 Summary of EE/CA Results

Location*	Acreage	Number of MEC Found	Number of MEC Associated with 1926 Explosion	Average MEC Density (MEC/acre)	Maximum Depth of MEC Found
Navy Hill Housing	43	9	9	0.2	24 inches
Fisher's Pond	0.1	1	1	10	12 inches
Farley Avenue	14	0	0	0	NA
CDC	5.5	34	32	6.18	18 inches
ERF	1.0	1	1	1	18 inches
PHS&T	7.0	0	0	0	NA

* With the exception of the southern portion of the Navy Hill Housing and the CDC, the remainder of the areas investigated during the EE/CA are considered disturbed. All areas except Farley Avenue are located within the inner radius.

2.2.2.3 Construction Support

Construction Support was implemented at several locations within the 1926 Explosion Radius MRS over a time period ranging from April 2009 to December 2012. However, only two

munitions related items were identified, both during construction of the PHST building. On July 16, 2010 one DMM item, consisting of an 8-inch Projectile was identified, then on October 11, 2010 an MD item identified as an 81mm Inert Mortar. The item was classified as inert because it had the same physical features as an ordnance item but did not and never had contained energetic material. The items are shown in **Appendix B** and included in the results detailed in Section 6.

2.3 1926 EXPLOSION RADIUS – OFF-POST MRS

2.3.1 Historical Information

The 1926 Explosion Radius – Off-Post MRS is the off-post portion of the area that falls within a 1-mile radius of the centers of the 1926 Lake Denmark Naval Ammunition Depot explosion. See Section 2.2.1 for historical information.

2.3.2 Previous Investigations and Removal Actions

2.3.2.1 Time Critical Removal Action I

From December 2006 to March 2007, a Time Critical Removal Action (TCRA) was performed for 22.6 acres of the Mount Hope Quarry where Tilcon planned future quarrying activities. The purpose of the TCRA was to reduce the imminent safety hazard presented to the Mount Hope Quarry site employees due to the potential presence of MEC. The TCRA involved 100% coverage with digital geophysical mapping (DGM) surveys and intrusive investigations across the Mount Hope Quarry site. Altogether, 25 MEC items were recovered, which equates to 1.11 MEC/acre. In addition, 3,775 pounds of MD and non-munitions related debris and 1,583 pounds of non-munitions related scrap metal were recovered. MEC recovered included 5-inch and 6-inch projectiles (21 containing HE). All items were consistent with the munitions associated with the 1926 explosion. Items were found at the following depths: 14 items at less than 1 foot bgs; nine items between 1 to 2 feet bgs; and two items greater than 2 feet bgs (26 inches and 48 inches) (Malcolm Pirnie, 2008).

2.3.2.2 Site Inspection

A visual survey of approximately 15 acres was conducted during the SI, in areas surrounding the Mount Hope Quarry. No MEC or MD was identified during the visual survey. No MC investigation activities were conducted at the 1926 Explosion Radius – Off-Post MRS during the SI because the existing historical information was determined sufficient to confirm the potential presence of MC.

Based on the results of the SI, it was recommended that an MMRP RI/FS for MEC and MC be conducted for the 1926 Explosion Radius – Off-Post MRS. As a result of observations made during the SI field work, an accelerated response action was not recommended for the majority of this MRS. However, based on MD findings made at Mount Hope Quarry after the completion of TCRA I, an accelerated response action was recommended for any areas to be quarried in the future and fall outside the original TCRA area (Malcolm Pirnie, 2008).

2.3.2.3 Time Critical Removal Action II

From May 2008 to June 2008, the TCRA II was performed for an additional 22 acres within the quarry. The MEC investigation involved mag and dig operations over 100% of the Mount Hope Quarry site. No MEC was located during the TCRA II; however, approximately 600 pounds (131 items) of MD and 1,581 pounds of scrap metal were recovered (Malcolm Pirnie, 2009).

2.3.2.4 Time Critical Removal Action III

The TCRA III was conducted in phases from December 2009 to March 2011. The TCRA III consisted of the following:

- Conducted removal and clearance in December 2009 of a soil pile created by Tilcon Quarry as part of the quarrying process.
- Completed soil pile removal and conducted a removal action beneath the pile from January to March 2010.
- Conducted a removal action of 2.6 acres of native soil (outside of the soil pile footprint) in May and June 2010.
- Completed the native soil removal action (1.7 acres) between February and March 2011.

During the intrusive operations, 39 MEC items were recovered, which equates to 9.1 MEC/acre. MEC recovered included 4-, 5-, and 6-inch common projectiles and BD fuzes, which were consistent with the munitions associated with the 1926 explosion. In addition, approximately 6,400 pounds of MD and 1,300 pounds of scrap metal were recovered. MEC was typically found at less than 2 feet bgs.

2.4 SHELL BURIAL GROUNDS MRS

2.4.1 Historical Information

The Shell Burial Grounds MRS (PICA-010-R-01) consists of two large burial areas where three craters were formed from the 1926 Lake Denmark Naval Ammunition Depot explosion. Two of the three craters are so close they are considered a single site named the Shell Burial Grounds – West. This larger burial ground covers approximately 4.2 acres and is located in the southern half of PTA near Building 3100. The third crater, referred to as the Shell Burial Grounds – East, covers approximately 1.5 acres and is located near Building 3150. The Shell Burial Grounds MRS also overlap with the IRP Sites PICA-052/162.

The Shell Burial Grounds MRS were used for disposal of approximately 25 tons of explosives released during the 1926 explosion. The Shell Burial Grounds MRS were also used for disposal of material by the Navy until 1945, after which time the craters were backfilled and covered with up to 20 feet of fill material. Munitions disposed of at the Shell Burial Grounds MRS might include projectiles, mines, depth charges, fuzes, explosives, small arms ammunition, propellants, and possibly rocket fuels (Malcolm Pirnie, 2006). It was also reported in the 1981 Installation Action Plan (IAP) that the MRS potentially contained acids, pickling liquors, cyanide, and phenol (Malcolm Pirnie, 2008). No records of the types of materials or amounts of material disposed of in the burial grounds were maintained. Currently, Institutional Controls (ICs) (i.e., chain-link fencing with warning signs) restrict access to the Shell Burial Grounds MRS and demarcate what is thought to be the horizontal extent of the two noncontiguous burial areas. Engineering Controls (limited access) have been implemented at IRP Sites PICA-052/162 to address soil contamination. Groundwater will be addressed by the MidValley Groundwater Site (IRP Site PICA-204) (PTA, 2013).

2.4.2 Previous Investigations

2.4.2.1 1989 SI and the 1998-2000 RI

During the 1989 SI and the 1998-2000 RI, groundwater was also sampled and analyzed for volatile organic compounds, semi-volatile organic compounds, explosives, metals, and cyanide. Five of the RI wells were screened in the bedrock aquifer, and five were screened in the unconsolidated overburden. During three rounds of sampling of these wells, only cyanide and a volatile organic compound (tetrachloroethylene) were detected at levels above the level of

concern.

During the 1998-2000 RI for the Shell Burial Grounds, one surface soil and three subsurface soil samples were collected and analyzed for VOCs, SVOCs, explosives, metals, and cyanide. No contaminants were found at levels that exceeded the LOCs. It should be noted that, due to safety restrictions, these samples were collected from areas surrounding the shell burial area and not the site itself (Malcolm Pirnie, 2006).

2.4.2.2 Site Inspection

No field investigation activities were conducted during the SI as historical information was determined sufficient to confirm the potential presence of MEC and form the basis of recommendation to proceed to an MMRP RI/FS for MEC. MC is being addressed under IRP Site PICA-162 and is currently in the RI/FS phase (Malcolm Pirnie, 2008).

2.5 GREEN POND MRS AND FORMER DRMO YARD

2.5.1 Historical Information

During the 1930s and 1940s, Green Pond Brook was channelized and subsequently dredged in the early 1980s to alleviate drainage problems upstream. The Green Pond MRS is 1.1 acres and falls within the 1926 Explosion Radius MRS and was potentially impacted by the release of explosives that occurred during the 1926 explosion. The Green Pond MRS is also a portion of the IRP Site PICA-193. MEC has been found protruding from the banks of Green Pond Brook, although the source of the MEC is unknown. The UXO Finds map, detailed in Section 2.1.2.1, indicates a 66mm shell was found in Green Pond Brook near the 9th Street Bridge. As a result, the MRS was extended north to the 9th Street Bridge during the SI. However, as shown on the map and updated UXO Finds map table included in **Appendix B**, the 66mm shell was identified as empty and has been reclassified as MD. The Former DRMO Yard extends along the western boundary of the Green Pond MRS and is a potential source of MEC. In accordance with the ROD, signed July 2005, long-term chemical and biological monitoring has been implemented to address surface water and sediment contamination, at IRP Site PICA-193, which includes the portion enclosing the Green Pond MRS.

The Former DRMO Yard (IRP Site PICA-072) consists of 9.5 acres and is covered predominantly with asphalt and five buildings, Buildings 314 and 314 B-E. According to the

HRR, the area was believed to be a low-lying marsh area that was later filled with debris related to the 1926 explosion. The Former DRMO Yard was used primarily for the storage of waste, including materials resulting from the manufacture and testing of explosives, pyrotechnics, and munitions; transformers potentially containing PCBs; and vehicles, scrap metal, batteries, and construction debris. The HRR also indicated that flashed (exposed to a burst of intense heat that burns off any chemicals or explosives) and unflashed shells were reportedly located behind Building 314 in dumpsters. According to the HRR, buried UXO was discovered during the installation of a fence post in 1993. Subsequent investigation activities were performed at that time; however, the results and the locations of the activities are not known. Land use controls (LUCs) were implemented at the IRP Site PICA-072, in accordance with the ROD signed June 2009. To address surface water and sediment contamination, long-term chemical and biological monitoring has been implemented at IRP Site PICA-193 and groundwater monitoring will be incorporated into the Mid-Valley groundwater study (IRP Site PICA-204).

2.5.2 Previous Investigations and Response Actions

2.5.2.1 Site Inspection

No field investigation activities were conducted at the Green Pond MRS or Former DRMO Yard during the SI as historical information was determined sufficient following the HRR to warrant a recommendation of an RI/FS to characterize the nature and extent of MEC and recommend future actions as necessary. The original boundary of the Green Pond MRS was extended north as a result of information discovered in the HRR to account for the discovery of new information pertaining to the 66mm shell recovered from Green Pond Brook where it flows under the 9th Street Bridge. No MC sampling was conducted as MC is being addressed under the 2005 Record of Decision (ROD) for IRP Site PICA-193. The 2005 ROD issued under the IRP by EPA Region 2 requires chemical and biological monitoring for Green Pond Brook and establishes LUCs applicable to the Green Pond MRS

2.5.2.2 Former DRMO Yard Resource Conservation and Recovery Act Activities

In 1991, a Resource Conservation and Recovery Act (RCRA) closure investigation was performed on an asphalt area that was formerly used to store batteries. The asphalt area is adjacent to Building 314 where a RCRA closure investigation was performed on a room inside the building that formerly stored photographic film. Also in 1991, a RCRA closure verification

sampling event was conducted at Building 314-E to evaluate an area used for storage of discarded lead batteries and equipment. The RCRA closure report for all three investigated areas was approved by the NJDEP. In 1993 an investigation was conducted to evaluate the potential for contamination of soil and groundwater from metals, total petroleum hydrocarbon (TPH), benzene, toluene, ethylbenzene, xylene (BTEX), and polychlorinated biphenyls (PCBs). Polycyclic Aromatic Hydrocarbons (PAHs), metals, and PCBs were detected above levels of concern in soil, and metals were detected above levels of concern in groundwater. A follow-up investigation was conducted in 2000. Surface soil grid samples were collected for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, PCBs, dioxins, and explosives. Six AOCs were found based on exceedance levels of metals, PCBs, and PAHs. Soil contamination at this site is widespread and contains "hot-spots" of metals and PCBs. Additional sampling was conducted in 2001 to delineate PCB contamination adjacent to Building 314-D. Extensive PCB-contaminated soil was detected in the area. In addition, lead is deemed a concern at the site. The ROD was signed in June 2009. Completed in 2009, the selected action included excavation and off-site disposal of lead and PCB contaminated soil, on-site consolidation of PAH, Arsenic, PCB, and metal contaminated soil (RCRA nonhazardous), installation of an asphalt cap, soil cover, and implementation of LUCs (PTA, 2013).

2.5.2.3 Former DRMO Yard Time Critical Removal Action

In 2009, a TCRA was performed (under the MMRP for PICA-007-R-01 Former DRMO Yard) over a 0.5-acre area of the Former DRMO Yard to remove improved conventional munitions (ICM) and submunitions from surface and near surface soil. The TCRA included conducting a surface clearance at the Former DRMO Yard, the removal of trees and shrubs and the installation of a 2-foot-thick soil cover over the Former DRMO Yard. In total, 192 ICMs were disposed of by detonation and 282 MD items were removed as part of the TCRA. During implementation of the action, all ICMs were found to be inert and not filled with high explosives (ARCADIS, 2011).

2.6 FORMER OPERATIONAL AREAS MRS

2.6.1 Historical Information

The Former Operational Areas MRS was established after the HRR and discovery of the UXO Finds map. The SI concluded that this MRS covers approximately 1,977 acres and included most areas of PTA, with the exception of areas that are operational ranges, areas that have already been identified

as an MRS, and the northeastern portion of PTA. According to the UXO Finds map for PTA, there have been numerous munition-related items found throughout the entire Former Operational Areas MRS; however, it is unknown why these items are present. According to an Installation Survey Report, in 1973 PTA had 2,036 acres located throughout the portion of the PTA defined as the Former Operational Areas MRS (Malcolm Pirnie, 2008) that were used for R&D and testing. These areas were allocated as follows:

- Code 300 Area (975 acres) – Conducted artillery firing and fragmentation pattern testing, using projectiles of up to 155mm. (A portion of the original Code 300 Area consists of the AOI Code 300 Area)
- Rocket surveillance areas (624 acres) – Conducted static firing and surveillance of rockets under climatic conditions.
- Testing areas (51 acres) included some operational range areas – Conducted testing of mines, bombs, and bomblets under simulated tropical conditions; buried explosives to develop technology; and performed pyrotechnic testing in some testing areas.
- Quality Assurance (QA) inspection and nuclear component testing (13 acres) – Tested nuclear components and conducted QA inspections.
- Other areas (373 acres) included computer centers, areas used for live ammunition environmental testing, and areas for experiments with lead azide as well as other explosive components.

A Former Sanitary Landfill (13-acre IRP Site PICA-067/068) and a dredge pile on top of the former landfill are also included in the southern portion of the Former Operational Areas MRS and comprise the AOI Former Sanitary Landfill and Dredge Pile. Both areas have been historically reported as MEC disposal areas. According to several reports, munitions shells were disposed of in the sanitary landfill. Dredge spoils from Green Pond Brook, which was dredged as a result of the presence of munitions shells, were reportedly placed at the location of the dredge pile in the Former Operational Areas MRS. In interviews with PTA personnel and contractors, it was noted that MEC may have been identified during utility trenching operations in the landfill. An explosive, nitrocellulose, has been found in numerous soil and groundwater samples collected from both areas (Malcolm Pirnie, 2008). A soil cover was placed over the PAH contaminated soil at the IRP Site PICA-067/068, in accordance with the revised ROD, approved by the USEPA and signed in July 2007. Groundwater will be addressed under an area-wide action at PICA-206 including LUCs and monitoring (PTA, 2013).

A waste burial area (8.5-acre IRP Site PICA-093) is located at the southern end of the Former Operational Areas MRS and comprises the AOI Waste Burial Area. This burial area consists of undeveloped land in a low-lying wetland and was used as an unregulated disposal area. The exact years of operation are unknown; however, it is believed that extensive landfilling activities occurred in the 1960s and 1970s. During a site walk in January 1998, MD, identified as large projectiles, was observed in the AOI Waste Burial Area; no base plates or fuzes/nose plugs appeared to be installed on these projectiles. In addition, potential UXO consisting of 40mm grenades was found in trenches installed under the IRP (Malcolm Pirnie, 2008). LUCS consisting of ICs and Engineering Controls were implemented at the IRP Site PICA-093, in accordance with the ROD approved by USEPA and signed September 2007. Groundwater will be addressed under an area-wide action in PICA-206 (PTA, 2013).

Site 20/24 (28-acre IRP Site PICA-063/066) is located in the southwestern portion of the Former Operational Areas MRS between Phipps Road and Green Pond Brook and comprises the AOI Site 20/24. The AOI Site 20/24 is a former pyrotechnic testing area and includes a portion of a former mortar training area. A one-acre shallow pond in the central portion of AOI Site 20/24, called Landfill Pond, was used for dumping of miscellaneous waste and debris from the early 1960s through 1972 (IT Corporation, 2000b). Blocks of high explosives; burned and crushed flare bodies; 75mm, 105mm, and 155mm projectiles; and boosters and tailpieces of mortars were discovered during the 2002 investigation of the AOI Site 20/24. A soil cap was constructed in 2002 over those portions of the AOI identified as showing elevated levels of PCBs and lead. A smaller secondary cap was also placed over a nearby secondary area showing elevated levels of PCBs where munitions were found (Shaw, 2005a).

LUCS were implemented at the IRP Site PICA-066, in accordance with the ROD, signed spring 2002. Also in accordance with the ROD, soils containing PCBs at concentrations over 297 mg/kg were excavated and disposed of off-site and a vegetated soil cover was completed in 2003. The wetlands that were destroyed by the capping were replaced with an enhanced wetland pursuant to the wetland permit-equivalent for the action. Cap maintenance and ICs will be maintained in accordance with the Land Use Control Implementation Plan (LUCIP) in the ROD. Groundwater at Site 20/24 (PICA-063/066) is being addressed in the IRP Site PICA-205 (Area B). The ROD to address groundwater was submitted to the regulators in June 2008. The first quarterly

amendment injection and monitoring was completed in September 2008. Amendment injections and monitoring have been ongoing since 2008 to decrease VOC concentrations (PTA, 2013).

Additionally during an interview conducted on 30 April, 2013 (included in **Appendix C**) a mortar range with three separate firing points and a target area near the safe haven in AOI Site 20/24 were identified (**Figure 1-8**). The munitions tested at the range were identified as consisting of 60mm and 81mm mortars with 120mm training rounds being fired from one of the firing points near the present day skeet range. Engineering controls were used to limit the length of firing due to an observation tower being present near the intersection of Horney Road and Phipps Road. The area was identified as a mortar range; therefore, it is assumed that the 120mm rounds were 120mm Practice Mortars.

2.6.2 Previous Investigations

2.6.2.1 Site Inspection

No field investigation activities were conducted during the SI because historical information provided justification for a recommendation to proceed to RI/FS for MEC, including MC, under the MMRP at the Former Operational Areas MRS without further investigation (Malcolm Pirnie, 2008).

2.7 LAKES MRS

The following subsections present information on Picatinny Lake and Lake Denmark, which comprise the Lakes MRS. Although the lakes are noncontiguous water bodies at PTA, they have been combined into one MRS as a result of the similarity in CSMs that have been developed for the lakes.

2.7.1 Historical Information

Picatinny Lake – A 3-inch projectile Barbette gun firing range, constructed between 1919 and 1922, was operated over Picatinny Lake until 1931 with a firing point located on the southeastern shore and a sand butt (i.e., impact area) located across the lake to the west, near Buildings 810 and 824 (Malcolm Pirnie, 2006). The firing range was most likely used for munitions testing and would have been located in a single fixed location. Historical reports document smokeless powder and explosives being stored underwater in the southern portion of the lake between 1910 and 1960 for protection from lightning, spontaneous ignition, and heat. Although pyrotechnic

and/or flare testing was conducted on Flare Island (a peninsula sometimes referred to historically as Whiley's Island), there is no historical documentation of former munitions testing on the other island located on Picatinny Lake, commonly known as Picnic Island. Several explosive-related accidents occurred in the back room of Building 800, which is located along the southwestern portion of the lake. These explosions could have potentially caused MEC releases into the lake. During IRP investigations, MEC was encountered during test pitting near several of the former production buildings along the southwestern portion of the lake (Malcolm Pirnie, 2008). There are also unconfirmed reports of munitions being fired over the lake into an operation range on the side of a hill. Munitions would then have the potential of rolling down the slope to enter the 1926 Explosion Radius MRS and Picatinny Lake portion of the Lakes MRS, and undershots could have landed within Picatinny Lake. The Lakes MRS layout and major features are shown on **Figure 1-10**.

Lake Denmark – Consists of a former mortar range used for experimental testing of 60mm and 81mm mortars, 4.2-inch inert mortars, and a 20mm cannon testing range. The Lake Denmark location and major features are provided on **Figure 1-11**. Based on a 1974 range map, the firing point for the former mortar range was located on the southwest end of the lake with the impact area located across the lake toward the northeast end of the lake (Malcolm Pirnie, 2006). The firing point for the former 20mm cannon testing range was located toward the southern end of the lake, near what is currently a softball field, with the target area toward the western shoreline on the north end of the Lake Denmark. The layouts of the former range and firing points (both abandoned and relocated firing points for the mortar range) are shown on the 1974 range map and presented on **Figure 1-12**. The MRS boundary was based on the mortar range shown on the above listed 1974 map as well as other historical maps and reports identified during the HRR. The 20mm cannon testing range was depicted on a 1947 PTA Division of Engineering drawing. The drawing indicated that a 20mm Cannon Testing Range fired across Lake Denmark toward an impact area located northeast of Building 1211 along the western shore of the lake. The firing point of the range was located on the southwestern side of Lake Denmark, near the present day softball fields (Malcolm Pirnie, 2006). In addition, historical records indicate that munitions and/or material from the 1926 explosion might have been disposed along the western shoreline (IT Corporation, 2001).

Additionally during an interview conducted on 30 April, 2013 (included in **Appendix C**) a Sagger Missile Firing point was identified for the Lake Denmark Range (**Figure 1-12**). During the interview it was detailed that the missiles were designed to float once the motors were expended and the missiles were recovered using boats after each firing. Additionally two observations points, one on each side of Lake Denmark, from which installation personnel would observe/view the missile and mortar firing. The location of the observation points are shown on **Figure 1-12**.

2.7.2 Previous Investigations

2.7.2.1 Bathymetric and Magnetic Surveys

Bathymetric and magnetic surveys of Picatinny Lake were conducted in 1995. Bathymetric results provided lake depth information (shown on **Figure 2-1**). The depth of the lake ranges from an average of 5 feet on the north end to an average depth of 12 feet toward the dam and outfall in the southwestern end of Picatinny Lake. Results of the magnetic surveys, presented on **Figure 2-2,** identified approximately 125 underwater magnetic anomalies. The majority of the anomalies were located around the islands and along the shorelines (Blackhawk, 1995).

Geophysical surveys were conducted in 1999 and presented in a 2005 RI report for Lake Denmark that included media sampling (Shaw, 2005b). Several areas of potential metallic deposits and linear magnetic anomalous features were identified as a result of the geophysical survey. After a review of the existing geologic data and further analysis of individual magnetic profile data, the linear features were determined to be geologic in nature; however, these geologic features may mask the detection of metallic deposits. Therefore, it was recommended in the Final Geophysical Field Survey report that areas along the linear features be further investigated (Weston Geophysical Corporation, 1999). **Figure 2-3** shows the coverage and results from the geophysical survey conducted in the Lake Denmark portion of the Lakes MRS.

2.7.2.2 Site Inspection

No field investigation activities were conducted within either the Picatinny Lake or Lake Denmark portions of the Lakes MRS as historical information provided justification for a recommendation to proceed to RI/FS for MEC under the MMRP without further investigation. No MC sampling was conducted as MC is being addressed under the IRP Sites PICA-057 and PICA-015 (Malcolm Pirnie, 2008). Refer to **Appendix B** for the IRP locations and descriptions.

2.7.2.3 USACE Analog Geophysical Survey

In 2010, both Picatinny Lake and Lake Denmark were drawn down several feet to facilitate construction activities on the dams. During this time USACE conducted a limited visual and/or analog survey, where possible, along the edges of the lakes. Several MD items were recovered on Flare Island at Picatinny Lake, as well as a 60mm white phosphorus (WP) mortar along the shore of Lake Denmark.

2.7.2.4 *IRP Investigations*

A majority of the buildings and several locations along the shores of Picatinny Lake were investigated under the IRP. During test pit installation, rocket-motor-housing sleeves (potential of explosive residue) and fins were found near former Building 565. BD fuzes and other MEC were reportedly found near Building 823 (Malcolm Pirnie, 2006).

2.7.2.5 PSE&G Power Line Right-of-Way

From December 2012 through January 2013, two UXO consisting of 60mm Mortars (one was inert with a PD fuze and the other HE) were identified by REMTEC, one on the western side of Lake Denmark and one on the eastern side of the lake, outside the MRS but near the northern MRS boundary, as work was being conducted along the Public Service Electric and Gas (PSE&G) electrical tower right-of-way. The mortar locations are shown on **Figure 2-4.**

2.7.2.6 Construction Support

Construction Support was implemented at several locations within the Lakes MRS over a time period ranging from April 2009 to December 2012, including upgrades to Picatinny Dam and Lake Denmark Dam. A total of five munitions related items were identified, three UXO at Lake Denmark and two MD at Picatinny Lake. On December 8, 2010 two UXO items were identified during upgrades at the Denmark dam, consisting of a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an M302A1 60mm WP mortar and M527B1 fuze and WP filler. The 60mm WP mortar was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD. Two MD items were identified at Picatinny Lake during upgrades at the Picatinny Dam; a 3-inch Empty Brass Ball was identified on May 9, 2011 and a M51A1 75 mm Cartridge Case was identified on October 10, 2011. The items are shown in **Appendix B** and included in

the results detailed in Section 6.

2.8 LAKE DENMARK – OFF-POST MRS

2.8.1 Historical Information

Testing at the former mortar range on PTA within the on-post portion of the Lake Denmark portion of the Lakes MRS might have contributed to MEC (specifically 60mm and 81mm mortars) being fired into the Lake Denmark – Off-Post MRS. The 4.2-inch mortars were considered inert and therefore could not have contributed MEC, and an explosive hazard, being in the MRS. The MRS boundary overlaps the adjacent RTI Superfund Site, which was used for testing and development of rocket engines and propellants; however, this historical information related to RTI Superfund Site is not the focus of the PTA RI.

2.8.2 Previous Investigations

2.8.2.1 Site Inspection

Visual surveys were conducted over 4.75 acres of the Lake Denmark – Off-Post MRS during the SI. No MEC or MD was observed. No MC sampling was conducted as historical information was determined sufficient to confirm the presence of MC. It was recommended in the SI that the Lake Denmark – Off-Post MRS proceed to a RI/FS under the MMRP for MEC, including MC (Malcolm Pirnie, 2008).

2.8.2.2 RTI Superfund Site

Based on a 2010 RI Report, there have been several investigations at the RTI Superfund Site since 1987. The 2010 RI Report also stated no energetic compounds were identified as constituents of potential concern (COPCs). Perchlorate, a COC associated with RTI, has been found in groundwater; however, the wide distribution and low concentrations of perchlorate suggest that there are no significant source areas remaining. According to the 2010 RI report, there is a waste and/or drum disposal area located in the northern portion of the Lake Denmark – Off-Post MRS (CRA, 2010). In 2008, 32 test pits were completed at this disposal area and no MEC observed. According to the 2010 RI Report, numerous surface assessments and soil borings were completed within the Lake Denmark – Off-Post MRS with no MEC observed. The sample locations and the locations of previous surveys and/or assessments conducted in the Lake Denmark – Off-Post MRS are provided on **Figure 2-4**.

2.9 INACTIVE MUNITIONS WASTE PIT MRS

2.9.1 Historical Information

The Inactive Munitions Waste Pit MRS testing area was reportedly used from 1955 to the mid-1980s for testing and storage of munitions and explosives. Limited historical information is available for Inactive Munitions Waste Pit MRS; however, two main reports, a 2006 IAP and 1989 SI, have been discovered that provide the basis for the Inactive Munitions Waste Pit MRS description and site history. The 2006 IAP Report states that the area was used for evaluating munitions; whereas, the 1989 SI Report states that the area was used for static testing of explosives and propellants (Malcolm Pirnie, 2006). Although the Inactive Munitions Waste Pit MRS name suggests that materials might have been buried in pits, there was no site feature or other evidence in either historical report indicating that burial of munitions took place in the area. Additionally, the 2006 IAP Report indicates that collected anecdotal information shows that after 1965, all material generated from munitions testing was removed and transported to the Picatinny Burning Ground.

Historical records and aerial photography also indicate that the potential testing area in the center of the Inactive Munitions Waste Pit MRS was filled with up to 12 feet of sand, gravel, and rock during the 1980s and 1990s (Malcolm Pirnie, 2006). The fill work has most likely obscured any surface signs of former use as a disposal or burial area. It was also reported that metal objects have been found partially buried at the Inactive Munitions Waste Pit MRS, but none of the objects identified constituted MEC or munitions debris (Malcolm Pirnie, 2006).

Additional historical research was performed as part of the RI during work plan development for the MRS because of recent IRP studies and their findings of DMM, consisting of a CDU-10/B gravel mine canister and numerous MD. The IRP studies included a follow-on investigation and FS addendum for the PTA 600 Area groundwater operable unit, also known as PICA-58. The IRP studies addressed areas associated with the 600 Area Groundwater Plume. Part of the additional research included historical aerial photograph analysis as well as meeting with the IRP contractor to discuss their findings.

Based on the aerial photographs included in the Inactive Munitions Waste Pit MRS White Paper in **Appendix D** it appears that initial clearing (disturbance) and construction of the former testing area was performed between 1957 and 1963. The 1963 aerial photograph shows that native

vegetation was removed and the area was leveled with fill. A burn cage is shown in the center of the cleared area. In a 1970 aerial photograph, the burn cage is shown relocated approximately 125 feet to the east and additional land to the south is disturbed. A 1979 aerial photograph indicates the presence of berms that might be demolition pits or burial locations, and the first appearance of Building 656. Building 656 was not evident in the 2002 aerial photograph, and large amounts of fill material are evident at the former testing area. Fill material, large boulders, and construction debris continue to be placed in the former testing area of the Inactive Munitions Waste Pit MRS.

Observations from aerial photographs show that the former testing area has been used as a disposal site for the last 40 years. Layers of fill and debris have been stacked at the former testing area and periodically leveled since the early 1960s. Recent intrusive work shows that debris is scattered throughout the former testing area. Although MD has been recovered, the MEC density has been found to be low, consisting of only one DMM (CDU-10/B gravel mine canister). The boundary of the former testing area is clearly defined by the aerial photographs. Overall cultural debris, munitions debris, and MEC have been found to be intermixed throughout the entire former testing area.

Refer to **Appendix D,** Inactive Munitions Waste Pit MRS White Paper, for additional details and photographs regarding the results of the research.

2.9.2 Previous Investigations

2.9.2.1 Site Inspection at IRP Site 12

Under the IRP PTA SI program, four surface soil samples were collected at IRP Site 12; Munitions Waste Pit (Bldg 656). Two samples from the perimeter of the burn cage (current location) and two samples from areas of minor debris and observed disturbed soil were collected and analyzed for solid propellants, explosives, and metals (Dames and Moore, 1989). Two sediment samples were collected from a swampy area, downgradient of the fill material location. Analytical results indicated that concentrations of copper; cyclotrimethylenetrinitramine (RDX); nitroglycerine, 1,3-dinitrobenzene (1,3-DNB); and 2,4-dinitrotoluene 2,4-DNT in at least one sample were positively detected by the laboratory but there were no comparison criteria available at the time. (Dames & Moore, 1989). After a review of the aerial photographs and the date of sampling, it was determined that these samples were collected after fill had been placed at the

former testing area. Because the four soil samples were collected within fill and not native soil, the sample results might not be representative of conditions in the Inactive Munitions Waste Pit MRS.

2.9.2.2 Site Inspection

No field activities were conducted in the Inactive Munitions Waste Pit MRS during the MMRP SI as historical information provided justification for a recommendation to proceed to RI/FS for MEC, including MC, without further investigation.

2.9.2.3 Vapor Intrusion and Source Area Investigation

In 2011, Shaw Environmental, Inc. (Shaw) performed test pit/trench excavations in the center of the Inactive Munitions Waste Pit MRS as part of a follow-on investigation for the source of a trichloroethylene (TCE) plume (under an FS addendum for Site PICA-58) in the 600 Area Groundwater (Shaw, 2010). During the investigation, MEC identified as intact gravel mine canisters and numerous MD were recovered. The excavations were halted in 2011 because of safety concerns raised by the identification of the intact gravel mine canisters. Additional trenching was conducted by Shaw in 2012 and will be presented as part of the RI results in Section 6. The trenching activities were continued in 2012 with additional MD being identified (Shaw, 2013).

2.10 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

2.10.1 Historical Information

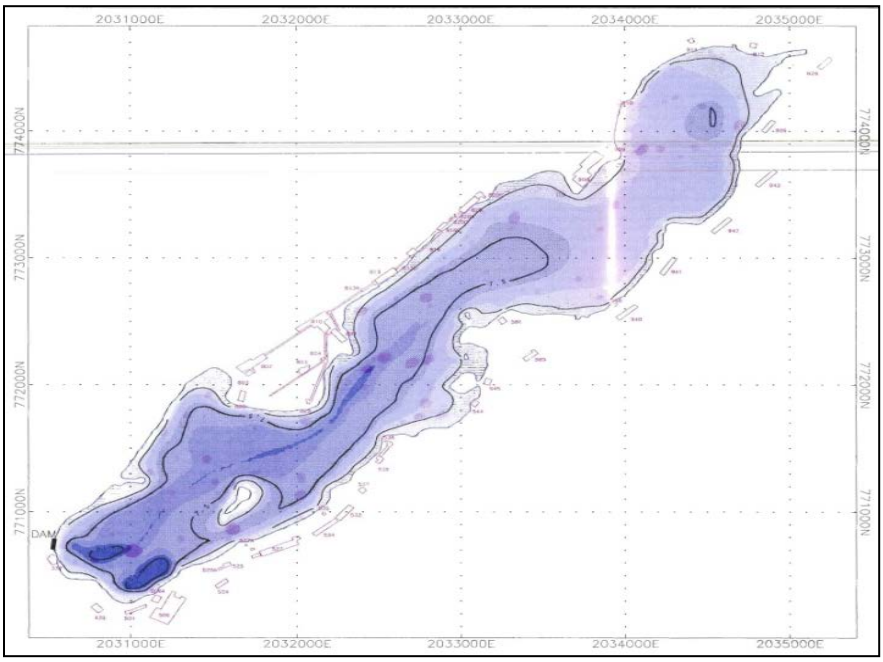
There is no historical documentation of munitions use at the Inactive Munitions Waste Pit – Off Post MRS. The MRS footprint falls within the 1,250 SDZ of the Inactive Munitions Waste Pit MRS on-post, but is a separate MRS because it is outside the PTA boundary.

2.10.2 Previous Investigations

2.10.2.1 Site Inspection

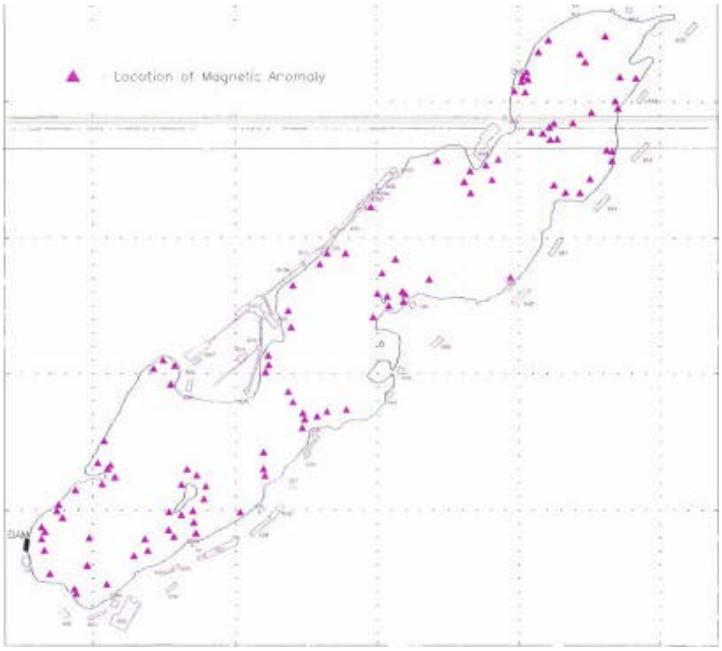
A limited visual survey was performed over 2.25 acres at the northern boundary (the top of the ridge on Green Pond Mountain) of the Inactive Munitions Waste Pit – Off Post MRS during the SI. No MEC or MD was observed and there were no structures or surface features identified that indicated the potential presence of a hazard. No MC sampling was conducted as part of the SI. It

was recommended in the SI that the Inactive Munitions Waste Pit – Off-Post MRS proceed to RI/FS for characterization of MEC and MC, based on the historical and SI information collected.



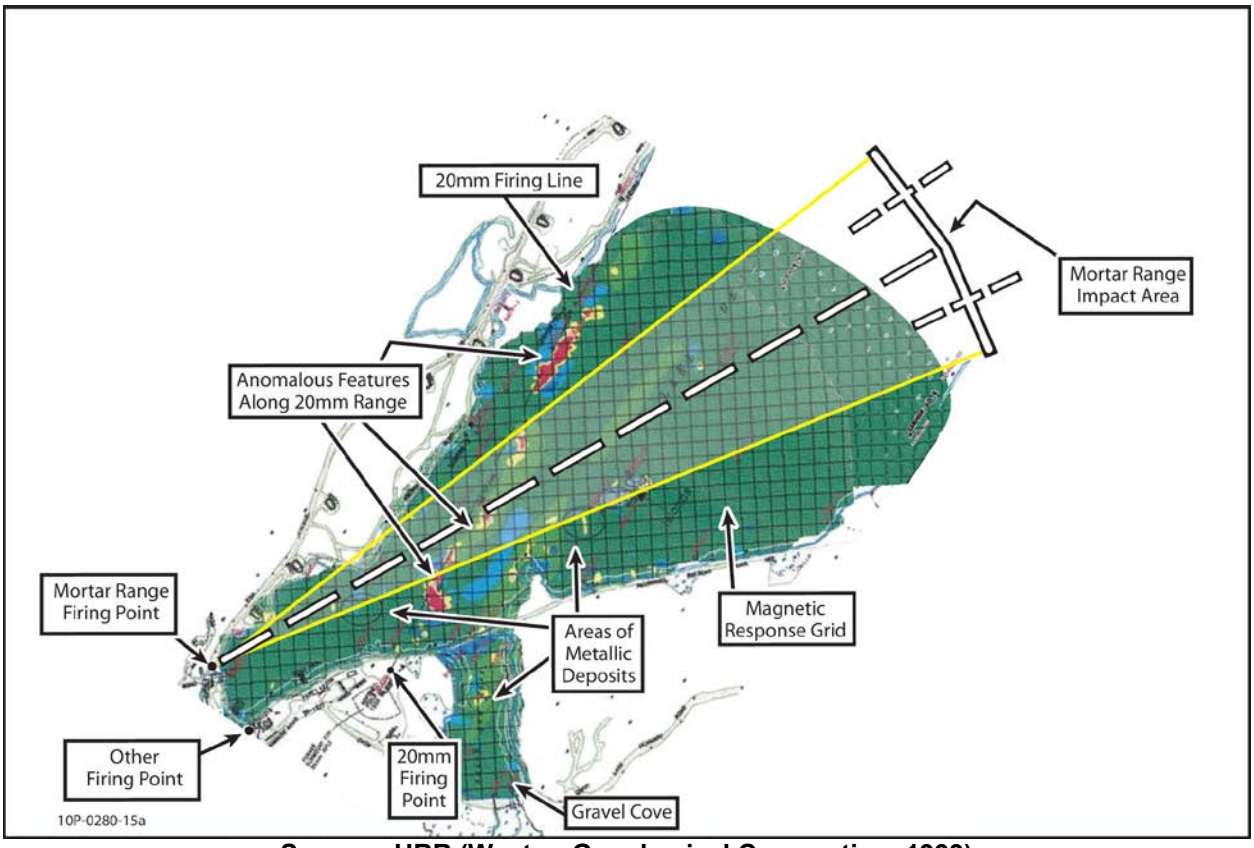
Source (Blackhawk Geosciences, 1995)

Figure 2-1 Lakes MRS - Picatinny Lake Bathymetric Results



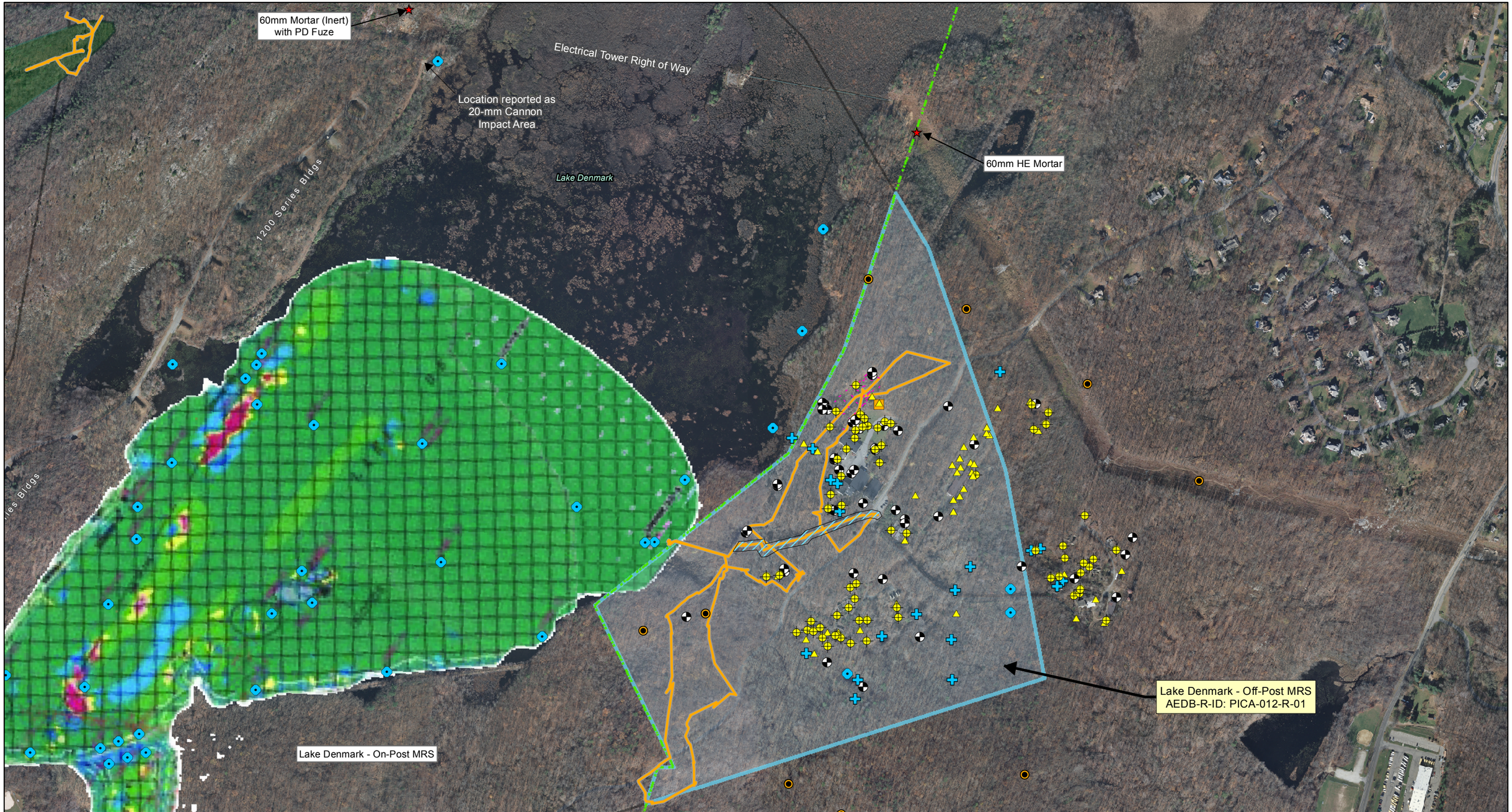
Source: (Blackhawk Geosciences, 1995)

Figure 2-2 Lakes MRS - Results from 1995 Picatinny Lake Magnetic Survey



Source: HRR (Weston Geophysical Corporation, 1999)

Figure 2-3 Lakes MRS - Lake Denmark Geophysical Survey Results



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lake Denmark Off-Post MRS
- Berm
- Test Pit Locations
- Subsurface Soil Boring Locations
- Subsurface Soil Sample Locations
- Sediment Sample Locations
- Surface Water/Sediment Sample Locations
- Background Soil Sample Locations
- Monitoring Well Locations
- Previous Geophysical Investigation
- SI Survey
- Approximate location of a former drum disposal area
- Mortars found during PSE&G work

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 600 1,200 Feet

0 200 400 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR

Verified By: NAS

Approved By: RSS

Figure 2-4
Lake Denmark - Off-Post MRS
Historical Investigation Locations

Date:3/6/2014

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_offpost_Historical.mxd

3. PHYSICAL SETTING

Section 3 presents the overall physical setting for PTA and detailed information on the physical setting of each MRS. Only the physical setting components (e.g., hydrology, ecology, receptors) that differ from, or require more detail than, the overall PTA physical setting will be described for each MRS. Note that MRS-specific information is provided starting in Section 3.2.

3.1 PICATINNY ARSENAL

3.1.1 Location

PTA is located in Morris County, NJ, approximately 45 miles west of New York City and approximately 4 miles north of Dover, NJ (shown in **Figure 1-1**). Interstate 80 and State Route 15 border the southern portion of PTA; Berkshire Valley Road borders the southwest and to the northwest is the Rockaway River Sate Wildlife Management Area. To the north of PTA is Green Pond. Lake Denmark Road bounds the northeast section of PTA.

3.1.2 Climate

PTA has a cool, humid continental climate. The average annual high temperature is 58.0 degrees Fahrenheit (^{o}F) with an average annual low temperature of 37.8 ^{o}F. Daytime high temperatures average from 30 ^{o}F in January to 80 ^{o}F in July. Average humidity during the year is 79% with highs observed up to 100% and lows of 49% (Weather Underground, Inc., 2013). Average annual precipitation is 52.39 inches with monthly averages between 0 and 6.6 inches.

Monthly Climate Observations (10-Year Summary)

	Average Temperature (°F)			Average Wind Speed (mph)			Average Humidity (%)			Average Precipitation (inches)
Month	**high**	**avg**	**low**	**high**	**avg**	**gust**	**high**	**avg**	**low**	**sum**
Sept	70.5	61.6	54.2	5.8	1.2	7.9	100.0	88.4	66.3	4.52
Oct	63.5	49.4	38.5	4.8	0.6	10.4	100.0	84.8	53.5	4.71
Nov	56.9	45.7	36.9	5.5	1.2	11.4	96.4	80.8	59.9	4.36
Dec	35.7	27.3	19.7	9.0	2.2	15.9	91.7	76.5	58.1	4.43
Jan	33.3	24.1	15.0	8.2	2.1	12.8	92.5	75.5	55.3	4.05
Feb	36.4	26.7	17.2	8.8	2.0	14.7	89.7	71.5	49.1	3.09
Mar	47.9	38.7	31.2	7.9	1.7	16.7	90.7	73.5	53.5	4.26
Apr	49.8	40.1	32.3	9.2	2.0	16.5	88.8	70.9	52.2	4.77
May	70.7	57.0	45.8	6.8	1.2	11.8	96.8	76.2	49.2	4.59
June	72.7	60.8	49.9	5.5	0.7	9.8	100.0	81.2	51.2	4.74
July	79.8	67.4	56.1	6.0	0.8	10.8	99.8	80.8	53.8	4.76
Aug	78.2	66.2	57.3	5.7	0.5	9.3	100.0	89.7	63.3	4.11

Source: weather station Marcella/Wild Cat Ridge/Hawkwatch/Rockaway Township, Station ID: KNJMARCE1, accessed 26 March 2013 (Weather Underground, Inc., 2013) - Data extracted from 1 Jan 2003 to 1 Jan 2013
http://www.wunderground.com/weatherstation/WXDailyHistory.asp
Precipitation Source: Weatherdb.com (extracts from NOAA database source) Accessed 17 October 2013.
http://average-rainfall.weatherdb.com/l/22231/Rockaway-New-Jersey

3.1.3 Geology

PTA is located in the New Jersey Highlands physiographic province geographic region. The New Jersey Highlands are composed of Proterozoic to Devonian rocks as part of the Appalachian Mountains formed when the continents collided. Four bedrock formations underlie PTA: Precambrian gneiss and other metamorphic rocks, Cambrian Hardyston quartzite, Cambrian Leithsville dolomite, and Silurian Green Pond conglomerate. Pleistocene glacial till and stratified drift overlie much of the formations. Rocks with highly oxidized iron content are prevalent. Iron ore was extensively mined in the region (Lucey, 1972).

3.1.4 Topography

The New Jersey Highlands physiographic province, where PTA is located, is between the Appalachian Piedmont physiographic province to the southeast and the Valley and Ridge province to the northwest. The New Jersey Highlands Region is part of the larger New York-New Jersey Highlands, which encompasses 1.1 million acres of Appalachian ridges and valleys stretching from the Hudson to the Delaware River.

PTA encompasses a wide central valley (Picatinny Valley) that is approximately 7 miles long and a narrower parallel intermontane valley (Green Pond Gorge) about 2 miles long. The total breadth across PTA averages 1 mile. PTA is situated between Green Pond Mountain on the northwest, Copperas Mountain on the east, and an unnamed hill on the southeast. Overall, the dominant topographic gradient is from the northeast to the southwest with severe slopes present along the northwestern boundary of PTA along Green Pond Mountain.

The majority of PTA appears on the Dover U.S. Geologic Survey (USGS) topographic quadrangle. Elevations on PTA range from 685 feet above mean sea level (amsl) in the valley to 1,287 feet amsl along the ridgeline of Green Pond Mountain. In general, elevations are lower to the south and east and higher to the north and west. The topographic elevations across PTA are shown on **Figure 3-1**.

3.1.5 Soils

Twenty-six major soil associations are present at PTA (U.S. Department of Agriculture (USDA), 2008). Soil types are shown on **Figure 3-2** and the soil unit descriptions are provided in **Appendix E**. Soil is generally coarse-textured sandy loams derived from bedrock, glacial till,

and colluviums (USDA, 1976). The soils at PTA are acidic and primarily derived from glacial deposits.

The central portion of PTA has soils that consist of loamy, silty, and gravel clay pan soils along with swampy areas that consist of peat and muck. There are seven hydric soil types found at PTA and three other types occur with hydric inclusions. The southern end of PTA consists of poorly sorted sands, gravels, and boulders bordered by a terminal moraine. To the northwest is a mountain range (Green Pond Mountain) with rough, stony land that formed on jagged, rocky slopes. Glacial till blankets the western and eastern flanks of PTA (Waterways Experiment Station [WES]-USACE, 1995). Up to 20 feet of glacial till consisting of sand, gravel, and boulders covers the western portion of PTA. The eastern portion of PTA consists of uniform glacial till with thicknesses ranging from 10 to 25 feet. The valley floor consists of till and drift from glacial lakes and streams with a thickness of up to 200 feet (Dames & Moore, 1991). Hydric soil makes up approximately 26% of the overburden at PTA (USAEC, 2001).

3.1.6 Hydrology

3.1.6.1 Surface Water

PTA lies within the recharge area of the New Jersey Watershed Management Area 6, northern New Jersey's primary water supply. PTA is composed of five main drainages: Green Pond Basin (Shrub wetlands and Gorge, headwaters of Green Pond Brook), Denmark Lake Basin (Shrub wetlands, headwaters of Burnt Meadow Brook), Middle Green Pond Brook and Picatinny Lake, Lower Green Pond Brook, and the Beaver Brook Sub-watershed (Van De Venter, 2007).

Surface water drains primarily from northeast to southwest with Green Pond Brook serving as the primary drainage for PTA, which originates at a 500-acre spring-fed lake known as Green Pond, located adjacent to the northern border of PTA. All drainages at PTA empty into the Rockaway River south and east of PTA. NJDEP recognizes the Rockaway River as a high-quality waterway. (Van De Venter, 2007).

Waterbodies within the Former Operational Areas MRS include Green Pond Brook, several unnamed small ponds and Bear Swamp Brook. The width of Green Pond Brook varies from 10 to 30 feet with a maximum depth of 5 feet. Burnt Meadow Brook originates from Egbert Lake and flows through Lake Denmark prior to its convergence with Green Pond Brook near the

middle of the arsenal. Green Pond Brook continues to flow southwest through Picatinny Lake before exiting PTA to the southwest. Approximately one mile south of PTA, Green Pond Brook joins the Rockaway River. The Rockaway River flows east through the Boonton Reservoir before joining the Passaic River. Bear Swamp Brook joins Green Pond Brook on the southern end of PTA. The width of Bear Swamp Brook is between 3 and 7 feet and the maximum depth is 2 feet. Ames Brook flows off PTA exiting along the eastern boundary.

Lake Denmark and Picatinny Lake are man-made features that collectively comprise 360 acres of open water. The lakes were constructed in the 1880s and are primarily used for industrial water supply and recreation. The maximum depth of Lake Denmark is approximately 7 feet. The maximum depth of Picatinny Lake is approximately 20 feet. Eighteen ponds are present at PTA, including EOD Pond, North Basin, South Basin, Fisher's Pond, which are all within the 1926 Explosion Radius MRS.

3.1.6.2 Groundwater

It is important to note that groundwater is being addressed under the IRP for all on-post MRSs; however, groundwater is not being addressed by the IRP for off-post MRSs (1926 Explosion Radius – Off-Post MRS, Lake Denmark – Off-Post MRS and Inactive Munitions Waste Pit – Off-Post MRS). Therefore only general information regarding the groundwater is included for PTA, while more specific information is included for the Off-Post MRSs. Four aquifers exist at PTA. The uppermost aquifer is an unconfined aquifer consisting of stratified drift on top of fine sand and silt lake sediments. Two confined glacial till aquifers (upper and lower) consisting primarily of sand and gravel underlie the upper most aquifer. The confined glacial till aquifers are the primary water source for PTA. The fourth and deepest aquifer is a bedrock aquifer separated from the confined glacial till aquifer by weathered bedrock with a maximum thickness of 60 feet (Dames & Moore, 1991).

Groundwater movement at PTA is in response to hydraulic gradients. In Morris County, the direction and magnitude of the natural gradients mimic the local topographic profile except that the water table profile has less relief. Groundwater flow is primarily horizontal and upward in both the unconfined and confined glacial aquifers and for the most part discharges into Green Pond Brook. PTAs groundwater resides in the confined glacial till aquifer, known as the Upper Rockaway Aquifer, and is a designated sole source aquifer (Van De Venter, 2007). Additional

details regarding all four aquifers are provided below:

As stated in the *Fourth Five Year Review Report* Picatinny Arsenal Finalized July 2011;

"Four major aquifers have been identified beneath Picatinny:

- The unconfined aquifer occurs within the valley floor and has a thickness of approximately 20 to 35 ft. This aquifer is continuous throughout the valley, with the exception of areas on the ridges where bedrock is exposed at the surface. Groundwater within this unit occurs from relatively near ground surface to about 30 ft below ground surface (bgs) in upland areas. Groundwater in the unconfined aquifer generally flows toward surface water discharge areas, such as Green Pond Brook, Bear Swamp Brook, and Lake Picatinny. Groundwater flow velocities vary greatly in the unconfined unit based on varying permeability and gradient, and are estimated to range from 50 ft per year to over 300 ft per year.

- The upper semi-confined aquifer is generally encountered in the southern half of the valley. The lower semi-confined aquifer occurs beneath the upper only in the central valley portion of this area. As the unconsolidated sediments become thinner on the sides of the valley, this lower aquifer pinches out against the bedrock. Groundwater flow direction in the semi-confined aquifers is generally down valley to the southwest and towards surface water discharge areas. Vertical flow is typically upward towards discharge areas except where affected by groundwater withdrawal wells. Groundwater flow velocities are generally similar to the unconfined aquifer, though in some areas the lower semi-confined aquifer consists of coarser deposit with generally low hydraulic gradients.

  These three valley-fill aquifers (unconfined, upper semi-confined, and lower semi-confined) have a maximum thickness of approximately 175 ft, and are impacted with various contaminants including chlorinated and hydrocarbon compounds, and explosives at the following PICA sites: Area D Groundwater (PICA 076); Area B Groundwater (PICA-204); Area E Groundwater (PICA 077); 800 Area Buildings (PICA-079); the Mid-Valley Groundwater (PICA-205); and the Optics Lab (PICA-013).

- The bedrock aquifer exhibits faults, fold axes, bedding planes, and foliation trends that affect contaminant transport. Groundwater flow in the bedrock is generally towards the central

valley and surface water features; however, locally the foliation and fracturing can alter and control flow directions along fractures and fault planes. Impacts to the bedrock aquifer, including trichloroethene (TCE) and explosives, have been documented in the Mid-Valley Groundwater (PICA 204); the 800 Building Area (PICA 079); Area K (PICA 50); and Area J (PICA 008).

Green Pond Brook is the main surface water drainage pathway within the valley. Two man-made lakes (Lake Denmark and Picatinny Lake) are present, both drained by Green Pond Brook. Two tributaries to Green Pond Brook, Robinson Run and Bear Swamp Brook, flow from the ridges on the southeast and northwest sides of the valley, respectively. Wetlands and transition zones around the brooks are present throughout Picatinny Arsenal. "

3.1.7 Ecology

A variety of wildlife habitats exist at PTA, including dry forested ridgetops, talus slopes, bottomland hardwoods, mesophytic hardwoods, conifer stands, old fields, riparian sites, shrub stands, wetlands, brooks, ponds, and lakes (USAEC, 2001). Mixed oak, northern hardwood, hemlock, and red maple swamp are the four predominant forest types on PTA. Scrub/shrub habitat is mainly found in wetlands associated with Lake Denmark. One-third of all undeveloped public lands surrounding PTA (5,948 acres) is contiguous with PTA boundary, facilitating fish and wildlife movement (USAEC, 2001).

There are 10 recognized cover types within five wetland regimes at PTA. Lakes and ponds account for 33% of the total wetland acreage. Vegetated wetland cover types include palustrine scrub/shrub, palustrine forested, and wet meadow. Red maple (*Acer rubrum*), aspen (*Populus* sp.), gray birch (*Betula populifolia*), and hemlock (*Tsuga canadensis*) are predominant tree species within the palustrine forests at PTA (Malcolm Pirnie, 2008).

Aquatic habitats are present in the two large lakes (Lake Denmark and Picatinny Lake), 18 ponds, and four perennial brooks (Green Pond, Burnt Meadow, Bear Swamp, and Ames) on PTA. In addition, the presence of intermittent streams and springs/seeps contributes to biodiversity because they provide habitat for ephemeral aquatic and amphibian species (Malcolm Pirnie, 2008).

3.1.7.1 Special Natural Areas

New Jersey National Heritage Program (NJNHP) identified two Natural Heritage Priority Sites located around Lake Denmark and a third Natural Heritage Priority Site located at Picatinny Lake that contain occurrences of state imperiled and other rare species. PTA includes a major portion of the NJ Natural Heritage Priority Sites (Green Pond Macro Site and the Lake Denmark Site) designated because of high wildlife concentrations, diversity, and connectivity. The Natural Heritage Priority Sites are identified as critically important natural areas for conserving and preserving New Jersey's biodiversity. PTA is also located in the Highlands Preservation Area and the Highlands Planning Area[1]. The unique Highlands Region of New Jersey serves as a recharge area for groundwater aquifers that provides drinking water to over 4 million people in the region. In addition, a large portion of the Highlands (approximately ½ or 500,000 acres) is considered important wildlife habitat (USAEC, 2001).The locations of the Natural Heritage Priority sites and the Highland Planning and Preservation Areas are presented on **Figure 3-3.** Reference Appendix I of the Final RI Work Plan, *New Jersey Natural Heritage Program Report*, for additional details regarding the Natural Heritage Priority Sites at PTA (WESTON, 2012).

3.1.7.2 Wetlands

Wetland areas are prominent at PTA and include two large lakes, 18 ponds, and four perennial brooks. **Figure 3-4** depicts wetlands identified based on the National Wetlands Inventory mapping for PTA. Wetlands identified based on the New Jersey State Wetlands mapping are shown on **Figure 3-5.** The wetlands are primarily comprised of muck and peat formed in poorly

[1] The Highlands is a physiographic province that stretches from western Connecticut to east central Pennsylvania. The New Jersey portion of the Highlands encompasses 88 municipalities in seven counties. The Highlands Region is an essential source of drinking water for half of the residents of New Jersey. Over 800,000 acres make up New Jersey's Highlands Region and the Highlands Act designates approximately 398,000 acres of exceptional natural resource value as the Highlands Preservation Area. Approximately 145,000 acres within the Highlands Preservation Area are undeveloped. By statute the Highlands region is divided into 2 distinct areas; the Preservation Area, which came under the strict land-use regulations of the NJ Department of Environmental Protection with passage of the Highlands Act; and the Planning Area, which balances growth and development with water-resource protection through voluntary municipal conformance to the Highlands Regional Master Plan. The water resource protection goals for the Preservation and Planning Areas are the same. In the Preservation Area, the goals are achieved by regulation; in the Planning Area they are achieved through innovative regional planning. All of the land in the Highlands Region that is not in the Highlands Preservation Area lies within the Highlands Planning Area. A complete description of the Highlands Preservation Area boundaries is set forth in Section 7 of the Highlands Water Protection and Planning Act.

The Highlands Planning Area is the portion of the Highlands Region that is not included in the Highlands Preservation Area. While the Act does not establish any new standards for the Highlands Planning Area, the Highlands regional master plan, which must be adopted by the Highlands Water Protection and Planning Council, will provide an avenue for enhanced standards, TDR and smart growth in this portion of the Highlands Region.

http://www.nj.gov/dep/highlands/faq_info.htm

drained glacial soils. Except for the open waters of lakes and ponds, the palustrine wetlands are nearly all red maple forests or scrub-shrublands. Wetlands distributed and scattered throughout PTA are very valuable to wildlife and serve as important groundwater recharge sites. The largest tract of red maple swamp is near the southern end of PTA (Van De Venter, 2007). Red maple swamp forests, lakes and ponds, and their associated wetlands comprise 92% of the wetlands on PTA. Picatinny Lake is designated by NJDEP and U.S. Fish and Wildlife Service (USFWS) as an open water wetland (USAEC, 2001).

3.1.7.3 Ecological Receptors

Site-specific beneficial resources at PTA include the forest and wildlife corridor offered by the dense forests and wetland areas providing habitat for many of the 41 mammalian, 208 avian, 21 amphibian, 19 reptile, and 26 fish species known to occur at PTA. Numerous invertebrates also occur at PTA, including common species from the Families Odonata and Lepidoptera (i.e., 63 dragonflies, 31 damselflies, 67 butterflies, and 136 moths).

3.1.7.3.1 Wildlife

Two federally listed endangered species exist on PTA, the Indiana bat and the bog turtle. An environmental assessment and endangered species management plan for the bog turtle was submitted in November 2004 and a plan for the Indiana bat was submitted in September 2007. Sixty-five species of animals state-listed as endangered, threatened, or species of concern either exist on or may be present within a ¼ mile of PTA. The habitats of the federally listed and state-listed species are presented on **Figure 3-6.** Fourteen species of rare plants listed as state-endangered or under protection from the Highlands Water Protection and Planning Act within the jurisdiction of the Highlands Preservation Act exist on PTA or in the immediate vicinity of PTA (USAEC, 2001; NJDEP, 2011). The rare plants are listed in Section 3.1.7.3.2. The Highland Planning and Preservation Areas are presented on **Figure 3-3**.

The following list presents the federal- and state-listed threatened and endangered species documented at PTA that either potentially exist or are confirmed residents:

- Mammals: Small-Footed Bat, Indiana Bat, Eastern Wood Rat, and Bobcat.
- Birds: Cooper's Hawk, Northern Goshawk, Grasshopper Sparrow, Long Eared Owl. Upland Sandpiper, American Bittern, Red-Shouldered Hawk, Northern Harrier,

Cerulean Warbler, Bobolink, Little Blue Heron, Peregrine Falcon, Bald Eagle, Cliff Swallow, Loggerhead Shrike, Red Headed Woodpecker, Osprey, Savannah Sparrow, Piedbilled Grebe, Vesper Sparrow, Barred Owl, Golden-Wing Warbler, Great Blue Heron, and the Least Bittern.

- Reptiles: Wood turtle, Bog turtle, Timber Rattlesnake, Northern Copperhead, and Eastern Box Turtle.
- Amphibians: Jefferson Salamander, Blue-Spotted Salamander, and Marbled Salamander.
- Fish: Brook Trout.
- Insects, Dragonflies, and Damselflies: Aesh. Canadensis, Mottled Darner, Spatterdock Darner, Black Tipper Darner, Aesh. Canadensis, Comet Darner, Lilypad Clubtail, Boreal Bluet, Enal. Carunculatum, Enal. Cyathigerum, New England Bluet, Single Striped Clubtail, Les. Congenter, Amber Wing Spreadwing, Leuc. Glacialis, Nasi Pentacantha, Phan. Spicatus, Soma. Linearis, Ski-Tailed Emerald, Williamson's Emerald, Sable Clubtail, Arrowhead Spiketail, Salt and Pepper Skipper, Harris Checkerspot, Long Dash Skipper, Gray Comma, Red Bordered Emerald, and Rippled Wave.

3.1.7.3.2 Vegetation

Of New Jersey's 2,117 known native plant species, 25% have been documented to occur at PTA, including 626 flowering plants and 90 non-flowering plants (USAEC, 2001). PTA is located within the Appalachian Oak forest region, a subdivision of the Eastern Deciduous Forest Biome.

Approximately 70% (4,082 acres) of PTA is characterized by second-growth forest on formerly cleared farmlands. Mixed oak (*Quercus*) species compose approximately 65% (2,656 acres) of the forested land on PTA (USAEC, 2001). Generally, wooded stands at lower elevations of PTA are dominated by species within the red oak subgroup (e.g., red oak (Q. *rubra*), black oak (Q. *velutina*), scarlet oak (Q. *coccinea*)), whereas stands at higher elevations are dominated by chestnut oak (Q. *montana*). Northern hardwood and red maple (*Acer rubrum*) swamp forest types are the second dominant forest types on PTA, with each comprising approximately 13% of the forested area (545 and 532 acres, respectively). Typical northern hardwood species are sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*). Most northern hardwood stands are located in Picatinny Valley and along the eastern ridge. Mature red maple swamp forest is present on the hydric and muck soil types at the base of the valley.

No federally listed threatened or endangered plant species have been documented at PTA. However, three state-listed endangered plant species have been documented as occurring within

some wetlands at PTA (i.e., slender wood reed grass (*Cinna latifolia*), meadow horsetail (*Equisetum pratense*), and large-leafed holly (*Ilex montana*). In addition, there are approximately 15 documented occurrences of floral species of special concern, many of them occurring in wetlands, although most are known to occur in the remote northern portion of PTA near Lake Denmark (USAEC, 2001).

Fourteen species of rare plants listed as state-endangered or under protection from the Highlands Water Protection and Planning Act within the jurisdiction of the Highlands Preservation Act exist on PTA or in the immediate vicinity of PTA (USAEC, 2001; NJDEP, 2011). The following list presents the rare plants that either potentially exist or exist at PTA:

- S1[2] Plants: Bradley's Spleenwort, Meadow Horsetail, Stiff Clubmoss, Featherfoil, Robbin's Pondweed, Small Bur Reed, Lesser Bladderwort, Slender Wood Reedgrass, Butterfly Pea, Common Blue Eyed Grass, Frasier's Marsh St. Johns Wort, Narrow Leaved Meadowsweet, and Large Leaved Holly.
- S2 Plants: Sphanum Tenellum, Mountain Spleenwort, Bebb's Sedge, Two Fruited Sedge, Hop Like Sedge, Beaked Sedge, Green Fruited Bur Reed, Allegheny Vine, Purple Virgin's Bower, Purple Cress, Velvety Tick Trefoil, Marsh Bedstraw, and Swamp Lousewort.
- S3 Plants: Floating Heart, Humped Bladderwort, Flat leaved Bladderwort, Purple Bladderwort, Virginia Snakeroot, Narrow Leaved Willow Herb, Purple Fringed Orchid, Wood Lily, Winged Monkey Flower, Tall Cinquifoil, and Meadow Willow.
- SH Plants: Water Lobelia, Narrow Leaved Bur Reed, and Trailing Tick Trefoil.

[2] S1=Critically imperiled in New Jersey because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Elements so ranked are often restricted to very specialized conditions or habitats and/or restricted to an extremely small geographical area of the state. Also included are elements which were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have been demonstrably reduced in abundance. In essence, these are elements for which, even with intensive searching, sizable additional occurrences are unlikely to be discovered.

S2=Imperiled in New Jersey because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.

S3=Rare in state with 21 to 100 occurrences (plant species and ecological communities in this category have only 21 to 50 occurrences). Includes elements which are widely distributed in the state but with small populations/acreage or elements with restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.

SH=Elements of historical occurrence in New Jersey. Despite some searching of historical occurrences and/or potential habitat, no extant occurrences are known. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, historically ranked taxa are considered possibly extant, and remain a conservation priority for continued field work with the expectation they may be rediscovered.

3.1.8 Cultural and Archaeological Resources

PTA contains archaeological remains of prehistoric Native American site activities and historic settlement and industries, as well as significant architectural properties related to its use as a powder depot, arsenal, and weapons and rocket testing facility. The history of Picatinny and the function and significance of the structures on the property have been well documented. At this time, there are no individual buildings or districts at PTA listed in the National Register of Historic Places. However, an identified eligible building must be treated as if it may yet be placed on the Register until any proposed action determines its final disposition. Many buildings or groups of structures are possibly eligible for listing as historic sites or districts under the National Historic Preservation Act. Many buildings are concentrated within the cantonment (i.e., barracks); some, such as housing, are clustered in semi-improved areas throughout PTA while most of the storage structures and test ranges are dispersed in undeveloped portions of PTA (Van De Venter, 2007).

A total of 108 potential and/or known historic archaeological sites and 27 potential and/or known prehistoric sites have been identified across PTA (Picatinny Environmental Affairs, 2011; and Chugach Industries, 2008). Also the PTA Administration and Research District in downtown PTA is identified by the New Jersey Historic Preservation Office (NJHPO) as a cultural resource (Chugach Industries, 2008; and Picatinny Environmental Affairs, 2011). Refer to **Figure 3-6** for the locations of culturally sensitive areas. Refer to Appendix J, Protection Procedures for Archaeological and Historical Artifacts, of the Final RI Work Plan for additional details regarding the culturally sensitive areas consisting of historic and/or prehistoric archaeological sites (WESTON, 2012). Culturally sensitive areas are those that meet one or more criteria making them likely locations for evidence of past human activity and/or occupation. Criteria include: areas where historic maps, aerial photographs, or pictures show that a dwelling or structure once stood but is now gone due to previous development; locations Native Americans have occupied that have the potential for lithic scatters, rockshelters, along with sacred places, such as cemeteries or spots of spiritual importance (published sources have been noted). Culturally sensitive - possibly disturbed areas are culturally sensitive areas that have experienced previous disturbances from PTA related development that sensitivity is weakened but significant archaeological finds may still exist.

3.1.9 Demographics

The area immediately surrounding PTA and encompassing the off-post MRSs are either undeveloped or sparsely developed residential property, with the exception of Mt. Hope Quarry, which is located adjacent to the southeast portion of PTA within the 1926 Explosion Radius Off-Post MRS. PTA is located approximately 4 miles (6,437 meters) north of the city of Dover, in Rockaway Township, Morris County, NJ. Other nearby towns are Wharton, located 3 miles (4,828 meters) to the south; Rockaway, located 4 miles (6,437 meters) to the southeast; Boonton, located 8 miles (12,875 meters) to the southeast; and Morristown, located 15 miles (24,140 meters) to the southeast.

Once gaining access through the initial post security at the entrance gate, most of PTA is easily accessible to Picatinny personnel, residents, site visitors, recreational users (hunters, fishers, and athletes), and maintenance workers. MRS specific access restrictions are provided in the following sections. The PTA community includes current Picatinny employees, retired and former employees, active, reserve, retired military and partnered communities in Morris County. The total population includes soldiers, civilian employees, dependents, and retirees. PTA has over 750 permanent residents and employs about 3,907 civilians, approximately 93 military personnel and about 1,035 contractors (Picatinny Arsenal, 2012a). The 2010 census reports a population of 24,156 for Rockaway Township, Morris County, NJ (U.S. Census, 2010).

3.1.10 Current and Projected Land Use

Picatinny Arsenal is the Joint Center of Excellence for Armaments and Munitions, providing products and services to all branches of the U.S. military. Picatinny is the site of the Armament Research, Development and Engineering Center (ARDEC) under the major command of Army Materiel Command (AMC) and Tank Automotive and Armaments Command (TACOM). PTA houses government-operated munitions R&D facilities, operational ranges for munitions testing, residential housing, and recreational facilities that include a golf course and water park. Refer to **Figure 3-7** for a map of the land use distribution. PTA will continue to be used for military R&D, industrial, residential housing, and recreational activities (fishing, boating, hunting, and golfing) in the future.

Although the intended land use of the property is not expected to change, various construction projects are planned either for routine installation maintenance or under a variety of programs,

including the Urgent Minor Military Construction Army program and the Military Construction Army program. A variety of development projects have also been completed under the Base Realignment and Closure (BRAC) program. Proposed PTA-wide long-term development includes demolition of approximately 220 buildings throughout PTA, construction of numerous new buildings throughout PTA, improvement to and widening of some roads in the downtown area, and some other general improvements (e.g., pave roads, add curbs, improve parking lots).

Human health receptors identified for PTA based on the current and projected land use include PTA personnel and PTA residents (families, contractors/visitors, and trespassers). Contractors/visitors include utility and maintenance workers and visitors of PTA personnel and residents.

PTA has existing institutional controls (ICs) and Land Use Controls (LUCs) in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s). A LUC Plan, which addresses the interim actions at MRSs, is currently being prepared for PTA under a separate program.

3.2 1926 EXPLOSION RADIUS MRS (PICA-003-R-01)

3.2.1 Location

Figure 1-3 presents the location of the 1926 Explosion Radius MRS.

3.2.2 Topography

The 1926 Explosion Radius MRS is situated in the center of PTA and extends across most of PTA, excluding the furthest northeast and southwest sections. The MRS follows the general topography of PTA (Section 1.2.1). The MRS is situated between Green Pond Mountain on the northwest, Copperas Mountain on the east, and an unnamed hill on the southeast. Overall, the dominant topographic gradient is from the northeast to the southwest with severe slopes present along the northwestern boundary of PTA along Green Pond Mountain.

3.2.3 Soils

Soil within the 1926 Explosion Radius MRS consists of clay silt loams, loam, silt, sand, clay,

gravel, rock outcropping, and glacial till (**see Figure 3-8)**. The primary soil unit consists of Rockaway sandy loams. The Rockaway sandy loam is coarse and ranges from stony to extremely stony. It is derived from granite and gneiss (USDA, 2008). The Rockaway sandy loam is typically well drained and does not meet hydric criteria. Soil unit descriptions are provided in **Appendix E**. As shown on **Figure 3-8,** fifteen soil units occur within the 1926 Explosion Radius MRS. Across the MRS the soil varies from extremely stony (Rockaway sandy loam, extremely stony) to muck (Adrian Muck).This difference in soil equates to a variance from well-drained soil (not meeting hydric criteria) to very poorly-drained soil (meeting hydric criteria) across the MRS.

3.2.4 Hydrology

The general hydrology of PTA is included in Section 3.1.6. Water bodies in the 1926 Explosion Radius MRS include most of Picatinny Lake, EOD Pond, North Basin and South Basin, Fisher's Pond, Bear Swamp Brook, Green Pond Brook, and several small streams.

3.2.5 Sensitive Environmental Resources within the MRS

Patches of forest, wetlands, and lakes used by state-listed species present at PTA are in the 1926 Explosion Radius MRS. This MRS is located in both the Highlands Preservation Area and the Highlands Planning Area (see **Figure 3-3)**.

3.2.6 Cultural and Archaeological Resources

The PTA Administration and Research District in downtown PTA is identified by the NJHPO as a cultural resource (Chugach Industries, 2008; and Picatinny Environmental Affairs, 2011). A portion of downtown PTA is located within the 1926 Explosion Radius MRS.

3.2.7 Current and Projected Land Use

The 1926 Explosion Radius MRS has approximately 800 buildings used for various purposes, including manufacturing, storage, testing, R&D, administration, and housing. The MRS also contains parking lots, recreational areas, and undeveloped property. Portions of the 1926 Explosion Radius MRS contain habitat used by state- and/or federal-listed threatened and/or endangered species. There are ICs and LUCs in place at PTA, encompassing the MRS. The ICs and LUCs include, but are not limited to, issuing safety permits for work on PTA, using UXO construction support as required during intrusive work, and requiring appropriate personnel to

attend a safety course(s).

A significant amount of development is planned for PTA in both the short and long term. Over 200 existing buildings will be demolished and numerous new buildings will be constructed throughout PTA, selected roads in the downtown area will be improved and widened, and additional general improvements (e.g., pave roads, add curbs, and improve parking lots) will occur. It is assumed that much of the proposed development will be in the 1926 Explosion Radius MRS, where large portions of downtown PTA (central portion of PTA where the majority of buildings are clustered) and numerous buildings are located (Parsons, 2007a, 2007b).

3.3 1926 EXPLOSION RADIUS – OFF-POST MRS (PICA-004-R-01)

3.3.1 Location

Figure 1-5 presents the location of the 1926 Explosion Radius – Off-Post MRS.

3.3.2 Topography

The 1926 Explosion Radius – Off-Post MRS has an elevation that varies approximately 800 to 1,000 feet amsl. The MRS is characterized by moderately steep terrain sloping east-southeast toward Hope Lake and Mt. Hope Pond.

3.3.3 Soils

The 1926 Explosion Radius – Off-Post MRS contains rock outcrop and Rockaway sandy loam (see **Figure 3-9)**. The primary soil units consist of Rockaway sandy loam that is coarse and ranges from stony to extremely stony. It is derived from granite and gneiss (USDA, 2008). Soil unit descriptions are provided in **Appendix E.** The Rockaway sandy loam is typically well drained and does not meet hydric criteria. As shown on **Figure 3-9,** eight soil units occur within the 1926 Explosion Radius – Off-Post MRS. Across the MRS the soil varies from extremely stony (Rockaway sandy loam, extremely stony) to muck (Carlise Muck).This difference in soil equates to a variance from well-drained soil (not meeting hydric criteria) to very poorly-drained soil (meeting hydric criteria) across the MRS.

3.3.4 Hydrology

3.3.4.1 Surface Water

The main surface water features on the 1926 Explosion Radius – Off-Post MRS are Mount Hope Pond and portions of Mount Hope Lake.

3.3.4.2 Groundwater

Three aquifers underlying PTA have been identified during previous subsurface investigations. An unconfined stratified drift aquifer, which is the water table aquifer, is perched on top of fine sand and silt lake sediments. These sediments form a discontinuous leaky confining bed between the water table aquifer and a lower confined glacial till aquifer consisting primarily of sand and gravel. The confined glacial till aquifer is the primary water source for PTA. A bedrock aquifer is also present and is separated from the confined glacial till aquifer by weathered bedrock with a maximum known thickness of 60 feet (Malcolm Pirnie, 2008). No monitoring wells are present in the 1926 Explosion Radius – Off-Post MRS, therefore due to proximity to PTA is assumed that portions of this MRS overlie all three aquifers. Additional details regarding the aquifers are presented in Section 3.1.6.2.

3.3.5 Sensitive Environmental Resources within the MRS

Both forested and wetland areas are present in the 1926 Explosion Radius – Off-Post MRS, which may contain state-listed species of concern for PTA. According to NJDEP's i-Map Landscape Project layer, the MRS contains habitat with at least one occurrence of a state-threatened species, as presented on **Figure 3-6** (NJDEP, 2011).

3.3.6 Cultural and Archaeological Resources

The Mount Hope Mine Historic District and the Ford-Faesch Manor House, both located on Mount Hope Road, have been identified by the NJHPO as historic places, and the bed of the Mount Hope Mine Railroad, which runs through the 1926 Explosion Radius – Off-Post MRS, is identified by NJHPO as a cultural resource. The Ford-Faesch Manor House is listed on the National Register of Historic Places and the Mount Hope Mine Historic District is listed as eligible under State Historic Preservation Officer opinion (**Figure 3-7**).

3.3.7 Current and Projected Land Use

The 1926 Explosion Radius – Off-Post MRS contains vacant land and several businesses,

including Mount Hope Quarry, which covers approximately 80% of the MRS. The current land use is industrial and recreational with some vacant land.

The 1926 Explosion Radius – Off-Post MRS, which has eight parcels with six property owners, consists of vacant land and commercial property. Mount Hope Quarry, owned and operated by Tilcon, covers approximately 80% of the MRS. The additional property owners are Ilac Realty, LLC; K. Doland; Rockaway Township; Morris County; and SMC-DAG, Inc. In February 2007, Lieutenant Colonel Skelton, the Garrison Commander at the time, sent a letter to each of the off-post property owners regarding the munitions-related investigations being conducted by the Army. Included with the letter was a map identifying areas that could potentially contain munitions or MC, along with a fact sheet about the project, the MMRP process, and the steps to take if UXO is found. The property owners were contacted by telephone to ensure that they did not have any questions/concerns about the project.

During the RI, the property owners indicated that there are no future plans to change the current land use. Additionally in November 2012, under the RI, Lieutenant Colonel Jason Mackay, the Garrison Commander at the time, sent a letter to the off-post property owners detailing the results of the RI conducted on their property.

3.4 SHELL BURIAL GROUNDS MRS (PICA-010-R-01)

3.4.1 Location

Figure 1-6 presents the location of the Shell Burial Grounds MRS.

3.4.2 Topography

The Shell Burial Grounds – East, near Bldg. 3150, is characterized by relatively flat land that slopes gently from east to west approximately 10 feet amsl, from 980 feet amsl to 970 feet amsl. The Shell Burial Grounds – West, near Bldg. 3100, is moderately sloped from the east to west approximately 15 feet amsl, from 830 feet amsl to 815 feet amsl.

3.4.3 Soils

The SI stated that the burial grounds were thought to be covered with approximately 20 feet of fill. During the RI it was determined that the Shell Burial Ground had varying depths of fill, from no fill in some areas to as much as 25 feet in others. No records were maintained of the types of

materials or amounts of material disposed of in the burial grounds. Native soils at Shell Burial Grounds – East, near Bldg. 3150, are acidic, somewhat poorly drained, loamy upland soils. The soil units consist of Rockaway sandy loam, very stony and Hibernia loam, stony. Native soils at Shell Burial Grounds – West, near Bldg. 3100, are deep, moderately permeable, well-drained soils and gravelly loam to gravelly sandy loam subsoils over a fragipan (see **Figure 3-10)**. The soil units consist of Rockaway sandy loam, very stony to extremely stony. Soil unit descriptions are provided in **Appendix E.**

3.4.4 Hydrology

No water bodies or wetlands exist within the Shell Burial Grounds MRS. Surface runoff at the Shell Burial Grounds – East is expected to flow west-northwest following topography. The EOD Pond is located approximately 500 feet (152 meters) northwest of Shell Burial Grounds – East. Picatinny Lake is approximately 1,300 feet north-northeast of Shell Burial Grounds – West.

3.4.5 Sensitive Environmental Resources within the MRS

The Shell Burial Grounds MRS is composed mainly of deciduous forest. There are no known ecological receptors identified at the Shell Burial Grounds MRS but the MRS is forested with deciduous trees.

3.4.6 Current and Projected Land Use

The Shell Burial Grounds MRS is not currently being used and has restricted access. ICs (limited access) have been implemented at the MRS to address soil contamination under IRP PICA-052 and PICA-162. A locked fence surrounds both burial areas. There are no planned land use changes for this MRS.

3.5 GREEN POND MRS (PICA-005-R-01) AND FORMER DRMO YARD

3.5.1 Location

Figure 1-7 presents the location of the Green Pond MRS and adjacent Former DRMO Yard.

3.5.2 Topography

The Former DRMO Yard is partially developed with offices and impervious surfaces and a relatively flat topography. The topography to the west of the Green Pond Brook (Former DRMO

Yard) is generally flat; whereas, to the east the land slopes gently. The Green Pond MRS elevation is approximately 700 feet amsl.

3.5.3 Soils

The main soil types at the Green Pond MRS and Former DRMO Yard are urban land, Carlisle Muck (frequently seen on flood plains and derived from organic material) and Preakness Sandy loam, consisting of coarse loamy outwash derived from granite and basalt (USDA, 2008). The Carlisle Muck and Preakness Sandy loam are typically poorly drained and meet hydric criteria. Both soils occur on outwash plains and are frequently flooded (**Figure 3-11)**. Soil unit descriptions are provided in **Appendix E.**

3.5.4 Hydrology

The Green Pond MRS is a small portion of Green Pond Brook, a water body located downstream of Picatinny Lake. Green Pond Brook generally has a wide, straight channel flowing to the southwest, with slow running warm water, although there are seasonal variations in the flow due to fluctuations in precipitation. Portions of the brook are channelized with steep banks. The bottom of Green Pond Brook consists of fine sediment and the lower reach of the brook is considered a gaining stream. A marshy area is located east of Green Pond Brook. To the west is the Former DRMO Yard, where no water bodies are present. Surface runoff from the former DRMO Yard flows into Green Pond Brook.

3.5.5 Sensitive Environmental Resources within the MRS

The Green Pond MRS has an aquatic warm bed habitat with some submerged aquatic vegetation beds. There is little shade and limited habitat present on the steeply sloped banks. Receptors include those species tolerant of slow, warm water. According to NJDEPs i-Map Landscape Project layer, the Green Pond MRS contains habitat with at least one occurrence of a state-threatened species (bog turtle) (**Figure 3-6**) (NJDEP, 2011). The Former DRMO Yard is partially developed with offices and impervious surfaces; there are no known ecological receptors identified at this portion of the Green Pond MRS.

3.5.6 Current and Projected Land Use

The Green Pond MRS is located within a heavily developed and utilized area of PTA, but the MRS is not currently being used for anything but water drainage. There are no planned changes

for land use for the Green Pond MRS. As mentioned previously in Section 2.5.2.1, the 2005 ROD for Green Pond Brook includes chemical and biological monitoring, as well as LUCs (Malcolm Pirnie, 2008). The Former DRMO Yard is currently used for offices and parking; there are no known land use changes planned for the Former DRMO Yard.

3.6 FORMER OPERATIONAL AREAS MRS (PICA-006-R-01)

3.6.1 Location

Figure 1-8 presents the location of the Former Operational Areas MRS.

3.6.2 Topography

The Former Operational Areas MRS is one of the largest MRSs. It extends across most of PTA and was designed with the intent to include any areas remaining within PTA boundary that may pose a munitions hazard. Areas were selected for inclusion in the Former Operational Areas MRS based on historical records, such as the UXO Finds map (**Appendix B**); status as non-operational ranges; and recognition that the areas were not already accounted for under another MRS. The topography is highly variable across the entire MRS and consistent with overall PTA topography (see Section 3.1.4, **Figure 3-1**).The dominant topographic gradient is from the northeast to the southwest, with severe slopes present along the northwestern boundary of PTA where it coincides with Green Pond Mountain.

3.6.3 Soils

Soil within the Former Operational Areas MRS consists of sandy and silty loams, loam, silt, sand, clay, gravel, rock outcropping, and glacial till (**Figure 3-12**). The main soil units consist of Rockaway sandy loams. The Rockaway sandy loam is coarse and ranges from stony to extremely stony. It is derived from granite and gneiss. The Rockaway sandy loam is typically well drained and does not meet hydric criteria. Other prominent units are Preakness dark surface variant sandy loams that are derived from coarse loamy outwash and Adrian Muck, which consist of organics over deposits of sand outwash (USDA, 2008). The Preakness sandy loam is typically well drained and does not meet hydric criteria, while the Adrian Muck is poorly drained and does meet hydric criteria. Soil unit descriptions are provided in **Appendix E**. As shown on **Figure 3-12,** twenty-nine soil units occur within the Former Operational Areas MRS. Across the MRS the soil varies from extremely stony (Rockaway sandy loam, extremely stony) to muck

(Adrian Muck).This difference in soil equates to a variance from well-drained soil (not meeting hydric criteria) to very poorly-drained soil (meeting hydric criteria) across the MRS.

3.6.4 Hydrology

Numerous streams, ponds, and wetlands are present throughout the Former Operational Areas MRS (**Figure 3-4)**. Waterbodies within this MRS include Stillwell Pond, 1400 Run, and portions of Green Pond Brook. The Former Operational Areas MRS, which is largely undeveloped, also has a significant amount of wetlands. AOI Site 20/24, in the southern portion of the MRS, consists of a cleared, reclaimed/filled wetland. In addition, a one-acre shallow pond referred to as Landfill Pond is located in the central portion of AOI Site 20/24.

3.6.5 Sensitive Environmental Resources within the MRS

As shown on **Figure 3-7,** the majority of the Former Operational Areas MRS is undeveloped and consists of deciduous forests, ponds, streams, and wetlands. Several sensitive species are known to inhabit this MRS, including the veery thrush (*Catharus fuscescens*), barred owl (*Strix varia*), and American woodcock (*Scolopax minor*). A habitat with at least one occurrence of a state-threatened species is present at the Former Operational Areas MRS according to NJDEP's i-Map Landscape Project layer (**Figure 3-6**) (NJDEP, 2011). A review of the Natural Heritage Database and Landscape Project (Version 3.1) was conducted by the New Jersey Natural Heritage Program in September 2012 as the result of a request made for the RI SLERA. Threatened, endangered, and special concern species were identified as occurring on the Former Operational Areas MRS, which is detailed further in Section 9.2.1.1.2.

3.6.6 Current and Projected Land Use

The Former Operational Areas MRS has approximately 320 building and is currently used for manufacturing, storage, testing, R&D, administration, recreation, parking lots, recreational areas, and portions of a golf course. Undeveloped areas are used for hunting (including the Waste Burial Area). AOI Site 20/24 is currently the site of a "safe haven" for trucks transporting explosives on interstate highways. According to Federal Highway Administration regulations, trucks transporting explosive materials are only permitted to make overnight stops at places designated as safe havens for that purpose. There are no known future land use changes for the Former Operational Areas MRS; however, there are both short-term and long-term development

and redevelopment plans for this MRS in accordance with the redevelopment plans for PTA, discussed in Section 3.1.10.

To support PTA's mission, the following various installation-wide construction projects are planned either for routine installation maintenance or under a variety of programs including Urgent Minor Military Construction Army and Military Construction Army. It is assumed that the majority of these projects will occur in downtown PTA, a portion of which is located within the Former Operational Areas MRS (Picatinny Arsenal, 2012b).

- Demolition of approximately 220 buildings throughout the installation
- Construction of numerous new buildings throughout the installation
- Some other general improvements (e.g., pave roads, add curbs, improve parking lots)
- Replacement of the service water distribution system

3.7 LAKES MRS (PICA-008-R-01)

3.7.1 Location

Figure 1-9 presents the location of the Lakes MRS, which is noncontiguous to account for both Picatinny Lake and Lake Denmark. Both lakes are combined in one MRS because of similarities in their CSMs.

3.7.2 Picatinny Lake

3.7.2.1 Topography

Picatinny Lake is a man-made lake situated at the base of the southeastern ridgeline of Green Pond Mountain (**Figure 1-10)**. Topography of the area around the lake slopes sharply from ridges to the northwest and southeast into the valley floor where the lake is situated. Picatinny Lake is at an elevation of approximately 720 feet amsl.

3.7.2.2 Soils

Soil in the area around Picatinny Lake consists of sandy loams that are very stony and what is classified as urban land (**Figure 3-13**). Flare Island is a manmade peninsula constructed from coal slag that has very little soil. The primary soil unit is the Rockaway Sandy Loam, very stony, which is typically well drained and does not meet hydric criteria. Soil unit descriptions are

provided in **Appendix E.**

3.7.2.3 Hydrology

Picatinny Lake receives water from Lake Denmark and Green Pond via Green Pond Brook. Picatinny Lake flows out over a spillway into Green Pond Brook. The 1995 bathymetric survey of Picatinny Lake indicated that the depth at its shallowest point in the northern portion is 5 feet, with an increase up to 12 feet near the dam and spillway at the southern end of the lake (Malcolm Pirnie, 2008).

3.7.2.4 Sensitive Environmental Resources within the MRS

Picatinny Lake is considered an open-water wetland. The northern end of Picatinny Lake is dominated by scrub/shrub wetland with smooth alder (*Alnus serrulata)* and swamp azalea *(Rhodendron viscosum).* Ecological receptors known to be present at the Lakes MRS include fish, birds (including waterfowl, wading birds, piscivorous birds, songbirds, and raptors), reptiles, amphibians, and mammals. The north end of Picatinny Lake contains a culturally sensitive area shown on **Figure 3-6** and detailed in Section 3.1.8.

3.7.2.5 Current and Projected Land Use

Picatinny Lake is used for boating and fishing; however, fish consumption advisories are in effect due to elevated contaminant levels in fish tissue. No wading, swimming, or scuba diving is permitted. Picatinny Lake is also used as a source of non-potable water (i.e., process water and fire protection). Surrounding the lake are many active, inactive, and/or demolished buildings. Some of the buildings are, or were, used as chemical, betatron, and x-ray laboratories or for munitions R&D, production, and storage. A steam and electric power generating plant (Bldg. 506) is at the south end of the lake. There are no current plans to change the land use.

3.7.3 Lake Denmark Area

3.7.3.1 Topography

Lake Denmark is a man-made lake with associated scrub/shrub wetlands situated at the base of the southern ridgeline of Copperas Mountain at an elevation of approximately 850 feet amsl (**Figure 1-11**). The eastern slopes of the mountain are steep.

3.7.3.2 Soils

The thickness of surficial deposits on the western shore of Lake Denmark is expected to be less than 10 feet. Sediment at Lake Denmark and the associated scrub/shrub wetlands consist of post-glacial alluvium that contains silts and clay, muck, and peat. The three major soil units are Rockaway sandy loam, stony Hibernia loam, and the extremely stony Ridgebury loam (USDA, 2008) (**Figure 3-14**). The Rockaway sandy loam is typically well drained and does not meet hydric criteria. The Hibernia loam is somewhat poorly drained and does not meet hydric criteria, while the Ridgebury loam is poorly drained and meets hydric criteria. Soil unit descriptions are provided in **Appendix E**. As shown on **Figure 3-14**, ten units occur within the Lake Denmark portion of the Lakes MRS. Across the MRS the soil varies from extremely stony (Rockaway sandy loam, extremely stony) to muck (Carlisle Muck). This difference in soil equates to a variance from well-drained soil (not meeting hydric criteria) to very poorly-drained soil (meeting hydric criteria) across the MRS.

3.7.3.3 Hydrology

Lake Denmark is fed by Burnt Meadow Brook, which enters from the north. Scrub/shrub wetlands are present on the northern portion of the lake. The outfall from Lake Denmark flows southwest into Picatinny Lake via Green Pond Brook. The depth of Lake Denmark averages 6.5 feet (Malcolm Pirnie, 2008).

3.7.3.4 Sensitive Environmental Resources within the MRS

The northern portion of Lake Denmark is dominated by scrub/shrub wetland with smooth alder (*Alnus serrulata)* and swamp azalea *(Rhodendron viscosum).* Undeveloped forest surrounds the lake with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present at the Lakes MRS include fish, birds (i.e., waterfowl, wading birds, piscivorous birds, songbirds, and raptors), reptiles, amphibians, and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, featherfoil (*Hottonia inflate*), Robbin's pondweed (*Potamogeton robbinsii*), small bur (*Sparganium minimum*), and lesser bladderwort (*Utricularia minor).* Lake Denmark is located adjacent to Area J, which is a summer roosting area for the federally endangered Indiana bat. Gravel Dam Cove, located in the southern end of Lake Denmark, is a unique pond habitat that supports breeding populations of the New England bluet, a rare damselfly (Malcolm Pirnie, 2008).

3.7.3.5 Current and Projected Land Use

Lake Denmark is used for boating and fishing; however, fish consumption advisories are in effect due to elevated contaminant levels. No wading, swimming, or scuba diving is permitted. Explosive storage magazines in the 1200 series are along the northwestern shoreline and three public service electric and gas utility towers are along the northern boundary of the Lake Denmark portion of the Lakes MRS. The towers are located in the PSE&G utilities right-of-way crosses the north end of the MRS from west-northwest to east-southeast. Near the southwestern portion of Lake Denmark (near the firing points shown on **Figure 1-12**) is a dam, the 1200A and S-1200 Buildings and a softball field. The southeastern portion of the Lake Denmark portion of the Lakes MRS is undeveloped. There are no current plans to change the land use.

3.8 LAKE DENMARK – OFF-POST MRS (PICA-012-R-01)

3.8.1 Location

Figure 1-13 depicts the location of the Lake Denmark – Off-Post MRS, which accounts for the remainder of the SDZ area for former range activities on Lake Denmark that falls outside the PTA boundary.

3.8.2 Topography

The Lake Denmark – Off-Post MRS is located directly adjacent to Lake Denmark which is a man-made lake with associated scrub/shrub wetlands situated at the base of the southern ridgeline of Copperas Mountain at an elevation of approximately 850 feet amsl (Malcolm Pirnie, 2008). Only a small portion of Lake Denmark (an unnamed cove) is located within the off-post MRS. The Lake Denmark – Off-Post MRS has an approximate elevation of 800 feet amsl to 880 feet amsl (**Figure 3-1**) with Palustrine forested, broad-leaved deciduous wetlands (**Figure 3-4** and **3-5**).

3.8.3 Soils

The Lake Denmark – Off-Post MRS is located directly adjacent to Lake Denmark and sediment at Lake Denmark and the associated scrub/shrub wetlands consist of post-glacial alluvium that contains silts and clay, muck, and peat. The four soil units at the Lake Denmark – Off-Post MRS consist of the very stony Rockaway sandy loam, the extremely stony Rockaway Sandy Loam, the stony Hibernia loam, and the extremely stony Ridgebury loam (**Figure 3-15**). Soil unit

descriptions are provided in **Appendix E.** The Rockaway sandy loam (stony and extremely stony) is typically well drained and does not meet hydric criteria. The Hibernia loam is somewhat poorly drained and does not meet hydric criteria, while the Ridgebury loam is poorly drained and meets hydric criteria. Soil unit descriptions are provided in **Appendix E**. No scrub/shrub wetlands are known to be present at the MRS, however Palustrine forested, broad-leaved deciduous wetlands (**Figure 3-4** and **3-5**) are present.

3.8.4 Hydrology

3.8.4.1 Surface Water

The Lake Denmark – Off-Post MRS is located adjacent to Lake Denmark, with a small cove extending into the MRS. Several palustrine forested, broad-leaved deciduous wetlands have been identified within the Lake Denmark – Off-Post MRS, shown on **Figures 3-4** and **3-5**.

3.8.4.2 Groundwater

At the Lake Denmark – Off-Post MRS two aquifers are present; an unconfined glacial (glacial sediment and saprolite) aquifer and a bedrock aquifer. The unconfined glacial aquifer exists primarily in the western side of the MRS and is directly underlain by the deeper (granitic bedrock) aquifer. The bedrock aquifer exists across the entire MRS and in some locations is the only aquifer present. Although identified separately, these aquifers are hydraulically connected to each other such that they function as a single groundwater system, as evidenced by their similar groundwater flow patterns and comparable permeabilities. Both aquifers have a low permeability such that they may be classified as low-yielding aquifers that can act as aquitards. Groundwater flows in both aquifers to the west toward Lake Denmark, with Lake Denmark being a groundwater discharge point for the unconfined glacial aquifer. Based on topography the deeper bedrock aquifer could discharge into Lake Denmark or potentially under the lake and onto PTA (CRA, 2010).

3.8.5 Sensitive Environmental Resources within the MRS

Based on the site walk conducted for the SI, the vegetation at the Lake Denmark – Off-Post MRS includes wetlands and mostly undeveloped, forested areas around the lake. The dominant canopy forest species are in the red oak subgroup, which contains red oak (*Quercus rubra*), black oak (*Q. velutina*), and scarlet oak (*Q. coccinea*). In addition, according to NJDEP's i-Map website,

Palustrine forested, broad-leaved deciduous wetlands are present throughout the Lake Denmark – Off-Post MRS (**Figure 3-5**) (NJDEP, 2011).

3.8.6 Current and Projected Land Use

The Lake Denmark – Off-Post MRS is either forested or contains buildings associated with on-going operations at the RTI Superfund Site. Sterigenics currently leases the RTI facility and is used as a gamma facility that provides sterilization and ionization services for the healthcare, food safety, and advance application industries. Field activities include intrusive and non-intrusive investigations. There are no current plans to change the land use (Malcolm Pirnie, 2008).

3.9 INACTIVE MUNITIONS WASTE PIT MRS (PICA-013-R-01)

3.9.1 Location

Figure 1-14 presents the location of the Inactive Munitions Waste Pit MRS.

3.9.2 Topography

The Inactive Munitions Waste Pit MRS is located approximately 1,175 feet amsl and is relatively flat to sloping. The MRS slopes generally from the northwest (PTA boundary) towards the southeast.

3.9.3 Soils

Soil units at the Inactive Munitions Waste Pit MRS consist of the Rockaway sandy loam and Rock Outcrop associations (**Figure 3-16**), which are deep, well to moderately well drained, stony sandy loams and do not meet hydric criteria. Soil unit descriptions are provided in **Appendix E.**

3.9.4 Hydrology

No water bodies or wetlands exist within the Inactive Munitions Waste Pit MRS.

3.9.5 Sensitive Environmental Resources within the MRS

The Inactive Munitions Waste Pit MRS consists of an open area used to store fill/debris that is surrounded by forested areas, including some shrubby habitat. NJDEP's i-Map Landscape Project layer indicates the Inactive Munitions Waste Pit MRS contains habitat with at least one occurrence of a state-threatened species (**Figure 3-6**) (NJDEP, 2011).

3.9.6 Current and Projected Land Use

The Inactive Munitions Waste Pit MRS is a non-operational area on PTA that acts as a buffer between active ranges. The former testing area at the center of the MRS is currently being used as a storage space for vehicles and fill/gravel and other rubble piles. There are no planned land use changes for the Inactive Munitions Waste Pit MRS.

3.10 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS (PICA-014-R-01)

3.10.1 Location

Figure 1-15 presents the location of the Inactive Munitions Waste Pit – Off-Post MRS. The MRS footprint falls within the 1,250 SDZ of the Inactive Munitions Waste Pit MRS.

3.10.2 Topography

The Inactive Munitions Waste Pit – Off-Post MRS consists of steep and mountainous terrain. The MRS slopes generally from the northeast (PTA boundary) towards the northwest.

3.10.3 Soils

Soils at the Inactive Munitions Waste Pit – Off-Post MRS consist of the Rockaway and Rock Outcrop associations, which are deep, well to moderately well-drained, stony sandy loams and do not meet hydric criteria (**Figure 3-16)**. Soil unit descriptions are provided in **Appendix E.**

3.10.4 Hydrology

3.10.4.1 Surface Water

No water bodies or wetlands exist within the Inactive Munitions Waste Pit – Off-Post MRS.

3.10.4.2 Groundwater

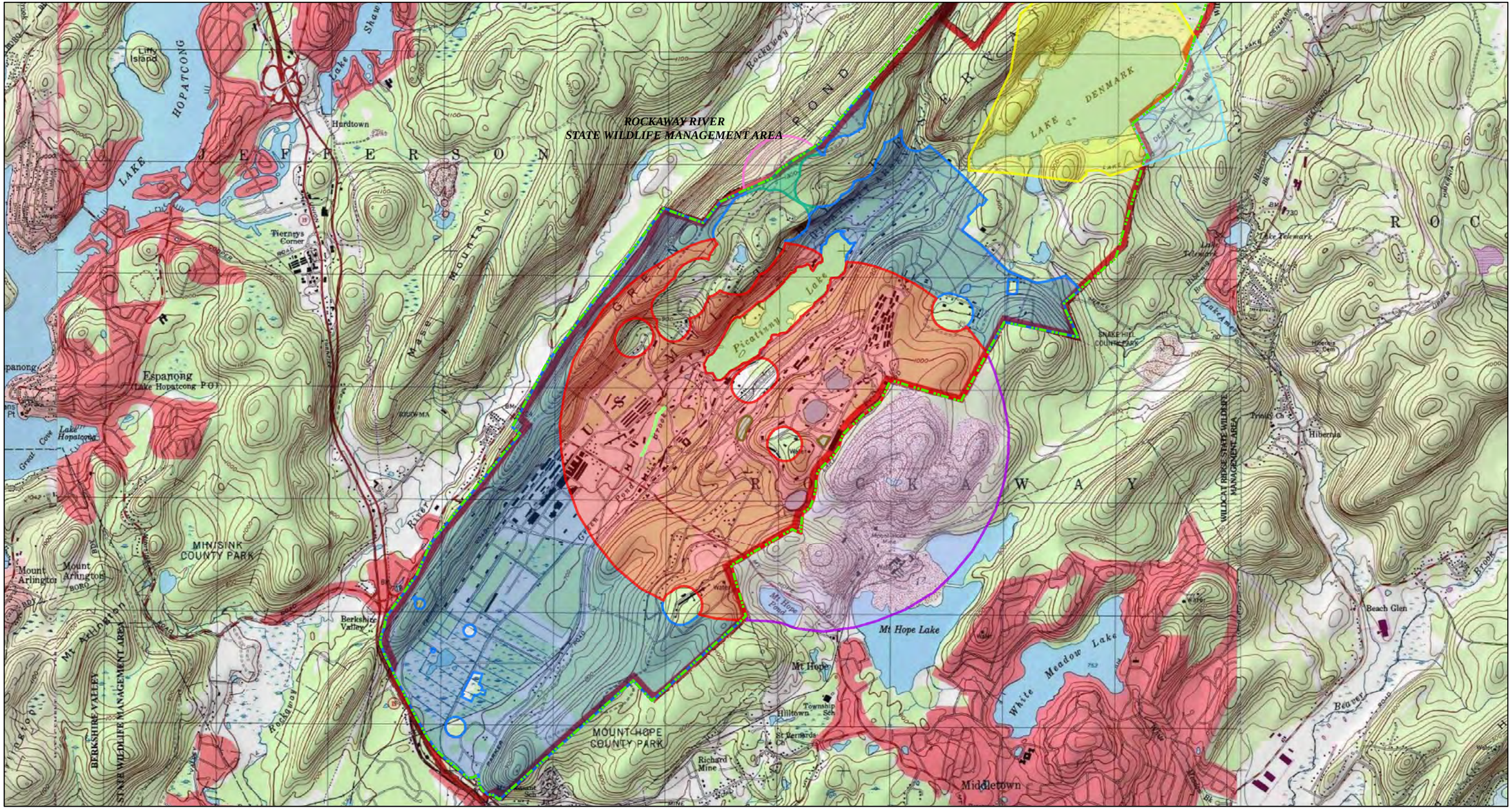
Due to proximity to PTA it is assumed that general information about PTA groundwater is applicable to the Inactive Munitions Waste Pit – Off-Post MRS. Additional details regarding PTA's groundwater is presented in Section 3.1.6.2. In the MRS, due to topography the groundwater in the Inactive Munitions Waste Pit MRS it is assumed that shallow groundwater flows to the northwest (off PTA) while groundwater flow in the bedrock complex depends on the fractures present.

3.10.5 Sensitive Environmental Resources within the MRS

The Inactive Munitions Waste Pit – Off-Post MRS consists of steep, mountainous terrain located within the Highlands Preservation Area and the Rockaway River State Wildlife Management Area. A habitat with at least one occurrence of a state-threatened species is present at the Inactive Munitions Waste Pit – Off-Post MRS, according to NJDEP's i-Map Landscape Project layer (**Figure 3-6**) (NJDEP, 2011).

3.10.6 Current and Projected Land Use

The Inactive Munitions Waste Pit – Off-Post MRS is currently undeveloped and is designated as a Wildlife Management Area. There are no planned land use changes for the Inactive Munitions Waste Pit – Off-Post MRS.



Legend

- Installation Boundary
- **Military Response Sites**
- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds
- USGS Quad Arsenal Boundary

NOTES:
Source: ESRI US topo maps Service, National Geographic Society, i-cubed, 2009

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 2,750 5,500 Feet

0 680 1,360 2,040 Meters

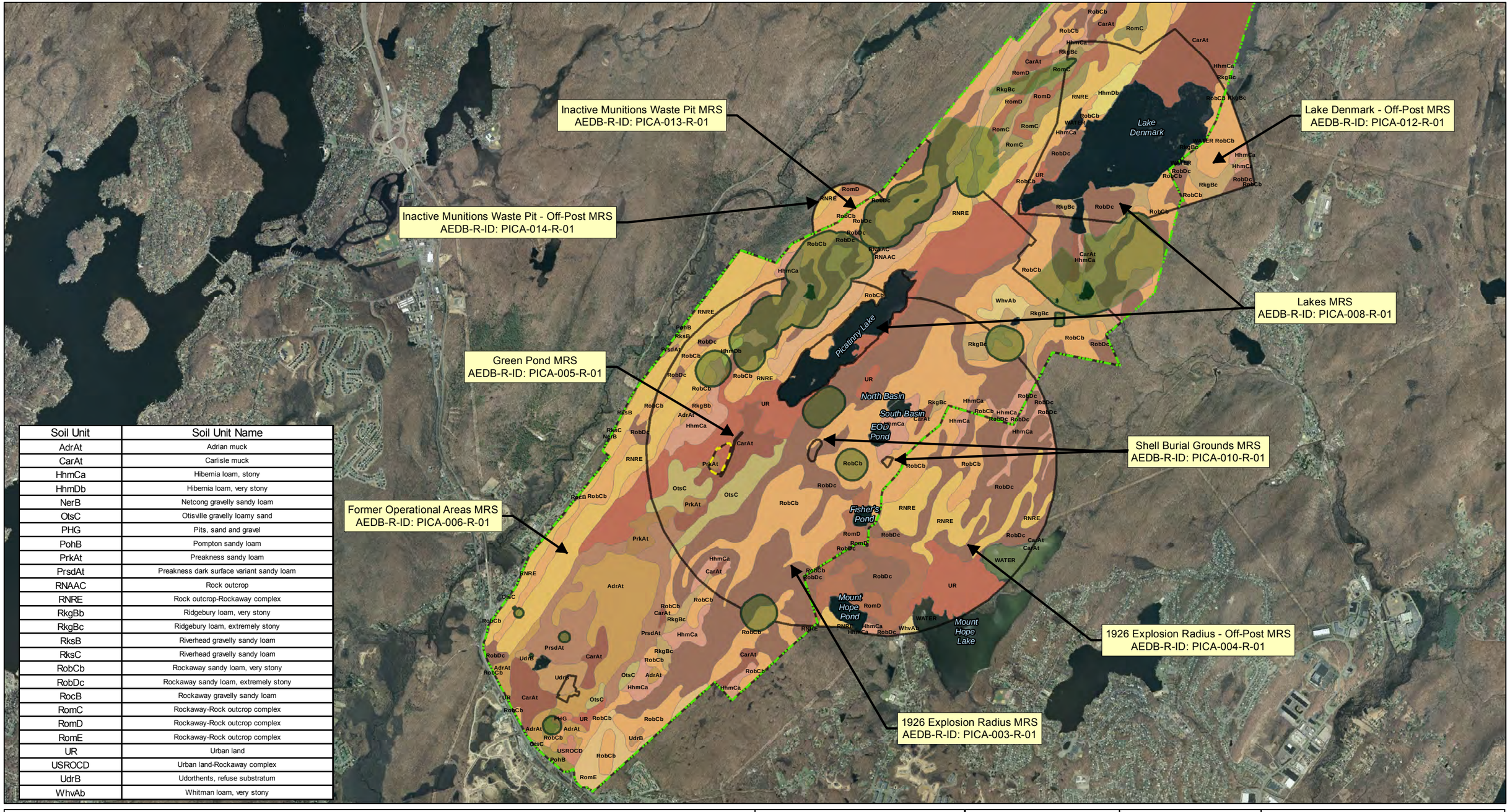
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-1
Picatinny Arsenal Topography

12/2/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\USGS_topography.mxd



Soil Unit	Soil Unit Name
AdrAt	Adrian muck
CarAt	Carlisle muck
HhmCa	Hibernia loam, stony
HhmDb	Hibernia loam, very stony
NerB	Netcong gravelly sandy loam
OtsC	Otisville gravelly loamy sand
PHG	Pits, sand and gravel
PohB	Pompton sandy loam
PrkAt	Preakness sandy loam
PrsdAt	Preakness dark surface variant sandy loam
RNAAC	Rock outcrop
RNRE	Rock outcrop-Rockaway complex
RkgBb	Ridgebury loam, very stony
RkgBc	Ridgebury loam, extremely stony
RksB	Riverhead gravelly sandy loam
RksC	Riverhead gravelly sandy loam
RobCb	Rockaway sandy loam, very stony
RobDc	Rockaway sandy loam, extremely stony
RocB	Rockaway gravelly sandy loam
RomC	Rockaway-Rock outcrop complex
RomD	Rockaway-Rock outcrop complex
RomE	Rockaway-Rock outcrop complex
UR	Urban land
USROCD	Urban land-Rockaway complex
UdrB	Udorthents, refuse substratum
WhvAb	Whitman loam, very stony

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Former DRMO Yard

Soils

AdrAt, CarAt, HhmCa, HhmDb, NerB, OtsC, PHG, PohB, PrkAt, PrsdAt, RNAAC, RNRE, RkgBb, RkgBc, RksB, RksC, RobCb, RobDc, RocB, RomC, RomD, RomE, UR, USROCD, UdrB, WhvAb

Map Unit Descriptions are provided in Appendix E

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Picatinny Arsenal
Morris County,
New Jersey

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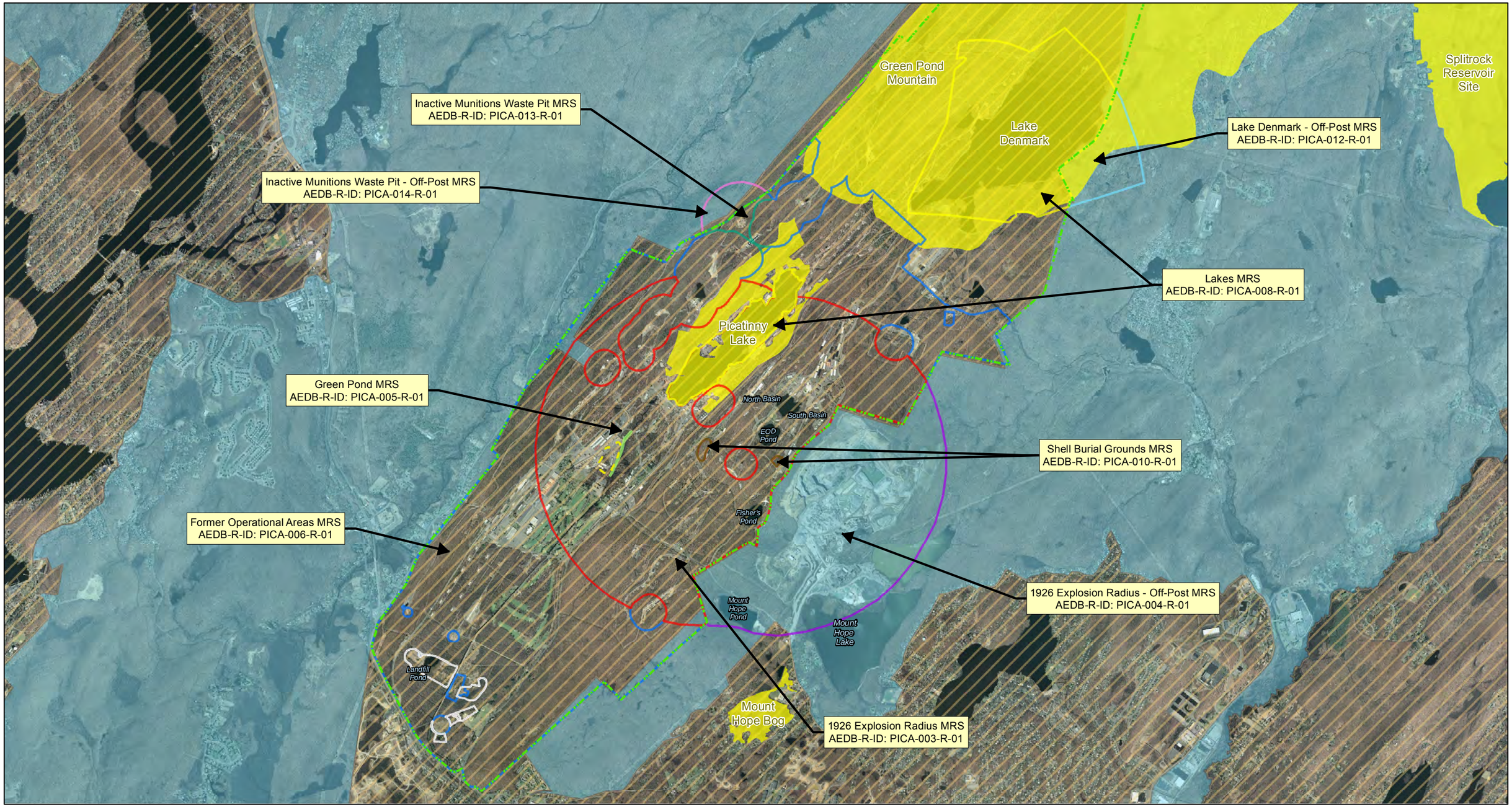
Figure 3-2
Picatinny Arsenal Soil Series

12/2/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Soils.mxd



Legend

- Installation Boundary
- Former DRMO Yard
- National Heritage Priority Sites
- Highlands Planning Area
- Highlands Preservation Area

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds

Mount Hope Bog — National Heritage Priority Sites ID

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

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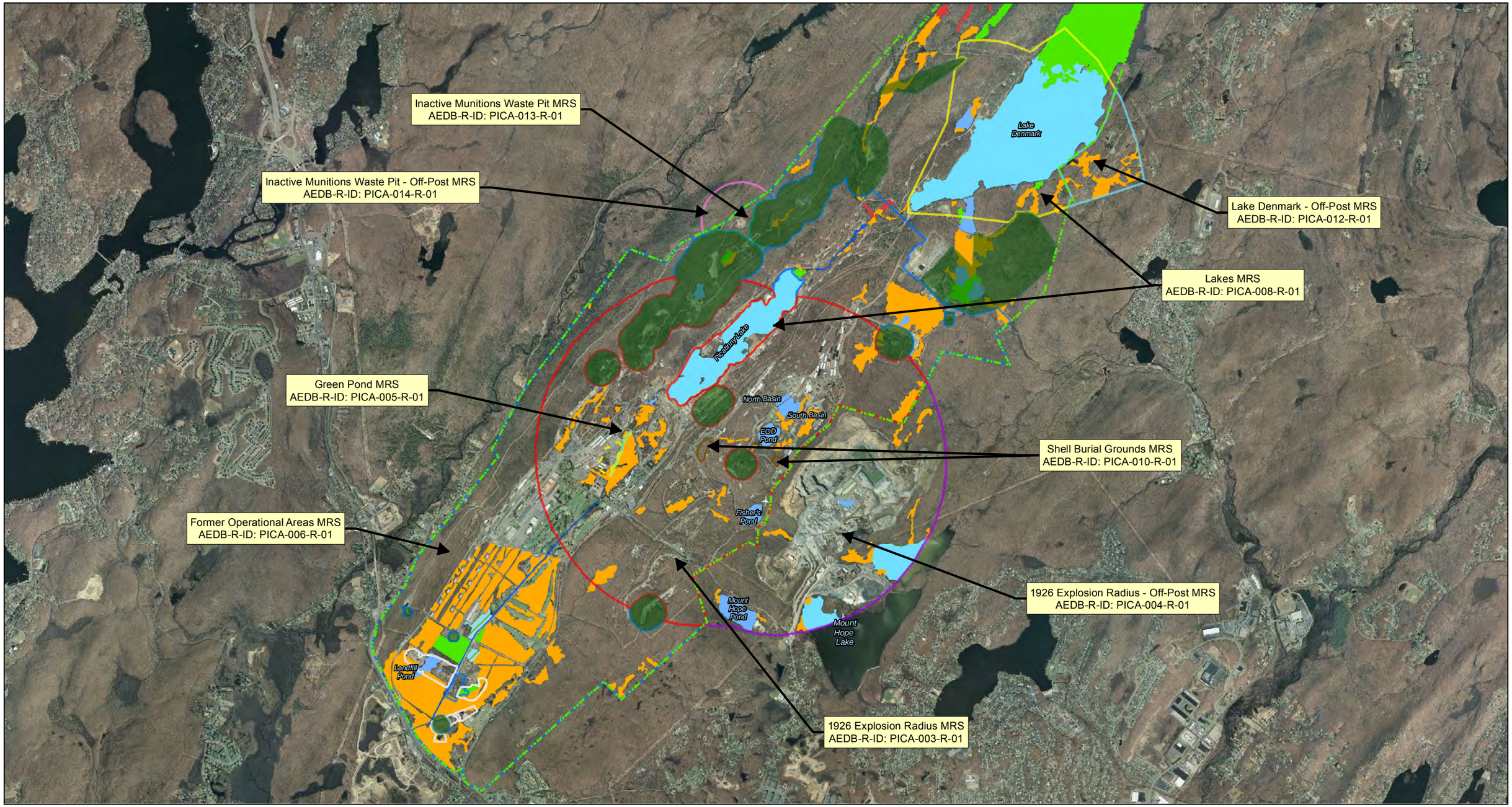
Figure 3-3
National Heritage Priority Sites and Highland Preservation Areas

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Nat_Heritage.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds

National Wetland Inventory

- Lake
- Freshwater Pond
- River/Stream
- Palustrine Emergent Wetlands
- Palustrine Forested, Broad-Leaved Deciduous Wetlands
- Palustrine Forested, Needle-Leaved Evergreen Wetlands
- Palustrine Schrub-Shrub Wetlands

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

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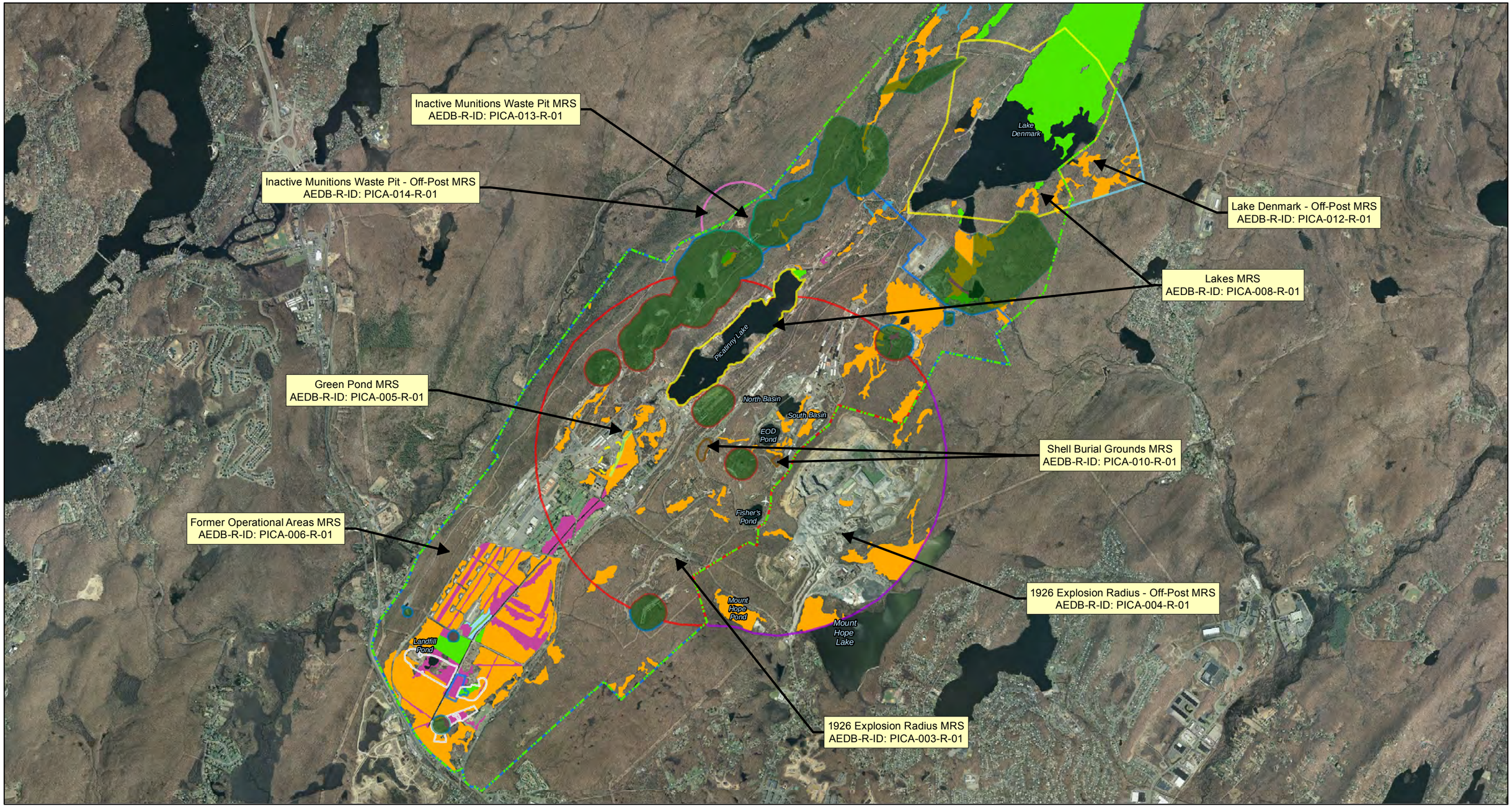
Verified By: NAS
Approved By: RSS

Figure 3-4
National Wetland Inventory Distribution

10/15/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\NWI_Distribution.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds

New Jersey Wetland Classification

- Disturbed/Managed/Modified Wetlands
- Palustrine Forested, Broad-Leaved Deciduous Wetlands
- Palustrine Emergent Wetlands
- Palustrine Forested, Needle-Leaved Evergreen Wetlands
- Palustrine Scrub-Shrub Wetlands

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

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Approved By: RSS

Figure 3-5
New Jersey State Wetland Distribution

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

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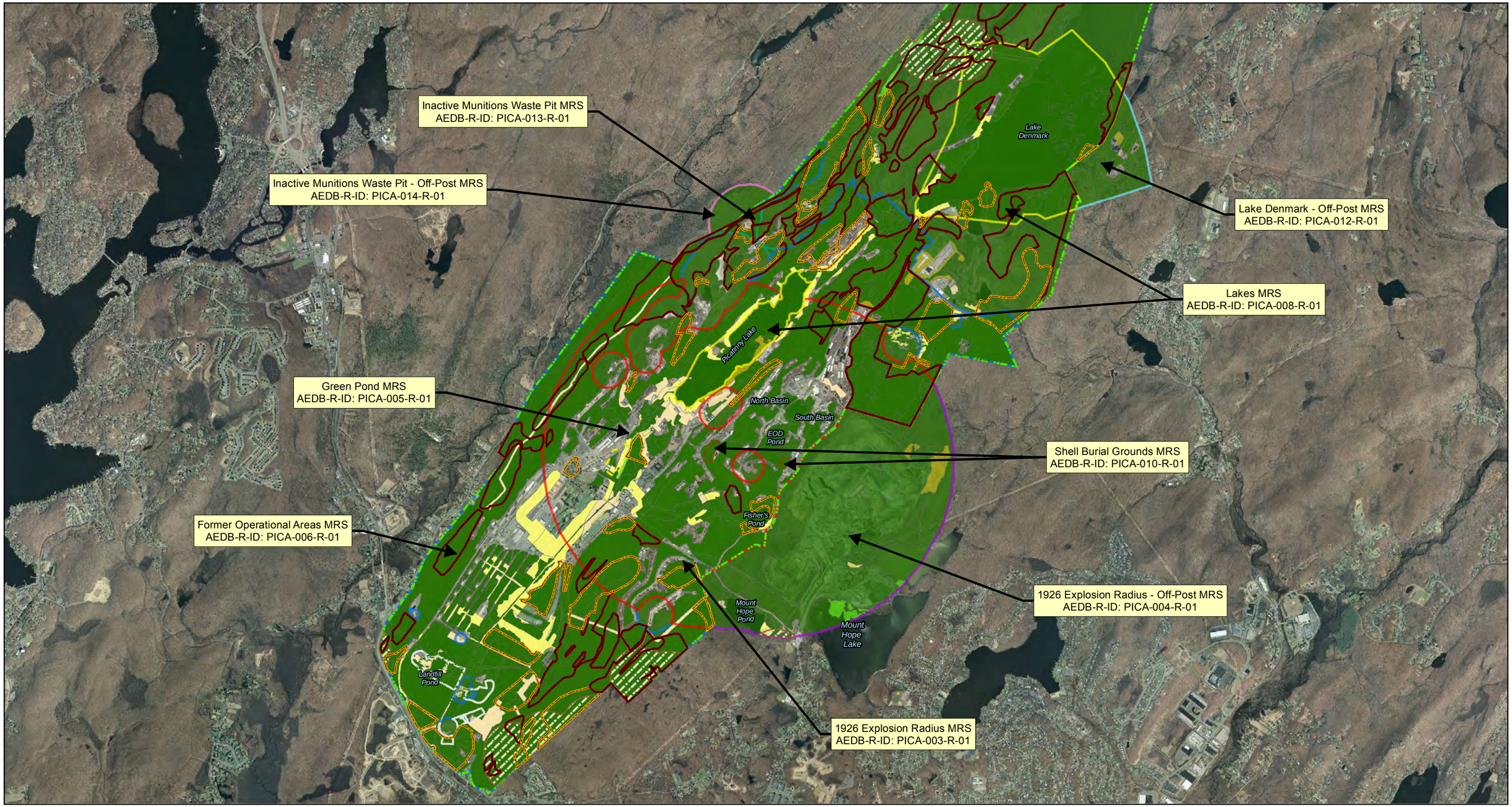

Legend

- Installation Boundary
- Former DRMO Yard

Cultural Survey Area

- Sensitive
- Sensitive - Possibly Disturbed
- Potential vernal habitat area
- Vernal habitat area

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds
- Rank 1 - Habitat Specific Requirements
- Rank 2 - Special Concern
- Rank 3 - State Threatened
- Rank 4 - State Endangered
- Rank 5 - Federally Listed

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-6
Species Habitats

10/15/2013

Contract # W912DR-09-D-0006
DO 0002

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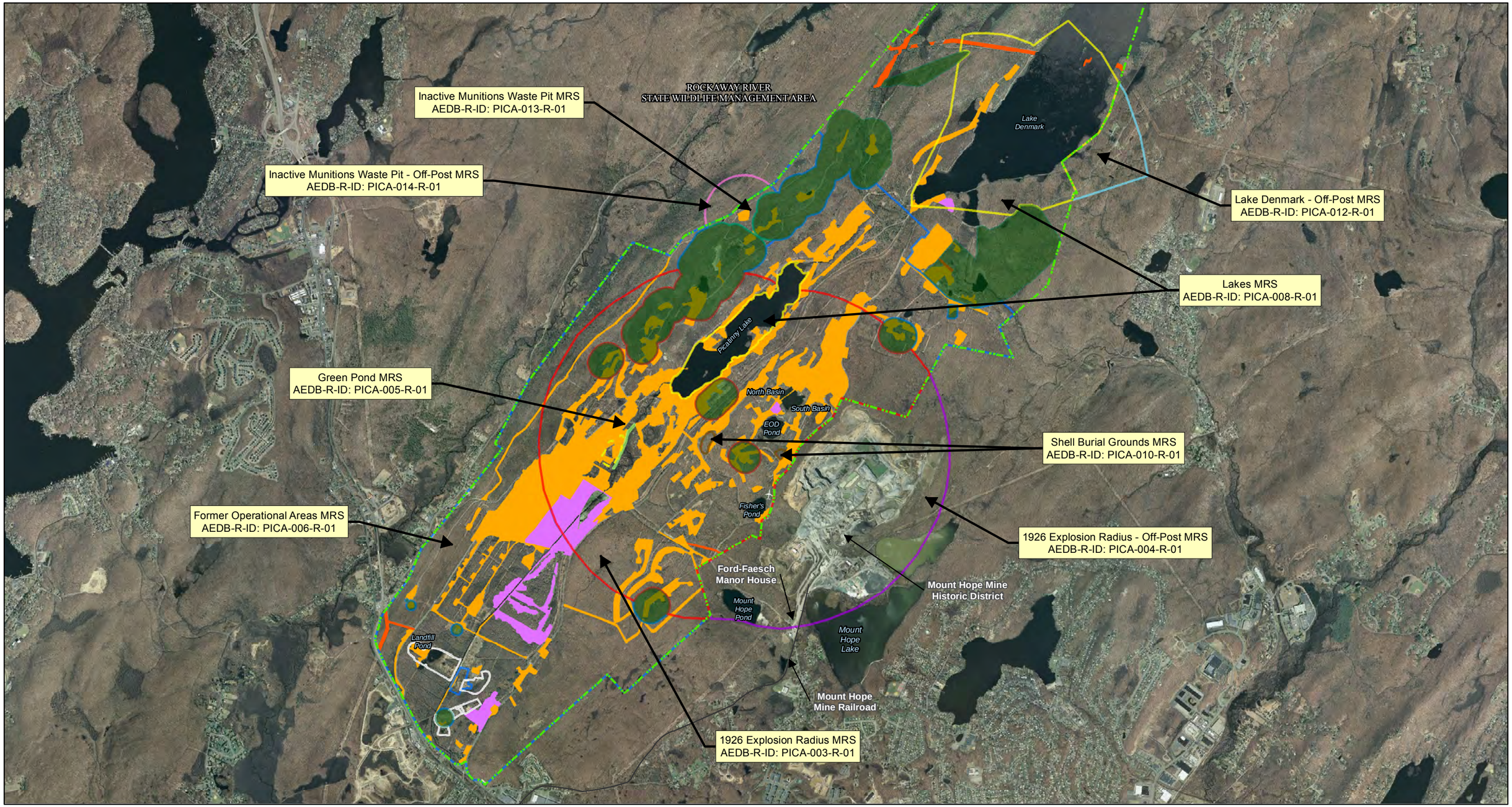

Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds
- Railroad

Land Use

- Developed-Military/Other Urban
- Developed-Residential
- Recreational
- Rights Of Way/ Exposed Rocks

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 3,000 6,000 Feet

0 750 1,500 2,250 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

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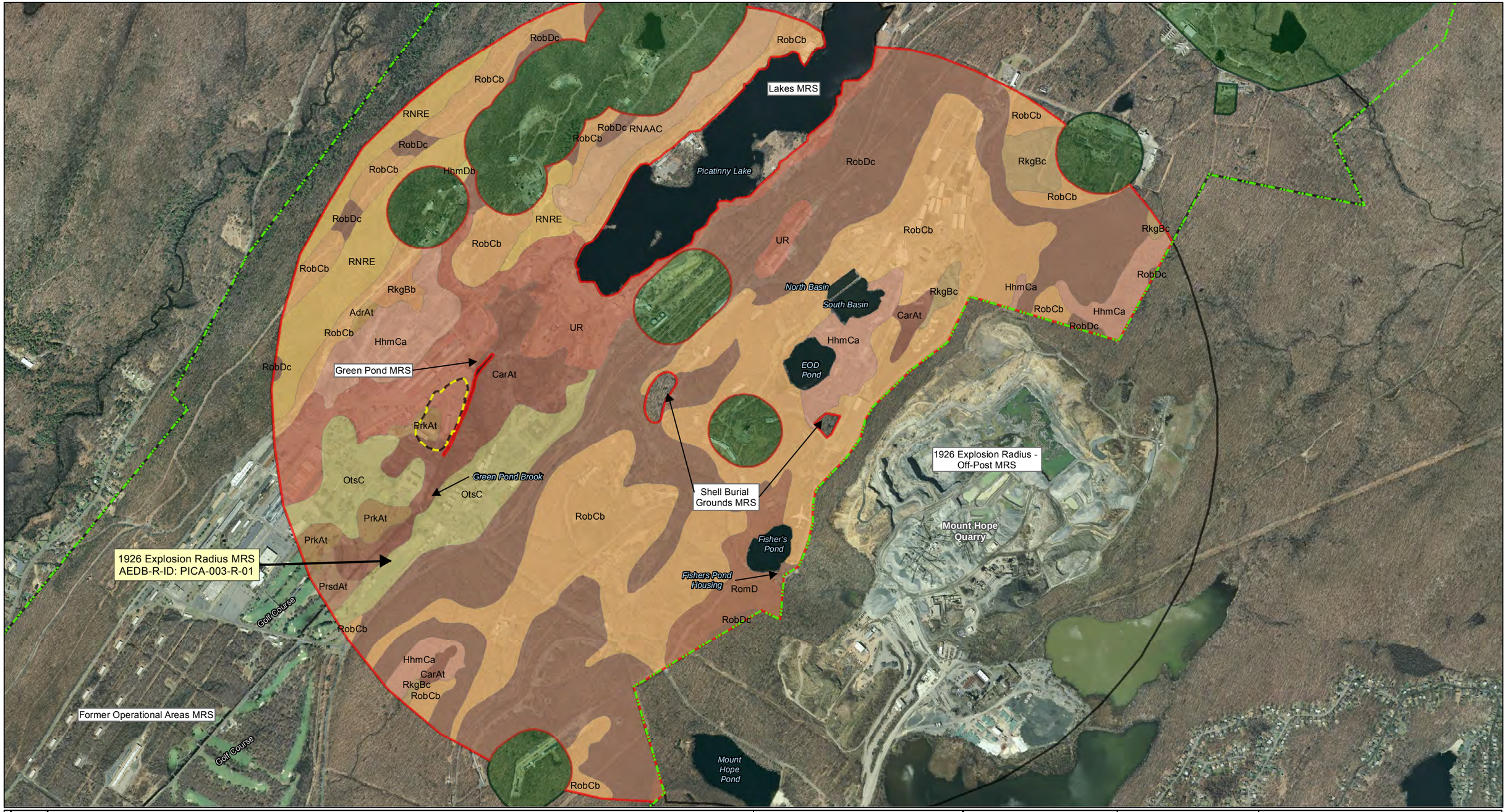
Verified By: NAS
Approved By: RSS

Figure 3-7
Land Use Distribution Map

10/18/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Landuse.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- 1926 Explosion Radius
- Former DRMO Yard

AdrAt	PrkAt	RkgBc
CarAt	PrsdAt	RobCb
HhmCa	RNAAC	RobDc
HhmDb	RNRE	RomD
OtsC	RkgBb	UR

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 1,300 2,600 Feet

0 320 640 960 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-8
1926 Explosion Radius MRS PICA-003-R-01 Soil Series

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

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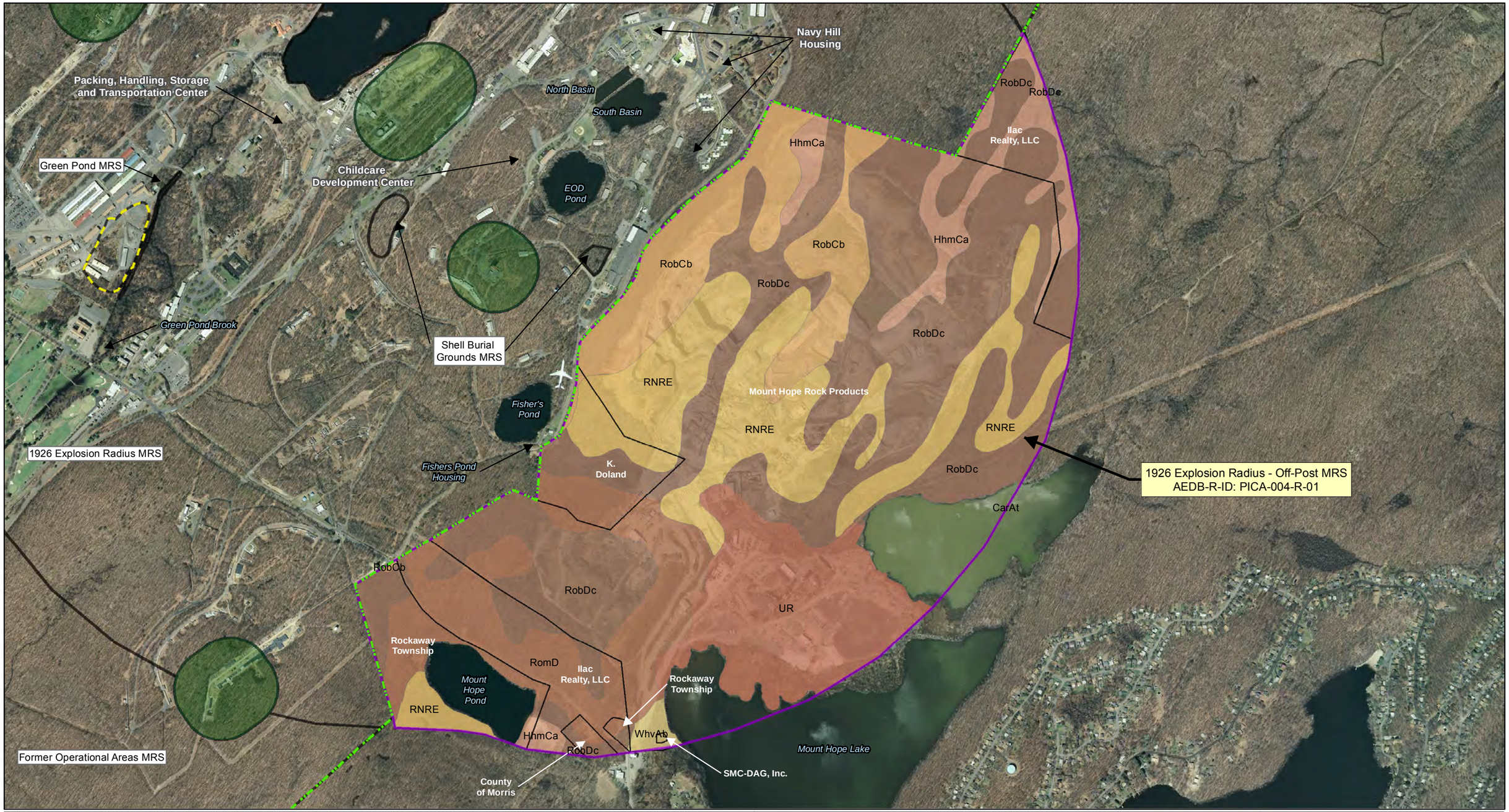

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- 1926 Explosion Radius - Off-Post
- Former DRMO Yard
- Current Property Boundaries
- CarAt
- HhmCa
- RNRE
- RobCb
- RobDc
- RomD
- UR
- WhvAb

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,050 2,100 Feet

0 260 520 780 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-9
1926 Explosion Radius - Off Post MRS
PICA-004-R-01 Soil Series

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

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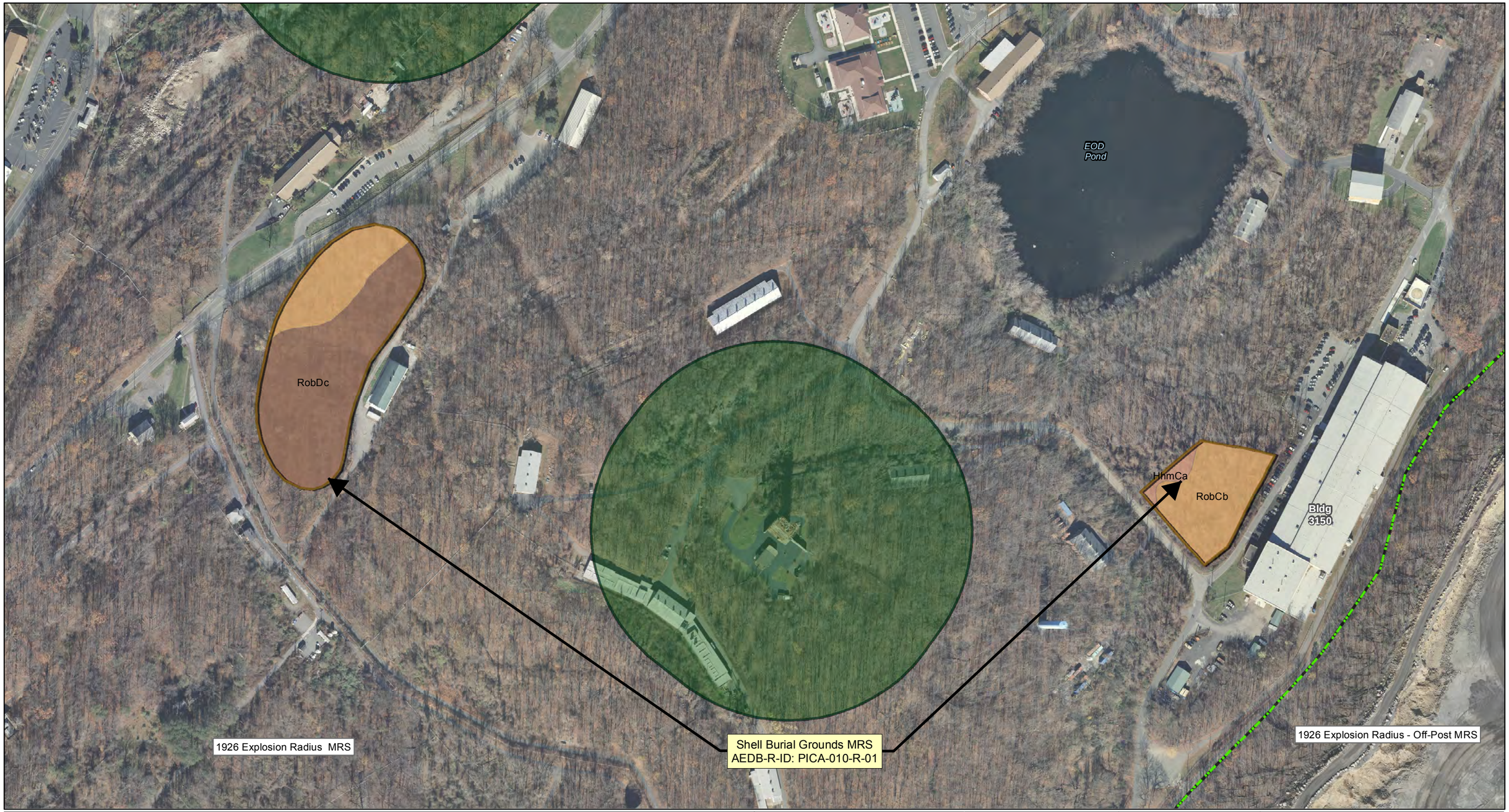

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Shell Burial Grounds
- Areas of Interest
- HhmCa
- RobCb
- RobDc

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 250 500 Feet

0 60 120 180 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-10
Shell Burial Grounds MRS
PICA-010-R-01 Soil Series

12/2/2013

Contract # W912DR-09-D-0006
DO 0002

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Legend

- Installation Boundary
- Green Pond MRS
- Former DRMO Yard
- CarAt
- PrkAt
- UR

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 200 400 Feet

0 70 140 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-11
Green Pond MRS and
Former DRMO Yard
PICA-005-R-01 Soil Series

12/2/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

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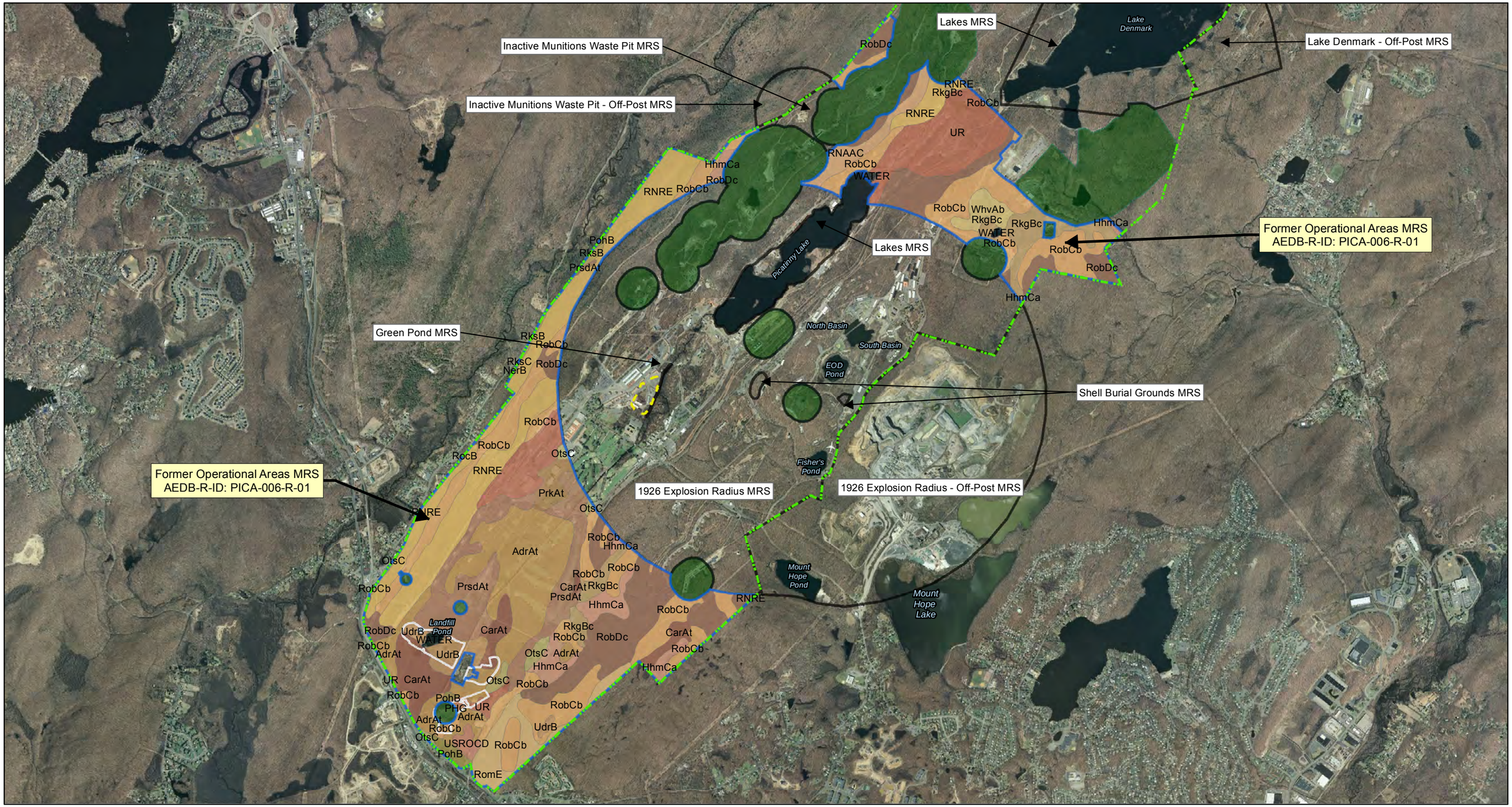

Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard
- Former Operational Areas
- Munitions Response Sites

AdrAt, CarAt, HhmCa, NerB, OtsC, PHG, PohB, PrkAt, PrsdAt, RNAAC, RNRE, RkgBb, RkgBc, RksB, RksC, RobCb, RobDc, RocB, RomD, RomE, UR, USROCD, UdrB, WhvAb

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 2,500 5,000 Feet

0 625 1,250 1,875 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-12
Former Operational Areas MRS
PICA-006-R-01 Soil Series

12/2/2013

Contract # W912DR-09-D-0006
DO 0002

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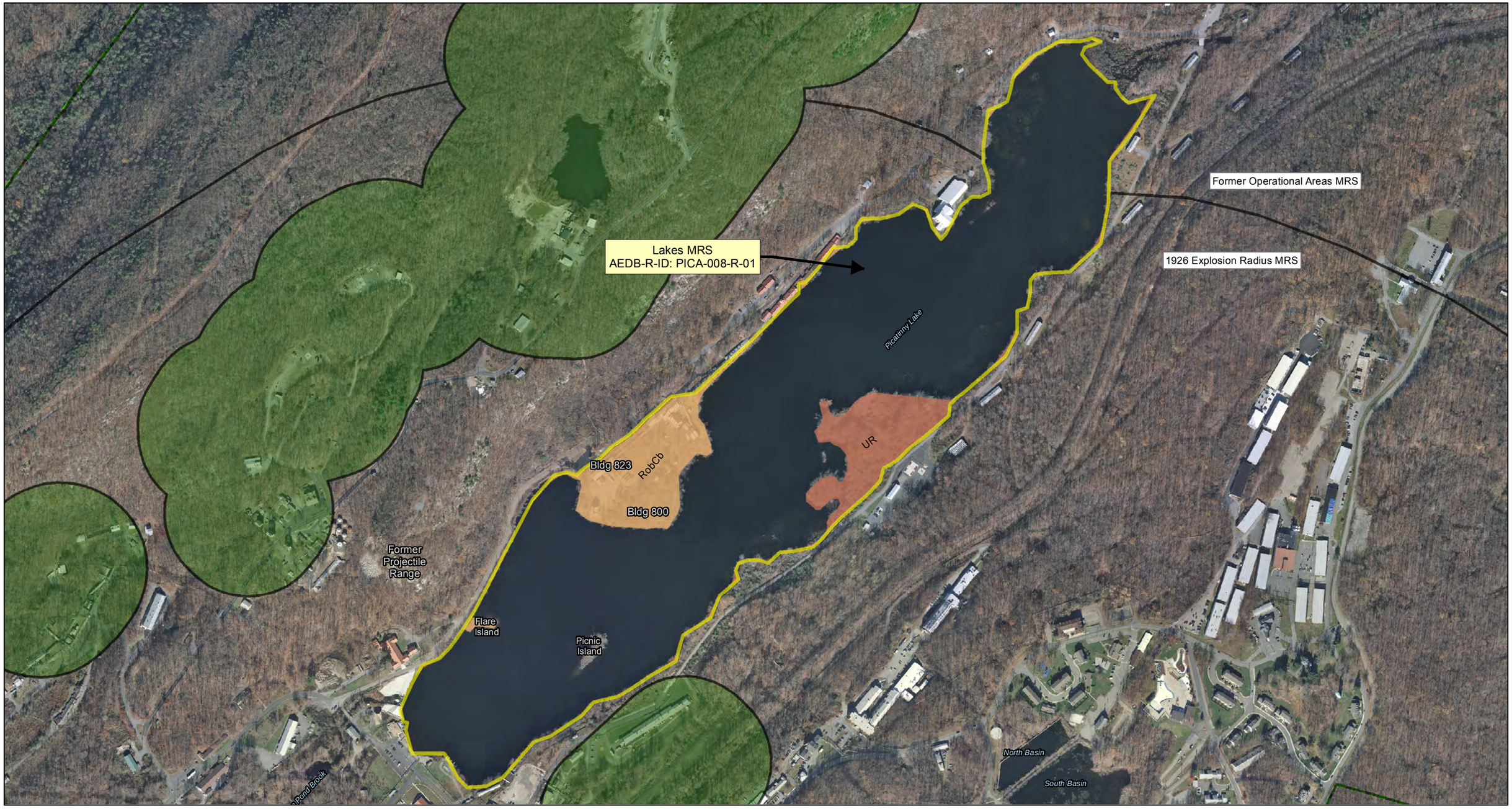

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- RobCb
- UR

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 550 1,100 Feet

0 130 260 390 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-13
Lakes MRS -
Picatinny Lake Portion
PICA-008-R-01 Soil Series

12/2/2013

Contract # W912DR-09-D-0006
DO 0002

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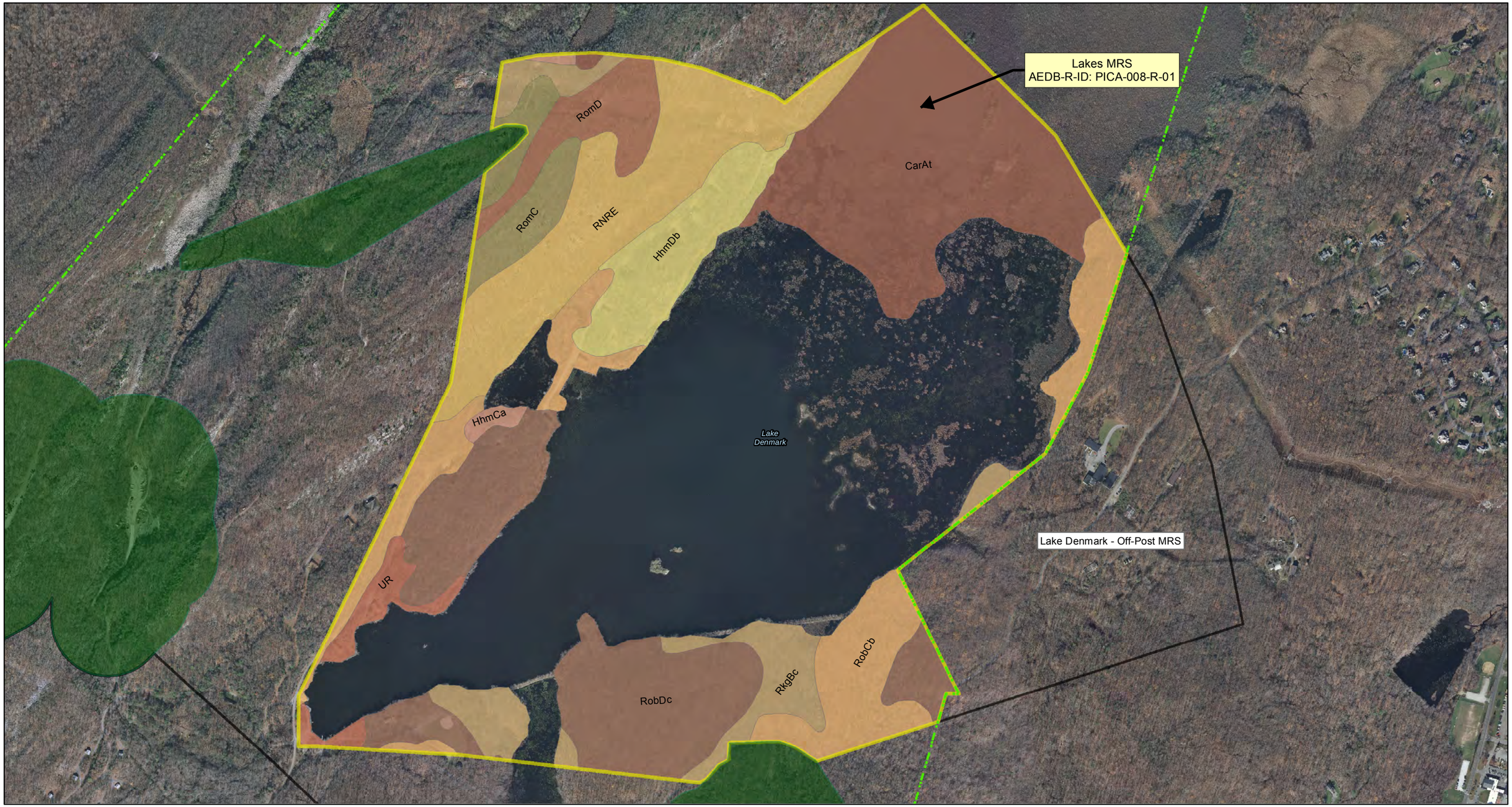

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS

CarAt, HhmCa, HhmDb, RNRE, RkgBc, RobCb, RobDc, RomC, RomD, UR

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

N

0 750 1,500 Feet

0 260 520 Meters

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-14
Lakes MRS -
Lake Denmark Portion
PICA-008-R-01 Soil Series

12/2/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

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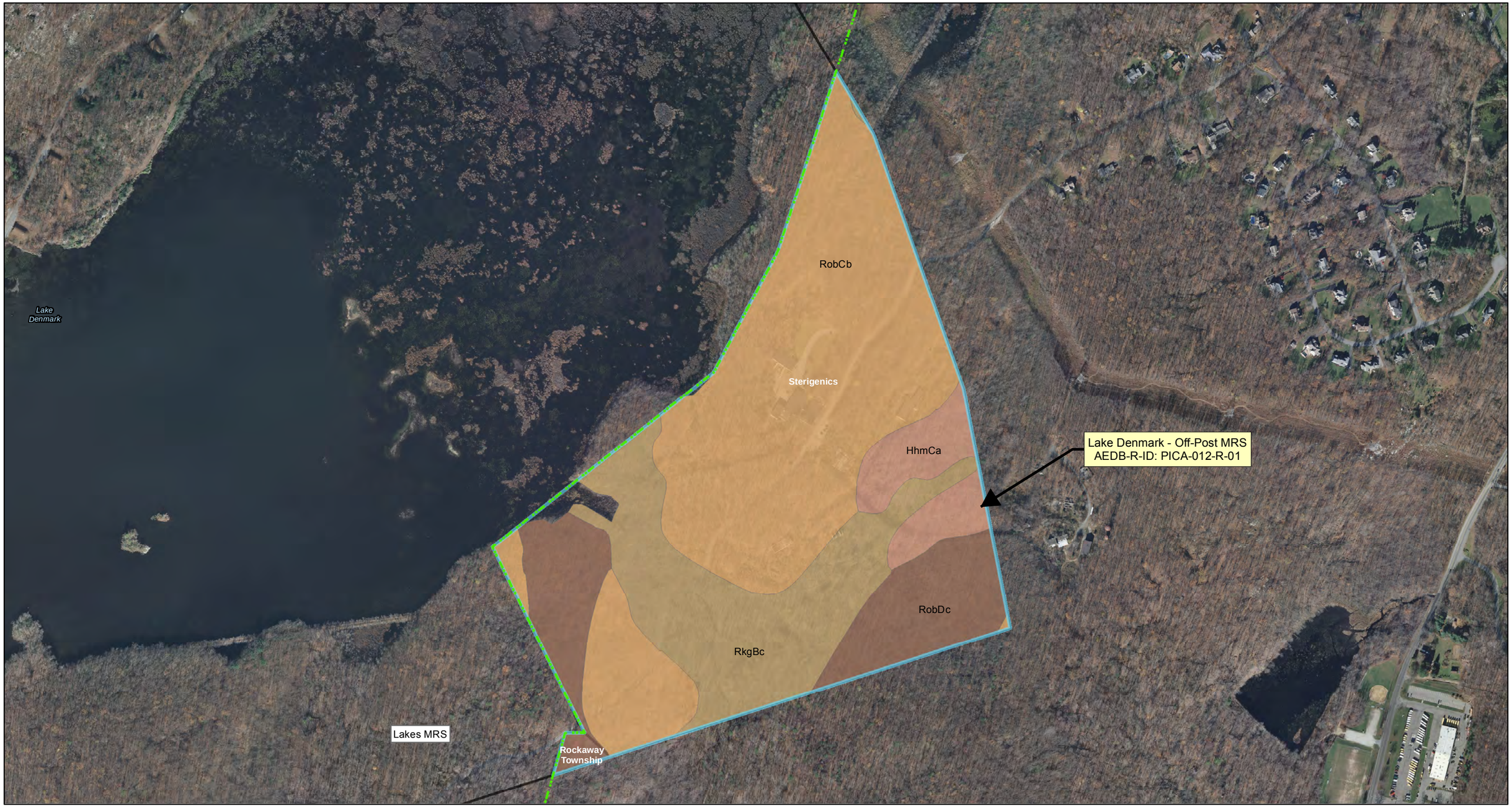

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lake Denmark Off-Post MRS
- Current Property Boundaries
- HhmCa
- RkgBc
- RobCb
- RobDc

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

N

0 500 1,000 Feet

0 175 350 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-15
Lake Denmark - Off-Post MRS
PICA-012-R-01 Soil Series

Date:12/3/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

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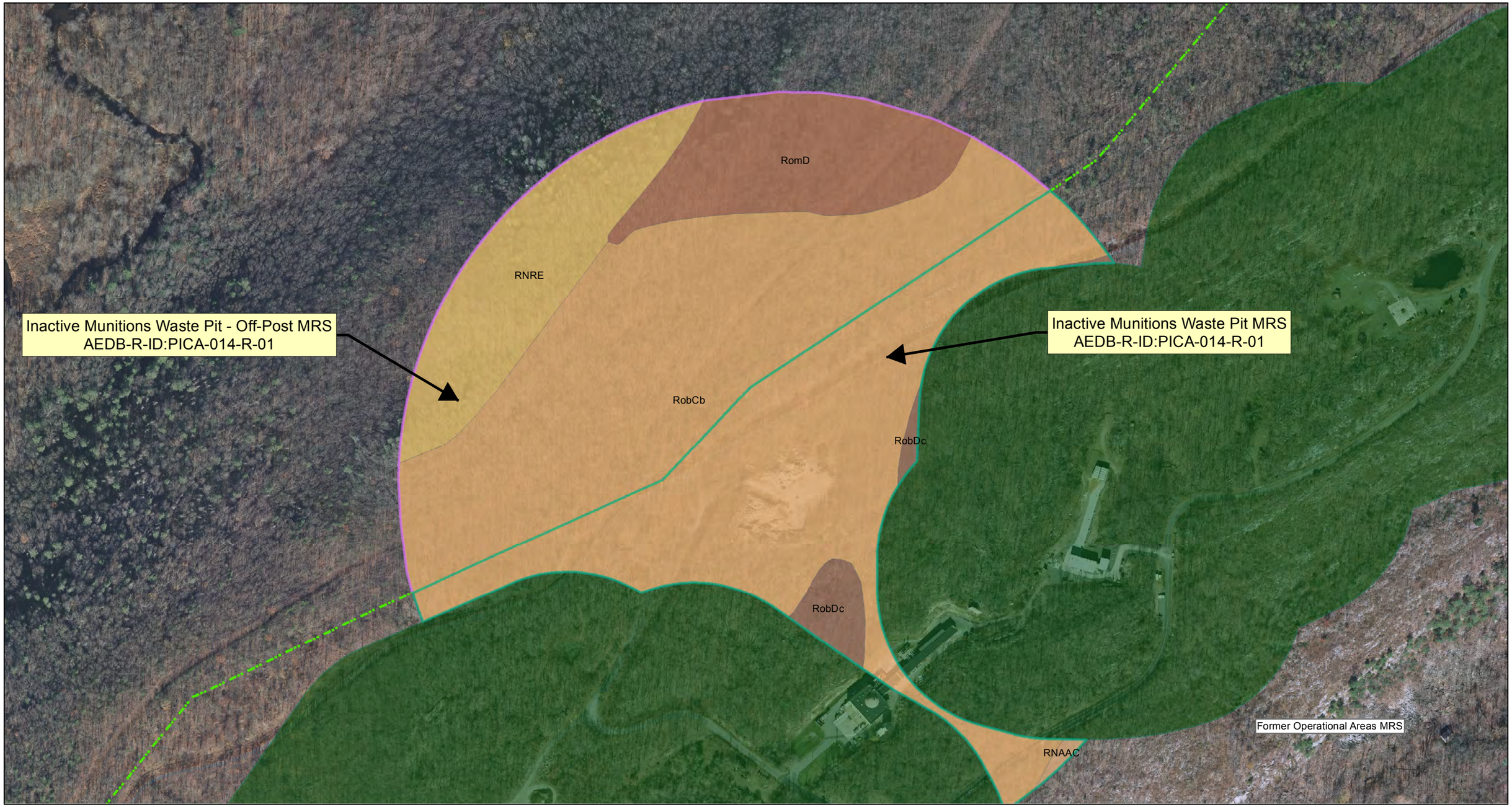


Legend

- Installation Boundary
- Operational Range Areas
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- RNAAC
- RNRE
- RobCb
- RobDc
- RomD

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Map Unit Descriptions are provided in Appendix E

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)
Soils Source: Natural Resources Conservation Service (NRCS) Soil Survey 2008

Picatinny Arsenal
Morris County,
New Jersey

N

0 300 600 Feet

0 70 140 210 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 3-16
Inactive Munitions Waste Pit MRS
PICA-014-R-01 Soil Series

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP_Soil.mxd

4. REMEDIAL RESPONSE OBJECTIVES

This section presents a discussion of the preliminary CSMs, project approach, data needs, and DQOs considered while developing response objectives during the RI for each MRS. A general discussion of these RI components is presented in the following paragraphs, and details unique to each MRS are outlined in the subsections below.

Conceptual Site Model

The CSM is used as a planning tool to integrate MRS information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to evolve through an iterative process of further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into four primary components: potential sources, interaction consisting of activity and access, and receptors for MEC and/or MC with complete, potentially complete and incomplete exposure pathways identified for each receptor. Each component is described below:

- Sources—Sources are those areas where MEC or MC have entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.
- Interactions—Interactions describe ways that receptors come into contact with a source, through a combination of activities and access. Interactions also include exposure pathways (ingestion, inhalation, and dermal contact) for each receptor. Ecological exposure can include coming into contact with MEC or MC lying on the ground surface or through disturbing buried MEC/MC while burrowing. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. However, there can be some movement of MEC through natural processes such as frost heave, erosion, and stream conveyance. For MC, this activity can include physical transportation of the contaminant and transfer from one medium to another through various processes such that media other than the source area can become contaminated.

- Access—Access is the ease with which a receptor can come into contact with a source. The presence of access controls helps determine whether an exposure pathway to a receptor is complete as fences or natural barriers can limit human access to a source area. Furthermore, the depth of MEC items in subsurface soils and associated MC may also limit access by a receptor. Ease of entry for adjacent populations (e.g., lack of fencing) can facilitate either intentional or accidental trespassing at an MRS.

- Activity—The hazard from MEC and/or MC arises from direct contact as a result of some human or ecological activity. Interactions associated with activities describe ways that receptors come into contact with a source.

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

The preliminary CSMs were developed following the SI (see Section 2) based on guidance from USACE Engineer Manual (EM) 1110-1-1200 (USACE, 2003); site-specific data; and general historical information, including literature reviews, aerial photographs, maps, training manuals, technical manuals, and field observations. The preliminary CSMs provided the basis for identifying data collection needs during the RI. The data collected during the RI have been incorporated into the preliminary model. The revised CSMs are presented in Section 6.

Data Quality Objectives and Data Needs

The DQOs are qualitative and quantitative statements that define the type, quantity, and quality of data necessary to support the decision-making process during the RI. The DQOs are developed for each MRS using the EPA QA/G-4HW guidance (2006). EPA QA/G-4HW was the guidance followed in the Final RI Work Plan (WESTON, 2012) for developing the DQOs, this guidance has since been superseded by QA/G-4 and QA/CS-1 guidance. The DQOs are developed to ensure that the following conditions are met: (1) the field sampling, chemical analyses, and physical analyses are reliable; (2) the preliminary data collected are sufficient; (3) the quality of data generated is acceptable for the intended use of the data; and (4) valid assumptions can be inferred from the data.

The DQO process follows seven steps that are incorporated into the characterization approach for each MRS:

1. **State the problem:** Provide a concise description of the problem.

2. **Identify the decisions:** Develop the decision statements to solve the problem.
3. **Identify inputs to the decision:** Identify the information and measurements needed to make the decisions.
4. **Define study boundaries:** Identify the conditions such as spatial and temporal boundaries.
5. **Develop a decision rule:** Qualify the decisions to understand the data needs.
6. **Specify tolerable limits on decision errors:** Develop the performance criteria.
7. **Optimize the design:** Design an effective data collection strategy based on the previous steps.

The DQOs and data needs determined at the planning stage are outlined in the PTA Final RI Work Plan (WESTON, 2012). The DQO were developed through the Technical Project Planning (TPP) process using USACE's EM 200-1-2 (USACE, 1998). The data needs include characterization of the nature and extent of contamination associated with former munitions activities at an MRS that may have resulted in the presence of MEC and/or MC. Individual DQOs established for each MRS are listed separately.

For MEC, data needs include determining the types, locations, condition, and number of MEC items present at each MRS so the potential hazard to human health can be assessed and remedial decisions can be made.

For MC, data needs include collection of sufficient information to characterize the MRS and to perform a baseline HHRA and a SLERA if a release of MC was identified associated with concentrated areas of MEC/MD present at the MRS. More specifically, the data needed are the MC concentrations in environmental media that provide an exposure pathway to human health and ecological receptors. Quantitative analytical data quality requirements are established in the Unified Federal Policy-Quality Assurance Project Plan (UFP-QAPP) developed as part of the Final RI Work Plan (WESTON, 2012) in accordance with the DoD QSM.

4.1 1926 EXPLOSION RADIUS MRS

Although the 1926 Explosion Radius is designated as two separate MRSs, the 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS, the division is due to variation in property ownership and not due to technical differentiation. Since the two MRSs have different land uses and receptors, the 1926 Explosion Radius MRS and the 1926 Explosion Radius – Off-Post MRS have separate CSMs. However, as discussed previously, with the exception of the

presence of a former projectile range and the Code 300 Area artillery firing range at the on-post MRS, the source and release mechanisms for the 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS are the same. The two MRSs were investigated as one site and are discussed as such in the DQOs.

4.1.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams used as the basis for the overall RI strategies for the 1926 Explosion Radius MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSM developed for the 1926 Explosion Radius MRS is exposure to suspect MEC at ground surface or in subsurface soil and a subsequent hazard identified as a release of MC to environmental media from a MEC source. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance); however, after entering PTA access to the majority of the 1926 Explosion Radius MRS is not restricted.

Potential current and future human receptors identified for the 1926 Explosion Radius MRS following the SI are PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreational users, and trespassers. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). Patches of forest, wetlands, and lakes used by state-listed threatened and endangered plants and animals are present in the 1926 Explosion Radius MRS.

Exposure pathways are considered complete because MEC has been found at the 1926 Explosion Radius MRS. Complete exposure pathways exist for PTA personnel, PTA residents, and contractors/visitors who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments of the water bodies within the MRS. Complete exposure pathways exist for biota that may contact MEC in surface soil or surficial sediments and that may nest or burrow at the 1926 Explosion Radius MRS and thereby contact MEC in subsurface soil. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil or may perform intrusive work during future construction activities.

Exposure pathways for MC at the 1926 Explosion Radius MRS are considered potentially complete because it has not been established that MC is present at concentrations of concern. Potentially complete exposure pathways exist for PTA personnel, PTA residents, and contractors/visitors who may contact MC in surface soil. Potentially complete exposure pathways also exist for contractors who may contact MC in subsurface soil or subsurface sediment while accessing underground utilities or performing intrusive work during future construction activities. Potential exposure routes include incidental ingestion, dermal contact, and (for soil) inhalation of dust. Contractors may also contact MC via dermal contact with surface water. Potentially complete exposure pathways exist for biota that may contact MC in surface soil and that may nest or burrow at the 1926 Explosion Radius MRS and may contact MC in subsurface soil. Aquatic and semi-aquatic receptors may contact MC in surface water and sediment of wetlands, lakes, ponds, and streams. Potential groundwater exposure pathways were not addressed in the RI as all groundwater within PTA is addressed under the IRP. Additional details regarding the CSM developed based on SI findings and used as the basis for RI/FS activities are provided in Section 3 of the Final RI Work Plan (WESTON, 2012).

4.1.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the 1926 Explosion Radius – On-Post and Off-Post MRSs are reiterated below:

> ***State the Problem:*** Because of the 1926 explosions, MEC, MPPEH, and MD were strewn up to a distance of approximately 1 mile from the center of the explosions (i.e., the Shell Burial Grounds MRS). Information regarding MEC, MPPEH, and MD found within the explosion radius is available from an EE/CA conducted on-post and from three TCRAs conducted off-post at the quarry, as well as through information obtained from PTA's Safety Office regarding MEC finds on PTA between 1986 and 1998. As this information does not adequately characterize the entire explosion radius, the anomaly and MEC density and distribution across the explosion radius are unknown. Although no information is available regarding MEC that may be present within the Code 300 Area, it is

possible the MEC density is greater than that expected from the 1926 explosion due to potential artillery testing activities.

Identify the Decisions: The results of previous investigations within the 1926 Explosion Radius – On-Post and Off-Post MRSs (e.g., the EE/CA, TCRAs, and SI) suggest that MEC may be present only within 0.5 mile of the explosion centers. Therefore, the explosion radius has been divided into an inner and outer radius. The inner radius covers the area within 0.5 mile of the explosion centers. The outer radius encompasses the area from 0.5 to 1 mile of the explosion centers. The primary decisions being addressed at the 1926 Explosion Radius – On-Post and Off-Post MRSs include:

- Determine the density and depth of MEC within the inner and outer radii.
- Determine whether MEC is present within the Code 300 Area from historical artillery firing practices. If MEC is present, determine the nature and extent of the MEC release.

Identify Inputs to the Decision: Several inputs will be required during the RI to support the decisions:

- Visual Sample Plan (VSP) input parameters for the AOI Code 300 Area were based on historical information. According to DoD, *Executive Order 11508 Installation Survey Report, Picatinny Arsenal, Dover, New Jersey* (January 1973), artillery testing activities were performed for artillery up to 155mm in the AOI Code 300 Area. No further information is available regarding this area, in any known historical report for PTA. Because the exact types and the quantity of projectiles used are unknown, as a conservative measure, a 57mm projectile has been assumed because of the relatively short hazardous fragment distance (HFD). Therefore, the smallest MEC release for the AOI Code 300 Area is based on a 57mm projectile. No known target exists in the AOI Code 300 Area; therefore, conservative assumptions about the shape, size, and nature of a potential target area have been used. The shape is assumed to be a circle with a 243-foot radius (based on 1.5 times the HFD of a 57mm projectile) and low anomaly densities (e.g., 40 anomalies/acre) have been assumed. **Table 4-1** presents the parameters for the AOI Code 300 Area. The transect distance and area coverage requirements presented in **Table 4-1** apply to the AOI Code 300 Area that lies within the 1926 Explosion Radius.
- Density transects (e.g., (Global Positioning System (GPS) locations of surface and subsurface anomalies; surface MEC, MPPEH, and MD; and the traversed transects) will be traversed within the Code 300 Area by the UXO technicians to determine the anomaly density and distribution.

Table 4-1 VSP Parameters and Coverage Requirements for the Code 300 Area

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Code 300 Area located within 1926 Explosion Radius (PICA-003-R-01)
Shape of Target Area	Circular
Target Area of Interest	243-ft radius (based on 1.5 times the HFD of a 57mm projectile)
Anomaly Density Indicator	40 anomalies/acre
Background Anomaly Density	10 anomalies/acre
Transect Width	10 ft (physical transect width)
Transect Spacing	193 ft (203 ft on centers)
Transect Distance	3.4 miles
Transect Area	4.2 acres (4.5% coverage for Code 300 Area)

- Digital and analog geophysical data will be collected in the inner and outer radii (as well as within the Code 300 Area). The DGM data will be evaluated and targets will be selected for the intrusive investigation. All detected analog anomalies will be investigated to determine the nature and extent of MEC and MPPEH within these areas.

***Define Study Boundaries*:** Three horizontal study boundaries have been identified:

- Inner radius—Includes the area within a 0.5-mile radius of the explosion centers. This excludes the operational range areas, the Shell Burial Grounds and Green Pond MRSs, and the areas previously investigated during the EE/CA or TCRAs.

- Outer radius—Includes the area between 0.5- and 1-mile radius of the explosion centers. This excludes the operational range areas, the Green Pond MRS, and the areas previously investigated during the EE/CA or TCRAs.

- Code 300 Area—Includes the area identified in the 1973 report as being used for "artillery firing of shells up to 155mm and fragmentation pattern testing." This excludes the areas that fall outside the 1926 Explosion Radius MRS and the operational range areas.

Physical constraints on the investigation include, but are not limited to, the following:

- Time—The presence of threatened and/or endangered species (e.g., avoiding an area during the breeding season).
- PTA mission—Coordination with PTA will be required to ensure that the sampling activities do not interfere with PTA's activities.
- Vegetation—Certain areas of PTA are marshy or heavily overgrown with vegetation. Sampling in these areas will be restricted to colder months when the ground is frozen and/or the vegetation has died back.
- Weather conditions.
- Access—Rights of entry will be required for sampling at the off-post MRSs.
- Topography and other physical conditions.

Develop a Decision Rule: The purpose of this step is to integrate the outputs from the previous steps into a statement that defines the conditions that would cause the decision-maker to choose among alternative actions. For the RI, the decision rules are as follows:

- If anomalies are found within the Code 300 Area, then their density and distribution will be defined.
- If surface MEC is found during the investigation, then the type and density of the surface MEC will be defined for both the inner and outer radii.
- If subsurface MEC is found during these investigations, then the type, depth, and density of the subsurface MEC will be defined within the inner and outer radii.

Specify Tolerable Limits on Decision Errors: The probability of decision errors can be controlled by adopting a scientific approach. In this approach, the data are used to select between one condition of the environment (the null hypothesis (H_o)) and an alternative condition (the alternative hypothesis (H_a)). The null hypothesis is treated as the baseline condition that is presumed to be true in the absence of strong evidence to the contrary. This feature provides a way to guard against making the decision error that the decision-maker considers to have the more undesirable consequences. A decision error occurs when the decision-maker rejects the null hypothesis when the null hypothesis is true (Type I decision error) or fails to reject the null hypothesis when the null hypothesis is false (Type II decision error). The consequences of a Type I decision error could include unnecessarily incurred project costs associated with additional investigation. The

consequences of a Type II decision error could include increased risks to receptors.

H_o for the 1926 Explosion Radius MRS is that the RI activities will confirm the results of the previous investigations and that MEC resulting from the 1926 explosion (both on- and off-post) is restricted to the 0.5-mile inner radius. The decision errors associated with this H_o are that there is MEC due to the 1926 explosion in the outer radius when there is not (Type I), and that there is no MEC due to the 1926 explosion in the outer radius, when there is (Type II). If H_o is rejected because MEC is identified in the outer radius, then the actual MEC density within the outer radius may be higher than the assumed MEC density used as an input in UXO Estimator. This could result in several outcomes, depending on numerous factors, including, but not limited to, the type of MEC found (e.g., manufactured before or after 1926) and the location of the MEC found (e.g., on- or off-post). The outcomes could include revising the CSMs, re-evaluating the input and output statistical parameters in UXO Estimator, and/or additional investigations. The ultimate outcome will be determined based on an assessment of the historical and new data.

The H_o for the Code 300 Area is that the MRS does not contain a MEC impact area resulting from historical artillery firing and not necessarily individual MEC. The H_o is based on the lack of historical records indicating that dedicated range and impact area existed and the lack of MEC finds within the Code 300 Area. The decision errors associated with this H_o are concluding that there is a MEC impact area within the Code 300 Area when there is not (Type I) and concluding that there is no MEC impact area within the Code 300 Area when there is (Type II). If H_o is rejected based on the identification of a potential MEC impact area (e.g., anomaly densities significantly greater than the background anomaly density over a large area) within the Code 300 Area, then intrusive investigations will be performed within the potential MEC impact area to determine the nature of the anomalies. If potential impact areas are not identified in the Code 300 Area, no additional intrusive investigations will be conducted in the Code 300 Area, with

the exception of the intrusive investigations associated with the grids within the outer radius that happen to fall within the Code 300 Area.

Optimize the Design: DGM grid surveys will be performed using a Geometrics EM61-MK2 electromagnetic induction sensor and analog grid surveys will be performed using either the Schonstedt GA-52 or the Vallon, or equivalent all metals sensor. The quantity of grids required to ensure at a 95% statistical confidence level that the MEC densities within the outer and inner radius are less than 0.5 and 3.0 MEC/acre, respectively, was determined using UXO Estimator. The 3.0 MEC/acre density for the inner radius is based on previous investigations (e.g., the Residential Communities Initiative (RCI) Housing EE/CA and the Tilcon Quarry TCRA) in which the MEC density in undisturbed areas was found to range from 0 to 6 MEC/acre, for an average of 3.0 MEC/acre. Using the assumption that the outer radius has < 0.5 MEC/acre and the inner radius has 3 MEC/acre, UXO Estimator established that approximately 6 acres of grids are needed in the outer radius and 1 acre of grids is required in the inner radius. For both radii, the grids will be 50 feet by 50 feet and will be randomly distributed across the areas that have not been investigated previously through either the EE/CA or the TCRAs. DGM grid surveys will be performed in accessible areas, and analog grid surveys will be performed in areas of dense vegetation. The resulting DGM data will be processed and evaluated to determine which targets meet the anomaly selection criteria for intrusive investigation. All detected analog anomalies will be investigated.

Within the Code 300 Area, density transect data will be collected in addition to the grids proposed for the inner and outer radii, to detect anomaly density and distribution across the Code 300 Area and to determine whether potential impact areas are present. The transect data will be collected by UXO technicians using the Vallon hand-held or equivalent all metals sensor. The Vallon, or equivalent all metals sensor, is being used due to the known magnetic rocks at PTA because this sensor is much less sensitive to magnetic rocks than magnetometers such as the Schonstedt. No anomalies will be intrusively investigated along the density transects. The position of all identified surface MEC/MPPEH/MD and subsurface

anomalies will be recorded in a handheld GPS unit (e.g., Trimble GeoXT or Garmin). The density transects were designed in VSP and are spaced 203 feet apart (on centers) for a total of 7 miles of transects. The anomaly data from the density transects will be imported into VSP and evaluated using the Geostatistical Mapping of Anomaly Density tool to locate the elevated anomaly density areas that could be potential impact areas. If potential impact areas are identified, 50-foot by 50-foot DGM or analog grids will be placed within the potential impact area, and the grids will be surveyed and intrusively investigated to determine the nature of the anomalies. This approach will ensure that the information collected during the field activities can be evaluated in VSP. Locations of anomalies will be recorded by GPS for more precise anomaly density mapping and to enable geostatistical analysis in VSP. To determine whether an impact area has been identified, the anomaly data will be imported to VSP and analyzed using the (1) Locate and Mark Target Areas based on Elevated Anomaly Density and (2) Geostatistical Mapping of Anomaly Density tools.

4.2 1926 EXPLOSION RADIUS – OFF-POST MRS

4.2.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the 1926 Explosion Radius – Off-Post MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSMs developed for the 1926 Explosion Radius – Off-Post MRS is exposure to suspect MEC at ground surface or in subsurface soil, with a subsequent hazard identified as a release of MC to environmental media from a MEC source. The MRS is located outside the secured PTA boundary. With the exception of the quarry, which has a guarded gate at the main entrance and signs posted along the perimeter of the property, the off-post properties are not secured.

Potential current and future human receptors identified for the 1926 Explosion Radius On-Post and Off-Post MRSs following the SI are quarry personnel, other workers (e.g., workers

associated with other businesses, contractors, utility workers), visitors, recreationists (e.g., hunters, fishermen), and trespassers. Recreational use on Mount Hope Lake includes camping and fishing. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3).

Exposure pathways for MEC are considered complete because MEC has been found within the 1926 Explosion Radius On-Post and Off-Post MRSs. Complete exposure pathways exist for the Mount Hope Quarry personnel who may contact, via handling/treading underfoot, MEC in the surface and subsurface soil. Complete exposure pathways exist for the workers/visitors and the recreationists/trespassers who may contact MEC in surface soil or surficial sediment and in the subsurface soil or sediment for contractors or utility workers performing intrusive work. The exposure pathways are complete for biota that may contact MEC in the surface soil during feeding and nesting activities and in subsurface soil during burrowing. Potentially complete exposure pathways exist for the aquatic and semi-aquatic ecological receptors that may contact MEC in the surficial sediments of Mount Hope Lake or Mount Hope Pond.

Exposure pathways for MC are considered potentially complete because it has not been established that MC is present at concentrations of concern. Potentially complete exposure pathways exist for Mount Hope Quarry personnel, residents, and contractors/visitors who may contact MC in surface soil. Potentially complete exposure pathways also exist for contractors who may contact MC in subsurface soil or subsurface sediment while accessing underground utilities or performing intrusive work during future construction activities. Potential exposure routes include incidental ingestion, dermal contact, and (for soil) inhalation of dust. Recreationists on Mount Hope Lake and contractors accessing underground utilities may contact MC through dermal contact with surface water. Potentially complete exposure pathways exist for biota that may contact MC in surface soil and that may nest or burrow at the 1926 Explosion Radius On-Past and Off-Post MRSs and may contact MC in subsurface soil. Aquatic and semi-aquatic receptors may contact MC in the surface water and sediment of Mount Hope Lake or Mount Hope Pond. Although potential MC transport/migration routes from soil to groundwater have been identified as noted above, exposure to MC in groundwater is not expected because the MC has low water solubility. Additional details regarding the CSM developed based on SI findings and used as the basis for RI/FS activities are provided in Section 3 of the Final RI Work Plan (WESTON, 2012).

4.2.2 Data Quality Objectives and Data Needs

The release mechanisms for the 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS are the same. Therefore, the two MRSs were investigated as one site and are discussed as such in the DQOs for the 1926 Explosion Radius MRS in Section 4.1.2.

4.3 SHELL BURIAL GROUNDS MRS

4.3.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Shell Burial Grounds MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRSs in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSMs developed for the Shell Burial Grounds MRS is exposure to suspect MEC in subsurface soil.

Potential current and future human receptors identified for the Shell Burial Grounds MRS following the SI are PTA personnel, residents, and contractors (utility workers, maintenance and construction workers) and visitors but because the MRS has restricted access (6 1/2-foot tall chain-link fencing with warning signs), the potential for the human receptors to access the MRS is low. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3).

Incomplete exposure pathways for MEC exist for humans because of ICs that restrict access or construction within the burial grounds. Incomplete pathways exist for ecological receptors because the MEC within the burial grounds may be under approximately 20 feet of fill, which is below the biologically active zone.

An MC CSM was not developed during the SI as MC is addressed under the IRP and the Shell Burial Grounds MRS was not recommended for further characterization under the MMRP. Additional details regarding the CSM developed based on SI findings and used as the basis for RI/FS activities are provided in Section 3 of the Final RI Work Plan (WESTON, 2012).

4.3.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Shell Burial Grounds MRS are reiterated below:

State the Problem: No field inspection activities were performed during the SI; therefore, it is unknown whether current ICs completely or accurately bound the horizontal extent of the two burial areas comprising the Shell Burial Grounds MRS, nor has the vertical extent of the burial areas been determined.

Identify the Decisions: The primary decisions being addressed at this MRS include:

- Determine the horizontal extent of the subsurface material to verify that the current ICs (fencing) bound the two burial areas using a non-intrusive investigative approach.
- Determine the vertical extent of the subsurface material as much as is possible without intrusive investigation.

Identify Inputs to the Decision: Several inputs will be acquired during the RI to support the decision:

- Collect and process EM and resistivity data.
- Evaluate digital data response characteristics.
- Collect planimetric survey information around the current fence line to integrate with and assess the geophysical data.
- Use historical and nearby well installation information with geophysical data to further estimate the depth of the burial areas.

Define Study Boundaries: The eastern burial[1] area covers approximately 1.5 acres. The western burial area covers approximately 4.2 acres. The DGM transects will extend beyond the current MRS boundaries to ensure that the extent

[1] The SI report refers to the two burial areas as the Northern Shell Burial Area and the Southern Shell Burial Area. To be more accurate, the Northern Burial Area (near Building 3100) is now referred to as the Shell Burial Grounds MRS – West; the Southern Burial Area (near Building 3150) is now referred to Shell Burial Grounds MRS – East.

of the buried material is captured and defined. The digital data response characteristics of these transects will be evaluated to determine whether additional transects need to be added or the proposed transects extended to ensure that the extent of the buried material is captured and defined.

Physical constraints of the investigation include:

- Time—The area is unmaintained and vegetation is overgrown. Surveys will be restricted to colder months when leaf cover and ground vegetation is thin to increase accessibility during the geophysical surveys and to maintain adequate GPS coverage.
- Access—Access is restricted to the burial grounds and they are enclosed by a fence. The geophysical survey activities will require coordination with the PTA safety office to gain entry access.
- Safety—It is documented that the burial grounds contain MEC and that approximately 20 feet of fill may cover the disposed material. To intrusively investigate beneath the fill to determine the vertical extent of buried material would require extensive excavation. The safety risk (could not investigate without encountering MEC) outweighs the data to be gained from intrusive investigation.

Develop a Decision Rule: The decision rules are as follows:

- If surveys detect buried material at each mound, then the horizontal and vertical extent of the buried material will be defined.
- If the burial areas are found to fall within the ICs after assessing the footprint of the burial areas against the current ICs (fenceline), then no change in the footprint of the MRS will be recommended.
- If the burial areas are found to extend beyond the current ICs, then assessment of additional controls or revised controls will be recommended based on current and future land use.

Specify Tolerable Limits on Decision Errors: It is currently thought that the ICs bound the subsurface material disposed of in the two burial areas. The null hypothesis (H_o) is that RI results will show that the burial area footprint is outside current ICs. The alternative hypothesis is that RI results will confirm that the burial area footprint is within current ICs. H_o is rejected if anomalous areas are confirmed only within the ICs.

A Type I decision error would be concluding that the burial area footprint is present within the current ICs when it is not. A Type II decision error would be concluding that the burial area footprint is present outside the current ICs when it is not. The consequences of both the Type I and Type II decision errors could include unnecessarily incurred project costs and increased risks to receptors.

Optimize the Design: DGM surveys will be performed using a Geometrics EM31-MK2 EM induction sensor that measures ground conductivity and magnetic susceptibility. Approximately 5,500 linear feet of transects at a 75-foot spacing will be traversed across the two burial areas. Both the ground conductivity and magnetic susceptibility will be processed and evaluated to identify the inflection point where the elevated response associated with the buried material meets a background response associated with an area free from conductive material. This inflection point will define the burial area boundaries. No intrusive investigations are required to determine the horizontal extent of the burial areas.

Electrical resistivity (ER) imaging surveys will be performed using an Advanced Geosciences, Inc. (AGI) SuperSting/Swift R8 earth resistivity imaging system to delineate the vertical extents of the burial areas. ER survey lines, two each, along the long and short axes, will be placed across each burial area to profile the varying subsurface conditions by measuring the voltage drop between various combinations of paired electrodes. The apparent resistivity data will be processed to produce resistivity cross-sections and will be analyzed against well logs of nearby wells, HRR information, and maps.

4.4 GREEN POND MRS AND FORMER DRMO YARD

4.4.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Green Pond MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSMs developed for the Green Pond MRS and the Former DRMO yard is exposure to suspect MEC at ground surface or in subsurface soil within the brook. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of the Green Pond MRS is not restricted after entering PTA. A chain-link fence with an entrance gate on East 6th Street surrounds the Former DRMO Yard, which borders the western boundary of the MRS.

Potential current and future human receptors identified for the Green Pond MRS and Former DRMO Yard following the SI are PTA personnel, residents, and contractors (utility and construction workers). The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). The Green Pond MRS has an aquatic warm bed habitat with some submerged aquatic vegetation beds. There is little shade and limited habitat on the steeply sloped banks. Receptors include those species tolerant of slow, warm water. According to the NJDEP i-Map Landscape project layer, the Green Pond MRS contains habitat with at least one occurrence of the state-listed threatened bog turtle.

Complete exposure pathways for MEC exist for PTA personnel and contractors/visitors who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments of the brook. Complete exposure pathways exist for biota that may contact MEC in surface soil or surficial sediments and that may nest or burrow at the site and thereby contact MEC in subsurface soil. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil or may perform intrusive work during future construction activities.

An MC CSM was not developed during the SI for the Green Pond MRS as MC is being addressed under the IRP and the MRS was not recommended for further characterization under the MMRP. Additional details regarding the CSM developed based on SI findings and used as the basis for RI/FS activities are provided in Section 3 of the Final RI Work Plan (WESTON, 2012).

4.4.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Green Pond MRS are reiterated below:

State the Problem: Burial areas containing MEC may exist along the banks of Green Pond Brook as a result of channelization and/or fill material potentially brought to the MRS and previous operations at the Former DRMO Yard (adjacent to the MRS). In addition, MEC may also be present based on the previous recovery of MEC protruding from the bank of Green Pond Brook and identified during the installation of fence posts at the Former DRMO Yard. The nature and extent of potential MEC burial areas or individual MEC is unknown at the Green Pond MRS and in the southern portion of the Former DRMO Yard.

Identify the Decisions: The primary decisions being addressed at the Green Pond MRS and Former DRMO Yard include:

- Determine whether MEC burial areas or individual MEC exist in and along the banks of Green Pond Brook and if so, define its extent.
- Determine whether MEC exists within the southern portion of the Former DRMO Yard and if so, define its extent.

Identify Inputs to the Decision: Several inputs will be acquired to support the decisions:

- Perform mag and dig surveys along the banks and in the water of Green Pond Brook and the southern portion of the Former DRMO Yard. Investigate all anomalies.
- Collect DGM data along the banks of the brook and evaluate the DGM data responses to identify and to determine the extents of the potential burial areas. Intrusively investigate the selected anomalies from the DGM data to determine whether the source of the anomalies is related to the potential MEC burial areas.

Define Study Boundaries: The Green Pond MRS is bounded to the north by 9th Street and to the west by the 300 Marsh Area. The Former DRMO Yard is adjacent to the west. The Former DRMO Yard is bounded to the east by Green Pond Brook and by Building 307 to the west.

Develop a Decision Rule: The decision rules are as follows:

- If MEC is found during the intrusive anomaly investigation, then assessment of the MEC density across the Green Pond MRS and in the southern portion of the Former DRMO Yard will be recommended.
- If MEC burial areas are present along the banks of Green Pond Brook, then the extent will be defined.

Specify Tolerable Limits on Decision Errors: DGM and mag and dig surveys utilizing GPS will be performed in and along the banks of Green Pond Brook and specific investigation areas of the Former DRMO Yard.

Optimize the Design: Mag and dig will be performed over approximately 2.1 acres in the southwest portion of the Former DRMO Yard in and along the banks of Green Pond Brook. The total mag and dig coverage is approximately 2.5 acres or 2.08 miles. EM31-MK2 transect surveys will be performed along the banks of Green Pond Brook to identify the burial areas. The total DGM coverage is 0.26 acre or 3,800 linear feet. Both the ground conductivity and magnetic susceptibility measurements will be processed and evaluated to identify large anomalous areas indicative of burial areas. Anomalies within the burial features will be selected, reacquired, and investigated by the UXO technicians. Additional surveys will be performed as necessary to delineate the burial areas. The point between the elevated responses associated with the burial area and the background response associated with an area free from conductive material will be defined as the burial area boundary.

4.5 FORMER OPERATIONAL AREAS MRS

4.5.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Former Operational Areas MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSM developed for the Former Operational Areas MRS is exposure to suspect MEC at ground surface or in subsurface soil, with a subsequent hazard identified as a release of MC to environmental media from a MEC source. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of the MRS is not restricted after entering PTA.

Potential current and future human receptors identified for the Former Operational Areas MRS following the SI are PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreational users, and trespassers. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). The majority of the Former Operational Ares MRS is undeveloped and consists of deciduous forests, ponds, streams, and wetlands. Several sensitive species are known to inhabit this MRS, including the veery thrush (*Catharus fuscescens*), barred owl (*Strix varia*), and American woodcock (*Scolopax minor*). A habitat with at least one occurrence of a state-listed threatened species is present at the Former Operational Areas MRS.

Exposure pathways for MEC are considered complete because MEC has been found in this MRS. Complete exposure pathways exist for PTA personnel and contractors/visitors who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments of the brook. Complete exposure pathways exist for biota that may contact MEC in surface soil or surficial sediments and that may nest or burrow at the Former Operational Areas MRS and thereby contact MEC in subsurface soil. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil or may perform intrusive work during future construction activities.

Exposure pathways for MC are considered potentially complete because it has not been established that MC is present at concentrations of concern. Potentially complete exposure pathways exist for PTA personnel, PTA residents, and contractors/visitors who may contact MC in surface soil. Potentially complete exposure pathways also exist for contractors who may contact MC in subsurface soil while accessing underground utilities or performing intrusive work during future construction activities. Potential exposure routes include incidental ingestion, dermal contact, and inhalation of dust. Potentially complete exposure pathways exist for biota that may contact MC in surface soil and that may nest or burrow at the Former Operational Area

MRS and may contact MC in subsurface soil. Although there may be potentially complete exposure pathways to MC in surface water and sediment, surface water at the Former Operational Areas MRS is addressed under the IRP. Potential groundwater exposure pathways are not addressed in the RI as all groundwater within PTA is addressed under the IRP. Additional details regarding the CSM developed based on SI findings and used as the basis for RI/FS activities are provided in Section 3 of the Final RI Work Plan (WESTON, 2012).

4.5.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Former Operational Areas MRS are reiterated below:

State the Problem: Several areas identified as being used for R&D activities have been documented within the Former Operational Areas MRS. The historical use and nature and extent of MEC at these areas is unknown. A MEC release may be present within the Code 300 Area because of artillery testing activities. The UXO Finds Map indicates sporadic MEC occurrences across the Former Operational Areas MRS but the source and release mechanisms have not been documented. The AOI Former Sanitary Landfill/ Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24 exist in the southern portion of the MRS[2]. MEC has been observed in these areas, but their footprints are not well defined.

Identify the Decisions: The primary decisions addressed at the Former Operational Areas MRS include:

- Determine whether a MEC release is present within the MRS and/or Code 300 Area using VSP.
- Determine approximate MEC density across the MRS.
- Determine the nature and extent of MEC release, if observed.

[2] These areas were classified as sub-sites in the Final RI Work Plan, but have been reclassified as Areas of Interest for the purpose of this RI report.

- Delineate the horizontal extent of the subsurface material at the Former Sanitary Landfill, Dredge Pile, and Waste Burial Area and evaluate the extent of MEC.
- Determine whether MEC burial sites are present within Site 20/24.
- Determine the nature and extent of MEC at MEC burial sites if detected.

Identify Inputs to the Decision: Several inputs will be acquired during the RI to support the decisions:

- Conduct a geophysical survey within the portions of the Former Operational Areas MRS where reported R&D activities may have occurred. Based on the potential infrastructure and standoff requirements used during testing activities at these R&D sites (Code Areas), it was determined that the entire Code Area would likely not be impacted by MEC. The smallest Code Area was identified as 8 acres in size. Based on the smallest Code Area, a more conservative MEC release of 5 acres was used as a VSP input parameter. Geophysical transects will be traversed across the applicable portions of the MRS on a 250-foot spacing to ensure a high probability of detection (greater than 95%) of a potential 5-acre MEC release. **Table 4-2** lists the VSP parameters and coverage requirements for the Former Operational Areas MRS. The 250-foot spaced transects will only be performed where R&D activities potentially occurred. They do not traverse the following sub-sites: Sanitary Landfill, Dredge Pile, Waste Burial Area, Site 20/24, or Code 300 Area. Each of these sub-sites is discussed independently.
- Perform mag and dig surveys in areas inaccessible to the DGM instrumentation. DGM surveys will be used near developed areas of the Former Operational Areas MRS to aid in managing the exclusion zone during intrusive work. This will allow the UXO team to schedule intrusive work so that evacuations in the developed areas are not necessary. Locations for each type of survey will be determined based on observed field conditions.
- Use revised VSP input requirements for the Code 300 Area better suited to the potential MEC release profile. It has been documented that artillery testing activities were performed for artillery up to 155mm. The smallest MEC release for the Code 300 Area is based on a 57mm projectile.

Table 4-2 VSP Parameters and Coverage Requirements - Former Operational Areas MRS

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Former Operational Areas (PICA-006-R-01)
Shape of Target Area	Circular
Target Area of Interest	5 acres
Anomaly Density Indicator	50 anomalies/acre (conservative value used for an impact area)
Background Anomaly Density	10 anomalies/acre
Transect Width	10 ft for mag and dig; 3.25 ft for DGM (physical team transect widths)
Transect Spacing	250 ft
Transect Distance	55.4 miles
Transect Area	58.4 acres (3.11% coverage of the MRS)

Note: These VSP parameters do not apply to the AOI Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, AOI Site 20/24, or the AOI Code 300 Area.

- Employ analog geophysical transects using the Vallon hand-held or equivalent all metals sensor in the AOI Code 300 Area. No intrusive investigations will be performed along these transects in the AOI Code 300 Area unless an area of increased anomaly density is detected, then intrusive investigations will be performed to determine the nature and extent of MEC. **Table 4-3** lists the VSP parameters and coverage requirements for the AOI Code 300 Area within the Former Operational Areas MRS.

- Collect EM31-MK2 DGM transects across the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24. The DGM anomaly response characteristics will be evaluated. EM61-MK2 transects will be used to evaluate the features identified in the EM31-MK2 surveys. Anomalies will be investigated to determine the nature and extent of MEC.

Define Study Boundaries: The 1,880-acre Former Operations Area MRS was created based on the UXO Finds Map and includes most areas except operational ranges and associated SDZs, areas already identified as MRSs, and the northeastern portion of PTA. The MRS is bound to the south, west, and southeast. There is no distinct boundary to the northeast. Intrusive work will not be performed at the Golf Course.

Develop a Decision Rule: The decision rules are as follows:

- If an area of increased anomaly density as determined by VSP evaluation is detected during the geophysical transect surveys, then an assessment will be recommended to determine whether the increased anomaly density is related to a MEC release.

Table 4-3 VSP Parameters and Coverage Requirements - Code 300 Area

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Code 300 Area located within the Former Operational Areas (PICA-006-R-01)
Shape of Target Area	Circular (based on the hazardous fragmentation distance of a 57mm projectile)
Target Area of Interest	243-ft radius
Anomaly Density Indicator	40 anomalies/acre (conservative value used for an impact area)
Background Anomaly Density	10 anomalies/acre
Transect Width	10 ft (physical team transect width)
Transect Spacing	193 ft (203 ft on centers)
Transect Distance	2.1 miles
Transect Area	2.6 acres (4.5% coverage of the Code 300 Area)

Note: These VSP parameters do not apply to the Sanitary Landfill, Dredge Pile, Waste Burial Area, Site 20/24, or the remaining portions of the Former Operational Area MRS.

- If MEC and/or MD are detected during mag and dig transect surveys, then the extent of the MEC and/or MD will be delineated and used to determine whether a MEC release is present.

- If MEC releases are confirmed after defining the horizontal extent of the Former Sanitary Landfill, Dredge Pile, and Waste Burial Area, then the extent will be delineated.

- If MEC burial sites are detected by DGM transect surveys at Site 20/24, then additional surveys will be performed as necessary to delineate the extent of the burial site.

- If MEC is present based on intrusive anomaly investigations, then an assessment will be recommended to determine the nature and extent of MEC.

Specify Tolerable Limits on Decision Errors: The H_o is that a MEC release related to an impact area from historical testing activities and equating to 5 acres exists. The alternative hypothesis is that no MEC releases relating to an impact area exist and that MEC only exists with a sporadic distribution and uncertain source/release mechanism. The rejection of the H_o will not require additional investigation to determine the extent of a MEC release or impact area.

The decision errors associated with this H_o are that there are no MEC releases relating to an impact area when there are (Type I) and that there is a MEC release relating to an impact area when there is not (Type II). The consequence of a Type I decision error could include increased risks to receptors. The consequence of a Type II decision error could include revising the CSMs, re-evaluating the input and output statistical parameters in VSP, and/or conducting additional investigations. The ultimate outcome will be determined based on an assessment of the historical and new data.

The H_o for Site 20/24 is that the RI results will show that there are no burial sites at Site 20/24. The alternative hypothesis is that RI results will confirm the presence of MEC burial sites. The H_o is rejected if anomalous areas are detected and intrusive investigations uncover MEC.

A Type I decision error would be concluding that MEC burial sites are present within Site 20/24 when they are not. A Type II decision error would be concluding that MEC burial sites are not present when they are. The consequences of both the Type I and Type II decision errors could include unnecessarily incurred project costs and increased risks to receptors.

The H_o for the Code 300 Area is that the location does not contain a MEC impact area because of historical artillery firing and does not necessarily contain individual MEC. The H_o is based on the lack of historical records indicating that a dedicated range or impact area existed and the lack of MEC finds within the Code

300 Area. The decision errors associated with this H_o are concluding that there is a MEC impact area within the Code 300 Area when there is not (Type I) and concluding that there is no MEC impact area within the Code 300 Area when there is (Type II). If H_o is rejected based on the identification of a potential MEC impact area (e.g., anomaly densities significantly greater than the background anomaly density over a large area) within the Code 300 Area, then intrusive investigations will be performed within the potential MEC impact area to determine the nature of the anomalies. If potential impact areas are not identified in the Code 300 Area, no additional intrusive investigations will be conducted in the Code 300 Area.

Optimize the Design: Mag and dig or DGM transect surveys will be performed across the majority of the Operational Areas MRS at 250-foot spacing consistent with the VSP calculations. Mag and dig surveys will be used in areas inaccessible (e.g., steep hillsides) to the DGM instrumentation. DGM surveys will also be used near developed areas of the Operational Areas MRS to aid in managing the exclusion zones during intrusive work. This will allow the UXO team to schedule intrusive work so that evacuations in the developed areas are not necessary. Non-intrusive, analog geophysical transects will be performed within the Code 300 Area at 203-foot spacing. Anomaly densities will be calculated from the transect surveys to determine the locations of potential MEC releases. EM31-MK2 transect surveys will be performed across the Former Sanitary Landfill, the Dredge Pile, the Waste Burial Area, and Site 20/24 at 125-foot spacing, as described below.

Sampling Design for Sub-Sites: Focused EM61-MK2 surveys will be performed based on the results of the EM31-MK2 assessment surveys. A nominal transect spacing of 75 feet will be used to further evaluate the interior of the delineated disposal areas. Smaller anomalous features or areas detected during the EM31-MK2 surveys will be evaluated with a tighter EM61-MK2 transect spacing to traverse the area with three or more transects to fully delineate its extent. Additional grid surveys will be performed to delineate MEC burial sites if necessary. All anomalies will be selected based on background noise levels and

predicted response values for a medium industry standard object (ISO) seed item as determined in the instrument verification strip (IVS). The EM61-MK2 anomaly detection results will guide the establishment of sample units or areas with similar anomaly characteristics and densities. The sample unit size and characteristics will be discussed with and approved by the project team. If the geophysical transect survey results indicate that the current sub-site boundaries are not completely delineated, transects will be extended or added to bound the extent of each sub-site.

Anomalies will be selected in the sample units using a hypergeometric estimation process. This process is used to determine the necessary number of geophysical anomalies to be intrusively investigated. Intrusive investigation results can then be extrapolated within the sample unit to estimate the proportion of MEC to non-MEC within a specific confidence level. The confidence level for this project is 95%. The results of the DGM surveys and intrusive investigations will delineate the Former Sanitary Landfill/Dredge Pile and Waste Burial Area and support determining MEC densities.

4.6 LAKES MRS

The Lakes MRS is composed of two non-contiguous Lakes, with a separate CSM[3] and DQO for each lake, described separately in the following sections.

4.6.1 Picatinny Lake

4.6.1.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Picatinny Lake portion of the Lakes MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the Picatinny Lake portion of the Lakes MRS in addition to providing an overview of complete and

[3] Note that the Picatinny Lake and Lake Denmark portions of the Lakes MRS were discussed together in the SI, but because of different military-munitions-related history were discussed separately in the Final RI Work Plan and in this RI report.

potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSMs developed for the Picatinny Lake portion of the Lakes MRS is exposure to suspect MEC at ground surface or in subsurface soil, with a subsequent hazard identified as a release of MC to environmental media from a MEC source. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of Picatinny Lake is not restricted after entering PTA. There are some limited access areas along the shoreline due to fencing.

Potential current and future human receptors identified for the Picatinny Lake portion of the Lakes MRS following the SI are PTA personnel, residents, contractors, visitors, and recreationists. The lake is used for recreational boating and fishing. No swimming is allowed and fish consumption advisories are in effect. The ecological receptors of concern for the Picatinny Lake portion of the MRS are flora and fauna present at PTA (Section 3.1.7.3). The northern end of Picatinny Lake is an open-water wetland dominated by scrub/shrub wetland with smooth alder (*Alnus serrulata*) and swamp azalea (*Rhodendron viscosum*). Ecological receptors known to be present at the Picatinny Lake portion of the Lakes MRS are fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals.

Exposure pathways for MEC are considered complete because the presence of MEC is assumed for the Picatinny Lake portion of the Lakes MRS. Complete exposure pathways exist for PTA personnel, residents, contractors/visitors, and recreationists who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments. Residents and personnel who work in the buildings close to the lake may have access to the shorelines. Swimming is banned but it is possible that recreationists and children could still try to swim in the lake and may contact MEC in the sediments. Potentially complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil and sediment or who may perform intrusive work during future construction or otherwise intrusive activities. Potentially complete exposure pathways exist from MEC in surface soil and surface sediment to terrestrial and aquatic vegetation and wildlife and from MEC in subsurface soil to biota that burrow or nest in the subsurface soil.

An MC CSM for the Picatinny Lakes portion of the Lakes MRS was not developed during the SI as MC is being addressed under the IRP and the MRS was not recommended for further characterization under the MMRP.

4.6.1.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Picatinny Lake portion of the Lakes MRS are reiterated below:

State the Problem: A large majority of Picatinny Lake lies within the 1926 explosion impact radius. MEC associated with the 1926 explosion and munitions testing and nearby production buildings may have contributed to munitions being present in the lake and along the shorelines.

Magnetic surveys of Picatinny Lake have identified 125 underwater anomalies. The anomalies were never investigated to determine the nature and extent of MEC, if present, in the lake.

A 3-inch projectile Barbette gun firing point and associated slug butt/impact area are also present within the Picatinny Lake Area. Burial of unused munitions was sometimes practiced at firing points during testing and training activities. Buried MEC may be present at the firing point. The presence and density of potential MEC at the slug butt/impact area are unknown.

Identify the Decisions: The primary decisions being addressed at the Picatinny Lake portion of the Lakes MRS include:

- Determine whether MEC is present on land portions of the Picatinny Lake portion of the Lakes MRS and the source (e.g., 1926 explosion, building explosion, and/or other sources). If MEC is present on the land portions, delineate the extent of MEC.
- Evaluate whether underwater geophysical anomalies are associated with MEC.
- Detect and investigate the potential burial features associated with discarded munitions disposal at the 3-inch projectile Barbette gun firing point.

- Determine whether a MEC release is present at the former 3-inch projectile Barbette gun slug butt/impact area.

Identify Inputs to the Decision: Several inputs will be acquired to support the decisions:

- Collect underwater DGM transects to fill data gaps from the previous magnetic surveys performed at Picatinny Lake.
- Evaluate existing magnetic survey data with the underwater DGM transect data to identify anomaly trends and distribution.
- Select underwater and near-shore anomalies across Picatinny Lake to evaluate the nature and distribution of MEC.
- Use a mag and dig transect approach along the shoreline of the lake to detect MEC releases associated with the 1926 explosion, building explosions, and the 3-inch projectile Barbette gun slug butt/impact areas.
- Perform DGM surveys at the firing point location as necessary to detect burial features and conduct intrusive investigation.
- Evaluate intrusive results for MEC, MD, and non-MD in the project Geographic Information System (GIS).

Define Study Boundaries: The Picatinny Lake portion of the Lakes MRS covers approximately 125 acres with the open water accounting for 108 acres. An earthen dam bounds the lake to the south with R&D and production buildings to the east and west. Wetlands exist on the north end of the lake. Approximately 17 acres of land surrounding the lake are within the Picatinny Lake portion of the Lakes MRS and include the former firing point for the 3-inch projectile Barbette gun and the slug butt. The extent of potential MEC will be delineated using DGM and mag and dig surveys.

Develop a Decision Rule: The results of the RI at Picatinny Lake will be used as decision rules as follows:

- If MEC is detected along the shoreline and in the water of Picatinny Lake, then the data will be assessed to determine the release mechanisms for MEC.
- If MEC burial areas are present at the firing point, then the nature and extent of MEC will be determined.

Specify Tolerable Limits on Decision Errors: The null hypothesis (H_o) is that a MEC release along the shoreline and within Picatinny Lake (anomalies detected in the lake will be selected based on anomaly distribution and anomaly trends to effectively characterize the area) does not exist. The alternative hypothesis is that MEC releases along the shoreline and within Picatinny Lake do exist.

The H_o for the 3-inch projectile Barbette gun firing point is that a MEC burial area (large anomalous features detected at the 3-inch projectile Barbette gun firing point will trigger intrusive investigations) is not present at the firing point. The alternative hypothesis is that a MEC burial area exists at the firing point.

A Type I decision error is concluding that a MEC release is not present along the shoreline and within Picatinny Lake when it is. A Type II decision error is concluding that a MEC release is present along the shoreline and within Picatinny Lake when it is not. The consequences of a Type I decision error could include increased risks to receptors. The consequences of a Type II decision error could include unnecessarily incurred project costs associated with additional investigation.

A Type I decision error for the 3-inch projectile Barbette gun firing point is concluding that a MEC burial is not present, when it is. A Type II decision error is concluding that a MEC burial area is present, when it is not. The consequences of a Type I decision error could include increased risks to receptors. The consequences of a Type II decision error could include unnecessarily incurred project costs associated with additional investigation.

Optimize the Design: Underwater DGM transects will be performed to fill data gaps identified in the existing magnetic geophysical data collected in the lake. A total of 3 miles or 1 acre of transects will be performed across the lake. The data will be analyzed cooperatively with the existing magnetic survey data to develop a composite dig list. Based on current anomaly trends and locations, it is estimated that approximately 25 anomaly locations will be selected for reacquisition and investigation in the lake and along the lake shoreline. Underwater intrusive investigations will be distributed across the lake to evaluate

the nature of the anomalous sources. Targets will be investigated in anomaly clusters or aerially extensive features so the results can be interpolated to characterize the location. Discrete standalone anomalies not associated with the anomaly clusters will also be evaluated for MEC. Approximately 20% of the anomalies previously detected in the existing magnetic DGM data will be reacquired and investigated. Select anomalies detected in the newly collected DGM data not in the existing anomaly list will be added to the dig list. The dig list will be complemented by the ability to investigate near shore anomalies during the land-based investigations. Prior to performing underwater intrusive investigations, DGM instrumentation will be used to refine target locations. Qualified divers will investigate the approximately 25 anomalies.

Land investigations will consist of performing 2.7 miles or 3.2 acres of mag and dig transect surveys along the shoreline of the lake and across the 3-inch projectile Barbette gun firing point and slug butt/impact area locations. A 100-foot by 100-foot grid (or 0.25-acre area based on accessibility) will be placed at the firing point to detect potential burial features. An EM61-MK2 will be used to survey the grid. Data will be evaluated for large anomalous areas indicative of burial features. Such features, if detected, will be intrusively investigated. Range layout and firing point location information is provided in a 1922 range map presented in the HRR. The map denotes the firing point location for the 3-inch projectile Barbette gun range.

The 100-foot by 100-foot grid will be centered on the firing point based on the 1922 map and existing structures (cement pads). If a full 100-foot by 100-foot grid cannot be placed at the firing point because of obstructions, an area of 0.25 acre will be digitally mapped around the firing point location.

4.6.2 Lake Denmark

4.6.2.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Lake Denmark portion of the Lakes MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the

Lake Denmark portion of the Lakes MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSMs developed for the 1926 Lake Denmark portion of the Lakes MRS is exposure to suspect MEC at ground surface or in subsurface soil with a subsequent hazard identified as a release of MC to environmental media from a MEC source. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of Lake Denmark is not restricted after entering PTA.

Potential current and future human receptors identified for the 1926 Explosion Radius On-Post and Off-Post MRS following the SI are PTA personnel, residents, contractors, visitors, and recreationists. Lake Denmark is used for recreational boating and fishing. No swimming is allowed and fish consumption advisories are in effect. The ecological receptors of concern for the Lake Denmark portion of the Lakes MRS are flora and fauna present at PTA (Section 3.1.7.3). The northern portion of the land surrounding Lake Denmark is dominated by scrub/shrub wetland with smooth alder (*Alnus serrulata*) and swamp azalea (*Rhodendron viscosum*). Undeveloped forest surrounds the lake with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present at the Lake Denmark portion of the Lakes MRS include fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, including featherfoil (*Hottonia inflate*), Robbin's pondweed (*Potamogeton robbinsii*), small bur (*Sparganium minimum*), and lesser bladderwort (*Utricularia minor*). Lake Denmark is located adjacent to Area J, which is a summer roosting area for the federally listed endangered Indiana bat. Gravel Dam Cove, located in the southern end of Lake Denmark, is a unique pond habitat that supports breeding populations of the New England bluet, a rare damselfly.

Exposure pathways for MEC are considered potentially complete for the Lake Denmark portion of the Lakes MRS because the presence and density of MEC are unknown. Potentially complete exposure pathways exist for PTA personnel, residents, contractors/visitors, and recreationists who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments. Residents and personnel who work in the buildings close to Lake Denmark may have access to

the shorelines. Swimming is banned, but it is possible that recreationists and children could still try to swim in the lake and may contact MEC in the sediments. Potentially complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil and sediment or who may perform intrusive work during future construction or otherwise intrusive activities. Potentially complete exposure pathways exist from MEC in surface soil and surface sediment to terrestrial and aquatic vegetation and wildlife and from MEC in subsurface soil to biota that burrow or nest in the subsurface soil.

For the land portion of the Lake Denmark portion of the Lakes MRS, exposure pathways for MC are considered potentially complete because it has not been established that MC is present at concentrations of concern. Potentially complete exposure pathways exist for PTA personnel, PTA residents, contractors/visitors, and recreationists who may contact MC in surface soil. Potentially complete exposure pathways also exist for contractors who may contact MC in subsurface soil while accessing underground utilities or performing other intrusive work. Potential exposure routes include incidental ingestion, dermal contact, and inhalation of dust. Potentially complete exposure pathways exist for biota that may contact MC in surface soil and that may nest or burrow at the Lake Denmark portion of the Lakes MRS and may contact MC in subsurface soil. Although there may be potentially complete exposure pathways to MC in surface water and sediment, surface water at the Lakes MRS is addressed under the IRP. Potential groundwater exposure pathways are not addressed in the RI as all groundwater within PTA is addressed under the IRP.

4.6.2.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Lake Denmark portion of the Lakes MRS are reiterated below:

> ***State the Problem:*** Existing underwater magnetic geophysical data collected in Lake Denmark may not completely delineate the mortar range impact area. The extent and density of MEC in the impact area are unknown. No intrusive investigations were performed to evaluate the existing magnetic anomalies to determine whether they are MEC.

Similarly, MEC density and distribution at the 20mm cannon range impact area are not available. The presence of a MEC release in this area is unknown.

Three former firing points are located at the southern end of Lake Denmark. Burial of unused munitions was sometimes practiced during training. Buried MEC may be present at each of the firing points.

Identify the Decisions: The primary decisions being addressed at the Lake Denmark portion of the Lakes MRS include:

- Determine whether a MEC release from the mortar and 20mm ranges is present on the land portions of the Lake Denmark portion of the Lakes MRS based on VSP calculations.
- Delineate the Lake Denmark mortar range impact area with additional geophysical transect surveys.
- Determine whether MEC burial features are present at the firing points and determine the nature and extent of MEC at burial sites.

Identify Inputs to the Decision: Several inputs will be acquired during the RI to support the decisions:

- Collect underwater DGM transects to fill data gaps from the previous magnetic surveys performed at Lake Denmark.
- Evaluate existing magnetic survey data with the underwater DGM transect data to identify anomaly trends and distribution.
- Select underwater and near-shore anomalies across Lake Denmark to evaluate the nature and distribution of MEC. Distribution of anomalies can be evaluated in existing and newly collected DGM data. Anomalous areas and trends will be selected for investigation. Investigations underwater and on the shoreline will provide supporting data on the nature of the anomalies.
- Perform DGM surveys and intrusive investigations at the firing point location as necessary to detect burial features.
- Conduct mag and dig transects based on VSP calculations on the land-based areas around Lake Denmark and along the shoreline of the lake. VSP input parameters were determined for the Lake Denmark portion of the Lakes MRS based on munitions use. The land on the northern end of Lake Denmark is part of the mortar range SDZ and also includes the 20mm cannon range impact area. The HFD for a 20mm projectile was used as the potential size of the MEC release on the northern side of the lake. The land on the southern end of Lake Denmark is part of the mortar range SDZ. The

smallest mortar used at the range was the 60mm. The HFD for a 60mm mortar was used as the potential size of the MEC release on the southern side of the lake. **Table 4-4** lists the VSP parameters and coverage requirements for the Lakes MRS – Lake Denmark Area.

- Evaluate intrusive results for MEC and MD in the project GIS.

Table 4-4 VSP Parameters and Coverage Requirements for the Lakes MRS (PICA-008-R-01) – Lake Denmark Area

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Lakes MRS (PICA-008-R-01) – Lake Denmark Area
Shape of Target Area	Circular
Target Area of Interest	61-ft radius for a 20mm projectile); 150 ft radius (for a 60mm mortar)
Anomaly Density Indicator	50 anomalies/acre (consistent with DGM surveys conducted during EE/CA and SI observations)
Transect Width	10 ft (team physical transect width)
Transect Spacing	120 ft (based on a 20mm projectile; 225 ft (based on a 60mm mortar)
Transect Distance	14 miles
Transect Area	17 acres (2.75% coverage of the MRS)

Define Study Boundaries: Approximately 263 acres of the Lake Denmark portion of the Lakes MRS are surface water. The remaining 353 acres are land that falls within the SDZ for the mortar range and 20mm range. The lake is bound by a dam and Gravel Dam Cove to the south and wetlands to the north. Undeveloped land is to the east and the southern ridgeline of Copperas Mountain lies to the west.

The shoreline and northern end of the lake is marshy and heavily vegetated. Accessing these areas with digital instrumentation will be difficult. The nearby high power transmission lines are accessed by helicopter and may impact data quality.

Develop a Decision Rule: The results of the RI at the Lake Denmark Area will be used as follows:

- If, through intrusive investigation of the DGM, transects confirm the mortar range impact area in Lake Denmark, then the density and extent of MEC will be evaluated based on trends and anomaly distribution in the lake.

- If a MEC release is present at the northern and southern ends of Lake Denmark, then the nature and extent will be determined.
- If MEC burial areas are present at any firing point, then the nature and extent of the MEC will be determined.

Specify Tolerable Limits on Decision Errors: The null hypothesis (H_o) is that a MEC release on the land portion and along the shoreline and within Lake Denmark does not exist. Anomalies detected in the lake will be selected based on anomaly distribution and anomaly trends to effectively characterize the area. The alternative hypothesis is that MEC releases do exist on the land portion and along the shoreline and within Lake Denmark.

The H_o for the firing points is that a MEC burial area is not present at the firing point. Large anomalous features detected will trigger intrusive investigations. The alternative hypothesis is that a MEC burial area exists at one or more of the firing points.

A Type I decision error is concluding that a MEC release is not present on the land portion, along the shoreline, or within Lake Denmark when it is. A Type II decision error is concluding that a MEC release is present on the land portion, along the shoreline, or within Lake Denmark when it is not. The consequences of a Type I decision error could include increased risks to receptors. The consequences of a Type II decision error could include unnecessarily incurred project costs associated with additional investigation.

A Type I decision error for the firing points is concluding that a MEC burial is not present when it is. A Type II decision error is concluding that a MEC burial area is present when it is not. The consequences of a Type I decision error could include increased risks to receptors. The consequences of a Type II decision error could include unnecessarily incurred project costs associated with additional investigation.

Optimize the Design: Underwater DGM transects will be performed to fill in data gaps identified in the existing magnetic geophysical data collected in Lake Denmark. A total of 5 miles or 2 acres of transects will be performed across the

northern end of Lake Denmark. The data will be analyzed cooperatively with the existing magnetic survey data to develop a composite dig list. Based on current anomaly trends and locations, it is estimated that approximately five anomaly locations will be selected for reacquisition and investigation in the lake and along the lake shoreline. Qualified divers will investigate at the five locations.

Land investigations will consist of performing 14 miles/17 acres of mag and dig transect surveys. A 100-foot by 100-foot grid (or 0.25-acre area based on accessibility) will be placed at each of the three firing points to detect potential burial features. An EM61-MK2 will be used to survey each grid. Data will be evaluated for large anomalous areas indicative of burial features. Such features, if detected, will be intrusively investigated.

The 100-foot by 100-foot grid size was selected based on the terrain and cultural development at the locations of the firing points. The mortar range firing points are located on the edge of Lake Denmark. Directly to the west are the 25th Avenue roadway and exposed bedrock. The 20mm range firing point is located near the baseball field. To the south of the firing point are a fence, backstop, and paved parking area near the baseball diamond. To the north of the firing point is Lake Denmark.

The grids at the mortar ranges firing points will be centered on each firing point based on the 1974 map. Terrain and development will dictate final grid placement. DGM will not be performed over exposed bedrock because it is unlikely burial would have taken place in those locations.

The grid location for the 20mm range firing point will be centered on the firing point based on the 1947 map. The developed areas on and near the baseball field will obstruct DGM effectiveness and accessibility. The grid will extend toward the lake as far as possible.

If a full 100-foot by 100-foot grid cannot be placed at the firing points because of obstructions, an area of 0.25 acre will be digitally mapped around the firing point locations. Final survey area placement will be based on field observations.

4.7 LAKE DENMARK – OFF-POST MRS

4.7.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Lake Denmark – Off-Post MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSM developed for the Lake Denmark – Off-Post MRS is exposure to suspect MEC at ground surface or in subsurface soil, with a subsequent hazard identified as a release of MC to environmental media from a MEC source. The MRS is located outside the secured PTA boundary. Access to Sterigenics operational areas is restricted by a guarded gate but access is generally unrestricted on the other areas of the Lake Denmark – Off-Post MRS.

Potential current and future human receptors identified for the Lake Denmark – Off-Post MRS following the SI include Sterigenics workers; utility workers; contractors; visitors; and recreationists, including hunters and hikers. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). The majority of the MRS consists of wetlands and forested areas, dominated by members of the red oak subgroup, which comprise much of Lake Denmark off-Post MRS. Flora and fauna that are found in the habitats in the Lake Denmark portion of the Lakes MRS also may be present in the Lake Denmark – Off-Post MRS. Nesting sites of the federally listed endangered Indiana bat are believed to located either at or near the MRS.

Exposure pathways for MEC are considered potentially complete for the Lake Denmark – Off-Post MRS because the presence and density of MEC is unknown. Potentially complete exposure pathways exist for contractors performing intrusive work at the RTI Superfund site. Potentially complete exposure pathways exist for recreationists via handling and treading on surface soil.

Potentially complete exposure pathways exist for biota that may contact MEC in surface soil and that may nest or burrow at the Lake Denmark – Off-Post MRS and thereby contact MEC in subsurface soil.

Exposure pathways for MC are considered potentially complete for the Lake Denmark – Off-Post MRS because it has not been established that MC is present at concentrations of concern. Potentially complete exposure pathways exist for Sterigenics workers and contractors who may contact MC in surface and subsurface soil when performing intrusive investigations or accessing underground utilities. Potential exposure routes include incidental ingestion, dermal contact, and inhalation of dust. Potentially complete exposure pathways exist for biota that may contact MC in surface soil and that may nest or burrow at the Lake Denmark – Off-Post MRS and may contact MC in subsurface soil. Exposure pathways are potentially complete through the food chain for both human and ecological receptors from consumption of biota that have bioaccumulated MC. Although potential MC transport/migration routes from soil to groundwater were identified above, exposure to MC in groundwater is not expected because the MC has low water solubility.

4.7.2 Data Quality Objectives and Data Needs

4.7.2.1 Data Quality Objectives Presented in Final Work Plan

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Lake Denmark – Off-Post MRS are reiterated below:

State the Problem: The Lake Denmark – Off-Post MRS is an SDZ of a former mortar range. No MEC or MD has been observed in the MRS; however, overshots from the mortar range may have impacted this MRS.

Identify the Decisions: The primary decisions being addressed at the Lake Denmark – Off-Post MRS include:

- Determine whether a MEC release is present within the MRS using VSP.

Identify Inputs to the Decision: Several inputs will be acquired during the RI of the Lake Denmark – Off-Post MRS to support the decisions. Initially, VSP input parameters were determined for the MRS based on the munitions used at the former Lake Denmark mortar range. The smallest mortar used at the range was a

60mm. The HFD of the 60mm mortar was used to determine the size of the potential MEC release. Intrusive results for MEC, MD, and non-MD will be evaluated in the project GIS. **Table 4-5** lists the VSP parameters and coverage requirements for the Lake Denmark – Off-Post MRS. Intrusive results for MEC, MD, and non-MD will be evaluated in the project GIS.

Table 4-5 VSP Parameters and Coverage Requirements for the Lake Denmark – Off-Post MRS (PICA-012-R-01)

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Lake Denmark – Off-Post MRS (PICA-012-R-01)
Shape of Target Area	Circular
Target Radius	150-ft radius
Anomaly Density Indicator	50 anomalies/acre
Transect Width	10 ft
Transect Spacing	225 ft
Transect Distance	4 miles
Transect Area	4.9 acres

Define Study Boundaries: the RTI Superfund Site and vacant land occupy the majority of the 113-acre Lake Denmark – Off-Post MRS. The MRS is bordered by PTA and Lake Denmark to the north and west. There are no distinct boundaries to the south and east; therefore, they will be defined by the extent of MEC associated with the former mortar range at the Lake Denmark – Off-Post MRS. The extent of potential MEC will be delineated using DGM.

Develop a Decision Rule: The results of the RI at the Lake Denmark – Off-Post MRS will be used as follows:

- If through intrusive investigation MEC is determined, then an assessment will be recommended to determine whether increased MEC densities represent MEC releases associated with the former mortar range at the Lake Denmark – Off-Post MRS.

Specify Tolerable Limits on Decision Errors: The null hypothesis (H_o) is that RI results confirm that a MEC release resulting from former mortar firing at the Lake Denmark – Off-Post MRS does exist. The alternative hypothesis is that RI results confirm that a MEC release resulting from former mortar firing at the Lake

Denmark – Off-Post MRS does not exist. A Type I decision error is concluding that a MEC release associated with the former mortar range at the Lake Denmark – Off-Post MRS is not present when it is. A Type II decision error is concluding that a MEC release associated with the former mortar range at the Lake Denmark – Off-Post MRS is present when it is not. The consequences of a Type I decision error could include increased risks to receptors. The consequences of a Type II decision error could include unnecessarily incurred project costs associated with additional investigation.

Optimize the Design: Mag and dig transect surveys will be performed across the Lake Denmark – Off-Post MRS at a 225-foot spacing based on VSP calculations. Total mag and dig coverage will be approximately 4 miles or 4.9 acres. MEC density will be determined based on intrusive work during the mag and dig surveys. Anomalies will be investigated to determine the approximate MEC density.

4.7.2.2 Revised Data Quality Objectives

The revised DQOs developed for the RI are presented in a technical memorandum submitted May 10, 2013 evaluating the use of instrument-assisted non-intrusive visual surveys to support the RI. The revised DQOs for the Lake Denmark – Off-Post MRS are reiterated below:

State the Problem:

- The Lake Denmark – Off-Post MRS is a portion of a former mortar range fan located on privately owned property adjacent to Picatinny Arsenal.
- According to the HRR, the range was used for experimental testing of 60mm, 81mm, and 4.2-inch mortars.
- Mortars may have impacted the Lake Denmark – Off-Post MRS during testing activities.
- The nature and extent of potential MEC in the MRS is unknown.

Identify the Decisions:

- Do concentrated munitions use areas exist within the Lake Denmark – Off-Post MRS?
- What is the nature and extent of MEC?
- Does MEC pose an unacceptable hazard in the Lake Denmark – Off-Post MRS?
- Is MC associated with MEC present and above applicable screening levels? Potential MC will be addressed in accordance with the approved work plan.

Identify Inputs to the Decisions:

- The Lake Denmark – Off-Post MRS is part of an EPA Superfund site. Significant surface and intrusive work have been performed by the EPA across much of the MRS. As shown by the quantity and location of past activities, the majority of the MRS would have been traversed by scientists or technicians during media sampling activities or other site assessments. It is estimated that as much as 5% of the MRS was traversed from previous environmental investigations. This quantity is similar to the amount of planned MMRP RI coverage. Much of the work also required MEC construction support using UXO Technicians. No MEC or MD has been previously reported during these activities.
- Approximately 4.75 acres of visual surveys were performed during the SI at the MRS. No MEC or MD was observed.
- Mag and dig transect surveys have been performed to the north and west of the MRS as part of the MMRP RI performed at the neighboring Lakes MRS. No MEC was recovered. One MD item was recovered from the underwater investigations in Lake Denmark as detailed further in Subsection 6.6.2.
- One MEC item documented as a UXO, 60mm high explosive mortar has been encountered along the Public Service Electric and Gas Company (PSE&G) power line right of way near PTA boundary. This was the first known MEC item recovered near the Lake Denmark – Off-Post MRS.

Define the Study Area Boundaries:

- The Lake Denmark – Off-Post MRS is 113 acres located on privately owned property.
- Non-intrusive visual surveys will be performed in locations where limited environmental sampling has been previously conducted. These are the locations where the greatest uncertainty for potential MEC would be located.

Develop Decision Rules:

- If no anomaly cluster areas (high density of subsurface anomalies) or concentrations of MEC and MD are traversed or detected, then the MEC density and, therefore, the explosive hazard potential, are low.
- If anomaly cluster areas are traversed and detected, then recommend future intrusive investigations as part of a data gap study to determine the source of the detected anomalies.

Specify Tolerable Limits on Decision Errors:

- The transect survey design was developed using VSP software. Additional information on the VSP parameters can be found in the Final RI Work Plan. Based on these parameters, VSP has calculated a transect spacing of 225 feet to ensure a 95% probability of traversing and detecting MEC impact areas with a 150-foot radius and density of 50 anomalies per acre.
- Because intrusive investigations along transects cannot be performed at this time, a denser transect spacing will be performed based on NJDEP recommendations. The transect spacing for the instrument aided non-intrusive visual surveys will be 100 feet.
- Anomaly density information collected during the transect surveys will be assessed in VSP to determine whether anomaly cluster areas are present within the Lake Denmark – Off-Post MRS. To identify anomaly clusters, VSP "flags" anomaly densities within the MRS matrix that are greater than a pre-defined critical density for the MRS. The critical density for an MRS is the point where the most rapid transition occurs between background densities and higher densities of anomalies, which are indicative of concentrated munitions use areas. The critical density will be determined based on the VSP calculation results and visual observations of MEC, MD and cultural debris locations.
- Errors will be minimized by using the proper detection instrumentation based on accessibility, munitions types, and geology.
- Minimize errors by using qualified UXO Technicians to perform the surveys.

Optimize the sampling design:

- Non-intrusive visual transect surveys will be performed in locations of the Lake Denmark – Off-Post MRS where there is the greatest uncertainty for potential MEC.

- Each anomaly location will be recorded using a GPS along the transect surveys.
- The locations of the anomalies will be assessed in VSP to determine if anomaly cluster areas are present.
- Visual observations and locations of MEC, MD and cultural debris will also be recorded and assessed.

Non-intrusive visual surveys will be performed at transect locations presented in **Figure 4-1**.

4.8 INACTIVE MUNITIONS WASTE PIT MRS

4.8.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Inactive Munitions Waste Pit MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSM developed for the Inactive Munitions Waste Pit MRS is exposure to suspect MEC at ground surface or in subsurface soil with a subsequent hazard identified as a release of MC to environmental media from a MEC source. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) and a locked gate controls access to the Inactive Munitions Waste Pit MRS. No personnel are allowed on-site during testing operations at nearby ranges.

Potential current and future human receptors identified for the Inactive Munitions Waste Pit MRS following the SI include authorized PTA personnel, PTA residents, and contractors/visitors. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). The Inactive Munitions Waste Pit MRS is surrounded by forested areas, including some shrubby habitat.

Potentially complete exposure pathways for MEC exist for PTA personnel/residents and contractors/visitors who may contact, via handling/treading underfoot, MEC in the surface soil or surficial sediment of the swampy area of the Inactive Munitions Waste Pit MRS. Potentially complete exposure pathways also exist for contractors who may contact MEC in subsurface soil

or subsurface sediment while performing intrusive work. Clearance must be given by PTA's Safety Office prior to any subsurface activity. Potentially complete exposure pathways exist for biota that may contact MEC in surface soil or surficial sediment and that may nest or burrow at the Inactive Munitions Waste Pit MRS and thereby contact MEC in subsurface soil.

Several chemical parameters were detected in environmental media. Complete exposure pathways exist for MC for receptors with access to the Inactive Munitions Waste Pit MRS. Complete exposure pathways for MC exist for PTA personnel/residents and contractors/visitors who may contact MC in surface soil or sediment at the MRS. Complete exposure pathways also exist for contractors who may contact MC in subsurface soil while performing intrusive work. Exposure routes include ingestion and dermal contact and, for soil, inhalation of dust. Complete exposure pathways exist for biota that may contact MC in surface and subsurface soil or sediment while feeding, nesting, or burrowing.

4.8.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Inactive Munitions Waste Pit MRS are reiterated below:

State the Problem: Based on available evidence, MEC and MD could have been released in the MRS from former testing activities and munitions disposal. It is unknown whether MEC or MC is present at the Inactive Munitions Waste Pit MRS. It is also unknown whether MEC resulting from release artillery testing activities is present within the Code 300 Area.

Identify the Decisions: The primary decisions being addressed at the Inactive Munitions Waste Pit MRS include:

- Determine the nature and extent of MEC in burial sites if present within the MRS.
- Determine whether a MEC release is present within the MRS as a result of potential munitions testing activities. If a MEC release is present, determine the nature and extent of the MEC release.
- Determine whether a MEC release is present within the Code 300 Area from historical artillery firing practices. If a MEC release is present, determine the nature and extent of the MEC release.

Identify Inputs to the Decision: Several inputs will be acquired to support the decisions:

- Perform EM31-MK2 transect surveys to detect burial features in the central portion of the Inactive Munitions Waste Pit MRS where potential testing and burial activities would have occurred.
- Perform mag and dig surveys to evaluate the remaining portion of the MRS for MEC/MD and MEC releases.
- Use VSP coverage requirements for the Code 300 Area, which are better suited to the potential MEC release profile. It has been documented that artillery testing activities may have been performed for artillery up to a 155mm projectile. The smallest MEC release for the Code 300 Area is based on a 57mm projectile. **Table 4-6** lists the VSP parameters and coverage requirements for the Code 300 Area within the Inactive Munitions Waste Pit MRS.

Table 4-6 VSP Parameters and Coverage Requirements - Code 300 Area

VSP Parameter	VSP Input and Coverage Requirements
Munitions Response Site	Code 300 Area located within the Inactive Munitions Waste Pit (PICA-013-R-01)
Shape of Target Area	Circular (based on the hazardous fragmentation distance of a 57mm projectile)
Target Area of Interest	243-ft radius
Anomaly Density Indicator	40 anomalies/acre (conservative value used for an impact area)
Background Anomaly Density	10 anomalies/acre
Transect Width	10 ft (physical team transect width)
Transect Spacing	193 ft (203 ft on centers)
Transect Distance	2,668 linear feet
Transect Area	.6 acres (28.5% coverage of the Code 300 Area)

Define Study Boundaries: The Inactive Munitions Waste Pit MRS study area consists of a potential testing area located centrally within the MRS and the surrounding 1,250-foot SDZ. The MRS includes forested areas and some shrubby habitat and a swamp located on the southern boundary of the potential former testing area. The Inactive Munitions Waste Pit MRS is bordered by PTA

boundary to the northwest. Additionally the MRS is bordered to the east and south by operational range areas that intersect the 1,250-foot SDZ. The Code 300 Area lies between the two operational ranges. The extent of potential MEC and burial sites will be delineated using DGM and mag and dig surveys. The DGM surveys will be concentrated near the potential former testing area in the center of the MRS, whereas the mag and dig transect surveys will be performed in the remaining SDZ radius.

Develop a Decision Rule: The results of the RI will be used as follows:

- If MEC burial sites are detected by DGM transect surveys, then the extent of MEC will be delineated.
- If an increased anomaly density is detected during the mag and dig transect surveys in the remaining portion of the Inactive Munitions Waste Pit MRS outside the Code 300 Area, then a determination will be made whether the increase in anomaly density is related to a MEC release.
- If an increased anomaly density is detected during the density transect surveys in the Code 300 Area, then a determination will be made whether the increase in anomaly density is related to a MEC release.
- If MEC is present in the Code 300 based on intrusive anomaly investigation results, then the nature and extent of MEC will be determined.

Specify Tolerable Limits on Decision Errors: The null hypothesis (H_o) for the area where potential munitions testing occurred in the Inactive Munitions Waste Pit MRS is that no MEC burial sites related to historical disposal activities exist. The alternative hypothesis is that burial sites exist and they contain MEC. The Type I decision error associated with this H_o is to conclude that burial sites are present when they are not. The Type II decision error is to conclude that no burial sites are present when they are. The consequences of a Type I decision error could include unnecessarily incurred project costs associated with additional investigation. The consequences of a Type II decision error could include increased risks to receptors. If H_o is rejected based on the detection of a potential burial site, intrusive investigations will be performed to determine the nature and extent of MEC if present. If no potential burial sites are detected within this area of the Inactive Munitions Waste Pit MRS, intrusive investigations will not be

performed.

The H_o for the remaining portions of the Inactive Munitions Waste Pit MRS outside the Code 300 Area is no MEC releases from potential munitions testing activities exist. The alternative hypothesis is that MEC releases exist and MEC and MD are present. The Type I decision errors associated with this H_o MEC release exist when they do not. The Type II decision error is to conclude that no MEC releases exist when they do. The consequences of a Type I decision error could include unnecessarily incurred project costs associated with additional investigation. The consequences of a Type II decision error could include increased risks to receptors. If H_o is rejected based on the detection of a potential MEC release, intrusive investigations will be performed to determine the nature and extent of MEC and MD if present. If no potential MEC releases are detected within this area of the Inactive Munitions Waste Pit, no additional grid surveys will be performed.

H_o for the Code 300 Area is that the location does not contain a MEC impact area because of historical artillery firing and does not necessarily contain individual MEC. The H_o is based on the lack of historical records that indicate that a dedicated range or impact area existed and the lack of MEC finds within the Code 300 Area. The decision errors associated with this H_o are concluding that there is a MEC impact area within the Code 300 Area when there is not (Type I) and concluding that there is no MEC impact area within the Code 300 Area when there is (Type II). If H_o is rejected based on the identification of a potential MEC impact area (e.g., anomaly densities significantly greater than the background anomaly density over a large area) within the Code 300 Area, then additional grid surveys will be performed within the potential MEC impact area to determine the nature of the anomalies. If potential impact areas are not identified in the Code 300 Area, no additional grid surveys will be conducted in the Code 300 Area.

Optimize the Design: DGM transects will be performed with the EM31-MK2 in the central area of the Inactive Munitions Waste Pit MRS where testing may have occurred. Both the ground conductivity and magnetic susceptibility measurements

will be processed and evaluated to identify high density areas indicative of burial sites. The EM31-MK2 will be conducted along a transect spacing of 25 feet covering approximately 2,767 linear feet. The point between the elevated responses associated with the burial site and the background response associated with an area free from conductive material will be defined as the burial site boundary. Mag and dig transect surveys will be conducted at 300-foot spacing in the remaining portions of the Inactive Munitions Waste Pit MRS to detect potential MEC releases. Density transect surveys will be conducted in the Code 300 Area at a spacing of 203 feet. This will satisfy the coverage requirements for both the Code 300 Area and the potential MEC release area associated with the Inactive Munitions Waste Pit MRS.

If the MEC is not BIP, biased sampling is proposed near MEC found during the MMRP RI only when field observation indicates that a potential release has occurred (e.g., visual evidence of staining, the munition is cracked or corroded, the item is not inert). No MC sampling is proposed for any MEC when the MEC is BIP.

4.9 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

4.9.1 Preliminary Conceptual Site Model and Project Approach

The preliminary CSM diagrams that were used as the basis for the overall RI strategies for the Inactive Munitions Waste Pit – Off-Post MRS were initially developed following the SI. The preliminary CSM for the MRS defines the source(s), activity(s), access, and receptors for the MRS in addition to providing an overview of complete and potentially complete pathways based on the results of the human and ecological risk screening performed for the SI.

The primary source of hazard identified in the preliminary CSM developed for the Inactive Munitions Waste Pit – Off-Post MRS is exposure to suspect MEC at ground surface or in subsurface soil, with a subsequent hazard identified as a release of MC to environmental media from a MEC source. The MRS is located outside the secured PTA boundary. Access is unrestricted but very difficult because of the steepness of the terrain in the western portion of the Inactive Munitions Waste Pit – Off-Past MRS.

Potential current and future human receptors identified for the Inactive Munitions Waste Pit – Off-Post MRS following the post-SI are recreationists such as hunters and hikers. The ecological receptors of concern for the MRS are flora and fauna present at PTA (Section 3.1.7.3). The Inactive Munitions Waste Pit – Off-Post MRS consists of steep, mountainous terrain located within the Highlands Preservation Areas and a Wildlife Management Area. A habitat with at least one occurrence of a state-listed threatened species is present at the MRS.

The exposure pathway for MEC for recreationists who might contact MEC via handling or treading on surface soil is incomplete due to the steep terrain and difficulty accessing the Inactive Munitions Waste Pit – Off-Post MRS. There are, however, potentially complete exposure pathways for biota that may contact MEC in surface soil and that may nest or burrow at the MRS and thereby contact MEC in subsurface soil. These pathways are potentially complete because the presence and density of MEC is unknown.

The exposure pathway for MC for recreationists who might contact MC in surface soil is incomplete due to the steep terrain and difficulty accessing the Inactive Munitions Waste Pit – Off-Post MRS. Potentially complete exposure pathways exist for biota that may contact MC in surface soil, may nest or burrow at the MRS, and/or may contact MC in subsurface soil. These exposure pathways are potentially complete because it has not been established that MC is present at concentrations of concern. Although potential MC transport/migration routes from soil to groundwater were identified, exposure to MC in groundwater is not expected because the MC has low water solubility and the Inactive Munitions Waste Pit – Off-Post MRS is currently undeveloped.

4.9.2 Data Quality Objectives and Data Needs

The DQOs developed for the RI are presented in the PTA Final RI Work Plan (WESTON, 2012), and the specific DQOs for the Inactive Munitions Waste Pit – Off-Post MRS are reiterated below:

> ***State the Problem:*** Based on available evidence, MEC and MD could have been released in the MRS from former testing activities on-post. Limited inspections within the Inactive Munitions Waste Pit – Off-Post MRS were performed during the SI. It is unknown whether MEC or MC associated with MEC is present at the

MRS.

Identify the Decisions: The primary decisions being addressed at the Inactive Munitions Waste Pit – Off-Post MRS include:

- Determine whether MEC is present within the MRS and at what density.
- Determine the nature and extent of MEC if a MEC release is observed.

Identify Inputs to the Decision: Several inputs will be acquired to support the decisions:

- Perform mag and dig surveys in accessible areas of the Inactive Munitions Waste Pit – Off-Post MRS at the top of the ridge and bottom of the slope to detect and recover surface and subsurface MEC. Investigate all anomalies.
- Perform mag and dig transect surveys to evaluate the remaining portion of the MRS near the PTA boundary for MEC/MD and MEC releases.
- Evaluate intrusive results for MEC, MD, and non-MD in the project GIS.

Define Study Boundaries: Accessible areas of the Inactive Munitions Waste Pit – Off-Post MRS are located in the northwest at the bottom of the steep slope and on top of the ridge, with the remaining portion to the southeast near the PTA boundary.

Decision Rule: The results of the RI will be used as follows:

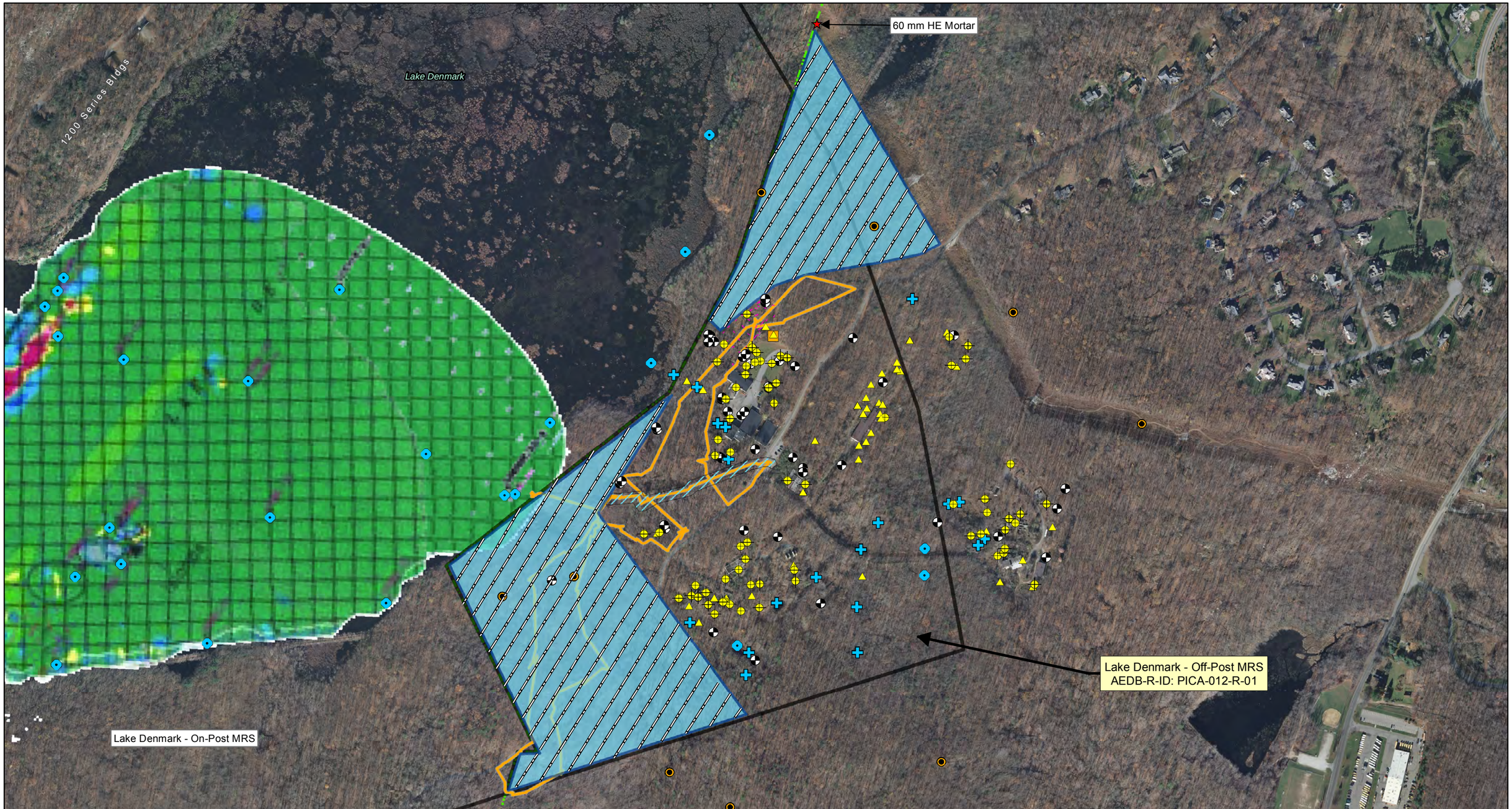
- If MEC is present based on intrusive anomaly investigations, then an assessment of the MEC density in the Inactive Munitions Waste Pit – Off-Post MRS will be recommended.
- If an increased anomaly density is detected during the mag and dig transect surveys in the remaining portion of the MRS then a determination will be made whether the increase in anomaly density is related to a MEC release.

Specify Tolerable Limits on Decision Errors: Full coverage mag and dig surveys using GPS will be performed in accessible areas at the top of the ridge and bottom of the slope in the northwest portion of the Inactive Munitions Waste Pit – Off-Post MRS.

The H_o for remaining portions of the MRS is that no MEC releases from potential munitions testing activities exist. The alternative hypothesis is that MEC releases exist and MEC and MD are present. The Type I decision errors associated with

this H_o are that MEC releases exist when they do not. The Type II decision error is to conclude that no MEC releases exist when they do. The consequences of a Type I decision error could include unnecessarily incurred project costs associated with additional investigation. The consequences of a Type II decision error could include increased risks to receptors. If H_o is rejected based on the detection of a potential MEC release, intrusive investigations will be performed to determine the nature and extent of MEC and MD if present. If no potential MEC releases are detected in accessible areas at the top of the ridge and bottom of the slope in the northwest portion of the Inactive Munitions Waste Pit – Off-Post MRS, no additional grid surveys will be performed.

Optimize the Design: Full coverage mag and dig surveys will be performed in accessible areas at the top of the ridge and bottom of the slope in the northwest portion of the MRS where the terrain is accessible to the UXO teams. All anomalies will be investigated to determine the approximate MEC density. Mag and dig transect surveys will be conducted at 300-foot spacing in the remaining portions of the Inactive Munitions Waste Pit – Off-Post MRS to detect potential MEC releases.



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Proposed Visual Survey Area
- Visual Survey Transects
- Mortar found during PSE&G work
- Subsurface Soil Boring Locations
- Subsurface Soil Sample Locations
- Sediment Sample Locations
- Surface Water/Sediment Sample Locations
- Background Soil Sample Locations
- Monitoring Well Locations
- Berm
- Previous Geophysical Investigation
- Test Pit Locations
- SI Survey
- Approximate location of a former drum disposal area

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 500 1,000 Feet

0 175 350 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 4-1
Lake Denmark - Off-Post MRS
Revised Survey Locations

Date: 12/3/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

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5. CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN AND MUNITIONS CONSTITUENTS

This section presents the comprehensive project approach, methods, and operational procedures used for the RI MEC and MC characterization performed at PTA. Similar to the preceding sections of the RI Report, this section is organized to first report details that are applicable to all the MRSs at PTA at the program level, including the duration of RI field activities, data collection and processing methodologies, investigation procedures, and management of munitions-related materials. Subsequent subsections address MRS-specific individual approaches, field investigations, and activities that were employed during the RI to characterize MEC and MC.

5.1 PTA RI CHARACTERIZATION ACTIVITIES

The following subsections detail components of the RI at the program-level for PTA and are applicable to all MRSs.

5.1.1 Duration of Field Activities

Field activities for the RI were conducted between November 2011 and November 2012 as shown in **Table 5-1**.

Table 5-1 Duration of PTA RI Field Activities

RI Field Activity	Duration of Activities
Location Surveying and Mapping	11/21/2011 – 12/08/2011
DGM Survey	12/09/2011 – 02/21/2012
Intrusive Investigation	04/04/2012 – 05/31/2012
Lakes DGM Survey	07/24/2012 – 07/28/2012
Lakes Underwater Intrusive Investigation	11/09/2012 – 11/12/2012
Lake Denmark – Off-Post MRS Transect Survey	09/18/2013 – 09/19/2013
MC Sampling in the Former Operational Areas MRS	12/12/2011 – 12/21/2011
MC Sampling in the Inactive Munitions Waste Pit MRS	05/22/2012 – 05/24/2012

Note: In accordance with the Final Work Plan (WESTON, 2012), non-biased random MC soil samples were collected only from the Former Operational Areas MRS. Biased soil samples were collected from the Inactive Munitions Waste Pit MRS only based on MEC findings during the RI; this is described in more detail in Sections 5.6.2 and 5.9.2.

5.1.2 Location Surveys and Mapping

Location surveys and mapping activities were conducted within PTA in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2012). Surveying was performed by Beatty & Watson, a licensed surveyor. The location surveys and mapping task included the following:

- Establish site control relative to North American Datum 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system, in units of U.S. Survey Feet.
- Install DGM survey control and mark out with survey nails.

Survey control locations used during the DGM surveys are listed in **Table 5-2**. Grid corners used as controls points for the 1926 Explosion Radius DGM grids and the Lake Denmark grid are provided in **Appendix F** DGM Data.

Table 5-2 Picatinny DGM Survey Control Points

Easting	Northing	Comment
1756259.369	14865171.32	CONTROL POINT
1763407.515	14872005.59	CONTROL POINT
1770711.426	14878534.4	CONTROL POINT
1770834.311	14878421.36	CONTROL POINT
1770714.045	14878321.8	CONTROL POINT
1770816.439	14878410.9	CONTROL POINT

Note: Coordinates are in NAD 83 UTM, U.S. ft

5.1.3 Geophysical and Navigational Equipment, System Verification Program and Data Processing

The following subsections describe the geophysical and navigational equipment used during the RI. Sections 5.1.3 through 5.1.7 of the report have been abridged to include only specific details pertaining to characterization activities employed at PTA during the RI to assess MEC. For more information regarding DGM equipment and procedures, refer to **Appendix G**.

5.1.3.1 Geophysical Equipment

The Geonics EM61-MK2 was used for DGM grid surveys in the 1926 Explosion Radius MRS, Former Operational Areas MRS, Lakes MRS, and some DGM transect surveys in the Former Operational Areas MRS. The EM61-MK2 in high-power mode was also used to conduct the

underwater DGM transect surveys in both the Picatinny Lake and Lake Denmark portions of the Lakes MRS.

To assist with detection of bulk burial features, the Geonics EM31-MK2 was used for DGM transect surveys in the Former Operational Areas MRS, the Shell Burial Grounds MRS, and the Inactive Munitions Waste Pit MRS. The Geometric G-858 cesium vapor magnetometer was additionally used for DGM transect surveys in the Shell Burial Grounds MRS as well as the Advanced Geosciences SuperSting R8 earth resistivity (ER) meter which was used to perform the resistivity surveys within the Shell Burial Grounds MRS.

The White's MXT all-metals detector was used by UXO Technicians for anomaly reacquisition and during intrusive activities in all MRSs. The Final RI Work Plan stated that the Vallon, or equivalent, all-metals sensor would be used and the White's MXT is considered an equivalent all-metals detector. The White's MXT was also used during the density transects in the AOI Code 300 area; the visual survey transects conducted in the Lake Denmark – Off-Post MRS; and the additional visual survey transects conducted in the 1926 Explosion Radius MRS, detailed in Section 5.2.1.2.3.

5.1.3.1.1 Navigation and Positioning Equipment

Navigation and positioning equipment and methods used for DGM surveying and reacquisition activities during the RI field activities included line and fiducial, and GPS via Trimble Real Time Kinematic (RTK) and the Trimble GeoXH 6000 units. In grid locations where GPS could not be used because of terrain or overhead obstructions, the line and fiducial surveying method was used. A Trimble R8 RTK GPS was used for survey and reacquisition activities within the Picatinny Lake grid in the Lakes MRS. The Trimble GeoXH 6000 was used for all EM31-MK2, EM61-MK2, and G-858 magnetometer transect surveys.

Mag and dig transect surveys employed Garmin 60CSx or Trimble GeoXH handheld GPS units for navigation. During surveying, item locations were logged using GPS integrated with personal handheld computers operating software capable of electronically logging the target attributes in real-time during the field investigations.

5.1.3.2 Quality Control Process for Geophysical Equipment

The geophysical system verification (GSV) process was used to monitor and verify geophysical equipment functionality during the DGM surveys. The GSV process uses an instrument verification strip (IVS) and a blind seeding program to monitor sensor detection performance (as described in the following subsections). The standard GSV process was used to monitor data quality during land-based EM61-MK2 and analog instrumentation survey activities. The underwater detection systems used a simplified IVS, without a blind seeding component. The underwater IVS consisted of one or two items each, placed in each lake to assess in situ performance. IVS-specific data and results collected daily during the DGM survey effort are provided with the DGM data in **Appendix F**.

The GSV process is not a suitable method for verifying instrument functionality for the EM31-MK2 and the G-858 Magnetometer, as the transect surveys were focused on the detection of bulk magnetic features, not discrete munitions items. The instrument calibration routine outlined by the manufacturer (see Section 3 of the Final RI Work Plan [WESTON, 2012]), along with the standard daily instrument function checks, were sufficient to determine that the system was functioning properly and capable of achieving the RI objectives.

Similarly, the GSV process was not a suitable method for verifying the functionality of the SuperSting R8 ER meter; therefore, prior to initiating the survey, the operator conducted a contact resistance test that measured the contact resistance between the ground and each electrode, as a QC measure for the SuperSting R8 ER meter. If any of the values seemed inconsistent, the electrode was reseated or the ground was moistened around the electrode to improve the current flow into the ground.

5.1.3.2.1 Instrument Verification Strip Design and Results

The IVS provided a means to verify on an ongoing basis that the geophysical equipment was operating properly. The land-based IVS was installed adjacent to the location of a previous contractor's geophysical prove-out behind Building 302 to support the RI at PTA. The IVS was linearly seeded with five items, including one small industry standard object (ISO), two medium ISOs, one inert 37mm projectile, and one inert 60mm mortar. **Table 5-3** lists the IVS seed items and descriptions.

The seeds were placed along the IVS to prevent overlapping signals. The seed layout of the IVS is detailed in **Figure 5-1**. The items were seeded linearly over 70 feet and were spaced 10 feet apart horizontally (least favorable orientation) with the long axis aligned parallel to the ground surface. Item types were confirmed with the USACE quality assurance (QA) Geophysicist prior to mobilization. Seed locations and depths were surveyed by the licensed surveyor. An unseeded test strip was also established adjacent to the seeded portion of the IVS to monitor background noise. IVS construction details and procedures are described in **Appendix G**.

Table 5-3 Instrument Verification Strip Seed Items and Descriptions

IVS Seed Item Type	Northing[b]	Easting[b]	Orientation	Depth	Description
Medium ISO[a] (2 inches by 8 inches)	14869936.76	1760164.57	Horizontal	6.5 inches	Part Number[c]: 44615K529 ASTM Specification: A53/A773.
60mm mortar	14869926.57	1760158.22	Horizontal	6.25 inches	Inert mortar.
37mm projectile	14869917.99	1760152.88	Horizontal	3.25 inches	Inert projectile.
Medium ISO[a] (2 inches by 8 inches)	14869903.59	1760143.90	Horizontal	7.5 inches	Part Number[c]: 44615K529 ASTM Specification: A53/A773.
Small ISO[a] (1 inch by 4 inches)	14869891.73	1760136.51	Horizontal	3.1 inches	Part Number[c]: 44615K466 ASTM Specification: A53/A773.

Notes:
a – Industry standard objects (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.
b - Coordinates are in NAD 83 UTM, U.S. ft.
c - Part number from the McMaster-Carr catalog.

The EM61-MK2 and White's MXT were tested daily at the IVS before and after the DGM surveys and intrusive investigations. The EM61-MK2 was passed through the IVS as depicted in **Figure 5-1**. The White's MXT was tested at the IVS by passing the equipment over the lines to determine whether the volume and frequency of the audible signal changes were consistent with the expected signals. The White's MXT was successfully tested at the IVS, showing its capabilities are equivalent to the Vallon for the detection of the items anticipated to being found at Picatinny Arsenal. The EM61-MK2 IVS results for the 22 days that DGM data were collected at PTA are presented in **Table 5-4**. Results collected for each day of DGM at the IVS show agreement and repeatable results for the series of seeds. The seed items placed within the IVS were observed in the geophysical data with signals consistent with the sensor response curves

developed for the EM61-MK2. All peak responses from the seed items were observed to be greater than the least favorable orientation response and to have consistent responses between surveys. These results demonstrate that the digital geophysical equipment was functioning within a tolerable range to achieve detection performance metrics.

Table 5-4 EM61-MK2 Instrument Verification Strip Results

Item Description	Medium ISO	60mm Mortar	37mm Projectile	Medium ISO	Small ISO
Item Depth (inches)	6.5	6.25	3.25	7.5	3.1
Least favorable orientation response (mV)*	144.95	83.72	46.10	118.82	36.70
Date	Response (mV)				
12/8/2011	127.57	67.60	34.07	116.44	36.93
12/9/2011	129.05	66.15	37.87	116.51	33.01
12/9/2011	130.87	72.03	36.98	110.56	31.99
12/9/2011	125.18	61.15	28.73	108.54	32.28
12/9/2011	127.04	58.75	35.9	106.45	32.8
12/12/2011	117.47	56.763	27.17	93.85	27.43
12/12/2011	123.43	56.1	28.214	91.58	27.93
12/13/2011	121.18	56.75	30.23	101.37	32.07
12/13/2011	120.08	57.702	28.5	88.66	23.76
12/14/2011	120.93	59.206	26.48	93.67	29.6
12/14/2011	121.43	61.692	26.707	98.49	31.14
12/15/2011	123.88	60.358	28.102	102.51	30.44
12/15/2011	126.93	60.54	29.295	105.47	31.63
12/16/2011	129.42	65.73	32.06	117.1	38.67
12/16/2011	132.38	62.582	30.363	108.96	29.44
12/19/2011	124.47	57.4	25.797	92.52	29.39
12/19/2011	116.37	54.377	27.664	86.5	28.55
12/19/2011	123.62	62.99	25.201	97.58	33.36
12/19/2011	114.80	67.95	28.72	113.03	34.18
12/19/2011	123.34	59.5	35.3	103.61	30.28
12/20/2011	125.98	65.496	31.227	105.64	33.03
12/20/2011	126.59	65.342	27.88	99.68	34.1
12/20/2011	129.49	71.962	35.22	121.51	37.33
12/20/2011	125.62	59.493	36.3	112.54	30.78
12/21/2011	126.78	62.22	26.25	107.24	31.34
12/21/2011	130.12	62.206	28.559	112.56	32.2
12/22/2011	128.33	58.09	29.444	102.75	28.66
12/22/2011	126.35	59.086	30.61	105.2	30.13

Table 5-4 EM61-MK2 Instrument Verification Strip Results (Continued)

Item Description	Medium ISO	60mm Mortar	37mm Projectile	Medium ISO	Small ISO
Item Depth (inches)	6.5	6.25	3.25	7.5	3.1
Least favorable orientation response (mV)*	144.95	83.72	46.10	118.82	36.70
Date	Response (mV)				
1/19/2012	126.18	67.28	39.01	95.24	24.46
1/19/2012	129.92	71.37	38.91	94.82	26.64
1/23/2012	117.18	65.39	39.72	85.00	24.51
1/23/2012	131.55	80.74	47.23	99.48	28.77
1/24/2012	137.14	76.57	47.94	102.35	26.37
1/24/2012	112.77	56.31	44.39	87.16	18.69
1/25/2012	144.69	85.31	46.84	108.15	36.50
1/25/2012	146.51	84.40	48.71	105.45	29.73
2/2/2012	141.07	74.25	46.08	114.49	30.59
2/2/2012	155.38	84.08	48.91	121.27	38.28
2/13/2012	144.85	82.76	50.85	107.94	30.56
2/13/2012	148.08	81.33	46.59	112.12	34.00
2/15/2012	137.27	73.72	45.52	102.91	26.81
2/15/2012	141.56	75.58	48.79	111.83	25.78
2/17/2012	135.97	75.30	44.84	106.75	31.43
2/17/2012	154.23	89.03	46.08	127.52	36.65
2/20/2012	146.99	77.32	47.14	104.29	26.87
2/20/2012	147.04	82.01	45.62	106.18	28.85
2/21/2012	146.92	81.96	41.95	117.69	32.31
2/21/2012	151.81	76.92	51.82	113.21	33.59
2/22/2012	148.24	75.20	48.10	105.76	30.81
2/22/2012	145.69	74.91	49.77	106.51	29.18

* mV = millivolts

5.1.3.2.2 Blind Seeding Program

A seeding program was instituted in the land-based DGM survey areas to provide ongoing monitoring of the geophysical instrumentation detection performance. The seed was blind to the geophysical data collection and processing teams. One seed item consisting of a medium ISO (2-inch by 8-inch steel pipe) was placed at approximately 6 inches below ground surface (bgs) in each DGM grid. The location and depth of the seed items were surveyed by the licensed surveyor. All seeds were recovered by the UXO dig teams during intrusive investigations in DGM grids.

The depth, type, geophysical response, and offset of the seed item placed within the DGM grid are provided in **Appendix G** DGM Equipment and Procedures. The blind seed items placed within the DGM survey areas were observed in the geophysical data with a signal consistent with the sensor response curves developed for the EM61-MK2 and within the 3-foot offset metric established in the Final RI Work Plan (WESTON, 2012).

5.1.3.3 Data Processing

5.1.3.3.1 Quality Control

Data processing quality control (QC) metrics were tracked daily throughout the life of the project. The Project Geophysicist performed QC measures not only on the QC instrument function tests, but also on the data collected by the EM61-MK2, EM31-MK2, and the G-858. The following parameters were analyzed:

- Coverage
- Velocity
- Sample separation
- Mean noise
- Noise standard deviation
- QC seed detection

5.1.3.3.2 Data Management

All data related to DGM surveys were managed using Geosoft® Oasis montaj software. All spatial data were managed using a GIS, and are stored in Environmental Systems Research Institute® (ESRI)-compatible GIS formats, primarily ArcInfo coverage and ArcView shape files. Data were stored in site-specific folders based on individual field efforts, data type, and file extensions. All DGM data were provided electronically to the USACE QA Geophysicist for QA. Data were provided via the WESTON TeamLink® website and were backed up on the WESTON internal network and project workstation.

Details regarding digital data processing are included in **Appendix G** DGM Equipment and Procedures.

5.1.4 Anomaly Selection

Anomalies were selected from the gridded data using the Blakely Test target selection algorithm. A target threshold value of 7.2 mV on Channel 2, as approved by the USACE QA geophysicist,

was used to select the initial target list. This threshold was based upon seed item responses and noise levels observed at the IVS during initial pre- and post-seeding surveys. In addition to the primary target list, QA targets were selected at the project geophysicist's discretion with responses as low as 5mV. Target review consisted of manually evaluating all selected targets and removing or merging multiple targets associated with large anomalies. Where necessary, targets were moved to the location of the peak response or target center of a given anomaly.

A target decay analysis was run to remove targets that had an atypical decay between the four time gate channels. An atypical decay is observed when an anomaly signal does not decrease through time, but instead shows an increase in any of the subsequent time gate channels. The most common causes of atypical decay are due to external radio frequency interferences or rouge terrain encountered during data collection. The details of the EM61-MK2 data processing parameters using Geosoft® are summarized in **Appendix G** DGM Equipment and Procedures.

5.1.5 Dig List Development

Following the selection of anomalies from the geophysical data evaluation, the anomaly locations and characteristics were compiled into a dig list. The dig list data were logged into a hand-held computer and managed using WESTON's RespondFast® UXO Investigation System (RespondFast®) software. The site geophysicist assigned each anomaly a unique target identifier and entered the corresponding information for the target into the database. The following information was included in the database for each anomaly:

- Grid ID.
- Unique target ID, including area (i.e., 1926OR-016-001 [Location-Grid ID-unique target ID]).
- Easting and northing position.
- Channel 2 response amplitude for anomalies.

Dig lists developed following digital data analysis are presented in **Appendix H**.

5.1.6 DGM Quality Control

Instrument functionality tests were conducted before and after DGM surveying adjacent to the IVS, located behind Building 302. The static test and static response test involved collecting non-dynamic data for a period of 3 minutes without and with a small ISO item for the EM61-MK2,

EM31, and G858. Tests for the EM61-MK2 show background noise levels ranging from 0.57 to 1.98 standard deviations, with minimum and maximum readings between 4.6 mV and 2.6 mV. The static spike test measurements range from a minimum of 148 mV to a maximum value of 181 mV with a standard deviation between 0.61 and 1.76. Static response test data for all instrumentation tested showed consistent response values within the ±20% metric over the test object in pre- and post-survey tests. The project metric for test data was established at a standard deviation of less than 2.5. Neither outside interference nor anomalous data spikes were observed during the static instrument tests. No deficiencies were noted in QC testing of the EM31-MK2 or G-858 during the RI. The instrument functionality test documentation is included in **Appendix F** DGM Data.

5.1.7 Anomaly Reacquisition

Anomalies detected during the DGM surveys were reacquired for further investigation. Anomaly reacquisition was performed using a Trimble Geo 6000 GPS unit for navigation to the precise location of each target. A reacquisition team navigated to each location, and marked it using the unique target identifier recorded on a non-metallic pin flag.

5.1.8 MEC Removal and Management

Surface and intrusive anomaly investigations were conducted according to the methodology established in the Final RI Work Plan [see Section 3.19 for details regarding RI intrusive investigation procedures (WESTON, 2012)] and summarized below.

5.1.8.1 Excavation Procedures

UXO Technicians investigating DGM targets began the anomaly investigations by sweeping a 3-foot radius around the pin flag with a White's MXT (all-metals) to focus the excavation at the peak response. The offset and northing and easting position of the peak response were recorded for each anomaly by UXO Technicians. Intrusive operations at each anomaly location were performed using hand tools. The UXO Technicians excavated at the location of the highest detector response until the source of the anomaly was found, or a depth of 4 feet[1] was reached. The target location was considered clear when a signal source was no longer detected after

[1] If the anomaly was not uncovered within the specified depth, it was reported to the SUXOS for documentation and evaluation whether or not additional excavations were required. The only items identified at 4 feet (48 inches) were deemed cultural items and no additional excavations were required.

removal of the conductive item, or the source of the signal was identified to be associated with a cultural feature such as a fence or building. Dig teams used the personal handheld computers with RespondFast® software to electronically log the target attributes in real time during the field investigations. Attributes logged in RespondFast® included item category, item type, depth, dig data, and final disposition. Results of the intrusive investigation are provided in the expanded dig lists in **Appendix H**. Photographs of the anomaly reacquisition process are provided in **Appendix I**.

5.1.8.2 Munitions with the Greatest Fragmentation Distance

The munition with the greatest fragmentation distance (MGFD) is the munition with the greatest fragment distance that is reasonably expected (based on research or characterization) to be encountered within the MRS. As specified in the DDESB- and U.S. Army-approved explosive site plan (ESP), Appendix H in the Final RI Work Plan (WESTON, 2012), the MGFD was determined to be the 6-inch Mk 20 projectile for the 1926 Explosion Radius MRS, the 1926 Explosion Radius – Off Post MRS, the Green Pond MRS, the Shell Burial Ground MRS, the Former Operational Areas MRS, the Picatinny Lake portion of the Lakes MRS, the Inactive Munitions Waste Pit MRS, and the Inactive Munitions Waste Pit – Off-Post MRS.

For the Lake Denmark portion of the Lakes MRS and the Lake Denmark – Off-Post MRS, the MGFD was the 4.2-inch M329 projectile.

5.1.8.3 Minimum Separation Distance

Based on the characteristics of the MGFD, the minimum separation distance (MSD) is the protective distance at which personnel must be separated from an intentional or unintentional detonation. The HFD is the maximum blast effect and the distance a piece of fragment can travel at a velocity that does damage and is more related to potential harm to individuals. The team separation distance (TSD) is the distance that munitions response teams must be separated from each other during munitions response activities involving intrusive operations. For Lake Denmark – Off-Post MRS and Lake Denmark, which is a portion of the Lakes MRS, the HFD established for nonessential personnel was set at a distance of 313 feet, and the TSD was determined to be 81 feet. The HFD established for the remaining MRSs nonessential personnel for was set at a distance of 324 feet, and the TSD was determined to be 73 feet.

5.1.8.4 Exclusion Zone

Exclusion zones (EZs) were established during intrusive investigations at PTA to protect nonessential personnel from unintentional detonations. The primary protective distance used was the MSD of 324 feet for unintentional detonations, which was based on the HFD of the 6-inch Mk 20 projectile for all MRSs, excluding the Lake Denmark portion of the Lakes MRS, where the MSD of 313 feet for unintentional detonations was used based on the HFD of the 4.2-inch M329 projectile. The applicable EZ distance was enforced during all intrusive investigations at PTA. Road guard personnel were placed at locations where roads or sidewalks entered the EZ perimeter. Personnel monitored pedestrian and vehicular traffic and communicated with dig teams performing the intrusive work. When pedestrian traffic entered the EZ, all intrusive activity was halted until the pedestrian traffic had exited the EZ perimeter. Intrusive activities were also halted when non-enclosed vehicles, such as golf carts, motorcycles, or personnel carriers, passed through the EZ. Once the pedestrian or non-enclosed vehicle had exited the EZ, intrusive activities were resumed.

5.1.8.5 Identification and Removal

Surface and intrusive investigation activities were conducted by teams of at least two people, consisting of one UXO Technician III (Team Leader) and either one UXO Technician II or UXO Technician I. Items that were considered MPPEH were inspected by the Technician II or III and then confirmed by the unexploded ordnance quality control specialist (UXOQCS). Once the item had been deemed safe to move, the item was placed in a small portable magazine for transporting to the main magazines, located within the enclosure area. The magazines were kept locked and maintained in accordance with the safety and security requirements established in the explosive safety plan (ESP).

5.1.8.6 Inspection of Material Potentially Presenting an Explosive Hazard

During the course of the RI intrusive activities, military munitions-related items were considered MPPEH until properly inspected by a qualified UXO Technician II or higher. As it was encountered in the field, MPPEH was inspected by a UXO Technician II and Technician III and classified as material documented as safe (MDAS) or material documented as an explosive hazard (MDEH). Items determined to be MDEH were then classified as MEC (UXO, DMM or MC). Items classified in the field as munitions debris (MD) pose no explosive hazard and were

transported to a collection point for final disposal as MDAS as described in the following section. Items classified in the field as MDEH were transported to the on-site magazine and demolition was conducted every Friday on an as needed basis.

5.1.8.7 Material Documented As Safe

All items classified as MDAS were recovered, certified and verified as free from explosives, and stored in a locked container. Following recovery, the Senior UXO Supervisor (SUXOS) inspected the MDAS and the UXOQCS performed a re-inspection to verify the process and ensure that only inert items were stored in the locked container. The SUXOS and UXOQCS inspection was conducted immediately prior to the turn-in of MDAS to the Picatinny Arsenal Recycle Center. Certified MDAS was turned-in to the Picatinny Arsenal Recycle Center with the completed DoD Form 1348-1A, signed by the SUXOS and UXOQCS to certify and verify the material listed had been 100% inspected by a UXO Technician II and 100% re-inspection by an UXO Technician III and classified as MDAS. The total amount of MDAS turned-in to the Picatinny Arsenal Recycle Center for disposal was 2,600 pounds.

After the DoD Form 1348-1A was signed by the SUXOS and UXOQCS, a copy was maintained and the original accompanied the MDAS to its final disposition at the Picatinny Arsenal Recycle Center. A copy of the DD Form 1348-1A is available in **Appendix J.**

During September and November 2012, an additional 9.82 pounds of MDAS identified through intrusive investigations were transferred by authorized WESTON personnel to an active WESTON project site for disposal. As such, no DoD Form 1348-1A for PTA is available for this MDAS since the weight was included on a separate DoD Form 1348-1A combined with MDAS from the active WESTON project site.

5.1.8.8 Munitions and Explosives of Concern Disposal

Due to proximity to infrastructure and local traffic routes, MPPEH and MEC recovered during intrusive investigations were transported to the on-site magazine and demolition was conducted every Friday on an as-needed basis. Items stored in the magazines were transferred to a demolition area (1222 Test Area), locally known as the Gorge, for disposal. For the intentional detonation of consolidated shots, sand was used as an engineering control for mitigation of fragmentation and blast effects.

One 60mm white phosphorus, fuzed, mortar could not be safely moved. The Picatinny EOD unit was contacted and responded to the mortar discovery. The item was blown-in-place (BIP) by EOD.

All other items identified as MPPEH were deemed safe to move and were stored in a magazine until demolition could be conducted.

5.1.9 Anomaly Investigation Quality Control

In accordance with the RI Work Plan (WESTON, 2012), the UXOQCS inspected at least 10% of the intrusive investigation locations using a White's MXT (all-metals) detector to determine whether the removal was effective. In the field, this was achieved by the UXOQCS joining the intrusive team/s and inspecting all of the intrusive investigations conducted during the day. The results of the QC inspections for the intrusive investigation are provided in the UXOQCS reports (**Appendix K**). There were no QC failures at PTA. The USACE Ordnance and Explosive Safety Specialist (OESS) also performed a QA inspection at the 1926 Explosion Radius MRS, 1926 Explosion Radius – Off-Post MRS, Former Operational Areas MRS, and the Lakes MRS grids. The Form 948 accepting the QC results is provided in **Appendix L**.

5.1.10 Munitions Constituents Assessment

5.1.10.1 Purpose of Munitions Constituents Sampling

Past land uses related to numerous munitions activities at PTA, including weapons production and testing as well as munitions and bulk explosives storage, have impacted portions of PTA with residual MEC. The purpose of the MC sampling was to determine whether MEC is a source for MC that has been released to the environment. To assess whether an MC release occurred within an MRS and poses a risk to potential receptors, field investigations and media sampling were conducted in accordance with the Final RI Work Plan (WESTON, 2012). The MC characterization approach for each MRS considered both available historical data and ongoing IRP investigations that overlap within MRS boundaries. Because co-located IRP investigations that include sampling and analysis of MC parameters as part of the IRP remedial objectives are occurring and/or have already occurred and further assessment of MC under the MMRP is not warranted; therefore, MC assessment was not included in the scope of RI field activities for the following MRSs:

- Green Pond MRS (PICA-005-R-01).
- Lakes MRS (PICA-008-R-01); water portion only.
- Shell Burial Grounds MRS (PICA-010-R-01).

Two types of potential soil samples, biased and random, were proposed. Biased samples are collected from the area that is most likely to have the highest levels of MC contamination. One discrete soil sample is collected immediately under, or adjacent to MEC, where contamination is likely (e.g., visual staining, near crack/corrosion). Random samples consist of a nonparametric systematic sampling approach with a random start to determine the number of samples and to specify sampling locations. The purpose of this sampling was to first determine whether MC contamination was present at an MRS, and if so, initiate subsequent collection of sufficient data to delineate the nature and extent of the contamination. The data collected were used to make qualitative and quantitative assessments of the presence of MC, and if any MC was present, to determine the associated risk to potential receptors.

Analytical data collected were evaluated using conservative screening levels selected for the RI to support identification of a potential release and to establishing baseline risks to both human health and ecological receptors for the RI. The selected screening levels are described below in Section 5.1.10.4. Based on the results of the initial screening-level evaluation, a quantitative human health risk assessment and/or ecological risk assessment were performed for an MRS, as warranted (see Section 9 for details related to RI risk assessment activities).

5.1.10.2 Munitions Constituents Sampling

Based on a review of the types of activities conducted at each MRS, biased soil samples were proposed for seven MRSs (WESTON, 2012). However, biased soil samples would only be collected if MEC was found and field observations indicated that a potential release had occurred (e.g., visual evidence of staining, the munition is cracked or corroded). Based on the RI findings obtained during anomaly investigation, no evidence of a potential MC release was observed associated with recovered MEC in any of the MRSs except the Inactive Munitions Waste Pit MRS. Therefore, biased soil samples were only collected from this MRS during the RI.

Random samples were additionally included in the MMRP RI Final Work Plan for the Former Operational Areas MRS as this was the only MRS that did not have sufficient historical information available to assess whether widespread MC contamination was likely in the portions where MC is not included within the scope of co-located IRP activities (WESTON, 2012).

5.1.10.3 Analytical Laboratory and Analyses

All field activities and chemical analyses were conducted in accordance with the Final RI Work Plan, specifically the project *Final Uniform Federal Policy-Quality Assurance Project Plan (*Final MMRP UFP-QAPP*)* Appendix B of the Work Plan (WESTON, 2012), in addition to guidance from USACE, NJDEP, and EPA Region 2, including the NJDEP *Field Sampling Procedures Manual* (NJDEP, 2005) and the *Technical Requirements for Site Remediation* (New Jersey Administrative Code [NJAC], 2011). MC samples were analyzed by TestAmerica Laboratories, Inc., a Department of Defense Environmental Laboratory Accreditation Program, and National Environmental Laboratory Accreditation Program-accredited laboratory. Copies of the laboratory analytical data packages are provided as **Appendix M**. **Appendix M** also includes the following: data validation reports (DVRs), MC sampling results summary tables, field sample logs and photographs, a VSP response summary, Former Operational Areas MRS analytical results figure, and Former Operational Areas MRS statistics and semivariogram plots.

Analyses requested included EPA Method 8330B for explosives, EPA Method 6010B for metals, and EPA Method 6850 for perchlorate, as necessary depending on the target analyses for each MRS. The individual analytes and/or target compounds requested for analysis are provided below on **Table 5-5**.

Table 5-5 MC Analytes

Explosives	Metals
2-Amino-4,6-Dinitrotoluene (2-AM-4,6-DNT)	Aluminum (Al)
4-Amino-2,6- Dinitrotoluene (4-AM-2,6-DNT)	Antimony (Sb)
2,4-Dinitrotoluene (2,4-DNT)	Barium (Ba)
2,6-Dinitrotoluene (2,6-DNT)	Cadmium (Cd)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Copper (Cu)
Nitroglycerin (NG)	Lead (Pb)
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	Manganese (Mn)
Pentaerythritol tetranitrate (PETN)	Strontium (Sr)
Tetryl	Zinc (Zn)
2,4,6-Trinitrophenol (2,4,6-TNP, aka picric acid)	
2,4,6-Trinitrotoluene (2,4,6-TNT)	

Note: Perchlorate analysis was also performed on samples collected from the Inactive Munitions Waste Pit MRS.

Analytical data collected for this project were validated in accordance with the project Final MMRP UFP-QAPP (WESTON, 2012). As discussed in the Final MMRP UFP-QAPP, analytical data were validated in accordance with EPA's National Functional Guidelines, applicable EPA Region 2 guidelines, and QC requirements established based on the latest version of the DoD

Quality Systems Manual (QSM), Version 4.2. Data qualifiers determined applicable to individual results are shown in the analytical data tables and discussed in the results provided in Section 6 and Section 9 of the RI Report. The data validation packages including validation report narratives for the analytical results and data qualifier codes are provided as part of **Appendix M.** No major issues were identified during data validation. A more detailed discussion of the issues is provided in the data validation narrative.

Overall, the data validation showed that the data received from the laboratory were valid and usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the Former Operational Areas MRS to meet the objectives of the RI and to complete the risk assessment.

5.1.10.4 Screening Levels

Screening levels were selected to support data evaluation performed as part of MMRP RI risk assessment activities to identify COPCs to human health and ecological receptors (refer to Attachment 1 of the Final MMRP UFP-QAPP for additional details). The most conservative of available screening levels were initially selected, as further discussed in Section 7 related to RI risk assessment activities, including residential exposure screening levels for human health assessments. Sources considered during selection of screening levels are provided below for both human health and ecological receptors:

- Human Health:
  a) NJDEP Residential Direct Contact Health Based Criteria and Soil Remediation Standard (SRS), Table 1A from Appendix 1; N.J.A.C. 7:26D, last updated May 2012; or
  b) USEPA Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites, Resident Soil column, last updated in November 2013.
- Ecological:
  a) USEPA Ecological Soil Screening Levels (EPA, 2013);
  b) USEPA Region 5 Ecological Screening Levels (EPA, 2003a); or
  c) If neither a nor b, provide screening levels for explosives, the lowest Final Ecological Screening Levels from the Los Alamos National Laboratory (LANL) ECORISK Database Release 3.1 (October, 2012) (LANL, 2012).

Consistent with typical risk evaluation protocols practiced by both DoD and EPA, available site-specific background levels for PTA were researched and considered during data evaluation and baseline risk assessment. PTA-specific background concentrations were found available for

metals as published in the *Picatinny Arsenal Facility-Wide Background Investigation*, dated May 2002 (IT, 2002). As recommended in USACE guidance, to distinguish between site-related versus non site-related MC, only chemical results in excess of both the selected screening level and background concentration were selected as COPCs or constituents of potential ecological concern (COPECs), during SLERA Step 3A, in the risk assessments (USACE, 2011).

5.2 1926 EXPLOSION RADIUS MRS

The 1926 explosion radius consists of two separate MRSs, the 1926 Explosion Radius MRS (PICA-003-R-01) and 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01). This division is due to land ownership differences (i.e., Army versus private owners) and not technical issues because the primary release mechanism for munitions at the 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS is the 1926 explosion. Additional release mechanisms on-post include the Code 300 Area artillery firing range and potential discarded military munitions (DMM). There are no known additional release mechanisms for the 1926 Explosion Radius – Off-Post MRS. Because the primary release mechanism was assumed to be the same for the two MRSs, they were investigated as one site and are discussed as one in this subsection.

5.2.1 MEC Characterization

5.2.1.1 RI Approach

The following subsections present the RI field efforts performed to achieve the DQOs at the 1926 Explosion Radius On-Post and Off-Post MRSs as described in Section 4.1.2. To achieve the characterization scope based on the DQOs, UXO Estimator was used to determine the area requiring investigation at the two decision units in the combined 1926 Explosion Radius MRS and the 1926 Explosion Radius – Off-Post MRS. UXO Estimator assumes that if MEC is present, there is a uniform probability of encountering MEC over the entire MRS. During the TPP process, UXO Estimator was determined to be the appropriate characterization tool for the RI. This use is consistent with the guidance presented in Army Engineering Manual (EM) 1110-1-4009, Errata Sheet No. 4 (USACE, 2010).

The MMRP RI field objective was to perform digital and analog geophysical grid surveys to determine the nature and extent of MEC across the MRSs. Additionally, density transect surveys were to be conducted in the AOI Code 300 Area to determine whether elevated anomaly density areas were present. The elevated anomaly density areas were then to be further investigated

through analog grid surveys to determine the nature of the anomalous readings.

5.2.1.2 RI Field Activities

The combined 1926 Explosion Radius On-Post and Off-Post MRSs were divided into two decision units (inner radius and outer radius) for the RI as explained in the Final RI Work Plan (WESTON, 2012), because previous investigations had indicated that MEC associated with the 1926 explosion appeared to only be present within 0.5 mile of the explosion centers. Refer to **Figure 5-2** for the locations of the decision units within the MRSs.

5.2.1.2.1 Grid Surveys

A total of 132 grids, covering approximately 7.6 acres, were investigated within the 1926 Explosion Radius On-Post and Off-Post MRSs during the RI, as summarized in **Table 5-6**. The level of investigation conducted within the Outer Radius Decision Unit during the RI exceeded the objectives and coverage requirements specified in the Final RI Work Plan (WESTON, 2012). During the RI field work, an area with an extremely high concentration of fuzes was identified in the Inner Radius Decision Unit of the 1926 Explosion Radius MRS near grid 26IR-010. Because this area did not appear to be representative of the remainder of the inner radius, it was removed from the Inner Radius Decision Unit and considered as a separate decision unit. As a result, the combined MRSs have the following three decision units: the Inner Radius, the Outer Radius, and the Fuze Area. Therefore, although the Inner Radius Decision Unit was investigated for the proposed amount of coverage as detailed in the RI Work Plan, the level of investigation included in the analysis of the Inner Radius Decision Unit did not meet the specifications and objectives in the RI Work Plan. Seventeen grids were proposed in the Inner Radius Decision Unit; however, one of the grids was removed from the Inner Radius Decision Unit and placed in the newly determined Fuze Area Decision Unit and one of the Outer Radius Decision Units was placed on the boundary between the Inner Radius and Outer Radius Decision Units. Therefore, 16.5 grids instead of 17 grids were investigated for the Inner Radius Decision Unit. As discussed in Section 6.2.2.1.2, the sampling program was set up to determine at a 95% confidence level that there are less than or equal to 3 UXO/acre within the Inner Radius Decision Unit. Investigating 16.5 grids versus 17 grids reduces the confidence level by less than one percent to 94.23%, which is not a significant decrease. Section 6.2.2.1.3 provides further discussion of the analysis of the Fuze Area Decision Unit.

Of the 132 grids investigated, 120 grids (7 acres) were originally proposed. Eleven additional grids (0.6 acre) were within the AOI Code 300 Area in the outer radius decision unit and were determined based on the results of transect investigation in the AOI Code 300 Area. Due to grid-26IR-017 being inadvertently placed on the boundary between the inner and outer decision units (splitting the acreages between the two decision units), an additional grid (26IR-018) was added to the inner decision unit. Detected anomalies in the grids were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.2.2 for the intrusive investigation results. Refer to **Table 5-6** for a complete summary of the investigated grids.

Table 5-6 Summary of Investigations within the 1926 Explosion Radius MRS

Decision Unit	Grid Location or Number	Survey Method	Proposed Number of Grids	Actual Number of Grids	Grid Size (ft^2)	Total Grid Area Investigated (ft^2)	Total Grid Area Investigated (acres)	Anomalies Investigated
Outer Radius	On-Post	DGM	28	28	2,500	202,500	4.65	928
		Analog	53	53				744
	Off-Post	Analog	21	21	2,500	52,500	1.21	251
	26OR-009[a]	Analog	1	1	3,125	3,125	0.07	25
	26IR-017[a]	Analog	0	0.5	2,500	1,250	0.03	55
	AOI Code 300 Area	Analog	Unknown[b]	11	2,500	27,500	0.63	26
		Totals:	**103**	**114.5**	**NA**	**286,875**	**6.59**	**2,029**
Inner Radius	26IR-01 – 09, 26IR-11 – 16, 26IR-018	DGM	11[c]	10	2,500	40,000	0.92	643
		Analog	5	6				76
	26IR-017[a]	Analog	1	0.5	2,500	1,250	0.03	31
		Totals:	**17**	**16.5**	**NA**	**41,250**	**0.95**	**750**
Fuze Area	26IR-010[d]	DGM	Area unknown before RI[e]	1	2,500	2,500	0.06	149
		Totals:	**0**	**1**	**NA**	**2,500**	**0.06**	**149**

Note:

[a] The grids covered 2,500 ft^2, with the exception of grids 26OR-009 and 26IR-017. Grid 26IR-017 was placed on the boundary between the inner and outer radius decision units; therefore, the area of investigation was divided between the two decision units. Grid 26OR-009 is slightly larger than the standard size because the topography made it difficult to install the grid to an exact shape.

[b] The number of grids within the AOI Code 300 Area was unknown since the number of grids to be sampled, if any, were based on the results of the analog geophysical transects conducted. Refer to Section 6.2.2.1.1.2.

[c] Grid 26IR-10 was included in this total, but not in the actual number of grids, because it was initially proposed for the Inner Radius Decision Unit, but was later moved into the fuze area.

[d] Grid 26IR-010 was part of the initial sampling design within the inner radius. However, it is located within an area with a high concentration of fuzes that was designated as a separate decision unit; therefore, the results of the investigation within Grid 26IR-010 was not included in the analysis of inner radius data. See Section 6.1 for further details.

[e] No grids were originally planned in this area because the fuze area was found during the RI.

Of the 132 grids, 121 grids were randomly placed throughout the 1926 Explosion Radius MRS. Because of accessibility issues (e.g., steep topography and/or vegetative cover), the 132 grids were either DGM surveyed using an EM61-MK2 or investigated using analog methods (i.e., mag and dig). From December 9 to 22, 2011, 39 grids were DGM surveyed using a man-portable EM61-MK2. These 39 grids and the 82 additional analog grids were investigated by qualified UXO Technicians between April 4 and May 11, 2012. A total of 2,664 anomalies were investigated (i.e., 1,182 anomalies within the analog grids and 1,482 anomalies within the DGM grids that were above the anomaly selection threshold, a Channel 2 response of 7.2 mV). Refer to **Figure 5-2** for the DGM and analog grid locations, excluding those performed in the AOI Code 300 Area discussed below. Refer to **Appendix F** for the DGM data and maps, and **Appendix H** for the intrusive investigation grid sheets.

5.2.1.2.2 AOI Code 300 Area Survey

As shown on **Figure 5-2**, the AOI Code 300 Area lies within the 1926 Explosion Radius MRS, the Former Operational Areas MRS, and the Inactive Munitions Waste Pit MRS. AOI Code 300 Area density transect data were collected for both the 1926 Explosion Radius MRS and the Former Operational Area MRS between April 9 and 16, 2012 and for the Inactive Munitions Waste Pit MRS on May 12, 2012. Transect data were collected by qualified UXO Technicians using analog geophysical sensors (White's MXT all-metals detectors) coupled to a handheld GPS. The GPS was used to guide the teams along predetermined transects.

Within the 1926 Explosion Radius MRS, density transect data were collected by logging the number of surface and subsurface magnetic anomalies detected within each 50 linear feet. The portion of the AOI Code 300 Area within the 1926 Explosion Radius MRS is heavily vegetated and has steep terrain; therefore, the method used to collect density transect data in this portion of the MRS was slightly different from the method used to collect data along the density transects within the Former Operational Areas MRS and Inactive Munitions Waste Pit MRS. For the portions of the AOI Code 300 Area that overlap the sections of the Former Operational Areas MRS and Inactive Munitions Waste Pit MRS, the density transect data were collected by logging the position of each of the identified surface MEC/MPPEH/MD and subsurface anomalies. The field team implemented the revised field method within the AOI Code 300 Area within the 1926 Explosion Radius MRS to more safely and efficiently collect the data. The changed approach did

not affect the ability to identify high anomaly density areas, as evidenced by the results, which are discussed below.

The locations of the density transects and the anomalies identified are shown on **Figure 5-3**. The purpose of these density transects was to identify high anomaly density areas (i.e., potential target areas) to be further investigated; therefore, no intrusive investigations were performed along the density transects. Instead, the data collected were evaluated in VSP's *geostatistical mapping of anomaly density* module. The output from this module indicated the presence of 11 high anomaly density areas, all of which are at least partially within the 1926 Explosion Radius MRS as shown on **Figure 5-4**. For this investigation, high anomaly density areas were defined as locations of at least 5 acres that had a minimum anomaly density of 25 anomalies/acre. Eleven 50-ft x 50-ft grids were placed within the six high anomaly density areas and investigated using analog geophysical methods to determine if the high anomaly density areas were associated with a historical munitions target area or some other source. Two additional areas, one within the Former Operational Areas MRS and one within the Inactive Munitions Waste Pit MRS, were observed to have a relatively high number of anomalies but were not identified as high anomaly density areas in VSP. The areas associated with grids Code300-12 and Code300-13 were added to the list of analog grids to be investigated to ensure that a potential target area was not missed as a result of an edge effect in the VSP analysis (i.e., the transect and anomalies at the edge of the Code 300 boundary and the transects outside the boundary were not included in the analysis).

Grids were placed within each of the identified potential target impact areas to determine the nature of the anomalies identified along the transects (i.e., to determine whether the elevated anomaly density was due to an impact area, fragmentation from historical munitions use, or another source). A total of 13 analog grids were investigated in the AOI Code 300 Area (11 in the 1926 Explosion Radius MRS, one in the Former Operational Area MRS, and one in the Inactive Munitions Waste Pit MRS). The analog grid surveys were conducted between September 24 and 27, 2012, and 669 anomalies were identified and investigated within the 13 grids. Refer to **Figure 5-5** for the locations of the grids for the entire AOI Code 300 Area (i.e., within the 1926 Explosion Radius MRS, Inactive Munitions Waste Pit MRS, and the Former Operational Areas MRS).

5.2.1.2.3 Visual Surveys

As discussed in Section 6.2, one 37mm projectile and five intact practice munitions were located in Grid 26OR-024 during the intrusive investigation within the Outer Radius Decision Unit of the 1926 Explosion Radius. Since the high concentration of munitions suggested a possible release mechanism different from the 1926 Explosion, UXO Technicians performed a handheld EM-assisted visual survey to record anomaly locations. The purpose of this survey was to determine if the grid was located within a high anomaly density area that could be a target area with a different release mechanism than the 1926 Explosion and identify additional potential MEC or practice munitions on the surface that could be indicative of a target area.

UXO technicians conducted a total of three visual survey transects totaling 0.55 miles. **Figure 5-6** shows the GPS locations of the three transects, as well as the approximate center line of the transects. Each transect was 10-ft wide and was completed by having the UXO technicians sweep adjacent 5-ft wide swaths with a handheld EM sensor (White's MXT). The locations of all surface and subsurface anomalies were recorded in a handheld GPS.

5.2.2 MC Characterization

As discussed below, no additional characterization activities were required during the RI to assess MC within the 1926 Explosion Radius MRS based on munitions-related findings, as detailed in Section 3.1.1 of the Final RI Work Plan.

The following three potential release mechanisms for MC were identified for the 1926 Explosion Radius MRS: dispersion of bulk TNT through the 1926 explosion, association with MEC from the explosion, and association with MEC in the MRS through other site uses (e.g., manufacturing and R&D activities).

- **Bulk TNT Dispersion** – Based on the IRP data, which include more than 1,000 soil samples analyzed for TNT and between 500 and 1,000 soil samples analyzed for TNT degradation products, it does not appear that TNT or its degradation products are present throughout the MRS boundary.
- **Association with MEC** – IRP data did not indicate the widespread presence of explosives in surface soils throughout the MRS boundary. Therefore, only biased soil samples were to be collected during the RI, with samples collected only when field observations indicated that a potential release had occurred (e.g., visual evidence of staining, cracked or corroded munitions, item that is not inert). Because none of these conditions were observed during the RI, no biased soil samples were collected.

5.3 1926 EXPLOSION RADIUS – OFF-POST MRS

As explained in Section 5.2.1, the 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01) was investigated in conjunction with the 1926 Explosion Radius MRS (PICA-003-R-01) because the division between the two is based on the physical location of the PTA boundary and is not due to differentiation between the potential source and the release mechanisms. Thus, the two MRSs were investigated together and divided into decision units for characterization based on the available historical information and real-time RI data. Refer to Section 5.2 for details regarding RI activities conducted at the 1926 Explosion Radius – Off-Post MRS.

5.4 SHELL BURIAL GROUNDS MRS

The Shell Burial Grounds MRS (PICA-010-R-01) consists of two large burial areas where three craters were formed from the 1926 Lake Denmark Naval Ammunition Depot explosion. Two of the three craters are close together and are considered a single site referred to as the Shell Burial Grounds – West. The third crater is referred to as the Shell Burial Grounds – East. **Figure 1-6** presents the location of the Shell Burial Grounds MRS.

5.4.1 MEC Characterization

5.4.1.1 RI Approach

The following subsections present the RI field efforts that were performed to achieve the DQOs at the Shell Burial Grounds MRS, previously described in Section 4.3.2. The characterization scope based on the DQOs were to determine the horizontal and vertical extent of the subsurface material and verify that existing ICs are adequate for the two burial areas. Currently, ICs (i.e., chain-link fencing with warning signs) restrict access into the MRS and define what is thought to be the horizontal extent of the burial areas.

The MMRP RI approach was to perform EM31-MK2 transect surveys to delineate the lateral boundaries of the burial areas. Electrical resistivity (ER) imaging surveys were then to be performed to delineate the lateral and vertical extents of the burial areas.

5.4.1.2 RI Field Activities

In order to delineate the horizontal boundaries of both burial areas, a total of 7,153 linear feet (3,490 feet in the Shell Burial Grounds - East and 3,663 feet in the Shell Burial Grounds - West)

of DGM transect surveys were performed using a man-portable EM31-MK2 (shown in **Figures 5-7, 5-8, 5-9,** and **5-10**). After analysis of the EM31-MK2 data, it was noted that no clearly defined anomalous areas indicative of burial features were observed. To supplement the EM31-MK2 data, a G-858 magnetometer survey was also conducted. A total of 8,160 linear feet (2,368 feet in Shell Burial Grounds - East and 5,791 feet in Shell Burial Grounds - West) of DGM transect surveys were performed using a man-portable G-858 magnetometer (shown in **Figure 5-11** and **Figure 5-12**). However, no clearly defined areas indicative of burial features were observed within the G-858 magnetometer survey data either.

Subsequently, the ER imaging surveys performed from February 6 through 9, 2012 to delineate the vertical extents of the burial areas were also used to delineate the lateral extents. The surveys were performed using an AGI SuperSting/Swift R8 ER imaging system. ER survey lines, two each along the long and short axes, were placed across each burial area to profile the varying subsurface conditions by measuring the voltage drop between various combinations of paired electrodes. The locations of the ER survey lines within each burial ground are shown in **Figures 5-13** and **5-14**. The electrode spacing used during the surveys was based on optimum parameters determined to provide the most reliable resolution and depth penetration necessary to image suspected structural features underlying the Shell Burial Grounds MRS. Because of the physical constraints bounding the survey area (roadways, fences, topography) it was determined that a dipole-dipole array using a 10ft electrode spacing would offer the best arrangement between effective depth of investigation and resolution. The typical array consisted of up to 56, ¼-inch diameter, 16-inch-long, stainless steel, non-polarizing (metal stakes) electrodes driven to an average depth of 8 inches into the soil.

Prior to data acquisition (as a standard operating procedure), salt water was poured at the base of each electrode to saturate the soil and enhance the contact and flow of current into the ground. A contact resistance test was then conducted prior to initiating data collection for each array to evaluate the electrode-to-soil coupling. Typical contact resistances of less than 2,000 ohms indicated good coupling. In portions of the Shell Burial Grounds MRS, contact resistance measurements exceeded 2,000 ohms. Exceedances usually occurred where rocky or poorly compacted soils were present. This poor resistance only affected the quality of data at depth, as a result the deeper low resistivity zone was not fully imaged in the profile of the Shell Burial Grounds - West.

A single array or single deployment distance (SDD) consisted of four Swift cables of 14 electrodes per cable, laid out with consecutive numbering (electrodes 1 through 56). Using an electrode spacing of 10 feet, the SuperSting R8 ER meter yielded an effective analysis depth of approximately 50 feet. The survey crew made every effort to maximize the depth of penetration by extending each array to its fullest horizontal extent within the limits of the Shell Burial Grounds MRS.

For transects exceeding 550 feet in length, an additional array was appended to the end of the initially deployed array. After the data were collected for the initially deployed array, the first segment of cable (containing electrodes 1 to 28) was moved behind the last cable in a roll-along method, making the order of electrodes 29 through 56 and 1 through 28. Data collection continued in this fashion until the total desired distance was achieved. Care was taken not to acquire double measurements in areas where the layouts overlapped. For each ER transect, the coordinates and elevations of the first and last electrode and any changes in topography were digitally mapped (see **Figure 5-13**) using an RTK GPS. Coordinates were projected to UTM, Zone 18 North, NAD83 in units of U.S. Survey Feet and used to provide horizontal and vertical control. The apparent resistivity data were then processed to produce resistivity cross-sections, analyzed against well logs of nearby wells, HRR information, and maps.

The ER investigation at the Shell Burial Grounds MRS – West included four ER transects designated as WER1 through WER4. The orientation and extent of each transect are shown in **Figure 5-13.** WER1 and WER2 were run longitudinally (southwest to northeast) parallel to Building 3100, WER3 was run laterally in a west to east direction, and WER4 was run (northwest to southeast) parallel to 99th Road. Transects ranged in length from 410 feet to 820 feet. Individual total line distances for WER1 through WER4 were 690 feet (210 m), 820 feet (250 m), 410 feet (125 m), and 410 feet (125 m), respectively.

The desired coverage (for WER1 and WER2) was longer than the SDD for a single Swift cable array; therefore, to achieve the desired lengths, profile lines were completed using the roll-along method in a leapfrogging fashion. A roll-along setup was used for the data collection at WER1 and WER2. Data were collected at WER3 and WER4 using an SDD. Refer to Section 6.3.1 for the results of the ER transect surveys.

The ER investigation at the Shell Burial Grounds MRS – East included four ER transects designated as EER1 through EER4. The orientation and extents of each transect are depicted in **Figure 5-14**. EER1 and EER2 transects were run longitudinally (southwest to northeast) parallel to Gately Road; WER3 and WER4 transects traversed a northwest to southeast direction. Transects ranged in length from 410 feet to 820 feet. Individual total line distances for EER1 through EER4 were 410 feet (125 m), 410 feet (125 m), 410 feet (125 m), and 410 feet (125 m), respectively. Resistivity data were collected along all four ER transects at Shell Burial Grounds MRS – East using an SDD for the Swift cable array for each transect. Refer to Section 6.3.1 for the results of the ER transect surveys.

5.4.1.3 Summary of RI Field Activities

Initially, only EM31-MK2 and ER transects were proposed for the Shell Burial Grounds MRS but following in-field evaluations of the data, it was determined that additional G-858 transects should be performed. No intrusive investigations were included in the scope of the RI field activities needed to achieve the MRS-specific DQOs. Refer to **Table 5-7** for a complete summary of the investigations performed to delineate the lateral and vertical extents of the burial areas within the Shell Burial Grounds MRS.

Table 5-7 Summary of Investigations within the Shell Burial Grounds MRS

DGM Survey Method	Investigation Area	Length of Proposed Transects	Length of Transects
EM31-MK2	East and West Burial Grounds	5,500 linear feet	7,153 linear feet
G-858	East and West Burial Grounds	None	8,160 linear feet
ER	East and West Burial Grounds	4,000 linear feet	4,660 linear feet

5.4.2 MC Characterization

Further assessment of MC under the MMRP was not warranted for this MRS and was not included in the scope of RI field activities because co-located IRP investigations that include MC parameters in their scope of remedial objectives are occurring at the Shell Burial Grounds MRS. Engineering controls (limited access) have been implemented at these IRP sites (PICA-052 and PICA-162) to address soil contamination. The IRP sites were included in the 45 Site FS, submitted in October 2009. Groundwater will be addressed by the MidValley Groundwater Site (PICA-204) (Picatinny Arsenal, 2013). Several wells are in-place under the MidValley Groundwater Site both up and downgradient to monitor for metals and explosives that may be coming from the Shell Burial Grounds.

5.5 GREEN POND MRS AND FORMER DRMO YARD

The Green Pond MRS (PICA-005-R-01) is located south of the 9th Street Bridge and east of and adjacent to the Former DRMO Yard. **Figure 1-7** shows the location of the MRS within PTA. The Green Pond MRS includes a portion of the Green Pond Brook stream channel and a 15-foot buffer zone on each side of the bank. The MRS falls within the 1926 Explosion Radius MRS and may be impacted by the release of explosives that occurred during the 1926 explosion. The Green Pond MRS is a portion of Green Pond Brook adjacent to the Former DRMO Yard. Although the Former DRMO Yard is not specifically in the MRS footprint, investigation of the Former DRMO Yard was conducted in conjunction with the investigation of the Green Pond MRS because of its proximity and possible similarity of potential MEC sources.

5.5.1 MEC Characterization

5.5.1.1 RI Approach

The following subsections present the RI field efforts that were performed to achieve the DQOs previously described in Section 4.4.2. The characterization scope based on the DQOs were to define the nature and extent of MEC burial areas or individual MEC items at the Green Pond MRS and associated southern portion of the Former DRMO Yard.

The MMRP RI approach was performing EM31-MK2 and analog transect surveys along the banks and in the water of Green Pond Brook and full coverage analog surveys in the southern portion of the Former DRMO Yard to find burial areas. When anomalies were detected during the DGM survey, data responses were to be evaluated to determine the extent of the potential burial areas. Both the ground conductivity and magnetic susceptibility (Inphase) measurements were to be processed and evaluated to identify high-density areas indicative of burial features.

5.5.1.2 RI Field Activities

In April 2012, 2,703 linear feet of DGM transect surveys were performed along the east and west banks of Green Pond Brook using an EM31-MK2 (**Figure 5-15** and **Figure 5-16**). Based on a review of the DGM data, the DGM transects were divided into two individual anomalies and five high-density areas for anomaly reacquisition and investigation. The EM31-MK2 transect data were positioned using the Trimble GeoXH 6000. From the DGM data, 32 targets were chosen that possibly represented individual MEC or indicated burial areas (based on an increase in the density of anomalies) and required reacquisition and intrusive investigation.

In April and May 2012, analog transect surveys were performed using a White's MXT all-metals detector along 1.24 acres. Analog transect surveys were conducted along a cumulative 0.37-acre area of both banks of Green Pond Brook, and 0.87-acre was 100% investigated in the southwest portion of the Former DRMO Yard (**Figure 5-17**). Analog transect surveys were conducted wherever accessible along the inner banks of Green Pond Brook.

5.5.1.3 Summary of RI Field Activities

Transect data were not able to be collected along the entire inner banks or within the water of the brook, as specified in the Final RI Work Plan because of safety concerns regarding the water depth, depth of silt/sediment along the bottom, and steepness and instability of the banks. Therefore, the total area investigated was less than the area proposed for investigation. Anomalies detected along the transects were investigated by UXO Technicians to determine the anomaly source. Refer to **Table 5-8** for a complete summary of the investigations performed within the Green Pond MRS and Former DRMO Yard.

Table 5-8 Summary of Investigations within the Green Pond MRS

Survey Method	Investigation Area	Proposed Area Investigated	Area Investigated	Anomalies Investigated
EM31-Mk2 Transects	Green Pond MRS	3,800 feet	2,703 feet	75
Analog Transects	Green Pond MRS	2.1 acres	1.24 acres	182
Analog total coverage	Former DRMO Yard		0.37 acres	115

During the RI, the Green Pond MRS and the Former DRMO Yard, which are located within the 1926 Explosion Radius MRS, were subjected to a different sampling approach and were investigated separately from the 1926 Explosion Radius MRS. The separation of the Green Pond MRS from the 1926 Explosion Radius MRS was made during the SI. However, during the RI, it was discovered that the release mechanism was the same for all three areas. Therefore, the Green Pond MRS, the Former DRMO Yard, and the 1926 Explosion Radius MRS are being consolidated into one MRS. The RI results for Green Pond MRS and the Former DRMO Yard are discussed separately from the 1926 Explosion Radius because of differences in the sampling approach. However, the results are incorporated into the qualitative statistical evaluation for the 1926 Explosion Radius shown in Section 6.2.2.1.4

5.5.2 MC Characterization

Further assessment of MC under the MMRP was not warranted for this MRS and was not included in the scope of RI field activities because co-located IRP investigations that include MC parameters in their scope of remedial objectives have already occurred at the Green Pond MRS. The ROD was completed in 2004 for IRP site PICA-193, and chemical and biological monitoring began in 2007 and will continue until 2021 (Picatinny Arsenal, 2013).

5.6 FORMER OPERATIONAL AREAS MRS

The Former Operational Areas MRS (PICA-006-R-01) consists of 1,880 acres and includes most areas of PTA surrounding the 1926 Explosion Radius MRS. The Former Operational Areas MRS excludes operational ranges, areas already identified as an MRS, and the northeastern portion of PTA. **Figure 1-8** presents the location of the Former Operational Areas MRS within PTA. A MEC release may be present within the portion of the MRS that is overlapped by a small portion of the AOI Code 300 Area. The AOI Code 300 Area field activities are discussed separately throughout this subsection.

5.6.1 MEC Characterization

5.6.1.1 RI Approach

The following subsections present the RI field efforts that were performed to achieve the DQOs previously described in Section 4.5.2. The characterization scope based on the DQOs were to define whether a MEC release had occurred and if there had been an occurrence, to approximate the MEC density across the Former Operational Areas MRS.

The MMRP RI approach was to perform a geophysical survey within the portions of the Former Operational Areas MRS where reported R&D activities might have occurred, including the portion of the AOI Code 300 Area that falls within the MRS boundary. Several AOIs were to be investigated using a focused approach slightly different than the methodology used for the majority of the MRS. The field objective for the AOIs was to delineate the horizontal extent of the subsurface material at the AOI Former Sanitary Landfill/Dredge Pile, and AOI Waste Burial Area and evaluate the extent of MEC. In addition, the RI evaluated whether MEC burial sites are present within AOI Site 20/24 to determine the nature and extent of MEC at the burial sites, if detected.

Nonintrusive, density transects would be performed within the AOI Code 300 Area portion of the Former Operational Areas MRS. Anomaly densities would be calculated from the transect surveys to determine the locations of potential MEC releases.

5.6.1.2 RI Field Activities

The main body of the Former Operational Areas MRS and the AOIs are discussed separately throughout the subsection. The survey activities performed within the Former Operational Areas MRS are presented in **Figure 5-18.**

Former Operational Areas (Non-AOI Areas)

EM61-MK2 transects were collected in two regions of the Former Operational Areas MRS that consisted of the developed portions of the MRS. In the northern half of the MRS, DGM transects were completed north of Picatinny Lake, and in the southern half of the MRS, DGM transects were completed west of the golf course. The EM61-MK2 transects and grids are presented in **Figures 5-19** and **5-20**. Along these DGM transects, several high-density areas were observed, where focused DGM grids were placed to further investigate the area. Seven EM61-MK2 (50 by 50 foot) grids were surveyed (four in the southern area and three in the northern area). Areas inaccessible to the DGM instrumentation, due to steep slopes, were investigated using analog transects and totaled 218,910 linear feet.

AOI Code 300 Area

A total of 13,443 linear feet of density transects were conducted in the area of the Former Operational Areas MRS overlapping with the AOI Code 300 Area as shown on **Figure 5-18**. This transect length exceeded the minimum VSP requirements of 2.1 miles (11,088 feet) listed in **Table 5-9**. After the density transects were completed, an analog grid, Code 300-13 (50 by 50 feet), was placed to characterize a potential high-density area. Refer to Section 6.5.2 for the intrusive investigation results.

AOI Former Sanitary Landfill/Dredge Pile

The RI field activities were performed to delineate the horizontal extent of the subsurface material at the Former Sanitary Landfill and Dredge Pile and to evaluate the extent of MEC in this portion of the Former Operational Areas MRS.

EM31-MK2 transect data were collected across the AOI Former Sanitary Landfill and after a review of the DGM data, the area of elevated response along the DGM transects were designated as distinct high-density region for anomaly reacquisition with the EM61-MK2 and eventual intrusive investigation. The EM31-MK2 transects (Conductivity and Inphase), the high-density area, and any metallic debris or objects noted along the surface are presented in **Figures 5-21** and **5-22**. EM61-MK2 transect surveys were then conduced in the designated region to evaluate the high-density areas. Refer to **Table 5-9** below for transect length and total number of targets chosen for intrusive investigation. The EM61-MK2 transects and geophysical targets are presented in **Figure 5-23**.

As a result of the steep terrain in the Dredge Pile, instead of the planned DGM transect approach using the EM31-MK2, analog investigations were performed in accessible areas using a White's MXT all-metals detector. Results of the intrusive investigations are discussed in Section 6.5.2.

AOI Waste Burial Area

The RI field activities were performed to delineate the horizontal extent of the subsurface material at the Waste Burial Area and evaluate the extent of MEC in this portion of the Former Operational Areas MRS.

EM31-MK2 transects were surveyed across the AOI Waste Burial Area and after a review of the DGM data, the area of elevated response along the DGM transects were designated as distinct regions for anomaly reacquisition using the EM61-MK2 and intrusive investigation. The EM31-MK2 transects (Conductivity and Inphase), the high-density areas, and any metallic debris or objects noted along the surface are presented in **Figures 5-24** and **5-25**. EM61-MK2 transect surveys were then conducted in the designated region to evaluate the high-density areas. The EM61-MK2 transects and geophysical targets are presented in **Figure 5-26**. Refer to **Table 5-9** for proposed and actual transect lengths. Results of the intrusive investigations are discussed in Section 6.5.2.

AOI Site 20/24

The RI field activities were performed to determine the nature and extent of any waste burial areas in the AOI Site 20/24 portion of the Former Operational Areas MRS.

EM31-MK2 transects were surveyed across the AOI Site 20/24 and after a review of the DGM data, the area of elevated response along the DGM transects were designated as a distinct region for anomaly reacquisition and investigation. The EM31-MK2 transects (Inphase and Conductivity and Inphase), a high-density area, and any metallic debris or objects noted along the surface are presented in **Figures 5-27** and **5-28**. EM61-MK2 transect surveys were then conducted in the designated region to evaluate the high-density area. Additional EM61-MK2 transect surveys were conducted over an area north of the AOI border because of an 81mm mortar identified on the ground surface during the EM31-MK2 transect survey. The EM61-MK2 transects and geophysical targets are presented in **Figure 5-29**. Refer to **Table 5-9** for proposed and actual transect lengths.

5.6.1.3 Summary of RI Field Activities

A total of 289,559 linear feet of transect surveys were conducted within the Former Operational Areas MRS, including a combination of 218,910 linear feet of analog transect surveys, and 70,649 linear feet of DGM transect surveys. Additionally, 13,443 linear feet of density transect surveys and one analog grid survey totaling 2,500 square feet were conducted in the portion of the AOI Code 300 Area that falls within the Former Operational Areas MRS boundary. Seven DGM grids were also surveyed totaling 175,000 square feet. All survey activities performed within the Former Operational Areas MRS are presented in **Figure 5-18**. Detected anomalies in the grids and along the transects were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.5.2 for the intrusive investigation results. The proposed transect length, actual transect length, grid acreage, anomalies investigated, and instrumentation for each investigation area are presented in **Table 5-9**.

Table 5-9 Former Operational Areas MRS Survey Summary

Investigation Area	Instrumentation	Proposed Transect Length (linear feet)	Actual Transect Length (linear feet)	Anomalies Investigated
Former Operational Areas MRS[1]	EM61-MK2	270,585	48,895	396
Former Operational Areas MRS[1]	White's MXT		218,910	1,051
AOI Code 300 Area	White's MXT	11,088	13,443	0
AOI Site 20/24	EM31-MK2 and EM61-MK2	5,860[2]	12,704[3]	251
AOI Waste Burial Area	EM31-MK2 and EM61-MK2	3,456[2]	4,407[3]	291
AOI Former Sanitary Landfill/Dredge Pile	EM31-MK2 and EM61-MK2	3,186[2]	4,644[3]	135
	TOTAL	294,175	303,003	2,124
Investigation Area	**Instrumentation**	**Proposed Grid Size (square feet)**	**Actual Grid Size (square feet)**	**Anomalies Investigated**
FOA-1	EM61-MK2	2,500	2,500	33
FOA-2	EM61-MK2	2,500	2,500	13
FOA-3	EM61-MK2	2,500	2,500	20
FOA-4	EM61-MK2	2,500	2,500	15
FOA-5	EM61-MK2	2,500	2,500	13
FOA-6	EM61-MK2	2,500	2,500	6
FOA-7	EM61-MK2	2,500	2,500	11
Code300-13	White's MXT	2,500	2,500	1
	TOTAL	200,000	200,000	112

[1] The investigation area in the Former Operational Areas MRS and associated transect lengths exclude the AOIs, which are listed separately.

[2] Proposed transect length for the AOIs was only for the EM31-MK2 transects, as it was unknown how many EM61-MK2 transect surveys would be required to be conducted to complete the EM31-MK2 transect survey.

[3] Actual transect length for the AOIs includes the total for both the EM31-MK2 and the EM61-MK2 transect surveys.

5.6.2 MC Characterization

Random, unbiased samples were proposed in the MMRP RI Final Work Plan for the Former Operational Areas MRS because the Former Operational Areas MRS was the only MRS without sufficient historical information available to assess whether widespread MC contamination was likely (WESTON, 2012). The locations of the random discrete samples were determined using

VSP software, version 6.0, and the samples were collected and analyzed for the list of explosives and metals potentially associated with MEC shown in **Table 5-5**. From December 12 to 21, 2011, 89 gridded soil samples (84 environmental samples and 5 field duplicates) were collected from 0 to 6 inches bgs. Based on the initial assessment of the randomly collected samples and in accordance with the MMRP RI Final Work Plan, additional step out samples were warranted for collection from several locations within the Former Operational Areas MRS to delineate the extent of potential MC (metal analytes only) releases. The random gridded sample locations and step out sample locations are shown in **Figure 5-30**. A discussion of the results of the random gridded samples collected and associated step out samples is presented in Section 6.5.4. The data evaluation conducted to assess potential MC risks within the Former Operational Areas MRS is presented in Section 9.1.

5.7 LAKES MRS

The Lakes MRS (PICA-008-R-01) consists of both Picatinny Lake and Lake Denmark and the shoreline area surrounding the lakes. Each lake has a different military-munitions-related history, and therefore, a different investigative approach was employed for each area as discussed separately in the following subsections.

5.7.1 Picatinny Lake MEC Characterization

Picatinny Lake consists of 125 acres of the Lakes MRS and includes a 108-acre manmade lake and 17 acres of shoreline surrounding the lake. **Figure 1-10** presents the location of Picatinny Lake within PTA.

5.7.1.1 RI Approach

The following subsections present the RI field efforts that were performed to achieve the DQOs previously described in Section 4.6.1.2. The characterization scope based on the DQOs were to: determine whether MEC is present within the Picatinny Lake portion of the Lakes MRS; identify the source; and to evaluate whether underwater geophysical anomalies were associated with MEC. Additional characterization field efforts were to investigate the potential burial features associated with discarded munitions disposal at the Barbette gun firing point; and determine whether a MEC release is present at the Barbette gun slug butt/impact area.

The RI approach was to collect underwater DGM transect data to fill data gaps from the previous

magnetic surveys (1995) performed at Picatinny Lake, and evaluate the composite data set to identify anomaly trends and distribution. The data were to be analyzed with the existing magnetic DGM survey data (1995) to develop a dig list. It was estimated that approximately 25 anomaly locations were to be selected for reacquisition and investigation in the lake and along the lake shoreline using qualified divers for underwater work. Underwater intrusive investigations were to be distributed across the lake to evaluate the nature of the anomalies. Discrete standalone anomalies not associated with the anomaly clusters were also to be evaluated for MEC. A portion of the anomalies reacquired and investigated were to be selected from the existing magnetic DGM data (1995).

An analog transect approach was to be used along the shoreline of Picatinny Lake to detect MEC releases associated with the 1926 explosion, the building explosions, and the Barbette gun slug butt/impact areas. Land investigations were to consist of performing 2.7 miles or 3.2 acres of intrusive analog transect surveys along the shoreline of the lake and across the Barbette gun firing point and slug butt/impact area locations. A 100-foot by 100-foot DGM grid (or 0.25-acre area based on accessibility) was to be placed at the firing point to detect potential burial features using an EM61-MK2. Data were to be evaluated for large anomalous areas indicative of burial features. Such features, if detected, were to be intrusively investigated.

5.7.1.2 RI Field Activities

A 0.59-acre DGM grid survey (PL-01) was performed on January 19 and 25, 2012 using an EM61-MK2 in cart mode at the Barbette gun firing point shown in **Figure 5-31**. As it was not possible to place a single 100- by 100-foot grid survey for data collection because of excessive vegetation, DGM data were collected in accessible areas near the original firing point location. The DGM grid was used to detect potential burial features. After analysis of the data collected on January 19, 2012 it was determined that several anomalous features appeared to be present along the edges of the data collection boundary; therefore, on January 25, 2012 additional EM61-MK2 data were collected to better define these anomalous features.

On 27 July 2012, a total of 15 DGM transect surveys were conducted across the water portion of Picatinny Lake in areas where potential data gap were identified in the historical geophysical data set (Blackhawk, 1995), shown in **Figure 5-32**. A total of 15,177 linear feet (2.82 miles) was surveyed using a Marine EM61-MKII in high-power mode. Using previously collected

bathymetry (1995) and side-scan data, the survey crew raised and lowered the sensor so it remained approximately 2 feet or less off the bottom of the lake while collecting data along each transect. Due to the shallowness of the water and aquatic vegetation the crew was unable to maneuver the vessel towing the Marine EM61-MKII as close the shoreline as originally proposed (shown on **Figure 5-32**). However, enough anomalies were detected along the transects combined with the existing anomalies to meet the objectives.

A total of 63 anomalies were detected in Picatinny Lake. The majority of these anomalies were clustered toward the shoreline adjacent to several operational buildings as shown in **Figure 5-33**. The underwater DGM transect data (2012) were compared to the existing underwater DGM data from Blackhawk (1995) and a total of 25 anomalies (consisting of both single anomalies and anomaly clusters) were chosen for intrusive investigation. From the existing DGM data (1995), 16 targets were identified for investigation (12% of the anomalies from the existing DGM data), and 9 targets were identified for investigation from the RI DGM data (2012) based on a threshold of 30MV in Channel 3. The anomalies chosen for intrusive investigation are presented in **Figure 5-32**.

The specific procedures and requirements for performing the underwater intrusive investigation were provided in the dive plan (EOTI, 2012). Prior to performing underwater intrusive investigations, GPS and DGM instrumentation were used to refine the target locations and then qualified divers investigated the chosen anomalies. Intrusive investigation results are provided in Section 6.6.1.2.

5.7.1.3 Summary of RI Field Activities

Detected anomalies in the grids and along the transects were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.6.1.2 for the intrusive investigation results. All survey activities performed within the Picatinny Lake portion of the Lakes MRS are presented in **Figure 5-33**. A complete summary of the investigations performed within the Picatinny Lake portion of the Lakes MRS are provided in **Table 5-10**.

Table 5-10 Picatinny Lake Survey Summary

Survey Method	Investigation Area	Proposed Area Investigated (miles/acres)	Total Area Investigated (miles/acres)	Anomalies Investigated
EM61-MK2 Grid	Barbette gun firing point	1 (100 by 100 ft) or 0.25 acre	0.59 acre	7
Analog Transects	Along shoreline	2.7 miles	2.7 miles	131
Underwater EM61-MK2 Transects	Within water portion of lake	3 miles	2.82 miles	25

5.7.2 Lake Denmark MEC Characterization

The Lake Denmark portion of the Lakes MRS consists of 616 acres of the Lakes MRS. This portion of the Lakes MRS consists of 263 acres of surface water area and 353 acres of land surrounding the lake. **Figure 1-11** presents the location of Lake Denmark within PTA.

5.7.2.1 RI Approach

The following sections present the RI field efforts that were performed to achieve the DQOs previously described in Section 4.6.2.2. The characterization scope based on the DQOs were to determine whether a MEC release from the mortar and 20mm ranges had occurred on the land portions of the area, to delineate the Lake Denmark mortar range impact area with additional underwater geophysical transect surveys, to determine whether MEC burial features are present at the firing points, and to determine the nature and extent of MEC at the burial sites.

The MMRP RI approach included collecting underwater DGM transect data to fill data gaps from the previous G-858 cesium vapor gradiometer magnetic surveys performed at Lake Denmark in January 1999 by ICF Kaiser Engineers, Inc. An evaluation of the existing magnetic survey data from 1999 combined with the underwater RI DGM transect data collected in 2012 would be performed to identify anomaly trends and distribution and to select underwater and near-shore anomalies across Lake Denmark to evaluate the nature and distribution of potential MEC. Additionally, the RI approach for Lake Denmark included performing DGM grid surveys and intrusive investigations at the firing point locations as necessary to detect burial features and performing mag and dig transect surveys with analog instrumentation based on VSP calculations over the land-based areas around Lake Denmark and along the shoreline of the lake.

5.7.2.2 RI Field Activities

A 0.23-acre DGM grid survey (LD-01) was performed on January 24, 2012 using an EM61-MK2 in cart mode at the Lake Denmark 20mm Cannon Firing Point. The resulting DGM map is presented in **Figure 5-34**. The Lake Denmark 20mm Cannon Firing Point DGM grid was used to detect potential burial features at the firing point.

Although two additional grids were proposed at the Mortar Range firing points shown on the 1947 map in the HRR, they were not surveyed because the southern end of Lake Denmark had been extensively reworked during dam construction and upgrades in 2011. The area had been leveled and overlain with fill, and concrete had been poured as part of the construction activities. UXO construction support was used during dam construction and three MEC items were recovered. On December 8, 2010 two UXO items, consisting of a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an M302A1 60mm WP mortar and M527B1 fuze and WP filler. The 60mm WP mortar was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD.

In April and May 2012, analog surveys were conducted along 64,581 linear feet of 14.37 acres of land surrounding Lake Denmark. The survey locations are shown in **Figure 5-35**. Analog transect surveys were conducted only in accessible areas. The analog transects in the central portion of the northwestern side of Lake Denmark were unable to be surveyed because of swampy terrain and the extent of the water. Of the 17 acres proposed by VSP, only 14.37 acres were able to be surveyed because a small section of the eastern land portion of Lake Denmark east of 25th Avenue was found to be inaccessible for investigation because of the presence of wetlands consisting of swampy terrain and pools of water.

A total of 3.08 miles of underwater DGM transect surveys were performed on July 25 and 26, 2012, as shown in **Figure 5-36**. Data from two linear transects and one meandering transect were collected in the open water portion of the lake north of the area of data collection in the 1999 underwater DGM survey. The meandering transects were used to penetrate as far into the wetland area as possible to maximize coverage. The northern wetland area was not accessible for further surveys during the RI. From the existing DGM data (1999), five targets were identified for investigation, and five targets were identified for investigation from the RI DGM data (2012)

based on a threshold of 30MV in Channel 3. The anomalies chosen for intrusive investigation are presented in **Figure 5-36.**

Refer to the dive plan for specific procedures and requirements for performing the underwater intrusive investigation (EOTI, 2012). Prior to performing underwater intrusive investigations, GPS and DGM instrumentation were used to refine the target locations, and then qualified divers investigated the chosen anomalies. Refer to Section 6.6.2.2 for the intrusive investigation results.

5.7.2.3 Summary of RI Field Activities

Detected anomalies in the grids and along the transects were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.6.2.2 for the intrusive investigation results. All survey activities performed within the Lake Denmark portion of the Lakes MRS are presented in **Figure 5-35**. Refer to **Table 5-11** for a complete summary of the investigations performed within the Lake Denmark portion of the Lakes MRS.

Table 5-11 Lake Denmark Survey Summary

Survey Method	Investigation Area	Proposed Area Investigated (miles/acres)	Actual Total Area Investigated (miles/acres)	Anomalies Investigated
EM61-MK2 Grid	20mm Cannon Firing Point	3: (100 x100 ft) or 0.25 acre	1: (0.23 acre)	66
Analog Transects	Land Portion	14 miles	14.37 miles	100
Underwater EM61-MK2 Transects	Within water portion of Lake	5 miles	3.08 miles	10

5.7.3 MC Characterization

Further assessment of MC under the MMRP was not warranted for this MRS and was not included in the scope of RI field activities because co-located IRP investigations that include MC parameters in their scope of remedial objectives are occurring at the Lakes MRS. The FS for the Lake Denmark IRP site PICA-054 was submitted in October 2009. A revised FS that included Lake Denmark was submitted in spring of 2012. The FS for Picatinny Lake IRP site PICA-053 was submitted in October 2009. A revised FS that included Lake Picatinny was submitted to regulators in spring of 2012 (Picatinny, 2013).

No additional characterization activities were warranted during the RI to assess MC within the land portion of the Lakes MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS.

5.8 LAKE DENMARK – OFF-POST MRS

The Lake Denmark – Off-Post MRS (PICA-012-R-01) consists of 113 acres and is a portion of the Lake Denmark mortar range SDZ. It was designated as a separate MRS from the Lakes MRS because it is located off-post and has a different CSM. The Lake Denmark mortar ranges are the primary release mechanism for both the Lake Denmark MRS and the Lake Denmark – Off-Post MRS. **Figure 1-13** presents the location of Lake Denmark – Off-Post MRS.

5.8.1 MEC Characterization

5.8.1.1 RI Approach

The following subsection presents the RI field efforts that were performed at the Lake Denmark – Off-Post MRS to achieve the DQOs, previously described in Section 4.7.2. The characterization requirement based on the DQOs was to determine whether a MEC release from the mortar ranges at Lake Denmark had occurred, based on VSP calculations as described below.

The MMRP RI approach included performing mag and dig transect surveys with analog instrumentation based on VSP calculations across the Lake Denmark – Off-Post MRS.

5.8.1.2 RI Field Activities

A total of 30,817 feet (5.84 miles) of visual surveys were conducted across the Lake Denmark – Off-Post MRS investigation areas on September 18th and 19th using a White's MXT. Within the two non-contiguous investigation areas, seventy-eight anomalies were identified and logged using a Trimble GeoXH 6000 GPS. The work plan addendum required 4.88 miles of coverage. Approximately 1 mile of additional coverage was achieved during the fieldwork. Within the northern investigation area 15 anomalies were identified and 63 anomalies were identified within the southern investigation area. The actual transect locations and subsurface anomalies are shown on **Figure 5-37**. Three of the anomalies identified in the southern portion were designated as trash pits. The anomalies were identified as trash pits due to the amount of surface debris in a localized area. A photo of one of the trash pits is included in the photo log.

The investigation area and several of the transects extend beyond the MRS boundary. The investigation was conducted outside the MRS boundary because of the 60mm HE mortar that was encountered along the PSE&G power line right of way near PTA boundary. This was the first known MEC item recovered near the Lake Denmark – Off-Post MRS and it was therefore deemed prudent to extend the investigation to as near as the mortar location as possible. However, as shown on **Figure 5-37** (areas where the visual survey transects do not overlap the proposed transects), transects were unable to be collected in this area as well as other areas that were identified as inaccessible by the field team. Transects along the northern MRS boundary were unpassable because of water and vegetation making visual surveys ineffective. The northeastern most corner of the MRS was turned into a parking area for PSE&G power line right-of-way activities. A small area in the southern portion of the MRS was inaccessible because of the Lake Denmark cove and associated wetlands.

5.8.1.3 Summary of RI Field Activities

Detected anomalies along the visual survey transects were investigated by UXO Technicians to determine the anomaly source and log the subsurface anomalies. Refer to Section 6.7.1 for the results of the non-intrusive density transects. All survey activities performed within the Lake Denmark – Off-Post MRS are presented in **Figure 3-37**. Refer to **Table 5-12** for a complete summary of the investigations performed within the Lake Denmark – Off-Post MRS.

Table 5-12 Lake Denmark – Off-Post MRS Survey Summary

Survey Method	Proposed Area Investigated (feet)	Actual Total Area Investigated (feet)	Recorded Anomalies
Visual Survey Transects	25,763	30,817s	78

5.8.2 MC Characterization

No characterization activities were warranted during the RI to assess MC within the Lake Denmark – Off-Post MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred; therefore, no samples were collected in the MRS.

5.9 INACTIVE MUNITIONS WASTE PIT MRS

The Inactive Munitions Waste Pit MRS (PICA-013-R-01) consists of 21 acres and the MRS boundary was defined by the 1,250 foot SDZ for a former testing area within the MRS. **Figure 1-14** presents the location of the Inactive Munitions Waste Pit MRS within PTA.

5.9.1 MEC Characterization

5.9.1.1 RI Approach

The following subsections present the RI field efforts that were performed to achieve the DQOs previously described in Section 4.8.2. The characterization scope based on the DQOs were to define the nature and extent of MEC burial areas and determine whether a MEC release had occurred at the Inactive Munitions Waste Pit MRS.

The MMRP RI approach included performing EM31-MK2 transect surveys to detect burial features in the MRS where potential testing and burial activities would have occurred. If MEC burial sites were detected by DGM transect surveys, then the extent of the burial feature would be delineated. Both the ground conductivity and inphase measurements were to be processed and evaluated to identify high-density areas indicative of burial sites (e.g., drums, disposed bulk munitions). The point between the elevated responses associated with the burial site and the background response associated with an area free from conductive material would be defined as the burial site boundary.

A second MMRP RI field objective was to conduct analog transect surveys to detect potential MEC releases. Density transects were to be conducted in the portion of the MRS that overlapped with the AOI Code 300 Area[2] to detect high-density areas that would be indicative of a MEC release. The density transect data would be combined with the analog results to determine whether a MEC release occurred in the Inactive Munitions Waste Pit MRS.

As detailed in Section 2.9.2, additional historical research was performed as part of the RI during work plan development for the MRS because of recent IRP studies and their findings of DMM, consisting of a CDU-10/B gravel mine canister and numerous MD. Based on this research a revised technical approach was applied at the central portion of the MRS, as detailed in

[2] Only a small portion of the Code 300 Area overlaps the Inactive Munitions Waste Pit.

Appendix D. The revised approach increased the amount of proposed DGM transects to include a scared area observed on the historic aerial photographs. The approach proposed that no additional intrusive investigations be conducted at the central portion of the Inactive Munitions Waste Pit MRS because of the completed and proposed additional IRP trenching activities which confirmed the presence and nature of MEC. The DGM transects would be sufficient to determine the extent of MEC within the burial area.

5.9.1.2 RI Field Activities

On January 30, 2012, DGM transect surveys were performed for the MMRP RI with the EM31-MK2 over the central portion of the Inactive Munitions Waste Pit MRS to detect subsurface anomalies and determine whether a munitions waste pit(s) was indicated in the subsurface. Large obstructions consisting of rubble piles (large boulders, gravel, sand, and construction debris) bounded the area, limiting the length of transects that could be completed. As a result of artillery carriages present on the east side of the Inactive Munitions Waste Pit MRS at the time, several DGM transects planned were not completed until August 20, 2012. Prior to completing the DGM transects in August 2012, an intrusive trenching investigation under the IRP was completed to investigate the source of a TCE plume at the MRS (Shaw, 2010). During this intrusive trenching investigation, MEC and MD were confirmed at the Inactive Munitions Waste Pit MRS (Shaw, 2013). Based on this information as well as the initial DGM data, the remaining DGM transects were completed for the MMRP RI to the east of the confirmed buried waste to support determining the lateral extent of the waste pit. Refer to **Appendix I** for photographs of the IRP trenching activities and items identified.

A total of 6,163 linear feet of EM31-MK2 transects were surveyed within the Inactive Munitions Waste Pit MRS. The DGM transects are depicted in **Figures 5-38** and **5-39**. No intrusive investigations for MEC were performed based on the DGM described above performed to define the lateral extent of buried debris as the presence of MEC and MD was confirmed based on the available historical information. However, limited intrusive investigation within the Inactive Munitions Waste Pit MRS was performed during the IRP trench excavation including visual inspection and characterization sampling for MC, which is described below in Section 5.9.2.

A total of 830 linear feet of analog surveys were performed using a White's MXT all-metals detector, as shown on **Figure 5-40,** in the portions of the Inactive Munitions Waste Pit MRS that

did not overlap with the AOI Code 300 Area. Detected anomalies along the analog transects were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.8.2 for the intrusive investigation results.

A total of 3,020 linear feet of density transect surveys were conducted in the area of the Inactive Munitions Waste Pit MRS overlapping with the AOI Code 300 Area. The density survey transects are depicted in **Figure 5-40**. The transect length exceeded the minimum VSP requirements of 2,668 linear feet listed in **Table 5-13**. After the density transect surveys were completed, an analog grid, Code300-12 (50 by 50 feet), was surveyed to characterize a potential high-density area. Refer to Section 6.8.2 for the intrusive investigation results.

5.9.1.3 Summary of RI Field Activities

Anomalies detected along the analog transects and within the AOI Code 300 Area grid were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.8.2 for the intrusive investigation results. All areas of survey activities performed within the Inactive Munitions Waste Pit MRS are presented in **Figure 5-40**. Refer to **Table 5-13** for a complete summary of the investigations performed within the Inactive Munitions Waste Pit MRS.

Table 5-13 Inactive Munitions Waste Pit MRS Survey Summary

Survey Method	Investigation Area	Proposed Area Investigated (feet)	Total Area Investigated (feet)	Anomalies Investigated
EM31-MK2 Transects	Former testing area	2,767	6,163	0
Analog Transects	Inactive Munitions Waste Pit MRS	815	830	0
Density Transects	AOI Code 300 Area	2,668	3,020 ft and 1 grid	3

5.9.2 MC Characterization

The Final RI Work Plan (WESTON, 2012) stated that, to the extent possible, MC sampling within the Inactive Munitions Waste Pit MRS would be conducted concurrently with IRP trenching investigations already underway within the MRS. Both random sampling and biased sampling approaches were detailed for the MRS. Random samples would only be collected from native soil, not the fill material. The random sampling approach was not employed as a result of both safety concerns and field observations, such as the trench consisted of fill material and

native soil was not encountered until near the bedrock. Except for the sample collected near the bedrock, sampling was conducted in a biased manner in conjunction with IRP sampling activities and the RI samples were co-located with the IRP samples.

Safety concerns regarding the loose nature of gravel fill encountered during excavation precluded entering the trench to collect "in-place" samples. Additionally, clear visual observations during excavation of potentially impacted soil from buried drums with DMM and leaking fluid contents indicated a need to collect biased samples to assess a "worst-case" scenario (i.e., collect the sample nearest the potential source of contamination). Three soil samples and one duplicate were collected and analyzed for the list of explosives and metals potentially associated with MEC listed in **Table 5-5,** in addition to perchlorate. Refer to **Figure 5-40** for locations of the MC samples. A substance uncovered during the IRP trenching activities had the appearance of perchlorate; therefore, perchlorate was analyzed at the request of PTA.

Sampling procedures were followed as detailed in the Final RI Work Plan (WESTON, 2012), except samples could not be collected "in-place" and had to be collected using a trowel from the interior of the bucket of the excavator, which was the sampling procedure approved for the IRP sampling activities. Biased samples, consisting of a discrete soil sample immediately under, or adjacent to debris where contamination is likely (e.g., visual staining, near crack/corrosion) were collected. In addition to the biased samples, one sample was collected near bedrock, in what appeared to be native soil but that had a faint odor. A discussion of the results of the field investigations are presented in Section 6.8.4 and a data evaluation conducted to assess potential MC risks at the Inactive Munitions Waste Pit MRS is presented in Section 9.2.

5.10 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

The Inactive Munitions Waste Pit – Off-Post MRS (PICA-014-R-01) consists of a 39-acre portion of an SDZ resulting from the former testing area within the Inactive Munitions Waste Pit MRS. **Figure 1-15** presents the location of the Inactive Munitions Waste Pit – Off-Post MRS adjacent to PTA. Similar to other on-post versus off-post MRSs at PTA, the differentiation in these MRSs is based on a physical boundary (i.e., PTA boundary) and not technical differences in the source or release mechanism related to potential hazards.

5.10.1 MEC Characterization

5.10.1.1 RI Approach

The following subsection presents the RI field efforts that were performed to achieve the DQOs previously described in Section 4.9.2. The characterization scope based on the DQOs were to define the nature and extent if a MEC release had occurred, and if there had been an occurrence, to approximate the MEC density at the Inactive Munitions Waste Pit – Off-Post MRS.

The MMRP RI approach was to conduct analog transect surveys to detect potential MEC releases and the approximate MEC density.

5.10.1.2 RI Field Activities

A total of 6,780 linear feet (1.51 acres) of analog surveys were performed using a White's MXT all-metals detector in the Inactive Munitions Waste Pit – Off-Post MRS as depicted on **Figure 5-40**. More linear feet of analog surveys were performed than proposed because, the DQOs state: "Full coverage mag and dig surveys will be performed in accessible areas at the top of the ridge and bottom of the slope in the northwest portion of the MRS where the terrain is accessible to the UXO teams." The proposed length of these surveys was not determined before the field effort because it was indeterminable what area(s) would be accessible for investigation; therefore the total survey length includes the portion conducted in accessible areas at the top of the ridge and bottom of the slope.

5.10.1.3 Summary of RI Field Activities

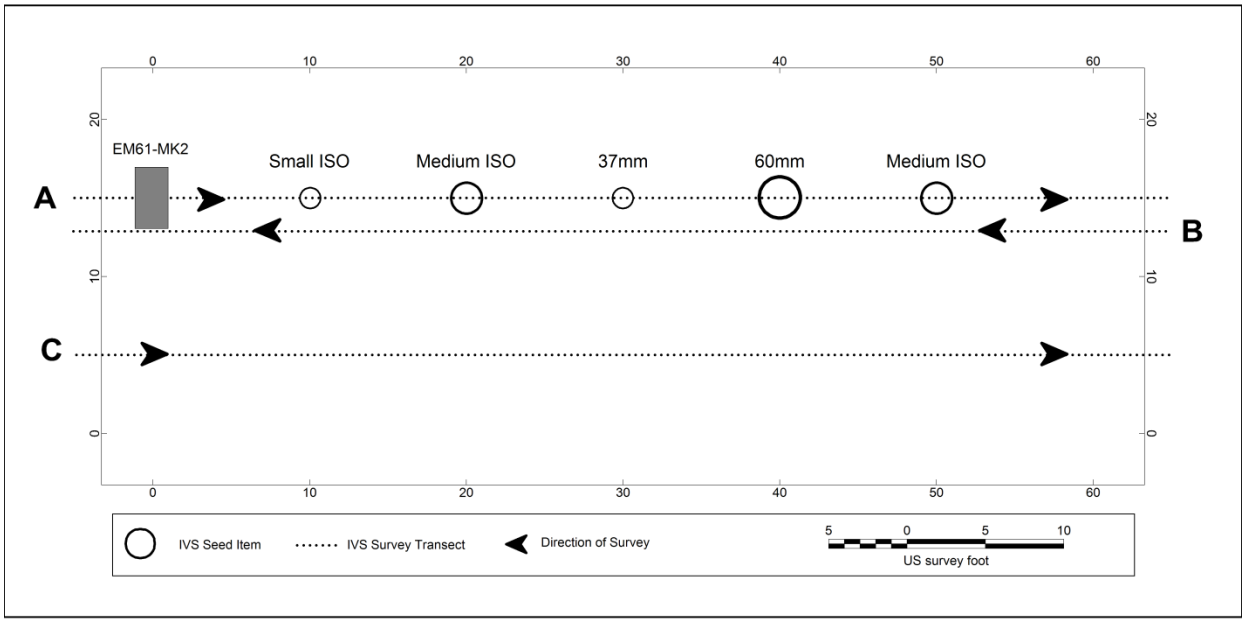
Detected anomalies along the analog transects were investigated by UXO Technicians to determine the anomaly source. Refer to Section 6.9.2 for the intrusive investigation results. The survey activities performed at the Inactive Munitions Waste Pit – Off-Post MRS are presented in **Figure 5-40**. Refer to **Table 5-14** for a complete summary of the investigations performed at the Inactive Munitions Waste Pit – Off-Post MRS.

Table 5-14 Inactive Munitions Waste Pit Off-Post MRS Survey Summary

Survey Method	Proposed Area Investigated	Total Area Investigated	Anomalies Investigated
Analog Transects	4,158 feet	6,780 feet/1.51 acres	6

5.10.2 MC Characterization

No additional characterization activities were warranted during the RI to assess MC in the Inactive Munitions Waste Pit – Off-Post MRS because no MEC was recovered, and the limited MD identified was not observed to be associated with any indications of a potential release.



Notes:
Line A: Directly over IVS seeds; used to verify that instrument response is within established response curve metrics.
Line B: Adjacent to Line A to use for offset detection and evaluate latency.
Line C: 10-ft offset from seeded IVS transect; used to measure local background noise.

Figure 5-1 Instrument Verification Strip Layout and Process

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Analog Grids Investigated
- DGM Grids Investigated
- AOI Code 300 Density Transects (Actual)
- AOI Code 300 Transects Proposed
- Inner Radius Decision Unit
- Outer Radius Decision Unit
- Fuze Area Decision Unit

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 1,350 2,700 Feet

0 330 660 990 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-2
1926 Explosion Radius MRS
PICA-003-R-01 Survey Locations

2/20/2014

Contract # W912DR-09-D-0006
DO 0002

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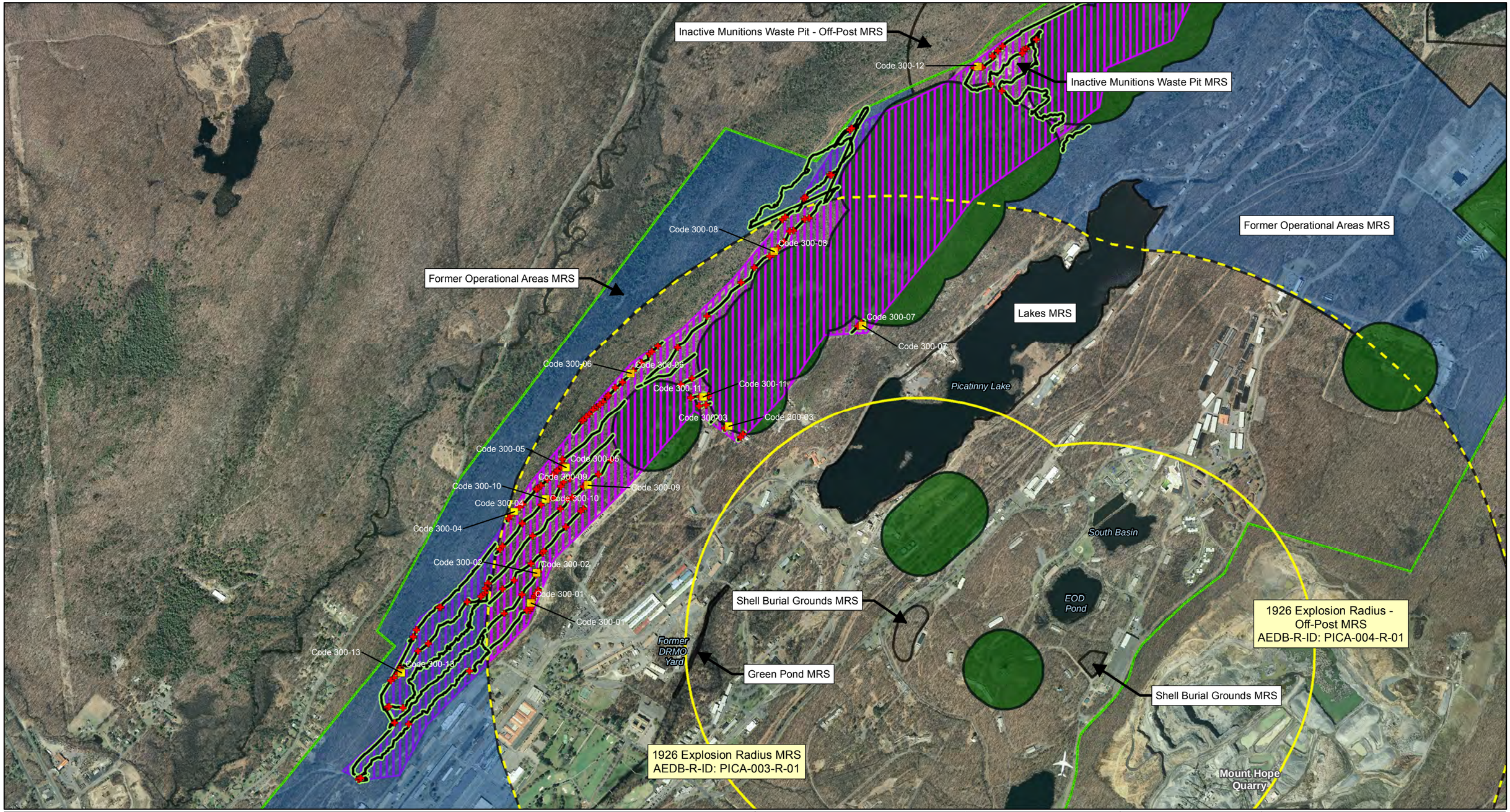

Legend

- Installation Boundary
- Operational Range Area
- Inner Radius Boundary
- Outer Radius Boundary
- Munitions Response Sites
- Former Operational Areas
- Code 300 Area
- Code 300 Area Grid
- Anomaly
- Density Transect

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,000 2,000 Feet

0 250 500 750 Meters

Created By: CEP

Verified By: NAS

Approved By: RSS

Figure 5-3
AOI Code 300 Area
Density Transect and Grid Locations

2/24/2014

Contract # W912DR-09-D-0006
DO 0002

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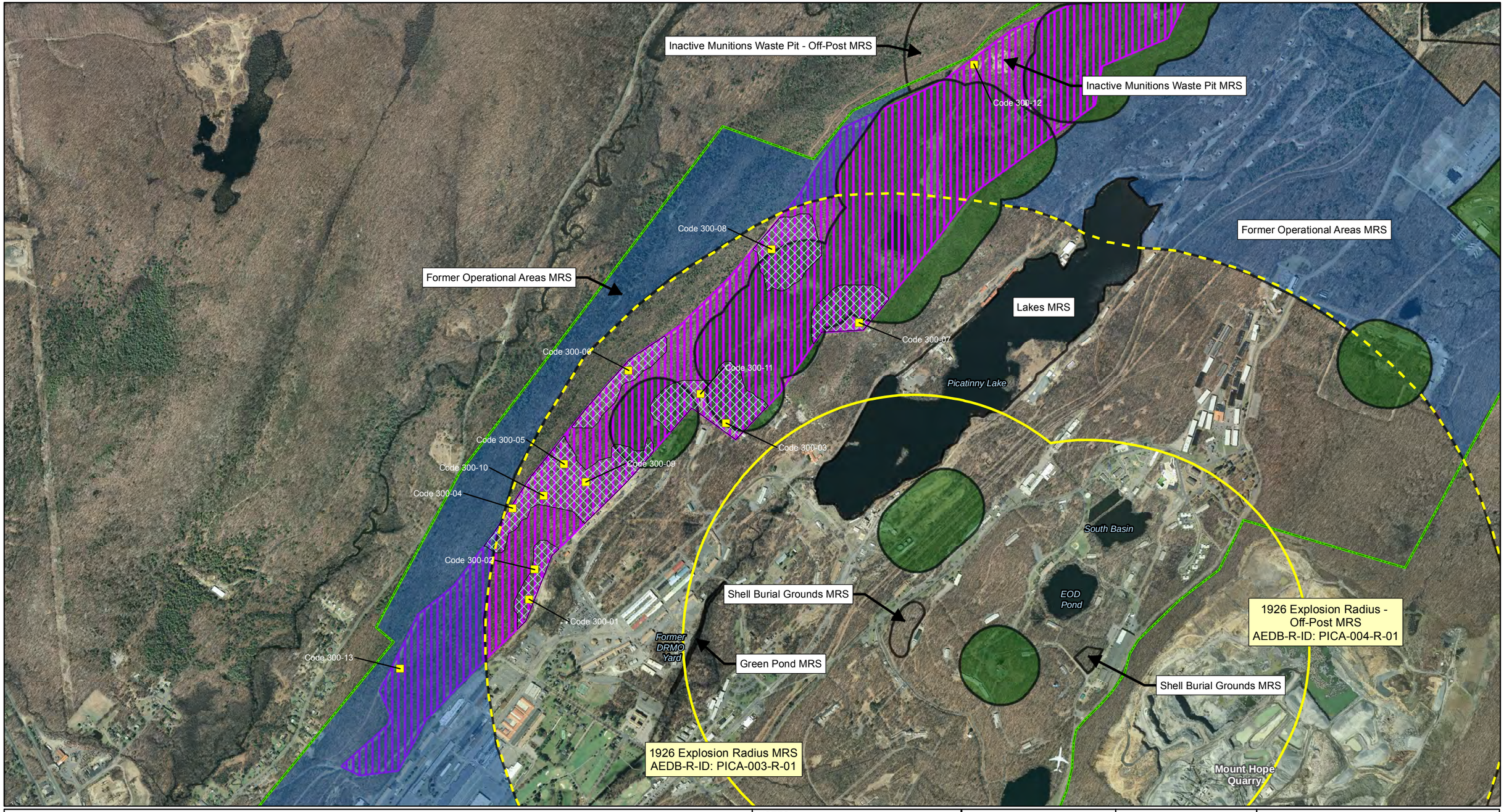

Legend

- Installation Boundary
- Operational Range Areas
- Inner Radius Boundary
- Outer Radius Boundary
- Munitions Response Sites
- Former Operational Areas
- Code 300 Area
- Code 300 Area Grid
- Elevated Anomaly Density Area

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

N

0 1,000 2,000 Feet

0 250 500 750 Meters

Picatinny Arsenal
Morris County,
New Jersey

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Figure 5-4
Code 300 Area High Anomaly Density Areas

2/24/2014

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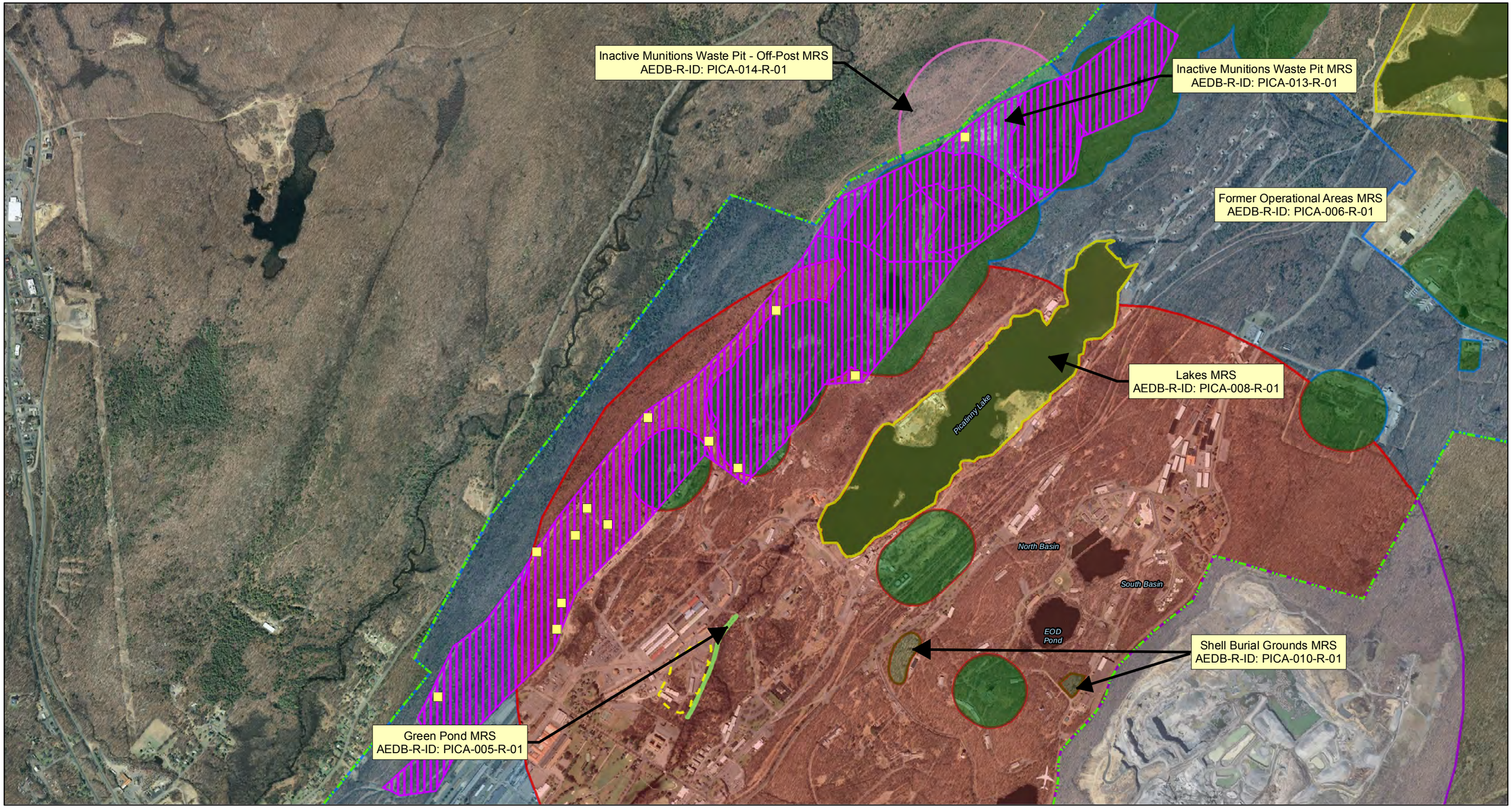

Legend

- Installation Boundary
- Operational Range Areas
- Former DRMO Yard
- Code 300 Area

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Lake Denmark - Off-Post
- Lakes
- Shell Burial Grounds
- Grids Investigated

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 — 2,500 Feet

0 — 320 — 640 — 960 Meters

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Approved By: RSS

Figure 5-5
Code 300 Area Grid Locations

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Code300_Grid_locs.mxd

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- GPS Points
- Interpolated Transect Paths

Grids

- Grid 26OR-023
- Grid 26OR-024
- Grid 26OR-025

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 150 300 Feet

0 50 100 Meters

Created By: BW

Verified By: NAS

Approved By: RSS

Figure 5-6
1926 Explosion Radius
EM Sensor-Assisted Visual Survey

2/28/2014

Contract # W912DR-09-D-0006
DO 0002

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Legend

- Installation Boundary
- Possible Burial Feature
- Metalic Debris or Object at Surface
- Shell Burial Grounds MRS
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
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N 0 150 Feet
0 10 20 30 Meters

Figure 5-7
Shell Burial Grounds MRS - West
EM31-MK 2 Survey Transects
Conductivity

2/20/2014

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_West_Cond.mxd

Legend
- Installation Boundary
- Shell Burial Grounds MRS
- Possible Burial Feature
- Metalic Debris or Object at Surface
- EM31 Proposed Transects

Inphase Response (ppm)
-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N
0 150 Feet
0 10 20 30 Meters

Figure 5-8
Shell Burial Grounds MRS - West
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

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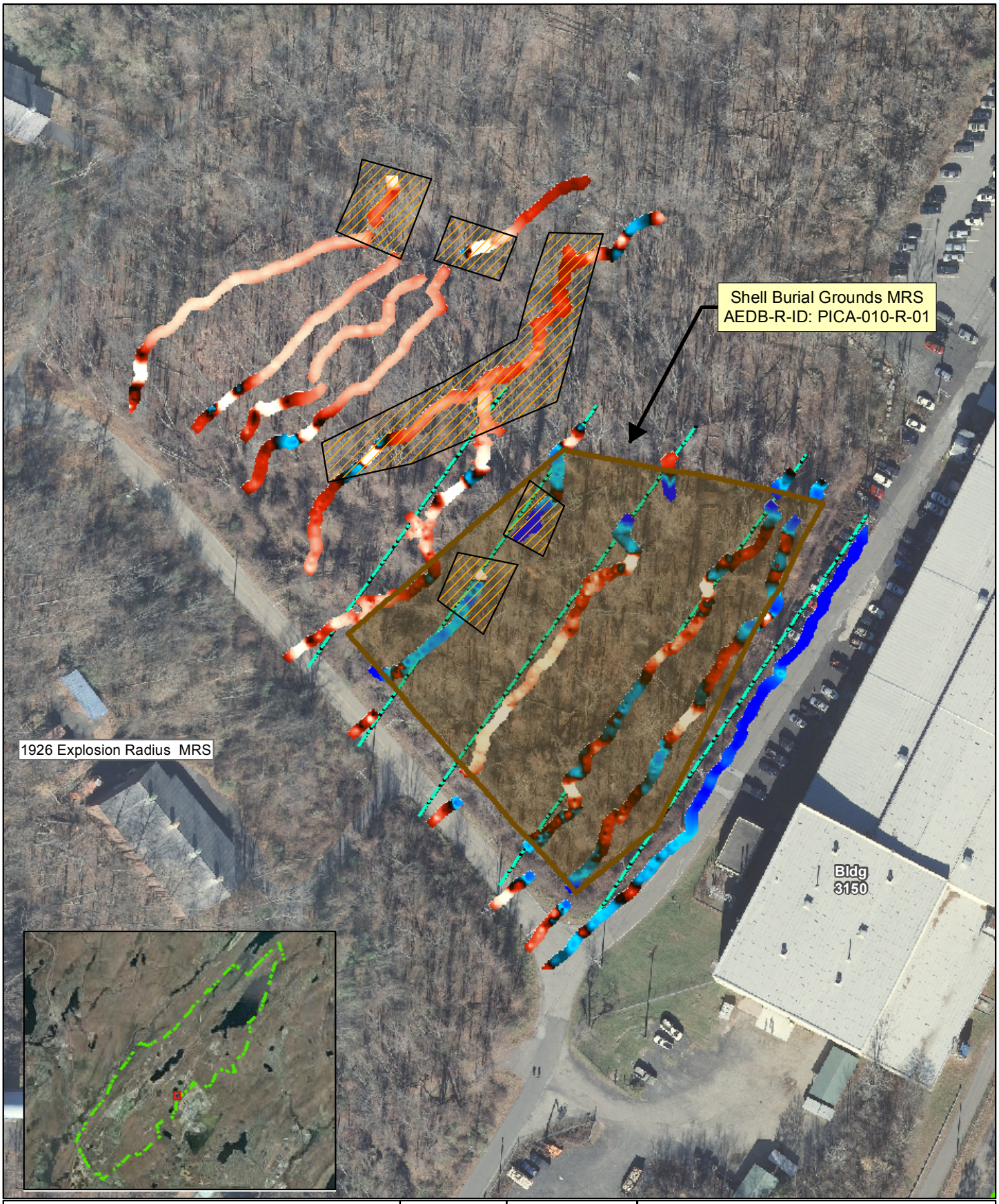


Legend

- Installation Boundary
- Shell Burial Grounds MRS
- Metalic Debris or Object at Surface
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

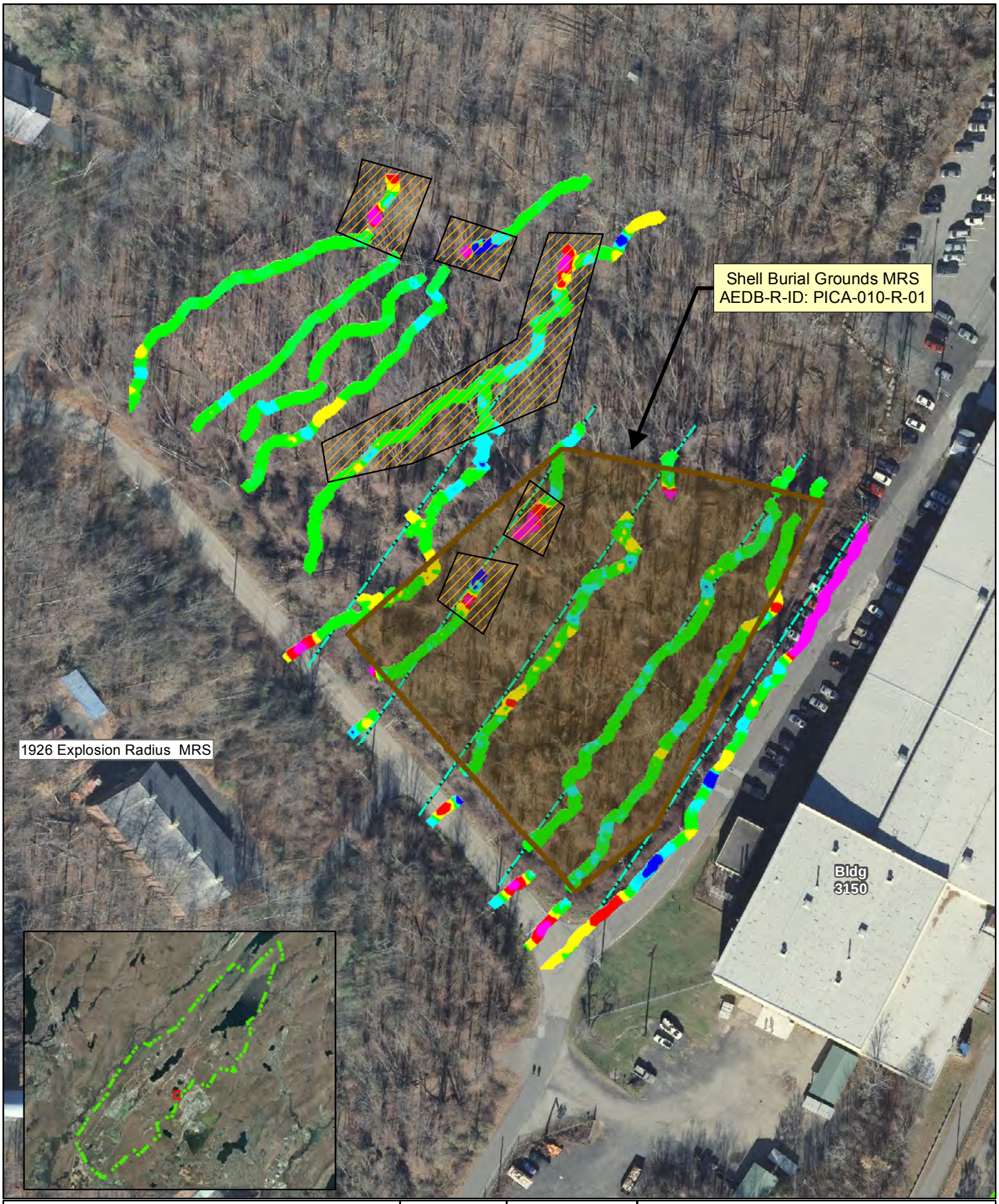
N 0 100 Feet
0 10 20 30 Meters

Figure 5-9
Shell Burial Grounds MRS - East
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_East_Cond.mxd



Legend
- Installation Boundary
- Shell Burial Grounds MRS
- Metalic Debris or Object at Surface
- EM31 Proposed Transects

Inphase Response (ppm)
-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

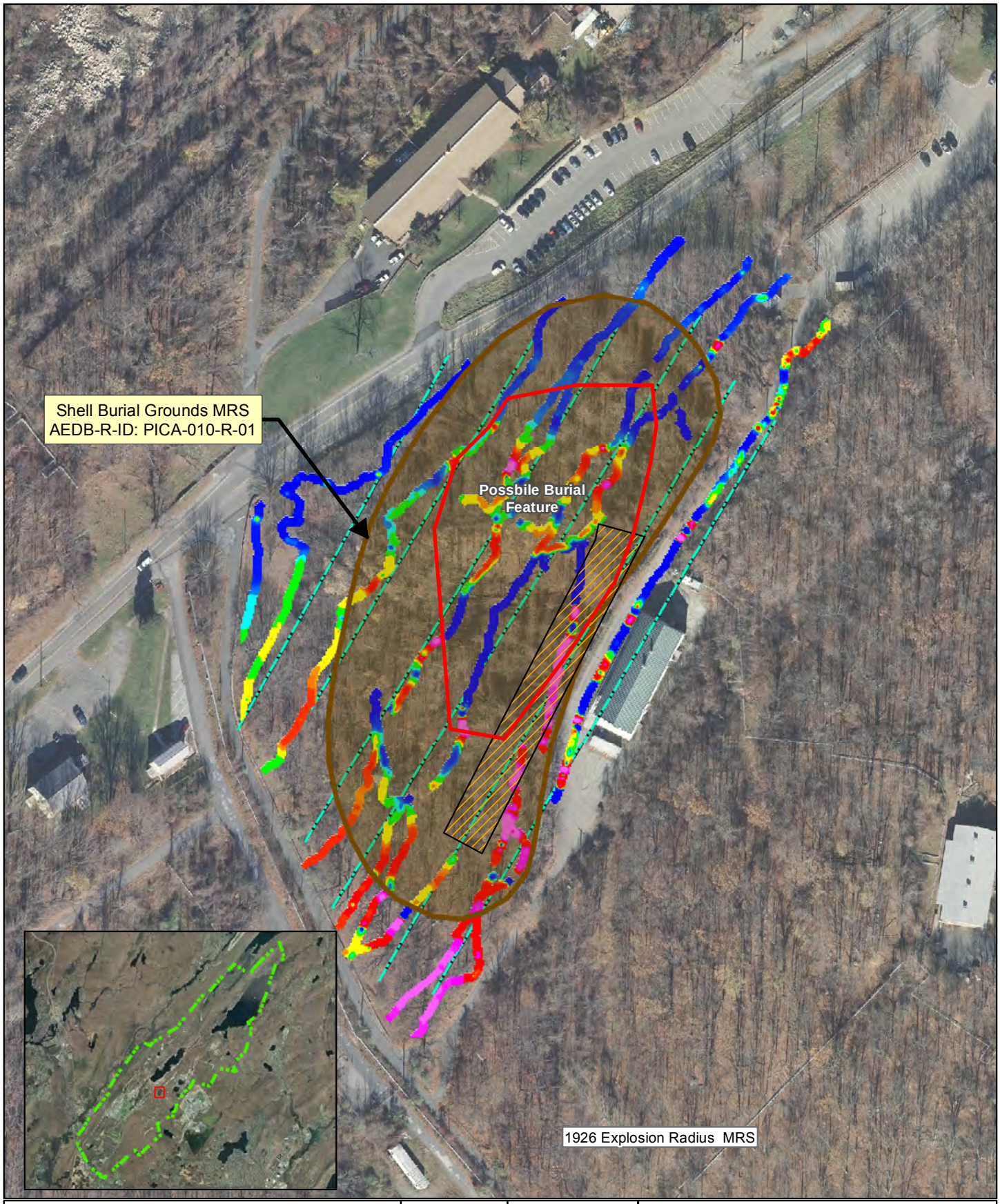
N
0 100 Feet
0 10 20 30 Meters

Figure 5-10
Shell Burial Grounds MRS - East
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_East_Inphase.mxd



Legend

- Shell Burial Grounds MRS
- Possible Burial Feature
- Metalic Debris or Object at Surface
- EM31 Proposed Transects

Total Field Response (nT)

48136 50449 51142 51564 51824 52138 52536

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

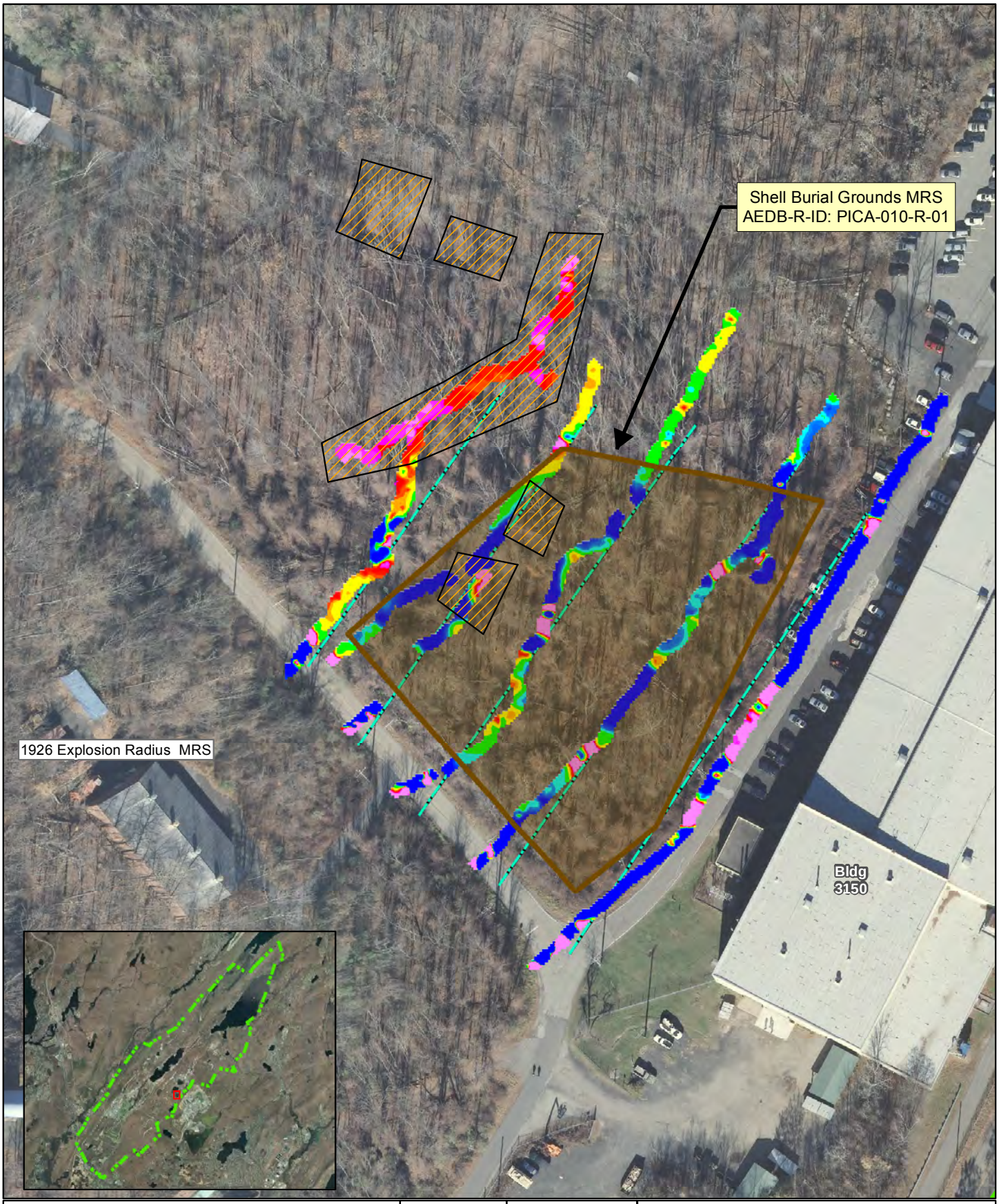
N 0 150 Feet
0 10 20 30 Meters

Figure 5-11
Shell Burial Grounds MRS - West
Total Field 858 Magnetometer
Survey Transects

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_West_Total.mxd



Legend

- Installation Boundary
- Shell Burial Grounds MRS
- Metalic Debris or Object at Surface
- EM31 Proposed Transects

Total Field Response (nT)

48136 50449 51142 51564 51824 52138 52535

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N 0 100 Feet
0 10 20 30 Meters

Figure 5-12
Shell Burial Grounds MRS - East
Total Field 858 Magnetometer
Survey Transects

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_East_Total.mxd

Legend
- Installation Boundary
- Shell Burial Grounds MRS
- Possible Burial Feature
- ER Transect Locations

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N
0 150 Feet
0 10 20 30 Meters

Figure 5-13
Shell Burial Grounds MRS - West
ER Transect Locations

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_West_ER_Trans.mxd

Legend
- Installation Boundary
- Shell Burial Grounds MRS
- ER Transect Locations

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

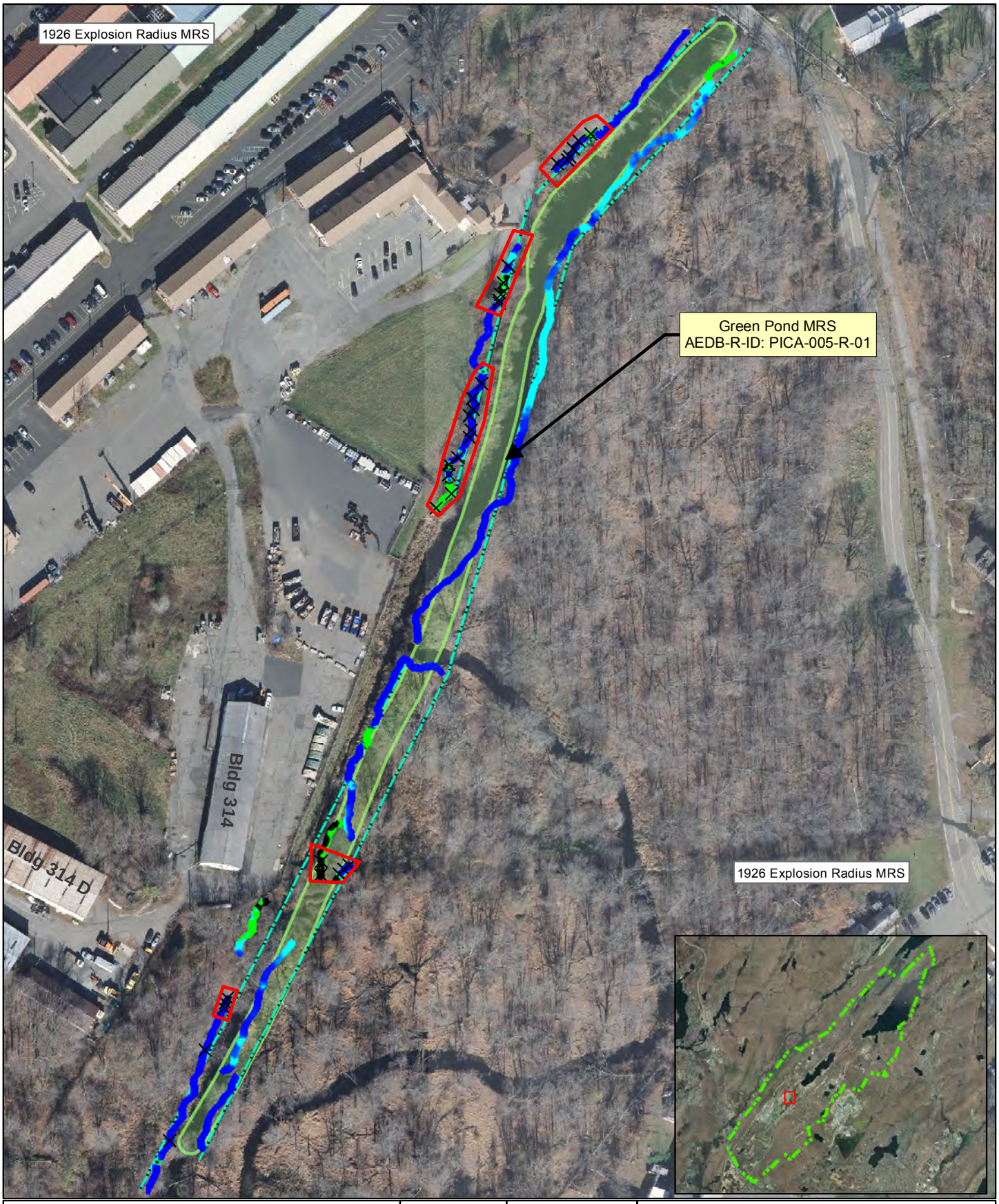
N
0 100 Feet
0 10 20 30 Meters

Figure 5-14
Shell Burial Grounds MRS - East
ER Transect Locations

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Shell_Burial_Grounds_East_ER_Trans.mxd



Legend

- Installation Boundary
- Green Pond MRS
- Intrusive Investigation Area
- Geophysical Target (Intrusive Investigation Location)
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N
0 150 Feet
0 20 40 60 Meters

Figure 5-15
Green Pond MRS
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Greenpond_Cond.mxd

Legend

- Installation Boundary
- Green Pond MRS
- Intrusive Investigation Area
- Geophysical Target (Intrusive Investigation Location)
- EM31 Proposed Transects

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 150 Feet

0 20 40 60 Meters

Figure 5-16
Green Pond MRS
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Greenpond_Inphase.mxd

Legend

- Green Pond MRS
- Former DRMO Yard
- Asphalt Cover
- Time Critical Removal Action Footprint
- Soil Cover
- Grids Investigated
- Mag & Dig Transects (Actual)
- Mag & Dig Transects Proposed
- EM31 Proposed Transects

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 200 400 Feet

0 70 140 Meters

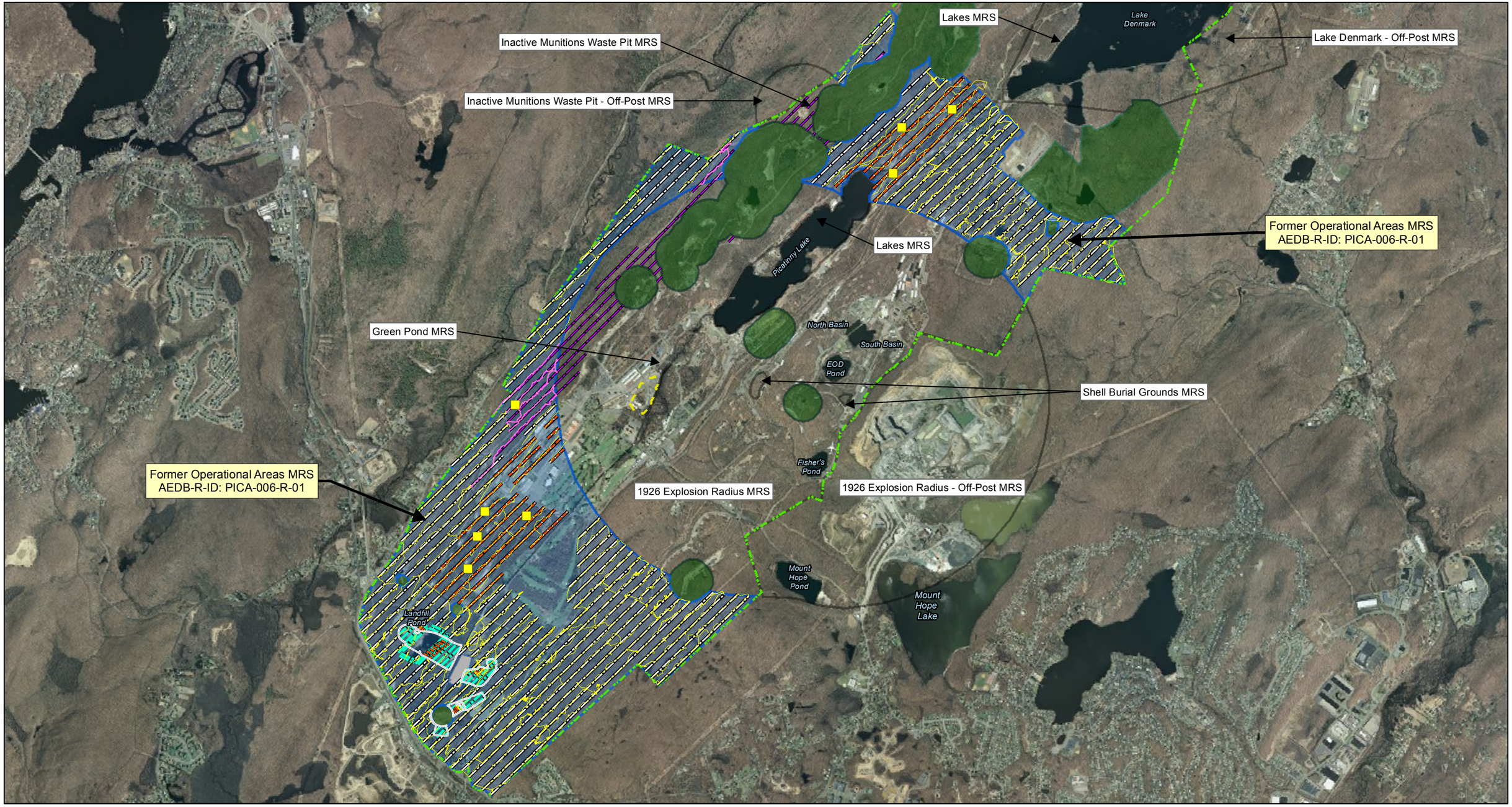
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-17
Green Pond MRS
Transect Locations

10/18/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Greenpond_DRMO_Grids_Transects.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Ineligible Area - Burning Ground
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest
- Former DRMO Yard
- Grids Investigated
- Mag & Dig Transects (Actual)
- Code 300 Density Transects (Actual)
- Transects Proposed
- Code 300 Transects Proposed
- EM31 Proposed Transects
- EM61 Proposed Transects

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

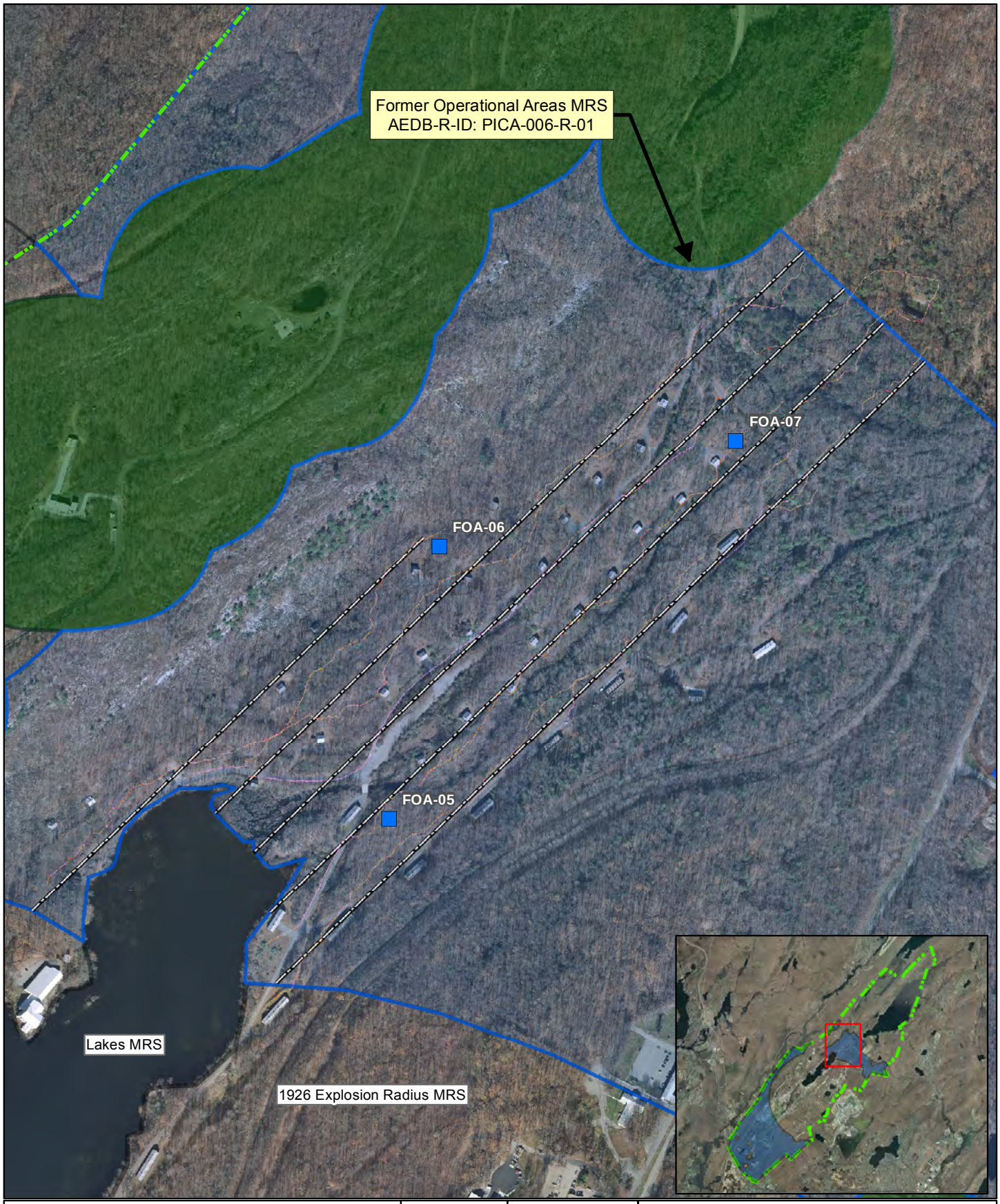
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-18
Former Operational Areas MRS
Survey Locations

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_Grids_Transects.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Grids Investigated
- Proposed Geophysical Transect

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 600 Feet

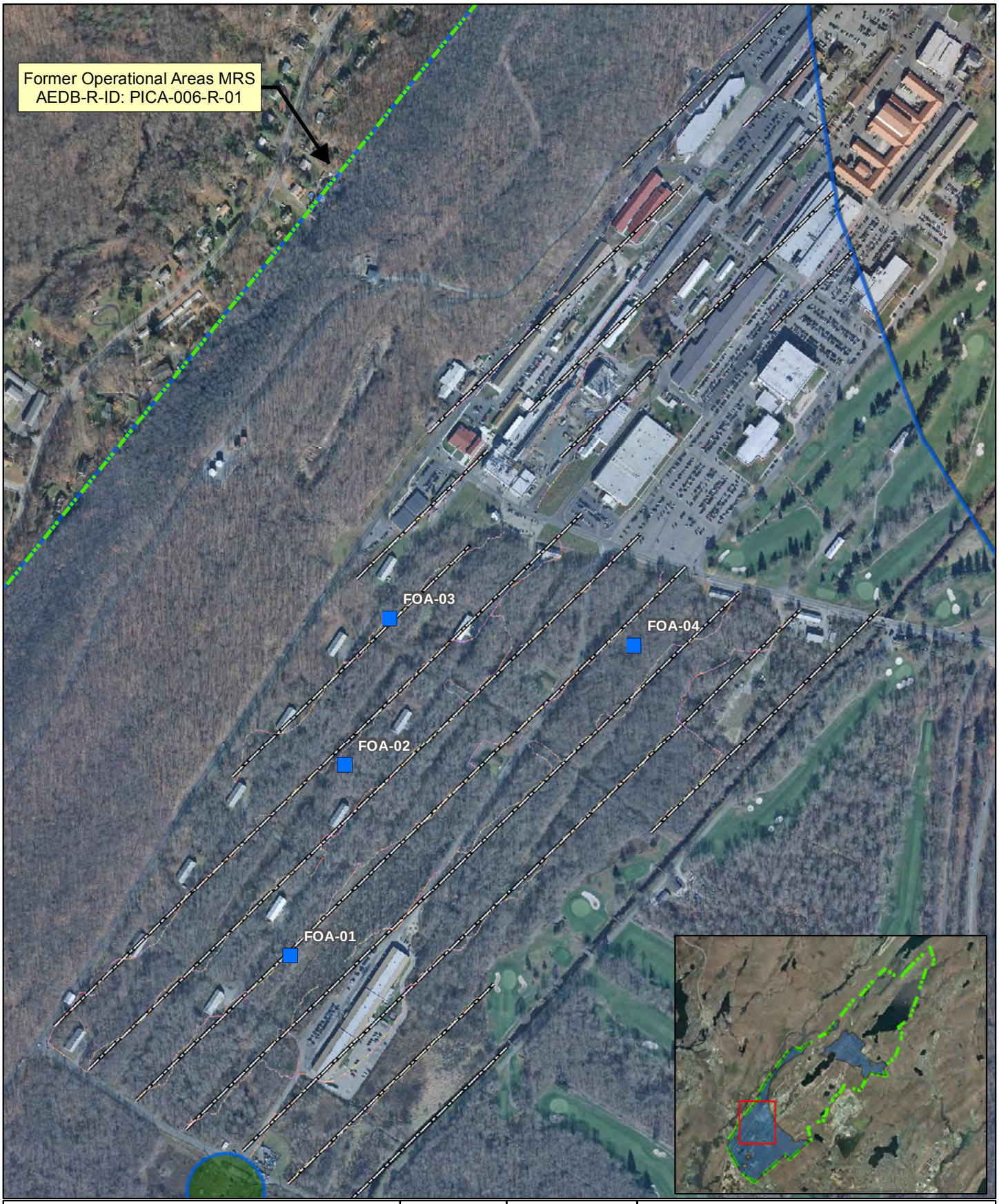
0 75 150 225 Meters

Figure 5-19
Former Operational Areas MRS - North
EM61-MK 2 Survey Transects

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_North_EM61.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Grids Investigated
- Proposed Geophysical Transect

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 600 Feet

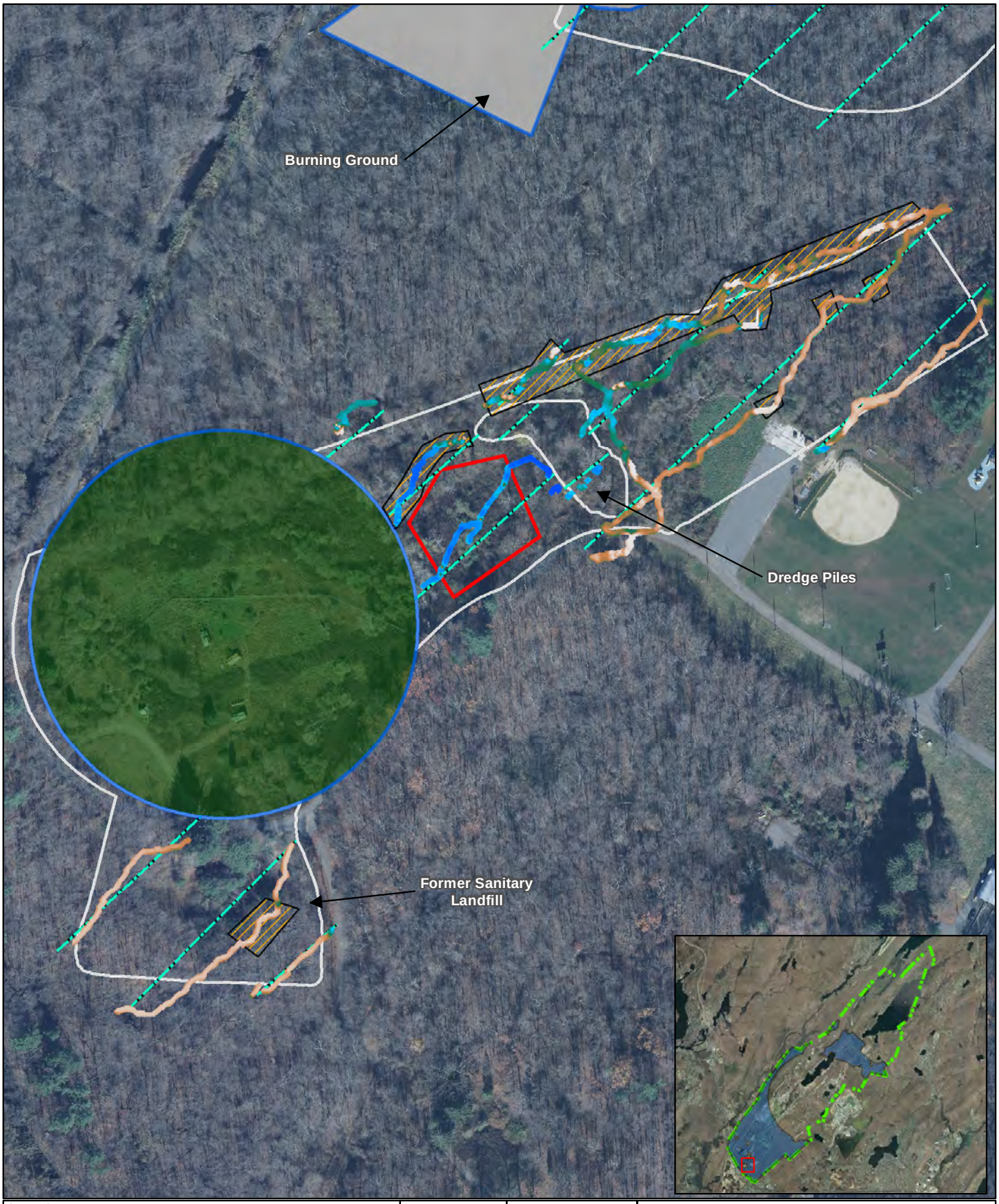
0 75 150 225 Meters

Figure 5-20
Former Operational Areas MRS - South
EM61-MK 2 Survey Transects

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_South_EM61.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Conductivity (ms/m)
-5 4 5 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

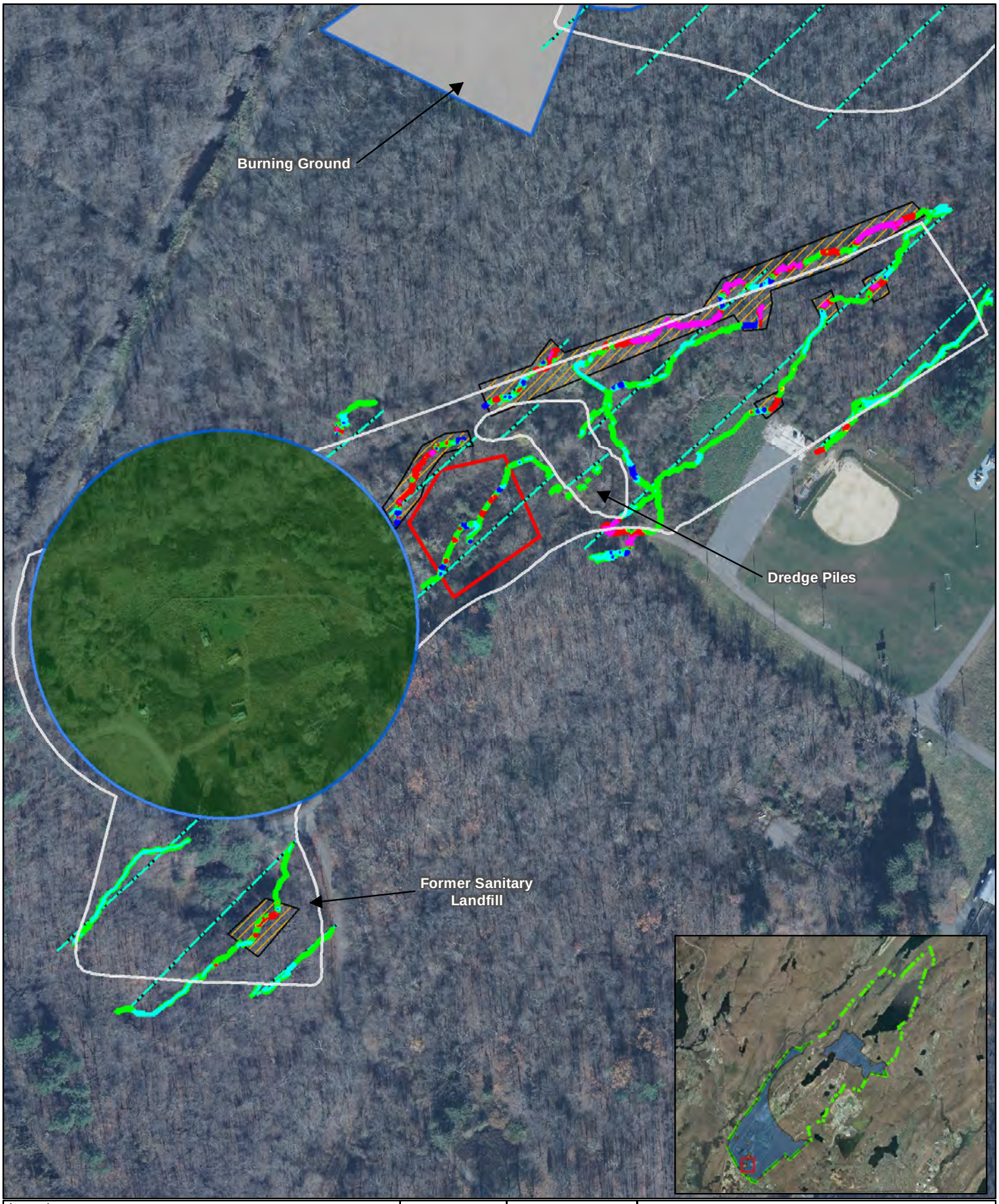
N
0 200 Feet
0 25 50 75 Meters

Figure 5-21
Former Operational Areas MRS
AOI Former Sanitary Landfill/Dredge Pile
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_AOI_Cond.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

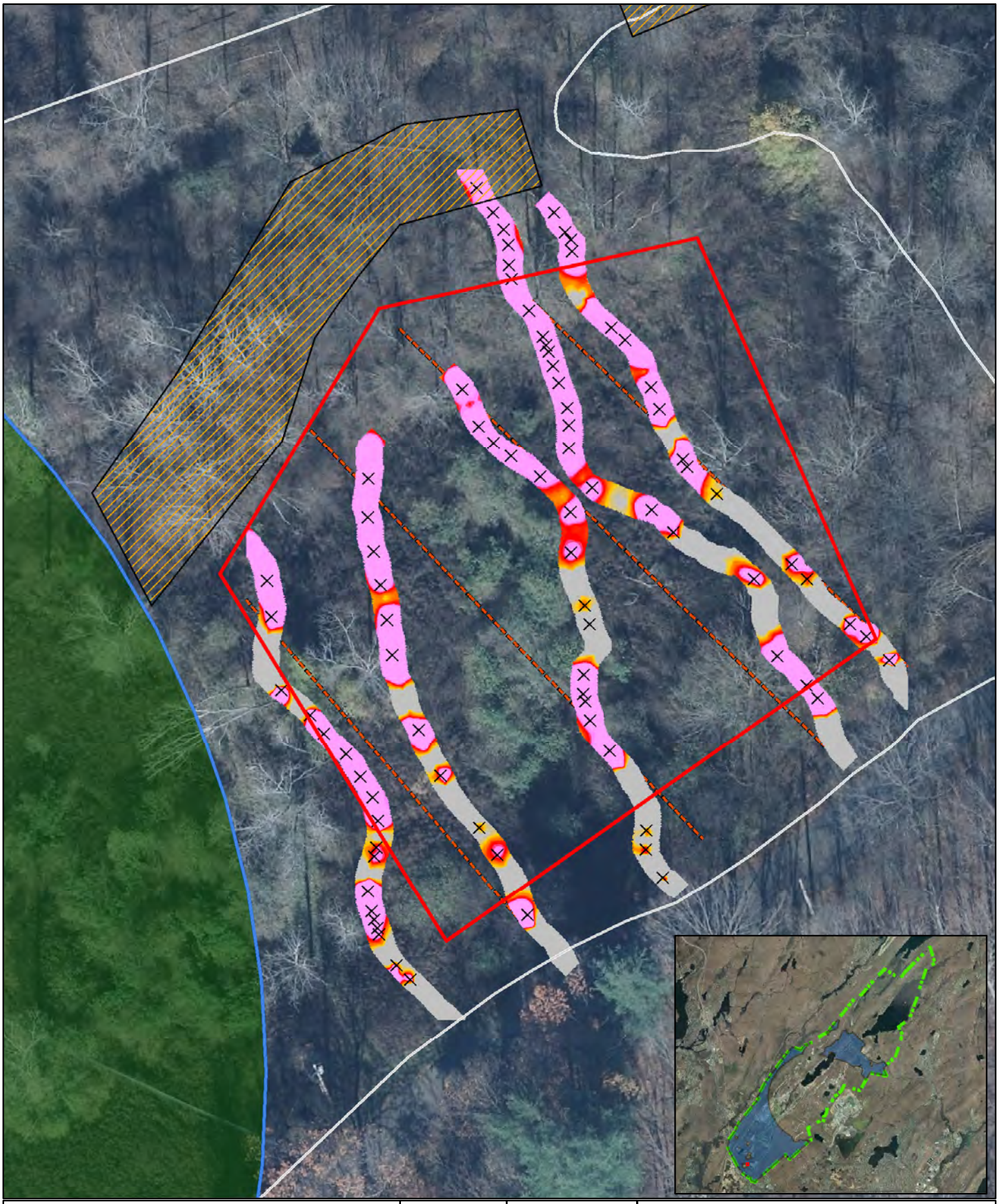
N
0 200 Feet
0 25 50 75 Meters

Figure 5-22
Former Operational Areas MRS
AOI Former Sanitary Landfill/Dredge Pile
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_AOI_Inphase.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- Geophysical Target
- EM61 Proposed Transects

Response (mV)

-3 -2 -1 0 1 2 3 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 40 Feet

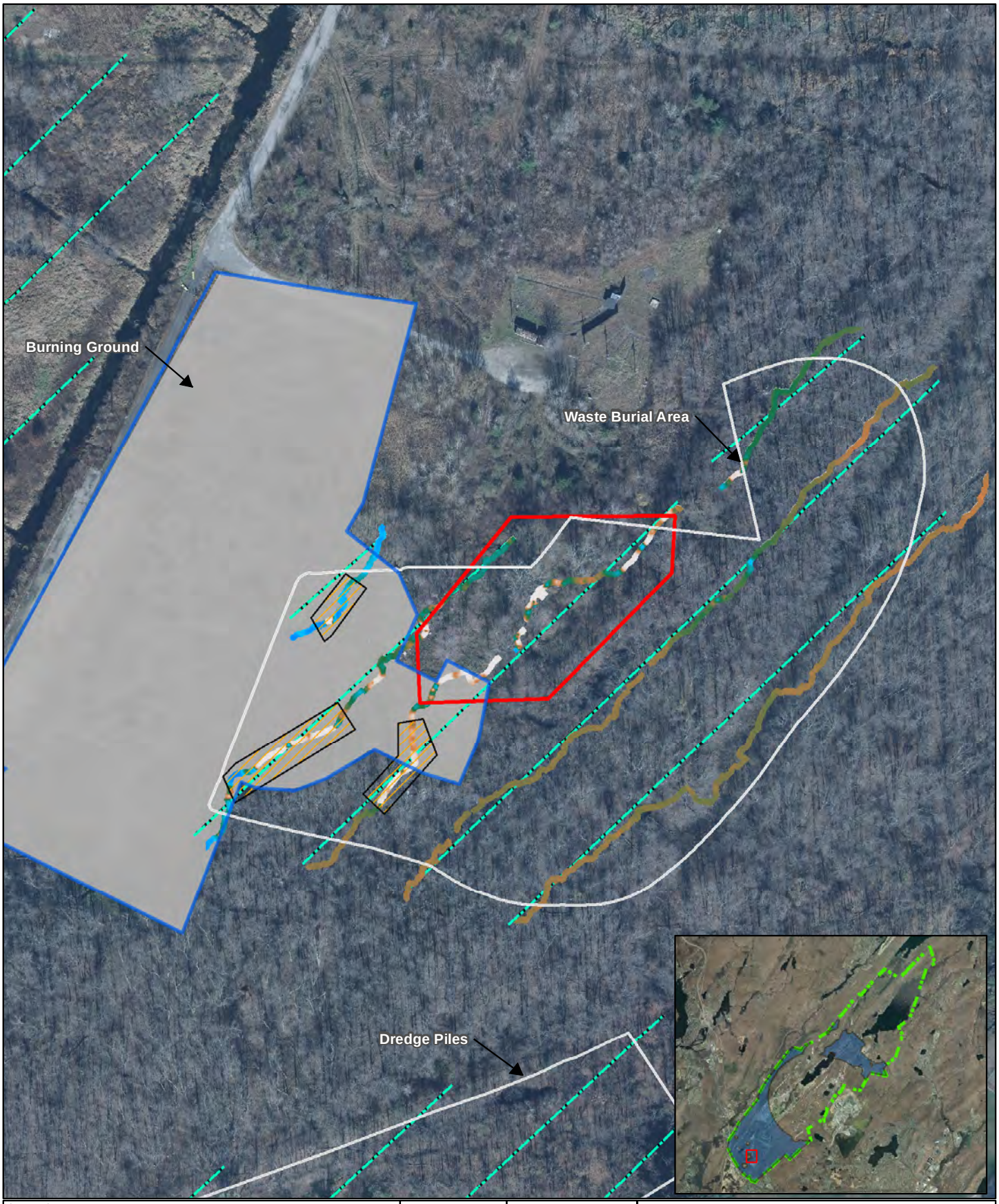
0 5 10 15 Meters

Figure 5-23
Former Operational Areas MRS
AOI Former Sanitary Landfill/Dredge Pile
EM61-MK 2 Survey Transects

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_AOI_Investigation_Area.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 175 Feet

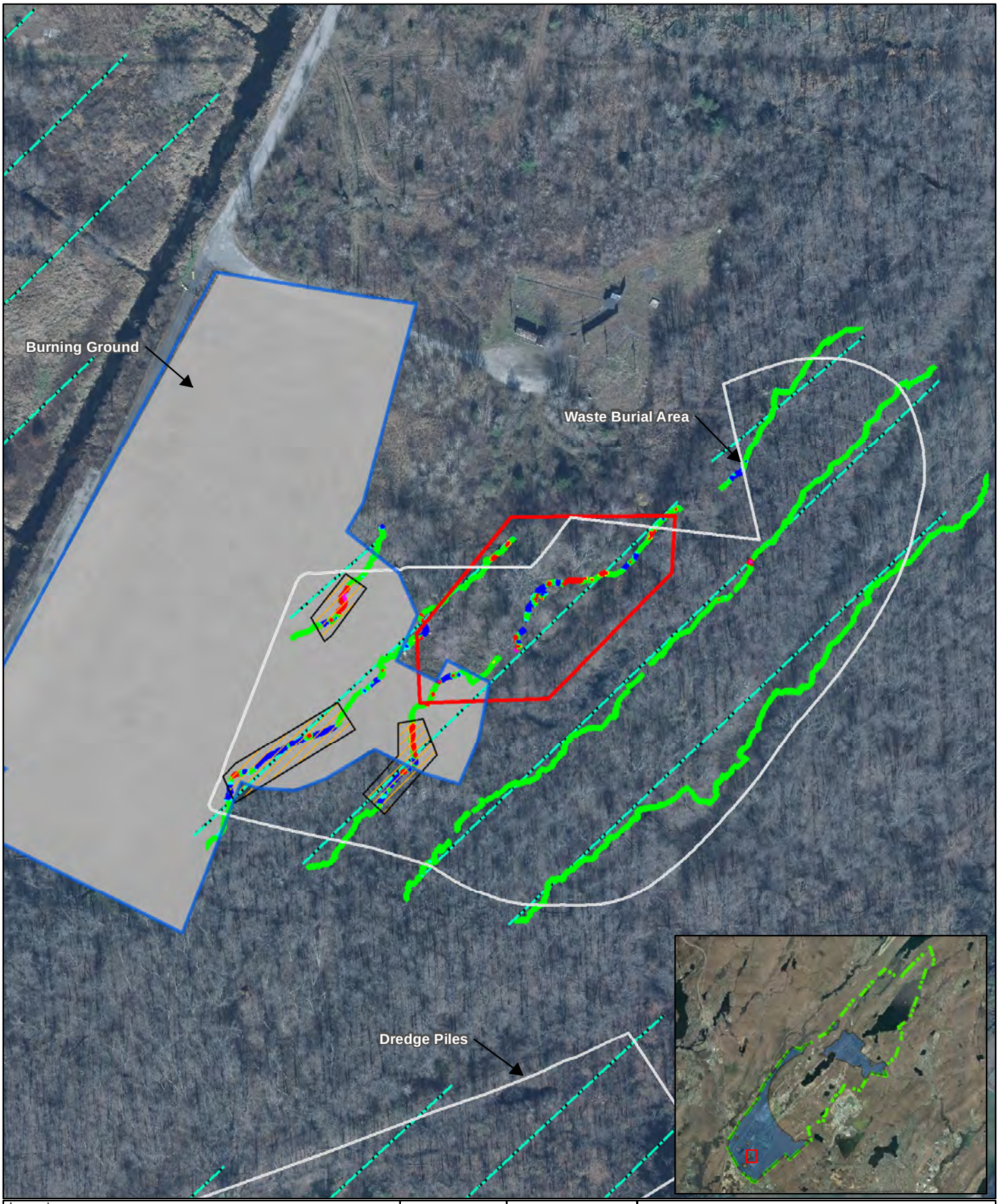
0 20 40 60 Meters

Figure 5-24
Former Operational Areas MRS
AOI Waste Burial Area
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_WasteBurialArea_Cond.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 175 Feet

0 20 40 60 Meters

Figure 5-25
Former Operational Areas MRS
AOI Waste Burial Area
EM31-MK 2 Survey Transects
Inphase

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_WasteBurialArea_Inphase.mxd

Legend

- Installation Boundary
- Former Operational Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Geophysical Target
- EM61 Proposed Transects

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 60 Feet

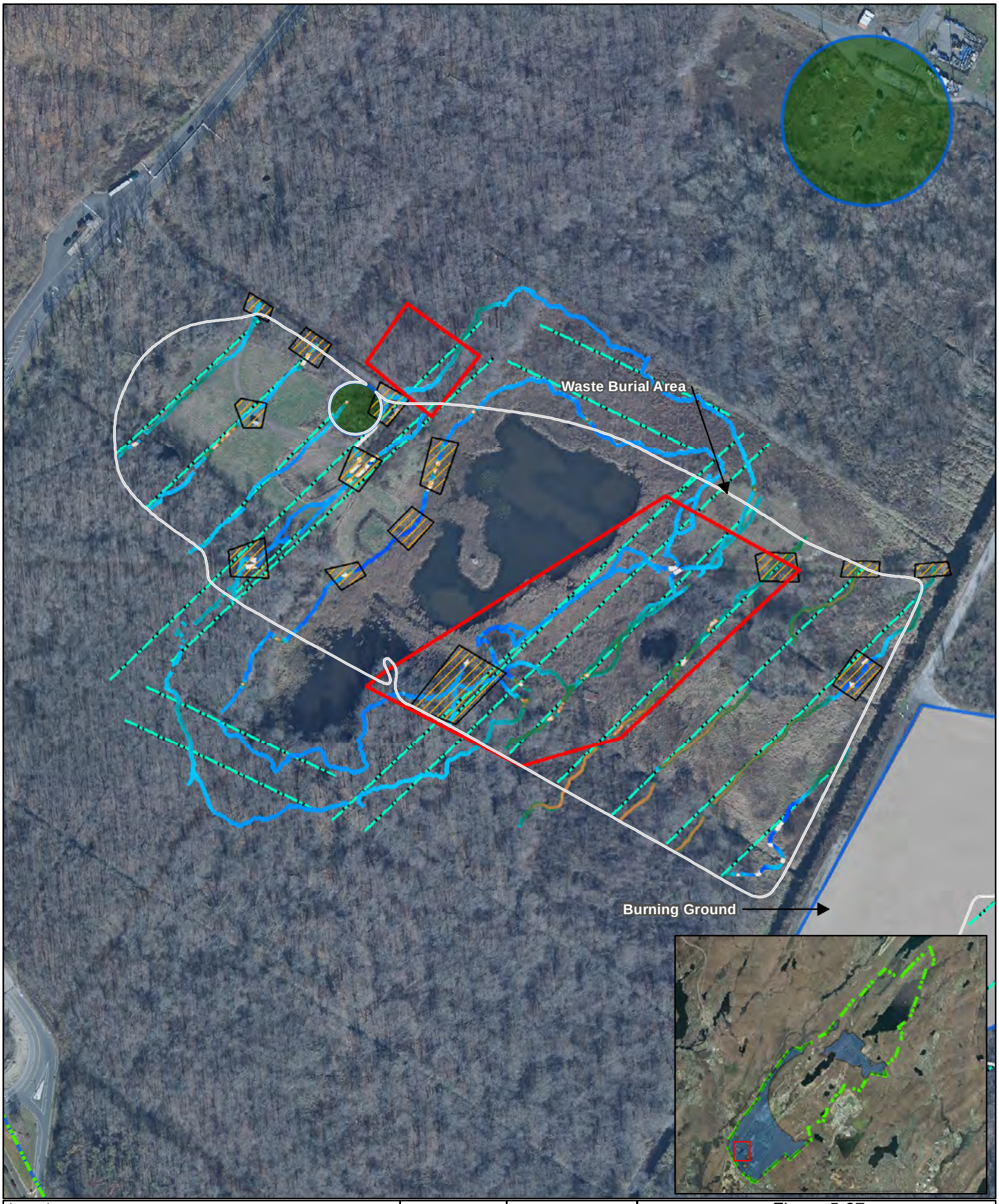
0 7.5 15 22.5 Meters

Figure 5-26
Former Operational Areas MRS
AOI Waste Burial Area
EM61-MK 2 Survey Transects

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_WasteBurialArea_Invest_area.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 6 7 8 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 275 Feet

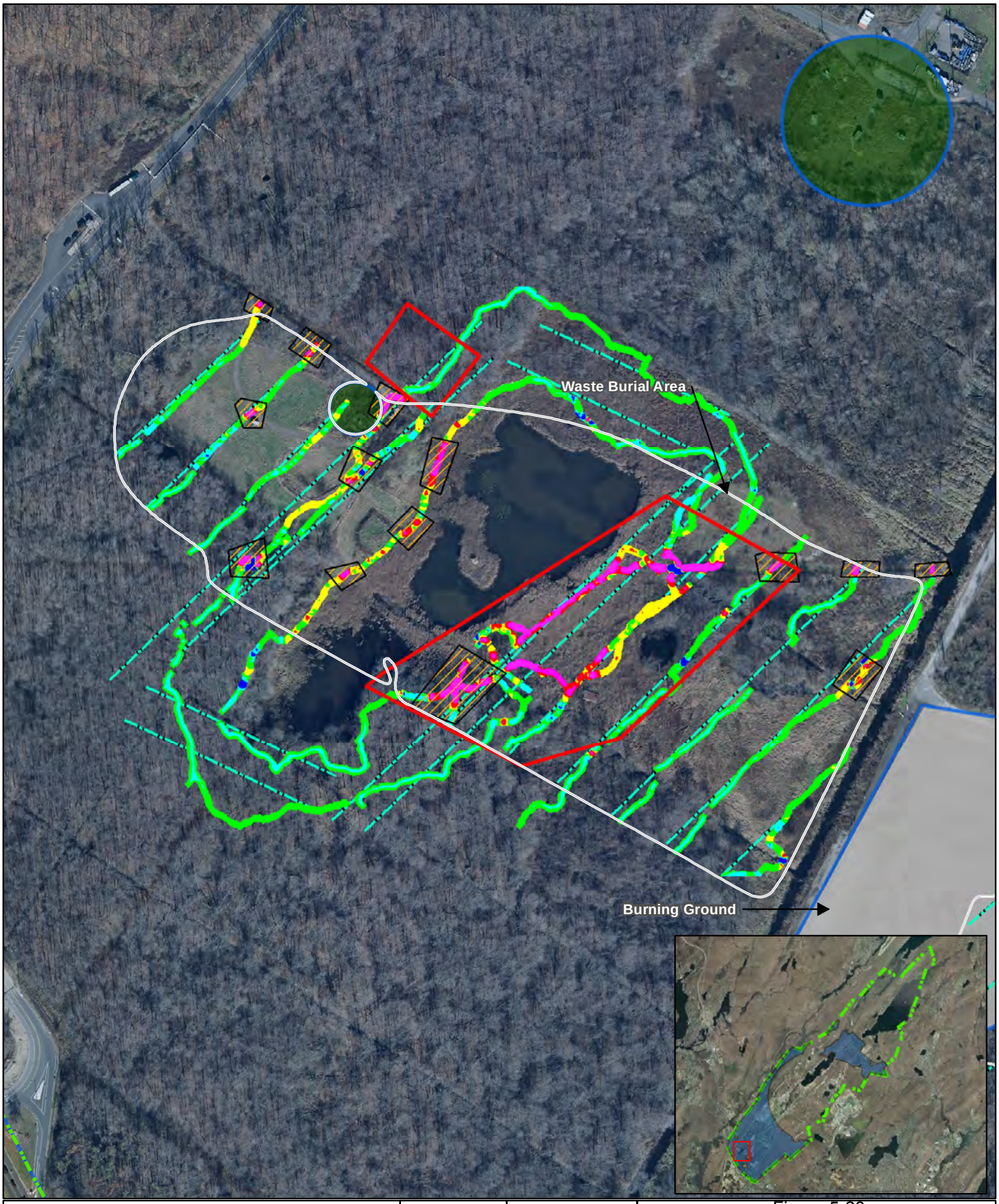
0 30 60 90 Meters

Figure 5-27
Former Operational Areas MRS
AOI Site 20/24 Area
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_site_2024_Cond.mxd



Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Ineligible Area - Burning Ground
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- EM31 Proposed Transects

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 275 Feet

0 30 60 90 Meters

Figure 5-28
Former Operational Areas MRS
AOI Site 20/24 Area
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_site_2024_Inphase.mxd

Legend

- Installation Boundary
- Former Operational Areas
- Operational Range Areas
- Areas of Interest
- EM61-MK2 Investigation Area
- Metalic Debris at Surface
- Geophysical Target
- EM61 Proposed Transects

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 200 Feet

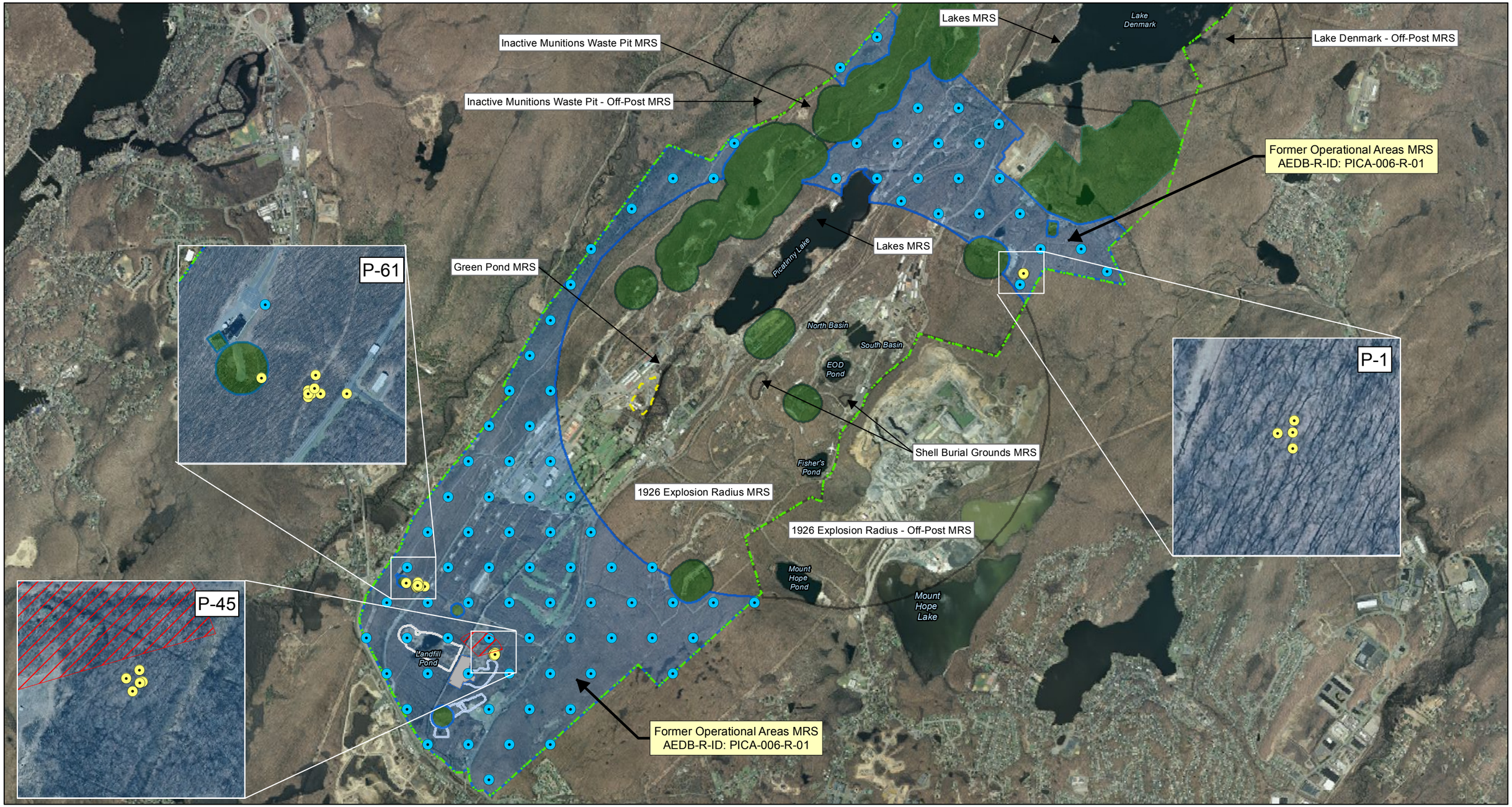
0 25 50 75 Meters

Figure 5-29
Former Operational Areas MRS
AOI Site 20/24 Area
EM61-MK 2 Survey Transects

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_site_2024_Investigation_Area.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest
- Ineligible Area - Burning Ground
- Former DRMO Yard
- Skeet Range
- MC Sampling Locations
- Step-Out Sampling Locations

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

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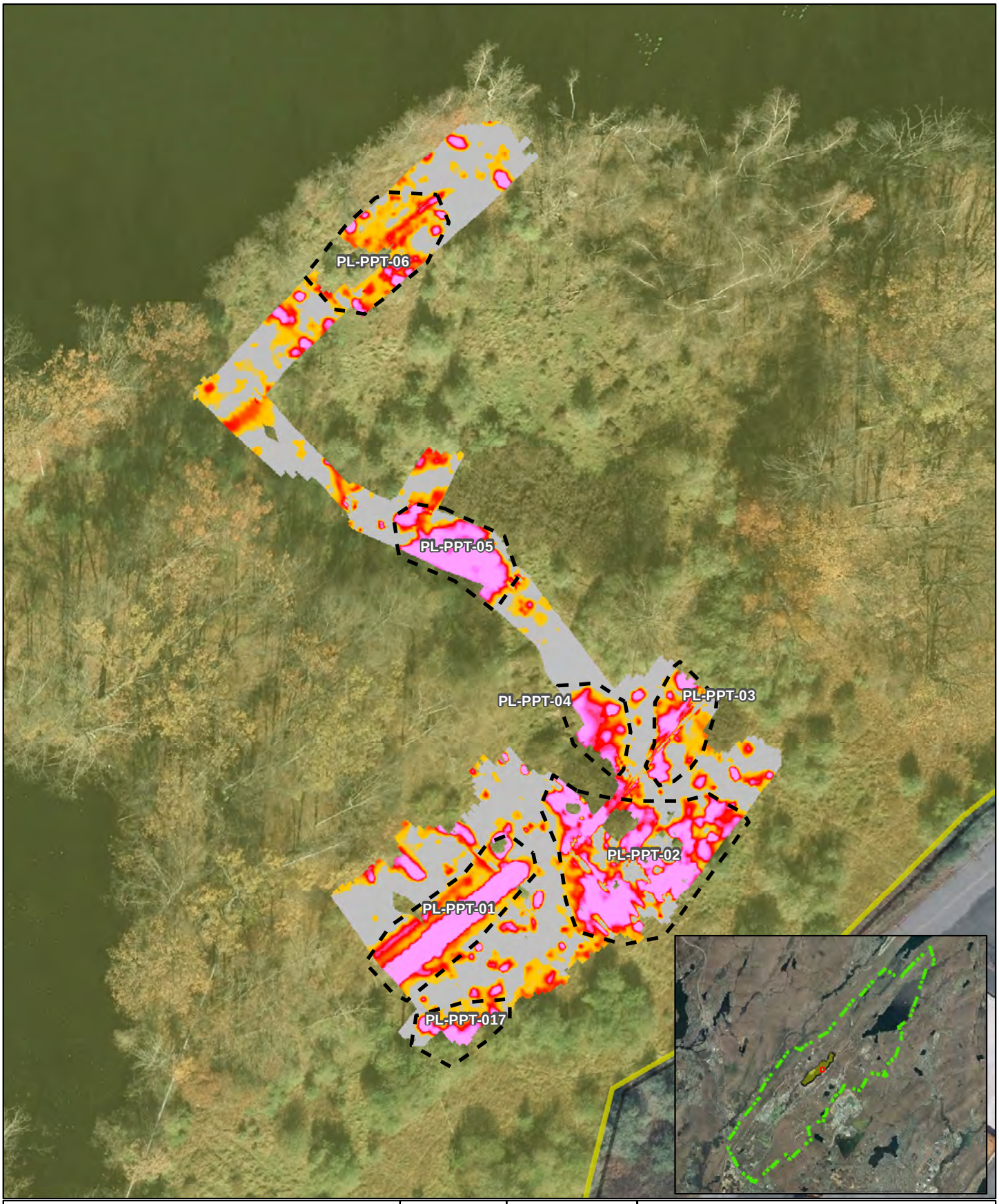
Approved By: RSS

Figure 5-30
Former Operational Areas MRS
MC Sampling Locations

2/21/2014

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\FOA_MC_Sampling.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Potential Burial Pit Feature

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N

0 60 Feet

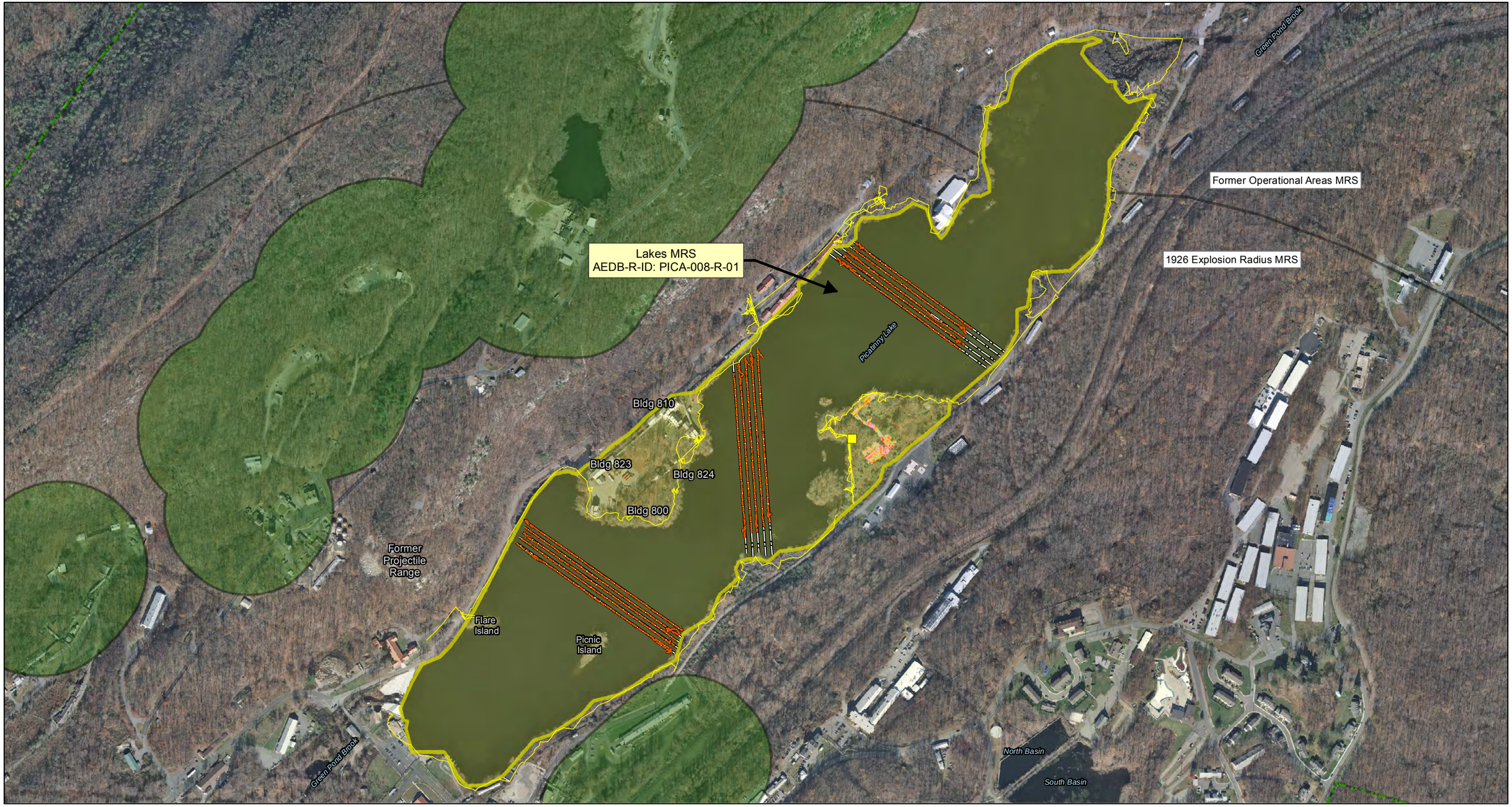
0 7.5 15 22.5 Meters

Figure 5-31
Lakes MRS - Picatinny Lake
Survey Grid PL-01
EM61-MK 2 Survey Transects

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Picatinny_lake_Investigation.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Grids Investigated
- Mag & Dig Transects (Actual)
- EM61 Underwater Proposed Transects
- EM61 Underwater Transects (Actual)

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 550 1,100 Feet

0 130 260 390 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

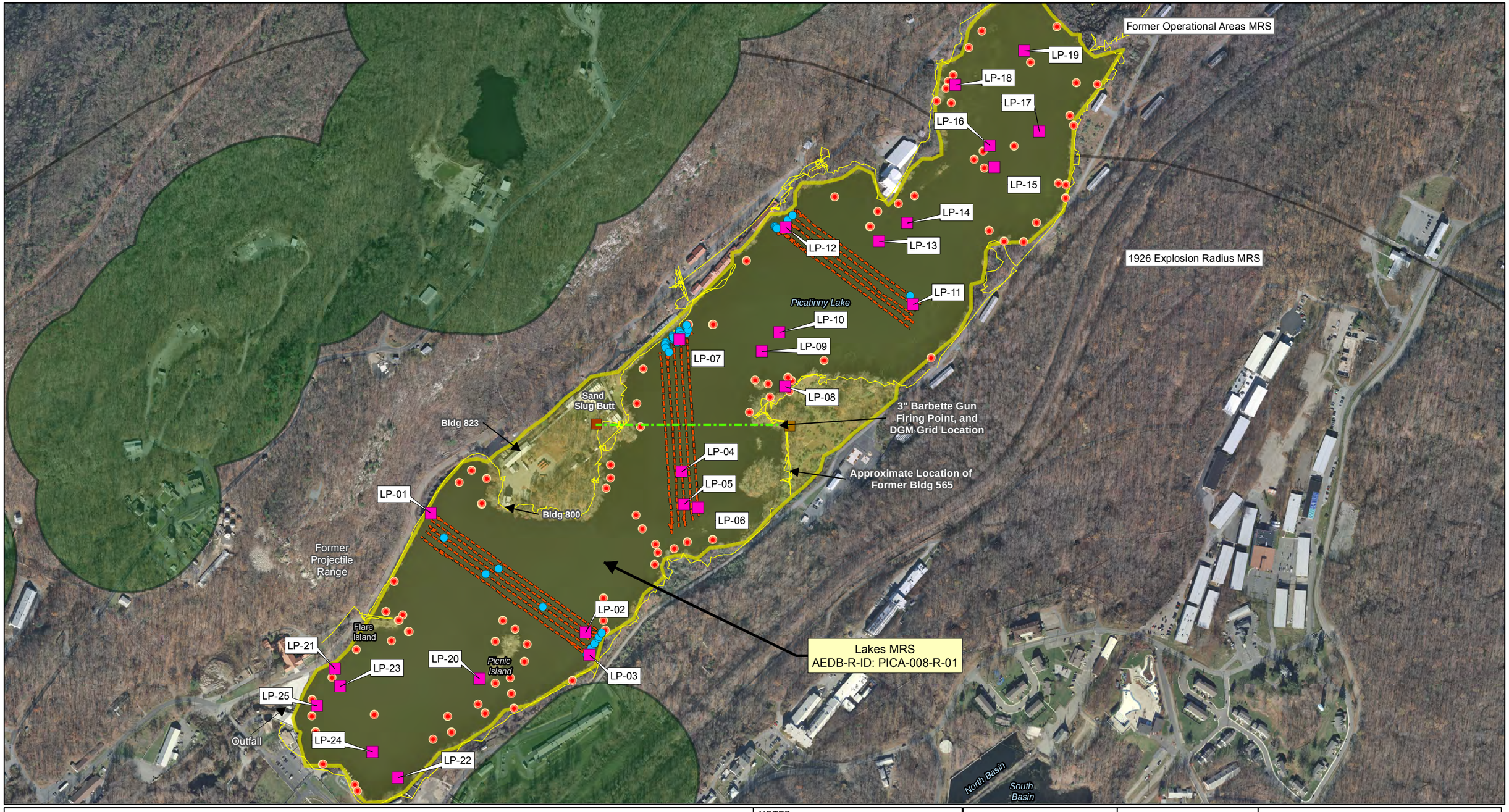
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-32
Lakes MRS - Picatinny Lake
Survey Locations

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Picatinny_Lake_GT.mxd



Legend

- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Geophysical Targets (1995)
- Geophysical Targets (2012)
- Anomalies Selected for Investigation
- Grid Location
- Slug Butt
- EM61 Underwater Transects
- Mag & Dig Transects (Actual)

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 500 1,000 Feet

0 120 240 360 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

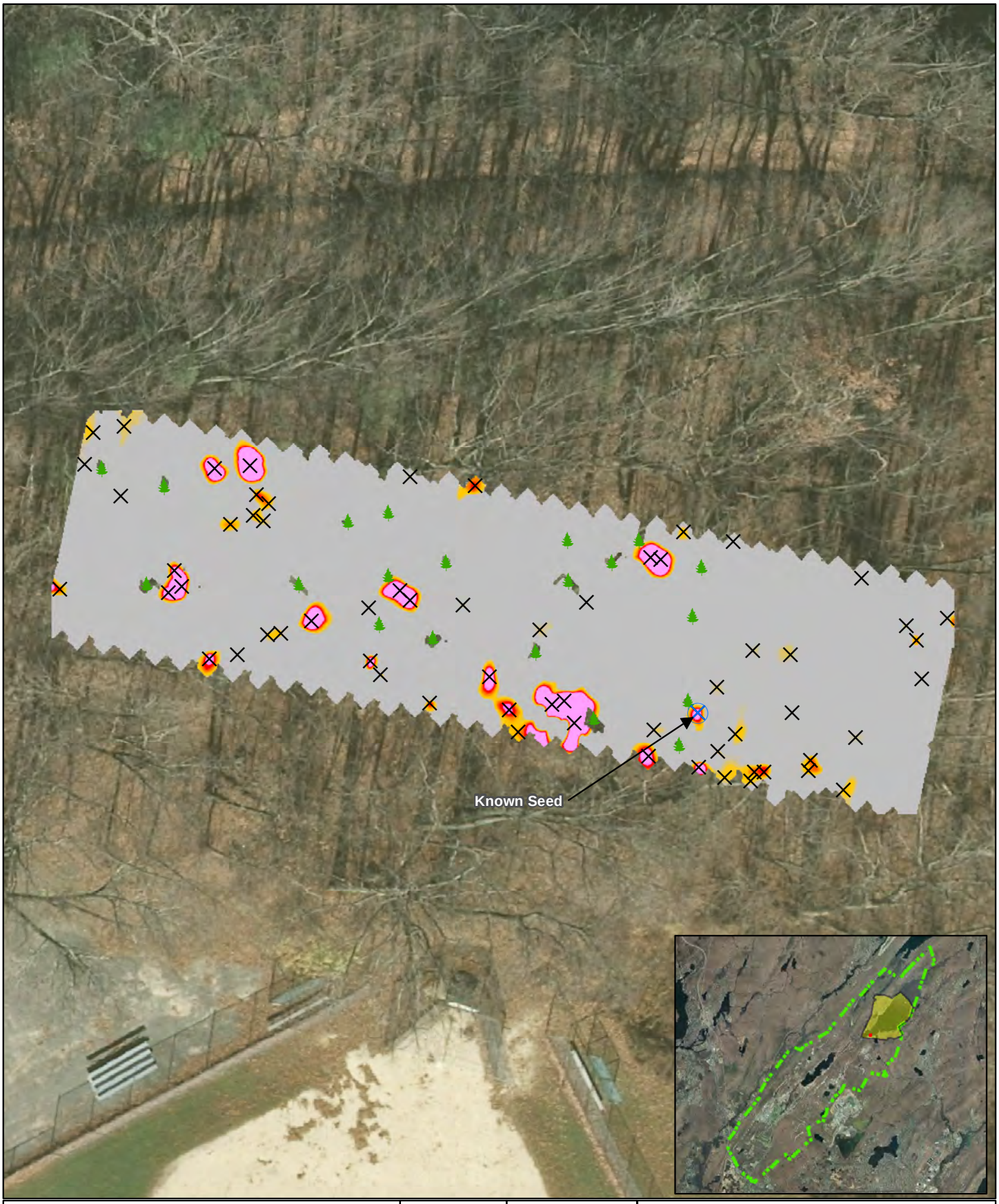
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-33
Lakes MRS
Picatinny Lake Anomaly Locations

10/15/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Pic_Lake_Anomaly_locs.mxd



Legend

- Installation Boundary
- Lakes MRS
- Geophysical Target
- Known Seed
- Tree

Response (mV)

-3 -2 -1 0 1 2 2 4 5 6 7 8 11 17 26 57

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

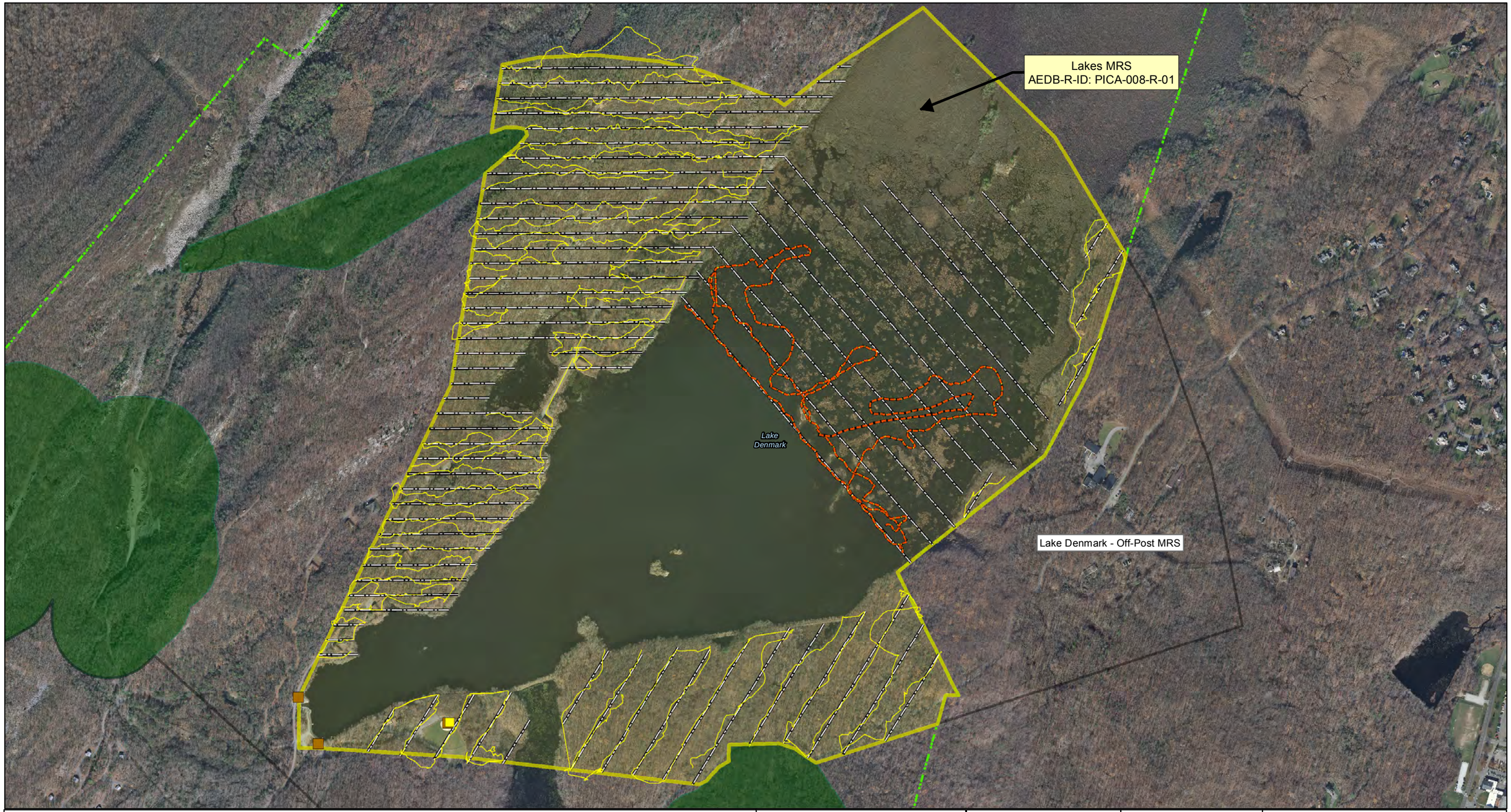
N 0 30 Feet
0 3.5 7 10.5 Meters

Figure 5-34
Lakes MRS - Lake Denmark
Survey Grid LD-01
EM61-MK 2 Survey Transects

10/17/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_Investigation.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Grids Investigated
- Proposed Grid Locations
- Mag & Dig Transects (Actual)
- EM61 Underwater Transects (Actual)
- Transects Proposed

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 750 1,500 Feet

0 260 520 Meters

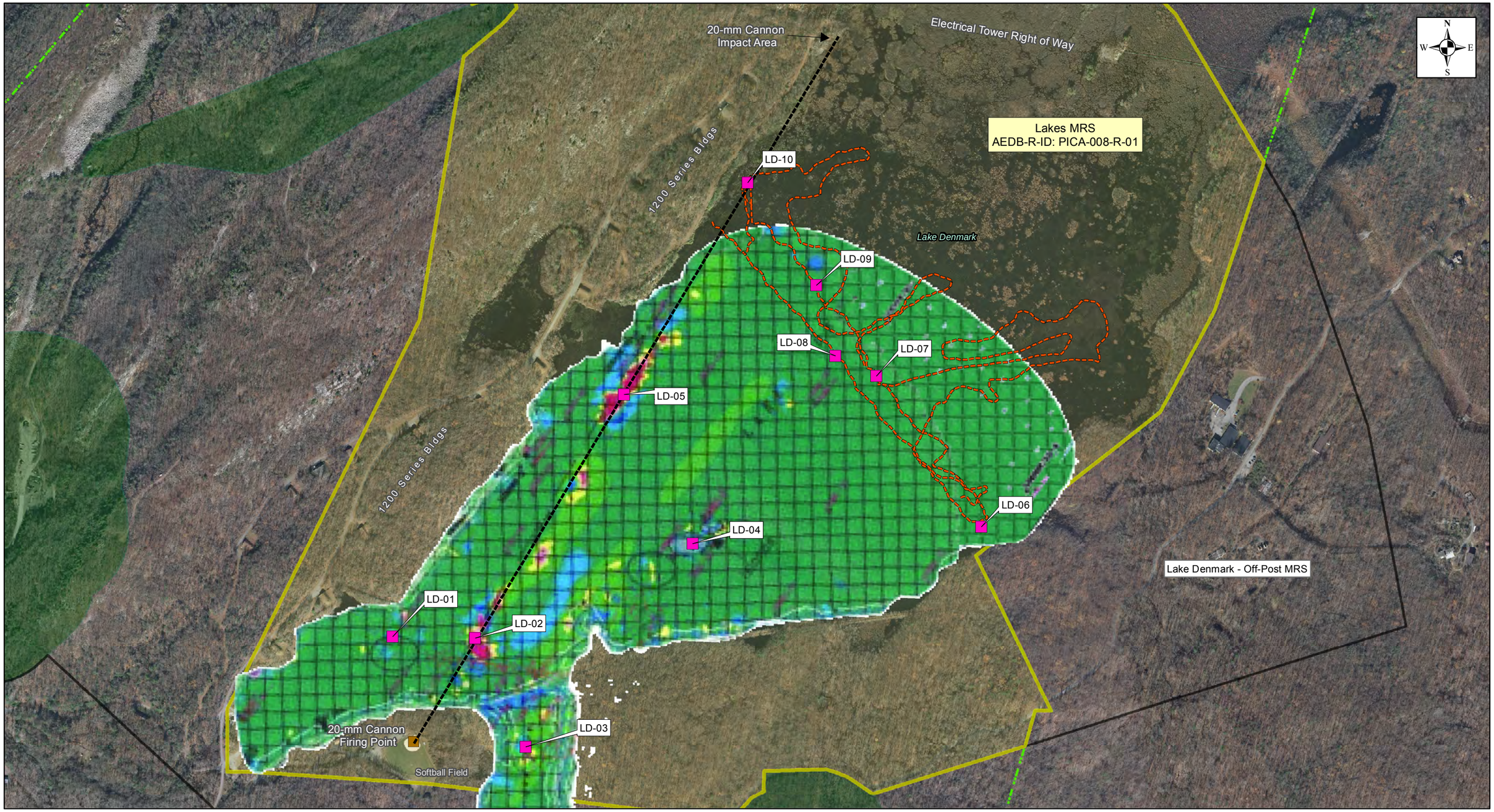
Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-35
Lakes MRS -
Lake Denmark Survey Locations

10/17/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_Grids_Trans.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- EM61 Underwater Transects
- Grid Locations
- Anomalies Selected for Investigation
- Previous Geophysical Investigation

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 600 1,200 Feet

0 150 300 450 Meters

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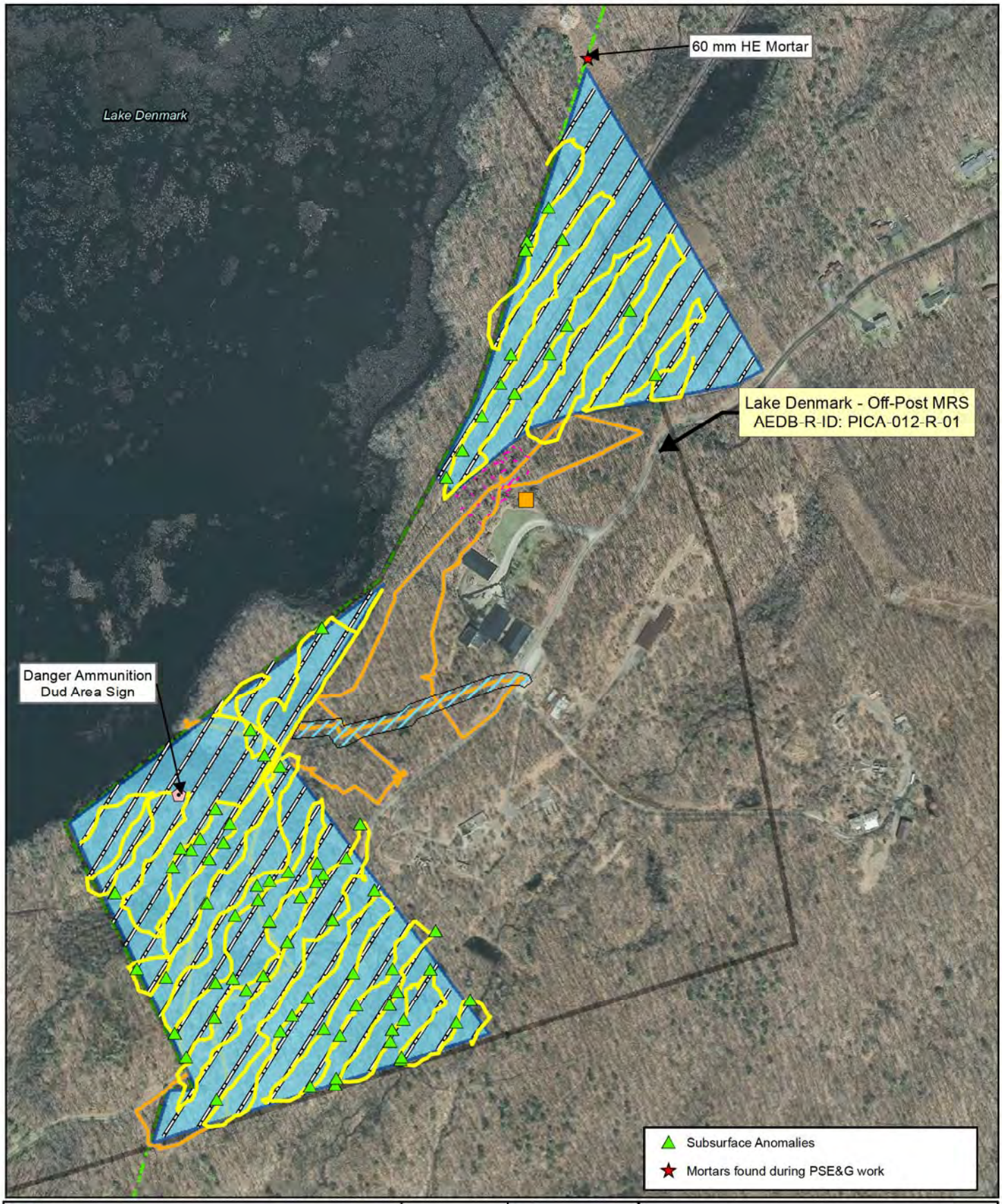
Verified By: NAS
Approved By: RSS

Date: 10/15/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_Underwater_Survey_Locs.mxd

Figure 5-36
Lakes MRS - Lake Denmark
Underwater Survey Locations



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Proposed Visual Survey Area
- Approximate location of a former drum disposal area
- Test Pit Locations
- Berm
- SI Survey
- Proposed Visual Survey Transects
- Visual Survey Transects

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

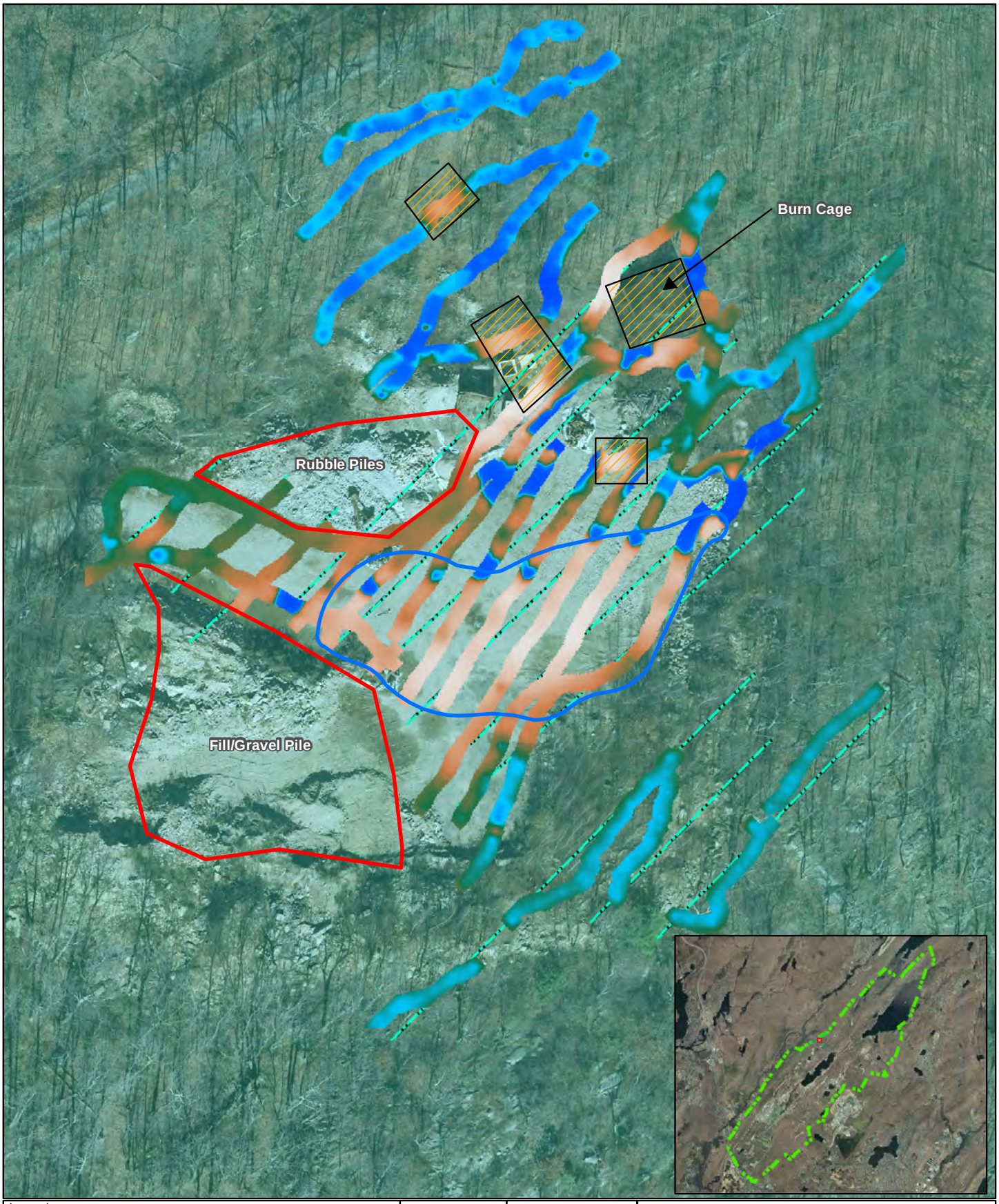
N 0 500 Feet
0 60 120 180 Meters

Figure 5-37
Lake Denmark Off-Post MRS
Survey Locations

12/4/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_offpost_Results_Update.mxd



Legend

- Installation Boundary
- Inactive Munitions Waste Pit
- Obstruction/Surface Feature
- Metalic Debris or Object at Surface
- Approximate Waste Pit Location
- EM31 Proposed Transects

Conductivity (ms/m)

-5 4 5 6 7 8 9 9 10 11 12 13 15 18 25 35

Picatinny Arsenal
Morris County,
New Jersey

Created By: CLR
Verified By: NAS
Approved By: RSS

N 0 60 Feet
0 7.5 15 22.5 Meters

Figure 5-38
Inactive Munitions Waste Pit MRS
EM31-MK 2 Survey Transects
Conductivity

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

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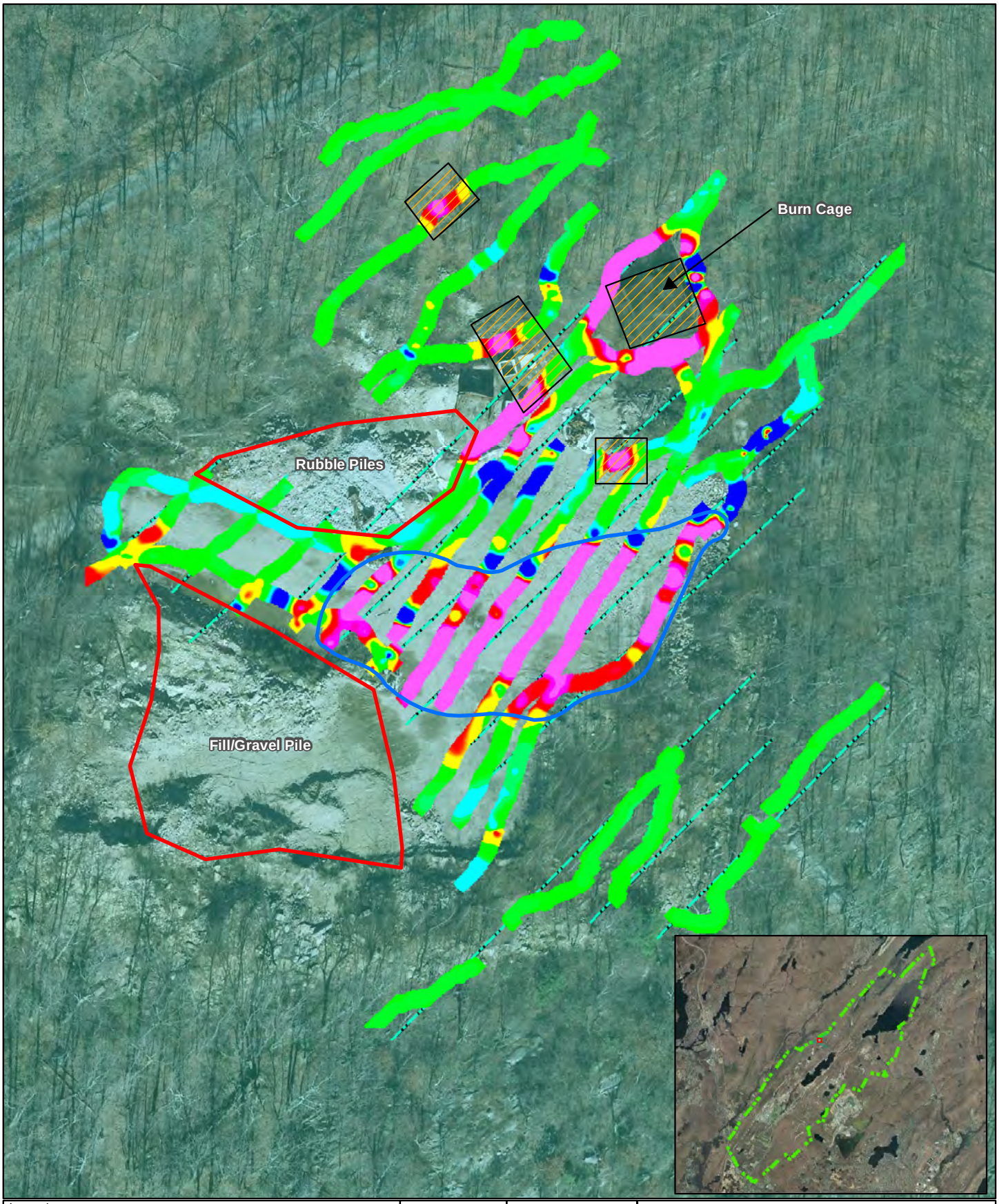


Legend

- Installation Boundary
- Inactive Munitions Waste Pit
- Obstruction/Surface Feature
- Metalic Debris or Object at Surface
- Approximate Waste Pit Location
- EM31 Proposed Transects

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

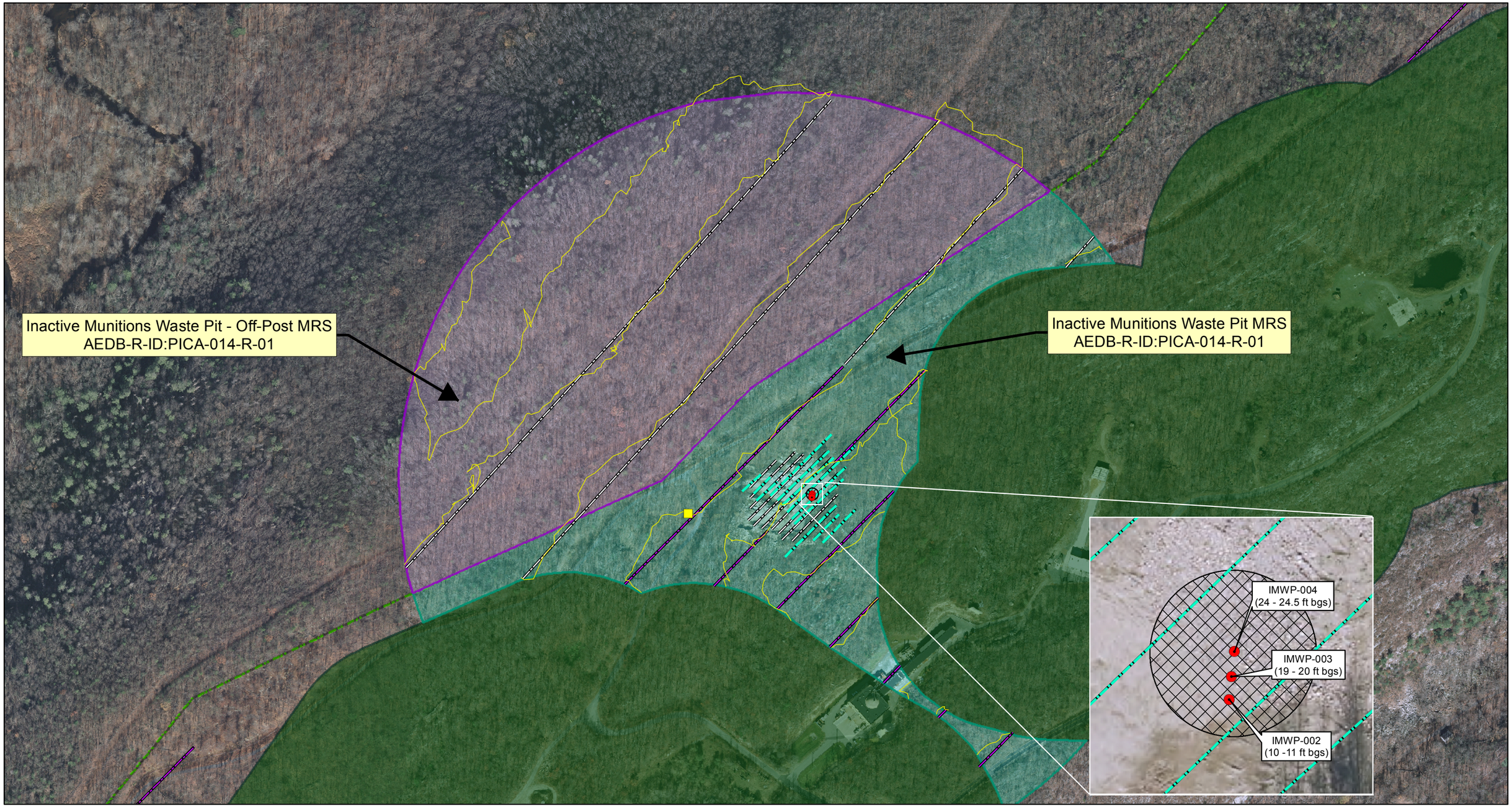
N 0 60 Feet
0 7.5 15 22.5 Meters

Figure 5-39
Inactive Munitions Waste Pit MRS
EM31-MK 2 Survey Transects
Inphase Response

12/3/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP_Inphase.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Inactive Munitions Waste Pit - Off-Post
- Inactive Munitions Waste Pit
- Grids Investigated
- Mag & Dig Transects (Actual)
- Transects Proposed
- Code 300 Transects Proposed
- EM31 Proposed Transects
- MC Sampling Locations
- May 2012 Trench/Test Pit Excavation Area

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 300 600 Feet

0 70 140 210 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 5-40
Inactive Munitions Waste Pit MRS
Survey Locations

2/20/2014

Contract # W912DR-09-D-0006
DO 0002

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6. REMEDIAL INVESTIGATION RESULTS AND REVISED CONCEPTUAL SITE MODELS

Section 6 presents the results of the RI, including the nature and extent of MEC and MC where applicable, and revised CSM for each MRS. The CSM for each MRS is based on the physical and ecological profile information (as presented in Sections 2, 3, and 4) and field data collected during the RI (as presented in this section and Section 5).

The field data are presented within the following sections and correspond to the field task components used to achieve MRS RI goals. For specific details/definitions of these tasks and equipment used, see Section 5. The main field task components are listed below:

- DGM data collection, processing, analysis and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of reacquired anomalies.
- Analog data collection and intrusive investigation ("mag and dig").
- MC sampling (as applicable).

The following sections detail the results of these activities.

6.1 GREEN POND MRS AND FORMER DRMO YARD

The Green Pond MRS is a portion of Green Pond brook adjacent to the Former DRMO Yard. Although the Former DRMO Yard is not specifically in the MRS footprint, investigation of the Former DRMO Yard was conducted in conjunction with the investigation of the Green Pond MRS because of proximity and the similarity of the potential MEC source.

During the RI, the Green Pond MRS and the Former DRMO Yard, which are wholly located within the 1926 Explosion Radius MRS, had a different sampling approach and were investigated separately from the 1926 Explosion Radius MRS. The separation of the Green Pond MRS from the 1926 Explosion Radius MRS was made during the SI. However, during the RI a release mechanism different from the release mechanism for the 1926 Explosion Radius was not discovered for these two areas. Therefore, the Green Pond MRS and the Former DRMO Yard have been re-incorporated into the 1926 Explosion Radius MRS and going forward in this

document are referred to as the Green Pond MRS and the AOI Former DRMO Yard. Refer to Section 5.5.1.3 for additional details.

While these two areas have been incorporated into the 1926 Explosion Radius MRS, the investigations were conducted separately, and the investigation protocols were different. For the Green Pond MRS and the AOI Former DRMO Yard, a biased sampling approach was used, yet a statistical sampling approach was used for the 1926 Explosion Radius MRS. Therefore, the RI results for Green Pond MRS and the AOI Former DRMO Yard are discussed separately from the 1926 Explosion Radius. However, the results are incorporated into the qualitative statistical evaluation for the 1926 Explosion Radius shown in Section 6.2.2.1.4

6.1.1 Digital Geophysical Mapping Results

Using an EM31-MK2, 2,703 linear feet of DGM transect surveys were performed along the east and west banks of Green Pond Brook within the Green Pond MRS. Based on a review of the DGM data, the DGM transects were divided into two individual anomalies and five high density areas for anomaly reacquisition and investigation. From the DGM data, 32 targets were chosen for requisition and intrusive investigation as detailed below.

6.1.2 Intrusive Investigation Results

The results of the DGM and analog investigations are as follows:

- DGM Target Investigation – Anomalies detected along the DGM transects in the Green Pond MRS were investigated to determine the anomaly source (either individual anomalies or burial areas). A total of 32 targets were selected from the geophysical data for intrusive investigation along the DGM transects. Of the 32 targets selected for intrusive investigation, 125 items classified as cultural debris and seven items classified as geologic "hot rocks[1]" were identified. The items were recovered from depths ranging from 0 to 8 inches bgs.

- Analog Transects – Analog transects were traversed using a White's MXT All-Metals detector along 0.37 acre of the banks of Green Pond Brook, and 0.87 acre was 100% investigated in the southwest portion of the AOI Former DRMO Yard for a total of 1.24 acres. Analog transects were conducted wherever accessible along the inner banks of Green Pond Brook. Transects were not able to be performed along the entire

[1] Hot rocks are defined as localized zones of rock or soil with high magnetic susceptibility. Geophysical equipment is often unable to distinguish between the high magnetic susceptibility zones and metallic anomalies (MEC, MD, cultural debris).

inner banks or in the water of the brook, as specified in the Final Work Plan, due to safety concerns regarding the water depth, depth of silt/sediment along the bottom, and steepness and instability of the banks.

A total of 430 anomalies were intrusively investigated along the analog transects within the Green Pond MRS. No MEC was observed, but a total of 57 MD items were recovered at depths ranging from 0 to 30 inches bgs within the Green Pond MRS. One item was classified as MPPEH, a 75mm Shrapnel projectile, during the intrusive investigation in the AOI Former DRMO Yard. The item was then determined to be an explosive hazard and was designated as UXO. The UXO was identified at 3 inches bgs. The remaining anomalies investigated from the analog transects beside Green Pond Brook and from the AOI Former DRMO Yard analog investigation, included 373 items classified as cultural debris, and 1 geologic "hot rock," and were recovered between 0 and 30 inches bgs. Two cultural debris items, were designated as archeological and were transferred to the Picatinny Arsenal archeologist. Of the MD identified in the Green Pond MRS, 36 were recovered from the same location and consisted of various fuzes, Viven-Bessiere (VB) grenades, and other miscellaneous ordnance at approximately 3 inches bgs.

For the Green Pond MRS and AOI Former DRMO Yard, the DGM surveys and analog transects detected a total of 562 anomalies. Only one UXO item was observed, a 75mm Shrapnel projectile, and one MD, a Ballistic Rocket Nose cone, within the AOI Former DRMO Yard. A total of 56 MD were detected in the Green Pond MRS. The remaining anomalies in the Green Pond MRS and AOI Former DRMO Yard, included 496 items designated as cultural debris, and eight geologic "hot rocks". Items were recovered at depths ranging from 0 to 33 inches bgs, with the MD being identified up to 30 inches bgs. Based on a review of the investigation data it was determined that no large burial areas, posing an explosive risk, were present in the Green Pond MRS. The locations of the items recovered are presented on **Figure 6-1**. Munition related items are summarized in **Table 6-1**. The complete dig list for Green Pond MRS and the AOI Former DRMO Yard is provided in **Appendix H**.

Table 6-1 Munition Item Summary at Green Pond MRS and AOI Former DRMO Yard

Target ID No.	Item location	Item Designation	Item Description	Item Quantity	Depth bgs (Inches)
909	Green Pond MRS	MD	Fuze Part	1	6
910	Green Pond MRS	MD	Fuze Part	1	4
917	Green Pond MRS	MD	MK10 naval fuzes, VB grenades, misc ord	36	3
923	Green Pond MRS	MD	40mm projectile	1	1
926	Green Pond MRS	MD	Fuze	1	6
1133	Green Pond MRS	MD	Fuze	1	3
1135	Green Pond MRS	MD	Fuze	1	30
1134	Green Pond MRS	MD	Fuze Part	1	30
1130	Green Pond MRS	MD	Tracer Element	3	30
1132	Green Pond MRS	MD	Fuze	2	30
1129	Green Pond MRS	MD	Tracer Element	6	30
1131	Green Pond MRS	MD	35mm Projectile	1	30
1154	Green Pond MRS	MD	Fuze	1	30
1178	AOI Former DRMO Yard	UXO	75mm Shrapnel Projectile	1	6
1306	AOI Former DRMO Yard	MD	Ballistic Rocket Nose cone	1	3

Note: MK = Mark
VB = Viven-Bessiere

6.2 1926 EXPLOSION RADIUS MRS

The 1926 Explosion Radius consists of two separate MRSs, the 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS. As discussed in Section 5.2, the 1926 Explosion Radius MRS has three decision units; the Inner Radius, the Outer Radius, and the Fuze Area. A portion of the AOI Code 300 Area overlaps the 1926 Explosion Radius MRS within the Outer Radius Decision Unit and a portion of the AOI Former DRMO Yard overlaps the 1926 Explosion Radius MRS within the Inner and Outer Decision Units.

6.2.1 Digital Geophysical Mapping Results

DGM surveys of 39 grids were conducted using a man-portable EM61-MK2. A total of 1,482 anomalies with responses greater than the anomaly selection threshold, a Channel 2 response of

7.2 mV, were selected for intrusive investigation within the DGM grids.

6.2.2 Intrusive Investigation Results

One hundred twenty-one random grid surveys, consisting of 39 DGM grids and 82 analog grids, were conducted across the MRSs to investigate for MEC as a result of the 1926 explosion. An additional 11 analog grid surveys were conducted within the AOI Code 300 Area, which overlaps a portion of the 1926 Explosion Radius MRS within the Outer Radius Decision Unit.

Fourteen MEC were found within the 1926 Explosion Radius MRS during the RI; five in the Fuze Area, which is located in the Inner Radius, and nine within the Outer Radius. It should be noted that none of the MEC identified within the Outer Radius were from the AOI Code 300 Area.

In the Fuze Area Decision Unit, three MK2 Base Detonating (BD) fuzes and two MK2 Point Detonating (PD) fuzes were found within Grid 26IR-010. The grid was part of a larger area with a significant number of fuzes on the ground surface (shown on **Figure 6-2**). Based on field observations, it does not appear that the fuzes were released during the 1926 explosion. If the fuzes were related to the 1926 explosion it would be expected that they would not be concentrated so heavily in such a limited area but would be more dispersed, as were other MEC associated with the explosion. In addition, based on the condition of the fuzes, it does not appear that they were involved in such a massive explosion. While the release mechanism for the fuzes is unknown, a building foundation is located adjacent to where the fuzes were found. It is possible that the fuzes were stored in this building and the building was damaged during the explosion. If so, the building may have been razed and the fuzes dispersed. Because the fuzes found within Grid 26IR-010 appear to have a different release mechanism than the MEC found throughout the rest of the 1926 Explosion Radius MRS, they are not included in the analysis of the Inner Radius results (refer to Section 6.2.2.1) and were therefore broken out into a separate decision unit. The boundary of the Fuze Area Decision Unit was delineated based on visual observation of fuzes on the ground surface and the horizontal extent of the Fuze Area was determined to be the point at which fuzes were no longer visible at the ground surface. The boundary was recorded using a handheld GPS. The fuzes were determined to be an explosive hazard and were designated as DMM.

In the Outer Radius Decision Unit, the nine MEC found include two munitions items associated with the 1926 Explosion: one 6-inch naval projectile (Grid 26OR-003) and one 5-inch armor-piercing round (Grid 26OR-064). Both items were determined to be an explosive hazard and were designated as DMM. Munitions found that are potentially associated with the 1926 Explosion included the base of one BD fuze, found within Grid 26OR-022. The item was determined to be an explosive hazard and was designated as DMM.

Munitions not associated with the 1926 Explosion found within the Outer Radius Decision Unit include five fuze components found within a burn pit in Grid 26OR-016. The source of the fuzes is unknown. The items were determined to be an explosive hazard and were designated as DMM. In grid 26OR-024, one DMM (one 37mm projectile) and five practice munitions (one 37mm projectile, two 3-inch MK1 practice Stokes mortars, and two World War I 75mm projectiles) were found within the Outer Radius Decision Unit within Grid 26OR-024. None of the items are associated with the 1926 explosion. One of the 37mm projectiles was determined to be an explosive hazard and was designated as DMM, while the rest of the items found in Grid 26OR-024 were not determined to be an explosive hazard and were designated as MDAS.

Because the DMM and practice munitions found in Grid 26OR-024 represented a high concentration of munitions, they also had the potential to have a release mechanism separate from the 1926 Explosion (i.e., that that area around the grid could be a potential target area). UXO technicians conducted handheld EM sensor-assisted visual surveys to determine the extent of the area and to evaluate potential sources. **Figure 6-3** shows the results of visual survey conducted using a White's MXT all-metals detector. A total of 0.55 miles of visual survey transects were conducted and 78 surface and subsurface anomalies were identified. None of the identified anomalies was intrusively investigated. Of the 37 anomalies, four were identified as MDAS laying on the ground surface, including one inert 75mm projectile.

The exact release mechanism for the munitions found within Grid 26OR-024 and the surrounding area are not known; however, they could be associated with activities that occurred at Picatinny Lake (i.e., range activities and/or operations associated with munitions manufacturing/testing that occurred within the buildings surrounding the lake). Unconfirmed reports have also indicated that firing used to occur across Picatinny Lake into the hillside to the northwest of Grid 26OR-024. Therefore, it is possible that munitions fired into the hillside could

have rolled down the hill into the grid. Although the exact release mechanism is not known; the intrusive investigation within grids and the additional visual surveys only identified one DMM within this area. These findings do not indicate there is a release mechanism that would result in a higher or lower probability of encountering DMM than in other parts of the Outer Radius Decision Unit; therefore, this area is evaluated as part of the Outer Radius Decision Unit instead of being evaluated as a separate decision unit.

Refer to **Table 6-2** for a summary of the MEC identified and **Figure 6-4** for the locations of the MEC. The complete dig lists for the 1926 Explosion Radius On-Post and Off-Post MRSs are provided in **Appendix H**. In addition to the MEC found during the RI, the following MD, non-munitions related cultural debris, small arms, geologic "hot rocks", seeds, and no contacts were identified within the Outer Radius Decision Unit grids:

- MD – 973 MD items totaling 1,173 pounds were found within 69 grids, consisting mainly of fragments, flash tubes, and fuzes, with various other items. Refer to **Figure 6-5** for the grids within which MD was found.
- Non-munitions Related Cultural Debris – 1,208 pounds of non-munitions related metal waste were found within the grids.
- Small Arms – 62 small arms, consisting mainly of 7.62mm blanks, 5.56mm blanks, shotgun primers, and various others.
- Geology – 93 Geologic "Hot Rocks."
- Seeds – 180 seeds consisting of 62 2-inch by 8-inch pipes and 118 grid corner nails.
- No Contacts – 114.

Table 6-2 Summary of MEC Found within the 1926 Explosion Radius MRS

Grid	Decision Unit	MEC Found	MEC Source[1]	Included in UXO Estimator Data Analysis[2]
26OR-003	Outer Radius	one 6-inch naval projectile	1926 explosion	Yes
26OR-064	Outer Radius	one 5-inch armor-piercing round	1926 explosion	Yes
26OR-016	Outer Radius	five fuze components (detonator)	DMM of unknown origin found in a burn pit.	No
26OR-022	Outer Radius	one base of BD fuze	DMM of unknown origin. Two possible sources include the 1926 explosion and Picatinny Lake range and manufacturing activities.	Yes
26OR-024	Outer Radius	one 37mm projectile	DMM of unknown origin; however, possibly associated with Picatinny Lake range and manufacturing activities. No items associated with explosion.	No
26IR-010	Fuze Area	three BD MK2 Fuzes two MK1 PD fuzes with boosters	High concentration fuze area associated with 1926 explosion.	No

1. According to historical reports, the following munitions were stored in the magazines at the time of the explosion: 25-pound Navy Mark I bombs, loaded and plugged, Mark II, III, IV, and V bombs, each loaded with TNT, Bomb accessories (e.g., fins, tails), Aerial bombs, TNT center section, 14-inch Class "B," loaded and fuzed, 14-inch AP rounds, loaded and fuzed, 8-inch shells, loaded and fuzed, 5-inch shells, loaded and fuzed. In addition, 3-inch, 4-inch, and 6-inch common projectiles have been found during time critical removal actions at the off-post portion of this MRS.

2. The MEC that are not included in the UXO Estimator Analysis are still used in the MEC HA to evaluate the residual MEC hazards.

6.2.2.1 RI Data Analysis

As detailed in the Final RI Work Plan, the null hypothesis (H_0) is treated as the baseline condition that is presumed to be true in the absence of strong evidence to the contrary. During the known previous investigations within the 1926 Explosion Radius MRS, and as indicated on previous EOD incident reports, MEC associated with the 1926 explosion has only been found within 0.5 mile of the explosion centers. Based on the available data, the H_0 developed for the MRS states that MEC resulting from the 1926 explosion is restricted to an area within 0.5 mile of the explosion centers and the 1926 Explosion Radius MRS is divided into an Inner and Outer Radius. The Inner Radius covers the area within 0.5 mile of the explosion centers and the Outer Radius encompasses the area 0.5 to 1 mile from the explosion centers.

To test the null hypothesis, the sampling design was developed using UXO Estimator to ensure at a 95% statistical confidence level (CL) that the MEC densities within the Inner and Outer radii were less than 3.0 and 0.5 MEC/acre, respectively. **Table 6-3** presents a summary of the range of munitions tested for the Inner and Outer Radius Decision Units. To analyze the RI data collected, the following inputs and assumptions were used in the evaluation:

- Munitions associated with the 1926 explosion could be found both on- and off-post.
- Munitions not associated with the 1926 explosion are present solely due to activities at PTA. Therefore, munitions that are not associated with the explosion can be found within the on-post portion of the MRS, but will not be located within the off-post portion.
    - DMM identified during the RI that are not associated with the 1926 explosion were excluded from further analysis because they have a different release mechanism than the primary release mechanism and the UXO Estimator sampling design assumes that a random probability of finding munitions exists within the decision unit. Therefore, using the DMM results would bias the evaluation because the items found have a specific, non-random release mechanism that is not representative of the random probability of finding MEC due to the 1926 explosion. As a result, MEC identified within Grids 26OR-016 and 26OR-024 were removed from the evaluation. Although the MEC identified within the grids were removed from the evaluation, the grid acreage was still included because no munitions related to the 1926 explosion or to incidental DMM deposition were identified.
- The fuzes found within Grid 26OR-010 were removed from the analysis of the Inner Radius Decision Unit because the area appears to have a different release mechanism than the remainder of the Inner Radius. As discussed above, the Fuze Area was evaluated as a separate decision unit within the 1926 Explosion Radius MRS.

Table 6-3 1926 Explosion Radius MRS Sampling Design

Decision Unit	Sampling Design	Area	Acreage	Acreage Investigated to Date[1]	Acreage Not Investigated To Date[2]	Assumed Remaining MEC (based on sampling design density range)
Outer Radius	< 0.5 MEC/acre	On-post	950.64	25.01	925.63	0 to 463
		Off-Post[3]	630.51	106.21	524.3	0 to 262
		Total	**1,581.15**	**131.22**	**1,449.93**	**0 to 725**
Inner Radius	< 3.0 MEC/acre	On-post	593.49	52.38	541.11	0 to 1,623
		Off-Post[4]	207.26	140	67.26	0 to 202
		Total	**800.75**	**192.38**	**608.37**	**0 to 1,825**
Fuze Area	< 173 MEC/acre[5]	On-post	1.63	0.06	1.57	0 to 272
		Total	**1.63**	**0.06**	**1.57**	**0 to 272**

Notes:

[1] The results include the acreage for the areas investigated during previous investigations and the RI.

[2] Remaining area is the area that remains to be investigated after completion of the RI.

[3] Approximately 308 acres of the off-post portion of the Outer Radius consists of the Mt. Hope Quarry, of which approximately 105 acres has been quarried or a removal action has occurred. The 105 acres are excluded from the MEC density range calculation.

[4] Approximately 170 acres of the off-post portion of the Inner Radius consists of the Mt. Hope Quarry, of which approximately 140 acres has been quarried or a removal action has occurred. The 140 acres are excluded from the MEC density range calculation.

[5] The Fuze Area Decision Unit was unknown prior to the RI; and therefore, there was no sampling design for it. The Sampling Design included in the table is based on an analysis of the RI results.

6.2.2.1.1 Outer Radius Decision Unit

6.2.2.1.1.1 1926 Explosion Release Mechanism

As discussed above, to test for H_0, the sampling design was set up to test at a 95% statistical CL that the MEC density associated with the 1926 explosion within the Outer Radius is less than 0.5 MEC/acre. The Outer Radius contains 1,449.93 acres that have not yet been investigated (after adjusting for the area investigated during the RI and previous investigations and quarried areas where MEC does not remain); thus, the null hypothesis assumes there are from 0 to 725 MEC associated with the 1926 explosion located within the Outer Radius (See **Table 6-3**).

The goal of the data analysis is to determine the potential number of MEC present within the Outer Radius that are associated with the 1926 explosion; therefore, only the MEC and DMM found during the RI that are associated with the 1926 explosion were used in the evaluation. No other source of MEC is anticipated for off-post properties; therefore, the scenario is representative of the total amount of MEC anticipated to be found within the off-post portion of the Outer Radius.

However, as the contribution of MEC from other sources (i.e., other on-post PTA related activities) is not taken into account in the evaluation, the scenario is not representative of the total amount of MEC anticipated to be within the on-post portion of the Outer Radius. The scenario evaluates the findings from the grids investigated during the RI within the Outer Radius. **Table 6-4** presents the inputs used to evaluate the RI results in UXO Estimator. The results of the analysis, in the form of the estimated residual MEC, are presented below and in **Table 6-5**:

- Original H_0 – 41.96% CL that there is less than 0.5 UXO/acre (from 0 to 725 total MEC associated with the 1926 explosion within the Outer Radius).
- Revised Hypothesis – 95% confidence that there is less than 1.174 UXO/acre (from 0 to 1,703 total MEC associated with the 1926 explosion within the Outer Radius).

Table 6-5 summarizes the quantitative estimates at the 95% CL of the upper bound of residual MEC within the Outer Radius, as well as the average amount of residual MEC within the Outer Radius. The total amount of residual MEC can be any value from 0 to the upper bound of calculated MEC based on the results of the RI.

Table 6-4 1926 Explosion Radius MRS Outer Radius UXO Estimator Inputs

Input	Value
Total Acres in Decision Unit	1581.15
Investigated Acres	6.59
UXO Found in Investigated Area	3
UXO Density Per Acre Sampling Design	0.5
Desired Upper Confidence Level (CL)	0.95

Results:

- There is 41.96% confidence that less than or equal to 0.5 UXO/acre is present within the decision unit. Therefore, sampling was inadequate to meet the UXO density at the 95.0% CL.
- The actual density at 95.0% CL is 1.174 UXO/acre.
- 8.851 more acres would have to be sampled with no additional UXO found to meet the specified target density of 0.5 UXO/acre at the 95.0% CL.
- The average density within the decision unit is 0.606 UXO/acre.

Table 6-5 Estimated Residual MEC from 1926 Explosion within the 1926 Explosion Radius MRS

Area	Site Information			Quantitative Estimate[1]				Qualitative Estimate[1]	
	Total Area (acres)	Area Investigated To Date (acres)[2]	Remaining Area to Investigate (acres)[3]	UXO Density (UXO/acre)	Estimated Upper Bound of Residual MEC	Average MEC Density	Residual MEC at Average Anomaly Density	UXO Density	Estimated Upper Bound of Residual MEC
Outer Radius									
On-Post	950.64	25.01	925.63	1.174	1087	0.606	561	0.159	148
Off-Post[4]	630.51	106.21	524.3	1.174	616	0.606	318	0.159	84
Total:	1,581.15	131.22	1,449.93	n/a	1,703	n/a	879	n/a	231
Inner Radius									
On-Post	593.49	52.38	541.11	3.151	1706	1.051	569	1.577	854
Off-Post[5]	207.26	140	67.26	3.151	212	1.051	71	1.577	107
Total:	800.75	192.38	608.37	n/a	1,918	n/a	640	n/a	959
Fuze Area[6]									
Total:	1.63	0.06	1.57	173.006	272	99.387	157	n/a[7]	n/a[7]

Notes

1. Quantitative and Qualitative estimates are at the 95% statistical CL.
2. The results include the acreage for the areas investigated during previous investigations and the RI.
3. Remaining area is the area that remains to be investigated after completion of the RI.
4. Approximately 308 acres of the off-post portion of the Outer Radius consists of the Mt. Hope Quarry, of which approximately 105 acres has been quarried or a removal action has occurred. The 105 acres are excluded from the MEC density range calculation.
5. Approximately 170 acres of the off-post portion of the Inner Radius consists of the Mt. Hope Quarry, of which approximately 140 acres has been quarried or a removal action has occurred. The 140 acres are excluded from the MEC density range calculation.
6. The Fuze Area Decision Unit was unknown prior to the RI; and therefore, there was no sampling design for it. The Sampling Design included in the table is based on an analysis of the RI results.
7. No previous investigations were conducted within the Fuze Area; therefore, no qualitative estimate can be made.

6.2.2.1.1.2 AOI Code 300 Area Release Mechanism

The AOI Code 300 Area was previously identified as being used for artillery firing of shells up to 155mm, along with fragmentation pattern testing. As discussed in Section 5.2.1.2.2, 11 analog grids were investigated within the portion of the AOI Code 300 Area that overlaps the 1926 Explosion Radius MRS. A total of 541 anomalies were selected for intrusive investigation and no MEC or MPPEH was found. Eighteen of the targets were cultural debris such as barbed wire and metal scrap and four targets from four different grids were MD, consisting of three fragments and a 105mm projectile empty shell. No MEC or MPPEH was identified; therefore, the RI did not identify an impact area within this portion of the AOI Code 300 Area. No MEC or MPPEH was identified outside the 1926 Explosion Radius MRS portion of the AOI Code 300 Area. Only one MD, a M42 empty body, was identified within the Inactive Munitions Waste Pit MRS; therefore, no impact areas were identified within the AOI Code 300 Area.

6.2.2.1.2 Inner Radius Decision Unit

6.2.2.1.2.3 1926 Explosion Radius Release Mechanism

As discussed above, to test for H_0, the sampling design was set up to test at a 95% statistical CL that the MEC density within the Inner Radius is less than 3.0 MEC/acre. The Inner Radius contains 608.37 acres that have not been investigated (after adjusting for area investigated and quarried areas where MEC does not remain); therefore, the null hypothesis assumes that from 0 to 1,825 MEC are located within the Inner Radius (see **Table 6-3**).

The purpose of the data analysis is to determine the potential number of MEC present within the Inner Radius associated with the 1926 explosion. The analysis evaluates the MEC identified within the grids investigated during the RI within the Inner Radius with the exception of Grid 26IR-010, which is associated with the Fuze Area. The only MEC found within the Inner Radius during the RI is within Grid 26IR-010. The results of the analysis are shown below and the UXO Estimator inputs are shown in **Table 6-6**:

- Original H_0 - 94.23% CL that there is less than 3.0 UXO/acre (from 0 to 1,825 total MEC/MPPEH within the Inner Radius).
- Revised Hypothesis - 95% confidence that there is less than 3.151 MEC/acre (from 0 to 1,918 total MEC associated with the 1926 explosion within the Inner Radius). The change of MEC density from 3.0 MEC/acre to a revised estimate of 3.151 MEC/acre

is a result of the decreased amount of investigation within the Inner Radius decision unit that resulted from Grid 26IR-010 being located within the newly identified Fuze Area decision unit.

Table 6-5 summarizes the quantitative estimates, at the 95% CL, of the upper bound of residual MEC within the Outer Radius, as well as the average amount of residual MEC within the Inner Radius. The total amount of residual MEC can be at any value from 0 to the upper bound of calculated MEC.

Table 6-6 1926 Explosion Radius MRS Inner Radius UXO Estimator Inputs

Input	Value
Total Acres in decision unit	800.75
Investigated Acres	0.95
UXO Found in Investigated Area	0
UXO Target Density Per Acre Sampling Design	3
Desired Upper CL	0.95

Results:

- There is 94.23% confidence that less than or equal to 3.0 UXO/acre is within the decision unit. Therefore, sampling was inadequate to meet the target density at the 95.0% CL.
- The actual density at the 95.0% CL is 3.151 UXO/acre.
- An additional 0.048 acres would require sampling with no other UXO found to meet the specified target density of 3 UXO/acre with 95.0% confidence.
- The average density within the decision unit is 1.051 UXO/acre.

6.2.2.1.3 Fuze Area Decision Unit

The Inner Radius Fuze Area Decision Unit was identified during the RI; thus there was no original sampling design to delineate the area. During the RI, the extent of the high density Fuze Area was delineated using a GPS and is shown on **Figure 6-2**. The total area of the Fuze Area Decision Unit is 1.63 acres and, as discussed in Section 6.2.2, five DMM were found within Grid 26IR-010.

The purpose of the data analysis is to determine the potential number of MEC present within the

Fuze Area Decision Unit associated with the 1926 explosion. The analysis evaluates the findings from Grid 26IR-010 that was investigated during the RI. The results of the analysis are shown below and the UXO Estimator inputs are shown in **Table 6-7**:

- Hypothesis - 95% confidence exists that there are less than 173.006 MEC/acre (from 0 to 272 total MEC associated with the 1926 explosion within the Fuze Area).

Table 6-5 summarizes the quantitative estimates at the 95% CL of the upper bound of residual MEC within the Fuze Area Decision Unit, as well as the average amount of residual MEC within the area. The total amount of residual MEC can be at any value from 0 to the upper bound of calculated MEC.

Table 6-7 1926 Explosion Radius MRS Fuze Area UXO Estimator Inputs

Input	Value
Total Acres in Decision Unit	1.63
Investigated Acres	0.06
UXO Found in Investigated Area	5
UXO Target Density Per Acre	173
Desired Upper CL	0.95

Results:

- There is 95.02% confidence that less than or equal to 173 UXO/acre is within the Decision Unit. Therefore, sampling was adequate to meet the target density at the 95.0% CL.
- No more acres must be sampled with any additional UXO found to meet the specified target density of 100 UXO/acre with a 95.0% CL.
- The average density within the Decision Unit is 99.387 UXO/acre.

6.2.2.1.4 Additional Data Analysis including Previous Investigation Data

Based on the RI intrusive investigation results within the outer and inner radii, the H_0 established in the Final RI Work Plan (WESTON, 2012) must be rejected for both the inner and Outer Radius Decision Units, for the following reasons:

- Inner Radius – An area within the Inner Radius with a high fuze density was split out from the Inner Radius Decision Unit as a separate decision unit. Therefore, the area for Grid 26IR-010, which is associated with the Fuze Area, was removed from the

analysis. As a result, the area of investigation for the Inner Radius was reduced so the area required to meet the H_0 was not investigated, resulting in a statistical CL that is slightly less than 95%.

- Outer Radius – H_0 was not met because MEC associated with the 1926 explosion were identified during the investigation. Given that the original MEC density used in the sampling design was an estimate (i.e., the project delivery team did not know what the actual MEC density was throughout the inner and outer radii at the time of the sampling design), and because three DMM/MEC associated with the 1926 explosion were found within the Outer Radius during the RI, it is possible that the actual density of MEC associated with the 1926 explosion within the Outer Radius is higher than 0.5 MEC/acre.

As discussed in the Final Work Plan, "If H_0 is rejected because MEC is identified within the Outer Radius, then the actual MEC density within the Outer Radius may be higher than the assumed MEC density used as an input in UXO Estimator. This could result in several outcomes, depending on numerous factors including, but not limited to, the type of MEC found (e.g., manufactured before or after 1926) and the location of the MEC found (e.g., on- or off-post). The outcomes could include revising the (Conceptual Site Model) CSMs, re-evaluating the input and output statistical parameters in UXO Estimator, and/or additional investigations. The ultimate outcome will be determined based on an assessment of the historical and new data." (WESTON, 2012).

According to EM 200-1-15, existing information may be used, together with the RI data, to meet the project DQOs without the collection of additional data. Although the previous investigation data is not statistically random (and therefore cannot be used to obtain a statistically valid, quantitative estimate of the residual MEC), it can be used as a qualitative guide to whether the residual amount of MEC is closer to zero or the upper bound.

Table 6-8 presents a summary of previous investigations and the MEC found during these investigations within the 1926 Explosion Radius MRS; each of these areas and the MEC found within them are shown on **Figure 6-6**. **Figure 6-6** also shows the UXO found on the UXO Finds Map (see Section 2.1.2.1 for further details on the UXO Finds Map). Further details regarding these investigations are contained in Sections 6.2.2.1.4.4 and 6.2.2.1.4.5.

Table 6-8 Summary of Previous Investigations within the 1926 Explosion Radius MRS

Location	Decision Unit	Acreage	Number of MEC Found	Number of MEC Associated with 1926 Explosion	Average MEC Density (MEC/acre)	Maximum Depth of Recovered MEC
Site Inspection[1]	Inner and Outer	15	0	0	0	NA
Navy Hill Housing[2]	Inner	37.85	9	9	0.24	24 inches
Navy Hill Housing[2]	Outer	5.15	0	0	0	NA
Fisher's Pond	Inner	0.1	1	1	10	12 inches
Farley Avenue	Outer	14	0	0	0	NA
CDC	Inner	5.5	34	32	6.18	18 inches
ERF	Inner	0.22	1	1	4.55	18 inches
PHS&T	Inner	7.0	0	0	0	NA
TCRA I	Inner	22.6	25	25	1.1	48 inches
TCRA II	Outer	22	0	0	0	NA
TCRA III[3]	Inner	4.3	39	39	7.67	24 inches
RI Green Pond MRS and AOI Former DRMO Yard[2]	Inner	.76	0	0	0	NA
RI Green Pond MRS and Former DRMO Yard[2]	Outer	0.48	1	0	2.08	3 inches
Totals:	N/A	119.96	110	107	0.89	N/A

Notes:

NA – Not applicable

[1] The Site Inspection did not include intrusive investigation; therefore, the data from the SI are not included in later calculations and the SI results are not broken out into inner and Outer Radius components on the table.

[2] The Navy Hill Housing Area and the Green Pond MRS and AOI Former DRMO Yard areas investigated during the RI fall within the Inner and Outer Radius.

[3] A total of 39 MEC were found; six within a soils pile formed from overburden from various locations on the quarry and 33 from the soil underneath the soil pile and an area just south/southwest of the pile.

6.2.2.1.4.4 Outer Radius

Several previous investigations were conducted within the Outer Radius of the 1926 Explosion Radius MRS. These include a portion of the EE/CA conducted on-post, as well as TCRA II, conducted off-post at the Mt. Hope Quarry. Additional details regarding these investigations can be found in Sections 2.2.2 and 2.3.2. The acreage investigated during previous investigations and the MEC findings for these three projects, as well as the RI data collected at the Green Pond MRS and AOI Former DRMO Yard, are:

- RCI Housing EE/CA in Farley Avenue – 14 acres; no MEC found.
- RCI Housing EE/CA at Navy Hill (Outer Radius portion only) – 5.15 acres; no MEC found.
- TCRA II at Tilcon Quarry – 22 acres; no MEC found.
- Green Pond MRS and AOI Former DRMO Yard during the RI – 0.48 acres; 0 MEC found associated with the 1926 Explosion.

Although UXO Estimator is designed to be used with randomly collected data, the information from the EE/CA and TCRA II were input into the tool and the total amount of data (including the RI data) were analyzed to determine what affect these additional data would have on the CL. While it is understood that these results cannot be used quantitatively, they can be used qualitatively to obtain additional insight regarding the likely residual UXO hazard within the Outer Radius. The quantitative results presented in Section 6.2.2.1.1 are used to determine the broad range of the possible residual MEC within the Outer Radius Decision Unit based solely on an analysis of the RI data that meet the statistical assumptions within UXO Estimator, while the qualitative analysis in this section is strictly an attempt to gain a better understanding of what the likely MEC density is within the decision unit based on all available data.

Note that only munitions from the 1926 explosion were used, and the inputs used included 48.22 acres investigated and three DMM identified.

As shown in **Table 6-9**, the UXO Estimator inputs for the qualitative analysis are to show to a 95% CL that there is less than 0.5 UXO/acre (from 0 to 725 total MEC associated with the 1926 explosion within the Outer Radius) using the RI and previous investigation results. **Table 6-5** summarizes the qualitative estimates at the 95% CL of the upper bound of residual MEC within

the Outer Radius. The total amount of residual MEC can be any value from 0 to the upper bound of calculated MEC. For qualitative analysis of the Outer Radius, there is 95% confidence that there is less than 0.16 MEC/acre (from 0 to 231 total MEC associated with the 1926 explosion within the Outer Radius). Based on the evaluation, even with the addition of previous investigation data, it cannot be definitively stated that there is zero residual MEC from the 1926 explosion remaining within the Outer Radius.

Table 6-9 Outer Radius Decision Unit UXO Estimator Inputs with Previous Investigations

Input	Value
Total Acres in Outer Radius Decision Unit	1,581.15
Investigated Acres	48.22
UXO Found in Investigated Area	3
UXO Target Density Per Acre	0.5
Desired Upper CL	0.95

Results:

- Sampling was adequate to be 95% confident that there is less than 0.159 UXO/acre within the Outer Radius Decision Unit. The value is within the target density.
- There is 100% confidence that there is less than or equal to 0.5 UXO/acre within The Decision Unit.
- The average density within the Decision Unit is 0.082 UXO/acre.

6.2.2.1.4.5 Inner Radius

Several previous investigations were conducted within the Inner Radius of the 1926 Explosion Radius MRS, including a portion of the EE/CA that had been conducted on-post, as well as TCRAs I and III, which had been conducted off-post at the Mt. Hope Quarry. The amount of acreage covered and the MEC findings for these projects, as well as the RI data collected at the Green Pond MRS and AOI Former DRMO Yard, are as follows:

- RCI Housing EE/CA in Navy Hill (Inner Radius portion only) – 37.85 acres; 9 MEC found.
- RCI Housing EE/CA in Fisher's Pond – 0.1 acres; 1 MEC found.
- RCI Housing EE/CA in PHST – 7 acres; 0 MEC found.

- RCI Housing EE/CA in CDC – 5.5 acres; 34 MEC found (32 associated with the 1926 explosion).
- RCI Housing EE/CA in ERF – 0.22 acres; 1 MEC found.
- TCRA I at Tilcon Quarry – 22.6 acres; 25 MEC found.
- TCRA III at Tilcon Quarry[2] – 4.3 acres; 39 MEC found.
- Green Pond MRS and AOI Former DRMO Yard during the RI – 0.48 acres; 0 MEC found associated with the 1926 Explosion.

Although UXO Estimator is designed to be used with randomly collected data, the information from the previous investigations were input into the tool and the total amount of data (including the RI data) was analyzed to determine what affect the additional data would have on the confidence levels. Whereas it is understood that these results cannot be used quantitatively, they can be used qualitatively to obtain additional insight regarding the likely residual UXO hazard within the Inner Radius. The quantitative results presented in Section 6.2.2.1.2 are used to determine the broad range of the possible residual MEC within the Inner Radius Decision Unit based solely on an analysis of the RI data that meets the statistical assumptions within UXO Estimator, while the qualitative analysis in this section is strictly an attempt to gain a better understanding of what the likely MEC density is within the decision unit based on all available data.

The revised input for evaluation includes the following:

- Data from the RI and previous investigations within the Inner Radius were included and the MEC/MPPEH associated with the 1926 explosion was used. Therefore, the inputs used included 79.0 acres investigated and 107 DMM identified.

As shown in **Table 6-10**, the UXO Estimator inputs for the qualitative analysis of the Inner Radius Decision Unit are to show to a 95% CL that there is less than 3.0 UXO/acre (from 0 to 1,825 total MEC associated with the 1926 explosion within the Inner Radius) using the RI and previous investigation results. **Table 6-5** summarizes the qualitative estimates at the 95% CL of the upper bound of residual MEC within the Inner Radius. The total amount of residual MEC can be any value from zero to the upper bound of calculated MEC. For qualitative analysis of the

[2] During the TCRA a soil pile, formed from overburden from various locations at the quarry, was investigated, along with the native soil underneath the soil pile and an area just south/southwest of the pile. The source location of the MEC found within the soil pile is not known; thus, the MEC was not included in the evaluation and only the MEC found in the native soil underneath the soil pile and in the area south/southwest of the soil pile are included.

Inner Radius, there is 95% confidence that there are less than 1.577 MEC/acre (from 0 to 959 total MEC associated with the 1926 explosion within the Inner Radius).

Table 6-10 Inner Radius UXO Estimator Inputs with Previous Investigations

Input	Value
Total Acres in Inner Radius Decision Unit	800.75
Investigated Acres	79.0
UXO Found in Investigated Area	107
UXO Target Density Per Acre	3
Desired Upper CL	0.95

Results:

- Sampling was adequate to be 95% confident that there is less than 1.577 UXO/acre within the Inner Radius Decision Unit. The value is within the target density.
- There is 100.00% confidence that there is less than or equal to 3 UXO/acre within the Decision Unit.
- The average density within the Decision Unit is 1.366 UXO/acre.

6.2.3 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the 1926 Explosion Radius MRS. The revised CSM for the 1926 Explosion Radius – Off-Post is presented in Section 6.3.1. The preliminary MEC CSM developed following the SI is discussed in Section 4.1.1, and the summary of the RI results for the 1926 Explosion Radius MRS is presented in Section 6.2.2. Based on the results of the data collected for the RI, which were collected to supplement previous information provided in the SI report and the HRR, it is proposed that the 1926 Explosion Radius consist of one MRA with two MRSs, the 1926 Explosion Radius MRS and the Fuze Area MRS. It is also proposed that the Green Pond MRS be incorporated into the 1926 Explosion Radius MRS and be removed as a separate MRS.

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The revised CSM for MEC is depicted on **Figure 6-7** for the 1926 Explosion Radius MRA as a flow chart summarizing the

pathway and exposure analysis discussed below.

6.2.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the 1926 Explosion Radius MRA.

6.2.3.1.1 Source

A MEC source is the location where MPPEH or ordnance is situated or is expected to be found. For the 1926 Explosion Radius MRS, which is part of the 1926 Explosion Radius MRA, historical information has indicated that MEC, including UXO and DMM, and MD were released as part of the 1926 explosion. In addition, as shown on the UXO Finds Map (**Appendix C**), munitions were found within the MRS boundary that were not related to the 1926 explosion, indicating the possibility that munitions had been discarded in the 1926 Explosion Radius MRS. The portion of the 1926 Explosion Radius MRS that overlaps with the AOI Code 300 Area has a release mechanism associated with munitions firing and testing and the portion that overlaps with the AOI Former DRMO Yard has a release mechanism associated with storage. No MEC were found in the Green Pond MRS during the RI.

During previous intrusive investigations at the 1926 Explosion Radius On and Off-Post MRSs, including TCRA I, II, III, and several EE/CAs, 109 MEC items were identified. Intrusive operations during the RI discovered an additional fourteen MEC items and 973 MD items. Confirmed MEC items discovered at the 1926 Explosion Radius MRS consist of one 6-inch naval projectile, one 5-inch armor-piercing round, one 37mm projectile, three MK2 BD fuzes, two MK2 PD fuzes, and the base of a PD fuze.

Based on the EE/CA, MEC density is known to vary across the 1926 Explosion Radius MRS. During the EE/CA, 43 MEC items associated with the explosion were found and a total of 71 acres were investigated. MEC was typically found within the Inner Radius in the undisturbed areas (e.g., areas without construction). Based on data from the RI, as well as data from previous investigations, the MEC density within the 1926 Explosion Radius MRS was calculated as the following. Note that the lower number is a qualitative estimate calculated from non-random data (i.e., data from the EE/CA) while the higher number is a quantitative estimate based only on the RI data.

- Inner Radius – MEC density per acre from 1.577 to 3.151.
- Outer Radius – MEC density per acre from 0.159 to 1.174.

As shown below, MEC associated with the 1926 explosion were found at depths up to 48 inches bgs; however, the majority of the MEC (102 of 104 or 98%) were found at a maximum depth of 24 inches bgs.

- During the 2008 EE/CA, 43 MEC were found at a maximum depth of 24 inches bgs.
- During TCRA I, 25 MEC were found—14 items were less than one foot (12 inches) bgs, nine items were from 1 to 2 feet (12 to 24 inches) bgs, and two items were at depths greater than 2 feet (26 inches and 48 inches).
- During TCRA III, 33 MEC were found at depths less than 2 feet (24 inches) bgs.
- During the RI, fourteen MEC were found at depths less than 12 inches bgs.

The AOI Code 300 Area also overlaps with the 1926 Explosion Radius MRS, which according to a 1973 DoD report, *Executive Order 11508 PTA Survey Report, Picatinny Arsenal, Dover, New Jersey*, was used for artillery firing of shells up to 155mm and fragmentation pattern testing (WESTON, 2012). During the RI, five MD items were recovered from the AOI Code 300 Area, including a 155mm projectile shell, an empty M42 submunition body, and three fragments. Three of the MD items, including the projectile shell, were discovered at ground surface and the remaining two items were found from 3 to 6 inches bgs. All confirmed MD recovered during the RI related to former use of the 1926 Explosion Radius MRS as a portion of the AOI Code 300 Area was determined to be MDAS; no MEC was identified. Because no MEC were identified in the AOI Code 300 Area, no information regarding MEC density is available and an impact area was not identified.

The portion of the 1926 Explosion Radius that overlaps with the AOI Former DRMO Yard has a release mechanism associated with storage of waste materials including materials used in manufacturing and testing explosives, pyrotechnics and munitions. The HRR also indicated that flashed and unflashed shells were reportedly located behind Building 314 in dumpsters. According to the HRR, buried UXO was discovered during the installation of a fence post in the AOI Former DRMO Yard in 1993. Subsequent investigation activities were performed; however, the results and the locations of the activities are not known. In 2009, during a TCRA performed

under the IRP over a 0.5-acre area of the AOI Former DRMO Yard 192 MEC/MPPEH were disposed of by detonation and 283 MD items were removed. The TCRA MEC/MPPEH items identified included Bomb Live Unit (BLU)s, 40mm, 105mm, 6-inch, and 37mm projectiles; point detonating (PD) fuzes, and M525 fuzes. Surface and subsurface removal activities in support of IRP activities at the former DRMO were conducted concurrently. A total of 208 MEC/MPPEH were disposed of by detonation and 14,950 lbs of MD was recovered (ARCADIS, 2010). The RI field activities resulted in one MEC (a 75mm Shrapnel Projectile Body) and one MD being found outside the Green Pond MRS, in the AOI Former DRMO Yard. Fifty-six MD were identified in the Green Pond MRS; however, no MEC were found.

For the Fuze Area MRS, which has been incorporated into the 1926 Explosion Radius MRA, a source and release mechanism for the fuzes has not been identified. However, a building foundation is located adjacent to where the fuzes were found. It is possible that the fuzes were stored in this building and the building was damaged during the explosion. If so, the building may have been razed and the fuzes dispersed. The MEC density within the Fuze Area MRS was calculated at 173 MEC/acre. All of the fuzes were found on the surface.

6.2.3.1.2 Access

Access describes the degree to which a MEC source or environment containing MEC is available to potential receptors. Access to PTA is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of the 1926 Explosion Radius MRA, including the AOI Code 300 Area and Fuze Area MRS, is not restricted once on PTA. Once within the 1926 Explosion Radius MRA boundary, potential receptors would have access to any MEC in surface or subsurface soil. The only restricted area is the enclosure located on the western portion of the 1926 Explosion Radius MRS, which is fenced and guarded. In addition, after the RI field work was completed and the Fuze Area was identified, PTA placed warning signs around the entire area. The signs were placed approximately every 50 feet at a height of approximately four feet.

6.2.3.1.3 Activity

Activity describes ways that receptors come into contact with a source. The 1926 Explosion Radius MRS is 1,544.13 acres (excluding the Fuze Area) and covers a large portion of the south-central part of PTA, including the majority of the downtown area. The AOI Code 300 Area,

which covers approximately 400 acres on the western portion of the 1926 Explosion Radius MRS, is located on mainly undeveloped land adjacent to an operational range. The Fuze Area, which covers approximately 1.6 acres, is located in the center of the 1926 Explosion Radius MRA adjacent to the Shell Burial Grounds MRS.

The 1926 Explosion Radius MRA has approximately 800 buildings used for various purposes, including manufacturing, storage, testing, R&D, administration, and housing. The MRA also contains parking lots, recreational areas, and undeveloped property. Portions of the 1926 Explosion Radius MRA contain habitat used by state and/or federal threatened and/or endangered species. The Fuze Area is currently undeveloped and unused; however, the foundation of a former building is present.

PTA has existing ICs and LUCs in place, including but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s). A LUC Plan, which addresses the interim actions at MRSs, is currently being prepared for PTA under a separate program.

There are no anticipated changes in land use at the 1926 Explosion Radius MRA; however, a significant amount of development is planned for PTA in both the short and long term. Because large portions of downtown PTA are located within the 1926 Explosion Radius MRA, it is assumed that much of the proposed development detailed below will also occur within the MRA (Parsons, 2007a, 2007b):

- Over 200 existing buildings will be demolished and numerous new buildings will be constructed throughout the installation.
- Selected roads in the downtown area will be improved and widened.
- Additional general improvements will occur (e.g., pave roads, add curbs, and improve parking lots).

The potential future use of the AOI Code 300 Area, the AOI Former DRMO Yard and the Fuze Area are not expected to change from the current use.

6.2.3.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC.

Human receptors identified for the 1926 Explosion Radius MRA include both current and anticipated future land users. Human receptors under both the current and most likely future land uses include PTA personnel, residents, and contractors (sampling, utility and construction workers), visitors, recreational users, and trespassers. Of these, the only receptor populations that might realistically apply to the Fuze Area MRS are contractors, recreational users, and trespassers.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the 1926 Explosion Radius MRA and, based on the MRA physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. The 1926 Explosion Radius MRA contains lakes and patches of forest and wetlands used by state threatened and endangered plants and animals. The MRA is also located in both a Highlands Preservation Area and a Highlands Planning Area, shown on **Figure 3-3**.

6.2.3.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the 1926 Explosion Radius MRA and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRA for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-7.**

Exposure pathways for MEC are considered complete, because MEC has been found within the 1926 Explosion Radius MRA. Complete exposure pathways exist for human receptors who may contact, via handling or treading underfoot, MEC within surface soil or surficial sediments of the water bodies within the 1926 Explosion Radius MRA. Complete exposure pathways exist for biota that may contact MEC within surface soil or surficial sediments and that may nest or burrow at the MRA and thereby contact MEC within subsurface soil. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil or subsurface sediment while accessing underground utilities or performing intrusive work during future construction activities.

6.2.4 Munitions Constituents Sampling and Analytical Results

No MC sampling was conducted in the 1926 Explosion Radius MRA because of the type and/or condition of MEC found at the MRS. Biased sampling was proposed only near MEC found during the MMRP RI, and only when field observation indicated that a potential release had occurred (e.g., visual evidence of staining; cracked or corroded munitions; the item is not inert). None of the MEC identified within the 1926 Explosion Radius MRA had any indication of a release; therefore, MC sampling was not conducted. Based on the results of the RI, exposure pathways for MC are considered incomplete.

In addition, in accordance with the Final Work Plan (WESTON, 2012), MC at the Green Pond MRS is being addressed under the IRP. Surface water and sediment samples have been collected and analyzed for explosives and metals from the area known as IRP Site PICA-193 under the IRP. The ROD was completed in 2004 for IRP site PICA-193, and chemical and biological monitoring began in 2007 and will continue until 2021 (Picatinny Arsenal, 2013).

6.3 1926 EXPLOSION RADIUS – OFF-POST MRS

As mentioned above in Section 6.2, the 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01) was investigated in conjunction with the 1926 Explosion Radius MRS because the division between the two is based on the physical location of the PTA boundary and not the result of differentiation between potential source and release mechanisms. Therefore the two MRSs were investigated together. Refer to Section 6.2.2 for details regarding the results of the intrusive investigations conducted within the 1926 Explosion Radius – Off-Post MRS.

6.3.1 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the 1926 Explosion Radius – Off-Post MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MEC CSM developed following the SI is discussed in Section 4.2.1, and the summary of the RI results for the 1926 Explosion Radius On and Off-Post MRSs is presented in Section 6.2.2. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The revised CSM for MEC is depicted

on **Figure 6-8** for the 1926 Explosion Radius – Off-Post MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.3.1.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the 1926 Explosion Radius – Off-Post MRS.

6.3.1.1.1 Source

A MEC source is the location where MPPEH or ordnance is situated or is expected to be found. Based on the available historical information, MEC, including UXO and DMM, and MD were released in the 1926 Explosion Radius Off-Post MRS from the 1926 explosion.

Prior to any TCRA activities, 16 MEC were found by quarry workers at Mount Hope Quarry and were reported to the PTA EOD. During TCRA activities to date, 64 MEC have been found at the quarry. MEC were found only during TCRAs I and III, which were conducted at locations much closer to the explosion center than the area cleared under TCRA II. During the RI, no MEC were found within the 1926 Explosion Radius – Off-Post MRS.

As shown below, MEC associated with the 1926 explosion (from both the On-Post and Off-Post MRSs) have been found at depths up to 48 inches bgs; however, the majority of the MEC (102 of 104 or 98%) were found at a maximum depth of 24 inches bgs.

- During the 2008 EE/CA, 43 MEC were found at a maximum depth of 24 inches bgs (On-Post).
- During TCRA I, 25 MEC were found—14 items were less than 1 foot bgs, 9 items were from 1 to 2 feet bgs, and 2 items were at depths greater than 2 feet (26 inches and 48 inches) (Off-Post).
- During TCRA III, 33 MEC were found at depths less than 2 feet (24 inches) bgs (Off-Post).
- The three MEC found during the RI were found at depths less than 3 inches bgs (On-Post).

6.3.1.1.2 Access

Access describes the degree to which a MEC source or environment containing MEC is available

to potential receptors. The 1926 Explosion Radius – Off-Post MRS is located outside the secured PTA boundary. With the exception of the quarry, which has a guarded gate at the main entrance and signs posted along the perimeter of the property, the off-post properties are not secured.

6.3.1.1.3 Activity

Activity describes ways that receptors come into contact with a source. The 1926 Explosion Radius – Off-Post MRS covers 836 acres and is located outside the eastern boundary of PTA. Mount Hope Pond and portions of Mount Hope Lake are located within the MRS boundary. The MRS contains vacant land and several businesses, including Mount Hope Quarry, which comprises approximately 80% (634 acres) of the MRS. Structures located within the 1926 Explosion Radius – Off-Post MRS are commercial businesses and their associated buildings, including those structures associated with the operations of Tilcon Quarry. In addition, public utility towers, large piles of cultural debris, and a stone wall were observed during the RI and previous investigations.

The current land use is industrial and recreational with some vacant land. During the RI, the property owners indicated there are no future plans to change the current land use.

6.3.1.1.4 Receptors

A receptor is an organism (human or ecological) that comes into physical contact with MEC. Human receptors identified for the 1926 Explosion Radius – Off-Post MRS include both current and anticipated future land users. Human receptors include quarry personnel, other workers (e.g., workers associated with other businesses, contractors, utility workers), visitors, recreationists (e.g., hunters, fishermen), and trespassers as current human receptors. Recreational use on Mount Hope Lake includes camping and fishing.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the 1926 Explosion Radius – Off-Post MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. Both forested and wetland areas are present in the MRS. No specific ecological receptors are identified; however, according to the NJDEP i-Map Landscape Project layer, the 1926 Explosion Radius –

Off-Post MRS contains habitat with at least one occurrence of a state-threatened species, shown on **Figure 3-6**. The MRS is also located in a Highlands Preservation Area, shown on **Figure 3-3**.

6.3.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the 1926 Explosion Radius – Off-Post MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-8.**

Exposure pathways for MEC are considered complete because MEC has been found in the 1926 Explosion Radius – Off-Post MRS during several Time Critical Removal Actions. Complete exposure pathways exist for the Mount Hope Quarry personnel who may contact, via handling/treading underfoot, MEC in the surface and subsurface soil. Complete exposure pathways exist for the workers/visitors and the recreationists/trespassers who may contact MEC in surface soil or surficial sediment and in the subsurface soil or subsurface sediment for contractors or utility workers performing intrusive work. The exposure pathways are complete for biota that may contact MEC in the surface soil during feeding and nesting activities and in subsurface soil during burrowing. Complete exposure pathways exist for the aquatic and semiaquatic ecological receptors that may contact MEC in the surficial sediments of Mount Hope Lake or Mount Hope Pond.

6.3.2 Munitions Constituents Sampling and Analytical Results

No MC sampling was conducted in the 1926 Explosion Radius – Off-Post MRS because no MEC was found at the MRS during the RI. Biased sampling was only proposed near MEC found during the MMRP RI, and only when field observation indicated that a potential release had occurred (e.g., visual evidence of staining; cracked or corroded munitions; the item is not inert). Therefore, exposure pathways for MC are considered incomplete.

6.4 SHELL BURIAL GROUNDS MRS

The Shell Burial Grounds MRS is documented as consisting of three craters formed during the 1926 explosion. Two of the three craters coalesce as a single site and are referred to as the Shell Burial Grounds – West. The third crater is referred to as the Shell Burial Grounds – East.

6.4.1 Digital Geophysical Mapping Results

Using an EM31-MK2, a cumulative 7,153 linear feet of DGM transect surveys were performed over the western and eastern burial ground. Additionally a cumulative 8,160 linear feet of DGM transect surveys were performed using a G-858 Magnetometer.

Eight transect lines, two facing approximately north/south and two transects facing approximately east/west over each burial ground area were traversed using ER for a total of 4,660 linear feet. The DGM transects were used to determine the horizontal and vertical extent of the burial pits and to determine whether the current fencing surrounded the burial pits. Refer to Section 5.4.1 and **Appendix N** for additional details regarding the procedures for collecting samples along the ER transects, the analysis, the 3D modeling and the results. A summary of the ER DGM transect findings, per burial ground, and the results are detailed in the sections below.

6.4.1.1 Shell Burial Grounds MRS – West (Near Building 3100)

ER Transect Specific Findings

An analysis of ER transect profiles WER1 and WER2 (**Appendix N** Figure 2) shows two significant anomalies situated laterally within the limits of the Shell Burial Grounds MRS - West. The larger of the two, identified as Pit 1, is characterized by three distinct layers (the cap, a high resistivity layer, and a low resistivity layer) occurring at a width of 340 feet along the WER1 profile. In **Figure 6-9** only the cap and underlying low resistivity layer are evident; these layers occur at a width of 280 feet along the WER2 profile. The depth of penetration was limited to approximately 22 feet because of poor contact resistance of some of the surface electrodes, affecting the quality of the data at depth. As a result the deeper low resistivity zone was not imaged in the WER2 profile. Increasing in depth, the layers are interpreted to be associated with the following depositional features:

- Residual cap material (overburden soils) occurring from 0 to 5+/- feet bgs.
- The high resistivity layer (>ρ Layer 2) – associated with the post-1945 resistive backfill material (estimated depth 5 – 25 feet bgs.).
- The low resistivity layer (<ρ Layer 3) – associated with conductive shell burial deposits (estimated depth 25 to 35+/- feet bgs).

Note: The electrical resistance (ρ of earth material) is the opposition to the passage of an electric

current through that material; the inverse quantity is electrical conductance (Ω, the ease at which an electric current passes.) The second anomaly feature, identified as Pit 2, depicts a single shallow layer within the upper 10 feet and occurs at a width of 110 feet along the transect. Based on the modeling results and adjacent ER transects, it is likely that this feature represents a feather edge of the backfill material used to cover Pit 2. **Figure 6-9** shows Pit 2 having a greater thickness (on the order of 15 feet) and a much higher resistance. Localized artifacts are evident in the profiles where surface fencing produced cultural influence in the data. The fence locations and extent of influence are shown in both profiles.

Profiles WER3 and WER4 (**Appendix N** Figure 2) were conducted to intersect WER1 and WER2 as tie lines to corroborate data at intersection points and to provide transverse images to use for the model. An analysis of WER3 shows a disturbed overburden with variable resistivity values. These characteristics are in stark contrast with WER1 and WER2, which reflect a more homogeneous backfill or overburden. There is no clear structural evidence in WER3 that could be associated with the burial area. In contrast, the profile for WER4 shows clear boundaries that correlate with Pit 1. Further evidence is provided by the model presented in Section 3.2 of **Appendix N**.

6.4.1.2 Shell Burial Grounds MRS – East (Near Building 3150)

An analysis of ER transect profiles EER1 and EER2 (**Appendix N** Figure 3) clearly shows a large single anomaly (depression) within the limits of the Shell Burial Grounds - East. The edges of the depression have a width of 210 feet along the EER1 profile and a width of 277 feet along the EER2 profile. Three distinct layers are evident. Consistent with the depositional sequence imaged at the Shell Burial Grounds - West, these layers are interpreted to be associated with the following depositional features:

- The residual cap material occurring from 0 to 5 to 10 feet bgs.
- The high resistivity layer (>ρ Layer 2) – associated with the post-1945 resistive backfill material (estimated depth 10 to 25 feet bgs,).
- The low resistivity layer (<ρ Layer 3) – associated with conductive shell burial deposits (estimated depth 25 to 35 feet bgs).

Conversely, what is most evident in each profile is the rapid transition or gradient from the high

conductive deeper materials (suspected to represent the Shell Burial Grounds) to the low conductive shallower backfill materials. A distinct interface is evident between the two layers generally occurring from 20 to 25 feet bgs and is interpreted to represent the approximate depth of the post-1945 backfill.

EER3 (**Figure 6-10**) shows a disturbed overburden with variable resistivity values. The low resistivity layer (<ρ Layer 3) – associated with conductive shell burial deposits is evident below 20 to 25 feet bgs. EER4 (**Figure 6-10**) shows the high resistivity layer (>ρ associated with the post-1945 resistive backfill material) estimated at depths from 10 to 25 feet bgs.

A 3D conceptual model was constructed using the Shell Burial Grounds - West and Shell Burial Grounds - East ER transect profile sections for the purpose of estimating the lateral and vertical extents of 1926 Explosion craters and the disposal material contained in them.

The Shell Burial Grounds - West consists of two individual burial areas resulting from two simultaneous explosions creating overlapping craters. Both interpreted burial areas extend slightly beyond the current fence line, shown on **Figure 6-9**. Pit 1 is approximately 30 feet deep and contains 33,000 cubic yards (20 acre-feet) of material. The cap material averages 4 to 5 feet thick and makes up ~25% of the volume. The fill above the cap comprises ~15% of the volume. The remaining 60% of the volume is a mix between moderate and highly conductive materials and is inferred to be the transition zone between backfill material and the deeper shell burial deposits. Pit 2 is approximately half as deep as Pit 1 and contains approximately 15% of the volume of Pit 1. The relative composition of Pit 2 is approximately the same as Pit 1.

The Shell Burial Grounds - East consists of a single large burial area that is approximately 40 feet deep and contains 80,000 cubic yards of material (50 acre-feet). The Shell Burial Grounds - East volume is approximately double the combined volume of the Shell Burial Grounds - West. The Shell Burial Grounds - East extends slightly beyond the current fence line, shown on **Figure 6-10**. The Shell Burial Grounds - East contains a basal zone of material that is extremely conductive. The presence of this zone, combined with anecdotal evidence regarding the large size of the eastern crater (known as Shell Burial Grounds – East), helped define the base of the Shell Burial Grounds - East burial area. The high and low conductivity debris zones were modeled as separate layers for the purpose of volume estimation. The high conductivity debris

zone, inferred to be shell burial deposits, occupies 10,000 cubic yards, which accounts for 16% of the total volume of the Shell Burial Grounds - East burial area material. The remainder of the volume of material in the high conductivity zone of the Shell Burial Grounds - East burial area pit is inferred to be a mix of construction debris and reworked native material.

6.4.1.3 Intrusive Investigation Results

In accordance with the Final Work Plan (WESTON, 2012) no intrusive investigations were performed because of the explosive hazard deemed to exist at the Shell Burial Grounds MRS.

6.4.2 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the Shell Burial Grounds MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MEC CSM developed following the SI is discussed in Section 4.3.1, and the summary of the RI results for the Shell Burial Grounds MRS is presented in Section 6.3.1. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted; due to MC being addressed under IRP Site PICA-162.The revised CSM for MEC is depicted on **Figure 6-11** for the Shell Burial Grounds MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.4.2.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the Shell Burial Grounds MRS.

6.4.2.1.1 Source

The Shell Burial Grounds MRS was used for disposal and burial of MEC and explosives released from the 1926 explosion. The MRS was also used for munitions disposal until 1945 by the Navy. Records on the amounts or types of explosive devices buried at the MRS were not kept. No intrusive field activities were conducted at the Shell Burial Grounds MRS prior to the RI, but potential munitions may include mines, depth charges, fuzes, projectiles, explosives, small arms ammunition, and propellants, based on the HRR (Malcolm Pirnie, 2006). MEC density is unknown, but the Shell Burial Grounds MRS was used for the disposal of up to 25 tons of MEC

and the density is assumed to be very high. It is also probable that MD associated with the 1926 explosion is contained in the burial areas.

6.4.2.1.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

Once on PTA, there is currently restricted access to Shell Burial Grounds MRS for current authorized receptors. Currently, ICs (i.e., 6 1/2-foot tall chain-link fencing with warning signs) restrict access into the Shell Burial Grounds MRS and bound what is thought to be the horizontal extent of the burial areas. After entering the MRS, receptors would have limited/to no access to any MEC in surface soil because of the depth of fill (0 to 10 feet of fill on top of debris, varying across the two burial grounds) present at the burial grounds; therefore, most MEC would be present in the subsurface. As was shown during the geophysical surveys, a portion of each burial area extends beyond the current fence line; therefore, receptors could have limited access to MEC present in the subsurface. The future land use for the Shell Burial Grounds MRS is considered not to include activities that will access surface and subsurface soils.

6.4.2.1.3 Activity

The Shell Burial Grounds MRS is not currently being used and access is restricted. There are no planned land use changes for the Shell Burial Grounds MRS. The MRS is composed mainly of deciduous forest.

6.4.2.1.4 Receptors

Human receptors identified for the Shell Burial Grounds MRS include both current and anticipated future land users.

The revised MEC CSM in the RI identifies PTA personnel, residents, and contractors (utility workers, maintenance and construction workers) and visitors as current human receptors, but because the Shell Burial Grounds MRS has restricted access, the potential for the human receptors to access the MRS is low. Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, and birds known to be present at

PTA and the Shell Burial Grounds MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. There are no known ecological receptors identified at the Shell Burial Grounds MRS. The potential access and activities were considered in evaluating the source-receptor interactions at the MRS.

6.4.2.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Shell Burial Grounds MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-11.**

Exposure pathways for MEC are considered complete in the subsurface, because it has historically been used for disposal of approximately 25 tons of explosives from the 1926 explosion. In addition, it was determined during the ER transect surveys that debris extends beyond the boundaries of the ICs (fenceline), which could provide access for receptors to contact munitions in the subsurface. A potentially complete pathway could exist for PTA personnel and contractors who may perform intrusive work during potential future IC installation/movement activities. Incomplete exposure pathways exist for PTA personnel, residents, and contractors for MEC in surface soil, given that buried debris containing possible MEC has been detected deeper than 5 feet bgs where environmental factors (e.g., frost) may bring subsurface MEC to the surface in the Shell Burial Grounds MRS. The exposure pathways are incomplete for biota that may contact MEC in the subsurface soil during burrowing based on the possible location of MEC source material at depth in subsurface soil. The pathway to ecological receptors is possibly present, but incomplete as no MEC source material was confirmed within 2 feet of ground surface where biota activity is most likely.

6.4.3 Munitions Constituents Sampling and Analytical Results

In accordance with the Final Work Plan (WESTON, 2012), no MC sampling was performed at the Shell Burial Grounds MRS because MC is being addressed under the IRP. Groundwater, surface, and subsurface soil samples were collected and analyzed for explosives and metals from the area known as IRP Site PICA-162 under the IRP. MC is being addressed under the IRP; therefore, the exposure pathways for MC were not determined for the Shell Burial Grounds MRS.

6.5 FORMER OPERATIONAL AREAS MRS

The Former Operational Areas MRS (PICA-006-R-01) consists of 1,880 acres across PTA from south of Lake Denmark to the southern boundary of PTA, excluding operational ranges and other RI MRS footprints. Several AOIs, deemed "sub-sites" in the Final RI Work Plan (WESTON, 2012), were investigated as part of the MRS, using different methodology, as detailed in Section 5. The AOIs are discussed separately from the main body of the Former Operational Areas MRS in the following sections.

6.5.1 Digital Geophysical Mapping Results

Overall 70,650 linear feet of DGM transect surveys and 7 grids were performed in the Former Operational Areas MRS. The transect length, grid acreage, instrumentation, and number of targets chosen for investigation per investigation area are presented in **Table 6-10**. The intrusive investigation results are discussed in Section 6.5.2.

6.5.2 Intrusive Investigation Results

For the Former Operational Areas MRS, the DGM surveys and analog transects consisted of 3,195 anomalies. A total of 75 MEC items, consisting of 72 UXO, and three DMM, as well as 444 MD and 187 Small Arms were observed. The remaining anomalies included 2,267 items classified as cultural debris, 9 seeds, 57 No Contacts, and 156 geologic "hot rocks". **Figure 6-12** shows the locations of the items recovered within the Former Operational Areas MRS. A summary of the items identified within the Former Operational Area MRS, separated by investigation area and classified by their final designations, is provided in **Table 6-11.** The following paragraphs detail the anomalies identified for each investigation area within the MRS. The complete dig list is provided in **Appendix H**.

Figure 6-13 depicts the MEC density across the Former Operational Areas MRS. Within the Former Operational Areas MRS, 75 MEC, 444 MD, and 187 small arms were identified from an investigation area of approximately 64.68 acres. As shown on **Figure 6-13,** the MEC density varies across the MRS, with the highest density of MEC identified within the southern portion of the Former Operational Areas MRS in and east of AOI Site 20/24. The Burning Ground (PICA-002) was not investigated during the RI and the MEC density was extrapolated from the surrounding areas. The Burning Ground was investigated under the IRP and has already been

remediated with a signed ROD; therefore the Burning Ground was ineligible for the MMRP RI. Within the elevated MEC density area, more than 2 MEC per acre was calculated with VSP and some individual point locations were identified with more than 4 MEC per acre. The highest density area was localized with densities rapidly decreasing to less than 0.1 MEC per acre in the Former Operational Areas MRS.

Table 6-11 Former Operational Areas MRS DGM Summary

Investigation Area	DGM Instrumentation	DGM Transects (linear feet)	Number of Targets for Investigation
Former Operational Areas MRS – Transects excluding AOI	EM61-MK2	48,895	392
AOI Site 20/24	EM31-MK2 and EM61-MK2	12,704*	212
AOI Waste Burial Area	EM31-MK2 and EM61-MK2	4,407	134
AOI Former Sanitary Landfill/Dredge Pile	EM31-MK2 and EM61-MK2	4,644	84
	SUBTOTAL	70,650	822
Former Operation Areas MRS – Grids	**DGM Instrumentation**	**DGM Grid Acreage**	**Number of Targets for Investigation**
FOA-1	EM61-MK2	2,500	33
FOA-2	EM61-MK2	2,500	12
FOA-3	EM61-MK2	2,500	19
FOA-4	EM61-MK2	2,500	14
FOA-5	EM61-MK2	2,500	10
FOA-6	EM61-MK2	2,500	6
FOA-7	EM61-MK2	2,500	11
	SUBTOTAL	17,500	105
		TOTAL	927

*- Included in this total are additional EM61-MK2 transects that were performed at the location of an 81mm Mortar identified just outside the northern boundary referenced below.

Table 6-12 Former Operational Areas MRS Anomaly Summary

Area of Interest/ Method of Investigation	UXO	DMM	MD	Cultural Debris	SEEDs	Small Arms	No Contact	Geologic "Hot Rocks"	TOTALS
Former Operational Areas MRS -DGM transects: excluding AOI	-	-	14	393	-	-	4	22	433
Former Operational Areas MRS -DGM Grids	-	-	5	76	9	1	38	2	131
AOI Code 300 Area -Analog Grid	-	-	-	1	-	-	-	-	1
Former Operational Areas MRS -Analog transects	55	1	81	1,338	-	149	-	100	1,724
AOI Site 20/24 -DGM transects	9	2	121	144	-	3	10	31	320
AOI Waste Burial Area -DGM transects	-	-	210	182	-	5	1	1	399
AOI Former Sanitary Landfill/Dredge Pile -DGM transects	8	-	13	133	-	29	4	-	187
TOTALS	72	3	444	2,267	9	187	57	156	**3,194**

6.5.2.1 Former Operational Areas DGM Transects– Excluding AOIs

A total of 433 anomalies were selected for intrusive investigation along the DGM transects in the Former Operational Areas MRS, excluding the DGM transects conducted in the AOIs. No MEC was identified but 14 MD items were identified consisting of fragments, fuzes, flares, 60mm mortar parts and a 40mm armor-piercing projectile. The remaining items consist of 393 items identified as cultural debris (wire, nails, pipe), 22 items identified as geologic "hot rocks," and 4 no contacts. Items were recovered at depths ranging from 0 to 8 inches bgs, with the MD being identified up to 6 inches bgs. **Figure 6-12** shows the locations of the items recovered within the Former Operational Areas MRS.

6.5.2.2 Former Operational Areas – DGM Grids

In the seven DGM grids within the Former Operational Areas MRS, no MEC was identified but five MD items were identified in two of the grids (FOA-03—60mm mortar tailboom and a fragment, FOA-04—two hand grenade smoke bodies and a 60mm mortar illumination body). The remaining anomalies investigated in the DGM grids consist of 1 small arms (shotgun shell) in FOA-04, 76 items identified as cultural debris (wire, nails), 9 seeds, two anomalies identified as geologic "hot rocks," and 38 no contacts. Items were recovered at depths ranging from 0 to 24 inches bgs, with the MD being identified up to 18 inches bgs. A summary of item type by grid is provided in **Table 6-13** below. **Figure 6-12** shows the locations of the items recovered within the Former Operational Areas MRS.

Table 6-13 Item Summary for Former Operational Areas MRS DGM Grids

Grid ID	MD	Small Arms	Cultural Debris	Seeds	Geologic	No contact
FOA-1	-	-	31	1	-	6
FOA-2	-	-	5	1	1	6
FOA-3	2	-	14	1	1	4
FOA-4	3	1	4	1	-	6
FOA-5	-	-	22	3	-	1
FOA-6	-	-	-	1	-	5
FOA-7	-	-	-	1	-	10

6.5.2.3 Former Operational Areas – Analog Transects – Excluding AOI

A total of 218,910 linear feet (41.5 miles) of analog transect surveys were performed using a White's XLT All-Metals detector. The detected anomalies were investigated by UXO Technicians to determine the anomaly source.

A total of 306 anomalies were intrusively investigated along the analog transect survey lines. MEC items recovered during intrusive investigations consisted of one DMM, a M302 60mm white phosphorous projectile and 55 UXO items (48 fuzed 81mm practice mortars, four fuzed 60mm practice mortars, two rifle grenades (fuze and body), and a 3.5-inch rocket fuze well). A total of 101 MDAS items were recovered at depths ranging from 0 to 33 inches bgs. The MDAS items identified in the Former Operational Areas MRS, excluding the AOIs, include 28 fragments; three 81mm practice mortar parts (two tail booms and spacer); twelve 60mm mortars (illumination, fuzes and parts); sixteen 22mm sub calibers; six 3.5-inch rocket parts; five 75mm projectiles; one M26 AP fragmentation mine, wax filled; and several grenades, flares, mines, and various other items. A total of 70 small arms were observed, including 23 shotgun primers, 41 blank ammunitions such as a 7.62mm, 4 casings, 1 shotgun shell, and 1 ball ammunition. The remaining non-MD related material included 901 items classified as cultural debris. The items were recovered from ground surface to 39 inches bgs.

Figure 6-12 shows the locations of the items recovered. The complete dig list is provided in **Appendix H**.

6.5.2.4 AOI Code 300 Area – Density Transects

As detailed in Section 5.6.1.2, 13,443 linear feet of density transects were performed within the portion of the Former Operational Areas MRS that overlaps with the AOI Code 300 Area. One analog grid (Code300-13) was placed to delineate a possible high density area. Only one item was identified and classified as cultural debris consisting of barbed wire, which was identified at the ground surface.

6.5.2.5 AOI Site 20/24

A total of 320 anomalies were identified within the AOI Site 20/24 portion of the Former Operational Areas MRS. The MEC identified within the AOI consisted of two DMM, a 60mm HE mortar and a 40mm HE projectile, and nine UXO, a fuzed 60mm white phosphorous mortar,

five fuzed 81mm practice mortars, two fuzed 60mm practice mortars, and one BLU-26 submunition. A total of 121 MD items consisting mainly of flares and 60mm and 40mm illumination mortar parts (bodies, casing, and tailbooms) were identified within AOI Site 20/24, as well as three small arms. The remaining items consisted of 144 items identified as cultural debris (foil, nails, and wire), 31 geologic "hot rocks," and 10 no contacts. Items were recovered at depths ranging from 0 to 24 inches bgs, with MD being identified to 15 inches bgs. The UXO and DMM were identified to 8 inches bgs. The items identified within AOI Site 20/24 are presented on **Figure 6-14.**

6.5.2.6 AOI Waste Burial Area

A total of 399 anomalies were identified within the AOI Waste Burial Area portion of the Former Operational Areas MRS. No MEC was identified but 210 MD consisting of flash tubes, 37mm projectile parts, 40mm and 60mm mortar parts, and 2.36-inch and 2.75-inch rocket components, were identified within the AOI. The remaining anomalies were 5 small arms (shotgun primers and blank ammunitions), 182 items identified as cultural debris (pipes, nails, and concrete), 1 geologic "hot rock," and 1 no contact. Items were recovered at depths ranging from 0 to 30 inches bgs, with the MD being identified to 30 inches bgs. The items identified within the AOI Waste Burial Area portion of the Former Operational Areas MRS are presented on **Figure 6-14.**

6.5.2.7 AOI Former Sanitary Landfill/Dredge Pile

A total of 17 anomalies were identified within the AOI Former Sanitary Landfill and Dredge Pile portion of the Former Operational Areas MRS. Eight UXO items (BLU-36 submunitions) were identified in the AOI. In addition to the UXO were 13 items identified as MD (BLU-36 pieces, 155mm powder can, rocket pieces, and fragments). The remaining items identified within the AOI consist of 29 small arms (shotgun primers and casings), 133 items identified as Cultural Debris (fencing, nails, foil, and wire), and 4 no contacts. Items were recovered at depths ranging from 0 to 39 inches bgs, with the MD being identified to 15 inches bgs. The UXO was identified to 18 inches bgs. The items identified within the AOI Former Sanitary Landfill and Dredge Pile portion of the Former Operational Areas MRS are presented on **Figure 6-14.**

6.5.3 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the Former Operational Areas MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MEC CSM developed following the SI is discussed in Section 4.5.1, and the summary of the RI results for the Former Operational Areas MRS is presented in Section 6.5.2. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. An MC CSM was developed and provided in Section 6.5.5. The revised CSM for MEC is depicted on **Figure 6-15** for the Former Operational Areas MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.5.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the Former Operational Areas MRS.

6.5.3.1.1 Source

The Former Operational Areas MRS was identified from the UXO Finds Map that was found in the PTA Safety Office (**Appendix C**). The UXO Finds Map documents the numerous MEC and MD recovered throughout the Former Operational Areas MRS between 1986 and 1998. In addition, a PTA Survey report (DoD, 1973) documents several areas within the Former Operational Areas MRS as being allocated for former R&D activities.

Throughout the Former Operational Area MRS, intrusive survey activities during the RI resulted in 75 MEC finds consisting of 9 fuzed 60mm mortars (Practice, HE and WP), 53 fuzed 81mm mortars, a 40mm HE Projectile, 9 BLU submunitions, a grenade rifle HEAT body and fuze, and a rocket fuze well. The majority of these items were identified within the southern portion of the Former Operational Areas MRS. Only one item, a 3.5-inch rocket fuze well, was found within the northern portion of the MRS.

Observed on the surface and in the subsurface were 444 MD—flares; flare components; fragments; fuzes; rifle grenades; hand grenades; 60mm mortars; 81mm mortars; 4.2-inch mortar; 3.5-inch rockets and their components; various 37mm, 40mm, 75mm, 20mm, 105mm projectiles; an AP wax filled fragmentation mine, 22mm subcalibers; M42 submunitions; and BLU-36

submunitions, consistent with historical training records and historical Former Operational Areas MRS activities as an R&D area.

Also in the 1973 Survey Report, a pyrotechnic testing area was identified near AOI Site 20/24. No pyrotechnic items were identified as MEC, but 89 MD items were identified as flares, a 60mm illumination canister, 40mm smoke canisters, flare bodies, flare caps, flare canisters, and casings.

During an interview conducted post-RI field activities (included in **Appendix C**), a mortar range was identified in the southern portion of the Former Operational Areas MRS. The mortar range was discovered to have three separate firing points and a target area near the safe haven in AOI Site 20/24. Engineering controls were used to limit the length of firing to prevent hitting the observation tower near the intersection of Horney Road and Phipps Road. The munitions tested at the range consisted of 60mm and 81mm mortars with 120mm practice rounds being fired from one of the firing points near the present day skeet range. No 120mm rounds have been identified within the MRS. A total of 62 MEC items consisting of 60mm and 81mm mortars were identified either within/near the target area or along the line of sight from the firing points to the target area. Additionally, 27 MD items consisting of 60mm and 81mm mortars and mortar pieces were also identified.

Characterization coverage of 2.71 acres was performed to ensure a 95% probability of traversing and detecting a MEC impact area.

Based on the RI, MEC density is known to vary across the MRS. During the RI, 75 MEC associated with the activities within the MRS were found and a total of 64.68 acres were investigated. MEC were typically found within the southern portion of the MRS, only one item, a 3.5-inch rocket fuze well, was found within the northern portion of the MRS. Based on data from the RI, the area with the highest density of MEC recovered was located in the southern portion of the Former Operational Areas MRS with the MEC density within this area calculated as more than 2 MEC per acre. Outside the high-density area shown on **Figure 6-13**, the MEC density decreased to less than 0.1 MEC per acre.

MEC identified within the Former Operational Areas MRS have been found at depths to 18 inches bgs; however, the majority of the MEC items (58 of 75 or 77%) were found at a maximum depth of 9 inches bgs.

6.5.3.1.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

There is currently unrestricted access to the Former Operational Areas MRS for current authorized receptors after entering PTA. After entering the MRS, receptors would have access to any MEC in surface soil by walking. A receptor may contact MEC in the subsurface performing intrusive activities. Maintenance activities in the Former Operational Areas MRS may disturb surface and subsurface soils.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

6.5.3.1.3 Activity

Current activities at the Former Operational Areas MRS include manufacturing, storage, testing, R&D, administration, and recreation. Included within the MRS boundary are also parking lots, recreational areas, and portions of a golf course. Undeveloped areas are used for hunting (including the Waste Burial Area). AOI Site 20/24 is currently the location of a “safe haven” for trucks transporting explosives on interstate highways. Biota activities at the Former Operational Areas MRS may include surface movement or burrowing activities.

For the purposes of the RI, the anticipated future land use at the Former Operational Areas MRS is the same as the current land use but includes short-term and long-term development and redevelopment.

The potential future use of the AOI Code 300 Area is the same as the current use.

6.5.3.1.4 Receptors

Human receptors identified for the Former Operational Areas MRS include both current and anticipated future land users. The potential receptors include PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreational users, and trespassers.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed

and unlisted mammals, birds, and wetland species known to be present at PTA and the Former Operational Areas MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. The majority of the MRS is undeveloped and consists of deciduous forests, ponds, streams and wetlands. Several sensitive species are known to inhabit the Former Operational Areas MRS, including the veery thrush (Catharus Fuscescens), barred owl (Strix varia), and American woodcock (Scolopax minor). A habitat with at least one occurrence of a state-threatened species is present at the MRS, according to the NJDEP i-Map Landscape Project layer.

6.5.3.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Former Operational Areas MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-15.**

Exposure pathways for MEC are considered complete because MEC was found within the Former Operational Areas MRS. Complete exposure pathways exist for the PTA personnel who may contact, via handling/treading underfoot, MEC in the surface and subsurface soil. Complete exposure pathways exist for the workers/visitors and the recreationists/trespassers who may contact MEC in surface soil or surficial sediment and in the subsurface soil or sediment for contractors or utility workers performing intrusive work. The exposure pathways are complete for biota that may contact MEC in the surface soil during feeding and nesting activities and in subsurface soil during burrowing. Complete exposure pathways exist for the aquatic and semiaquatic ecological receptors that may contact MEC in the surficial sediments of Landfill Pond or Green Pond Brook. While Landfill Pond or Green Pond Brook were not investigated, the exposure pathways for aquatic and semiaquatic ecological receptors are considered complete because of the amount of MEC items identified in the near vicinity of Landfill pond and a portion of Green Pond Brook. As shown on **Figure 6-13**, the extrapolated MEC density denotes a high probability of MEC existing within these water features.

6.5.4 Munitions Constituents Sampling and Analytical Results

As discussed in Section 5.6.2, random gridded soil samples for MC analysis were collected from the Former Operational Areas MRS. From December 12 to 21, 2011, 89 gridded soil samples, 84

environmental samples, and 5 field duplicates were collected from 0 to 6 inches bgs and analyzed for the MC list given in **Table 5-5**. Samples were collected in accordance with the Final RI Work Plan (WESTON, 2012). Field sheets and photographs for the sampling event are provided in **Appendix M**. Analysis of the samples indicated that eight metals, listed in **Table 6-14**, were detected at three locations at concentrations greater than the PTA-specific background concentrations as well as the human health screening levels. Metals were also found at several locations at concentrations greater than the PTA-specific background concentrations as well as the ecological screening levels. Refer to **Table 6-14** for additional information regarding the analytical results. No explosive compounds were found at concentrations greater than the screening levels. The screening levels, location of samples where analytes were detected at concentrations greater than screening levels, and the respective analytical results are presented on the Former Operational Areas MRS Analytical Results figure in **Appendix M**. Detailed information for all samples can be found in the Former Operational Areas MC Sampling Summary Table in **Appendix M**.

Table 6-14 Initial Soil Sampling Results

Metal	Range of Concentrations Detected (mg/kg)[1]	No. of Detections Greater Than PTA-Specific Background and Human Health Screening Levels[2]	No. of Detections Greater Than PTA-Specific Background and Ecological Screening Levels
Aluminum	2,900 – 44,000	0	8
Antimony	0.48 J[3] – 67 J	1	8
Barium	11 J – 1,900 J	0	4
Cadmium	0.05 J – 19 J	0	19
Copper	5.8 J – 130 J	0	18
Lead	10 – 27,000 J	1	32
Manganese	18 J – 27,000	2	12
Zinc	19 J – 990 J	0	22

Notes:
[1] mg/kg – milligrams per kilogram
[2] Only the data from the December 2011 sampling event are summarized in the table
[3] J – estimated value

To delineate the horizontal and vertical extent of contamination, step-out samples were collected from each location where concentrations greater than the human health screening levels were found. Each location is discussed below.

6.5.4.1 Location P-1

Soil sample FOAG-SS71 was collected in December 2011 from Location P-1 in the northeastern portion of the Former Operational Areas MRS, adjacent to IRP Site PICA-050. The sole analyte

detected at concentrations greater than the NJDEP residential soil remediation standard (SRS) in sample FOAG-SS71 was manganese, which was detected at a concentration of 27,000 mg/kg. The NJDEP residential SRS is 11,000 mg/kg.

On May 3, 2012, six step-out soil samples were collected from three locations approximately 20 feet north, south, and west of sample FOAG-SS71 (**Figure 6-16**). Two samples were collected from each location; one from 0 to 6 inches bgs and one from 1.5 to 2 feet bgs. Analysis of the samples for the metals listed in **Table 4-1** indicated the presence of manganese in all three samples collected from 0 to 6 inches at concentrations greater than the NJDEP residential SRS. None of the deeper samples exhibited manganese concentrations greater than the NJDEP residential SRS. Manganese was found at a maximum concentration of 21,000 mg/kg.

On September 25, 2012, nine additional step-out soil samples, eight environmental samples and one field duplicate, were collected from the following locations and analyzed for manganese only. Analysis of the samples, which were collected from 0 to 6 inches bgs, did not indicate the presence of manganese at concentrations greater than the NJDEP residential SRS.

- Four soil samples, three environmental samples and one field duplicate, were collected 100 feet north, south, and east of soil sample FOAG-SS71.
- Three soil samples were collected 200 feet north, south, and east of FOAG-SS71.
- Two soil samples were collected along the border of PICA-050.

6.5.4.2 Location P-45

Soil sample FOAG-SS42 was collected in December 2011 from Location P-45 on the southern portion of the Former Operational Areas MRS near the Former Skeet Range. Two analytes, lead and antimony, were detected at concentrations of 27,000 and 67 mg/kg, respectively, that are greater than the NJDEP residential SRSs of 400 mg/kg and 31 mg/kg, respectively.

On May 3, 2012, nine step-out soil samples, eight environmental samples and one field duplicate, were collected from four locations approximately 20 feet north, south, east, and west of sample FOAG-SS42. Two samples were collected from each location; one from 0 to 6 inches bgs and one from 1.5 to 2 feet bgs. Analysis of the samples for the metals in **Table 5-5** indicated the presence of lead in all the samples at concentrations greater than the NJDEP residential SRS. The concentrations detected ranged from 3,500 mg/kg to 22,000 mg/kg. Antimony was detected

in seven samples at concentrations greater than the NJDEP residential SRS. The concentrations detected ranged from 15 mg/kg to 4,300 mg/kg.

As a result of the proximity of Location P-45 to the Former Skeet Range, the *Final Picatinny Arsenal Former Skeet Range (CC-057) Remedial Investigation Report*, May 2012 was reviewed to determine whether the antimony and lead detected in the soil samples could be related to activities on the Skeet Range. Location P-45 is located immediately adjacent to the Former Skeet Range Impact fan, as shown on **Figure 5-30**. Analytical results of surface soil samples collected under the IRP from within the fan indicate the presence of lead at concentrations up to 102,000 mg/kg. Therefore, Location P-45 will be included in the Former Skeet Range cleanup and will not be addressed under the MMRP.

6.5.4.3 Location P-61

Soil sample FOAG-SS23 was collected in December 2011 from Location P-61 on the southern portion of the Former Operational Areas MRS. The only analyte detected at concentrations greater than the NJDEP residential SRS was manganese, which was detected at a concentration of 12,000 mg/kg.

On May 3, 2012, seven step-out soil samples, six environmental samples and one field duplicate, were collected from three locations approximately 20 feet north, south, and east of sample FOAG-SS23 (**Figure 6-17**). Two samples were collected from each location; one from 0 to 6 inches bgs and one from 1.5 to 2 feet bgs. Analysis of the samples for the metals on **Table 5-5** indicated the presence of manganese in two samples, both collected from 0 to 6 inches bgs, at concentrations greater than the NJDEP residential SRS. None of the samples collected south of sample FOAG-SS23 and none of the deeper samples exhibited manganese concentrations greater than the NJDEP residential SRS. Manganese was detected at a maximum concentration of 15,000 mg/kg.

On September 25, 2012 and October 19, 2012, five additional step-out soil samples were collected from the following locations and analyzed solely for manganese.

- Two soil samples, FOAG-SS223 and FOAG-SS523, were collected approximately 50 feet and 115 feet north, respectively, of FOAG-SS23.
- Two soil samples, FOAG-SS323 and FOAG-SS623, were collected approximately 70

feet and 220 feet east, respectively, of FOAG-SS23.

- One soil sample, FOAG-SS423, was collected approximately 280 feet northwest of FOAG-SS23. The sample could not be collected closer to FOAG-SS23 because of the presence of a fence with no access gate that blocked access to the area west of Location P-61.

Analysis of the samples, which were all collected from 0 to 6 inches bgs, indicated the presence of manganese in two samples at concentrations greater than the NJDEP residential SRS. Manganese was found in samples FOAG-SS223 and FOAG-SS523 at concentrations of 31,000 mg/kg and 37,000 mg/kg, respectively.

6.5.5 Revised Munitions Constituent CSM

The following sections present the revised CSM for MC at the Former Operational Areas MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MC CSM developed following the SI is discussed in Section 4.5.1, and the summary of the RI results for the Former Operational Areas MRS is presented in Section 6.5.4. The revised MC CSM for the Former Operational Areas MRS is depicted on **Figure 6-18** as a flow chart summarizing the exposure pathways analysis discussed below.

6.5.5.1 Revised Munitions Constituent Exposure Pathways Analysis

The exposure pathways analysis describes MC source areas, the source media and potential exposure media, release and transport mechanisms, and exposure routes for potential receptor populations. For an exposure pathway to be complete, all of the following elements must be present: a source and mechanism of MC release, a retention and/or transport medium, a point of contact with the exposure medium, and an exposure route at the contact point. If any one of these elements is missing, the pathway is considered incomplete. A pathway is considered potentially complete when the presence of MC is suspected but has not been confirmed, and receptors may be exposed while engaging in some activity that results in contact with the exposure medium.

6.5.5.1.1 Source

The primary source of MC at the Former Operational Areas MRS is through site usage, including discarded or malfunctioned munitions, testing activities, and munitions waste disposal. MC was detected at concentrations of concern in RI surface soil samples from the Former Operational Areas MRS; therefore, **Figure 6-18** depicts MC in surface soil as the source medium.

MC may also be found in association with MEC at the Former Operational Areas MRS. No evidence of a potential release from MEC encountered during the RI was observed; therefore, biased soil samples for MC were not collected during the RI. However, random gridded soil samples were collected across the MRS to determine if MC is present through historical site usage.

6.5.5.1.2 Release Mechanisms, Exposure Media, and Routes

Primary release mechanisms constitute any soil disturbance that may cause redistribution of contamination. The current degree of disturbance at the Former Operational Areas MRS is relatively low because a large portion of the MRS is undeveloped. The primary exposure medium is surface soil. Exposure routes for human and ecological receptors are ingestion, dermal contact, and inhalation, and for ecological receptors only, uptake or assimilation of MC into plants and invertebrates in direct contact with soil.

Release mechanisms from surface soil include infiltration/percolation of precipitation through soil, leaching from soil to groundwater, surface runoff to nearby water bodies, and uptake of MC into plants and invertebrates in direct contact with soil. MC migration via infiltration or leaching is likely because a large portion of the Former Operational Areas MRS is undeveloped and not covered with impermeable surface. However, migration of dissolved MC is a minor migration pathway as the MC is relatively immobile and has low water solubilities.

Secondary release mechanisms include discharge of groundwater to a surface water body or recharge of groundwater from a surface water body and biotransfer of bioaccumulative constituents through the food web. A potential exposure route for ecological receptors is ingestion of food items that have assimilated MC. Activities at the Former Operational Areas MRS may have also impacted surface water bodies directly (e.g., by discarding munitions in surface water). However, surface water, sediment, and groundwater at the Former Operational Areas MRS are being addressed under the IRP.

6.5.5.1.3 Receptors

Current activities at the Former Operational Areas MRS include manufacturing, storage, testing, R&D, administration, and recreation. The majority of the MRS is undeveloped and consists of deciduous forests, ponds, streams, and wetlands. Parts of the Former Operational Areas MRS also contain parking lots, recreational fields, and portions of the PTA golf course. Hunting is

permitted in undeveloped areas. There are no housing areas located within the MRS, and future residential development is not currently planned as all housing areas are proposed to be located within the 1926 Explosion Radius MRS. For the purposes of the RI, the anticipated future land use at the Former Operational Areas MRS is the same as current land use but includes short-term and long-term development and redevelopment.

Based on the current and most likely future land uses at the Former Operational Areas MRS, potential human receptor populations include site workers (indoor workers, outdoor workers, construction/utility workers, and future construction workers), visitors, and recreationists. Access within the Former Operational Areas MRS, once on PTA, is unrestricted.

Potential ecological receptors at the Former Operational Areas MRS include terrestrial plants, soil invertebrates, small and large birds and mammals, and reptiles and amphibians. Aquatic and semiaquatic ecological receptors were not identified for the Former Operational Areas MRS because surface water and sediment are being addressed under the IRP.

6.5.5.2 Munitions Constituent Exposure Conclusions

The information collected during the RI was used to update the preliminary MC CSM for the Former Operational Areas MRS and to identify complete, potentially complete, or incomplete exposure pathways, as presented on **Figure 6-18.**

Exposure pathways for surface soil are considered complete because MC is present at concentrations of concern and human and ecological receptors may be exposed through ingestion, dermal contact, inhalation (e.g., metals that are adsorbed onto respirable particulates where dust is generated), or uptake/assimilation (ecological receptors only). Exposure pathways for terrestrial biota through the food web are potentially complete because detected MC are bioaccumulative (i.e., cadmium, copper, lead, and zinc) and the potential for ecological exposure exists. Exposure pathways for subsurface soil are incomplete. No subsurface soil samples were collected at the Former Operational Areas MRS because constituent concentrations detected in step-out samples collected from 1 to 1.5 feet bgs were less than human health risk-based screening levels and vertical delineation was not performed. Surface water, sediment, and groundwater exposure pathways were not evaluated because the exposure media are being addressed under the IRP.

6.6 LAKES MRS

The Lakes MRS (PICA-008-R-01) consists of both Picatinny Lake and Lake Denmark and the shoreline area surrounding the lakes. Each lake has a different military-munitions-related history; therefore, a different investigative approach was used and the results are discussed separately in the following sections. **Figure 1-9** shows the location of the MRS within PTA.

6.6.1 Picatinny Lake

The following sections present the results of the RI field efforts that were performed at the Picatinny Lake portion of the Lakes MRS (**Figure 1-10**) to achieve the DQOs:

6.6.1.1 Digital Geophysical Mapping Results

The following sections present the results of the DGM grid surveys conducted at the Picatinny Lakes portion of the Lakes MRS.

6.6.1.1.1 DGM Grid Survey

A 0.59-acre DGM grid survey (PL-01) was conducted at the 3-inch Barbette Gun firing point, resulting in a total of seven potential burial pit features being selected from the geophysical data for intrusive investigation within the DGM grid. The location of the 3-inch Barbette Gun firing point grid (PL-01) within the Picatinny Lake portion of the Lakes MRS is shown on **Figure 5-32**. All detected anomalies were investigated by UXO Technicians to determine the anomaly source. The areas where the anomalies were identified in the DGM data are presented in **Figure 5-31**. The intrusive investigation results are discussed further in Section 6.6.1.2.

6.6.1.1.2 Underwater DGM Transects

A total of 15 DGM transect surveys were conducted across the water portion of the lake, totaling 15,177 linear feet (2.82 miles) using a Marine EM61-MKII in high powered mode. A total of 25 anomalies (consisting of both single anomalies and anomaly clusters) were chosen for intrusive investigation, 16 targets (12% of the anomalies) were identified for investigation from the existing 1995 DGM data, and 9 targets were identified for investigation from the RI DGM data (2012). The anomalies chosen for intrusive investigation are presented on **Figure 5-33**. The intrusive investigation results are discussed further in Section 6.6.1.2.

6.6.1.2 Intrusive Investigation Results

The following sections present the results of the intrusive investigation conducted at the Picatinny Lakes portion of the Lakes MRS.

6.6.1.2.1 Grid Intrusive Investigation

On May 26, 2012, the potential burial features present at the 3-inch Barbette Gun firing point grid (PL-01) were intrusively investigated. The potential burial features were observed to contain construction debris, such as a concrete slab, reinforced concrete and metal rebar. No MEC or MD items were observed; the anomalies only included items classified as cultural debris. Photographs of the items identified within the grid are provided in **Appendix I**.

6.6.1.2.2 Analog Land Transects

In May 2012, a total of 3.18 acres of analog surveys were performed using a White's MXT All-Metals detector. Analog transects were conducted along 14,297 linear feet (2.7 miles) of Picatinny Lake shoreline. Dam construction and reworking of the southern Picatinny Lake shoreline limited the extent of planned analog transects in the Picatinny Lake portion of the Lakes MRS. Analog transects were conducted only in accessible areas where there were no obvious signs that construction activities had occurred. UXO construction support was used during dam construction and two MD items were identified during upgrades at the Picatinny Dam; a 3-inch Empty Brass Ball was identified on May 9, 2011 and a M51A1 75 mm Cartridge Case was identified on October 10, 2011.

On May 19, 20, and 26, 2012, a total of 131 anomalies were intrusively investigated along the Picatinny Lake analog transects. One UXO item, a 37mm Smoke Projectile, was recovered near Building 813. A total of 39 MD items were recovered from 0 to 12 inches bgs. The remaining anomalies include 140 items classified as cultural debris (pipes, railroad debris, and cans) and 2 geologic "hot rocks." Items were recovered at depths ranging from 0 to 12 inches bgs, with the MEC being found at 6 inches bgs. **Figure 6-19** presents the locations of the items identified within the Picatinny Lake portion of the Lakes MRS. The slug butt/impact area for the 3-inch Barbette gun was traversed during the analog transects and no items were identified.

6.6.1.2.3 Underwater Investigation

From November 10 to 12, 2012, 25 underwater anomalies in Picatinny Lake were intrusively

investigated. One UXO item was identified, as a supplemental charge for a 155mm projectile. MD consisting of an expended smoke canister at target PL-21 and a 3-inch flare base was identified at an additional anomaly (PL-23*) that was selected and investigated to replace the original target PL-23 (deemed unsafe due to its location, which was too close to the spillway/dam for safe dive operations). The new anomaly (PL-23*) was chosen to replace the original target PL-23 because the other nearby (previously not chosen) anomalies were also deemed unsafe due to the same safety hazard. While in the field, it was decided that investigating near the island would be beneficial because no anomalies had been chosen for investigation near Flare Island (where MD has been identified on land). The MD identified as a flare base was recovered at this new anomaly location (PL-23*). The remaining anomalies consisted of eight items designated as cultural debris, two anomalies considered to be geologic "hot rocks," 10 anomalies that were no finds[3] (registered an audible response but were unable to be located), and 14 anomalies that were no contacts[4]. Anomaly LP-25 was not investigated as a result of safety concerns because the anomaly is located within the outfall from the dam. The majority of the lake bottoms of both lakes are covered with a thick aquatic grass that is rooted in deep, fine silt. Fine silt has little resistance and at times, divers could penetrate more than 1 foot with the geophysical instrument but could not access the anomaly. **Figure 6-19** shows the locations of the items recovered, and **Table 6-15** provides a summary of the munition-related items identified at the Picatinny Lake portion of the Lakes MRS. The complete dig list is provided in **Appendix H**.

6.6.2 Lake Denmark

The following sections present the results of the RI field efforts that were performed at the Lake Denmark portion (**Figure 1-11**) of the Lakes MRS to achieve the DQOs.

[3] No finds are defined as an anomaly that was detected by an audible response through an analog geophysical instrument but could not be visually seen or physically located. In this scenario, the diver widened the search radius from the buoy in increments of 1 foot to a maximum radius of 10 feet from the marker buoy. Intrusive operations commenced again after the diver had audible contact.

[4] No contacts for the underwater intrusive activities are defined as an anomaly that had no audible contact through an analog geophysical instrument. Intrusive operations down to 1 foot were conducted without any audible contact. In this event, no audible contact was detected within a minimum of 3 feet from the projected location of the anomaly.

Table 6-15 Munition Related Items Summary at Picatinny Lake

Target ID No.	Item Designation	Item Description	Investigation Type	Dig Date	Quantity
Picatinny Lake Banks-1120	MD	Lugs and Fuze Parts	Analog	5/19/2012	15
Picatinny Lake Banks-1121	MD	Lugs and Fuze Parts - Debris too large to clear. Left in place with Corps approval	Analog	5/19/2012	1
Picatinny Lake Banks-1123	MD	Fragment	Analog	5/19/2012	1
Picatinny Lake Banks-1129	MD	BLU-26, Practice	Analog	5/19/2012	1
Picatinny Lake Banks-1140	UXO	37mm Projectile, Smoke	Analog	5/19/2012	1
Picatinny Lake Banks-1184	MD	Grenade Fuze	Analog	5/26/2012	5
Picatinny Lake Banks-1185	MD	Grenade Fuzes and levers - Debris too large to clear. Left in place with Corps approval	Analog	5/26/2012	1
Picatinny Lake Banks-1186	MD	Grenade Lever (spoon)	Analog	5/26/2012	1
Picatinny Lake Banks-1187	MD	Grenade Fuze	Analog	5/26/2012	7
Picatinny Lake Banks-1188	MD	Grenade Fuzes and levers - Debris too large to clear. Left in place with Corps approval	Analog	5/26/2012	1
Picatinny Lake Banks-1189	MD	Grenade Fuzes and levers (spoons)	Analog	5/26/2012	3
Picatinny Lake Banks-1190	MD	Grenade Fuzes and levers - Debris too large to clear. Left in place with Corps approval	Analog	5/26/2012	1
Picatinny Lake Banks-1192	MD	Grenade Fuzes and levers - Debris too large to clear. Left in place with Corps approval	Analog	5/26/2012	1
Picatinny Lake Banks-1193	MD	Grenade Fuzes and levers - Debris too large to clear. Left in place with Corps approval	Analog	5/26/2012	1
PL-07	UXO	Supplemental charge for 155mm projectile	Underwater DGM	11/10/2012	1
PL-21	MD	Expended smoke canister	Underwater DGM	11/10/2012	1
PL-23*	MD	3-inch flare base	Underwater DGM	11/11/2012	1

6.6.2.1 Digital Geophysical Mapping Results

The geophysical survey results presented in this section are for the Lake Denmark portion of the Lakes MRS.

6.6.2.1.1 DGM Grid Survey

A 0.23-acre DGM grid survey (LD-01) was performed using an EM61-MK2 in cart mode at the Lake Denmark 20mm Cannon Firing Point, presented on **Figure 5-34**. A total of 64 anomalies were selected from the geophysical data for intrusive investigation within the DGM grid. The intrusive investigation results are discussed further in Section 6.6.2.2.

6.6.2.1.2 Underwater DGM Survey

Two linear underwater DGM transect surveys and one meandering transect survey, totaling 3.08 miles, were conducted in the open water portion of Lake Denmark, north of the area investigated in the 1999 underwater DGM survey. After a review of the DGM data, 10 targets were chosen for further investigation, shown on **Figure 5-36**. The intrusive investigation results are discussed further in Section 6.6.2.2.

6.6.2.2 Intrusive Investigation Results

The following sections present the results of the intrusive investigation conducted at the Lake Denmark portion of the Lakes MRS.

6.6.2.2.1 Grid Intrusive Investigation

Detected anomalies from the 20mm Cannon Firing Point grid (LD-01) were investigated on 25 May 2012 to determine the anomaly source. No MEC or MD items were observed, but 25 Small Arms were identified—two shotgun primers, one blank ammunition, and 22 casings. The remaining anomalies included 59 items classified as cultural debris (foil, wire, cans and others), 3 geologic “hot rocks,” and one seed item. Items were recovered at depths ranging from 0 to 6 inches bgs.

6.6.2.2.2 Analog Land Transects

A total of 14.37 acres of analog surveys were performed using a White’s MXT all-metals detector. Analog transect surveys were conducted along 64,581 linear feet surrounding Lake Denmark. A total of 102 anomalies were intrusively investigated along the Lake Denmark analog

transects. No MEC was observed, but a total of two MD items, a fragment and a 152mm Practice Projectile, were recovered at depths ranging from 0 to 6 inches bgs. The remaining anomalies included 119 items classified as cultural debris such as cables, wires, and cans, and seven items classified as geologic "hot rocks." The items were recovered from 0 to 12 inches bgs. **Figure 6-20** shows the locations of the items recovered.

6.6.2.2.3 Underwater Investigation

On 11 November 2012, nine underwater targets in Lake Denmark were intrusively investigated. One additional anomaly, LD-03, was unable to be investigated due to safety issues at the location (unsafe diving conditions related to the thickness of the aquatic vegetation). No MEC was identified, but one MD item was identified as a M49/A28 60mm mortar (fuzed/fired). The 60mm mortar was initially classified as MPPEH, but was then designated as safe (expended) and is classified as MD in the dig list provided in **Appendix H**. The remaining anomalies consisted of one item designated as cultural debris (can), three items that were no finds (anomalies registered an audible response but were unable to be located), and four anomalies that were no contacts. Anomaly LD-10 was inaccessible (location was too shallow for diving); therefore, another anomaly location was determined in the field and investigated, LD-10*. LD-10* anomaly was chosen to replace the inaccessible/unsafe target due to proximity to the original target (LD-01). **Figure 6-20** shows the locations of the items recovered.

Table 6-16 provides a summary of the munition-related items. The complete dig list is provided in **Appendix H**.

Table 6-16 Lakes MRS: Lake Denmark Munitions Item Summary

Target ID No.	Items Initial Designation	Item Description	Investigation Type	Dig Date
LDM-T07-1006	MD	Fragment	Analog	5/9/2012
LDM-T29-1201	MD	152mm Practice Projectile	Analog	5/30/2012
LD-01*	MD	60mm Mortar (Fuzed/Fired)	Underwater DGM	11/12/2012

6.6.3 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the Lakes MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MEC CSM developed following the SI is discussed in Section 4.6.1

and Section 4.6.2, and the summary of the RI results for the Lakes MRS is presented in Section 6.6.1.2 and Section 6.6.2.2. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted, due to MC in the water being addressed under IRP and a release was not identified. The revised CSM for MEC is depicted on **Figure 6-21** for the Lakes MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

The Lakes MRS was documented in the preliminary CSM as the combined water bodies and some associated land portions surrounding Picatinny Lake and Lake Denmark. Although the lakes are non-contiguous water bodies at PTA, they have been combined into one MRS because of the similarity in the CSMs that were developed for them.

6.6.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the Lakes MRS.

6.6.3.1.1 Source

Picatinny Lake

The Picatinny Lake portion of the Lakes MRS was used as the location of a 3-inch Barbette gun range and for storing smokeless powder and explosives underwater. Additional sources are munitions dumped in the lake, munitions from the 1926 explosion, building explosions along the banks of the lake, and shortfalls from an experimental mortar range.

Two MD items were identified at Picatinny Lake during upgrades at the Picatinny Dam; a 3-inch Empty Brass Ball was identified on May 9, 2011 and a M51A1 75 mm Cartridge Case was identified on October 10, 2011.

Intrusive investigations during the RI resulted in two MEC being identified, a supplemental charge for a 155mm in the water portion of Picatinny Lake and a 37mm smoke projectile identified along the northwestern shoreline. MD consisting of grenade fuzes, a grenade lever, a fuze adaptor, a 57mm base plate, and a practice BLU-26 were identified onshore, and an expended smoke canister and a 3-inch flare base were also identified in the water.

MEC identified within the Picatinny Lake portion of the Lakes MRS was found at a depth of 4 inches bgs along the shoreline; however, the depth of MEC within the lake is unknown.

Based on the RI, MEC density is known to vary across the Picatinny Lake portion of the Lakes MRS. During the RI, two MEC items were identified within 300 feet of each other on the northwestern side of the lake (one in the water and one on land). The MD was located either on the peninsula where the 3-inch Barbette gun firing point was located, the peninsula where the slug butt several building explosions were located, or in the water near Flare Island, as shown on **Figure 6-19**. As shown on the UXO Finds maps in **Appendix B**, MEC and MD have historically been found along the southeastern portion of the shoreline and on the peninsula where the slug butt and several building explosions were located.

Lake Denmark

The Lake Denmark portion of the Lakes MRS was used for experimental testing of 60mm and 81mm mortars, and 4.2-inch inert mortars. The firing point for the mortar testing was located on the southern end of the lake with impact areas at the north and northwest end of the lake. A 20mm cannon range was also present across the lake, with the firing point located near the current softball field, and the target area on the western side of Lake Denmark near the Lakes MRS boundary. Also during an interview a Sagger Missile Firing point was identified for the Lake Denmark Range (**Figure 1-12**). During the interview it was detailed that the missiles were designed to float once the motors were expended and the missiles were recovered using boats after each firing.

On December 8, 2010 two UXO items were identified during upgrades at the Denmark dam, consisting of a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an M302A1 60mm WP mortar and M527B1 fuze and WP filler. The 60mm WP mortar was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD.

Intrusive investigations during the RI for the Lake Denmark portion of the Lakes MRS resulted in no MEC being found, but three MD (one in the water portion and 2 on land). The MD item (60mm mortar) identified in the southwestern water portion of Lake Denmark was approximately 1,200 feet from the firing point. The 60mm mortar was initially classified as MPPEH, but was then designated as safe (expended) and is classified as MD in the dig list provided in

Appendix H. The two additional MD items identified on the land portion were a 152mm Practice Projectile and a fragment.

Between December 2012 and January 2013, MEC consisting of two 60mm mortars (one was inert with a PD fuze and the other HE) were identified by REMTEC, one on the west side of Lake Denmark and one on the east side of the lake near the Lakes MRS north boundary, as work was being conducted along the PSE&G electrical tower right-of-way. Note the 60mm HE mortar was identified just outside the Lakes MRS boundary and near/possibly outside of the installation boundary.

Based on the RI, MEC density is known to vary across the Lake Denmark portion of the Lakes MRS. During the RI, two MEC associated with the activities within the MRS were found by REMTEC. One of the MEC items, a 60mm HE mortar, was identified near/outside the northern MRS boundary. Overall two UXO items have been identified within the Lake Denmark portion of the Lakes MRS, both 60mm mortars (inert with a PD fuze and WP), shown on **Figure 6-20**. The second 60mm WP mortar was recovered during a USACE site walk in 2010 near the 20mm cannon firing point. Based on data from the RI, the MEC density within the Lakes MRS was determined to be low and to vary across the MRS.

MD identified within the Lake Denmark portion of the Lakes MRS has been found at depths of 12 inches bgs on land; however, the depth of the MEC is unknown since the mortars were not identified during the RI.

6.6.3.1.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

Picatinny Lake

Once on PTA, there is currently unrestricted access to the majority of the Picatinny Lake portion of the Lakes MRS for current authorized receptors. Portions of the Lake have limited access because of fencing. The lake is accessible for various recreational activities including fishing and boating. Fishing is allowed from the lake shore (except certain areas, which are restricted due to site activities, such as buildings where propellant mixing occurs), by boat, or, during the winter

fishing is allowed from the ice. Engineering controls, including warning signs are present at the major access points of Picatinny Lake describing restrictions of site use. Due to state-wide mercury, PCB, and dioxin contamination, a fishing advisory is in place to control consumption of Picatinny Lake fish. Both gasoline-powered boats and nonmotorized boats are allowed on the lake, but the speed of gasoline-powered boats is limited such that wake generation is not permitted. Under the existing program, boats may be launched from permissible areas, which are not limited to ramps/docks. No swimming or sail boarding is allowed in Picatinny Lake (ARCADIS, 2012).

A receptor may contact MEC that is on the ground surface simply by walking. A receptor may contact MEC in the subsurface by performing intrusive activities. Maintenance activities near the dam, boat docks, or buildings around Picatinny Lake may disturb surface and subsurface soils. It is unlikely that a receptor would contact MEC within the water portion of the lake because of access restrictions on swimming and wading.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

Lake Denmark

Once on PTA, there is currently unrestricted access to the Lake Denmark portion of the Lakes MRS for current authorized receptors. Additionally, a portion of Lake Denmark to the east, bordering the installation boundary is not fenced, therefore unauthorized receptors (trespassers) could have to access to the Lake Denmark portion of the Lakes MRS. The lake is accessible for various recreational activities including fishing and boating. Fishing is allowed from the lake shore (except certain areas, which are restricted due to site activities, such as the western shore of the lake), by boat, or, during the winter fishing is allowed from the ice. Engineering controls, including warning signs are present at the major access points of Lake Denmark describing restrictions of site use (ARCADIS, 2012).

A receptor may contact MEC that is on the ground surface simply by walking. A receptor may contact MEC in the subsurface by performing intrusive activities. Maintenance activities in the vicinity of the dam, boat docks, softball field, or buildings around Lake Denmark may disturb surface and subsurface soils. It is unlikely that a receptor would contact MEC within the water portion of Lake Denmark because of access restrictions on swimming and wading.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

6.6.3.1.3 Activity

Picatinny Lake

Current activities at the Picatinny Lake portion of the Lakes MRS include being used as a nonpotable water source for firefighting and production purposes, fishing, and recreational boating. LUCs are in place that ban swimming/wading in the water. Fish consumption advisories are in effect because of elevated contaminant levels in fish tissue. There no current plans to change the land use.

Lake Denmark

Current activities at the Lake Denmark portion of the Lakes MRS include being used for recreational boating and fishing. LUCs are in place that ban swimming/wading in the water. Fish consumption advisories are in effect because of elevated contaminant levels in fish tissue. Former ranges at Lake Denmark and the surrounding upland forested areas are designated as other than operational ranges. There no current plans to change the land use.

6.6.3.1.4 Receptors

Picatinny Lake

Human receptors identified for the Picatinny Lake portion of the Lakes MRS include both current and anticipated future land users. The revised MEC CSM in the RI identifies PTA personnel, residents, contractors, visitors, and recreationists.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the Picatinny Lake portion of the Lakes MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. Picatinny Lake is considered to be an open-water wetland. The northern end of Picatinny Lake is dominated by scrub/shrub wetland with smooth alder (Alnus serrulata) and swamp azalea (Rhodendron viscosum). Ecological receptors known to be present at the Picatinny Lake portion of the Lakes MRS include fish, birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors, reptiles, amphibians, and mammals.

Lake Denmark

Human receptors identified for the Lake Denmark portion of the Lakes MRS include both current and anticipated future land users. The revised MEC CSM in the RI identifies PTA personnel, residents, contractors, visitors, recreationists, and trespassers.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the Lake Denmark portion of the Lakes MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. The northern portion of Lake Denmark is dominated by scrub/shrub wetland with smooth alder (Alnus serrulata) and swamp azalea (Rhodendron viscosum). Undeveloped, forest surrounds the lake with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present at the Lake Denmark portion of the Lakes MRS include fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, including featherfoil (Hottonia inflate), Robbin's pondweed (Potamogeton robbinsii), small bur (Sparganium minimum), and lesser bladderwort (Utricularia minor). Lake Denmark is also located adjacent to Area J (shown in **Appendix B**), which is a summer roosting area for the federally endangered Indiana bat. Gravel Dam Cove, located in the southern end of Lake Denmark, is a unique pond habitat that supports breeding populations of the New England bluet, a rare damselfly.

6.6.3.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Lakes MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-21.**

Exposure pathways for MEC are considered complete because MEC was identified within both portions of the Lakes MRS. Complete exposure pathways exist for PTA personnel, residents, contractors/visitors, and recreationists/trespassers who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments. Residents and personnel who work in the buildings close to the lakes may have access to the shorelines. Swimming is banned, but it is

possible that recreationists/trespassers and children could still try to swim in the lakes and may contact MEC in the sediments. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil and sediment or who may perform intrusive work during future construction or otherwise intrusive activities. Complete exposure pathways exist from MEC in surface soil and surface sediment to terrestrial and aquatic vegetation and wildlife and from MEC in subsurface soil to biota that burrow or nest in the subsurface soil.

6.6.4 Munitions Constituents Sampling and Analytical Results

In accordance with the Work Plan (WESTON, 2012), a MEC release was not observed during the intrusive investigation; therefore, no MC characterization was warranted. The water portions of the Lakes MRS, along with the land portion of Picatinny Lake, are being addressed under the IRP. Lake Denmark (Site 54) is known as IRP Site PICA-015, and Picatinny Lake is IRP Site PICA-057. The production buildings around Picatinny Lake are known as PICA-135. The FS for both water sites was submitted in October 2009. Surface water and sediment samples were collected and analyzed for explosives and metals under the IRP. The RI/FS for the land portion of Picatinny Lake, which included the collection of groundwater, soil, and sediment samples that were analyzed for explosives and metals, was submitted in December 2009.

Although complete exposure pathways for MC exist, MC is addressed under the IRP.

6.7 LAKE DENMARK – OFF-POST MRS

Lake Denmark – Off-Post MRS has been the focus of numerous previous investigations and sampling events. All of these investigations were pre-RI activities and did not definitively assess the nature and extent of contamination at the MRS. The RI results will use all of the previously compiled information to evaluate the presence or absence of MEC within the Lake Denmark – Off-Post MRS.

The field activities originally planned have not been conducted within the Lake Denmark – Off-Post MRS because of access restrictions for intrusive investigations. The property is in receivership; therefore, the New York District Army Corps of Engineers Real Estate Office would need to petition the New Jersey court system through the Department of Justice (DoJ) to acquire access agreements. However, the petition process would likely take longer than the period of performance associated with the MMRP RI contract. Attempts to gain access for

intrusive work through other avenues were unsuccessful. Therefore, the intrusive work planned as part of the MMRP RI and detailed in the Final RI Work Plan, will not be permitted. However, instrument-assisted non-intrusive visual surveys are possible at the Lake Denmark – Off-Post MRS through an access agreement with Sterigenics. The Amendment to the Final Work Plan, submitted June 12, 2013, details the field approach change and revised DQOs. The original and revised DQOs are also provided in Section 4.7.2.

6.7.1 Digital Investigation Results

Using a White's MXT, 30,817 feet (5.84 miles) of visual surveys were traversed across the portions of the Lake Denmark – Off-Post MRS that constituted the investigation areas, shown on **Figure 4-1**. Within the two non-contiguous investigation areas, 78 anomalies were identified and logged; 15 anomalies were identified within the northern investigation area and 63 anomalies were identified within the southern investigation area. Three anomaly locations were identified as non-munitions related trash pits because of the quantity of surface debris in these areas. No MEC, MD or munitions related features such as cratering were observed. The proposed and actual transects as well as the anomaly locations are presented on **Figure 5-37**.

The anomaly locations were further assessed using VSP to determine the anomaly density and distribution across the MRS. The anomaly density plot is presented in **Figure 6-22**. VSP was used to analyze the non-intrusive visual survey data collected at the Lake Denmark – Off-Post MRS to identify anomaly cluster areas that may suggest the location of concentrated munitions use such as an impact area (represented by high density areas). The northern portion of the MRS was determined to have an anomaly density of approximately 11 anomalies per acre while the southern portion of the MRS has an anomaly density of approximately 24 anomalies per acre.

Two areas in the southern portion of the MRS were identified as having elevated anomaly densities relative to the low background anomaly density. These elevated anomaly density areas consist of approximately 54 anomalies per acre across an area of approximately 3 acres and 1.5 acres. The location of these elevated anomaly density areas are presented on **Figure 6-22**. While these two areas have anomaly densities greater than the background density of 24 anomalies per acre, the anomaly densities are substantially lower than what would be anticipated at a typical impact area. In addition, no MEC or MD was observed on the ground surface in these anomaly density areas or anywhere in the MRS. MEC and MD would typically be visible on the ground

surface at an impact area.

In accordance with the revised DQO's presented in Section 4.7.2.2, no intrusive activities were planned or conducted at the Lake Denmark – Off-Post MRS.

6.7.2 Munitions Constituents Characterization

No MEC or MD was identified at the Lake Denmark Off-Post MRS during the RI fieldwork. It was determined that sampling for MC was not warranted. This is consistent with the MC DQOs documented in the Final RI Work Plan.

6.7.3 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the Lake Denmark – Off-Post MRS based on the results of the data collected for the RI to supplement information provided during previous investigations, and previous information in the SI report and the HRR. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The revised CSM for MEC is depicted on **Figure 6-23** for the Lake Denmark – Off-Post MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.7.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the cumulative data collected across the Lake Denmark – Off-Post MRS during the MMRP SI and RI fieldwork in addition to coverage from environmental investigations performed as part of the RTI Superfund site in order to make MEC exposure analysis conclusions.

6.7.3.2 Source

The Lake Denmark – Off-Post MRS is a 113 acre portion of a mortar range safety fan centered in Lake Denmark. MEC may be present in the MRS due to misfires or overshoots from the Lake Denmark mortar range. These activities could have resulted in MEC occurring at low densities located sporadically across the MRS, unlike heavily concentrated areas within an impact area. An example of this sporadic occurrence could be the 60mm HE mortar recovered north of the MRS boundary. Mortars may be on the ground surface or in the subsurface and may occur at

such low densities that they would not have been observed during the numerous environmental sampling activities. However, it is unlikely that the Lake Denmark – Off-Post MRS would have been impacted due to the location of an observation point for the Lake Denmark mortar ranges, shown on **Figure 1-12**. In order to impact the MRS, mortars would need to have been fired near and/or beyond the observation point, which would have posed a safety hazard to personnel.

The majority of the Lake Denmark – Off-Post MRS has been traversed during environmental sampling activities as part of the RTI Superfund site. Intrusive mag & dig surveys have been completed south and east of the MRS, in the Lake Denmark portion of the Lakes MRS on Picatinny Arsenal. SI and RI visual surveys have also been performed in the Lake Denmark – Off-Post MRS. The locations of the historical sampling and SI transects are shown on **Figure 2-4**. No MEC or MD has been reported in the Lake Denmark – Off-Post MRS to date. Because no MEC or MD have been discovered in the MRS during previous investigation at the MRS and the results of the RI fieldwork suggest a low subsurface anomaly density that is not consistent with impact areas, it is not expected that a MEC source or explosive safety hazard is present at the Lake Denmark – Off-Post MRS.

6.7.3.3 Activity

The Lake Denmark – Off-Post MRS is in receivership and is currently leased by Sterigenics. The majority of the MRS is part of the RTI Superfund site. A small portion of the MRS is owned by Rockaway Township. Current activities at the MRS include environmental remediation and sampling work. Most of the activities involve foot traffic; however, the sampling and remedial activities may include disturbing surface and subsurface soils. For the purposes of this RI, the anticipated future land use at the Lake Denmark – Off-Post MRS is not anticipated to change.

6.7.3.4 Access

Access to a portion of the Lake Denmark – Off-Post MRS, consisting of the RTI Superfund Site, is restricted by a perimeter fence. ROEs are also required for access to the privately owned property. The remaining portion of the MRS does not have any physical boundaries, and is open to recreational use. Once on the MRS, receptors would have access to MEC on surface and in subsurface soil if they exist.

6.7.3.5 Receptors

Human receptors identified for the Lake Denmark – Off-Post MRS include both current and anticipated future land users. Human receptors include Sterigenics workers, utility workers, contractors, and visitors. Additional receptors could include recreationists including hunters and hikers.

Ecological receptors (biota) for the purposes of the revised MEC CSM at the Lake Denmark – Off-Post MRS are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the vicinity, based on the MRS physical setting, reasonably anticipated to be present on either a permanent or transient basis. Undeveloped, forest exists within the MRS with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present, in the vicinity of the MRS, at the Lake Denmark include fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, including featherfoil (Hottonia inflate), Robbin's pondweed (Potamogeton robbinsii), small bur (Sparganium minimum), and lesser bladderwort (Utricularia minor). The Lake Denmark – Off-Post MRS is also located near a summer roosting area for the federally endangered Indiana bat.

6.7.3.6 Munitions and Explosives of Concern Exposure Conclusions

Given that no MEC source has been identified and an explosive safety hazard is not anticipated to exist at the Lake Denmark – Off-Post MRS, there are no activity/access/receptor interactions ongoing or anticipated under current or future land use where the receptor may come in contact with MEC. As a result, the revised CSM for MEC identifies incomplete pathways for surface and subsurface soils for all receptors having access to the MRS.

6.8 INACTIVE MUNITIONS WASTE PIT MRS

The Inactive Munitions Waste Pit MRS consists of 21 acres on Green Pond Mountain and is bordered by the PTA installation boundary to the northwest. Based on the available historical information, MEC and MD, have been released in the Inactive Munitions Waste Pit MRS from former testing activities and munitions disposal. A portion of the AOI Code 300 Area also overlaps the MRS that, according to the 1973 Survey Report, was used for artillery firing of

shells up to 155mm and fragmentation pattern testing (WESTON, 2012).

6.8.1 Digital Geophysical Mapping Results

Based on the 6,163 linear feet of DGM transect surveys conducted within the Inactive Munitions Waste Pit MRS, the lateral and vertical extent of a large waste pit has been determined and is presented in **Figure 6-24**. The waste pit area is estimated to extend laterally over 0.24 acre (10,498 square feet) from ground surface down to bedrock, approximately 24.5 feet bgs. Assuming an even distribution of buried material, the approximate maximum volume of the waste pit is 257,201 cubic feet (9,526 cubic yards).

6.8.2 Intrusive Investigation Results

6.8.2.1 DGM Intrusive Investigation

No intrusive investigations for MEC were performed based on the DGM described above to define the lateral extent of buried debris because the presence of MEC and MD was confirmed based on the available historical information. However, intrusive investigation within the Inactive Munitions Waste Pit MRS was performed via trench inspection and characterization sampling for MC, described below in Section 6.8.4, in conjunction with an ongoing IRP investigation. During the intrusive investigation, munitions-related debris determined to be MEC was further confirmed as being present within debris buried at the MRS, described below in Section 6.8.2.1.3.

6.8.2.1.1 Analog Transects

No anomalies were detected that warranted intrusive investigation during the 830 linear feet of analog transects performed within the Inactive Munitions Waste Pit MRS, around the periphery of the burial site identified via DGM and not overlapping with the AOI Code 300 Area.

6.8.2.1.2 AOI Code 300 Area Density Transects

A total of 3,020 linear feet of density transects were conducted in the area of the Inactive Munitions Waste Pit MRS overlapping with the AOI Code 300 Area. After the density transects were completed an analog grid Code300-12 (50 x 50 feet) was placed to characterize a potential high density area. The location of the grid is shown on **Figure 6-27**. A total of 14 anomalies were identified within the grid; only one item was identified as MD, an M42 submunition body,

which was recovered from 3 inches bgs. The remaining 13 items were classified as cultural debris. The items were recovered from 0 to 3 inches bgs. Results for the entire AOI Code 300 Area are discussed further in Section 6.1.2.1.1.2. Documentation of the final resolution of all anomalies intrusively investigated is provided in the dig list in **Appendix H**.

6.8.2.1.3 Non-RI Intrusive Investigation

Shaw E & I completed an intrusive investigation, consisting of trenching activities, under the IRP to investigate the source of a TCE plume (Shaw, 2010) at the former testing area at the center of the Inactive Munitions Waste Pit MRS. The trench was intended to be a 60-ft trench with a depth extending into clean native soil or top of bedrock. The loose gravel nature of the fill material resulted in the final excavation of a test pit with an approximate 40-ft diameter opening at the surface and a final depth of 24.5 ft bgs terminating at the bedrock interface. The location of the trench is shown on **Figure 6-24**. During the intrusive investigation, MEC and MD were confirmed at the MRS. Only one MEC item was identified during the investigation, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines) recovered during the 2011 phase of work. MD recovered during the trenching activities are listed below (Shaw, 2013):

Quantity	Description
1	Cartridge, Photoflash: Practice, M121, Expended
13	M72 Rocket Launcher for 66mm Rocket (LAW), Empty - no sights
1	XM31 Anti Tank Land Mine, Expended
1	155mm Fragment (ogive)
1	Aircraft Flare, MK45, Expended
1	PD Fuze, Expended
1	BLU 3/B plate
1	CDU-10 canister cover
3	BLU 39/B Skitters, CN/CS Tear Gas, Inert
7	40mm Grenade Cartridge Cases, Expended
1	Electric Blasting Cap, Expended
12	Fuzes M48, M51, M81 Series, M557 Series, and M572

6.8.3 Revised MEC Conceptual Site Model

The following sections present the revised CSM for MEC at the Inactive Munitions Waste Pit MRS based on the results of the data collected for the RI to supplement previous information provided in the SI report and the HRR. The preliminary MEC CSM developed following the SI is discussed in Section 4.8.1 Remedial Response Objectives, and the summary of the RI results for the Inactive Munitions Waste Pit MRS is presented in Section 6.8.2. The information

collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. An MC CSM was developed and provided in Section 6.8.5. The revised CSM for MEC is depicted on **Figure 6-25** for the MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.8.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for the Inactive Munitions Waste Pit MRS.

6.8.3.1.1 Source

Confirmed MEC discovered at the Inactive Munitions Waste Pit MRS consists of one gravel mine canister (Shaw, 2013). Intrusive operations during the IRP activities recovered MD at the former testing area in the center of the Inactive Munitions Waste Pit MRS consisting of: M72 Rocket Launcher for 66-mm (LAW) rockets, CN/CS teargas canisters (inert), expended 40-mm grenade cartridge cases, an exploded XM31 antitank landmine, 155-mm fragments, expended MK45 aircraft flare, and expended PD fuzes (Shaw, 2013). Outside the former testing area in the remainder of the MRS, one MD item was identified, in the AOI Code 300 grid Code300-12 as an M42 submunition body.

MD and DMM comingled with other debris, including drums, that were identified within the Inactive Munitions Waste Pit MRS are consistent with historical information. The debris layer was observed below unconsolidated fill material, and terminated approximately 4.5 feet above where bedrock was encountered at 24.5 feet bgs within the excavated test trench. Based on surface DGM performed during the RI, the lateral extent of debris was observed to encompass approximately 0.24 acres within the Inactive Munitions Waste Pit MRS boundary.

Although the IRP trench investigation identified debris located primarily below 10 feet, intrusive operations performed elsewhere within the former burial pit during the IRP trench investigation have discovered MD and MEC within 10 feet of ground surface. Specifically, one DMM item, a gravel mine canister, was encountered at 4.5 feet bgs (Shaw, 2013). Assuming an average distribution of debris is buried within the Inactive Munitions Waste Pit MRS, the volume of the source area for residual MEC at the MRS is calculated to be 257,201 cubic feet (9,526 cubic yards).

In the AOI Code 300 Area, only one MD item was identified in Grid Code300-12 during the RI, an empty M42 submunition body at 3 inches bgs. No MEC was identified within the AOI Code 300 area, including the portions in the Former Operational Areas MRS and 1926 Explosion Radius MRS. As previously discussed in Section 5.9.1.2, surveying in the AOI Code 300 Area was completed to meet VSP input and coverage parameters and exceeded the minimum requirements defined in the Final Work Plan for RI characterization (WESTON, 2012).

Based on the weight of evidence obtained during the RI, the MEC density in the former testing area/burial pit is considered high compared to the surrounding portions of the Inactive Munitions Waste Pit MRS where no MEC was identified. There is evidence that MEC remains at the former testing area/burial pit at the center of the Inactive Munitions Waste Pit MRS comingled with debris in subsurface soil, and MD at ground surface in the portion that overlaps with the AOI Code 300 Area. Based on RI observations, the bulk of buried debris containing potential MEC is located from 10 to 20 feet bgs, although activities document one MEC discovery in the Inactive Munitions Waste Pit MRS at 4.5 feet bgs. Based on the 0.24-acre lateral extent of the burial pit characterized via DGM and assuming an even distribution of debris down to bedrock, the estimated quantity of waste material remaining containing MEC, and MD is 257,201 cubic feet (9,526 cubic yards).

6.8.3.1.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

Currently, the Inactive Munitions Waste Pit MRS is a restricted access area (fully fenced) within PTA that abuts operational ranges to the east and south, with the installation boundary forming the northwestern extent of the MRS. The Inactive Munitions Waste Pit MRS is only accessible to authorized personnel. Control measures maintained by PTA for the Robinson Enclosure area, which encompasses the MRS, include fencing, guarded access points, pre-authorization requirements for access, and escorts for visitors. The current access restrictions are not anticipated to change in the future, and the Inactive Munitions Waste Pit MRS is not currently included in any future overall redevelopment plans for PTA because of its proximity to operational ranges.

Once within the MRS boundary, potential receptors would have access to any MEC in surface or subsurface soil outside the burial area. Within the burial area potential receptors would have access to any MEC in the subsurface only, but is highly unlikely to occur given the depth of confirmed MEC (at least 4.5 feet bgs), and the observed depth of the bulk of debris characterized during the RI, which was found to contain MEC at depths equal to and greater than 10 feet bgs. However, personnel/contractors attempting to remediate the TCE (reason for IRP trenching) could come in contact with any MEC in the subsurface.

6.8.3.1.3 Activity

Authorized PTA personnel and/or contractors currently use the center portion of the Inactive Munitions Waste Pit MRS for material and equipment staging (e.g., vehicles, sand, and gravel) The current use is not anticipated to change in the future, and the Inactive Munitions Waste Pit MRS is not currently included in any future overall redevelopment plans for PTA because of its proximity to operational ranges. Intrusive activities may be required by authorized PTA personnel or contractors. Visitors may be authorized to enter the MRS and would potentially engage in the same activities described for PTA personnel/contractors. Recreational use within the Inactive Munitions Waste Pit MRS is allowed for hunting in a regulated manner. Hunting is permitted only on Saturdays and holidays and is restricted to only five hunting individuals at one time within the Robinson Enclosure area.

Although trespassers were considered as potential human receptors based on information available when the SI was performed, the findings of the RI do not support this potential category of receptors and trespassers are not being carried forward as receptors in the revised CSM. The control measures observed to be maintained by PTA for the Robinson Enclosure area, which encompasses the Inactive Munitions Waste Pit MRS, include fencing, guarded access points, pre-authorization requirements for access, and escorts for visitors. Thus, the potential for trespassers to be exposed to residual MEC is highly unlikely.

As a result of the restricted access provided by the fence around the Inactive Munitions Waste Pit MRS, the current use of the property for equipment/material staging, and the largely open ground surface where the burial pit has been delineated based on DGM, biota activities are expected to be limited within the MRS at the burial site primarily to activity in soil located within 2 feet bgs. Sparse forested areas, including some shrubby habitat, surround the Inactive Munitions Waste Pit

MRS but none of the natural communities occupy land where the former burial pit has been delineated. The NJDEP i-Map Landscape Project layer indicates that the MRS contains habitat with at least one occurrence of a state-listed threatened species.

6.8.3.1.4 Receptors

Human receptors identified for the Inactive Munitions Waste Pit MRS include both current and anticipated future land users. At this time, current and future users are considered to consist of authorized PTA personnel, contractors, visitors (e.g., regulatory personnel) and recreational users. Unauthorized trespassers are highly unlikely given the controlled access to the Inactive Munitions Waste Pit MRS.

For the Inactive Munitions Waste Pit MRS, potential ecological receptors (biota) for the purposes of the revised MEC CSM were identified as the listed and unlisted mammals, birds, and vegetation species known to be present at PTA and, based on the MRS physical setting (detailed in Section 3), which could be present on either a permanent or transient basis. The NJDEP i-Map Landscape Project layer indicates that the Inactive Munitions Waste Pit MRS contains habitat with at least one occurrence of a state threatened species. Sparse forested areas, including some shrubby habitat, surround the MRS, but none of these natural communities occupy land where the former burial pit was demarcated employing DGM during the RI. Although present within the Inactive Munitions Waste Pit MRS, an exposure pathway to confirmed MEC at the MRS to ecological receptors is highly unlikely to occur given the depth of confirmed MEC (at least 4.5 feet bgs), and the observed depth of the bulk of debris characterized during the RI, which was found to contain MEC at depths equal to or greater than 10 feet bgs.

6.8.3.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI and IRP trenching activities were used to update the preliminary MEC CSM for the Inactive Munitions Waste Pit MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. The revised exposure pathways analysis is presented on **Figure 6-25.**

Exposure pathways for MEC are considered complete because MEC was found within the burial area of the Inactive Munitions Waste Pit MRS. Complete exposure pathways exist for the PTA

personnel who may contact MEC in the subsurface soil. Complete pathways for the confirmed subsurface MEC source were identified for authorized human health receptors engaging in intrusive activities in the Inactive Munitions Waste Pit MRS, because of the restricted access and current use/activities ongoing within the MRS, neither of which is expected to change based on the proximity to operational ranges. Surface MEC related to historical burial of munitions or use pertaining to the AOI Code 300 Area was not observed during the RI. MD was only discovered at ground surface in the AOI Code 300 Area overlap area. Surface MEC exposure pathways are not anticipated to be present to human receptors given that buried debris containing confirmed MEC has been detected deeper than 4 feet bgs where environmental factors (e.g., frost) may bring subsurface MEC to the surface in the Inactive Munitions Waste Pit MRS.

The exposure pathways are incomplete for biota that may contact MEC in the subsurface soil during burrowing based on the confirmed location of MEC source material at depth in subsurface soil. The pathway to ecological receptors is probably present, but incomplete as no MEC source material was confirmed within 2 feet of ground surface where biota activity is most likely.

6.8.4 Munitions Constituents Sampling and Analytical Results

Both random sampling and biased sampling approaches for the Inactive Munitions Waste Pit MRS were detailed in the Final RI Work Plan; however, as stated in Section 5.9.2 only a biased approach was used. Biased soil samples for MC analysis were collected from the Inactive Munitions Waste Pit MRS during the IRP (PICA-58) trenching activities. From May 22 to 24, 2012, three soil samples and one field duplicate were collected and analyzed for perchlorate and the MC list presented in **Table 5-5**. Samples were collected in accordance with the Final RI Work Plan (WESTON, 2012). Field sheets and photographs for the sampling event are provided in **Appendix M**.

The samples were collected at various depths and from locations with varying soil conditions. The sample locations and depths are shown on **Figure 6-24**. The samples were collected in fill/debris until native soil/bedrock was reached at approximately 20 ft bgs, where one sample was collected in native soil. Refer to **Table 6-17** for additional details. One analyte in one sample was detected at concentrations greater than the background concentration, ecological health criteria, and the human health criteria: 2,4-dinitrotoluene at 8.3 mg/kg. Two additional explosives, 2,6-dinitrotoluene and tetryl were detected in a soil sample at concentrations greater

than the ecological health criteria but less than the human health criteria with a maximum detection of 0.44 and 6.1 mg/kg respectively. Cadmium, copper, and zinc were detected in a soil sample at concentrations greater than the PTA-specific background concentration and the ecological health criteria but less than the human health criteria with a maximum detection of 29, 220, and 190 mg/kg respectively. The sampling results were not affected by the utilization of solely a biased approach. The statistical approach was designed to determine extent of potential contamination from munitions related site activities. Because only low levels (below the Human Health criteria in all but one sample at the greatest depth) were identified in biased areas where the concentration should have been the highest, it was determined that extent of contamination with exceedences was limited to the area of fill. Detailed information, including analytical results for the samples, can be found in **Appendix M**.

Table 6-17 Inactive Munitions Waste Pit MRS – MC Sampling

Sample ID	Date Collected	Depth (ft bgs)	Field Sampling Notes
IMWP-002	5/22/2012	10-11	The excavator encountered debris, including munitions, 55-gallon drums, and related debris.
IMWP-003	5/23/2012	19-20	The excavator encountered stained soil from 18 to 20 ft bgs and transitioned from fill to native soil. Sample was collected from below bulk of debris.
IMWP-004	5/24/2012	24-24.5	The excavator likely hit bedrock; sample was collected in native soil having a faint odor.
IMWP-006	5/23/2012	19-20	Duplicate of sample IMWP-003.

The IRP studies addressed areas associated with the 600 Area Groundwater Plume Investigation, which included the trenching activities at the IRP Site PICA-058 (former testing area in the Inactive Munitions Waste Pit MRS). The data report/FS covers the affected groundwater in the 600 Area, surface water, soils, or waste material that may have contributed to the groundwater contamination (SHAW, 2013). In addition to the trenching activities and soil sampling, other sampling/monitoring activities were included in the 600 Area Groundwater Plume Investigation, including those listed below:

- Passive soil gas survey in all Areas of Concern.
- Very low frequency surface geophysical survey of the 600 Area.
- Installation of eleven bedrock monitoring wells.

- Borehole geophysics and packer testing of the AWDF and installed monitoring wells.
- Aquifer Pumping Test.
- Groundwater and surface water oxygen isotope sampling.
- Groundwater, Surface Water, Sediment, and Soil Sampling.
- Human and Ecological Risk Assessment.

A total of nine groundwater and surface water sampling rounds were conducted from November 2004 through June 2008, and included analysis for volatile organic compounds (VOCs) with Tentatively Identified Compounds and Baseline explosives. Two additional rounds of groundwater and surface water sampling were completed in May 2010 and February 2011. During the soil sampling conducted during June 2011 and May 2012 (in association with the trenching) VOC's, SVOCs, metals and baseline explosives (RDX only) were the compounds analyzed.

VOC level of concern exceedances were detected in groundwater, and included TCE and Methyl Tertiary Butyl Ether (MTBE). Surface water VOC exceedances included TCE, but were not observed in sediment and soil. Baseline explosive (RDX) exceedances were detected in groundwater and surface water, but not in sediment. RDX groundwater concentrations within the 600 Area was subject to a separate report and determined to require no further action. The TCE sampling data shows a steady state plume originating in IRP site PICA-058 (former testing area in the Inactive Munitions Waste Pit MRS), which currently discharges to surface water at two locations, and impacted the (now off-line) AWDF non-potable well. TCE was identified as the sole COC for groundwater (SHAW, 2013).

6.8.5 Revised Munitions Constituents CSM

The following sections present the revised CSM for MC at the Inactive Munitions Waste Pit MRS based on the results of the data collected during the RI to supplement previous information provided in the SI report and the HRR. The preliminary MC CSM developed following the SI is discussed in Section 4.8.1. The field investigation and data evaluation pertaining to MC at the Inactive Munitions Waste Pit MRS are provided in Sections 5.9.2 and 6.8.4, respectively. The revised CSM for MC is depicted on **Figure 6-26** for the Inactive Munitions Waste Pit MRS as a flow chart summarizing the pathway and exposure analysis presented below.

6.8.5.1 Revised Munitions Constituents Exposure Pathways Analysis

This section summarizes the RI data results for the MC exposure pathway analysis for the Inactive Munitions Waste Pit MRS.

Historical data collection has included surface soil and sediment evaluation for MC as reported in the HRR and included in the pathway analysis developed following the SI (Malcolm Pirnie, 2008). Although no COPCs or COPECs were identified following the SI, potentially and/or complete pathways were identified to both human health and ecological receptors for some of the pathways evaluated based on historical data; therefore, additional MC characterization was completed during the RI at the Inactive Munitions Waste Pit MRS. Based on the characterization efforts, the findings of the RI were used to update the preliminary CSM for MC to determine whether the pathway for MC is complete or incomplete for potential human health and ecological receptors at the Inactive Munitions Waste Pit MRS. The following sections detail the individual pathway elements evaluated to update the CSM.

6.8.5.1.1 Source

Potential MC was assessed at the Inactive Munitions Waste Pit MRS in soil found directly in contact with MEC intermingled with other debris. Although the bulk of the debris was observed at depths from 10 to 20 feet bgs during the RI in 2012, the 2011 discovery of a gravel mine canister (identified as MEC) occurred at a depth of 4.5 feet bgs (Shaw, 2013). As reported above in Section 6.8.1, geophysical data acquisition during the RI indicates that the burial pit is present over a 0.24-acre portion of the Inactive Munitions Waste Pit MRS with a conservative volume of approximately 257,201 cubic feet (9,526 cubic yards) assuming the depth of debris extends to bedrock (approximately 24.5 feet bgs).

Historical information regarding the type of munitions potentially buried at the Inactive Munitions Waste Pit MRS is inconclusive. A wide variety of MD was observed in buried debris during the IRP trenching activities. The list of MEC and MD identified during the IRP trenching activities is included in Section 6.8.2.1.3. MC sampling, evaluated perchlorate and the baseline list of explosives and metals that were identified in the UFP-QAPP prepared for the RI based on munitions typically associated with historical PTA activities (WESTON, 2012).

Discrete sampling conducted during the MMRP RI and during collocated IRP activities at biased

locations associated with discovered munitions-related debris has not indicated that elevated concentrations of MC greater than selected screening levels are present (see Section 6.8.4 and Shaw, 2013). During the RI, various compounds, including all metals analyzed and several explosives compounds, were positively detected by the laboratory in the biased samples (see the Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M**), but only one sample analyzed by the laboratory yielded results that indicated the presence of a screening level exceedance. The compound 2,4-dinitrotoluene was detected at a concentration of 8.3 mg/kg, which exceeds the selected screening level of 1.6 mg/kg, in the sample collected from native soil, just above bedrock and approximately 4 feet below the bulk of buried debris observed during the RI. The 2,4-dinitrotoluene was only detected in one sample at the greatest depth sampled (24-24.5 ft bgs) and was not detected in the groundwater, surface water, or sediment sampling conducted for the 600 Area. Therefore, based on a weight of evidence approach that incorporates both exposure potential and supplement data from collocated IRP activities, inferring that a hazardous release of MC is not present from potential source material, and 2,4-dinitrotoluene was not selected as a COPC.

All metals analytes, except for antimony, were positively detected by the laboratory. However, only aluminum, cadmium and zinc were detected at levels that warranted further review for COPC selection. Aluminum was detected in all samples at a concentration of 11,000 mg/kg, which was slightly above the project screening level of 7,700 mg/kg selected to assess a target HQ of 0.1. Cadmium was detected in one sample (PTA-2012-IMWP-002) at a concentration of 29 mg/kg, which slightly exceeded the project screening level of 7 mg/kg selected to assess a target HQ of 0.1. Adjusting the screening levels upwards to assess a target HQ of 1.0, equivalent to the published valued, resulted in nonselection as a COPC because the observed concentrations were well below the alternative screening levels. Zinc was the only other metal analyte detected at notable concentration, which was 190 mg/kg in one sample (PTA-2012-IMWP-002) and slightly above the PTA-specific background value of 77 mg/kg, but well below the project screening level of 2,300 mg/kg. Neither aluminum, cadmium or zinc were identified as COPCs for further quantitative analysis.

6.8.5.1.2 Release Mechanisms, Exposure Routes and Media

Release of MC to environmental media occurs initially through direct contact at the munitions

impact/disposal site. The potential source area for MC at the Inactive Munitions Waste Pit MRS is buried munitions-related debris, the bulk of which was observed at depths between 10 and 20 feet bgs; therefore, the primary release mechanism is adsorption to adjacent soil. Based on biased analytical sampling of soil in direct contact with buried debris including MEC, a direct release of MC to soil was not observed. When present, MC in soil has the potential for secondary release via infiltration within soil or leaching to groundwater, however, the lack of an identified MC source in soil infers that this potential transport mechanism is not contributing concentrations of MC to groundwater at the MRS. It should be noted however that groundwater at PTA is regulated under the IRP and was not assessed within the MRS as part of the MMRP RI.

Sediment and air are not anticipated to be primary or secondary release exposure mediums for MC associated with historical munitions burial in the Inactive Munitions Waste Pit MRS based on the depth of debris observed during the RI. Exposure routes for MC to affect potential receptors include ingestion, incidental ingestion, inhalation, and direct contact based on specific media-to-receptor pathways. There are no surface water bodies present in the MRS.

When biota are exposed to elevated concentrations of MC in environmental media, uptake via food chain interactions has the potential to bioaccumulate and affect human receptors engaging in hunting/consumption of contaminated organisms.

6.8.5.1.3 Receptors

MC exposure receptors are the same as MEC exposure receptors within the PTA boundary as stated in Section 6.8.3.1.4:

- Authorized installation personnel and contractors.
- Visitors and recreational users.
- Biota.

All potential release mechanisms, exposure routes, and media were considered in evaluating the MC source-receptor interactions at the MRS based on the available information for the Inactive Munitions Waste Pit MRS following the RI.

6.8.5.2 Munitions Constituents Exposure Conclusions

As shown on **Figure 6-26**, all considered pathways in the exposure analysis for MC at the Inactive Munitions Waste Pit MRS were determined to be incomplete.

Based on the location of observed debris with MEC in subsurface soil, primary or secondary release to sediment/surface water and air is not anticipated to be exposure pathways of concern as there is no source impacting the media. Similarly, no source for exposure to potential ecological receptors is probable based on the depth of buried debris. Therefore, the exposure pathways are incomplete on **Figure 6-26**.

For the Inactive Munitions Waste Pit MRS, current conditions within the MRS boundary limit access (direct-contact exposure) to any potential subsurface MC to authorized PTA personnel, including visitors, or contractors conducting construction/maintenance activities, and regulated recreational use for hunting. Currently, use of the MRS by authorized personnel is limited to ground surface activities, although intrusive work could be required.

Although analytical sampling did detect some MC compounds in biased samples collected adjacent to discovered munitions-related debris, the concentrations were not found to be indicative of a release that would present a source of MC contamination that would adversely affect potential receptors. Low levels of MC are present, the subsurface soil pathway for MC exposure to human health receptors within the Inactive Munitions Waste Pit MRS was found to be incomplete for all receptors except authorized PTA personnel or contractors that may perform a removal action in accordance with the proposed alternative for the 600 Area Groundwater Plume FS. For these receptors the pathway is considered potentially complete because the removal action alternative has yet to be chosen as the preferred alternative.

Within the MRS boundary, groundwater is not currently extracted/used and was not observed in direct contact with buried debris. Therefore, the groundwater pathway for MC exposure to human health receptors within the Inactive Munitions Waste Pit MRS was found to be incomplete. However, the potential for MC to leach over time and affect human health receptors from the aquifer downgradient of the MRS was additionally evaluated employing IRP data being collected to assess groundwater associated with the 600 Area. Based on the data, last collected in 2008, the only explosive detected was RDX in one well (Shaw, 2009). The source is being addressed under the IRP (the recommendation of NFA has since been approved) and is not believed to be associated with the Inactive Munitions Waste Pit MRS. The chemical 2,4-dinitrotoluene, which was the only MC compound detected at concentrations greater than the screening level in RI soil samples, was not detected by the laboratory at any concentration

greater than the method detection limits (Shaw, 2009).

6.9 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

The Inactive Munitions Waste Pit – Off-Post MRS consists of a 39-acre portion of a 1,250-foot SDZ implemented around the on-post Inactive Munitions Waste Pit MRS. The MRS is a state-owned Wildlife Management Area and is heavily wooded, with steep terrain.

6.9.1 Digital Geophysical Mapping Results

In accordance with the Work Plan (WESTON, 2012), no DGM surveys were conducted in the Inactive Munitions Waste Pit – Off-Post MRS because of steep terrain.

6.9.2 Intrusive Investigation Results

Based on the 6,780 linear feet (1.51 acres) of analog transects completed in the Inactive Munitions Waste Pit – Off-Post MRS, a total of six anomalies were intrusively investigated, which are depicted on **Figure 6-27**, and fully detailed on the target dig list for the MRS provided in **Appendix H**. Four MD items were identified—a 37mm projectile and three fragments, as well as two cultural debris items. The MD was identified just below ground surface, from 2 to 4 inches bgs, and all items were determined to be MDAS prior to final transfer to PTA. The two cultural debris items were identified as a piece of scrap metal and a metallic bolt and were discovered at 1 inch bgs. **Table 6-18** below provides a summary of the recovered MD.

Table 6-18 Munition Related Items Summary at the Inactive Munitions Waste Pit – Off-Post MRS

Target ID No.	Items Initial Designation	Item Description	Investigation Type	Dig Date	Depth bgs (inches)
IMW-T04-1003	MD	37mm Projectile, Empty Casing	Analog	5/24/2012	2
IMW-T04-1004	MD	Fragment	Analog	5/24/2012	4
IMW-T04-1005	MD	Fragment	Analog	5/24/2012	2
IMW-T04-1006	MD	Fragment	Analog	5/24/2012	2

6.9.3 Revised Munitions and Explosives of Concern Conceptual Site Model

The following sections present the revised CSM for MEC at the Inactive Munitions Waste Pit – Off-Post MRS based on the results of the data collected for the RI to supplement previous information gathered for the SI and the HRR. The preliminary MEC CSM developed following

the SI is discussed in Section 4.9.1 Remedial Response Objectives, and the summary of the RI results for the Inactive Munitions Waste Pit – Off-Post MRS is presented in Section 6.9.2. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The revised CSM for MEC is depicted on **Figure 6-28** for the Inactive Munitions Waste Pit – Off-Post MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

6.9.3.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the RI data results for the MEC exposure pathway analysis for Inactive Munitions Waste Pit – Off-Post MRS.

6.9.3.1.1 Source

Based on the available historical information, MEC and MD were potentially released in the Inactive Munitions Waste Pit – Off-Post MRS as it falls within the SDZ for the on-post Inactive Munitions Waste Pit MRS. The previous munitions use at the Inactive Munitions Waste Pit MRS was undocumented. Potential uses may have included the evaluation of munitions and static testing of explosives and propellants, which could have resulted in munitions being kicked-out from the testing area into the Inactive Munitions Waste Pit – Off-Post MRS. No additional sources of possible munitions have been identified for the Off-Post MRS. MD discovered at the MRS during the RI was limited in extent and consisted of one 37mm projectile and three fragments, all found within four inches of ground surface. The MD was determined to be MDAS in nature and is likely associated with a release from the testing conducted at the Inactive Munitions Waste Pit MRS.

The highest density of anomalies that was detected occurred in the southwestern portion of the MRS, and although MD was confirmed to be present, no MEC was discovered. Based on the DQOs and RI objectives established in the Final Work Plan and discussed in Section 5.10.2.2, intrusive investigations achieved the RI objective for coverage and did not identify a MEC source.

6.9.3.1.2 Access

No MEC was identified within the Inactive Munitions Waste Pit – Off-Post MRS; therefore,

potential receptors would not have access to MEC. However MD was identified and would be accessible to any potential receptors within the MRS. MD was discovered during the RI within four inches of ground surface, making transport from subsurface to surface possible over time from fate and transport dynamics such as frost heave. The Inactive Munitions Waste Pit – Off-Post MRS does not have any physical boundaries other than the PTA boundary fence to the southeast, is owned by the State and is open to recreational use.

As no change to the current land use is anticipated at this time, no modifications to access were contemplated for future use regarding MD exposure for any receptors that will access the Inactive Munitions Waste Pit – Off-Post MRS.

6.9.3.1.3 Activity

The Inactive Munitions Waste Pit – Off-Post MRS occupies land designated within a state-owned (NJDEP Division of Fish & Wildlife) Wildlife Management Area that is vacant, steeply sloped, and heavily forested (WESTON, 2012). As a result of the steep topography and limited accessibility (the nearest roadway is more than 0.5-mile away), the land has been left unmaintained as a natural habitat. Recreational use (e.g., hunting, hiking) is permitted, but use for such purposes, if any, is believed to be extremely low.

6.9.3.1.4 Receptors

Human health receptors identified for the Inactive Munitions Waste Pit – Off-Post MRS include both current and anticipated future land users and consist of State employees/contractors, PTA personnel/contractors, visitors, and recreational users. Although exposure to residual MD for any human receptor is of very low potential for the MRS because of its poor accessibility and steep topography.

All potential ecological receptors for PTA (refer to Section 6.8.3.1.4), except those associated with water bodies as there are none at the Inactive Munitions Waste Pit – Off-Post MRS, are anticipated to be present and engage in activities within the Inactive Munitions Waste Pit – Off-Post MRS because it is an unmaintained forest within a Wildlife Management Area and falls within the Highlands Preservation Area. A habitat with at least one occurrence of a state-listed threatened species is present at the MRS, according to the NJDEP i-Map Landscape Project layer (WESTON, 2012).

6.9.3.2 Munitions and Explosives of Concern Exposure Conclusions

As shown on **Figure 6-28**, all considered pathways in the exposure analysis for MEC at the Inactive Munitions Waste Pit-Off-Post MRS were determined to be present, but incomplete based on a lack of confirmed MEC source.

6.9.4 Munitions Constituents Sampling and Analytical Results

In accordance with the Final Work Plan (WESTON, 2012), no analytical samples were collected to assess MC at the Inactive Munitions Waste Pit – Off-Post MRS because no MEC was discovered and the MD items that were recovered were identified as single, non-clustered items, without evidence of an MC release (non-leaking, no soil staining observed).

6.9.5 Revised Munitions Constituents Conceptual Site Model

The following sections present the revised CSM for MC at the Inactive Munitions Waste Pit – Off-Post MRS based on the results of the data collected during the RI to supplement previous information provided in the SI report and the HRR. The preliminary MC CSM developed following the SI is discussed in Section 4.9.1. No changes were found that warranted revisions to the pathways and potential exposure routes identified prior to the RI. However, potential human receptors were expanded to coincide with the revised CSM developed for MEC post-RI activities to include PTA and State personnel, contractors, and visitors in addition to recreational users.

As only four MD items were recovered during the geophysical survey conducted in the Inactive Munitions Waste Pit – Off-Post MRS, analytical sampling to assess MC was not warranted in accordance with the decision logic provided in the UFP-QAPP in the Final Work Plan (WESTON, 2012). However, given that the MC sampling and assessment for the on-post Inactive Munitions Waste Pit MRS did not identify a release of MC associated with the bulk of MEC and MD, it is assumed that MC hazards are also not present off-post because no additional sources for MC were discovered. The findings of the RI support the conclusion that pathways for MC are incomplete for the Inactive Munitions Waste Pit – Off-Post MRS.

Legend

- Former DRMO Yard
- Green Pond MRS
- Cultural Debris
- Geology
- UXO
- Munitions Debris

UXO Finds Map Items

- Munitons Debris
- MEC

Note: Some Munitions Debris items were identified at the same locations

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 200 400 Feet

0 70 140 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 6-1
Green Pond Brook MRS
Intrusive Results

12/5/2013

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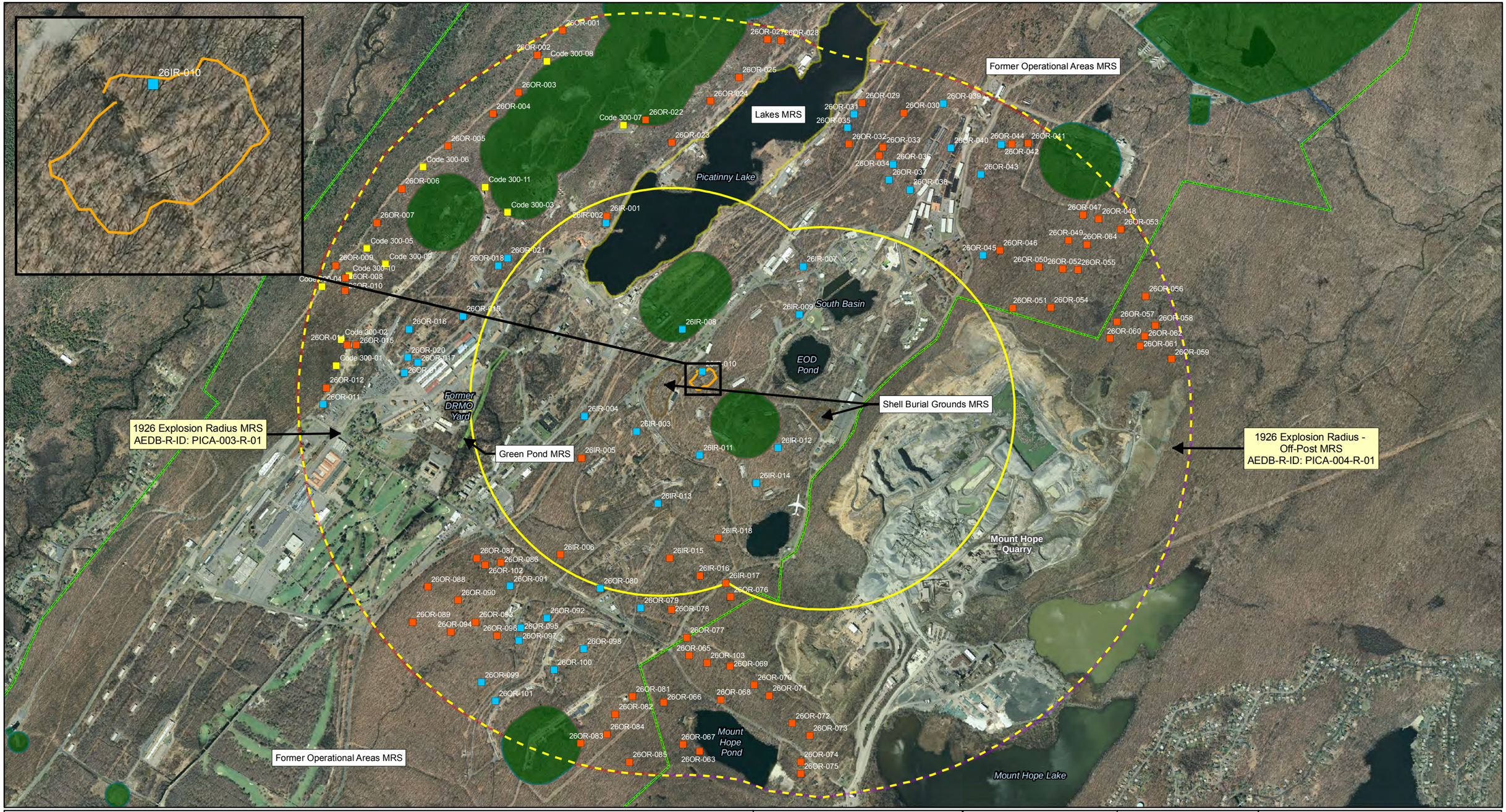
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Greenpond_DRMO_Yard_Results_v2.mxd



Legend

- Installation Boundary
- Operational Range Area
- Fuze Area

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Lakes
- Shell Burial Grounds
- Inner Radius Boundary
- Outer Radius Boundary
- Code 300 Area Grid (all Analog)
- Other Analog Grid
- DGM Grid

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

N

0 1,000 2,000 3,000 Feet

0 250 500 750 1,000 Meters

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New Jersey

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Figure 6-2
1926 Explosion Radius MRS
Grid Locations

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Verified By: NAS
Approved By: RSS

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\\arcadis-us.com\officedata\WhitePlains-NY\WHI_GIS\GIS_data\Projects\ARMY\Installations\Picatinny_Arsenal\MMRP_RI\MXDs\Figure_6-1.mxd

Legend

- GPS Points
- Anomaly Locations
- Munition Debris
- UXO
- Interpolated Transect Paths
- Trash Pit Area

Munitions Response Sites

- 1926 Explosion Radius
- Installation Boundary

Grids

- Grid 26OR-023
- Grid 26OR-024
- Grid 26OR-025
- Operational Range Areas

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 150 300 Feet

0 50 100 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

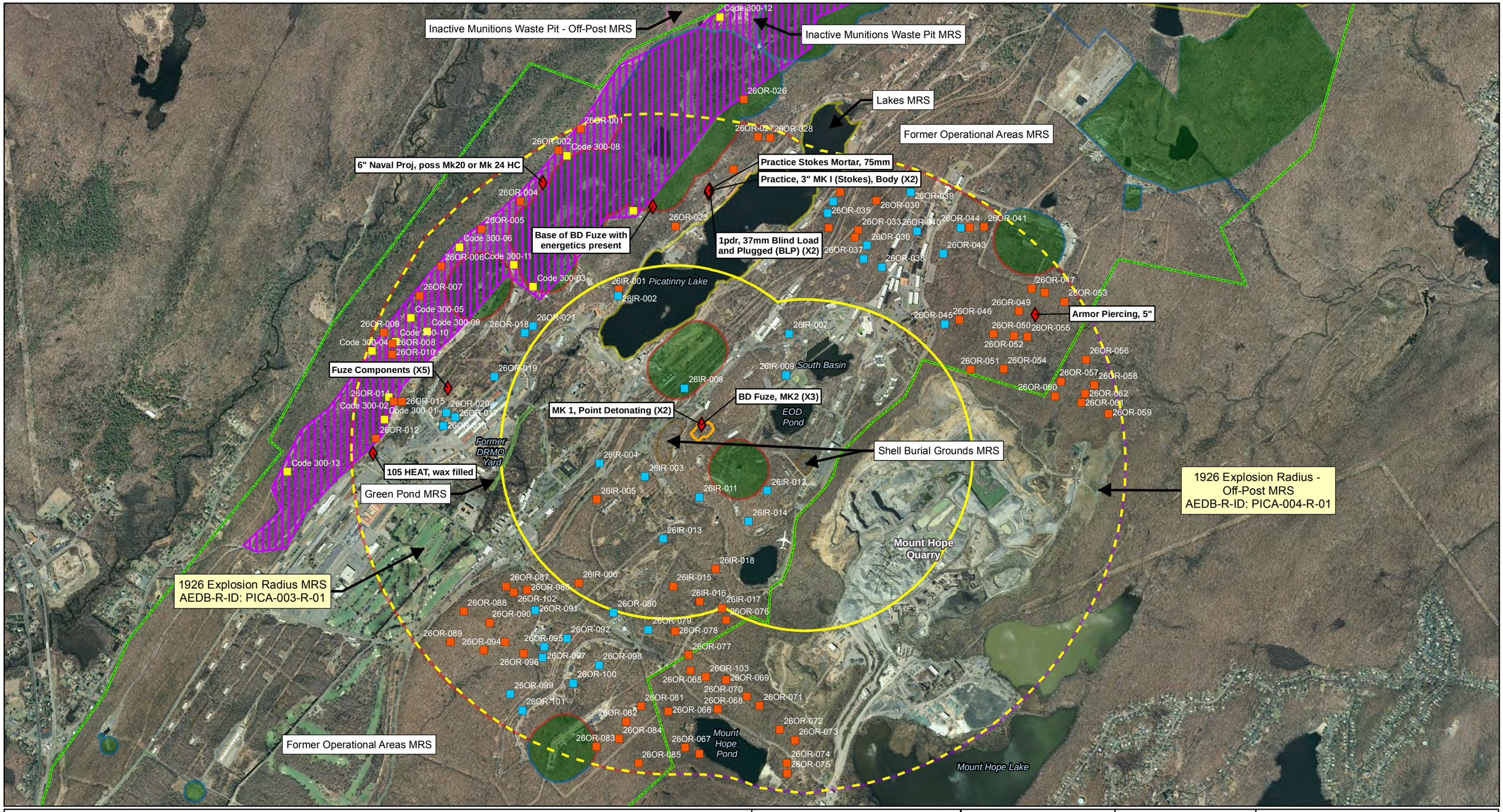
Figure 6-3
1926 Explosion Radius
EM Sensor-Assisted Visual Survey Results

Created By: BW
Verified By: NAS
Approved By: RSS

12/4/2013

Contract # W912DR-09-D-0006
DO 0002

Z:\GISPROJECTS_ENV\Weston\figure6-3.mxd



Legend

- Installation Boundary
- Operational Range Area
- Inner Radius Boundary
- Outer Radius Boundary

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Former Operational Areas
- Green Pond
- Lakes
- Shell Burial Grounds
- Fuze Area
- Code 300 Area Grid (all Analog)
- Other Analog Grid
- DGM Grid
- UXO/DMM/MPPEH Find

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,000 2,000 3,000 Feet

0 250 500 750 1,000 Meters

Created By: CEP
Verified By: NAS
Approved By: RSS

Figure 6-4
1926 Explosion Radius MRS MEC Finds

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DO 0002

\\arcadis-us.com\officedata\WhitePlains-NY\WHI_GIS\GIS_data\Projects\ARMY\Installations\Picatinny_Arsenal\MMRP_RI\MXDs\Figure_6-2.mxd

Legend

- Installation Boundary
- Operational Range Area
- Fuze Area
- Inner Radius Boundary
- Outer Radius Boundary

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post

- Former Operational Areas
- Green Pond
- Lakes
- Shell Burial Grounds

Analog/DGM Grid

- MD Present
- MD Not Present

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

N

0 1,000 2,000 3,000 Feet

0 250 500 750 1,000 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

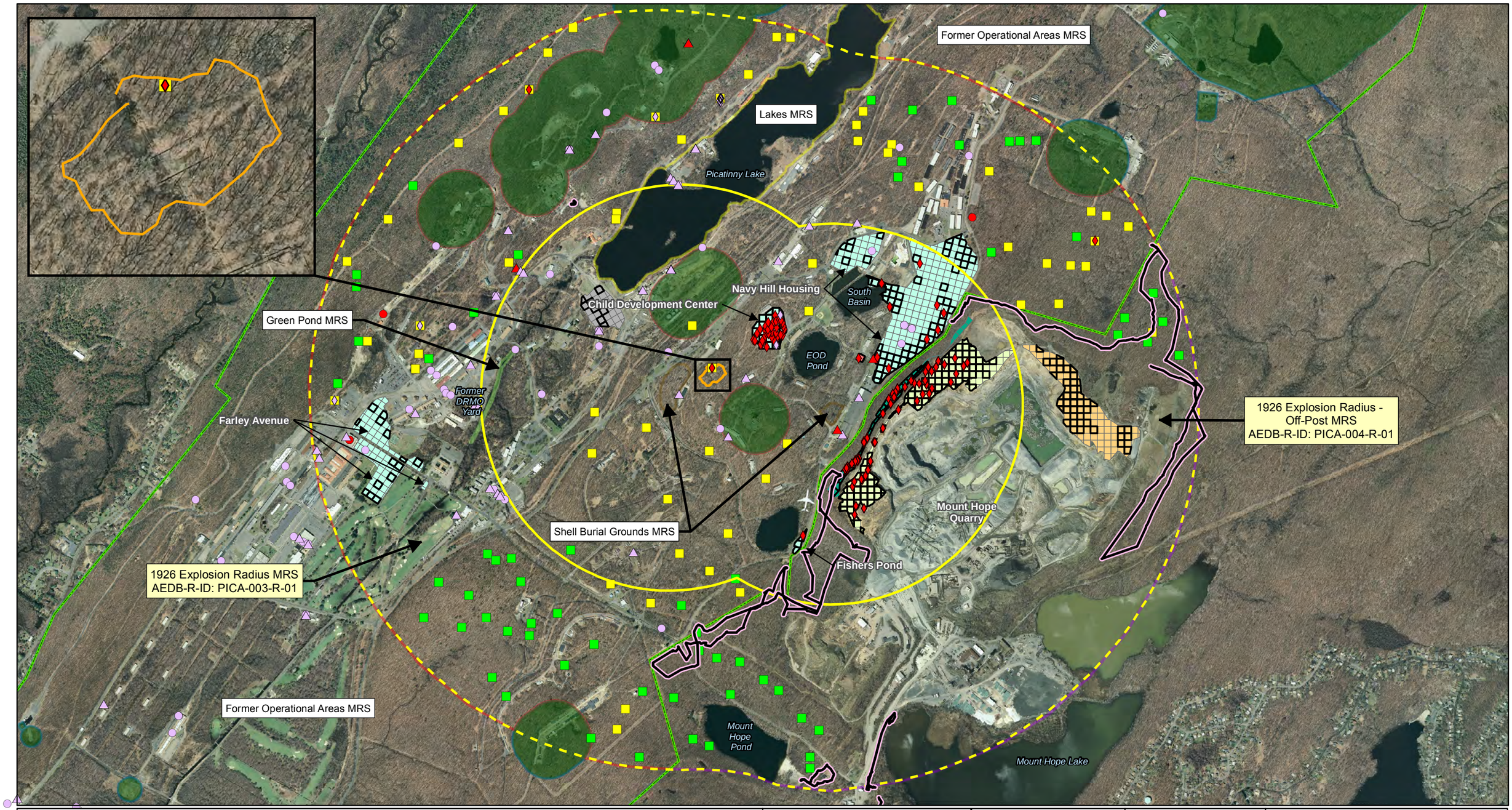
Figure 6-5
1926 Explosion Radius MRS
MD Finds

Created By: CEP
Verified By: NAS
Approved By: RSS

6/27/2013

Contract # W912DR-09-D-0006
DO 0002

\\arcadis-us.com\officedata\WhitePlains-NY\WHI_GIS\GIS_data\Projects\ARMY\Installations\Picatinny_Arsenal\MMRP_RI\MXDs\Figure_6-3.mxd



Legend

- Installation Boundary
- Operational Range Area
- Fuze Area
- MD Found
- SI Visual Survey Path
- Inner Radius Boundary
- Outer Radius Boundary

Munitions Response Sites

- 1926 Explosion Radius
- 1926 Explosion Radius - Off-Post
- Former Operational Areas
- Green Pond
- Lakes
- Shell Burial Grounds

- TCRA I Grid
- TCRA II Grid
- TCRA III Grid
- EECA Grid

MEC Finds

- 1926 Source
- Non-1926 Source
- 04/17/2013 Find

MEC from UXO Finds

- 1926 Source
- Non-1926 Source

MD from UXO Finds

- 1926 Source
- Non-1926 Source

- PHST Grid
- ERF Grid

RI DGM and Analog Grids

- MD Present
- MD Not Present

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,000 2,000 3,000 Feet

0 250 500 750 1,000 Meters

Created By: CEP

Verified By: NAS

Approved By: RSS

Figure 6-6
1926 Explosion Radius MRS MEC Nature and Extent

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\\arcadis-us.com\officedata\WhitePlains-NY\WHI_GIS\GIS_data\Projects\ARMY\Installations\Picatinny_Arsenal\MMRP_RI\MXDs\Figure_6-4.mxd

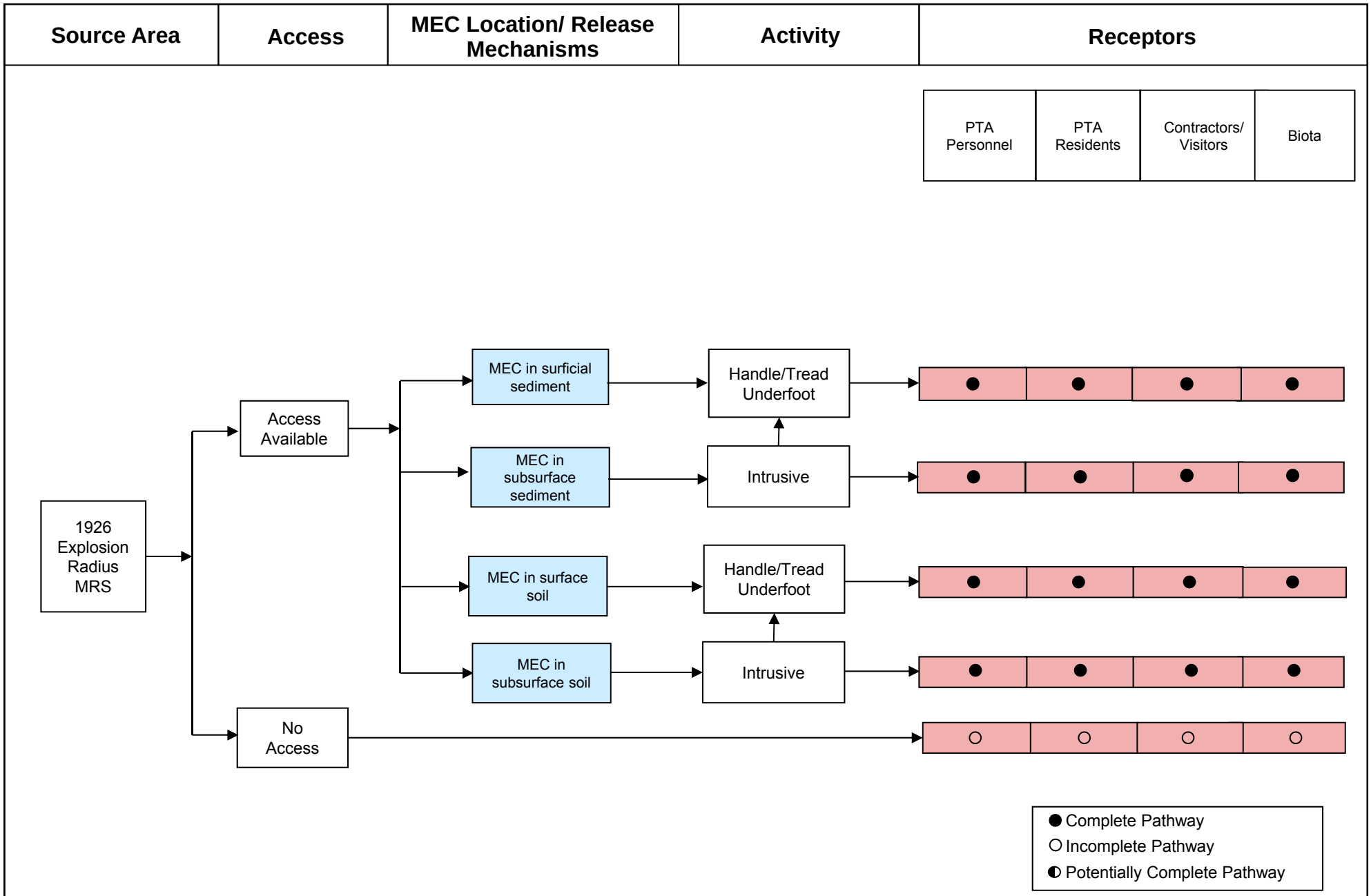


FIGURE 6-7
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
1926 EXPLOSION RADIUS MRA
PICATINNY ARSENAL, NEW JERSEY

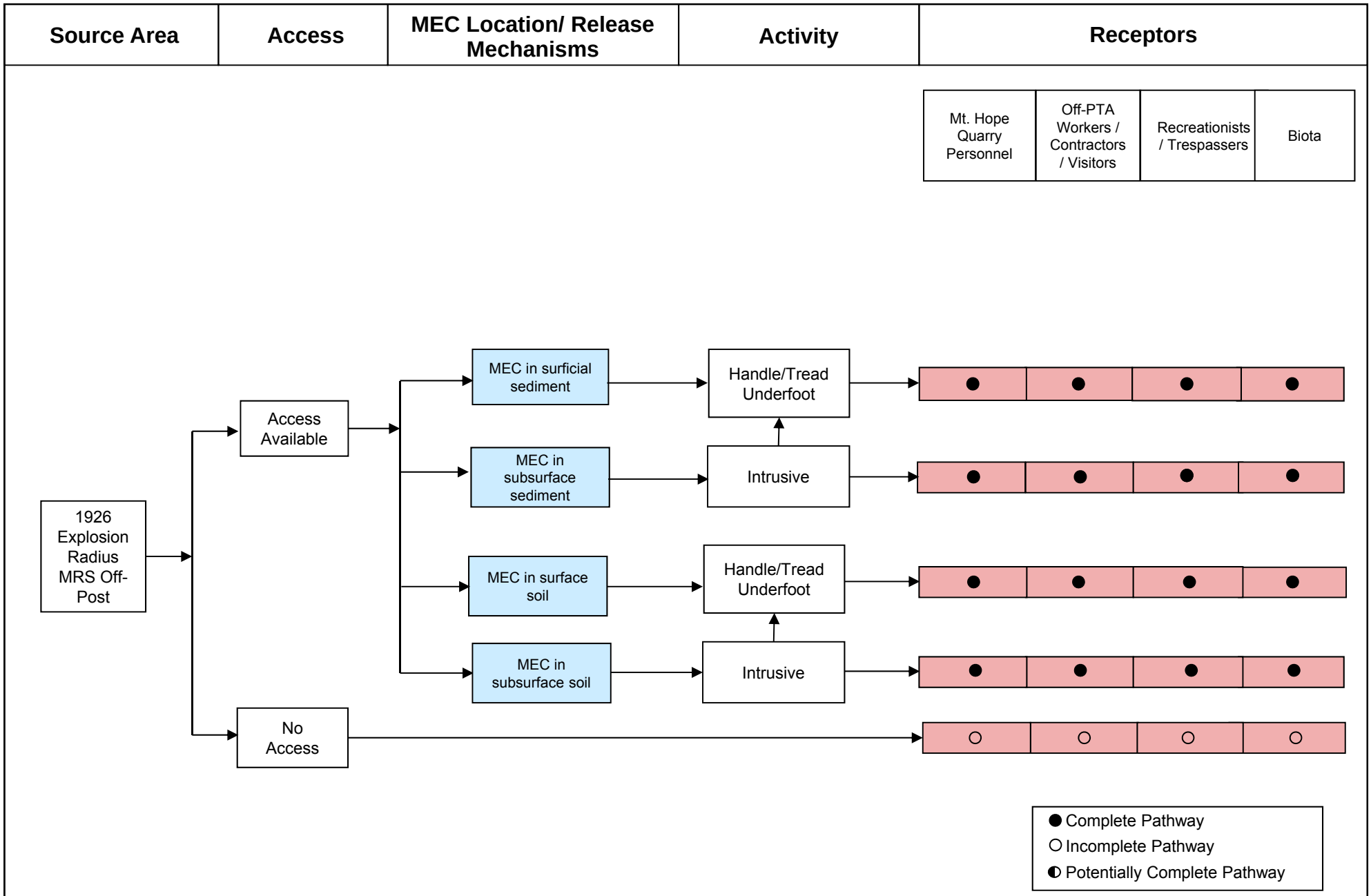
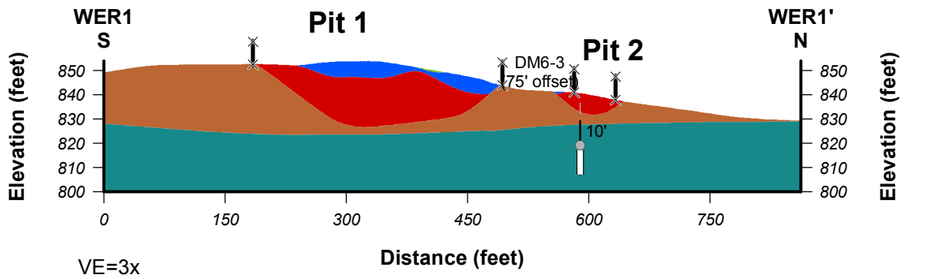
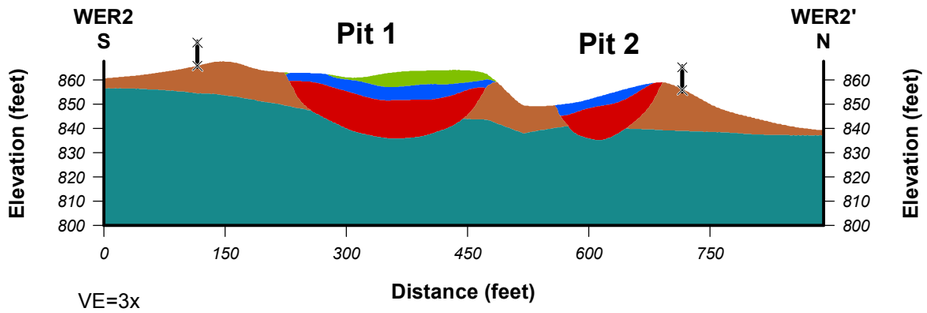
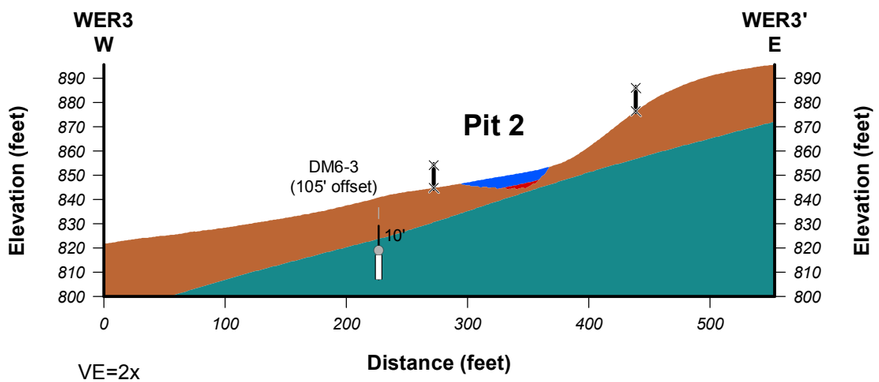
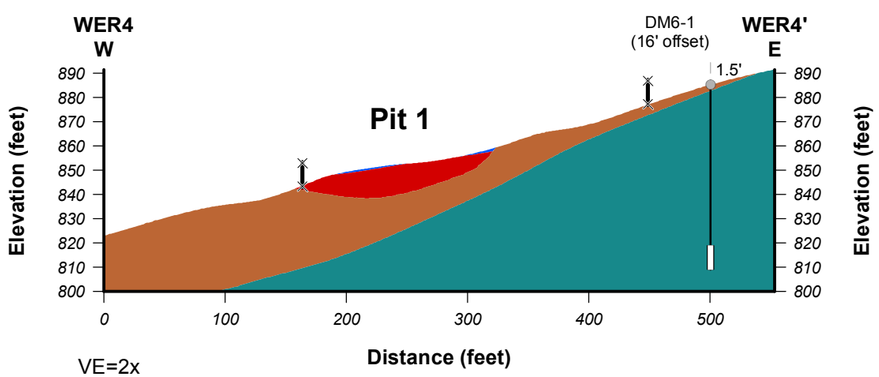


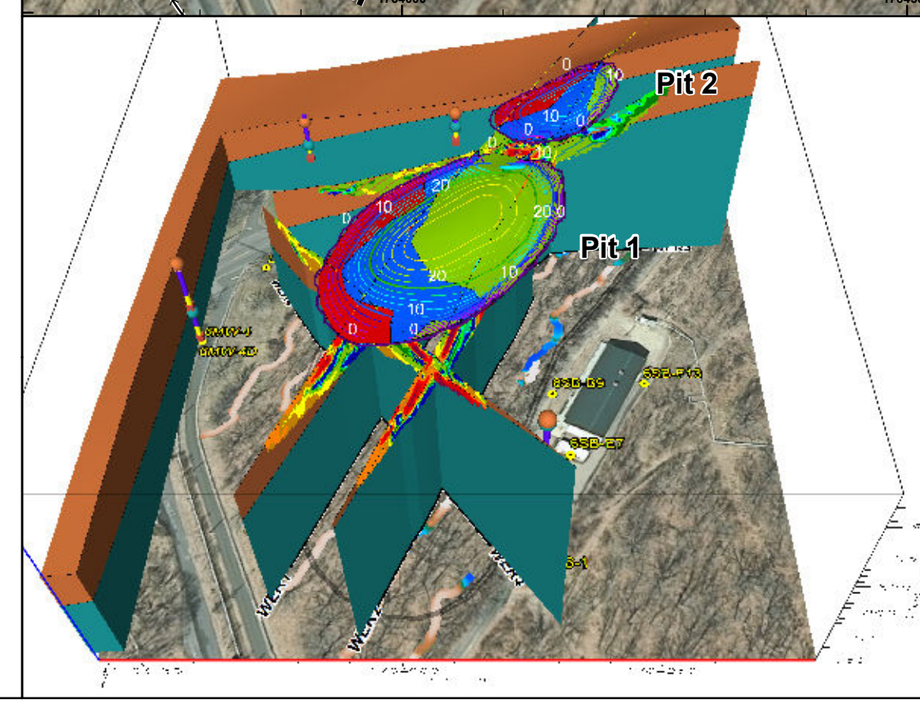
FIGURE 6-8
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
1926 EXPLOSION RADIUS MRS OFF-POST
PICATINNY ARSENAL, NEW JERSEY











Legend

Map View

- Well Locations
- Resistivity Transect
- Geologic Section Line
- Fenceline
- Depth / Thickness (feet)

Depth / Thickness (feet)

- < 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40

Cross-Sections

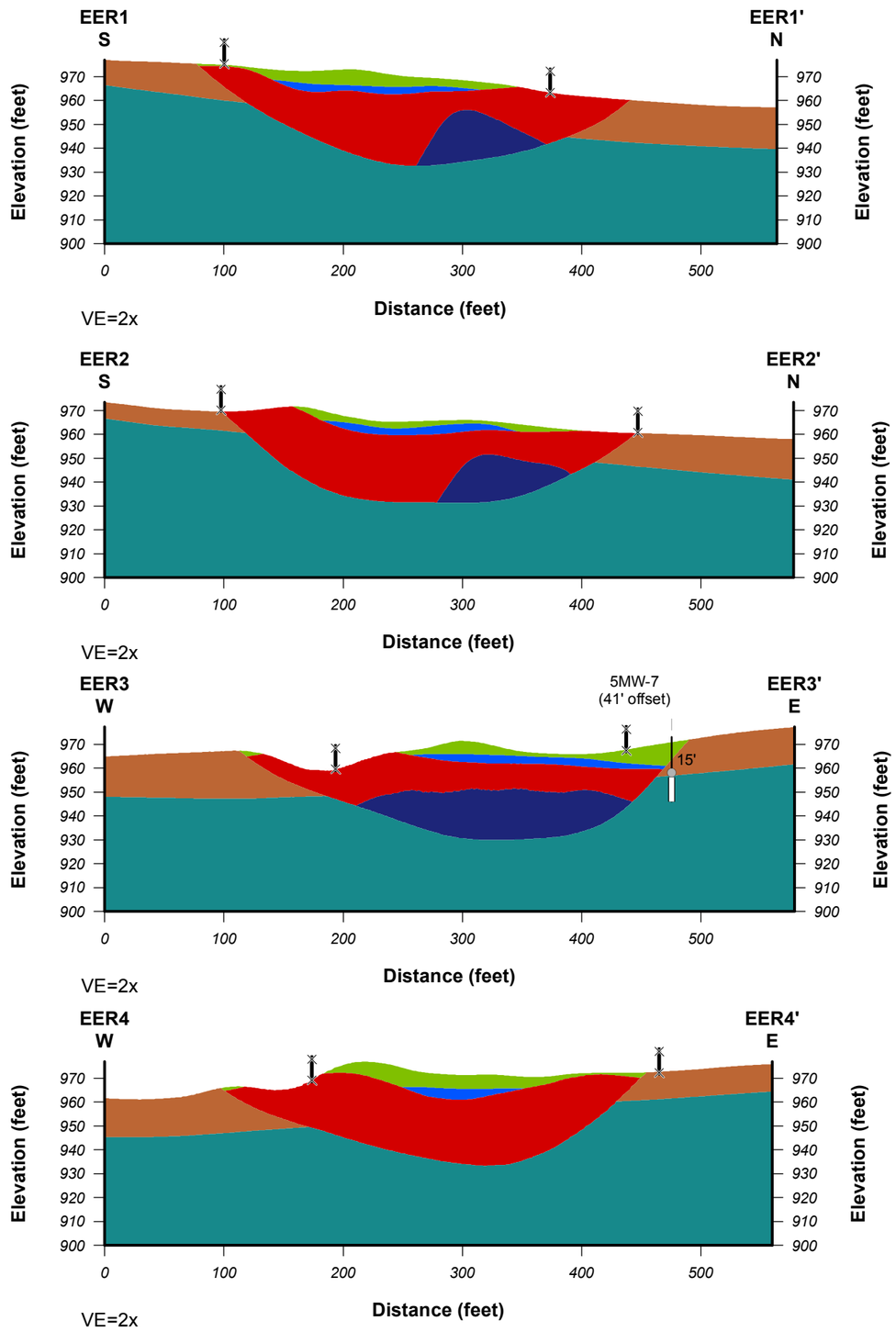
- Bedrock (ft bgs)
- Fenceline
- Well Casing
- Well Screen

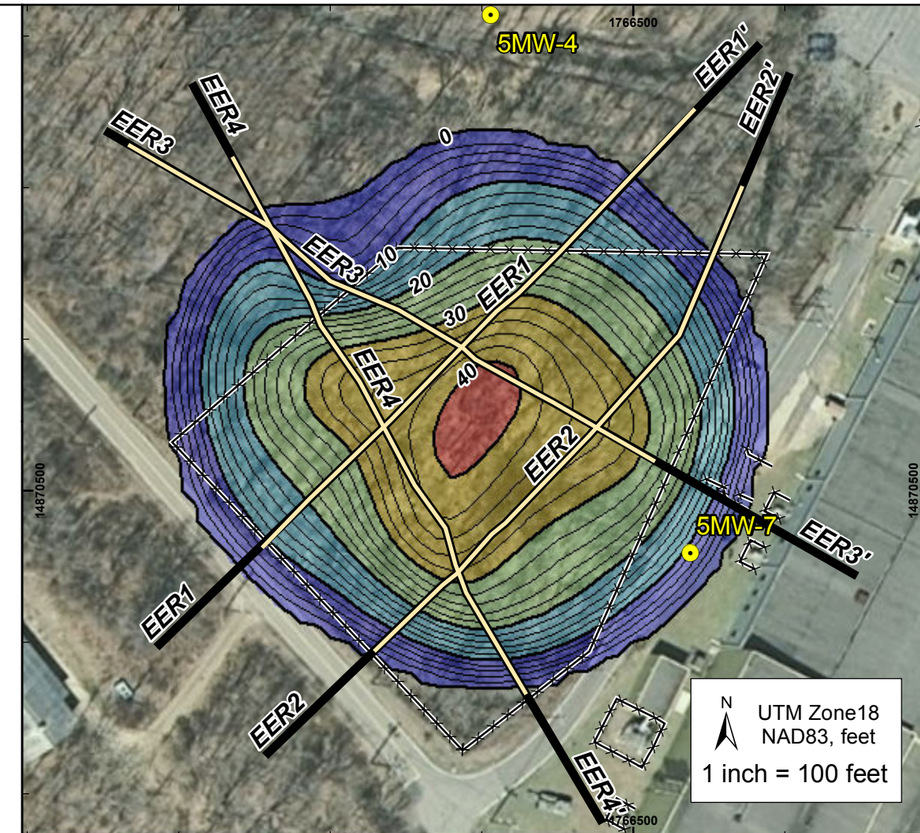
Geologic Zone

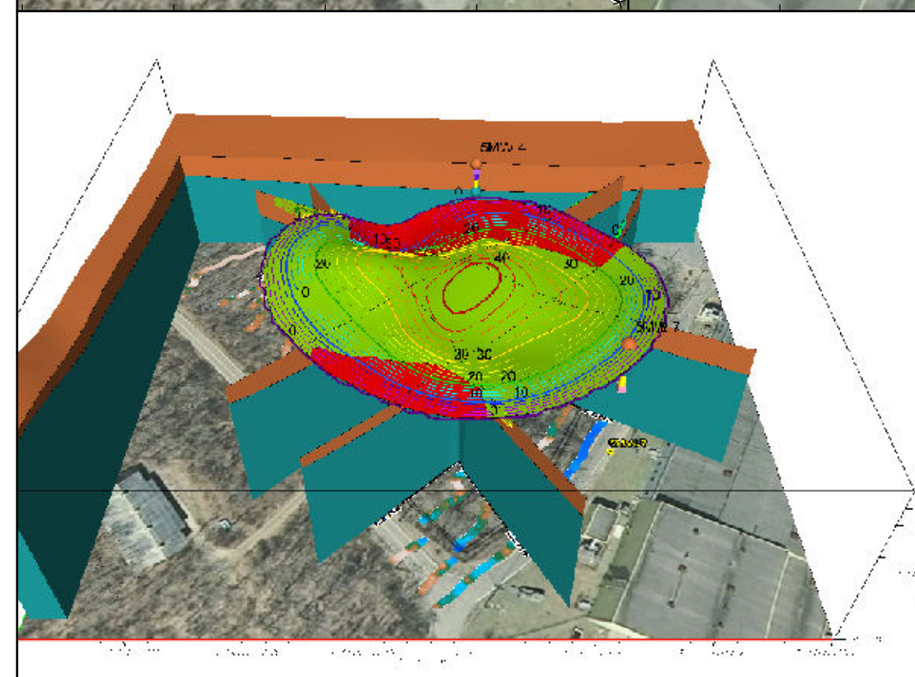
- Fill Material
- Cap Material
- Low Conductivity Debris
- Native Overburden
- Bedrock

Disposal Pit	Zone	Maximum Depth or Thickness (feet)	Volume (1000 yd3)
Pit 1	Total	30	33
	Pit	20	23
	Cap	8	6.5
	Fill	4	3.5
Pit 2	Total	18	5
	Pit	17	4
	Cap	5	0.9
	Fill	4	0.1
Combined	Total	30	38
	Pit	20	27
	Cap	8	7.4
	Fill	4	3.6

Figure 6-9
Model of Shell Burial Grounds West







Legend

Map View

- Well Locations
- Resistivity Transect
- Geologic Section Line
- Fenceline

Crater Depth (feet)

- < 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40

Cross-Sections

- Bedrock (ft bgs)
- Well Casing
- Well Screen
- Fenceline

Geologic Zone

- Fill Material
- Cap Material
- Low Conductivity Debris
- High Conductivity Debris
- Native Overburden
- Bedrock

Pit	Zone	Maximum Depth or Thickness (feet)	Volume (1000 yd3)	Volume (acre-f)
EER	Total	41	80	50
	High Cond	22	10	6
	Low Cond	33	54	33
	Cap	5	3	2
	Fill	7	12	7

Figure 6-10
Model of Shell Burial Grounds East

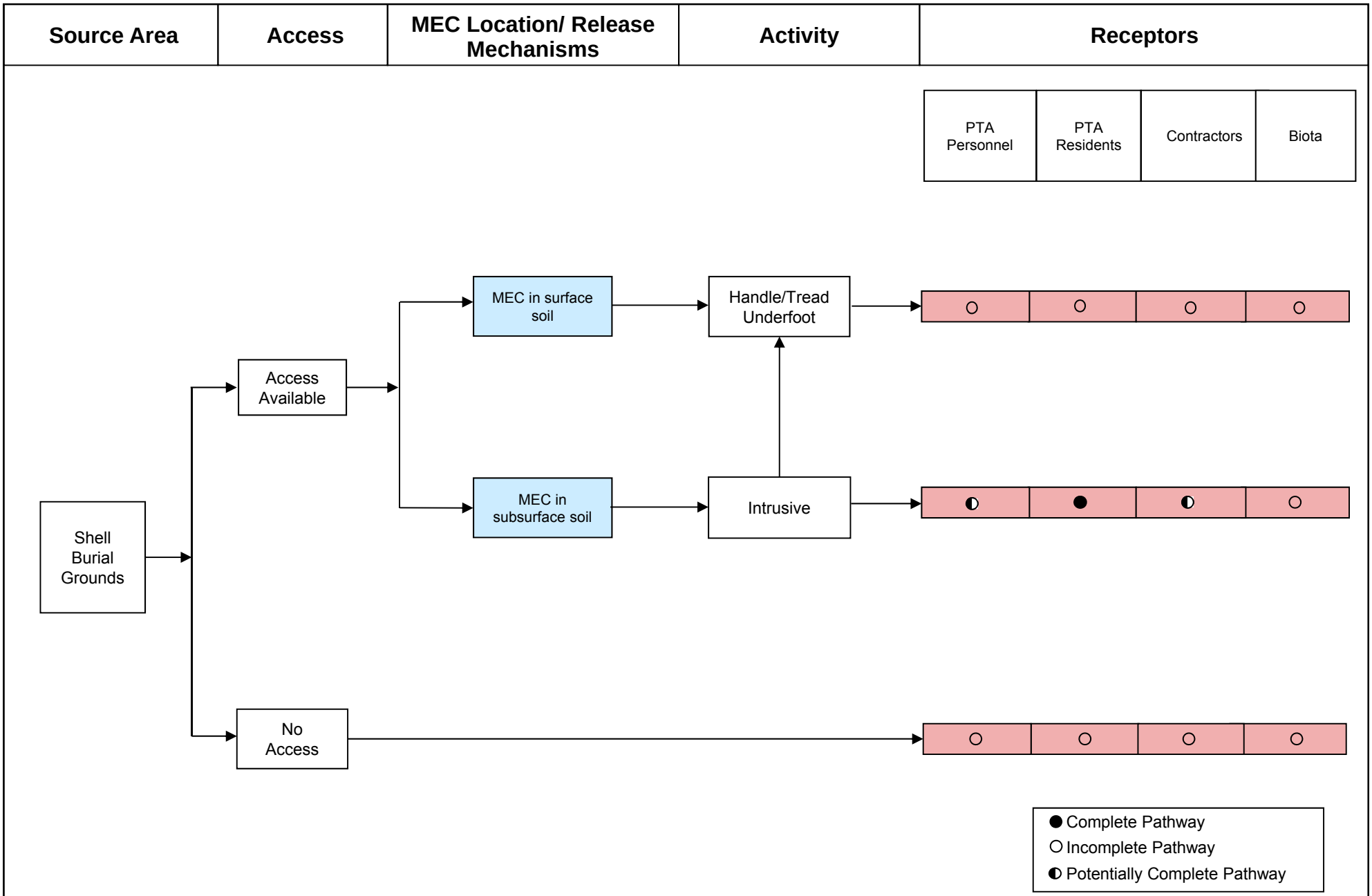
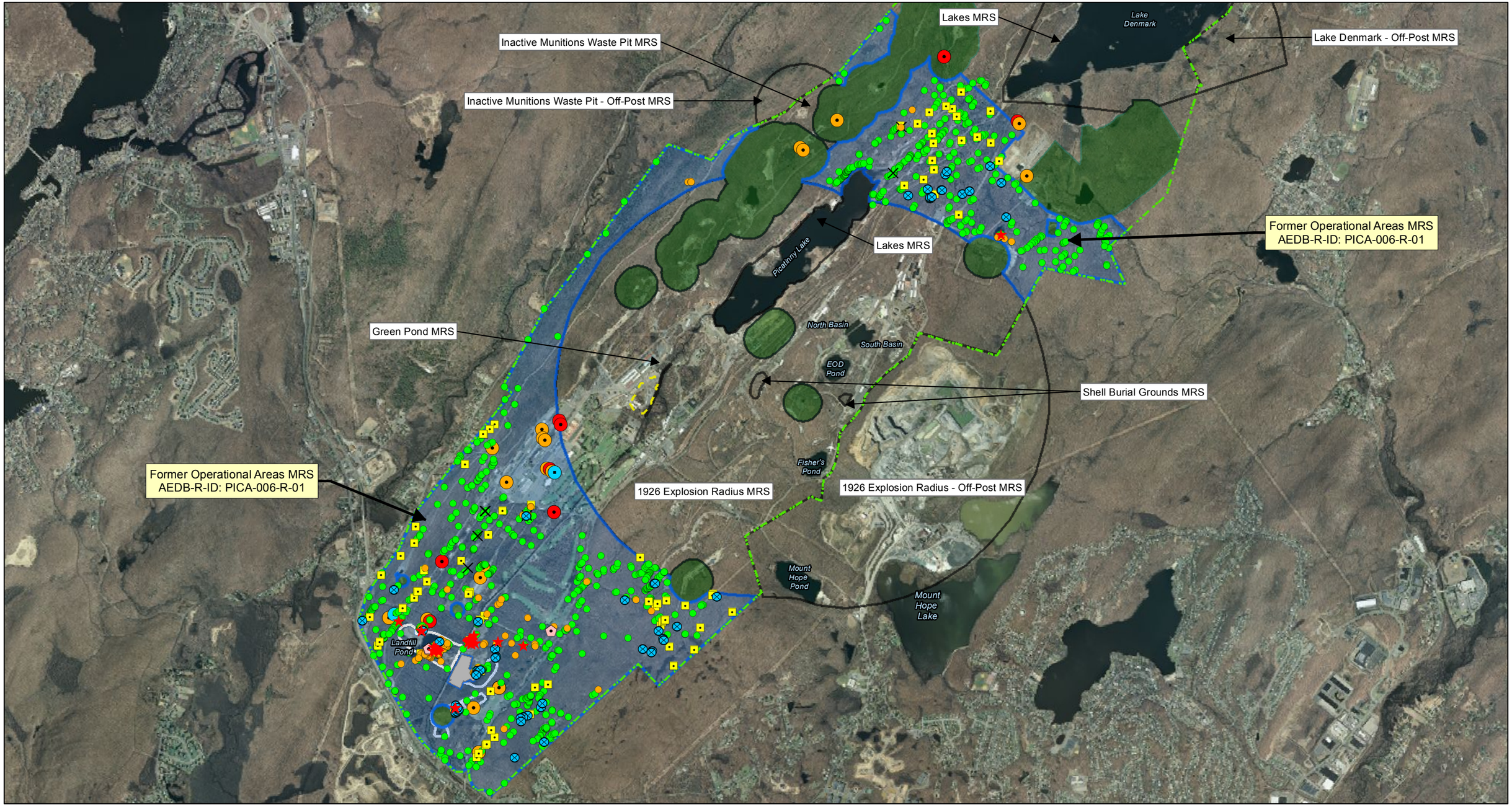


FIGURE 6-11
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
SHELL BURIAL GROUNDS MRS
PICATINNY ARSENAL, NEW JERSEY



Legend

- Installation Boundary
- Operational Range Areas
- Ineligible Area - Burning Ground
- Former DRMO Yard
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest
- DMM
- UXO
- Cultural Debris
- Geology
- Munitions Debris
- Seed
- Small Arms

UXO Finds Map Items

- Munitions Debris
- MEC
- Small Arms

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

Picatinny Arsenal
Morris County,
New Jersey

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Figure 6-12
Former Operational Areas MRS
Intrusive Results

Created By: CLR
Verified By: NAS
Approved By: RSS

4/8/2014

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DO 0002

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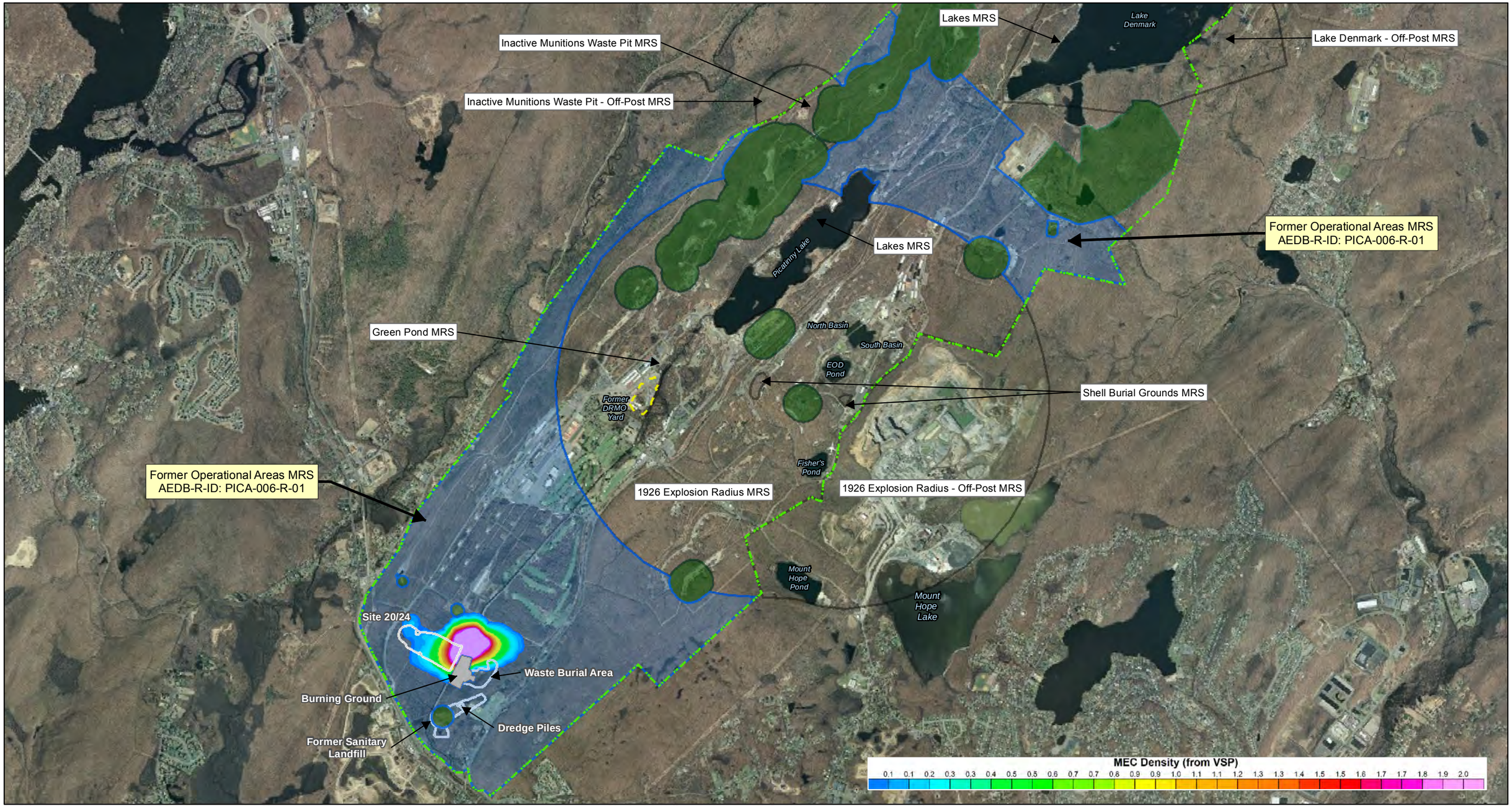

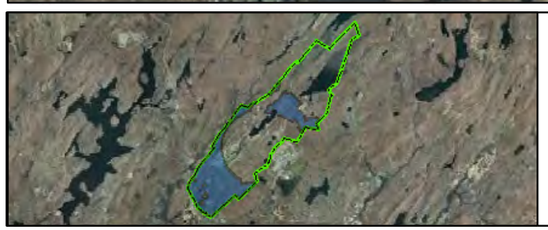

Legend

- Installation Boundary
- Former DRMO Yard
- Operational Range Areas
- Ineligible Area - Burning Ground
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

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Morris County,
New Jersey

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Figure 6-13
Former Operational Areas MRS
MEC Density
PICA-006-R-01

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Approved By: RSS

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DO 0002

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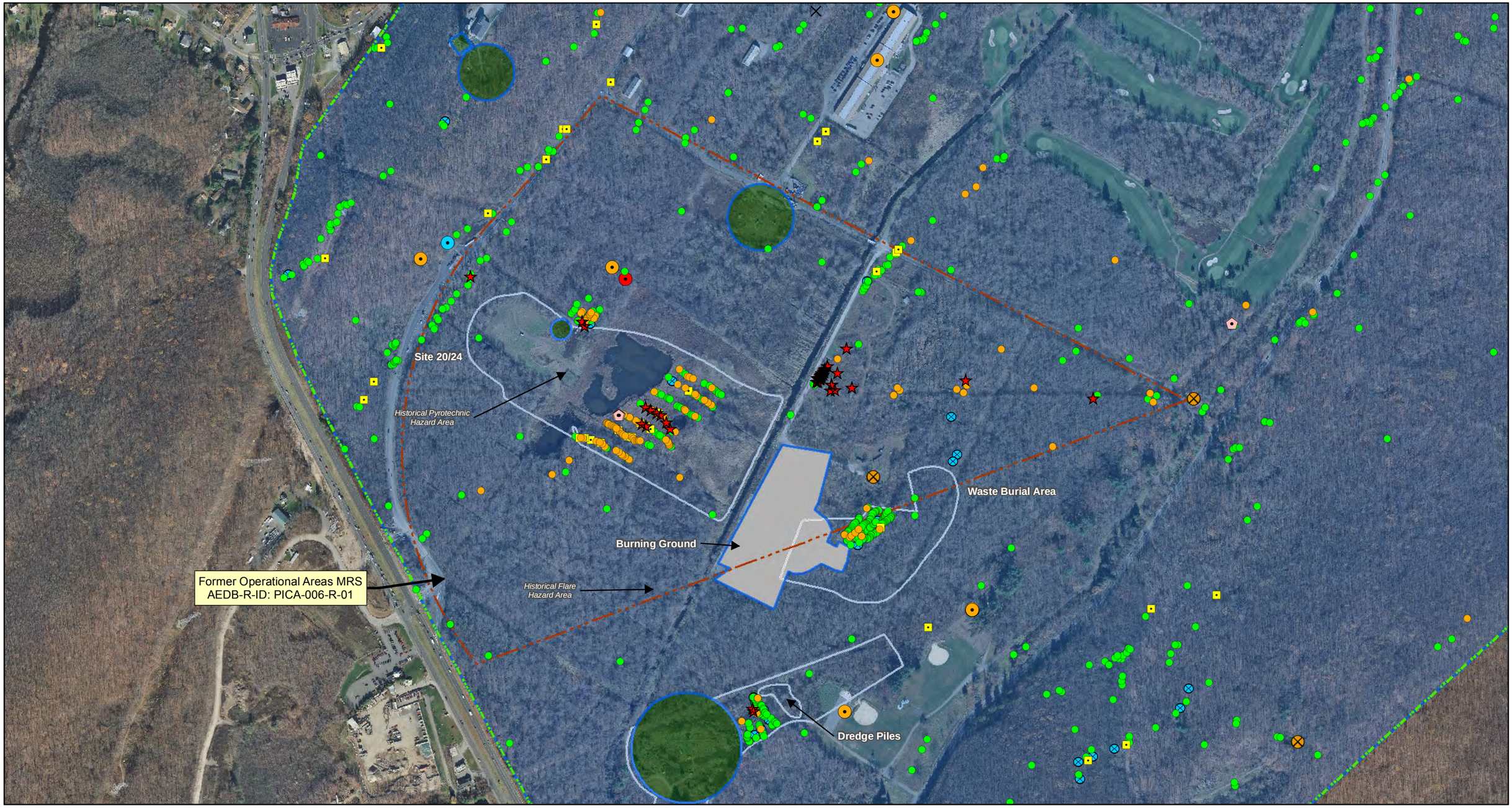

Legend

- Installation Boundary
- Operational Range Areas
- Ineligible Area - Burning Ground
- Areas of Interests
- Munitions Response Sites
- Former Operational Areas
- Historical Range Fan
- Firing Point
- DMM
- UXO
- Cultural Debris
- Geology
- Munitions Debris
- Seed
- Small Arms

UXO Finds Map Items

- Munitions Debris
- MEC
- Small Arms

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 500 1,000 Feet

0 120 240 360 Meters

Picatinny Arsenal
Morris County,
New Jersey

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Approved By: RSS

Figure 6-14
Former Operational Areas MRS
AOI Intrusive Results

12/5/2013

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DO 0002

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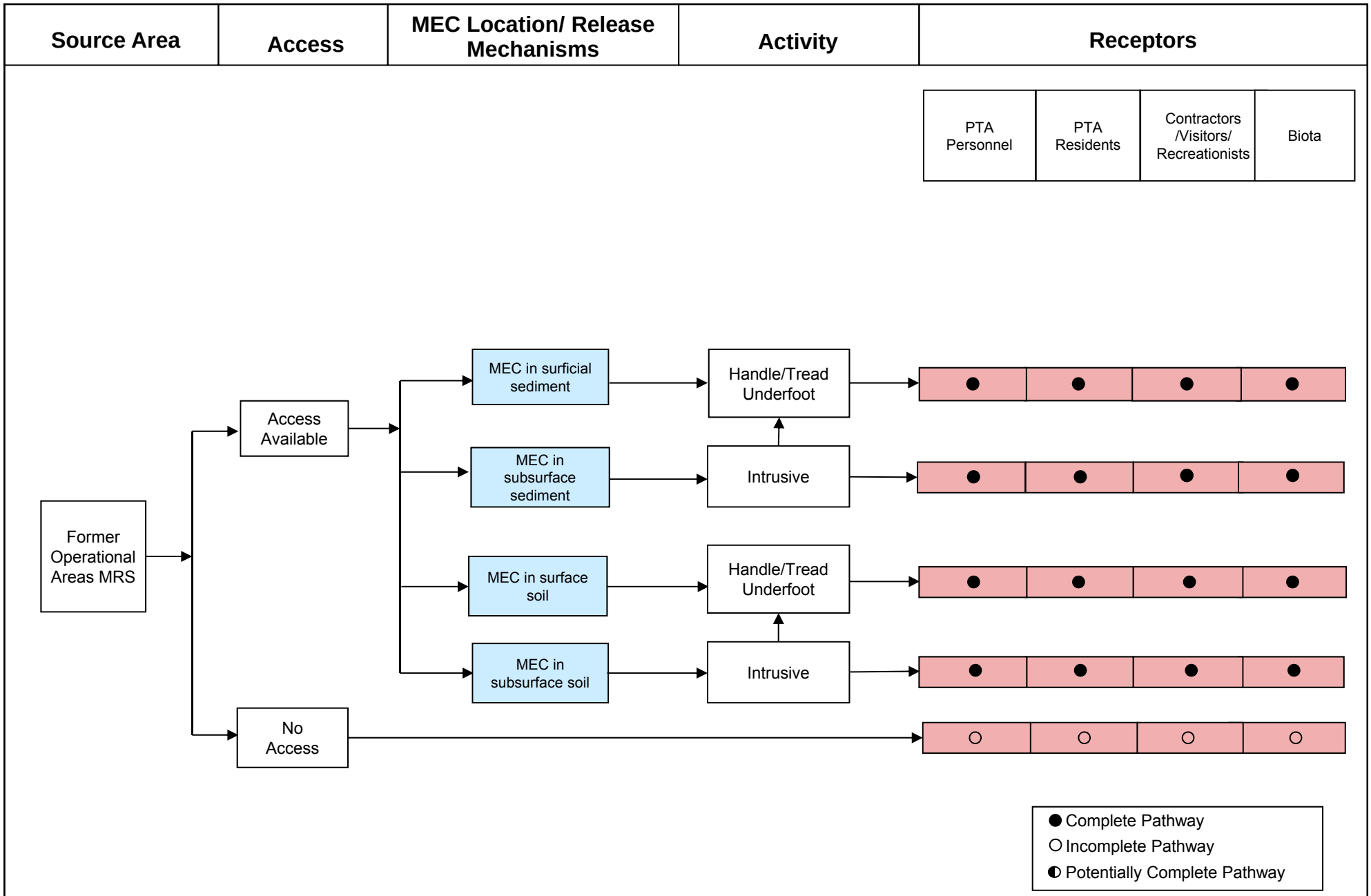
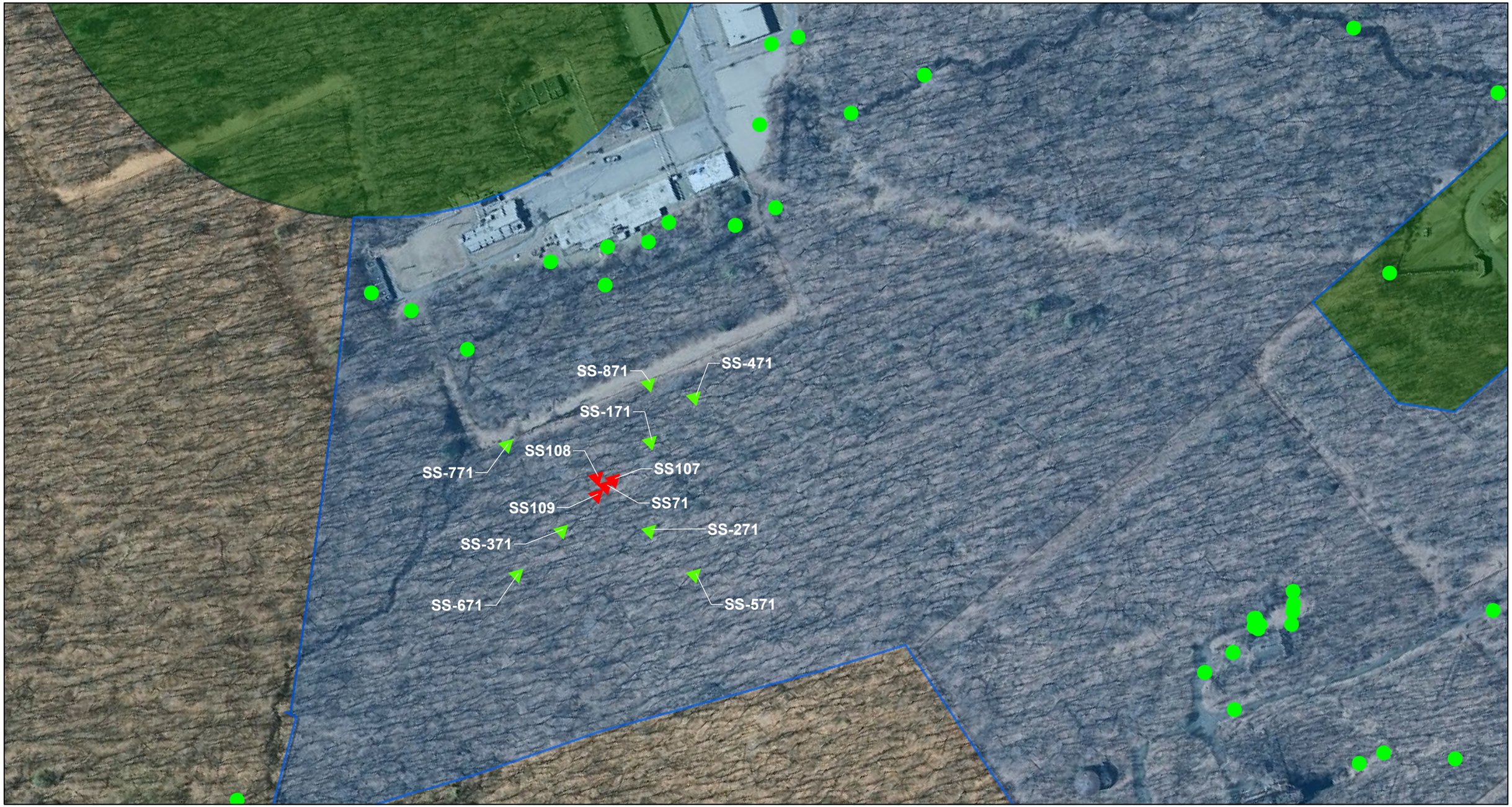
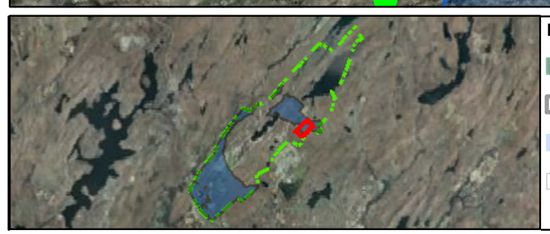


FIGURE 6-15
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
FORMER OPERATIONAL AREAS MRS
PICATINNY ARSENAL, NEW JERSEY





Legend

- Operational Range Areas
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest

Manganese Results

	SS71 and Step Outs	IRP
	<11000 (mg/kg)	<11000 (mg/kg)
	=>11000 (mg/kg)	=>11000 (mg/kg)

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 150 300 Feet

0 30 60 90 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 6-16
MMRP and IRP Manganese
P-1 Sample Locations
PICA-006-R-01

Created By: CLR
Verified By: NAS
Approved By: RSS

2/20/2014

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Legend

- Operational Range Areas
- Munitions Response Sites
- Former Operational Areas
- Areas of Interest

Manganese Results

	SS23 and Step Outs	IRP
	<11000 (mg/kg)	<11000 (mg/kg)
	=>11000 (mg/kg)	=>11000 (mg/kg)

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

N

0 150 300 Feet

0 30 60 90 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 6-17
MMRP and IRP Manganese
P-61 Sample Locations
PICA-006-R-01

Created By: CLR
Verified By: NAS
Approved By: RSS

12/4/2013

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DO 0002

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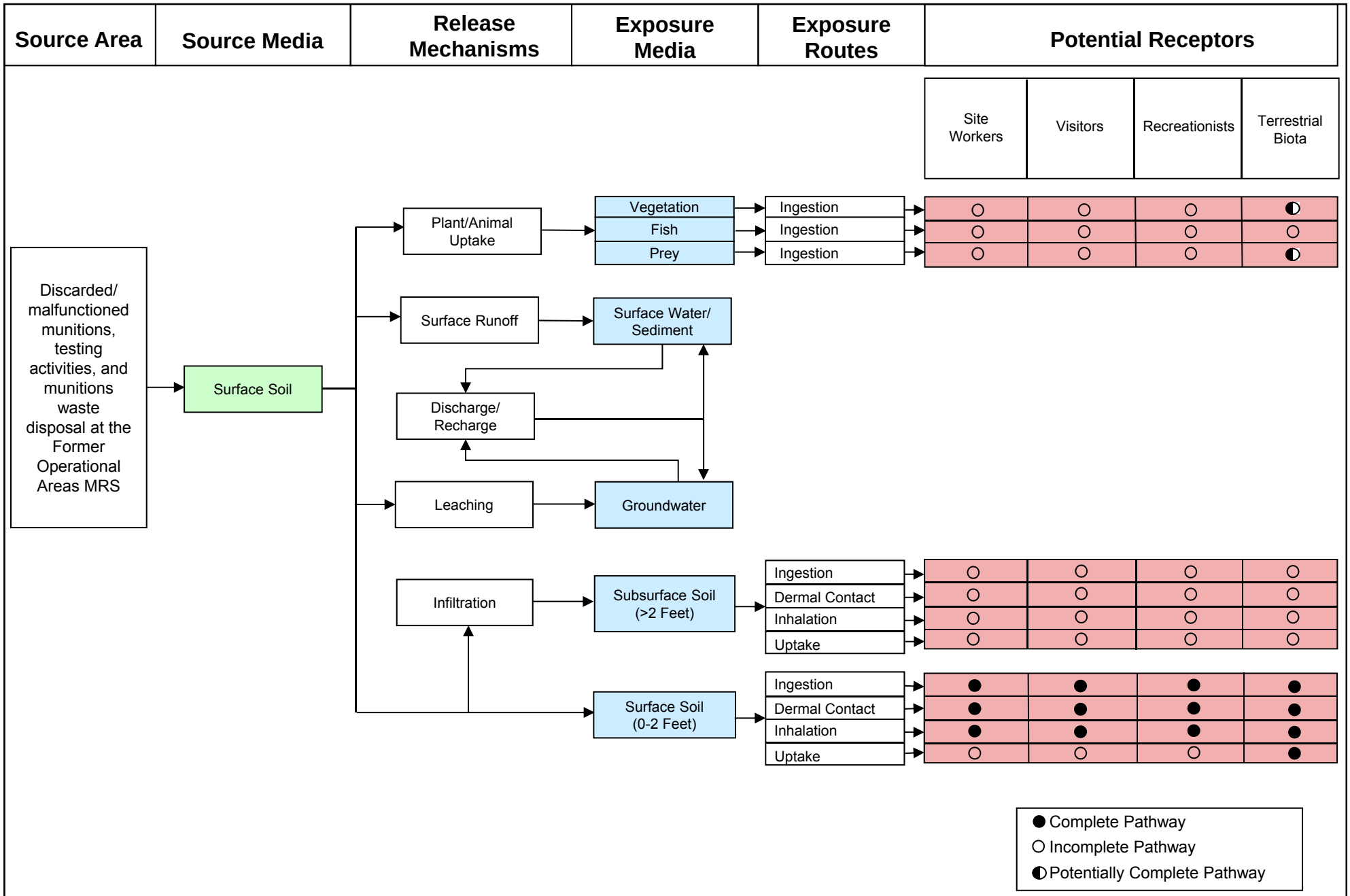
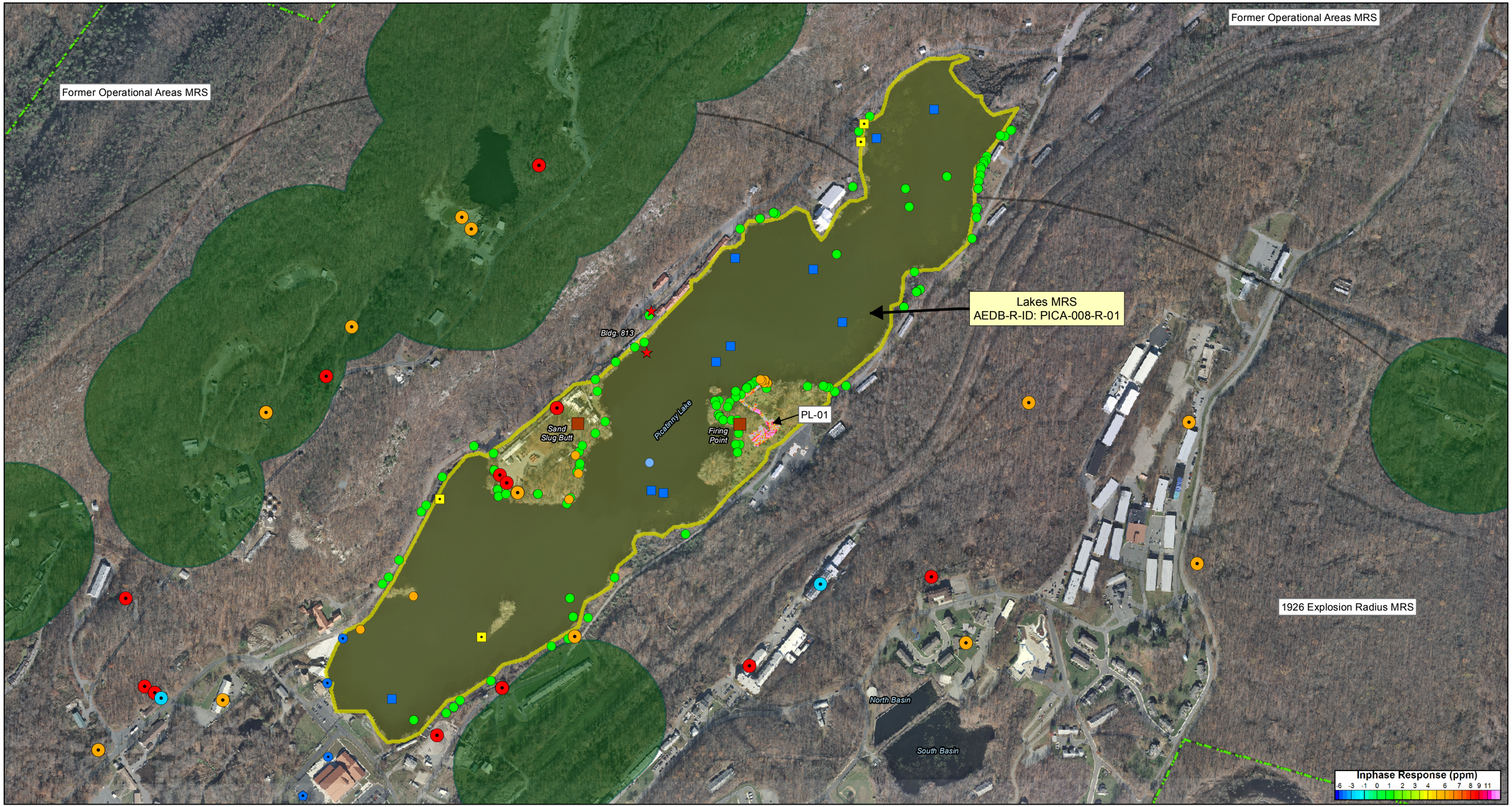


Figure 6-18
MC Exposure Pathways Analysis – Former Operational Areas MRS
Remedial Investigation Picatinny Arsenal
Morris County, New Jersey



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Cultural Debris
- Geology
- UXO
- Munitions Debris
- No Contact (No audible response)
- No Find (Audible response, anomaly could not be found)
- Firing Point and Slug Butt

UXO Finds Map Items

- Munitions Debris
- MEC
- Small Arms

Items Identified during Construction Support

- Munitions Debris
- DMM

Note: Some Munitions Debris items were identified at the same locations

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 600 1,200 Feet

0 200 400 Meters

Created By: CLR

Verified By: NAS

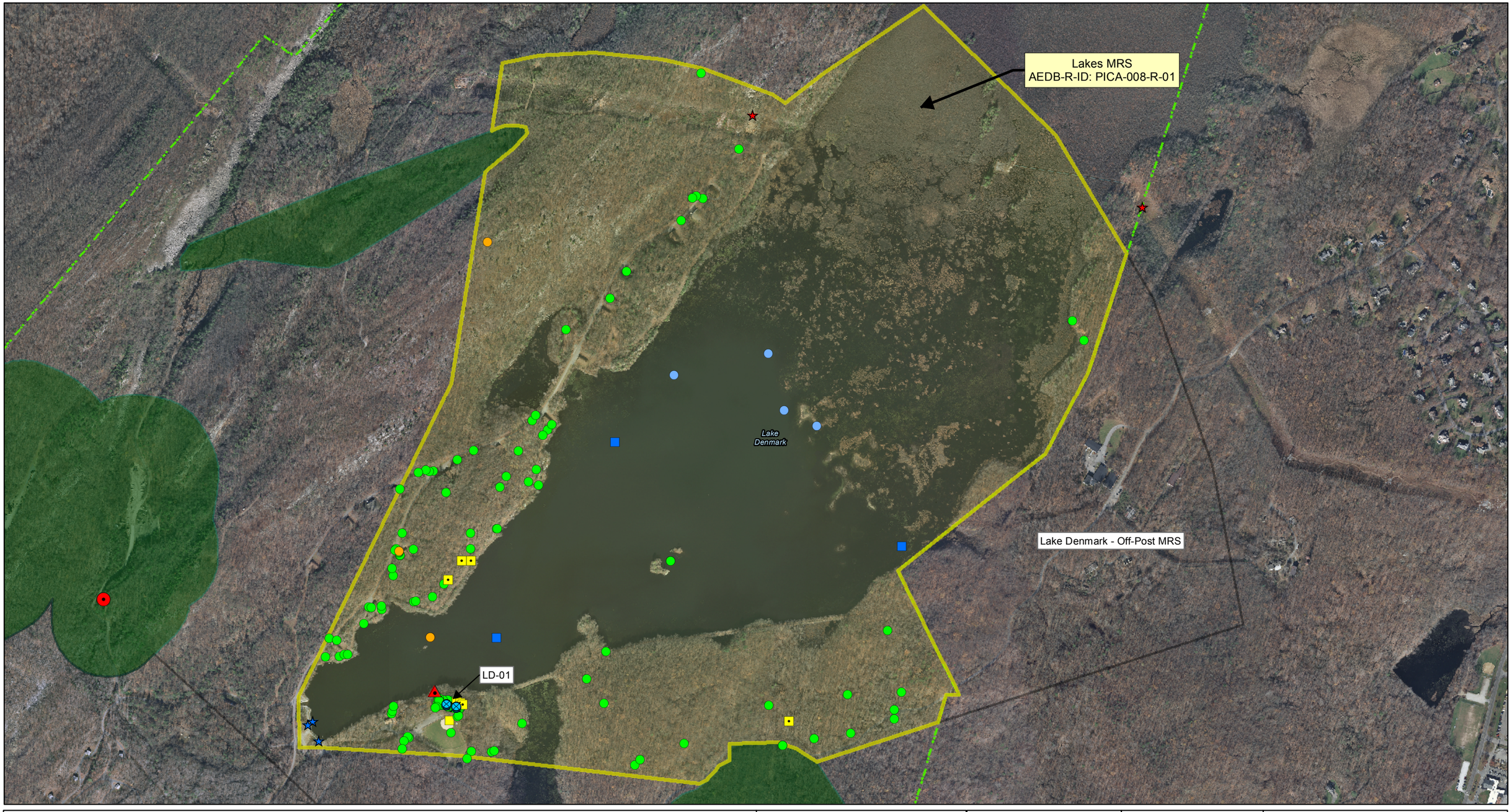
Approved By: RSS

Figure 6-19
Lakes MRS - Picatinny Lake Portion
Intrusive Results

Date:2/25/2014

Contract No. W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Picatinny_Lake_Results_v2.mxd



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Site Boundaries
- Lakes MRS
- Grid Boundary
- Cultural Debris
- Munitions Debris
- Geology
- Small Arms
- No Contact (No audible response)
- No Find (Audible reposnse, anomaly could not be found)
- Mortar recovered during PSG&E work
- Mortar recovered during USACE 2010 Site Walk

UXO Finds Map Items

- MEC

Items Identified during Construction Support

- UXO

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 6-20
Lakes MRS - Lake Denmark Portion
Intrusive Results

N

0 750 1,500 Feet

0 260 520 Meters

Created By: CLR

Verified By: NAS

Approved By: RSS

Date:8/27/2014

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_Results_v2.mxd

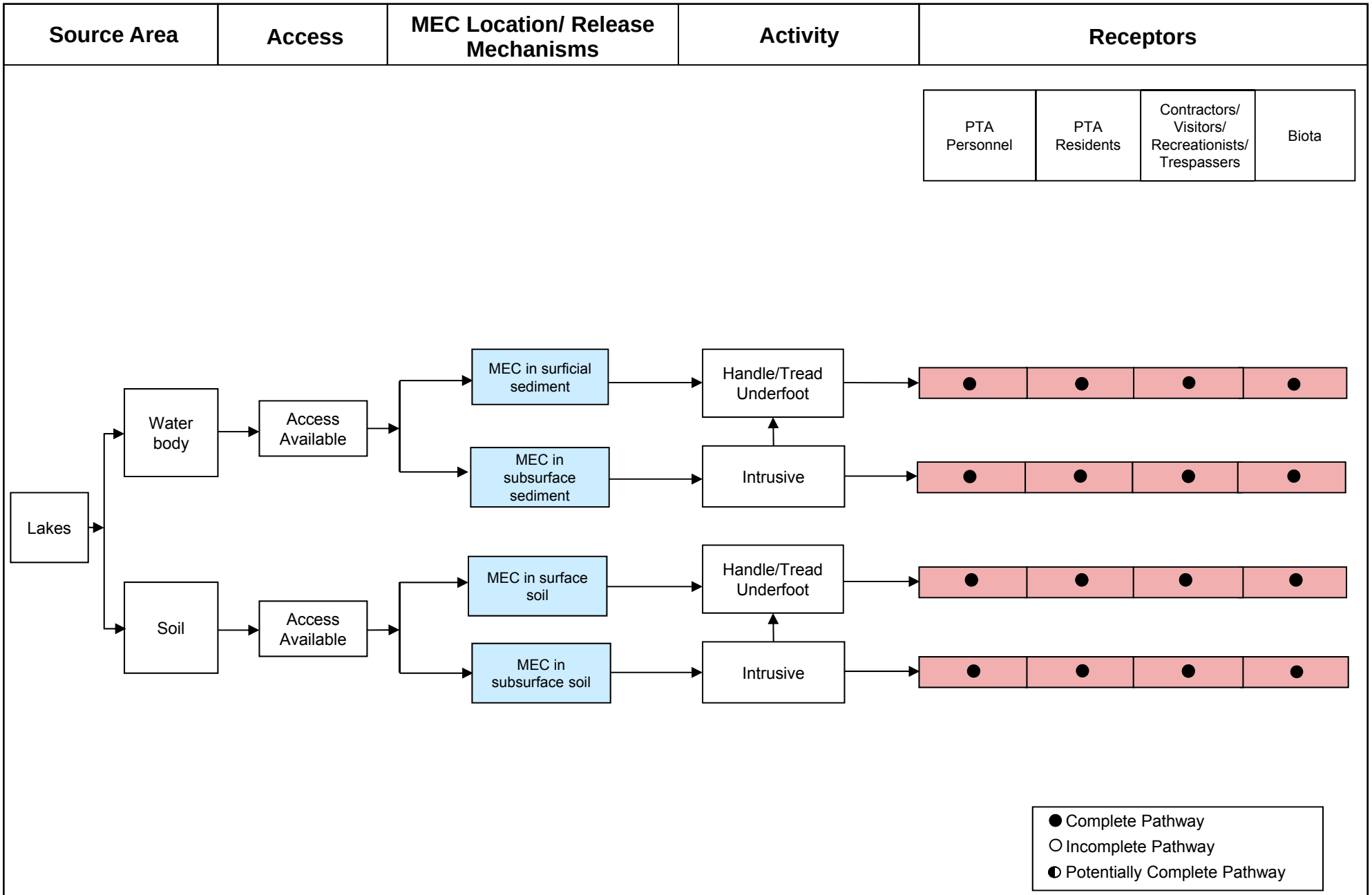
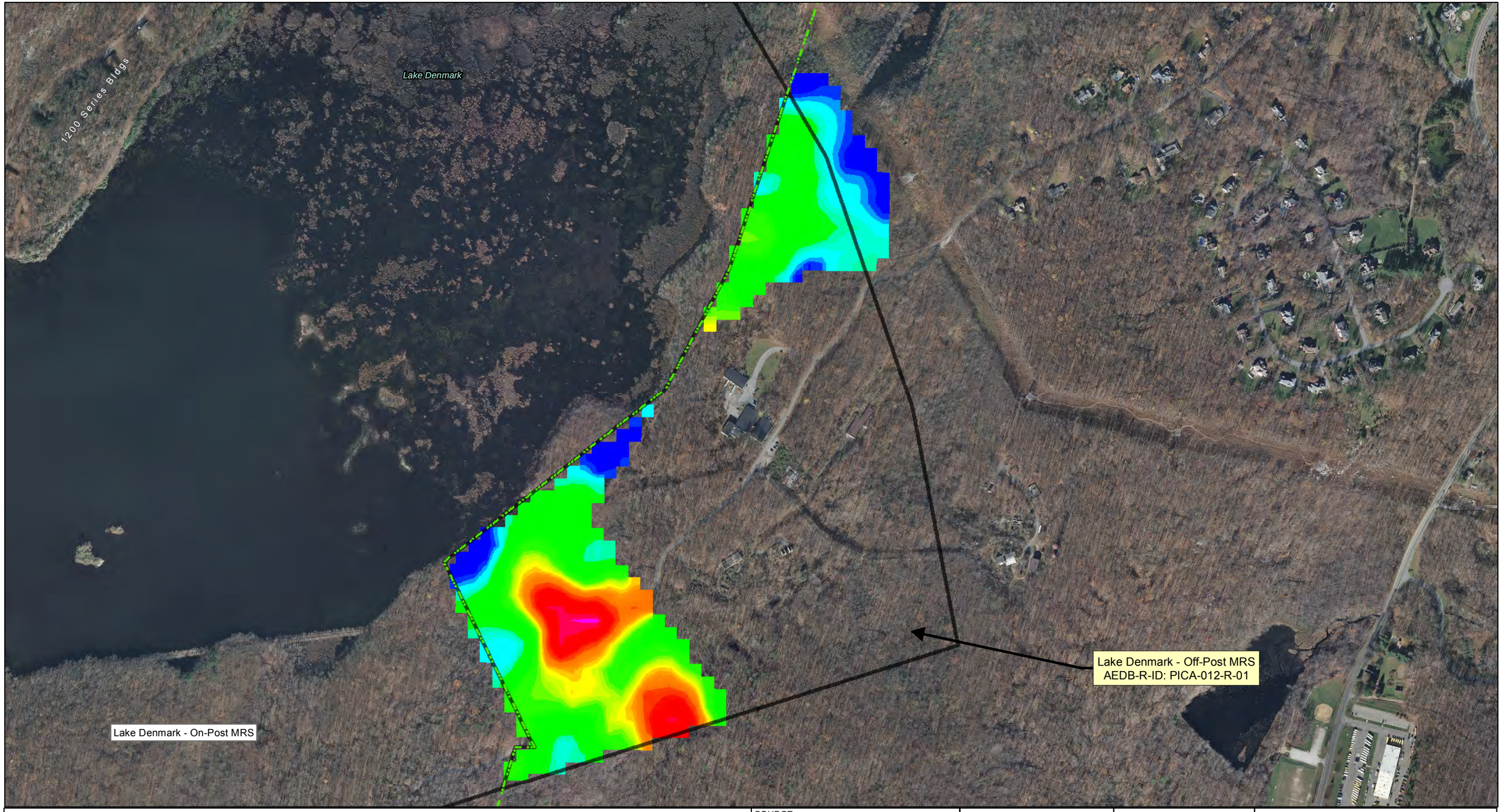


FIGURE 6-21
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
LAKES MRS
PICATINNY ARSENAL, NEW JERSEY



Legend

- Installation Boundary
- Munitions Response Site Boundaries

Anomaly Density (anom/acre)
from VSP

2 3 5 6 8 9 11 12 14 15 17 18 20 22 23 25 26 28 29 31 32 34 35 37 38 40 42 43 45 46 48 49 51 52 54 55 57 58

SOURCE:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

N

0 500 1,000 Feet

0 175 350 Meters

Created By: CLR

Verified By: NAS

Approved By: RSS

Figure 6-22
Lake Denmark - Off-Post MRS
Density Map

Date:10/30/2013

Contract No. W912DR-09-D-0006
Delivery Order 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\Lake_Denmark_offpost_VSP.mxd

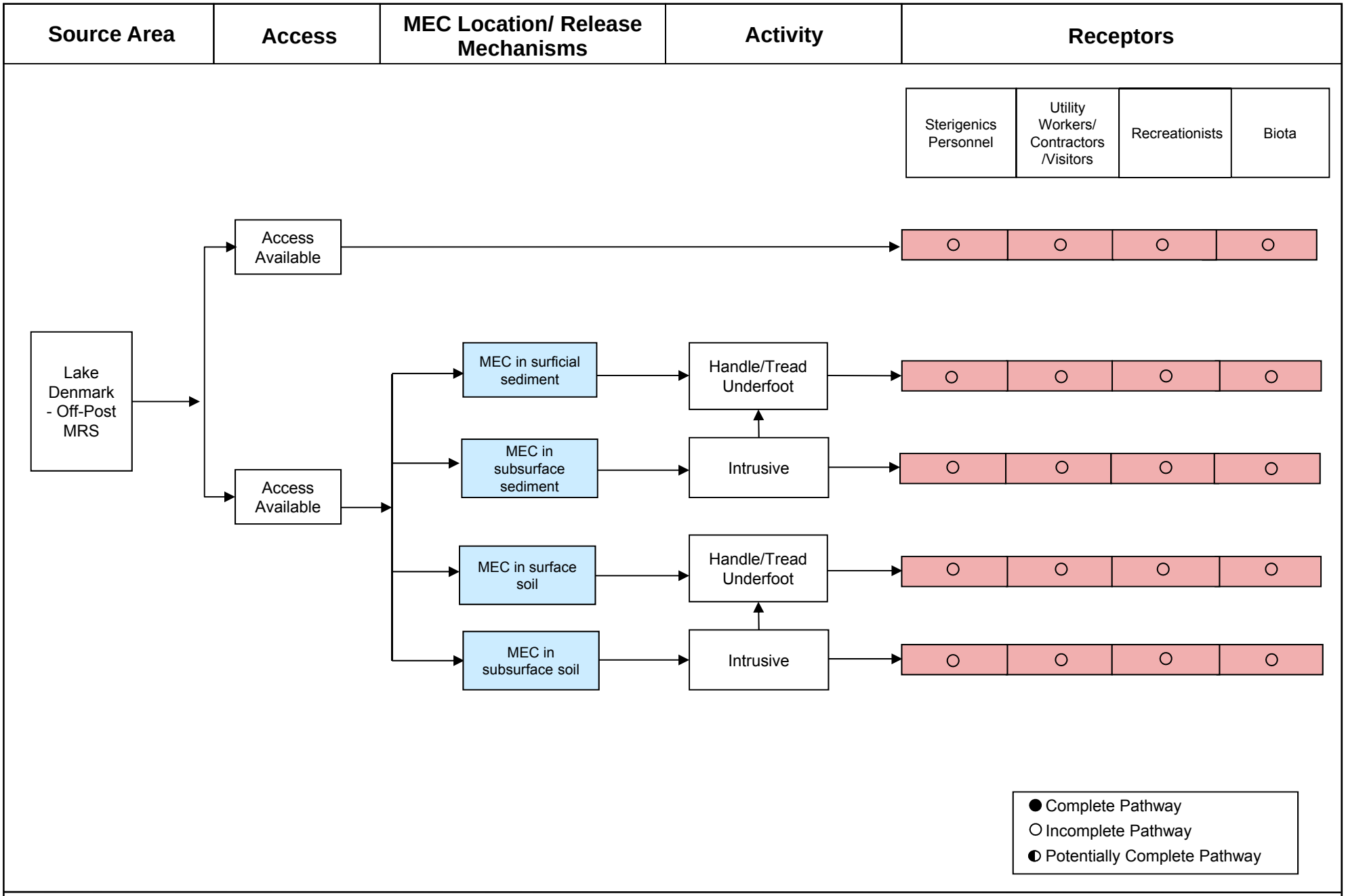
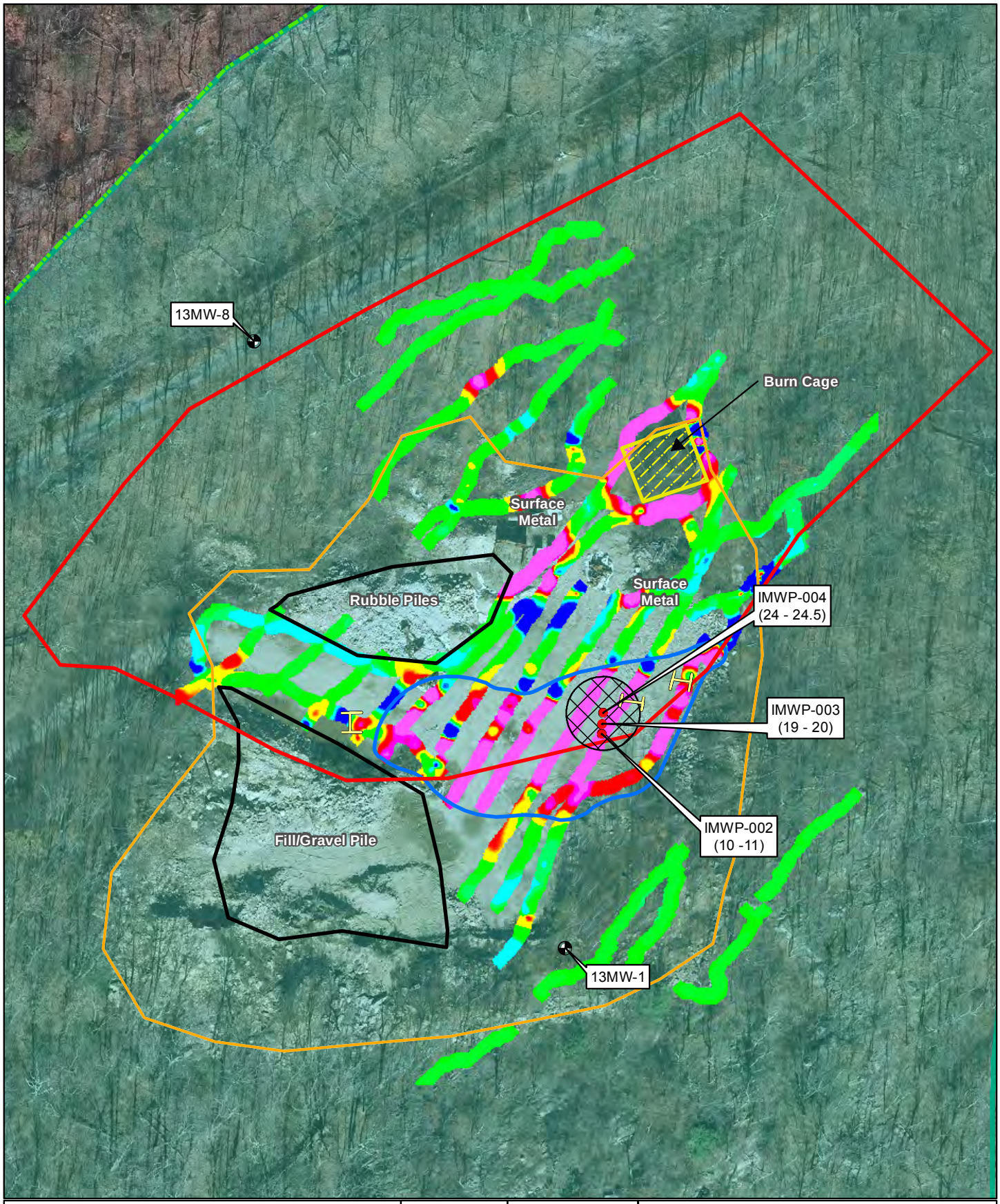


FIGURE 6-23
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
LAKE Denmark – Off-Post MRS
PICATINNY ARSENAL, NEW JERSEY



Legend

- Installation Boundary
- Inactive Munitions Waste Pit
- Fill/Gravel Rubble Piles
- Burn Cage Current Location
- Limit of Disturbance in 1963 Aerial Photo
- Approximate 2012 Limit of Disturbance
- Approximate Waste Pit Location
- May 2012 Trench/Test Pit Excavation Area
- Shaw Completed Test Pit Location
- MC Sampling Locations

Inphase Response (ppm)
-6 -3 -1 0 1 2 3 4 6 7 8 9 11

Picatinny Arsenal
Morris County, New Jersey

WESTON SOLUTIONS

Created By: CLR
Verified By: NAS
Approved By: RSS

N
0 70 Feet
0 9 18 27 Meters

Figure 6-24
Inactive Munitions Waste Pit MRS
EM31 DGM Results

10/23/2013

Contract # W912DR-09-D-0006
DO 0002

Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP_EM31_Results.mxd

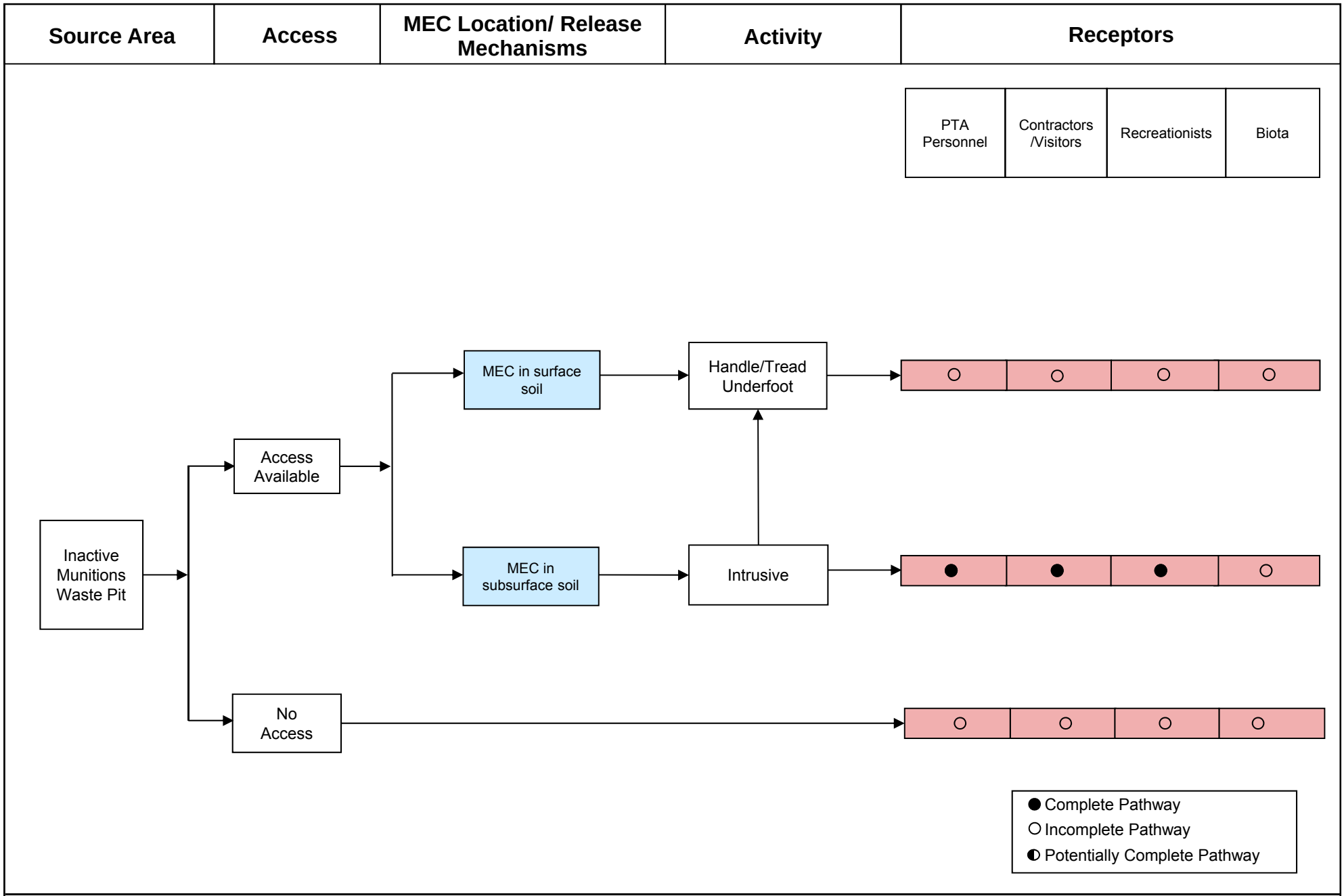
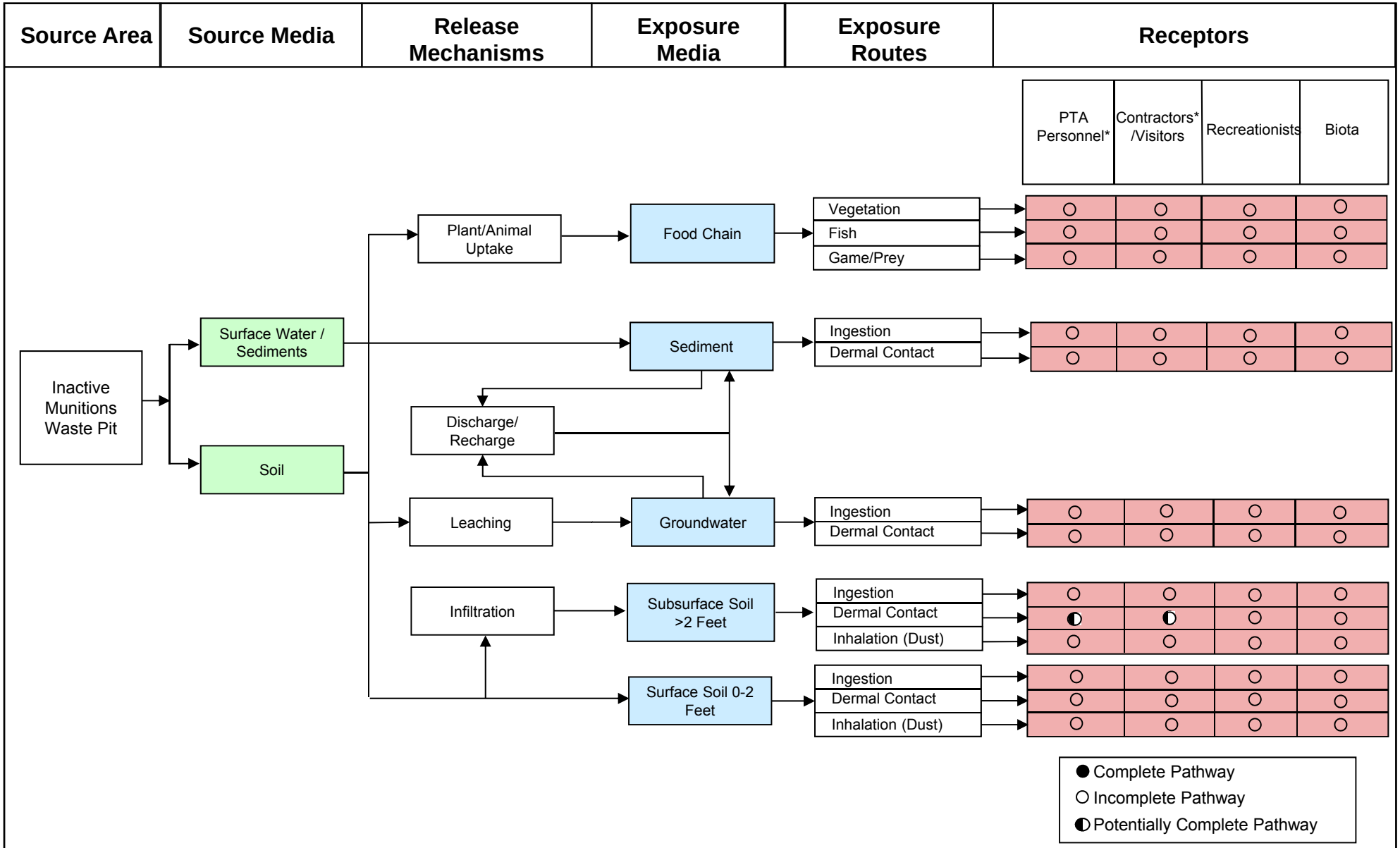
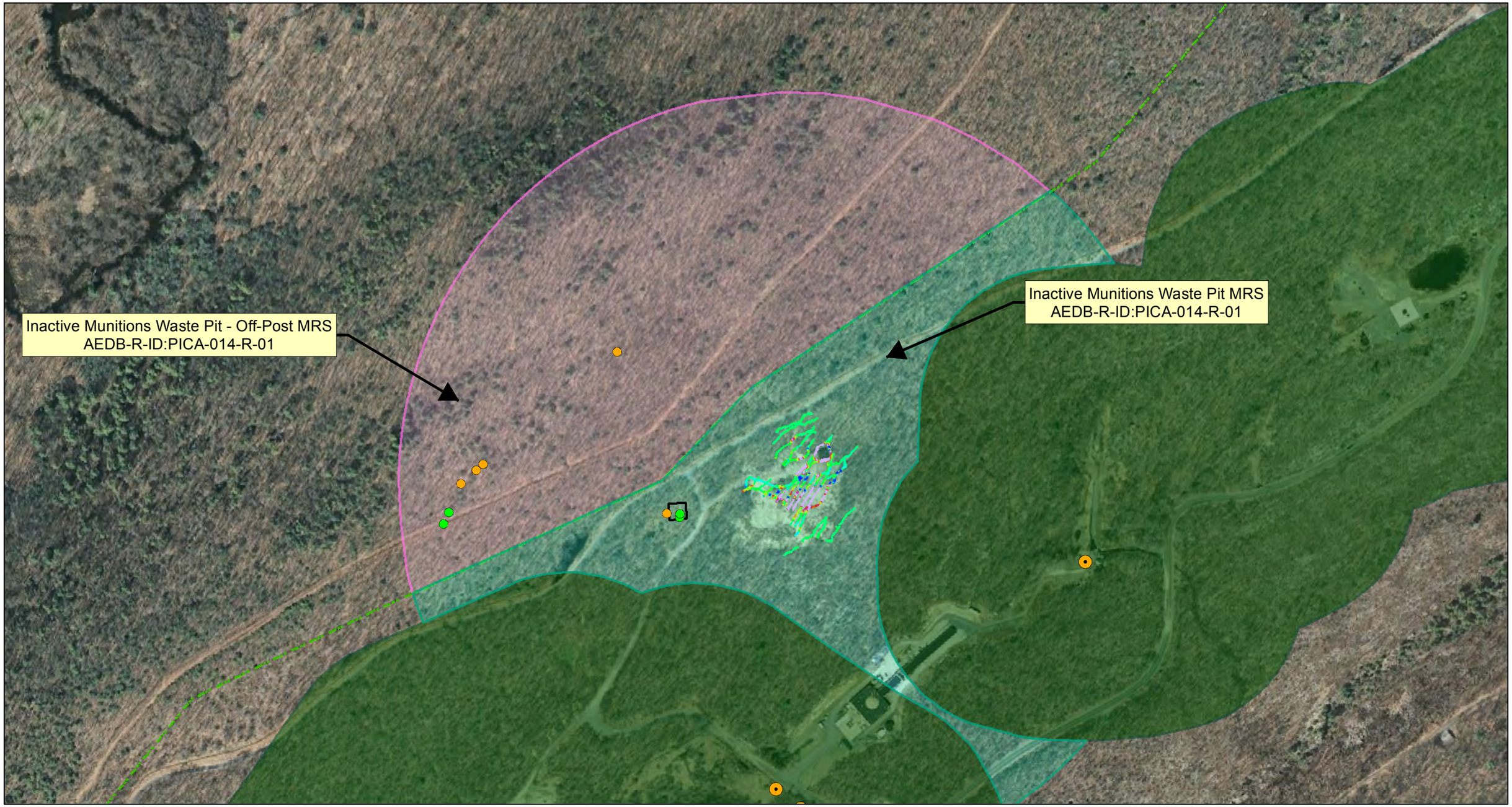


FIGURE 6-25
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
INACTIVE MUNITIONS WASTE PIT MRS
PICATINNY ARSENAL, NEW JERSEY



*Note, that PTA Personnel and Contractors are considered potentially complete at depth only under the assumption that a removal action may be conducted in accordance with a proposed removal action.

FIGURE 6-26
REMEDIAL INVESTIGATION - MC EXPOSURE PATHWAY ANALYSIS
INACTIVE MUNITIONS WASTE PIT MRS
PICATINNY ARSENAL, NEW JERSEY



Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Inactive Munitions Waste Pit
- Inactive Munitions Waste Pit - Off-Post
- Grid Boundary
- Cultural Debris
- Munitions Debris

UXO Finds Map Items

- Munitions Debris

Inphase Response (ppm)

-6 -3 -1 0 1 2 3 4 6 7 8 9 11

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 300 600 Feet

0 70 140 210 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 6-27
Inactive Munitions Waste Pit MRS
Intrusive Results

12/4/2013

Contract # W912DR-09-D-0006
DO 0002

File: Y:\Picatinny\MXD\RI_Sept2012\Alt\RTC\IMWP_Results_v2.mxd

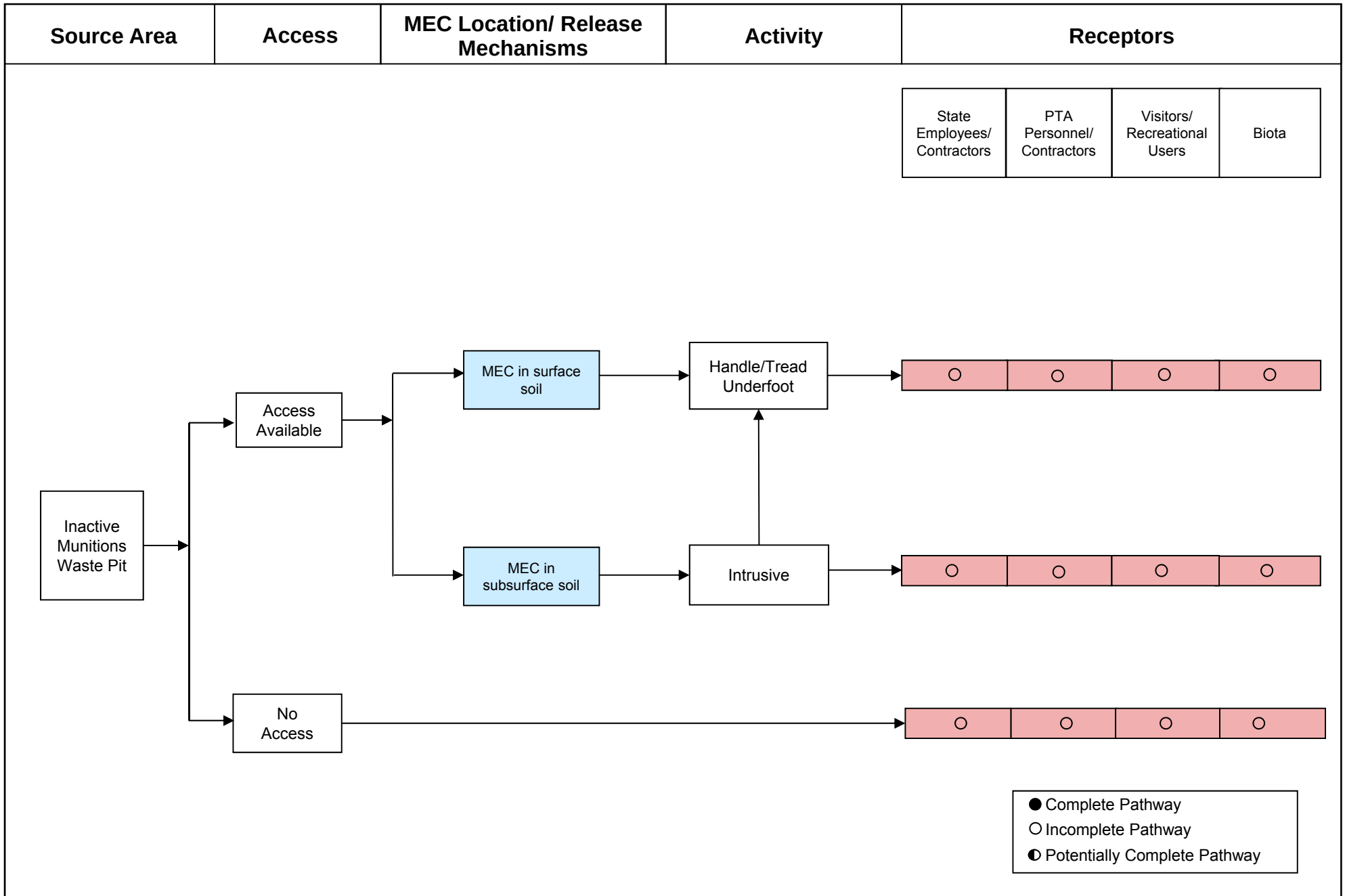


FIGURE 6-28
REMEDIAL INVESTIGATION - MEC EXPOSURE PATHWAY ANALYSIS
INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS
PICATINNY ARSENAL, NEW JERSEY

7. MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

7.1 MEC HAZARD ASSESSMENT GENERAL

The MEC hazard assessment (MEC HA), a tool used to assess the risk from MEC at an MRS, was completed in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment (MEC HA) Methodology* (EPA, 2008a). The purpose of the MEC HA is to evaluate the potential explosive hazard associated with conventional MEC present at an MRS. The MEC HA does not address hazards posed by chemical warfare materiel, MEC that is located underwater, or environmental and/or ecological hazards associated with MEC.

Each MRS is either scored as a whole or is evaluated by dividing the MRS into subunits. The MEC HA, which is used to score an MRS under a variety of MRS-specific conditions, including various cleanup scenarios and land-use assumptions, can be used to score a site several times to evaluate current site conditions, as well as reasonably anticipated future land uses. The MEC HA can also be used to assess MRS conditions after completion of different levels of proposed cleanup or the application of land use controls. The MEC HAs prepared for this RI include data/information available through the date of the RI and were developed for current land use scenarios only since, based on PTA's short and long-term development plans, the future use of the MRSs are not expected to change from the current use. The MEC HAs for this RI do not provide an evaluation of various cleanup and land use control alternatives for the MRS since, at the current time, it is unknown what anticipated cleanup and land use controls would be implemented at each MRS. The MEC HAs are provided in **Appendix O**.

The MEC HA evaluates risk through a review of three components of a potential explosive hazard.

- **Severity** – the potential consequences (e.g., death, severe injury, property damage) of a MEC item functioning.
- **Accessibility** – the likelihood that a receptor will be able to come in contact with a MEC item.
- **Sensitivity** – the likelihood that a receptor will be able to interact with a MEC item such that it will detonate.

Each component is assessed through the use of input factors that each have two or more categories associated with them and each category is associated with a numeric score that reflects the relative contributions of the different input factors to the hazard assessment. The sum of the input factor categories is then assigned to one of four defined ranges, called hazard levels. Each of the four hazard levels reflects site attributes that describe groups of sites and site conditions ranging from the highest to lowest hazards. The four hazard levels and corresponding minimum and maximum scores for each level of the MEC HA are shown in **Table 7-1**.

Table 7-1 Summary of the MEC HA Hazard Levels

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

7.1.1 MEC HAZARD ASSESSMENT COMPONENTS

7.1.1.1 Severity

This component is defined in the MEC HA guidance (EPA, 2008a) as "[t]he potential consequences of the effect (i.e., injury or death) on a human receptor should a MEC item detonate." Two input factors are required to determine this component, energetic material type and location of additional human receptors. Each input factor is described in more detail below.

- Energetic Material Type – This factor describes the hazard associated with MEC known or suspected to be present at the MRS. MEC items identified, either on the surface or subsurface, are included in the MEC HA and the energetic material type associated with each item is selected (i.e., high explosive and low explosive filler in fragmenting rounds, white phosphorus, pyrotechnic, propellant, spotting change and incendiary). The energetic material with the highest value entered into the MEC HA (i.e., most hazardous) is included as the input factor category score.

- Location of Additional Human Receptors – This factor, which assumes that a receptor has unintentionally initiated the detonation of a MEC item, accounts for the possibility that secondary receptors could also be affected. Unintentional detonation of MEC would result not only in injury (or death) to the individual initiating the detonation, but also to other receptors that may be exposed to the overpressure or fragmentation hazards from the MEC detonation. For this input factor category, a determination is made whether there are places where people

congregate that are either within the MRS or within the explosive safety-quantity distance (ESQD). The ESQD is based on the maximum fragment distance-horizontal of all the MEC items encountered within the MRS. The MRS is given a single value score if there is an affirmative response and no score if there is a negative response to the determination as to whether additional receptors may be exposed.

7.1.1.2 Accessibility

This component, defined in the MEC HA guidance (EPA, 2008a) as "[t]he likelihood that a human receptor will be able to come into contact with a MEC item", contains five input factors, which are described in the following sections.

7.1.1.3 Site Accessibility

Site accessibility describes the ease with which receptors can access the MRS. There are four potential site accessibility input factor categories, full, moderate, limited, and very limited. Each category is associated with a numerical value used in scoring. Below is a brief description of each category.

1. **Full Accessibility** – indicates there are no barriers to entry such as fencing, although signage may be present.
2. **Moderate Accessibility** – indicates there are some barriers to entry, such as barbed wire fencing or rough terrain.
3. **Limited Accessibility** – indicates there are significant barriers to entry, such as unguarded chain link fence or requirements for special transportation to reach the site.
4. **Very Limited Accessibility** – indicates there is either a guarded chain link fence or terrain that requires special equipment and skills (e.g., rock climbing) to access.

7.1.1.4 Potential Contact Hours

Potential contact hours, which is an estimate of the total number of receptor hours per year, assumes that both the number of receptors and the amount of time they spend at the MRS can affect the likelihood of the receptor encountering MEC. The potential contact hours takes into consideration the activities performed at the MRS as well as the receptor/exposure scenarios presented in the RI. The receptor hours per year for each activity are then summed and determined to be in one of the following four categories:

1. Many hours - greater than 1,000,000 receptor hours/year
2. Some hours - 100,000 to 999,999 receptor hours/year

3. Few hours - 10,000 to 99,999 receptor hours/year
4. Very few hours - less than 10,000 receptor hours/year

7.1.1.5 Amount of MEC

This input factor, which qualitatively describes the amount of MEC that may be present due to past munitions-related activities at the MRS, is assessed by determining the type of munitions activities that took place at the MRS (e.g., target area, OB/OD area, maneuver area, safety buffer area, storage). Each category is associated with a value based on the relative hazard of each munitions activity.

7.1.1.6 MEC Depth Relative to Maximum Receptor Intrusive Depth

This input factor describes whether MEC items are located where receptor activities take place. The shallowest recorded MEC depth is compared to the deepest intrusive depth recorded and one of the following categories is selected. Each category is associated with a numerical value used to score the MRS.

1. Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC.
2. Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth does not overlap with subsurface MEC.
3. Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth overlaps with minimum MEC depth.
4. Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth does not overlap with minimum MEC depth.

7.1.1.7 Migration Potential

This input factor describes the likelihood that MEC items can be moved and potentially exposed by natural processes such as erosion or frost heaving (repeated freeze/thaw cycles). Some elements that could affect the potential for migration include frost line depth, seasonal heavy rains, topographic slope, soil type, and vegetation. One of two categories is selected, possible or unlikely, and the selected category's associated numerical score is used to score the MRS.

7.1.1.8 Sensitivity

The sensitivity component is defined in the MEC HA guidance (EPA, 2008a) as "the likelihood that a MEC item will detonate if a human receptor interacts with it." Two input factors are required to determine this component, MEC classification and MEC size.

- **MEC Classification** – The MEC HA guidance (EPA, 2008a) defines six categories of MEC; UXO Special Case, UXO, Fuzed DMM Special Case, Fuzed DMM, Unfuzed DMM, and Bulk Explosives. Each MEC classification has a numerical value and the value associated with the selected classification is used to score the MRS.
- **MEC Size** – The MEC Size input factor is used to account for the ease with which a MEC item can be moved by a receptor, which increases the likelihood that a receptor will pick it up or otherwise disturb the item. Two categories are used to describe the MEC size.
  - Small – which are items that weigh less than 90 pounds
  - Large – which are items that weight 90 pounds or more

7.1.2 SITE-SPECIFIC MEC RISK ASSESSMENT

A baseline MEC assessment was completed for each applicable MRS at PTA using the MEC HA Guidance and accompanying automated scoring worksheets. MEC HAs were not completed for the following MRSs:

- **Lakes MRS (water portion only)** – MEC HAs are not applicable to water MRSs.
- **Inactive Munitions Waste Pit – Off-Post and Lake Denmark – Off-Post MRS** – no MEC were identified at the MRSs during the RI.
- **Shell Burial Grounds MRS** – no MEC were identified at the MRS during the RI. Due to the high potential for MEC to be present (based on historical reports), a probability assessment was conducted and is included in **Appendix O** and detailed in Section 7.2.

The input factors and the MEC HA score associated with each MRS are shown on **Tables 7-2 through 7-7**.

Table 7-2 1926 Explosion Radius MRS - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	All munitions listed use high explosive as filler type (e.g., fuzes and artillery projectiles).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA residents, government workers and contractors, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are no barriers preventing receptor access. While a small portion of the site is fenced and access is restricted, the majority of the site is accessible. The MEC HA does not allow the selection of a category which provides for barriers being present over only a portion of the site. Full accessibility was selected to remain conservative and capture the full risk potential.
IV.	Potential Contact Hours	≥1,000,000 receptor-hrs/yr	120	The combination of PTA employees and residents and temporary construction workers equate to 11,742,000 potential contact hours.
V.	Amount of MEC	Safety Buffer Areas	30	This MRS is unique regarding the source of munitions potentially on-site. Safety Buffer Areas was selected because it most correctly resembles the mechanism by which UXO items were dispersed across the MRS by the 1926 explosion. The UXO is similar to kick-outs from an OB/OD area.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC.	240	This category was selected because a) munitions were known to have been found on the ground surface and in the subsurface and b) the maximum intrusive depth for the MRS of 6 ft (based on current and potential future construction requiring subsurface work) is greater than the minimum depth at which munitions were encountered (0 ft).
VII.	Migration Potential	Possible "	30	Conditions exist at the MRS in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility and moderate to severely sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO Special Case	180	The selection of "Safety Buffer Areas" as an input factor indicates munitions cannot be assumed to be DMM and are conservatively considered UXO. Fuzes were identified at the MRS and are considered special case munitions; therefore the category "UXO Special Case" was selected as the input factor category.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**850**
Hazard Level Category				**1**

Table 7-3 Fuze Area MRS - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	Fuzes, which are the only MEC found at the site, use high explosive as filler type.
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA residents, government workers and contractors, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are no barriers preventing receptor access.
IV.	Potential Contact Hours	100,000 to 999,999 receptors hrs/yr	70	The site is undeveloped; however, there is the potential for receptors to walk across the MRS to gain access to an adjacent property. A conservative estimate for this receptor access equates to 133,225 potential contact hours.
V.	Amount of MEC	Burial Pit	140	This MRS is unique regarding the source of munitions potentially on-site. “Burial Pit” was selected based on the RI CSM.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC."	240	This category was selected because a) munitions were known to have been found on the ground surface and in the subsurface and b) the maximum intrusive depth for the MRS of 0 ft (based on being undeveloped property with no planned construction) overlaps the minimum depth at which munitions were encountered (0 ft).
VII.	Migration Potential	Possible	30	Conditions exist at the MRS in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility and moderate to severely sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	Fuzed DMM Special Case	105	The selection of "Burial Pit" as an input factor indicates munitions are DMM. Fuzes were identified at the MRS and are considered special case; therefore, the category "Fuzed DMM Special Case" was selected as the input factor category.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**835**
Hazard Level Category				**2**

Table 7-4 1926 Explosion Radius MRS - Off-Post MRS Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	All munitions listed use high explosive as filler type (e.g., fuzes and artillery projectiles).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., residents, quarry workers, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are no barriers preventing receptor access. While a small portion of the site is fenced and access is restricted, the majority of the site is accessible. The MEC HA does not allow the selection of a category that provides for barriers being present over only a portion of the site. Full accessibility was selected to remain conservative and capture the full risk potential.
IV.	Potential Contact Hours	100,000 to 999,999 receptor hrs/yr	70	The combination of quarry workers and recreational users equate to 106,000 potential contact hours.
V.	Amount of MEC	Safety Buffer Areas	30	This MRS is unique regarding the source of munitions potentially on-site. Safety Buffer Areas was selected because it most correctly resembles the mechanism by which UXO items were dispersed across the MRS by the 1926 explosion. The UXO is similar to kick-outs from an OB/OD area.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth overlaps with minimum MEC depth.	150	This category was selected because a) no munitions were known to have been found on the ground surface and b) the maximum intrusive depth for the MRS of 6 ft (based on quarry activities) is greater than the minimum depth at which munitions were encountered (0.083 ft). While the actual maximum depth cannot be determined at this time, a maximum depth of six feet is used. Increasing the depth further will not affect the MEC HA score.
VII.	Migration Potential	Possible	30	Conditions exist at the MRS in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility and moderate to severely sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO Special Case	180	The selection of "Safety Buffer Areas" as an input factor indicates munitions cannot be assumed to be DMM and are conservatively considered UXO. Fuzes were identified at the MRS and are considered special case munitions; therefore the category "UXO Special Case" was selected as the input factor category.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
		Total Score	**710**	
		Hazard Level Category	**3**	

Table 7-5 Former Operational Areas MRS - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	One or more munitions listed use high explosive as filler type (e.g., submunitions, fuzes, grenades, and mortars).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA residents, government workers and contractors, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are no barriers preventing receptor access. While a small portion of the site is fenced and access is restricted, the majority of the site is accessible. The MEC HA does not allow the selection of a category which provides for barriers being present over only a portion of the site. Full accessibility was selected to remain conservative and capture the full risk potential.
IV.	Potential Contact Hours	≥1,000,000 receptor-hrs/yr	120	The combination of PTA employees, residents, temporary construction workers, and recreational users equate to 11,992,000 potential contact hours.
V.	Amount of MEC	Target Area	180	Target Area was selected because target and research and development ranges were identified as being located within the MRS footprint.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC."	240	This category was selected because a) at least one munitions item has been found on the ground surface and b) the maximum intrusive depth for the MRS of 6 ft (based on current and potential future construction requiring subsurface work) is greater than the minimum depth at which munitions were encountered (0 ft).
VII.	Migration Potential	Possible	30	Conditions exist at the MRS in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility and moderate to severely sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO Special Case	180	The selection of "Target Area" as an input factor indicates munitions are UXO. Fuzes, white phosphorus filler, and mortars were identified at the MRS and are considered special case; therefore, the category "UXO Special Case" was selected.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**1000**
Hazard Level Category				**1**

Table 7-6 Former Operational Areas Mortar Range MRS - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	One or more munitions listed use high explosive as filler type (e.g., submunitions, fuzes, grenades, and mortars).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA residents, government workers and contractors, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are no barriers preventing receptor access.
IV.	Potential Contact Hours	100,000 to 999,999 receptor hrs/yr	70	The combination of PTA employees, residents, temporary construction workers, and recreational users (hunters) equate to 812,000 potential contact hours.
V.	Amount of MEC	Target Area	180	Target Area was selected because a mortar range impact area was identified within the MRS boundary.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC."	240	This category was selected because a) at least one munitions item has been found on the ground surface and b) the maximum intrusive depth for the MRS of 6 ft (based on current and potential future construction requiring subsurface work) is greater than the minimum depth at which munitions were encountered (0 ft).
VII.	Migration Potential	Possible	30	Conditions exist at the MRS in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO Special Case	180	The selection of "Target Area" as an input factor indicates munitions are UXO. Fuzes, white phosphorus filler, and mortars were identified at the MRS and are considered special case; therefore, the category "UXO Special Case" was selected.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**950**
Hazard Level Category				**1**

Table 7-7 Lakes MRS (Land Portions Only) - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	One or more munitions listed use high explosive as filler type (e.g., rockets and mortars).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA residents, government workers and contractors, and visitors).
III.	Site Accessibility	Full Accessibility	80	There are either no barriers or very limited partial barriers (i.e., a fence around a portion of Picatinny Lake) preventing receptor access. The partial fence does not reasonably limit receptor access; therefore, full accessibility was selected as the input factor category.
IV.	Potential Contact Hours	≥1,000,000 receptor-hrs/yr	120	The combination of PTA employees, residents, temporary construction workers, and recreational users equate to 1,251,500 potential contact hours.
V.	Amount of MEC	Function Test Range	165	Function Test Range was selected because munitions testing ranges existed on the MRS.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located surface and subsurface. After Cleanup: Intrusive depth overlaps with subsurface MEC."	240	This category was selected because a) at least one munitions item has been found on the ground surface and b) the maximum intrusive depth for the MRS of 0 ft (based on current and potential future intrusive activities) is greater than or equal to the minimum depth at which munitions were encountered (0 ft).
VII.	Migration Potential	Possible	30	Conditions exist at the MRS around the lake in which frost heave (i.e., freezing temperatures and generally coarse-textured sandy loam soils that promote capillary flow) and erosion (i.e., sandy loam soils with moderate erodibility and moderate to severely sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO Special Case	180	The selection of "Function Test Range" as an input factor indicates munitions are UXO. Mortars identified at the MRS are considered special case; therefore, the category "UXO Special Case" was selected.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**985**
Hazard Level Category				**1**

Table 7-8 Inactive Munitions Waste Pit MRS - Input Factors and Score

Input Factor		Input Factor Category	Score	Rationale for Selection of Input Factor
I.	Energetic Material Type	High Explosive and Low Explosive Filler in Fragmenting Rounds	100	All munitions listed use high explosive as filler type (e.g., mines and fuzes).
II.	Location of Additional Human Receptors	Inside the MRS or inside the ESQD arc	30	There are human receptors that could congregate within the MRS or ESQD arc (e.g., PTA workers and contractors).
III.	Site Accessibility	Limited Accessibility	15	The MRS is fully fenced and access is restricted to authorized personnel only.
IV.	Potential Contact Hours	10,000 to 99,999 receptor-hrs/yr	40	Access is restricted to authorized personnel only. Therefore, a conservative estimate of less than 99,999 hours, which equates to the “Few Hours” category was selected for essential personnel who may enter this area.
V.	Amount of MEC	Function Test Range	165	Function Test Range was selected the area was known to be used as an ordnance testing area.
VI.	Minimum MEC Depth Relative to Maximum Intrusive Depth	"Baseline Condition: MEC located only subsurface. Baseline Condition or After Cleanup: Intrusive depth does not overlap with minimum MEC depth."	50	This category was selected because a) no munitions are documented to have been found on the ground surface and b) the maximum intrusive depth for the MRS of 0 ft is less than the minimum depth at which munitions were encountered (4.5 ft). The maximum intrusive depth is 0 ft because the site us fully fenced and access is prohibited.
VII.	Migration Potential	Unlikely	10	Conditions do not exist at the MRS in which frost heave (i.e., minimum detection depth of 4.5 ft is below the frost line) and erosion (i.e., relatively deep munitions depth [4.5 ft] and slightly sloped topography) could potentially expose subsurface MEC.
VIII.	MEC Classification	UXO	110	The selection of "Function Test Range" as an input factor indicates munitions are UXO. None of the munitions items identified at the MRS were identified as being fuzed nor are considered special case munitions; therefore, the category "UXO" was selected.
IX.	MEC Size	Small	40	The smallest munitions item found on site was less than 90 lbs.
Total Score				**560**
Hazard Level Category				**3**

7.2 SHELL BURIAL GROUNDS MRS – MEC PROBABILITY ASSESSMENT

The MEC probability assessment (**Appendix O)** is being used to determine the probability of encountering MEC at the Shell Burial Grounds MRS instead of a MEC Hazard Assessment because MEC has not been confirmed at the MRS. The probability will be scored as "no probability," "low probability", or "moderate to high probability." Results of the assessment will determine what action, if any, is needed in accordance with the DoD, Ammunition and Explosives Safety Standards Manual 6055.09-M and the U.S. Army Corps of Engineers, Explosives – Safety and Health Requirements Manual EM 385-1-97.

The scoring system used to determine the MEC probability at the Shell Burial Grounds MRS is based on the U.S. Army Corps of Engineers, Explosives – Safety and Health Requirements Manual EM 385-1-97. Two scores are combined to create one score. The first score, munitions type scoring, is derived from munitions type and can be determined by physical or historical evidence of MEC regardless of configuration. The second score, hazard source, is based on the physical or historical evidence of previous MRS usage including MEC burial.

The munitions type scoring descriptions are presented in Table 1 of the probability assessment in **Appendix O**.A munitions type score of 10 was selected for the Shell Burial Grounds MRS because of historical evidence presented in Section 2.4. According to the HRR, the following material was part of the 1926 explosion and may be present within the Shell Burial Grounds MRS:

- TNT
- 25-pound Navy Mark I bombs, loaded and plugged
- Mark II, III, IV, and V bombs, each loaded with TNT
- Bomb accessories (e.g., fins, tails)
- Aerial bombs, TNT center section
- 14-inch Class "B," loaded and fuzed
- 14-inch armor piercing rounds, loaded and fuzed
- 8-inch shells, loaded and fuzed
- 5-inch shells, loaded and fuzed

Although not listed in the historical documents, 3-inch, 4-inch, and 6-inch common projectiles were also present at Picatinny Arsenal at the time of the 1926 explosion.

A hazard source score of 5 (Appendix O, Table 2) was selected for the Shell Burial Grounds MRS based on the historical evidence presented in Section 2.4. The craters left by the 1926

explosion were reportedly used to dispose of approximately 25 tons of explosives and/or munitions. The Navy also continued to dispose of additional material in the craters until 1945.

The munitions type score and hazard source score are combined to determine the final MEC assessment for a MRS as presented in **Table 7-9**.

Table 7-9 MEC Assessment

Description	Probability
Combined score from Tables 1 and 2 = 8 through 15.	"Moderate to high probability" for encountering MEC.
Combined score from Tables 1 and 2 = 1 through 7.	"Low probability" for encountering MEC.
Combined score from Tables 1 and 2 = 0.	"No probability" for encountering MEC.

The Shell Burial Grounds MRS has a munitions type score of 10 and a hazard source score of 5 (cumulative score of 15), which equates to a "moderate to high probability" for encountering MEC (refer to **Table 7-9**). In accordance with the U.S. Army Corps of Engineers, Explosives – Safety and Health Requirements Manual EM 385-1-97, a "moderate to high probability" of encountering MEC means any activity within the MRS must be conducted using anomaly avoidance techniques or UXO-qualified personnel must attempt to identify and remove any explosive hazards prior to any intrusive activities. Before the removal action begins, a Department of Defense Explosives Safety Board approved Explosives Safety Submission will be required prior to additional soil disturbance activities that cannot be achieved using anomaly avoidance techniques.

7.3 MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

The purpose of the Munitions Response Site Prioritization Protocol (MRSPP) is to prioritize potential actions at MRSs for national funding and responses. The MRSPP is comprised of three modules; EHE, which evaluates explosive hazards, CHE, which evaluate hazards from chemical warfare materiel, and HHE, which evaluates the risks associated with munitions constituents. Each module is discussed in more detail below.

1. EHE – is composed of the following elements:
   a. **Munitions Type** – is similar to the Type of Filler input factor on the MEC HAs. Refer to **Tables 7-1** through **7-7**. For those MRSs without an MEC HA, no munitions were found. Additional detail regarding munitions types associated with each MRS can be found on Table 1 of each MRSPP in **Appendix P**.
   b. **Source of Hazard** – is used to describe the type(s) of munitions activities that occurred on the MRS. There is no similar input factor on the MEC HAs. Therefore, the classification selected for each MRS is detailed below.
      i. 1926 Explosion Radius MRS – OB/OD was selected since the area where the explosion occurred is similar to an OB/OD. Although the explosion area is more similar to a safety buffer associated with an OB/OD this category is not available on the MRSPP.
      ii. Fuze Area MRS – Former Burial Pit was selected since the source of the munitions was likely burial of fuzes when a building was razed.
      iii. 1926 Explosion Radius – Off-Post MRS – OB/OD was selected since the area where the explosion occurred is similar to an OB/OD. Although the explosion area is more similar to a safety buffer associated with an OB/OD this category is not available on the MRSPP.
      iv. Shell Burial Grounds MRS – Former Burial Pit or Other Disposal Area was selected since this MRS was used for the disposal of approximately 25 tons of explosives from the 1926 explosion and the navy continued to use these areas for disposal of munitions until 1945.
      v. Former Operational Areas MRS - Former Range was selected since portions of this site were historically used for munitions testing
      vi. Former Operational Areas Mortar Range MRS – Former Range was selected because the MRS was historically used as a mortar range.
      vii. Lakes MRS – Former Range was selected since Lake Denmark was used as a mortar impact area and experimental munitions testing range and Picatinny Lake has had several uses, including a range and a testing and storage area.
      viii. Lake Denmark – Off-Post MRS – Evidence of No Munitions was selected since no MEC were found during the RI.
      ix. Inactive Munitions Waste Pit MRS – Former Range was selected since this site, which was an open field, was used from 1955 to the mid-1980s for the testing and storage of munitions and explosives.
      x. Inactive Munitions Waste Pit-Off-Post MRS – Evidence of No Munitions was selected since no MEC were found during the RI.

c. **Location of Munitions** – describes whether munitions were found in the surface or subsurface, and is similar to the Minimum MEC Depth Relative to Maximum Intrusive Depth MEC HA input factor. Refer to **Tables 7-**1 through **7-7**. Additional detail regarding the depth that munitions were found at each MRS can be found on Table 3 of each MRSPP in **Appendix P**.

d. **Ease of Access** – is similar to the Site Accessibility MEC HA input factor. Refer to Tables 7-1 through 7-7. Additional detail regarding this category can be found on Table 4 of each MRSPP in **Appendix P**.

e. **Status of Property** - is used to describe whether the property is or is not under DoD control. There is no similar input factor on the MEC HAs. One of two classifications was selected for each MRS for this category. For all on-post MRSs, DoD control was selected and for all off-post MRSs, non-DoD control was selected.

f. **Population Density** – is used to describe how many people per square mile live within a two-mile radius of the MRSs boundary. There is no similar input factor on the MEC HAs. For all MRSs, the classification selected was 100-500 persons per square mile.

g. **Population Near Hazard** – is used to describe the number of inhabited structures located within two miles of the MRS boundary. There is no similar input factor on the MEC HAs. For all MRSs, the classification selected was 26 or more inhabited structures.

h. **Types of Activities/Structures** – describes the types of land use present within two miles of the MRS boundary. There is no similar input factor on the MEC HAs. For all MRSs, the highest classification, Residential, Educational, Commercial, or Subsistence, was selected.

i. **Ecological and Cultural Resources** – describes whether ecological and/or cultural resources are present on an MRS. There is no similar input factor on the MEC HAs. Therefore, the classification selected for each MRS is given below.

   i. 1926 Explosion Radius MRS – Ecological and Cultural Resources Present was selected

   ii. Fuze Area MRS – No Ecological and Cultural Resources Present was selected.

   iii. 1926 Explosion Radius – Off-Post MRS – Ecological and Cultural Resources Present was selected

   iv. Shell Burial Grounds MRS – No Ecological and Cultural Resources Present was selected

   v. Former Operational Areas MRS - Ecological and Cultural Resources Present was selected

vi. Former Operational Areas Mortar Range MRS – Ecological Resources Present was selected

vii. Lakes MRS – Ecological and Cultural Resources Present was selected

viii. Inactive Munitions Waste Pit MRS – Ecological and Cultural Resources Present was selected

2. CHE – was not applicable to any MRS since there is no evidence of CWM use throughout PTA's history

3. HHE – 1) For all MRSs where MC is completely covered under the IRP (Shell Burial Grounds MRS), no longer required was selected; 2) For all MRSs where MC is partially covered under the IRP (i.e., collocated IRP sites are located within the MRS), and partially covered under the MMRP, but no samples were collected during the MMRP, no known or suspected MC hazard was selected (1926 Explosion Radius MRS and Lakes MRS); 3) For MRSs where MC is completely covered under the MMRP but no samples were collected, no known or suspected MC hazard was selected (Fuze Area MRS, 1926 Explosion Radius – Off-Post MRS, Lake Denmark – Off-Post MRS, Inactive Munitions Waste Pit – Off-Post MRS); 4) For MRSs that were sampled and the risk assessment determined that the MC was not posing a risk, no known or suspected MC hazard was selected (Former Operational Areas MRS, Former Operational Areas Mortar Range MRS, and Inactive Munitions Waste Pit MRS).

Refer to **Table 7-10** for a summary of the MRSPP scores and a comparison to the scores calculated during the SI.

Table 7-10 MRSPP Scores

MRS	MRSPP Score During SI	MRSPP Score During RI	Comments
1926 Explosion Radius MRS	3	3	No change from SI to RI
Fuze Area	NA	3	An MRSPP was not completed during the SI since this MRS was not yet identified
1926 Explosion Radius – Off-Post MRS	3	2	An increase to the score was made since OB/OD was added to the source of hazard table.
Shell Burial Grounds MRS	5	5	No change from SI to RI
Former Operational Areas MRS	3	3	No change from SI to RI
Former Operational Areas Mortar Range MRS	NA	3	An MRSPP was not completed during the SI since this MRS was not yet identified
Lakes MRS	4	4	No change from SI to RI
Lake Denmark – Off-Post	5	No Known or	A decrease to the score was made between the

		Suspected MEC, CWM, or MC Hazard	SI and RI since during the SI MEC were suspected at this MRS; however, no MEC were found during the RI
Inactive Munitions Waste Pit MRS	4	4	No change from SI to RI
Inactive Munitions Waste Pit – Off-Post MRS	4	No Known or Suspected MEC, CWM, or MC Hazard	A decrease to the score was made between the SI and RI since during the SI MEC were suspected at this MRS; however, no MEC were found during the RI

8. CONTAMINANT FATE AND TRANSPORT

8.1 FATE AND TRANSPORT DYNAMICS

The intent of this section of the RI Report is to describe the contaminant fate and potential transport mechanisms for MEC and MC identified at each MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to migration mechanisms away from the source area. Understanding the fate of the MEC and MC present in, or released to, the environment is important in evaluating the potential hazards to human health and the environment. For example, MEC and MC may be found on the ground surface or in the subsurface; however, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC and MC, thereby increasing the chance of exposure to it by human and ecological receptors.

As stated in Section 5.5.1.3 the results of the RI have determined that the Green Pond MRS should be consolidated back into the 1926 Explosion Radius MRS. Therefore; the results of the investigation for the Green Pond MRS are discussed in Section 8.2.

8.1.1 MEC FATE AND TRANSPORT

Various types of MEC were identified and characterized during the RI; therefore, generic migration mechanisms and disposition factors are discussed in the following paragraphs as applicable to all MRSs where MEC was discovered. Specific information pertaining to each MRS with a complete pathway for MEC exposure based on confirmation of source identification is detailed in the sections below.

Potential routes of migration include physical processes that might result in movement or relocation of MEC from its original placement. If not removed, the MEC has the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement:

- Person(s) picking up or moving a potential MEC item.
- Construction, excavation, or other soil moving activities disturbing potential MEC.
- Natural processes such as erosion/deposition or frost heave moving potential MEC.

Natural erosion of soil over time by wind or water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of a wash).

In addition to erosion, buried objects have been known to move or migrate toward the surface during freezing and thawing cycles. This movement occurs when cold penetrates the ground, and the water below the buried objects freezes and expands, gradually pushing the items upward. This phenomenon is often referred to as "frost heave" and is most likely to affect items buried above the frost line. The soil type influences the occurrence of frost heave: gravel, sand, and clay are not typically susceptible to the process, whereas silty soil is susceptible. Per the New Jersey Administrative Code, New Jersey Register, Vol. 45, No. 11, June 3, 2013, the frostline at PTA is 3 feet bgs; therefore, only MEC or MD identified within 3 feet of the ground surface would typically be affected by frost heave.

8.1.2 MC FATE AND TRANSPORT

MC was evaluated as needed where MEC was confirmed and/or a release was suspected based on the Final Work Plan. MC fate and transport dynamics may be more or less complex, given site-specific conditions and individual constituent(s); therefore, MC is addressed in the MRS-specific sections below where identification of a MC hazard source during the RI provides the basis for a detailed discussion.

8.2 1926 EXPLOSION RADIUS MRA

8.2.1 Munitions and Explosives of Concern

Based on RI characterization activities at the 1926 Explosion Radius MRA MEC were identified at depths up to 48 inches bgs; the majority of the MEC were found between 0 and 24 inches bgs. The three UXO items found during the RI that are associated with the 1926 explosion were at depths less than 3 inches bgs. MD items recovered during the RI from the portion of the AOI Code 300 Area that overlaps the 1926 Explosion Radius MRS were discovered at ground surface or depths between 3 and 6 inches bgs. MEC identified at the fuze area were found at the surface. It is possible for natural processes to result in the movement, relocation, or unearthing of MEC,

increasing the chance of exposure by human and ecological receptors. The topography of the 1926 Explosion Radius MRA varies from steep slopes to low-lying wetlands and water bodies. The steep sloped areas are prone to erosion, shown by the amount of talus/debris witnessed at the bottom of cliffs and hills during the RI activities. The composition of the soils varies across the MRA, with some areas (sands and muck) prone to frost heave and others (gravelly stone areas) with a low potential. The MEC was identified above the frost line (3 feet) and the soils contained within the area range from muck to sandy loams and are moderately susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion and frost heave are likely to impact source material. It is generally accepted within ecological risk assessments that burrowing mammals may be exposed to soils up to four feet bgs. As the majority of the MEC were found at depths between 0 and 24 inches bgs, biota (e.g., small and large mammals) may also unearth residual MEC and MD by digging or burrowing in the soil.

The Green Pond MRS is located within a heavily developed and utilized area of PTA, but the MRS is not currently being used for anything but water drainage. Due to the steep topography and remote nature of the Green Pond MRS, intrusive activities by human receptors are not likely, although due to the shallow depth of recovered MD, biota may unearth residual MD by digging or burrowing in the soil.

Individuals, including PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreationists, and trespassers, could come in contact with potential MEC simply by walking. The 1926 Explosion Radius MRS contains hundreds of buildings used for various purposes and is easily traversed. Contractor and PTA personnel could unearth potential MEC when performing intrusive activities. There are future plans for development of PTA, including the downtown area, which is located mostly within the 1926 Explosion Radius MRS, and potential MEC may be disturbed or relocated during construction, excavation, or other soil-moving activities. The likelihood of disturbing potential MEC is greater within the inner radius where the estimated MEC density is greater than in the outer radius.

8.2.2 Munitions Constituents

No MC sampling was conducted within the 1926 Explosion Radius MRA because the MEC and MD items discovered during the RI did not present any evidence of a release (e.g., visual

evidence of staining, cracked or corroded munitions, the item is not inert). Therefore, release of MC from a MEC item is highly unlikely.

Because existing COCs at the Green Pond MRS are being addressed under the IRP, fate and transport of MC and environmental conditions affecting such fate and transport are addressed under the IRP program.

8.3 1926 EXPLOSION RADIUS – OFF-POST MRS

As mentioned previously, the 1926 Explosion Radius – Off-Post MRS was investigated in conjunction with the 1926 Explosion Radius MRS as the division between the two is based on the physical location of the PTA boundary, and not due to differentiation between potential source and release mechanisms.

8.3.1 Munitions and Explosives of Concern

During the RI, no MEC were found within the 1926 Explosion Radius – Off-Post MRS. However during TCRA activities to date, 64 MEC items have been found by quarry workers at the Mount Hope Quarry. It is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, increasing the chance of exposure to it by human and ecological receptors. As indicated in Section 8.2.1, MEC associated with the 1926 explosion has been found at depths up to 48 inches bgs; however, most of the MEC has been found between 0 and 24 inches bgs.

The topography of the 1926 Explosion Radius – Off-Post MRS varies from steep slopes to low-lying wetlands and water bodies, including Mount Hope Pond and portions of Mount Hope Lake. The steep sloped areas are prone to erosion, shown by the amount of talus/debris witnessed at the bottom of cliffs and hills during the RI activities. The composition of the soils varies across the MRS, with some areas (sands and muck) prone to frost heave and others (gravelly stone areas) with a low potential. The MEC was identified above the frost line (3 feet) and the soils contained within the area range from muck to sandy loams and are moderately susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion and frost heave are likely to impact source material. It is generally accepted within ecological risk assessments that burrowing mammals may be exposed to soils up to four feet bgs. Therefore, biota (e.g., small and large mammals) may unearth residual MEC and MD by digging or burrowing in the soil.

Individuals, including quarry personnel, other workers (e.g., workers associated with other businesses, contractors, utility workers), visitors, recreationists (e.g., hunters, fishermen), and trespassers, could come in contact with potential MEC simply by walking. With the exception of the quarry, properties within the 1926 Explosion Radius – Off-Post MRS are not secure. Quarry workers, contractors, and utility workers could unearth potential MEC during quarrying operations or when performing other intrusive activities. MEC may be disturbed or relocated during potential future construction, excavation, or other soil-moving activities. The likelihood of disturbing potential MEC is greater within the inner radius where the estimated MEC density is greater than in the outer radius.

8.3.2 Munitions Constituents

No MC sampling were required during the RI to assess MC within the 1926 Explosion Radius – Off-Post MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS. The release of MC from a MEC item is highly unlikely.

8.4 SHELL BURIAL GROUNDS MRS

8.4.1 Munitions and Explosives of Concern

Based on RI characterization activities at the Shell Burial Grounds MRS, the bulk source for MEC and MD is buried approximately 25 feet to 35 feet bgs. The anticipated MEC and MD at the Shell Burial Grounds MRS is too deep for natural erosion to affect, especially since the MRS has a relatively flat topography that would make a large-scale erosional event such as a land slide unlikely. Soils contained within the Shell Burial Grounds MRS are typically not susceptible to frost heave. Additionally, the anticipated MEC and MD are present below the frost line (3 feet) and not susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion and frost heave are not likely to impact source material.

Biota that may nest or burrow are also not anticipated to be impacted by residual MEC and MD due to the depth of buried debris observed during DGM transects performed during the RI. The maximum anticipated depth of biological activity is anticipated to be less than 4 feet bgs, which is far shallower than the anticipated depth of MEC and MD. Impact/displacement through human

activities (e.g., intrusive activities) are the only potential factors that could impact the fate of residual MEC and transport it to another location within the MRS.

8.4.2 Munitions Constituents

No MEC or MD was found during the RI; therefore, the release of MC from a MEC item is highly unlikely. Because existing COCs at the Shell Burial Grounds MRS are being addressed under the IRP, fate and transport of MC and environmental conditions affecting such fate and transport are best addressed under the IRP program.

8.5 FORMER OPERATIONAL AREAS MRS

8.5.1 Munitions and Explosives of Concern

Based on RI characterization activities at the Former Operational Areas MRS, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, increasing the chance of exposure by human and ecological receptors. The recovered MEC was found between 0 and 18 inches bgs, with the one UXO item found at 3 inches bgs and the DMM found between 3 and 8 inches bgs. The recovered MD was found between 0 and 33 inches bgs. The topography of the Former Operational Areas MRS varies from steep slopes to low-lying wetlands and water bodies. The steep sloped areas are prone to erosion, shown by the amount of talus/debris witnessed at the bottom of cliffs and hills during the RI activities. The composition of the soils varies across the MRS, with some areas (sands and muck) prone to frost heave and others (gravelly stone areas) with a low potential. The portion of the MRS where the majority of MEC was identified has a relatively flat topography consisting mainly of wetlands. The MEC was identified above the frost line (3 feet) and the soils contained within the area range from muck to sandy loams and are moderately susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion and frost heave are likely to impact source material. Biota is also anticipated to impact residual MEC and MD due to the shallow depth of MEC observed during the RI, which was identified within the zone of biological activity.

Individuals, including PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreational users, and trespassers, could come in contact with potential MEC simply by walking. The Former Operational Areas MRS is partially developed and easily traversed. Contractor and PTA personnel could come in contact with potential MEC when

performing intrusive activities. The future plans for development at PTA include the downtown area, which is partially located in the Former Operational Areas MRS, and there is a likelihood of disturbing potential MEC during construction, excavation, or other soil-moving activities. The likelihood of disturbing potential MEC is much greater within the high-density MEC area present in the southern portion of the MRS. The likelihood of disturbing potential MEC is low within the majority of the Former Operational Area MRS (outside the high-density area).

8.5.2 Munitions Constituents

Gridded surface soil samples and associated step-out samples were collected for MC analyses during the RI at the Former Operational Areas MRS. Metals were detected at concentrations of concern in surface soil; specifically, aluminum, antimony, barium, cadmium, copper, lead, manganese, strontium, and zinc were detected above PTA-specific background concentrations. Due to the undeveloped nature of the MRS, MC may be released from surface soil by natural processes such as wind and water erosion or by any anthropogenic disturbance that results in movement or redistribution of soil. MC may migrate to the subsurface via infiltration/percolation of precipitation and leaching from soil to groundwater. The Former Operational Areas MRS consists of 1,880 acres and encompasses numerous small surface water bodies (e.g., ponds) and wetlands.

Therefore, MC may also migrate to nearby surface water bodies via surface runoff and may be assimilated into plants and invertebrates in direct contact with soil as the following metals detected in surface soil are bioaccumulative: cadmium, copper, lead, and zinc.

Migration of dissolved MC will be highly dependent on the metal and soil environment; however, for all of the metals exhibiting soil concentrations above background, transport in groundwater is anticipated to be minimal. Because the soil was sampled from the vadose zone (i.e., unsaturated conditions), it can be safely assumed that the soil is not suboxic and manganese and sulfate reduction are not occurring. Aluminum, lead, and manganese (which is expected to be present as Mn(III/IV) oxide phases rather than as Mn(II) given the soil conditions) will all exhibit very low solubilities in PTA groundwater, which is typically between pH 6 to greater than 7 (Morel and Hering, 1993; Sposito, 1989). Solubility of barium is most often limited in oxic soils by barium sulfate (barite) precipitation, and is typically not mobile in most soil systems (Morel and Hering, 1993; EPA Fact Sheet, 2010). The other metals of concern,

including antimony, cadmium, copper, strontium, and zinc, all exhibit moderate to high uptake capacity by soil. Specifically, these metals tend to be adsorbed by oxide surfaces and clay mineral ion exchange sites, which will limit the mobility and dissolved concentration of the metal outside of the source zone (Appelo and Postma, 2005; Wilson, 2010).

Given the presence of numerous small surface water bodies and wetlands throughout the Former Operational Areas MRS, it is likely that shallow groundwater is in communication with surface water. Therefore, secondary release mechanisms include discharge of groundwater to a surface water body or recharge of groundwater from a surface water body and biotransfer of bioaccumulative constituents through the food web. It is not known if discharge or recharge is the dominant pathway; similarly, the likelihood of biotransfer of MC through the food web is not known. Some metals are bioaccumulative, so there is a potential for biotransfer to occur. It should be noted that groundwater at PTA is regulated under the IRP and was not assessed within the MRS as part of the MMRP RI.

8.6 LAKES MRS

8.6.1 Munitions and Explosives of Concern

Based on RI characterization activities at the Lakes MRS, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, increasing the chance of exposure by human and ecological receptors. The MEC items recovered at Picatinny Lake were found at 4 inches bgs but the depth of the MEC item identified within the water portion of Picatinny Lake is unknown. The depth of MEC found at Lake Denmark is also unknown because the MEC items were not recovered during RI activities. In 2010 Lake Denmark water levels were drawn down and a surface walk was performed, one MEC item was identified and therefore was identified at/near ground surface. In December 2012 through January 2013 two 60mm Mortars (one was inert with a PD fuze and the other HE) was identified by REMTEC, one on the western side of the lake and one of the eastern side of the lake near the northern MRS boundary, as work was being conducted along the PSE&G electrical tower right-of-way. The 60mm HE mortar was identified outside the MRS boundary. The recovered MD was found at 0 and 6 inches bgs at Lake Denmark and between 0 and 12 inches bgs at Picatinny Lake. The soils found in the Lakes MRS are low to moderately susceptible to frost heave because of their capacity to retain moisture and because of seasonally cold temperatures typical for PTA. The depth of the MEC, while in

some cases is unknown, the MEC item identified within the Picatinny Lake portion of the Lakes MRS, was identified in the shallow subsurface, making frost heave a possibility for uncovering remaining MEC items.

The topography of the Picatinny Lake portion of the Lakes MRS slopes sharply from ridges to the northwest and southeast into the valley floor where the lake is situated. The topography of the Lake Denmark portion of the Lakes MRS is a low-lying valley situated at the base of the southern ridgeline of Copperas Mountain. The western portion of Lake Denmark is steeply sloped. Natural erosion over time of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of a wash). Therefore, surface interactions such as wet/dry erosion and frost heave are likely to impact source material on the ground surface.

Within the lake bodies, erosion of the banks or internal channeling, in addition to human processes, such as drawing down the lakes, could cause MEC to be revealed on the ground surface. Additionally frost heave, especially near the shores and shallow areas that are prone to freezing solid, could potentially move MEC items at depth to the ground surface. Biota is also anticipated to impact residual MEC and MD in both the lakes and ground surface, due to the shallow depth of MEC observed during the RI, which was identified within the zone of biological activity.

Individuals, including PTA personnel, residents, contractors, visitors, recreationists, and trespassers, could come in contact with potential MEC simply by walking. Both land portions of the Lakes MRS are partially developed and easily traversed. Contractor and PTA personnel could come in contact with potential MEC when performing intrusive activities. However, the likelihood of disturbing potential MEC is low on the land portion of the MRS due to the low number of items identified within the Lakes MRS. LUCs are in place that ban swimming/wading in the water portions of the MRS; therefore, the likelihood of disturbing potential MEC is low within the water portion of the Lakes MRS.

8.6.2 Munitions Constituents

Only the land portion of Lake Denmark is not being addressed for MC under the IRP. The release of MC from a MEC item is highly unlikely because no MEC was found during the RI activities and the two MEC identified by REMTEC within the Lake Denmark portion of the Lakes MRS did not present any evidence of a release.

The water portions of the Lakes MRS along with the land portion of Picatinny Lake are being addressed under the IRP. Lake Denmark is known as IRP site PICA-015, and Picatinny Lake is IRP site PICA-057. The production buildings around Picatinny Lake are known as IRP site PICA-135. Existing COCs at the Lakes MRS are being addressed under the IRP. Fate and transport of MC and environmental conditions affecting such fate and transport are addressed under the IRP program.

8.7 LAKE DENMARK – OFF-POST MRS

Based on RI characterization activities at the Lake Denmark – Off-Post MRS, no MEC source(s) were identified. The topography of the MRS consists of associated scrub/shrub wetlands situated at the base of the southern ridgeline of Copperas Mountain. The soil types identified within the Lake Denmark – Off-Post MRS (stony and sandy loams) are typically not susceptible to frost heave; however, one of the soils identified within the MRS is susceptible. Therefore, surface interactions such as frost heave and wet/dry erosion are likely to impact residual munitions in the MRS. Subsequent transport either from subsurface to surface and/or along ground surface because of erosion may occur. Impact/displacement through human and biota activities (e.g., handling, treading) are also potential factors that could impact the fate of residual munitions and transport it to another location within the Lake Denmark – Off-Post MRS. Because of the ongoing sampling/investigations within the RTI Superfund portion of the MRS, intrusive activities by human receptors are likely, although no MEC items have been found. There is potential for biota to impact residual MEC and MD by nesting or burrowing.

8.8 INACTIVE MUNITIONS WASTE PIT MRS

8.8.1 Munitions and Explosives of Concern

Based on RI characterization activities at the Inactive Munitions Waste Pit MRS, the bulk source for MEC and MD is buried approximately 10 to 20 feet bgs. However, several MD items and one

MEC item were discovered at approximately 4.5 feet bgs in the Inactive Munitions Waste Pit MRS. The anticipated MEC and MD at the MRS is too deep for natural erosion to affect, especially since the MRS has a relatively flat topography that would make a large-scale erosional event such as a land slide unlikely. Soils contained within the MRS are typically not susceptible to frost heave. Additionally, the anticipated MEC and MD are present below the frost line (3 feet) and not susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion and frost heave are not likely to impact source material. Biota that may nest or burrow are also not anticipated to impact residual MEC and MD due to the depth of buried debris observed during the RI. The maximum depth of biological activity is anticipated to be less than 4 feet bgs, which is shallower than the depth of MEC and MD. Impact/displacement through human activities (e.g., intrusive activities) are the only potential factors that could impact the fate of residual MEC and transport it to another location within the Inactive Munitions Waste Pit MRS.

8.8.2 Munitions Constituents

Fate and transport dynamics specific to MC are not applicable to the Inactive Munitions Waste Pit MRS because no evidence of a MC hazard source was identified during the RI to provide the basis for a detailed discussion. Analytical sampling and risk evaluation did not warrant selection of any COPCs or COPECs for quantitative risk assessment.

8.9 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

8.9.1 Munitions and Explosives of Concern

Based on RI characterization activities at the Inactive Munitions Waste Pit – Off-Post MRS, no MEC source(s) were identified. The topography of the MRS consists of steep and mountainous terrain. Natural erosion over time of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MD by the removal of the overlying soil/rocks. In some cases, if soil/rocks are unstable and the erosive force is sufficient to act on the size of MD item(s) present, this process can also result in the movement of MD from its original position to another location (typically somewhere downstream of the wash).The recovered MD was found between 2 and 4 inches bgs, which combined with the steepness of the terrain could lead erosion to reveal residual MD on the ground surface. The soil types identified within the Inactive Munitions Waste Pit – Off-Post MRS (rock outcrop and stony loams) are typically not susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion are likely to impact residual MD

in the MRS. Subsequent transport either from subsurface to surface and/or along ground surface due to erosion may occur. Impact/displacement through human and biota activities (e.g., handling, treading) are also potential factors that could impact the fate of residual MD and transport it to another location within the Inactive Munitions Waste Pit – Off-Post MRS. Due to the steep topography and remote nature of the MRS, intrusive activities by human receptors are not likely, although biota may engage in such activities.

8.9.2 Munitions Constituents

Fate and transport dynamics specific to MC are not applicable to the Inactive Munitions Waste Pit – Off-Post MRS because no evidence of a MC hazard source or MC risks was identified during the RI to provide the basis for a detailed discussion.

9. RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

Risk assessments for munitions constituents (MC) have been performed for the Former Operational Areas MRS and the Inactive Munitions Waste Pit MRS as described in Sections 9.1 and 9.2, respectively. MC risk assessments were performed for only these two MRSs because MC sampling was not required (and therefore not performed) in the other MRSs. The basis and rationale for MC sampling as part of the RI is discussed in more detail in Section 5.1.10.

9.1 FORMER OPERATIONAL AREAS MRS

The risk assessment conducted at the Former Operational Areas MRS presents an evaluation of potential human health and ecological risks associated with exposure to constituents detected in surface soil[1] at the MRS. ARCADIS/Malcolm Pirnie is performing the risk assessment on behalf of WESTON. In accordance with the MMRP RI Work Plan (WESTON, 2012), gridded soil samples were collected from the MRS[2] and analyzed for select metals and explosives. As concentrations above both the human health and ecological MMRP screening levels were detected in some of these samples, an HHRA and SLERA are required. The Former Operational Areas MRS HHRA and SLERA were conducted in accordance with the protocol presented in the MMRP RI Work Plan. Surface water, sediment, and groundwater at the Former Operational Areas MRS are being addressed under the IRP and were therefore not evaluated in the risk assessment. The risk assessment tables are presented at the end of the section.

The objectives of the risk assessment are as follows:

- To assess potential human health risks, currently and in the future, in the absence of any major action to control or mitigate soil contamination (i.e., baseline risks).

[1] For the purposes of the risk assessment conducted at the Former Operational Areas MRS, surface soil is defined as soil samples collected from depths from less than 2 feet bgs. No subsurface soil samples (i.e., from depths greater than 2 feet bgs) were collected at the MRS as constituent concentrations detected in step-out samples collected from 1 to 1.5 feet bgs were less than human health risk-based screening levels and vertical delineation was not performed.

[2] As discussed in Section 5, nine MRSs were investigated under the PTA RI as part of the MMRP. In accordance with the MMRP RI Work Plan, both gridded and biased soil samples were proposed for the Former Operational Areas MRS, whereas only biased soil samples were planned for the remaining MRSs. The required conditions were not met for collecting biased soil samples (i.e., only collected when field observation, such as evidence of staining, indicated that a potential release had occurred); therefore, biased soil samples were not collected at the MRS.

- To evaluate the potential for adverse health effects in ecological receptors, currently and in the future, in the absence of any major action to control or mitigate soil contamination.
- To assist in determining the need for, and extent of, soil remediation.
- To provide a basis for comparing various remedial alternatives and determining which of them will meet the goals of protection of human health and the environment and ARARs, as defined in the NCP (40 CFR Part 300.5).

9.1.1 HUMAN HEALTH RISK ASSESSMENT

The HHRA methodology follows guidance outlined in the EPA *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A)* (EPA, 1989), RAGS Parts D, E, and F (EPA, 2001, 2004, and 2009, respectively) and other relevant EPA guidance cited throughout the RI Report. The goal of the Superfund HHRA process is to provide a framework for developing the risk information necessary to assist in determining possible remedial actions. Risk assessment is a tool used to characterize and assess the toxicity of chemical contaminants, evaluate potential pathways and routes through which an individual may be exposed to contaminated environmental media, and characterize cancer risks and non-cancer hazards (EPA, 1989).

The focus of the Former Operational Areas MRS HHRA is to determine the potential for adverse health effects associated with exposure to constituents in surface soil at the MRS. The potential for adverse health effects is presented as incremental lifetime cancer risks and non-cancer hazards. In accordance with EPA (1995a) guidance, the cancer risks and non-cancer hazards are based on an estimate of the reasonable maximum exposure (RME) and, where applicable, average or central tendency exposure (CTE) expected to occur given both current and future conditions at the MRS.

The Former Operational Areas MRS HHRA is composed of the following four parts, described in more detail below:

Data Evaluation. Surface soil data were evaluated to determine their usability and to select COPC.

Exposure Assessment. Actual and/or potential constituent release and transport mechanisms were identified, potentially-exposed human populations and possible exposure pathways were described, concentrations of the COPCs at points of potential human exposure were determined,

and human exposures to the COPCs were estimated.

Toxicity Assessment. Qualitative and quantitative toxicity information for each COPC was identified and summarized.

Risk Characterization. The likelihood and magnitude of adverse health effects, in the form of incremental lifetime cancer risks and non-cancer hazard quotients (HQs), were estimated. Sources of uncertainty in the Former Operational Areas MRS HHRA were noted and discussed. The results of the HHRA are presented in a series of tables consistent with the EPA's RAGS Part D (EPA, 2001) format. The tables are provided in **Appendix O**.

9.1.1.1 Data Evaluation

The data evaluation focuses on the compilation of soil data and identification of COPCs in surface soil. The data are used in the exposure assessment to calculate representative concentrations for each COPC and to model human exposure through the pathways described in RAGS Part D Table 1 (EPA, 2001). The COPC concentrations serve as the basis for the incremental lifetime cancer risks and non-cancer hazards estimated in the Former Operational Areas MRS HHRA.

As described in Section 5 of the PTA RI Report, discrete soil samples were collected throughout the Former Operational Areas MRS at pre-determined locations that were randomly selected using VSP software, version 6.0. Sampled areas excluded ponds, the PTA golf course, and any collocated IRP sites. **Figure 5-38** depicts the Former Operational Areas MRS soil sample locations.

During the initial soil sampling conducted in December 2011, 79 samples were collected from the top 6 inches of soil and analyzed for explosives and select metals (i.e., aluminum, antimony, barium, cadmium, copper, lead, manganese, strontium, and zinc). As described in Appendix B of the Final RI Work Plan, the list of metals was selected based on metals known to be associated with munitions formerly and currently used at PTA. **Table 9-1** lists the Former Operational Areas MRS sample IDs and corresponding locations originally designated in the work plan[3].

Following preliminary evaluation of the laboratory analytical results, horizontal and vertical

[3] Note: **Figure 5-38** shows sample locations according to the FOA MRS sample IDs in **Table 9-1**.

delineation samples (termed "step-out samples") were collected in May 2012 to delineate areas of observed elevated metals concentrations around each of the following three sample locations: PTA-2011-FOAG-SS23 (P-61), PTA-2011-FOAG-SS42 (P-45), and PTA-2011-FOAG-SS71 (P-1). Two soil samples, both from depths less than 2 feet bgs, were collected at each of 8 total step-out locations and analyzed for the list of select metals only. Additional step-out samples were collected in September and October 2012 around PTA-2011-FOAG-SS23 (P-61) and PTA-2011-FOAG-SS71 (P-1). These step-out samples were collected from depths of 0 to 0.5 foot bgs and were analyzed for manganese only. **Table 9-2** lists the step-out sample IDs, indicates the individual step-out sample depths, and notes the corresponding sample locations. The step-out sample locations are shown on **Figure 5-38.**

Sample PTA-2011-FOAG-SS42 (P-45) was collected from the southern portion of the Former Operational Areas MRS, near the Former Skeet Range. Two analytes, lead and antimony, were detected at concentrations of 27,000 mg/kg and 67 mg/kg respectively, which are above the screening levels. Eight step-out soil samples were collected from four locations approximately 20 feet north, south, east, and west of P-45. Two samples were collected from each location; one from 0 to 0.5 feet bgs and one from 1.5 to 2 feet bgs. Analysis of these nine samples also indicated the presence of elevated levels of lead and antimony.

Based on a review of the *Final Picatinny Arsenal Former Skeet Range (CC-057) Remedial Investigation Report*, May 2012, it was determined that location P-45 is adjacent to the Former Skeet Range impact fan and analytical results of surface soil samples collected under the IRP near P-45 indicate the presence of lead at concentrations up to 102,000 mg/kg. Therefore, based on a discussion with USACE, it was determined that location P-45 should be added to the Former Skeet Range cleanup. As a result, sample PTA-2011-FOAG-SS42 and the associated step-out samples[4] were not included in the Former Operational Areas MRS risk assessment.

The assumptions made in the VSP were reviewed to determine if they were supported by the data. Post-data collection analyses, shown below, indicate that the sampling design assumptions are valid for the FOA dataset. Because no explosive compounds were detected in the samples, these analyses

[4] The sample IDs for the associated step-out samples are as follows: PTA-2012-FOAG-SS100 (0-0.5), -SS100 (0.5-1), -SS101 (0-0.5), -SS101 (0.5-1), -SS102 (0-0.5), -SS102 (0.5-1), -SS103 (0-0.5), and -SS103 (0.5-1).

were only conducted for the metal parameters. Additional details regarding the analyses are contained in **Appendix M**.

1. The results of the single simple sign test analyses indicated that the Null Hypothesis (H_0), "the median of the dataset is greater than the threshold (Human Health Criteria)" should be rejected.
2. Greater than 67 percent of the metal datasets were within the mean ($\mu \pm \sigma$ standard deviation) range, indicating that the variance is representative of the population. Note that the observed standard deviations resulted in a right skewed dataset.
3. Based on the variogram analysis it was determined that the data are not spatially correlated.

Because the analyses indicated that the data are not normally distributed, non-parametric methods of analysis are recommended for all future post-collection data analysis.

9.1.1.1.1 Data Usability and Quality Assessment and VSP Assumption Verification

Data Validation

Surface soil samples from the Former Operational Areas MRS were analyzed by an NJDEP and NELAP certified laboratory and were validated according to the methods described in the MMRP RI Work Plan (WESTON, 2012). Measurement performance criteria evaluated during validation include precision, accuracy, representativeness, comparability, and completeness.

- Precision - is a measure of the reproducibility of an analysis under a given set of conditions. Precision was evaluated through a review of field duplicate and laboratory duplicate samples. Field and laboratory duplicate samples were collected and analyzed at the minimum frequency specified in the QAPP (once every 20 samples for field duplicates). As discussed in the validation reports in **Appendix M**, some of the metals were qualified as estimated, "J" due to out of control recovery limits for the field duplicate samples.

- Accuracy – is a measure of the bias that exists in a measurement system. Accuracy was evaluated through a review of system calibration, laboratory control samples, MS/MSD samples, rinsate blanks, method blanks, and serial dilutions. All appropriate blank samples were collected at the minimum frequency specified in the QAPP (e.g., once per equipment batch for equipment blanks). As discussed in the validation reports in **Appendix M**, some of the data were qualified as estimated, "J", due to out of control MS/MSD, or surrogate recoveries and/or out of control differences for serial dilution samples. In addition, antimony was qualified as non-detect "U" in several samples since antimony was found in one of the continuing calibration blanks. MS/MSD samples were

collected and analyzed at the minimum frequency specified in the QAPP (once every twenty samples). As discussed in the validation reports in **Appendix M**, some of the metals and explosive results were qualified as estimated "J" due to out of control recovery limits for the MS/MSDs or the RPD between the MS/MSD pair. Only one analyte, picric acid, was qualified as rejected "R" in three samples, PTA-2011-FOAG-SS48, PTA-2011-FOAG-SS66, and PTA-2011-FOAG-SS71, due to low matrix spike and matrix spike duplicate recoveries. Since this represents less than four percent of all the picric acid results, and since these samples were not associated with MEC, the rejected values do not impact project decisions.

With the exception of antimony and cadmium, all metals were detected in all samples. The explosive compounds were not detected in the majority of the samples. In all cases (i.e., all samples and all analytes), the limits of quantitation (LOQs) achieved for the non-detected analytes were below the human health levels of concern (LOCs) identified in the QAPP. This includes all the antimony results that exhibited LOQs above the PQLs specified in the QAPP due to the detection of antimony in the associated blanks.

For all explosive compounds the LOQs were below the ecological LOCs identified in the QAPP. Cadmium was not detected in 11 of 99 samples; two of the non-detect results were above the ecological LOC. Since only two percent of the cadmium results had LOQs above the ecological LOC this did not impact the SLERA. For antimony, all non-detect results (62 out of 90 samples or 69%) had LOQs above the ecological LOC, although only half of the LOQs were above the background threshold value (described in Section 9.1.1.1.2). As discussed in Section 9.1.2.5, while having antimony reporting limits above the LOC introduced some uncertainty into the SLERA, it did not impact the overall conclusions reached in the SLERA.

- Representativeness – is a measure of the degree to which the sampling data accurately and precisely represent site conditions. Representativeness was evaluated through a review of raw data and through a comparison of whether the proposed sampling plan was implemented. A review of the sampling conducted indicated that samples in the Former Operational Areas MRS were collected from randomly-selected areas determined using VSP software; the samples are therefore considered highly representative of overall site conditions. The samples were also collected in accordance with the field handling protocols (including storage, field handling, and shipping) outlined in the approved RI Work Plan, which were designed to preserve the representativeness of the collected samples and the precision and accuracy of the results.

- Comparability – is a measure of the degree of confidence with which two data sets can be compared to each other. Comparability was evaluated through an assessment of whether appropriate and acceptable analytical methods were used and through an evaluation of the field collection procedures. Since all the samples were analyzed using standard, EPA-approved analytical methods and since the samples were collected using the same soil sampling method employed during the IRP, it was determined that all the data sets collected are comparable.

- Completeness – is a measure of the amount of valid data obtained. Completeness was evaluated through an assessment of how many data results were qualified as rejected as a result of the data validation process and how many valid samples were collected in relation to the number of samples needed to meet the intended use of the data. Only two data results were qualified as rejected; therefore, the percentage of data rejected is insignificant. Completeness of the data set was calculated using the following equation; therefore, the data set is 100% complete.

  % completeness = V/T X 100

  Where:

  V = the number of planned, systematic samples. The number of systematic samples required in VSP (N) was 74 samples. Note that to account for invalid data, VSP adds a factor of 20% to this number. Therefore, N+20 was 89. However, since only one analyte in two samples were qualified as rejected, and since it was determined that all of the samples were properly collected, invalid data do not have to be taken into account. Therefore, v = 74. Only systematic samples are considered in this equation since VSP does not calculate a required number of biased samples. This is because biased samples cannot be predetermined as the collection of biased samples is dependent on field conditions and the results of the systematic samples.

  T = the total number of collected systematic samples that are valid. A total of 79 systematic samples were collected.

As shown on the validation reports, overall the data are of acceptable quality, subject to the data validator's qualifying marks and, with the exception of one rejected compound, all analytical data obtained were considered useable. There are three samples with rejected picric acid results. These are all systematic samples that are not associated with MEC. Therefore, none of the rejected results correspond to critical samples. Altogether, picric acid was only rejected in three of the 79 systematic samples collected (i.e., 3.7% of the samples). All of the remaining picric acid results were non-detect. Therefore, the rejected values do not impact project decisions. All data qualified as estimated "J" were treated the same as data without such qualifiers since the small degree of uncertainty for the estimated quantities had no substantial impact on data interpretation.

VSP Assumption Verification

EPA's *DQA 2000 for Practical Methods for Data Analysis* indicates that the method and approach chosen for assumption verification depends on the nature of the study and its

documentation. Therefore, post data analysis and assumption verification was based on the VSP model that was used as the estimating tool to determine the number of samples. The VSP sampling design report (Attachment 3 in the QAPP) contains descriptions of the sampling approach, calculation equation and inputs, statistical assumptions and sensitivity analysis. According to the VSP design report the statistical assumptions associated with the formulas for computing the numbers of samples are:

1. the computed sign test statistic is normally distributed;
2. the variance estimate, S^2, is reasonable and representative of the population being sampled;
3. the population values are not spatially or temporally correlated; and
4. the sampling locations will be selected probabilistically.

Only the first three assumptions were assessed for post data collection analysis. The fourth assumption was not assessed because the gridded sample locations were selected based on a random start point; therefore, the locations were selected probabilistically.

Assumption 1: Normality

In the sampling approach the assumption that the data cannot be normally distributed was selected and the normality tests agree with the assumptions.

Assumption 2: Reasonable Variance

A data set with a reasonable variance will be one where 95% of the distribution lies within two standard deviations of the mean. In assessing the variance a range of estimates around an estimate of the mean of the population that accounts for the uncertainty (sampling variability) of that estimator was determined. This estimate is the standard error of the mean. As shown in Appendix M, lead was the only analyte that had 95% of its data within the range. Since the standard error is calculated from the standard deviation and variance of the datasets, the assumption of the value of the standard deviation does not hold with the post sample collection data. This difference is expected in any large site, such as the FOA MRS, as is also evident in the semi-variogram plots (Refer to **Appendix M**).

Assumption 3: Spatial and Temporal Correlation

Assessment of temporal correlation is not applicable to this dataset as there is no repeat sampling at any of the sample locations. For the assessment of spatial correlation a two dimensional semi-variogram analysis model was developed. The input parameters of the model are the same for all analytes and are shown in the Tables in **Appendix M**. These tables also show the model results from which the variogram plots was developed. The calculated variances were plotted on the Y-axis and their corresponding lag distances on the X-axis. The plots show the directional trends of the data for each analyte and all the plots are omni-directional and anisotropic (i.e., varies differently in different directions as is evident in the jagged nature of the plots). This anisotropic nature of the plots indicates there are no spatial correlations within the datasets.

All data are also considered usable from the field perspective. Because sample collection activities met the requirements outlined in the Final RI Work Plan and the data collected satisfied the requirements of precision, accuracy, representativeness, comparability, and completeness, the data effectively satisfy the DQOs outlined in the RI Work Plan.

In using the analytical data to select COPCs and derive representative exposure point concentrations (EPCs), analytical results of duplicate samples were averaged with those of the corresponding parent samples. In calculating the arithmetic average of duplicate and parent samples, if a COPC was detected in one sample but not the other, one-half the sample quantitation limit (SQL) was used as a proxy concentration for the non-detect result (EPA, 1989). If a COPC was not detected in either sample, the greater of the two SQLs was retained as the sample result.

9.1.1.1.2 Selection of Constituents of Potential Concern

The following screening process was used to identify those COPCs in surface soil at the Former Operational Areas MRS that, if contacted, may pose human health risks. The approach outlined below is consistent with the risk assessment protocols in the Final RI Work Plan (WESTON, 2012) and also with the Soil Background Meeting Minutes, dated April 18, 2013 and approved by EPA on May 30, 2013:

1. All detected constituents designated by EPA as Class A or known human carcinogens were selected as COPCs, regardless of the other selection criteria.

2. Comparison of maximum detected concentrations to screening toxicity values:
   - Constituents with maximum detected concentrations greater than chemical-specific screening toxicity values were selected as COPCs.
   - The applicable screening values are the lower of the EPA Regional Screening Levels (RSL) for Resident Soil (EPA, 2013a) and the NJDEP Residential Direct Contact Soil Cleanup Criteria (SCC) (NJDEP, 2012). In accordance with the Final RI Work Plan (Weston, 2012), residential soil screening levels were used, because residential development is currently present within one of the MRSs included in the scope of the RI, the 1926 Explosion Radius MRS. Screening values based on adverse, non-cancer health effects were reduced by a factor of 10 (to represent a target HQ of 0.1) to address potential non-cancer health effects from exposure to multiple chemicals.
3. Comparison of maximum detected concentrations to background levels:
   - Explosives - not applicable.
   - Metals with maximum detected concentrations greater than chemical-specific screening toxicity values but less than background threshold values established for PTA under the IRP (IT Corporation, 2002) will be identified as non-site-related COPCs and will be qualitatively addressed in the risk characterization and quantitatively evaluated in the uncertainty analysis for the most sensitive potential receptor population.[5]
4. Constituents without screening toxicity values were retained as COPCs.

Based on the approach outlined above, the following MC, which are all metals, were selected as COPCs in the Former Operational Areas MRS surface soil. No explosive compounds were selected as COPCs, and no metals were identified as non-site-related COPCs.

- Metals – aluminum, antimony, barium, cadmium, and manganese.

The surface soil data summary and selection of COPCs is presented in **Appendix N** RAGS Part D Table 2. The range of detected concentrations, data qualifiers, location of the maximum detected concentration, frequency of detection, range of detection limits, concentration used for screening, screening toxicity value, COPC flag, and rationale for elimination or selection of a

[5] Background threshold values represent "the background mean plus three standard deviations, unless the value exceeded the maximum detected concentration in which case the maximum detected concentration became the threshold value" (IT Corporation, 2002). The background surface soil data set was composed of 40 samples that were collected from 0 to 1 foot bgs in previously undisturbed areas both on-post (27 samples) and off-post (13 samples). Sample locations were selected based on current and historical land use and proximity to anthropogenic activity. The purpose of the background study was to quantify levels of metals at PTA and the surrounding area, to differentiate between naturally-occurring concentrations and those that may be attributable to site activities, and to aid in the decision making process for environmental investigations at PTA.

chemical as a COPC are provided in RAGS Part D Table 2 (EPA, 2001).

9.1.1.2 Exposure Assessment

The objective of the exposure assessment is to estimate the type and magnitude of human exposure to the COPCs in surface soil. The objective is accomplished by establishing assumptions regarding the potential for human exposure (e.g., exposed populations, exposure frequency) to surface soil throughout the Former Operational Areas MRS. Representative EPCs for each COPC are calculated and used to model potential human exposure in the form of daily chemical intakes, dermally absorbed doses (DAD), or exposure concentrations (EC). These exposure estimates are combined in the risk characterization with COPC-specific toxicity values to calculate incremental lifetime cancer risks and non-cancer hazards.

Figure 9-1 presents the human health CSM, which illustrates constituent source areas, the source medium and potential exposure media, release and transport mechanisms, and exposure routes for potential human receptor populations (described in more detail below). For an exposure pathway to be complete, all of the following elements must be present: a source and mechanism of constituent release, a retention and/or transport medium, a point of contact with the exposure medium, and an exposure route at the contact point. If any one of these elements is missing, the pathway is considered incomplete.

9.1.1.2.1 Potential Exposure Pathways and Potentially-Exposed Populations

The potential for exposure was evaluated for a number of current and future scenarios, as outlined in RAGS Part D Table 1 (EPA, 2001). The scenario timeframe, medium, exposure medium, exposure point, human receptor population, receptor age, exposure route, type of analysis, and rationale for selection or exclusion of an exposure pathway are provided.

The following human receptor populations may be exposed to COPCs in surface soil throughout the Former Operational Areas MRS:

1. Current/Future Outdoor Site Workers[6] (adults) - including PTA personnel or contractors who work outside of the buildings and structures throughout the Former Operational

[6] Whereas indoor site workers (e.g., PTA personnel who work inside buildings within the Former Operational Areas MRS) may also be exposed to constituents in surface soil, their potential exposures are likely to be less frequent and less intimate than those of other worker populations included in the Former Operational Areas MRS HHRA. Therefore, evaluation of the outdoor worker exposure scenario is also considered protective of indoor worker

Areas MRS. Potential exposure pathways and routes of exposure include incidental ingestion of and dermal contact with COPCs in surface soil, as well as inhalation of wind-generated respirable particulates emitted from surface soil to outdoor air.

2. Current/Future Construction/Utility Workers (adults) - who may perform short-term intrusive work at the Former Operational Areas MRS for utility installation, maintenance, or repair. Potential exposure pathways and routes of exposure include incidental ingestion of and dermal contact with chemicals in surface soil, as well as inhalation of wind-generated respirable particulates emitted from surface soil to outdoor air.

3. Current/Future Recreationists (adults and children) - including PTA personnel and their immediate family members who reside in base housing and may use designated recreational areas or access undeveloped portions of the Former Operational Areas MRS for recreational purposes (e.g., hunting or hiking). Potential exposure pathways and routes of exposure include incidental ingestion of and dermal contact with COPCs in surface soil, as well as inhalation of wind-generated respirable particulates emitted from surface soil to outdoor air.

4. Future Construction Workers (adults) - who may perform construction work during planned redevelopment activities throughout the Former Operational Areas MRS. Potential exposure pathways and routes of exposure include incidental ingestion of and dermal contact with COPCs in surface soil, as well as inhalation of respirable particulates emitted from surface soil during future construction activities.

5. Future Residents (adults and children) - including PTA personnel and their immediate family members who may reside in base housing at the Former Operational Areas MRS at some point in the future. While future residential development is not planned, a hypothetical residential exposure scenario was included in the Former Operational Areas MRS HHRA. Potential exposure pathways and routes of exposure for hypothetical future residents include incidental ingestion of and dermal contact with COPCs in surface soil, as well as inhalation of wind-generated respirable particulates emitted from surface soil to outdoor air.

9.1.1.2.2 Exposure Point Concentrations

The following sections describe the approach used to calculate representative COPC concentrations in surface soil and outdoor air at the Former Operational Areas MRS.

COPC Concentrations in Surface Soil

EPA (2002a, 1992a, 1989) recommends that the arithmetic average concentration of the data be used for evaluating long-term exposure and that, because of the uncertainty associated with

exposure and potential indoor site worker exposure, and associated health risks/hazards were not evaluated in the MRS HHRA.

estimating the true average concentration, the 95% upper confidence limit (UCL) on the arithmetic average be used as the EPC. The 95% UCL concentration provides reasonable confidence that the true average will not be underestimated. EPA also indicates that where there is a question about the distribution of the data, a statistical test should be used to identify the best distributional assumption for the data set (EPA, 1992b).

The ProUCL® v.4.1.01 (ProUCL) program developed by EPA's Technology Support Center for Monitoring and Site Characterization was used to test the distributional assumptions and calculate 95% UCL concentrations. When entering data into ProUCL, if a COPC was not detected in a sample, the SQL was entered as a proxy concentration and the sample result was coded as non-detect. ProUCL contains rigorous parametric and nonparametric statistical methods that can be used on full or uncensored data sets and on data sets with below detection limit observations (also called left-censored data sets). Depending on the distribution and 95% UCL estimation method, ProUCL will use only detected data or will incorporate detection limits (EPA, 2010).

The EPCs for the COPCs in soil are presented in RAGS Part D Tables 3 (EPA, 2001). The ProUCL output sheets for the individual COPCs are also provided in **Appendix O**.

COPC Concentrations in Outdoor Air

Concentrations in outdoor air were based on the EPCs for the COPCs in surface soil. As all of the COPCs identified for the Former Operational Areas MRS are non-volatile, it was assumed they would only enter the air as respirable particulates (e.g., fugitive dust).

The outdoor worker, construction/utility worker, recreationist, and resident exposure scenarios assume wind generation of COPCs as or on particulates. EPCs in outdoor air (C_a), measured in micrograms (µg) per cubic meter (m^3), were estimated by multiplying the EPCs for the COPCs in surface soil (C_s) by a particulate emission factor (PEF), according to the following equation:

$$C_a\left(\frac{\mu g}{m^3}\right) = C_s\left(\frac{mg}{kg}\right) \times \frac{1}{PEF\ (m^3/kg)} \times \frac{10^3 \mu g}{mg}$$

A PEF was calculated using the equation and parameter values for a commercial/industrial exposure scenario recommended in the *Supplemental Guidance for Developing Soil Screening*

Levels (EPA, 2002b). **Table 9-3** shows the PEF calculation and parameter values used for the Former Operational Areas MRS.

The construction worker scenario assumes exposure to particulate emissions during short-term, large-scale construction work for future MRS development or redevelopment. A sub-chronic PEF was calculated using an equation that models emissions caused by vehicle traffic on temporary, unpaved roads, which is the approach recommended for a construction scenario in EPA guidance (EPA, 2002b). This approach may be overly conservative given that fugitive emissions caused by vehicle traffic on temporary, unpaved roads at PTA would likely be minimized through engineering controls (e.g., dust suppression by water trucks). **Table 9-4** shows the sub-chronic PEF calculation and parameter values used for the Former Operational Areas MRS.

9.1.1.2.3 Estimates of COPC Intake/Exposure

Consistent with the NCP and other EPA guidance (1989; 1995a), estimates of COPC intake and exposure were developed to portray current/future and future RME and, where applicable, CTE scenarios. The RME scenario considers the highest exposure that might reasonably be expected to occur, one that is well above the average case of exposure but within the range of possibility. Use of the RME individual to model baseline human health risks is a conservative approach, in that it yields upper-bound cancer risk and non-cancer hazard estimates (EPA, 1989). If cancer risks greater than the risk range of 10^{-6} to 10^{-4} (i.e., one-in-a-million to one-in-ten thousand) established by the NCP were determined for an exposure pathway, the pathway was then re-evaluated using CTE parameter values. Use of the RME individual to model baseline human health risks effectively bounds the cancer risks and non-cancer hazards estimated in the Former Operational Areas MRS HHRA.

Exposure Equations

The exposure equations for estimating COPC intakes, DADs, and ECs are presented in RAGS Part D Tables 4.1 to 4.10 (EPA, 2001).

For the current/future outdoor site workers, current/future recreationists, and hypothetical future residents, application of the ingestion and dermal exposure equations results in chronic daily intake (CDI), specifically termed absorbed dose for dermal contact exposure, expressed in mg

per kg of body weight per day (mg/kg-day). The estimated daily intake is the amount of chemical at the exchange boundary (i.e., the stomach for ingestion and skin for dermal). A fundamental assumption in the estimate of the DAD is that absorption continues long after the exposure has ended (EPA, 2004). As such, the final absorbed dose (DA_{event}) is estimated to be the total dose dissolved in the skin at the end of the exposure. For the current/future construction/utility workers and future construction workers, where the exposure duration (ED) is assumed to be one year, application of the ingestion and dermal exposure equations results in sub-chronic daily intake and absorbed dose for dermal contact exposure.

Application of the ingestion and dermal equations requires a chemical concentration or the average concentration contacted over the exposure period (e.g., mg/kg soil). In the Former Operational Areas MRS HHRA, the chemical concentration or the average concentration contacted over the exposure period is the 95% UCL concentration. The equations also require a contact rate (i.e., the amount of soil contacted per unit time or event), body weight (i.e., the average body weight over the exposure period), and averaging time (AT) (i.e., the time period over which exposure is averaged).

The AT depends on the type of toxic effect being assessed. When evaluating exposures for potential non-cancer health effects, intakes were calculated by averaging over the period of exposure. The result derived from averaging the intakes over the period of exposure is equivalent to the receptor-specific ED multiplied by 365 days/year. When evaluating potential carcinogenic risks, intakes were calculated by prorating the total cumulative intake over a lifetime (i.e., lifetime average daily intake). For calculation purposes, prorating the total cumulative intake over a lifetime is equal to 70 years multiplied by 365 days/year (i.e., 25,550 days). The distinction is consistent with the hypothesis that the mechanism of action for each of these health effects endpoints is different. The approach for carcinogens was based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime.

Receptor-Specific Exposure Parameters

The exposure parameters used to estimate COPC intakes for the RME scenario are presented in RAGS Part D Tables 4.1.RME to 4.10.RME. Most parameter values are based on EPA (2004, 2002b, and 1989) guidance; however, some are based on professional judgment. These include

the exposure frequency (EF) for a construction/utility worker, which assumes that work around an excavation occurs 5 days per week for approximately six months (25 weeks), and the EF for recreationists, which assumes recreational fields or undeveloped areas are accessed twice per week during the warmer 6 months (25 weeks) of the year.

A few exposure parameter values were modified for use in the CT evaluations, as presented in RAGS Part D Table 4.1.CTE to 4.10.CTE (EPA, 2001). Some of these modified values (e.g., ED, soil to skin adherence factor [AF]) are referenced to EPA guidance, while others (e.g., EF) are based on professional judgment.

9.1.1.3 Toxicity Assessment

The toxicity assessment, also termed the dose-response assessment, serves to characterize the relationship between the magnitude of exposure and the potential that an adverse health effect will occur. It involves determining whether exposure to a chemical can cause an increase in the incidence of a particular adverse health effect and characterizing the nature and strength of the evidence of causation. The toxicity information is then quantitatively evaluated, and the relationship between the dose of the chemical received and the incidence of adverse health effects in the exposed population is evaluated.

EPA and other regulatory agencies have performed toxicity assessments for numerous chemicals, and the guidance they provide was used in the Former Operational Areas MRS HHRA. The toxicity assessments include RfDs and RfCs for the evaluation of non-cancer health effects from chronic and sub-chronic exposure to chemicals, and cancer potency slope factors (CSFs) and unit risk factors (URFs) for evaluating incremental cancer risk from exposure to chemicals prorated over a lifetime. Sources of toxicological information and toxicity values, in order of preference consistent with EPA (2003b) guidance, include:

1. Tier 1 - Integrated Risk Information System (IRIS) (EPA, 2013c). IRIS is an EPA administered internet database that has received internal and external scientific review and contains current information on human health effects that may result from exposure to chemicals in the environment.
2. Tier 2 - Provisional Peer-Reviewed Toxicity Values (PPRTV) (EPA, 2013d). PPRTVs were developed by the EPA Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center, as presented in a series of chemical-specific issue papers.

3. Tier 3 - Additional EPA and non-EPA sources of toxicity information, including but not limited to the California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment's chronic reference exposure levels and cancer potency values, the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (ATSDR, 2012a), and toxicity values published in the EPA Health Effects Assessment Summary Tables (HEAST) (EPA, 1997a).

9.1.1.3.1 Non-cancer Health Effects from Chronic Exposure to COPCs

EPA (1990) indicates that acceptable exposure levels for chemicals with non-cancer health effects should represent concentration levels to which the human population, including sensitive subpopulations (e.g., the elderly, young children), may be exposed without adverse health effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety. The potential for non-cancer health effects associated with oral and dermal exposures is evaluated by comparing an estimated chemical intake or DAD over a specified time period with an RfD derived for a similar exposure period. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Therefore, the ratio of the intake or DAD to the RfD, termed the HQ, assumes there is a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive subpopulations to experience adverse health effects.

The potential for non-cancer health effects associated with inhalation exposures is evaluated by comparing COPC concentrations in air (i.e., ECs) to RfCs derived for a similar exposure period (EPA, 2009). The HQ was estimated by calculating the ratio of the EC to the RfC.

EPA has indicated that RfDs and RfCs are based on the assumption that thresholds exist for certain toxic effects and that they often have an uncertainty spanning perhaps an order of magnitude. Chronic RfDs and RfCs were specifically developed to be protective of long-term exposure to a chemical. For current/future construction/utility workers and future construction workers, where exposure is assumed to occur over a one-year period, subchronic RfDs and RfCs were used, where available. Chronic RfDs and RfCs were used as conservative approximations where subchronic values were not available.

The RfDs and RfCs for the characterization of potential chronic and subchronic non-cancer health effects via oral and inhalation exposures are presented in RAGS Part D Tables 5.1 and 5.2, respectively, along with the primary target organ, the combined uncertainty and modifying

factors used in the derivation of the RfD or RfC, and the source of the toxicity value. Generally, order-of-magnitude uncertainty factors reflect the various types of toxicological data (e.g., a laboratory animal study extrapolated to the human condition) used to estimate the RfDs and RfCs. Modifying factors, which can range from greater than zero to 10, reflect qualitative professional judgment regarding scientific uncertainties (e.g., the completeness of the overall database) not covered by the uncertainty factor. Application of the uncertainty and modifying factors is intended to result in RfDs and RfCs that are protective of human health.

RfDs are not available to evaluate dermal exposure. In their absence, oral RfDs were used and adjusted following EPA (2004) guidance to reflect absorbed dose. The use of adjusted oral RfDs allows for comparison between exposures estimated as absorbed doses and toxicity values expressed as absorbed doses. The oral-to-dermal adjustment factors and the adjusted RfDs are presented in RAGS Part D Table 5.1 (EPA, 2001).

9.1.1.3.2 Carcinogenic Effects from Lifetime Exposure to COPCs

Regardless of the mechanism of effect, risk evaluation methods employed by EPA generally derive from the hypothesis that thresholds for cancer induction by carcinogens do not exist and that the dose-response relationship is linear at low doses. Based on this hypothesis, the EPA has derived estimates of incremental cancer risk from lifetime exposure to potential carcinogens. This is accomplished by establishing the carcinogenic potency of the chemical through critical evaluation of the various test data and by fitting the dose-response data to a low-dose extrapolation model. The CSF, which describes the dose-response relationship at low doses, is expressed as a function of intake (i.e., $[\text{mg/kg-day}]^{-1}$).

Incremental lifetime cancer risks are estimated by multiplying an estimated daily intake or DAD prorated over 70 years by the CSF. The resulting risk estimate is expressed as a unitless probability (e.g., 2×10^{-5} or 2 in 100,000) of an individual developing cancer. The unitless probability represents the incremental (or increased) lifetime cancer risk associated with the estimated exposure above the background risk of developing cancer. The linear equation is valid only at low risk levels (i.e., below estimated risks of 0.01). According to EPA, the linear equation approach does not necessarily give a realistic prediction of risk. The true value of the risk at trace ambient concentrations is unknown and may be as low as zero.

To evaluate inhalation exposures, inhalation URFs that relate cancer potency to a chemical concentration in air were used instead of inhalation CSFs (EPA, 2009). Incremental lifetime cancer risks from inhalation exposure were estimated by multiplying the EC by the URF.

The oral CSFs and inhalation URFs for the carcinogenic COPCs are presented in RAGS Part D Tables 6.1 and 6.2, respectively. These toxicity values were used to estimate finite, upper limits of risk at low dose levels administered over a lifetime. For children, the estimated cancer risk reflects the potential risk over a lifetime due to childhood exposure. The weight-of-evidence classification under EPA's 1986 guidelines for carcinogen risk assessment (EPA, 1986) or cancer guideline description under EPA's revised carcinogen risk assessment guidelines (EPA, 2005a) for carcinogenicity and the source of the CSFs or URFs are also presented in RAGS Part D Tables 6.1 and 6.2 (EPA, 2001).

As with RfDs, EPA has not derived CSFs to evaluate dermal exposure. In their absence, CSFs for oral exposure were used and adjusted per EPA guidance to reflect absorbed dose. Using the adjusted CSFs for oral exposure allows for risk estimation based on exposures estimated as absorbed doses and CSFs expressed as absorbed doses. The oral-to-dermal adjustment factors and the adjusted CSFs are presented in RAGS Part D Table 6.1 (EPA, 2001).

9.1.1.3.3 Chemical Mixtures

EPA guidance was also used to account for the overall potential for cancer risks and non-cancer health effects from exposure to multiple chemicals. For the evaluation of non-cancer health effects, EPA guidance assumes that sub-threshold exposures to several chemicals at the same time could result in an adverse health effect. The sum of the non-cancer HQs described below (for individual chemicals, exposure routes, exposure pathways, or potentially-exposed populations) is the HI. Generally, HIs are only used in the evaluation of a mixture of chemicals that induce the same effect by the same mechanism of action. In the Former Operational Areas MRS HHRA, the HIs of a mixture of chemicals that can have different effects were used as a screening-level approach, as recommended by the EPA (1989). The screening-level approach may overestimate the likelihood of adverse, non-cancer health effects. Therefore, for HIs greater than 1, toxic endpoint-specific HIs were calculated based on the toxicological endpoint used to derive the RfD.

For the evaluation of carcinogenic risks, EPA guidance indicates that the individual risks associated with exposure to each chemical can be summed. Summing was used in the Former Operational Areas MRS HHRA and assumes independence of action by the chemicals involved (i.e., that there are no synergistic or antagonistic chemical interactions and that all chemicals produce the same effect: cancer).

9.1.1.4 Risk Characterization

Risk characterization involves combining exposure estimates with toxicity information to generate estimates of cancer risk and non-cancer hazard for each human exposure scenario evaluated in the HHRA. In the following sections, the cancer risks and non-cancer hazards are presented and discussed. Sources of uncertainty in the Former Operational Areas MRS HHRA and the potential for adverse human health effects to be over- or under-estimated are also noted.

9.1.1.4.1 Cancer Risks and Non-cancer Hazards

As described in Section 9.1.1.3.2, individual cancer risks are expressed as unitless probabilities (e.g., 2 x 10^{-5} or 2 in 100,000) of a person developing cancer. The total individual (i.e., COPC-specific) cancer risks are summed for each exposure pathway and scenario to arrive at an estimate of the potential for cancer risk from cumulative exposure. For known or suspected carcinogens, the NCP established that acceptable exposure levels are generally concentration levels that represent an incremental upper-bound lifetime cancer risk in the range from 10^{-6} (i.e., 1E-06 or 1 in 1,000,000) to 10^{-4} (i.e., 1E-04 or 1 in 10,000) or less (EPA, 1990). The cancer risks estimated for each exposure scenario were therefore compared to the risk range established by the NCP.

As described in Section 9.1.1.3.1, the potential for non-cancer health effects associated with chemical exposure was evaluated by calculating the ratio of an estimated intake or EC over a specified time period with a chemical-specific RfD or RfC derived for a similar exposure period. The RfD or RfC is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The non-cancer HQ therefore assumes there is a level of exposure below which it is unlikely for even sensitive subpopulations to experience adverse health effects. The total individual HQs were summed for each exposure pathway and scenario to yield HIs representative of the potential for adverse, non-cancer health effects from cumulative exposure.

For the non-cancer assessment, exposure scenarios with an HI greater than 1 (i.e., 1E+00) are of potential concern.

The COPC and exposure route-specific incremental lifetime cancer risks and non-cancer hazards associated with potential exposure to the receptors evaluated in the Former Operational Areas MRS HHRA are presented in RAGS Part D Tables 7.1.RME to 7.7.RME. The total cancer risk and total non-cancer HI for the COPCs summed for all exposure pathways and routes for a given receptor are presented in RAGS Part D Tables 9.1.RME to 9.7.RME. Where the total non-cancer HI is greater than 1, toxic endpoint-specific HIs were also calculated and presented in the corresponding RAGS Part D Table 9. Where the total incremental lifetime cancer risk or total non-cancer HI presented in RAGS Part D Table 9.RME is greater than, respectively, the risk range established by the NCP or a target HI of 1, the COPCs that are the predominant contributors to the risk or hazard estimates are presented in the corresponding RAGS Part D Table 10.RME. In addition, RAGS Part D Tables 7.CTE, 9.CTE, and 10.CTE show cancer risks and non-cancer hazards estimated using CTE parameter values for those receptors and exposure scenarios (EPA, 2001).

Table 9-5 presents a summary of the cancer risks and non-cancer HIs estimated for each receptor population evaluated for the RME scenario and, where applicable, the CTE scenario. As shown, incremental lifetime cancer risks estimated using RME parameters range from 1E-11 for the current/future construction/utility worker to 4E-09 for the hypothetical future resident adult. All estimated cancer risks are less than the risk range established by the NCP. Non-cancer HIs estimated using RME parameters range from 0.1 for the current/future recreationist adult to 10 for the future construction worker. The only HIs greater than 1 were estimated for the construction worker and hypothetical future resident child (HI = 3). Under the CTE scenario, the non-cancer HI for the construction worker is 5, and the non-cancer HI for the resident child is still 3.

As shown in RAGS Part D Table 10.5.RME for the construction worker and RAGS Part D Table 10.7.RME for the resident child, the potential for adverse, non-cancer health effects is from exposure to manganese. For the future construction worker, the non-cancer HI of 10 was estimated for inhalation exposure to manganese released as particulates from surface soil to outdoor air. The future construction worker exposure scenario assumed uncontrolled particulate

emissions are generated by vehicle traffic on temporary, unpaved roads. This scenario is overly protective, given that fugitive emissions during future construction work at PTA would likely be minimized through engineering controls (e.g., dust suppression by water trucks). The PEF used to estimate COPC concentrations in outdoor air was 2.23E+06 m^3/kg. In contrast, the default PEF used to generate the EPA RSLs for manganese in residential soil (1,800 mg/kg) and industrial soil (23,000 m/kg) is 1.4E+09 m^3/kg (EPA, 2013a). Use of this EPA default PEF for the Former Operational Areas MRS risk assessment would result in a construction worker inhalation HQ of 0.02 for manganese (vs. 10) and a receptor-specific HI of 0.7, which is less than the target HI of 1 established by the NCP. For the hypothetical future resident child, the non-cancer HI of 3 was estimated for ingestion exposure to manganese in surface soil. This exposure scenario is also overly protective, given there are no known future land use changes for the Former Operational Areas MRS and residential development of the Former Operational Areas MRS is not included in PTA's master plans (Parsons, 2007a, 2007b).

The EPC for manganese was 5,156 mg/kg, which was the 95% UCL concentration calculated using a data set composed of 103 surface soil samples. Detected manganese concentrations ranged from 18 to 37,000 mg/kg, and the mean concentration was 2,420 mg/kg, but the majority of concentrations (79 of 103 or 76%) were less than the site-specific background threshold value of 1,250 mg/kg. The maximum concentration was detected in FOAG-SS523 (0-0.5 feet bgs), which was a step-out sample from PTA-2011-FOAG-SS23. The most elevated manganese concentrations (e.g., nine samples with concentrations greater than 7,000 mg/kg) were detected in PTA-2011-FOAG-SS23 (9,300 mg/kg), PTA-2011-FOAG-SS71 (27,000 mg/kg), and step-out samples associated with these two sample locations[7]. The mean concentration of an alternate manganese data set excluding these nine samples would be 648 mg/kg, and the 95% UCL concentration would be 1,148 mg/kg. Use of 1,148 mg/kg as an alternate EPC to evaluate potential construction worker exposures to manganese would yield a non-cancer HI of 2 under the RME scenario and a non-cancer HI of 1 under the CTE scenario. An EPC of 1,148 mg/kg would result in a non-cancer HI of 0.6 for the resident child under both the RME and CTE

[7] The step-out samples and corresponding manganese concentrations (mg/kg) were: PTA-2012-FOAG-SS106(0-0.5) = 14,000; PTA-2012-FOAG-SS105(0-0.5) = 15,000; PTA-2012-FOAG-SS107(0-0.5) = 18,000; PTA-2012-FOAG-SS108(0-0.5) = 21,000; PTA-2012-FOAG-SS109(0-0.5) = 16,000; FOAG-SS223(0-0.5) = 31,000; FOAG-SS523(0-0.5) = 37,000.

scenarios. This alternate EPC is less than the background threshold value of 1,250 mg/kg, indicating even background manganese concentrations would yield non-cancer hazards greater than 1 under the RME scenario for the construction worker. In addition, both EPCs for manganese presented in this HHRA (5,156 mg/kg and 1,148 mg/kg) are less than the EPA RSL for industrial soil of 23,000 mg/kg, which is being applied as the soil cleanup level for manganese at PTA sites evaluated under the IRP. In fact, only two soil samples (FOAG-SS223 and FOAG-SS523), which are located within 150 feet of each other, had detected manganese concentrations greater than 23,000 mg/kg.

PTA-2011-FOAG-SS23 and PTA-FOAG-SS71 (i.e., the samples associated with the highest manganese concentrations) are located on opposite sides of the Former Operational Areas MRS, in wooded areas that are not continuously occupied under the current land use scenario. Even under a future site redevelopment scenario, it is not likely that construction workers or resident children would be exposed to the most elevated manganese concentrations to the extent assumed by the exposure models used in this risk assessment. Repeated exposures would more likely be to MC in soil across a larger geographic area. Therefore, the alternate EPC of 1,148 mg/kg and the background threshold value of 1,250 mg/kg are most representative of manganese concentrations to which humans would be routinely exposed.

To determine whether the most elevated manganese concentrations are potentially associated with former range activities, a review of historical use areas was conducted. Historical use areas within the Former Operational Areas MRS are shown on DoD Executive Order 11508 Installation Survey Report, Picatinny Arsenal, Dover, New Jersey, January 1973, as discussed further in the Summary of SLERA and depicted on Figures 9-3 and 9-4. As shown on Figure 9-3, PTA-FOAG-SS71 and the associated step out locations are within areas historically identified as technical areas (i.e., labeled “Code 300 – Technical”). As shown on Figure 9-4, PTA-2011-FOAG-SS23 and step out samples are within or at the boundary of areas historically identified as training areas (i.e., labeled former “Code 100 – Training”). However, as indicated in Section 6 of this RI Report, no evidence of potential disposal areas or firing points was observed during investigations at the majority of the Former Operational Areas MRS (i.e., excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24 where MC is being addressed under the IRP). In addition, intact MEC was found, but mainly in the southern portion of the Former Operational Areas MRS (excluding the AOI Former Sanitary

Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24, where MC is being addressed under the IRP). Therefore, concentrations of manganese are not likely associated with former use of MEC at the Former Operational Areas MRS.

Based on this review and to be consistent with the approach being applied at PTA sites evaluated under the IRP, no further action based on the potential for human health risk is warranted.

9.1.1.4.2 Uncertainties

A basic assumption underlying this HHRA is that the surface soil data adequately characterize environmental conditions and the potential for constituents to be present at the Former Operational Areas MRS. However, there are always some uncertainties associated with environmental sampling and analysis. Uncertainty associated with environmental sampling is generally related to limitations in terms of the number and distribution of samples, while uncertainty associated with the analysis of samples is generally due to systematic or random errors (i.e., false positive or negative results). Efforts to minimize uncertainty were made by employing a statistical approach (i.e., VSP software) to determine soil sample locations, by collecting and analyzing soil samples in accordance with the Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP), and by independently validating the analytical data. The field investigation approach resulted in a robust data set, which supports the assumption regarding adequate site characterization and contributes to decision certainty in the HHRA.

Step-out samples were collected to determine the spatial extent of relatively elevated manganese concentrations around two sample locations (FOA-2011-FOAG-SS23 and -SS71). While step-out sampling increases confidence in the degree of site characterization, inclusion of these samples in the data sets used to derive EPCs likely over-estimated the average concentration of manganese, and possibly other metals, throughout the Former Operational Areas MRS. Of the 103 total soil samples used to calculate the EPC for manganese, 25 were step-out samples. As demonstrated in the risk characterization, the 95% UCL concentration for manganese was 5,156 mg/kg, yet manganese concentrations in 76% of the samples were less than the PTA background value of 1,250 mg/kg. An alternate EPC calculated using a data set excluding the nine highest manganese concentrations (all detected in step-out samples) would be 1,148 mg/kg. Therefore, inclusion of the step-out samples in the risk assessment data sets likely over-estimated exposure concentrations and the associated potential for adverse health effects.

Non-detect constituents were not selected as COPCs, as their presence and concentration in surface soil was not confirmed and analytical quantitation limits were determined to be adequate to assess potential risk. Explosives that were analyzed for but not detected in surface soil may be present at an unknown concentration somewhere between zero and the sample reporting limit. Reporting limits for non-detect explosives[8] were therefore compared to EPA RSLs for residential soil to evaluate whether they may be present at concentrations that pose human health risks and hazards. EPA RSLs are available for all non-detect explosives, except for picric acid. In all cases, the maximum reporting limit is less than the corresponding RSL, indicating exposure to non-detect explosives, if in fact present, is not likely to result in adverse human health effects. The presence of picric acid in surface soil remains a source of uncertainty in the HHRA.

The exposure assessment relied on a series of assumptions regarding the potential for human exposure, outlined in the human health CSM and approximated in the exposure equations by parameters such as receptor-specific ED, EF, and exposure time. This HHRA attempted to address some of the uncertainty in these assumptions by evaluating RME conditions in the various current/future exposure scenarios. The assessment primarily relied on EPA's standard default exposure assumptions, with appropriate modifications to reflect site-specific conditions. The intention was to over-estimate the potential for risk and hazards, so that actual risks are less than those predicted in this HHRA.

EPCs for the non-volatile COPCs released from surface soil to outdoor air were estimated with calculated PEFs. Due to their relative simplicity, these calculations and models tend to over-estimate the potential for COPC emissions. For example, source depletion over time (e.g., through COPC release or migration) was not accounted for and vegetative cover was assumed to be only 50%, while the majority of the Former Operational Areas MRS is either developed with buildings/pavement or covered with vegetation. Uncertainty associated with such modeling is related to the accuracy with which environmental conditions and processes are simulated. Overall, the potential inhalation exposure scenarios were modeled in ways that likely over-estimate the potential for exposure and adverse health effects.

[8] Non-detect explosives were 2,4,6-trinitrotoluene, 2,6-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, HMX, PETN, picric acid, and RDX.

Lastly, the toxicity values used in this HHRA can result in over-estimates or under-estimates of the potential for adverse health effects. In most cases, toxicity values are derived by extrapolating from laboratory animal data to humans. Uncertainty factors are usually applied to avoid under-estimating the potential for adverse human health effects. For some COPCs, health criteria are insufficient to determine RfCs, cancer slope factors, and/or unit risk factors for assessing oral and inhalation exposures. As a result, the cancer risks and non-cancer hazards associated with exposure to those metals may be under-estimated.

9.1.2 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

This SLERA evaluates the potential for adverse effects in ecological receptors from exposure to constituents detected in surface soil at the Former Operational Areas MRS. The SLERA follows applicable and current USACE guidance (2010a), EPA guidance (1997c and updates), and other relevant ecological risk assessment guidance. The SLERA includes Steps 1, 2, and 3a (to refine the results of the SLERA) of EPA's *Ecological Risk Assessment Guidance for Superfund* (ERAGS) (EPA, 1997b). Step 1 includes the screening-level problem formulation, Step 2 involves the screening-level ecological effects evaluation, exposure estimation, and ecological risk characterization. As described in ecological risk assessment guidance applied specifically at military installations (EPA, 2000a; Tri-Services Environmental Risk Assessment Work Group, 2008; U.S. Navy, 1999), Step 3a involves refinement of the screening-level ecological effects evaluation, exposure estimation, and risk characterization. The objectives of the SLERA are to evaluate the potential for adverse health effects in ecological receptors and present the results in a manner that facilitates risk management decision-making. The need for further ecological evaluation (e.g., Baseline Ecological Risk Assessment) will be determined by USACE and the regulatory agencies based on the SLERA findings and recommendations.

The SLERA consists of the following:

- Screening-Level Problem Formulation – provides the ecological setting, such as predominant vegetation and potential wildlife habitat on, and in the vicinity of, the Former Operational Areas MRS; presents an exposure pathway analysis and ecological CSM; and identifies appropriate assessment and measurement endpoints.
- Screening-Level Ecological Effects Evaluation – presents constituent-specific ecological screening values (ESV) and identifies constituents of potential ecological concern (COPEC) in surface soil at the Former Operational Areas MRS.

- Screening-Level Exposure Estimates – calculates quantitative estimates of exposure of the measurement receptors to the COPECs in surface soil and identifies appropriate ecotoxicity screening values for the measurement endpoints.
- Screening-Level Ecological Risk Characterization – presents HQs (i.e., ratio of exposure estimate to screening ecotoxicity value) for each COPEC and qualifies the potential for adverse ecological effects; discusses potential sources of uncertainty associated with assessing ecological risks; and draws conclusions regarding the need to perform further ecological evaluation.

9.1.2.1 Screening-Level Problem Formulation

Problem formulation serves to establish the goals, breadth, and focus of the SLERA (EPA, 1997b) and is based on the current understanding of the area and information collected during the SI/RI process. The following describes the environmental setting, surface waters and wetlands, physical and chemical stressors, ecological exposure pathways, and the selection of appropriate assessment and measurement endpoints.

9.1.2.1.1 Environmental Setting

PTA is within the unique Highlands Region of New Jersey, which serves as a recharge area for groundwater aquifers that provides drinking water to over four million people in the region. In addition, a large portion of the Highlands (approximately one-half or 500,000 acres) are considered important wildlife habitat (USAEC, 2001). PTA is in a valley formed by the Green Pond and Copperas Mountains to the northwest and an unnamed hill to the southeast (USGS, 1997). The Delaware Water Gap Recreation Area, which is the gateway to the Pocono Mountains of Pennsylvania, is located 45 miles west of PTA. The region provides significant open space, recreation, and scenic beauty for millions of visitors and residents.

The following information for the entire PTA is applicable to the Former Operational Areas MRS because the MRS covers a large portion of the undeveloped areas of PTA (i.e., exclusive of the downtown area). Approximately 1,100 acres of PTA (i.e., about 1/5 of the acreage) is developed; the remainder is either forested (approximately 4,000 acres) or consists of lakes, ponds, brooks, springs and associated wetlands (over 600 acres). PTA offers a significant greenbelt corridor due to the following:

- One third of all undeveloped public lands surrounding PTA (5,948 acres) are contiguous within the PTA boundary, facilitating fish and wildlife movement (USAEC, 2001).

- The Berkshire Valley Fish and Wildlife Management Area (1,705 acres) is located southwest of PTA.
- A 248-acre Forest Legacy Area[9] is near PTA.
- Large tracts of open space are adjacent to, and in the vicinity of, PTA.
- PTA offers a variety of habitats including dry forested ridgetops talus slopes, bottomland hardwoods, mesophytic hardwoods, conifer stands, old fields, riparian sites, shrub stands, wetlands, brooks, ponds, and lakes (USAEC, 2001).

Figure 3-7 depicts land uses at and surrounding the Former Operational Areas MRS. As shown, whereas a portion of the Former Operational Areas MRS is developed, the majority of the MRS is undeveloped and consists of deciduous forests, ponds, streams, and wetlands.

9.1.2.1.1.1 Vegetation

Of New Jersey's 2,117 known native plant species, 25% have been documented to occur at PTA, including 626 flowering plants and 90 non-flowering plants (USAEC, 2001). PTA is located within the Appalachian Oak forest region, a subdivision of the Eastern Deciduous Forest Biome. Approximately 70% (4,082 acres) of PTA is characterized by second-growth forest on formerly cleared farmlands. Mixed oak (*Quercus*) species compose approximately 65% (2,656 acres) of the forested land on PTA (USAEC, 2001). Generally, wooded stands at lower elevations of PTA are dominated by species within the red oak subgroup (e.g., red oak [Q. *rubra*], black oak [Q. *velutina*], scarlet oak [Q. *coccinea*]), while stands at higher elevations are dominated by chestnut oak (Q. *montana*). Northern hardwood and red maple (*Acer rubrum*) swamp forest types are the second dominant forest types on PTA, with each comprising approximately 13% of the forested area (545 and 532 acres, respectively). Typical northern hardwood species are sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*). Most northern hardwood stands are located in Picatinny Valley and along the eastern ridge. Mature red maple swamp forest is present on the hydric and muck soil types at the base of the valley.

No federally threatened or endangered plant species have been documented at PTA; however, three state listed plant species have been documented as occurring within some wetlands at PTA (i.e., slender wood reed grass [*Cinna latifolia*], meadow horsetail [*Equisetum pretense*], and large-leafed holly [*Ilex Montana*]) and there are several (approximately 15) documented

[9] According to the US Forest Service website (http://www.na.fs.fed.us/legacy/), "*The Forest Legacy Program is a partnership between States and the USDA Forest Service to identify and help conserve environmentally important forests from conversion to nonforest uses*."

occurrences of floral species of special concern, many of them occurring in wetlands, although most are known to occur in the remote northern portion of PTA.

The majority of the Former Operational Areas MRS is covered by forested uplands and wetlands.

9.1.2.1.1.2 Wildlife

Site-specific beneficial resources at PTA include the forest and wildlife corridor offered by the dense forests and wetland areas providing habitat for many of the 41 mammalian, 208 avian, 21 amphibian, 19 reptile, and 26 fish species known to occur at PTA. Numerous invertebrates also occur at PTA, including common species from the Families Odonata and Lepidoptera (i.e., 63 dragonflies, 31 damselflies, 67 butterflies, and 136 moths).

Threatened, Endangered and/or Special Concern Species

A review of the Natural Heritage Database and Landscape Project (Version 3.1) was conducted by the New Jersey Natural Heritage Program in September 2012 from a request made for this SLERA and the following threatened, endangered, and special concern species were identified as occurring on the Former Operational Areas MRS:

1. Two mammals – federal and state endangered Indiana bat (*Myotis sodalis*) and state endangered bobcat (*Lynx rufus*).
2. Nineteen birds – state endangered red-shouldered hawk (*Buteo lineatus*), northern goshawk (*Accipiter gentilis*), and golden-winged warbler (*Vermivora chrysoptera*), state threatened barred owl (*Strix varia*), red-headed woodpecker (*Melanerpes erythrocephalus*), state special concern Cooper's hawk (*A. cooperii*), great blue heron (*Ardea herodias*), Blackburian warbler (*Dendroica fusca*), black-throated green warbler (*D. virens*), blue-headed vireo (*Vireo solitarius*), Canada warbler (*Wilsonia canadensis*), cerulean warbler (*Setophaga cerulea*), hooded warbler (*W. citrina*), veery (*Catharus fuscescens*), winter wren (*Troglodytes troglodytes*), wood thrush (*Hylocichla mustelina*), and worm-eating warbler (*Helmitheros vermivorum*).
3. One amphibian – state threatened wood turtle (*Glyptemys insculpta*).
4. Two reptiles – state endangered timber rattlesnake (*Crotalus horridus horridus*) and state special concern northern copperhead snake (*Agkistrodon contortrix contortrix*).
5. Seven insects – state special concern arrowhead spiketail (*Cordulegaster obliqua*), brush-tipped emerald (*Somatochlora walshii*), New England bluet (*Enallagma laterale*), sable clubtail (*Gomphus rogersi*), ski-tailed emerald (*S. elongata*), spatterdock darner (*Rhionaeschna mutata*), and Williamson's emerald (*S. williamsoni*).

The following additional threatened, endangered, and special concern species were identified as occurring in the vicinity of the Former Operational Areas MRS (i.e., within ¼ mile):

1. Two birds – state special concern black-throated blue warbler (*D. caerulescens*) and broad-winged hawk (*B. platypterus*);
2. Three vascular plants – state endangered Robbin's pondweed (*Potamogeton robbinsii*) and two species listed by the Pinelands Commission and Highlands Water Protection and Planning Act, floating heart (*Nymphoides cordata*) and purple bladderwort (*Utricularia purpurea*);
3. One freshwater mussel – state special concern creeper (*Strophitus undulatus*).

Based on information in the Installation Natural Resources Management Plan (INRMP), bobcat, red-shouldered hawk, and timber rattlesnake were known to have resident breeding populations at PTA, Cooper's hawk and barred owl were known to be present at PTA only during the breeding season, and northern goshawks were known to nest and forage sporadically at PTA (USEAEC, 2001).

Other Species

Seven species of bats have been documented at PTA and bats represent approximately 20% of the potential mammalian wildlife at PTA (USAEC, 2001). The little brown bat (*Myotis lucifugus*) is the most often observed bat species in the cantonment and semi-improved areas, while the northern long-eared bat (*M. septentrionalis*) is the most prevalent bat species in the forested portions of PTA. The federally endangered Indiana bat is thought to be a summer resident at the PTA. Indiana bat hibernacula were discovered in abandoned mines within two miles of the PTA in 1993 and 1994.

Common small mammals which provide the major prey base for predators at PTA include the white-footed mouse (*Peromyscus leucopus*), meadow vole (*Microtus pennsylvanicus*), and short-tailed shrew (*Blarina brevicauda*) (USAEC, 2001).

The developed portions of PTA also afford habitat for more common urban wildlife species adapted to human presence. These include small mammals (e.g., gray squirrels [*Sciurus carolinensis*], eastern cottontail rabbits [*Sylvilagus floridanus*]) and songbirds (e.g., American robin [*Turdus migratorius*], song sparrow [*Melospiza melodia*]).

Red fox (*Vulpes fulva*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and opossum (*Didelphis marsupialis*) have been observed at PTA periodically. Other furbearers, like river otter (*Lutra canadensis*), muskrat (*Mustela vison*), beaver (*Castor canadensis*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*), offer consumptive and non-consumptive recreation to PTA personnel.

Game species at PTA include:

1. Fish – native brook trout (*Salvelinus fontinalis*) in the upper Green Pond Brook, stocked rainbow or brown trout (*Salmo gairdneri* or *trutta*) in the mid-reach of Green Pond Brook, and several warm water species like largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*).
2. Upland birds – wild turkey (*Meleagris gallopavo*), ruffed grouse (*Bonasa umbellus*), American woodcock, and the stocked ring-necked pheasant (*Phasaianus colchius*).
3. Waterfowl – wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), green-winged teal (*Anas carolinesis*), black duck (*Anas rubripes*), and Canada goose (*Branta Canadensis*).
4. Mammals – white-tailed deer (*Odocoileus virginianius*) and black bear (*Ursa americanus*).

    - Several species, including the veery (*Catharus fuscescens*), barred owl, and American woodcock (*Scolopax minor*) are known to inhabit areas within the Former Operational Areas MRS.

9.1.2.1.1.3 Surface Waters and Wetlands

PTA is situated in NJ Watershed Management Area 6 and is an important recharge area for northern NJ's primary water supply. There are two large lakes (Lake Denmark and Picatinny Lake), four perennial brooks (Green Pond, Burnt Meadow, Bear Swamp, and Ames), 18 ponds, several intermittent streams, and a few springs/seeps on PTA. Surface water drains primarily from northeast to southwest following the topographic gradient of the area. The primary drainage feature on PTA is Green Pond Brook, which originates at a 500-acre spring-fed lake, known as Green Pond, located adjacent to the northern border of PTA.

On PTA, Green Pond Brook's width varies from 10 to 30 feet, with a maximum depth of 5 feet. Burnt Meadow Brook originates from Egbert Lake and flows through Lake Denmark prior to its convergence with Green Pond Brook near the middle of the arsenal. Green Pond Brook continues to flow southwest and through Picatinny Lake before exiting PTA to the southwest.

Approximately one mile south of PTA, Green Pond Brook joins the Rockaway River. The Rockaway River flows east through the Boonton Reservoir before joining the Passaic River. Bear Swamp Brook joins Green Pond Brook on the southern end of PTA. Bear Swamp Brook has a width between 3 and 7 feet and a maximum depth of 2 feet. Ames Brook carries headwaters from 250 acres of PTA and exits along the PTA eastern boundary.

Lake Denmark and Picatinny Lake are man-made features that collectively comprise 360 acres of open water. The lakes were constructed in the 1880s and are primarily used for industrial water supply and recreation. The maximum depth of Lake Denmark is approximately 7 feet; Picatinny Lake's maximum depth is approximately 20 feet. Several ponds are present at PTA such as EOD Pond, North and South basins, Fisher's Pond, which are all within the lower portion of the 1926 Explosion radius MRS. Waterbodies within the Former Operational Areas MRS include Green Pond Brook, several small ponds, and, on the southern portion, Bear Swamp Brook.

PTA contains 1,250 acres (approximately 21% of total PTA acreage) of mostly forested and scrub/shrub wetlands. Red maple swamp forests, lakes and ponds, and their associated wetlands comprise 92% of all wetlands present on PTA. The largest tract of red maple swamp is present on the southern end of PTA, the majority within the southern portion of the Former Operational Areas. The northern portion of the Former Operational Areas is dominated by forested uplands.

Palustrine shrub lands are hydrologically connected to Lake Denmark. Prior to development of the arsenal and surrounding area, a majority of the lower one-third of the valley was occupied by wetlands. Hydric soils are found on 26% of PTA, mainly in the Picatinny Valley and scattered riparian areas throughout PTA. The results of the review of the Natural Heritage Database and Landscape Project (Version 3.1) conducted by the New Jersey Natural Heritage Program in September 2012 indicate several areas of known or potential vernal pools at the Former Operational Areas MRS.

Figure 3-4 depicts wetlands identified based on the NWI mapping for the Former Operational Areas. **Figure 3-5** depicts wetlands identified based on the New Jersey State Wetlands mapping. As shown on **Figures 3-4** and **3-5**, the majority of the northern portion of Former Operational Areas consists of uplands, and wetlands cover approximately half of the southern portion of the Former Operational Areas.

9.1.2.1.2 Ecological Exposure Pathways

Evaluating potential exposure pathways is one of the primary tasks of an ecological characterization. For an exposure pathway to be complete, a constituent must be able to travel from the source to ecological receptors and be taken up by the receptors via one or more exposure routes. Ecological exposure pathways are discussed below.

Potentially complete exposure pathways are illustrated in the ecological CSM, **Figure 9-2**. The primary sources of MC in surface soil at the Former Operational Areas MRS are through site usage, including discarded or malfunctioned munitions, waste from testing activities, and munitions waste from disposal practices.

Primary release mechanisms constitute any soil disturbance that may cause redistribution of contamination. Release mechanisms from surface soil include infiltration/percolation of precipitation through soil, leaching from soil to groundwater, surface runoff to a nearby water body, and uptake of constituents into plants and invertebrates in direct contact with soil. Secondary release mechanisms include discharge of groundwater to a surface water body or recharge of groundwater from a surface water body and biotransfer of bioaccumulative constituents through the food web. Activities at the Former Operational Areas may have also impacted surface water bodies directly. However, surface water, sediment, and groundwater at the Former Operational Areas MRS and in Green Pond Brook are being addressed under the IRP.

The following exposure pathways were considered complete for the Former Operational Areas MRS:

1. Uptake by plants and invertebrates in direct contact with soil where MC/constituents are present.
2. Terrestrial wildlife (i.e., birds, mammals, reptiles, and amphibians) exposure through incidental ingestion of soil at the Former Operational Areas MRS during feeding/foraging, nesting/burrowing, and/or preening activities.
3. Terrestrial wildlife exposure through ingestion of dietary/prey items, to the extent that MC/constituents in soil are taken up into plants and soil invertebrates, and transferred through the food web.

Exposure to MC/constituents through dermal contact and inhalation, while possible, were not included in the SLERA because of the general lack of information needed to evaluate the routes

of exposure. Although there may be potentially complete exposure pathways associated with MC/constituents potentially present in surface water and sediment, as discussed previously surface water and sediment are being addressed under the IRP and were not considered in the SLERA.

9.1.2.1.3 Assessment Endpoints

Assessment endpoints refer to the valued resources that are to be protected from adverse effects caused by exposure to site-related constituents. For most potential receptors, EPA (1997c) guidance recommends that protection of the population or community of plants and/or animals is the appropriate level to be provided by any action that may be required. However, because it is difficult to measure effects on populations or communities to verify if the risk predictions are accurate, adverse effects on individual organisms, considered to be representative of the entire population, are usually substituted.

For the SLERA, assessment endpoints are any adverse effects on ecological receptors, (i.e., plant and animal populations and communities) that may be present at the Former Operational Areas MRS. Ultimately the ecosystem-based assessment endpoint is the protection of the overall structure and function of the forest corridor, afforded in part, by the upland and wetland forests at the Former Operational Areas MRS. The overall structure and function of the forest corridor was assessed through the following community-based and population-based assessment endpoints:

1. Terrestrial plant communities - Long-term maintenance of a healthy and diverse plant community. Plants are primary producers and provide a critical food source and are the first link in the terrestrial food chain for higher trophic level consumers. In addition, vegetation provides critical habitat for wildlife. The SLERA does not evaluate vegetation exposure on a species-by-species basis; only at the community level.

- Plants that occur in the deciduous upland and wetland forests of the Former Operational Areas MRS are woody and herbaceous species that could serve as a food source and cover for songbirds and small herbivores.

2. Soil invertebrate communities - Long-term maintenance of a healthy and diverse invertebrate community. Soil invertebrates present in surface soil at the Former Operational Areas MRS provide a source of food for ground gleaning birds and small mammals. They also play a vital role in the ecosystem as primary and secondary decomposers.

3. Terrestrial bird and mammal populations - Long-term maintenance of the survival, growth, and reproduction of bird and mammal populations within several feeding guilds

that inhabit/utilize the forest corridor at PTA. Each of the feeding guilds that are represented by the various bird and mammal species present at PTA play vital roles in the ecosystem, primarily related to the incorporation and transfer of energy from one trophic level to the next and population control. Various species of herbivorous, insectivorous, and omnivorous small birds and mammals, along with various species of carnivorous predatory birds (e.g., hawks, owls) and mammals (e.g., bobcat, fox) that feed on these small birds and mammals have been documented at PTA.

The following specific wildlife species were selected as representative of these feeding guilds based on their life-history information and presence or likely presence in the forested uplands and wetlands of the Former Operational Areas MRS. While many threatened, endangered, and special concern plant and animal species have been documented at PTA, they were not specifically selected as representative species. Rather, the representative species selected for each feeding guild are intended to be representative of all individual species that may be present and occupy that feeding guild, including those species which are considered threatened, endangered, or of special concern. The potential for adverse effects on reptile and amphibian populations was evaluated qualitatively in the uncertainty section due to the general lack of readily available information on constituent metabolism and toxicity in these potential receptors.

Feeding Guild	Representative Species
Herbivorous Small Mammal	Eastern gray squirrel
Omnivorous Small Mammal	Deer mouse
Insectivorous Mammal	Northern long-eared bat
Carnivorous Mammal	Bobcat
Insectivorous Bird	American woodcock
Carnivorous Bird	Red-tailed hawk

9.1.2.1.4 Measurement Endpoints

A measurement endpoint is a measurable ecological characteristic that is related to the characteristic chosen as the assessment endpoint. Measurement endpoints can be measures of effect (i.e., changes in community structure) on assessment endpoints, or they can be measures of exposure (e.g., constituent concentrations in soil compared to screening ecotoxicity values), used to infer the potential for adverse effects to communities and the ecosystem in question (EPA, 1997c).

In this SLERA, measured constituent concentrations in surface soil at the Former Operational

Areas MRS in conjunction with measures of toxicity were used as measurement endpoints. Additionally, to assess the potential for adverse effects from exposure to bioaccumulative MC/constituents for the population-based assessment endpoints, estimated constituent concentrations in dietary/prey items and estimated exposures based on food web accumulation modeling were used in conjunction with toxicity reference values ((TRVs); i.e., chronic no observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs)) as measurement endpoints for representative wildlife species.

The following measurement endpoints were used to evaluate the community-based assessment endpoints:

1. Measured constituent concentrations in surface soil at the Former Operational Areas MRS compared to ESVs protective of terrestrial plants.
2. Measured constituent concentrations in surface soil at the Former Operational Areas MRS compared to ESVs protective of soil invertebrates.

The following measurement endpoints were used to evaluate the population-based assessment endpoints:

1. Food web accumulation modeling (i.e., accumulation of bioaccumulative constituents from incidental ingestion of soil during feeding/foraging, nesting/burrowing, and/or preening activities and ingestion of bioaccumulative constituents in dietary/prey items of the organism's diet) for representative terrestrial herbivorous small mammal species (i.e., Eastern gray squirrel) compared to mammalian TRVs for survival, reproduction, and growth effects.
2. Food web accumulation modeling (i.e., accumulation of bioaccumulative constituents from incidental ingestion of soil during feeding/foraging, nesting/burrowing, and/or preening activities and ingestion of bioaccumulative constituents in dietary/prey items of the organism's diet) for representative terrestrial omnivorous small mammal species (i.e., deer mouse) compared to mammalian TRVs for survival, reproduction, and growth effects.
3. Food web accumulation modeling (i.e., accumulation of bioaccumulative constituents from incidental ingestion of soil during feeding/foraging, nesting/burrowing, and/or preening activities and ingestion of bioaccumulative constituents in dietary/prey items of the organism's diet) for representative terrestrial insectivorous bird (i.e., American woodcock) and mammal (i.e., northern long-eared bat) species compared to avian and mammalian TRVs for survival, reproduction, and growth effects.
4. Food web accumulation modeling (i.e., accumulation of bioaccumulative constituents from incidental ingestion of soil during feeding/foraging, nesting/burrowing, and/or preening activities and ingestion of bioaccumulative constituents in dietary/prey items of

the organism's diet) for representative terrestrial carnivorous bird (i.e., red-tailed hawk) and mammal (i.e., bobcat) species compared to avian and mammalian TRVs for survival, reproduction, and growth effects.

9.1.2.2 Screening-Level Exposure and Effects Analysis

The screening-level exposure and effects analysis serves to establish appropriate exposure point concentrations, compare exposure point concentrations to appropriate ecological screening levels (ESLs), and select COPECs. First, all usable data were compiled and summarized. Data usability was discussed previously in Section 9.1.1.1. The data were organized and summarized for the Former Operational Areas MRS as described for HHRA.

9.1.2.2.1 Selection of Constituents of Potential Ecological Concern

The following screening process was used to identify COPECs in surface soil at the Former Operational Areas MRS.

1. Constituents with maximum detected concentrations greater than applicable ESVs were selected as COPECs:

   The applicable risk-based ESVs, which are protective of adverse effects on organisms, were identified. These ESVs are typically derived using species that are the most sensitive to effects or at the base of the food web in a community. Many of the ESVs used in the SLERA were derived by considering the potential for bioaccumulation using food chain modeling. Therefore, these ESVs, like many currently available screening thresholds, are based on generic assessment endpoints and are assumed to be widely applicable to sites around the United States (EPA, 1997b).

   a. For plants and soil invertebrates, the following hierarchy of sources was used.

      i. EPA Ecological Soil Screening Levels (Eco-SSLs) (accessed online at: http://www.epa.gov/ecotox/ecossl/), which were derived to be protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil.

      ii. The Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants (Efroymson et al., 1997a) or the Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997b). These screening benchmarks were developed based on the results of toxicity studies, either in the field or laboratory, to be protective of exposure to plants and soil invertebrates (i.e., earthworms).

      iii. For explosives, ESLs from the Los Alamos National Laboratory (LANL) ECORISK Database Release 3.0 (October 2011) (LANL, 2011). ESLs for generic plants (terrestrial autotroph producer) and earthworms (soil-dwelling invertebrate) were used, where available.

b. For terrestrial wildlife (i.e., birds and mammals), the following hierarchy of sources was used.

   i. Where available, avian and mammalian Eco-SSLs.

   ii. EPA Region 5 ESLs (accessed online at: http://www.epa.gov/reg5rcra/ca/edgl.htm), which are based on toxicity in avian and mammalian receptors. The majority of the ESLs are based on food-chain modeling using the masked shrew (*Sorex cenerus*) as a surrogate for small mammal populations.

   iii. For explosives, ESLs from the LANL ECORISK Database Release 3.0 (LANL, 2011). The lowest ESLs for avian and mammalian receptors were used, where available.

2. With the exception of the essential nutrients (i.e., calcium, magnesium, potassium, and sodium), constituents without ESVs were retained as COPECs.
3. Essential nutrients were removed as COPECs because it is unlikely they present risks to potential ecological receptors.
4. For the population-based assessment, MC/constituents identified as Important Bioaccumulative Compounds as listed in Table 4-2 of the EPA guidance document, *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment* (EPA, 2000a) were also selected as COPECs.

Table 9-6 for the Former Operational Areas MRS presents the data summary and COPEC selection for the community-based assessment. The ESVs and their basis, the rationale for COPEC selection, and the location of the maximum detected concentration are provided. As shown, three explosives and seven metals were initially selected as COPECs for the community-based assessment for soil at the Former Operational Areas MRS based on exceedance of the ESVs or lack of ESVs. The potential for impact is limited because the explosives were detected infrequently, i.e., in fewer than 5% of the samples (i.e., 2,4-dinitrotoluene and nitroglycerin in only 1 of 78 samples and tetryl in 3 of 78 samples). Therefore, the explosives were subsequently eliminated as COPECs for the community-based assessment.

Table 9-7 presents the data summary and COPEC selection for the population-based assessment. The ESVs and their basis, the rationale for COPEC selection, indication of whether MC/constituents are considered bioaccumulative, and the location of the maximum detected concentration are provided. As shown, eight metals were selected as COPECs for the population-based assessment for soil at the Former Operational Areas MRS based on exceedances of the ESVs. All detected MC/constituents that are considered bioaccumulative were selected as COPECs based on exceedance of the ESVs.

9.1.2.3 Screening-Level Exposure Estimates

Screening-level exposures were estimated for two scenarios, one conservative scenario (Step 2) and one refined scenario (Step 3a). For the community-based assessment, COPEC concentrations in soil were used as exposure point concentrations, which were then compared to measures of effects in the risk characterization section.

For the population-based assessment, constituent intakes (in the form of a dose, in mg COPEC per kg body weight per day) based on total exposure from incidental ingestion of COPECs in soil during feeding/foraging, nesting/burrowing, and/or preening activities and ingestion of bioaccumulative COPECs in dietary/prey items of each representative wildlife receptor species were estimated. The estimated intakes were then compared to measures of effects or toxicological criteria for each COPEC and receptor in the screening-level risk characterization section. While exposure via incidental ingestion of soil is likely the greatest for burrowing wildlife, this route of exposure is considered minimal as compared to dietary exposure. For many species (e.g., red-tailed hawk), the amount of soil incidentally ingested during feeding or preening is considered negligible. Therefore, intakes for the representative wildlife receptors were only estimated for bioaccumulative COPECs.

The following equation (modified from EPA, 1993c) was used to estimate COPEC intakes through dietary intake, including incidental ingestion of soil:

$$Intake_{total} = [[\sum(CF_i * FIR * PF_i)] + (C_s * FIR * PS) * AUF]$$

where:
$Intake_{total}$ = Total intake (mg/kg body weight-day)
CF_i = COPEC concentration in i^{th} food type (mg/kg, dry weight)
FIR = Normalized food ingestion rate (kg/kg-day, dry weight)
PF_i = Proportion of ith food type in the diet (%)
C_s = Soil concentration (mg/kg, dry weight)
PS = Proportion of soil in the diet (kg/day)
AUF = Area use factor (proportion of species' lifetime spent in area) (unitless)

The COPEC concentrations in each food type were estimated by multiplying the EPC by a corresponding LANL Bioaccumulation Factor (BAF):

$$CF_i = C_s \text{ x } BAF$$

where:

CF_i = COPEC concentration in i^{th} food type (mg/kg, dry weight)
C_s = Soil concentration (mg/kg, dry weight)
BAF = Bioaccumulation factor from soil to food source (unitless)

The bioaccumulation factors were derived based on the default uptake models or other literature values, as shown in **Table 9-8**. Receptor dietary consumption was categorized into vegetation, invertebrates, or prey (i.e., small mammals and/or birds) items. Other exposure parameters used to estimate COPEC intakes through dietary intake, including incidental ingestion of soil, are described below.

9.1.2.3.1 Conservative Scenario (Step 2) Exposure Parameters

For this SLERA, maximum constituent exposures were estimated in a conservative scenario for Step 2. Therefore, the EPC for each constituent in soil was assumed to be equivalent to the maximum detected concentration for both the community-based and population-based assessments. However, because plants and invertebrates are more or less sedentary, exposure was also evaluated on a sample-by-sample basis in the screening-level risk characterization for the community-based assessment.

For the population-based assessment, the food intake rates, proportion of soil in the diet, proportion of dietary items in diet, and minimum body weight were used to estimate COPEC intakes for the representative wildlife receptor species. For the conservative scenario, it was also assumed that 100% of the diet consists of the most abundant and contaminated food item and the entire home range is within the Former Operational Areas MRS (i.e., area use factor of 1). These exposure parameters were derived from literature sources and are shown in **Table 9-9**.

9.1.2.3.2 Refined Scenario (Step 3a) Exposure Parameters

The first step of the SLERA refinement was to evaluate the list of COPECs identified using the approach described in Section 9.1.2.2.1 by considering site-specific background concentrations. If maximum detected concentrations were greater than applicable ESVs but less than the site-specific background threshold values established for PTA under the IRP (IT Corporation, 2002), they were identified as non-site-related COPECs to be addressed qualitatively in the Risk Characterization. The purpose of this additional screening was to differentiate between naturally-occurring concentrations and those that may be attributable to site activities in order to aid in the decision making process for environmental investigations at PTA. The approach is consistent

with the risk assessment protocols in the Final RI Work Plan (WESTON, 2012) and also with the Soil Background Meeting Minutes, dated April 18, 2013 and approved by EPA on May 30, 2013. However, all metals were detected above background; therefore, none were identified as non-site-related COPECs.

For the refined scenario (Step 3a), average constituent exposures were estimated. Therefore, the EPC for each constituent in soil was set at the 95% UCL concentration for both the community-based and population-based assessments. However, as with the conservative scenario, plants and invertebrate exposure were also evaluated on a sample-by-sample basis in the screening-level risk characterization.

For the population-based measurement endpoints, average intake rates and body weights were used to estimate COPEC intakes for the refined scenario. The proportion of dietary items in the diet was revised to more closely represent the true diet of the representative wildlife receptor species. Area use factors (AUFs) are 1 for all receptors except the red-tailed hawk and the bobcat. An AUF of 0.9 was used for the red-tailed hawk, with a home range of about 1,660 acres, compared to that of the Former Operational Areas MRS (i.e., approximately 1,880 acres). An AUF of 0.2 was used for the bobcat, with a home range of about 8,063 acres compared to the area of the Former Operational Areas MRS. The exposure parameters used in the refined scenario are shown in **Table 9-10**.

9.1.2.3.3 Toxicity Reference Values

TRVs were used to measure the potential for adverse effects in ecological receptors as a result of exposure to detected COPEC concentrations in surface soil at the Former Operational Areas MRS. The ESVs used to select COPECs were also used as TRVs for the community-based assessment. For COPECs where no ESVs were available, other sources were consulted for plant and invertebrate TRVs. The TRVs for the community-based assessment are shown in **Table 9-11**.

TRVs generally protective of survival, growth and reproduction in avian and mammalian receptors were selected for the population-based assessment. Avian TRVs are shown in **Table 9-12** and mammalian TRVs are shown in **Table 9-13**. Both NOAELs and LOAELs were selected and are shown on **Tables 9-12** and **9-13**. However, only NOAEL-based TRVs were

used in the conservative scenario (Step 2). NOAEL-based and LOAEL-based TRVs were used in the refined scenario (Step 3a). Additionally, only NOAEL-based TRVs, regardless of the scenario, were used to evaluate the potential for risk to representative wildlife species for feeding guilds in which threatened, endangered, or special concern species occur and have been identified at PTA.

9.1.2.4 Risk Characterization

Risk characterization is the final phase of risk assessment in which the likelihood of adverse effects is evaluated by combining the analyses of exposure and effects. In this phase, the likelihood of adverse ecological effects occurring is estimated. Major uncertainties, assumptions, and strengths and limitations of the assessment are summarized in **Section 9.1.2.5**.

The HQ method was used for the community-based and population-based measurement endpoints. The HQ is expressed as measure of exposure divided by measure of effect. The measures of exposure and effects for the community-based measurement endpoints include measured COPEC concentrations in soil and media-specific benchmarks. The measures of exposure and effects for the population-based measurement endpoints are estimated COPEC intakes and wildlife TRVs. HQs were calculated based on both NOAEL (HQnoael) and LOAEL (HQloael) measures of effect, where applicable. HQs are generally interpreted as follows:

- An HQnoael < 1 indicates that toxicological effects and potential risk are likely not occurring.
- An HQnoael > 1 and an HQloael < 1 indicates that toxicological effects and potential risk may occur.
- An HQloael >1 indicates that toxicological effects and potential risk are more likely to occur.

The most that can be concluded from a calculated HQ greater than 1 is that there is an increased potential that an adverse effect may occur in at least one individual. While this potential increases as the magnitude of the HQ increases, the level of concern does not increase linearly with increases in HQ. This lack of linearity is based on the fact that typical dose response curves for constituents are not linear.

CERCLA, under which ERA guidance has been prepared, does not specify how the magnitude of HQs should be interpreted for risk characterization, and independent scientific literature also

does not recommend thresholds for HQs for interpretation for risk characterization (EPA 1990; Suter, 2007). Scientists recognize that HQs are not a direct measure of ecological risk, but rather are a measure of the degree of potential concern (Tannenbaum et al., 2003). True measures of risk imply the probability that an adverse environmental effect will occur (i.e., the fraction of a population that will potentially experience adverse effects). In practice, HQs are the only measure used in the ecological risk assessment process to determine if adverse effects may be occurring in the environment. The unqualified and conservative interpretation of HQs in ecological risk assessment for the purposes of remedial decision making has been criticized by the scientific community (e.g., Tannenbaum et al., 2003), including the following specific criticisms:

- HQs cannot be interpreted based on assumptions of linearity.
- HQs commonly exceed 1.0.
- HQs are frequently unreasonably high.

Although it is recognized that the magnitude of a HQ is not proportional to the magnitude of effect, the magnitude of the exceedance (i.e., how much above one the HQs are) was considered in this SLERA because there is a qualitative difference between HQs of 2, 20, and 200.

Despite these uncertainties in the utility of using HQ point estimates to infer risk to assessment endpoints, this metric has the advantage of being a standard practice. A discussion of major sources of uncertainty in this SLERA is provided in Section 9.1.2.5.

9.1.2.4.1 Screening-Level Risk Characterization (Conservative Scenario)

Community-Based Assessment

HQs were calculated as the EPC, represented by the maximum detected concentration, divided by the TRVs for plants and invertebrates. It should be noted that the HQs for the community-based assessment are essentially effect quotients in that they represent the ratio of exposure concentration (e.g., concentration in soil) to a benchmark media concentration that equates to effects as opposed to the HQs for the population-based assessment which represent the ratio of a modeled dose to established “safe” dose levels (i.e., NOAELs) and “low effects” dose levels (i.e., LOAELs). However, EPA (1997) and USACE (2010a) make no distinction between HQs based on media concentrations and TRVs as benchmark media concentrations versus estimated doses and TRVs as dose levels. The frequency of detection, range of detected concentrations,

EPCs, TRVs, PTA background values, and HQs are shown in **Tables 9-14** and **9-15**, for plants and invertebrates, respectively. HQs for each constituent are summarized in **Table 9-30**.

As shown in **Table 9-14** for plants, HQs range from 2 for copper and lead to 168 for manganese and 770 for aluminum. A summary of the results from **Table 9-14** are presented below:

- Concentrations of aluminum in every sample exceed the ESV; however, exceedance of the PTA background value only occurs in 13 locations. Toxicity and bioaccumulation of aluminum is associated with soluble aluminum. Aluminum becomes soluble and biologically active in acidic soils at pH of less than 5.5. Based on the major soil types at PTA, pH generally ranges from 4.5 to 6.5 (USDA, 2013). However, aluminum was detected at concentrations exceeding the ESV in all background samples. The PTA background value for aluminum exceeds the ESV by orders of magnitude.
- Concentrations of barium and copper exceed the TRV in fewer than 10 locations and exceed the PTA background value in 17 and 20 locations, respectively.
- Concentrations of lead and zinc exceed the TRV in 13 and 11 locations, respectively, and exceed the PTA background value in 34 and 30 locations, respectively.
- Concentrations of manganese exceed the TRV in 54 locations and exceed the PTA background value in 24 locations. The PTA background value exceeds the TRV.
- With the exception of aluminum, manganese, and strontium, all HQs are less than 10.
- There is no plant TRV for strontium. Concentrations of strontium exceed the PTA background value in 19 locations.

As shown in **Table 9-15** for invertebrates, HQs range from 2 for copper to 82 for manganese. A summary of the results from **Table 9-15** is presented below:

- Concentrations of barium and copper exceeded the TRV in fewer than 10 locations.
- Concentrations of manganese and zinc exceeded the TRVs in 34 and 18 locations, respectively.
- The PTA background value for manganese exceeds the TRV.
- There are no invertebrate TRVs for aluminum and strontium.

Population-Based Assessment

HQs were calculated as total intake divided by the TRVs for birds and mammals. Calculation of HQs are shown for the representative wildlife receptors in **Tables 9-16** to **9-21**. HQs for

individual COPECs are summarized in **Table 9-30**.

For the eastern gray squirrel, red-tailed hawk, and bobcat, all HQnoaels are less than 1. For the deer mouse (**Table 9-17**), only the HQnoael for cadmium (9) is greater than 1. For the American woodcock (**Table 9-18**), all HQnoaels are greater than 1 and range from 4 for zinc to 17 for cadmium and lead. For the northern long-eared bat (**Table 9-20**), all HQnoaels are greater than 1 and range from 2 for copper and zinc to 22 for cadmium.

9.1.2.4.2 Screening-Level Risk Characterization (Refined Scenario)

For the community-based assessment, HQs were calculated as the EPC, represented by the 95% UCL concentration, divided by the TRVs for plants and invertebrates. The frequency of detection, range of detected concentrations, EPCs, TRVs, PTA background values, and HQs are shown in **Tables 9-22** and **9-23**, for plants and invertebrates, respectively. HQs for individual COPECs are summarized in **Table 9-31**.

Community-Based Assessment

As shown in **Table 9-22** for plants, HQs are equal to 1 for barium and zinc and are 23 and 287 for manganese and aluminum, respectively. As shown in **Table 9-23** for invertebrates, the HQ for barium is equal to 1, for zinc is 2, and for manganese is 11.

Population-Based Assessment

HQs were calculated for the representative wildlife receptors as shown in **Tables 9-24** to **9-29**. HQs for individual COPECs are summarized in **Table 9-31**.

For the eastern gray squirrel, red-tailed hawk, and bobcat, all HQnoaels are less than 1. For the deer mouse (**Table 9-25**), HQnoaels were equal to (cadmium) or less than 1. For the American woodcock (**Table 9-26**), individual HQnoaels range from 1 for copper to 5 for lead. For the northern long-eared bat (**Table 9-28**), individual HQnoaels range from 1 for copper and zinc to 3 for cadmium.

For the eastern gray squirrel and deer mouse, all HQloaels are less than 1. For the American woodcock (**Table 9-26**), HQloaels are all less than 1 with the exception of lead which has an HQloael of 3. HQloaels were not calculated for the red-tailed hawk, the northern long-eared bat,

or the bobcat because threatened or endangered species present at PTA are within the same feeding guild and the bobcat is a state species of special concern.

9.1.2.5 Uncertainties

Uncertainties in the SLERA process are related to environmental sampling, assumptions regarding the potential exposure of ecological receptors, and the ESVs and TRVs used to select COPECs and calculate HQs.

Uncertainties associated with environmental sampling were largely discussed previously in Section 9.1.1.4.2. Non-detect constituents are not evaluated as COPECs in this SLERA, as their presence and concentration in soil has not been confirmed. Explosive compounds that were analyzed for but not detected in soil samples may be present at an unknown concentration somewhere between the sample reporting limit and zero. Reporting limits for non-detect explosives were therefore compared to ESVs, as available, to evaluate whether non-detect explosives may be present at concentrations that pose ecological risks. The lowest ESVs for plants, invertebrates, birds, and mammals were determined based on the hierarchies in Section 9.2.2.1. **Table 9-32** shows the ESV and the range of reporting limits for the explosives that were not detected. As shown, reporting limits were all below the ESVs, with the exception of picric acid for which no ESVs are available.

Additionally, as described in Section 9.1.1.1.1, for the non-detect antimony results (62 out of 90 samples or 69%), all of the RLs were above the ecological LOC (0.27 mg/kg), although only half of them were above the PTA-specific background concentration (0.96 mg/kg), and all except three of them were within the range of detected antimony concentrations.

Antimony was not identified as a COPEC in the SLERA for the community-based assessment, based on comparison of the maximum detected concentration (4.5 mg/kg) to the ESV protective of plants and soil invertebrates (78 mg/kg). Antimony was identified as a COPEC for the population-based assessment because the maximum concentration was greater than the ESV (0.27 mg/kg), which is the EcoSSL for mammals (there is no EcoSSL for birds), and also the background threshold value (0.96 mg/kg). However, intakes for the representative wildlife receptors were not estimated for antimony in the food web accumulation modeling, because antimony is not considered bioaccumulative. Therefore, antimony does not contribute to the most

significant wildlife exposure (i.e., exposure to COPECs bioaccumulated in the diets of wildlife). While the calculated 95% UCL concentration (as discussed in Section 9.1.1.2.1) is greater than the ESV of 0.27 mg/kg, it is less than the background threshold value. Therefore, while antimony reporting limits above the LOC introduces some uncertainty, it does not impact the overall conclusions reached in the SLERA. For constituents identified as COPECs, the SLERA necessarily overestimates the potential for risk of adverse health effects by making conservative assumptions about the potential for ecological exposure. These assumptions include:

- Ecological receptors forage/feed exclusively within the Former Operational Areas MRS and are exposed to the COPEC present in surface soil on a daily basis. This is an especially conservative assumption for evaluating receptors with large home ranges or that are migratory. Northern New Jersey may be at the northern boundary for year-round resident American woodcock; therefore, American woodcock at PTA may migrate. In addition, northern long-eared bats migrate to winter hibernacula, which may be up to 56 kilometers from summer habitat.
- Each COPEC is present at a concentration equal to its maximum detected or 95% UCL concentrations where ecological receptors are present or forage/feed. This is unlikely because the COPECs are not likely present across the entire Former Operational Areas MRS at concentrations equivalent to the maximum detected or 95% UCL concentrations.
- The COPECs are 100% bioavailable in soil or food/prey items. This is also not likely for most COPECs. For example, aluminum becomes soluble and biologically active in acidic soils at pH of less than 5.5. While soil pH at PTA may range from 4.5 to 6.5 (USDA, 2013), concentrations of aluminum in all the background locations are greater than the ESV. It is unlikely that aluminum is related to toxicity under background conditions.

Other sources of uncertainty in the food web modeling include the use of literature-based bioaccumulation factors. Metals in soil must first be bioavailable to primary producers and bioavailability of metals in soil is dependent on site-specific soil conditions including: pH, organic matter, and the concentration of iron and aluminum oxyhydroxides. Therefore, the extent to which COPECs may bioaccumulate into plants, soil invertebrates, and small mammals or birds is unknown.

Sources of uncertainty in the ESVs and TRVs used to select COPECs and calculate HQs stem mostly from differences in their derivation. In some cases, the TRVs were derived using clinical dose-response trials with laboratory animals under controlled environmental conditions. Differences in toxicity may exist between laboratory animals and wildlife. Additionally, toxicity

values from various sources can differ by orders of magnitude for the same constituent, depending on the test species used and the type of trial conducted. The use of TRVs from multiple sources, depending on their availability, may limit the comparability of HQs for a single receptor. The usefulness of TRVs as indicators of potential ecological risk is limited in cases where TRVs are exceeded by background concentrations. Lastly, the lack of TRVs for some detected constituents contributes to uncertainty in either direction.

ESVs or TRVs were not available to evaluate the potential for ecological risk from exposure to strontium in surface soil. Therefore, the potential for adverse effects in terrestrial wildlife from exposure to strontium in soil was not quantitatively evaluated in this SLERA. Ingestion of low levels of stable strontium does not pose a risk of harm to organisms provided adequate calcium, phosphorus, and vitamin D are present; however, at higher exposure levels, especially when inadequate calcium, phosphorus, and vitamin D are available, stable strontium can interfere with normal bone development (ATSDR, 2004).

While the assessment endpoint for the representative wildlife receptors is long-term maintenance of the survival, growth, and reproduction of bird and mammal populations, the food web modeling estimates the potential for effects to the survival, growth, and reproduction of an individual of the species. The potential for effects on populations is unknown. One way to better determine the potential for population effects is to evaluate population densities for the receptor species in relation to the contaminated site. Approximate population densities for the representative wildlife receptors is shown below:

- Eastern gray squirrel: 2-20 individuals per acre (Burt and Grossenheider, 1976).
- Deer mouse: Although population density varies considerably and seasonally and is correlated with food abundance and vegetative cover (EPA, 1993), Burt and Grossenheider (1976) indicate summer populations of 10-15 individuals per acre is high.
- American woodcock: summer densities of 19 to 25 individuals per 247 acres (EPA, 1993).
- Red-tailed hawk: usually are lower than about 1 pair per 500 acres (EPA, 1993).
- Northern long-eared bat: No data available; however, up to 60 bats may roost together in maternity colonies while males and non-breeding females roost alone (Burt and Grossenheider, 1976).

- Bobcat: Bobcat are mostly solitary and have extensive home ranges (Burt and Grossenheider, 1976); therefore, a density of 1 individual might be considered for the entire Former Operational Areas MRS.

Most of these receptors have population densities of 1 to many individuals in areas smaller than the Former Operational Areas MRS. The one exception is the bobcat, a mostly solitary animal with a home range larger than the Former Operational Areas MRS (i.e., about 8,000 acres).

9.1.3 RISK ASSESSMENT SUMMARY AND CONCLUSIONS

The risk assessment evaluated the potential for adverse human and ecological health effects from exposure to explosives and metals detected in surface soil (0 to 2 feet bgs) at the Former Operational Areas MRS. Current EPA risk assessment guidance, screening levels, and recommended exposure equations and parameter values were used.

9.1.3.1 Summary of HHRA

COPCs for the HHRA were identified by comparing maximum detected constituent concentrations to EPA RSLs for resident soil and, for metals, to site-specific background threshold values. The COPCs in surface soil were limited to the following metals: aluminum, antimony, barium, cadmium, and manganese. EPCs in surface soil were calculated as the 95% UCL concentration, and EPCs in outdoor air were estimated using calculated PEFs. Ingestion, dermal contact, and inhalation exposures were modeled for the following potential human receptor populations: current/future outdoor site workers, construction/utility workers, recreationists (adults and children), future construction workers, and hypothetical future residents (adults and children). Exposure estimates were combined with chemical-specific toxicity values to calculate incremental lifetime cancer risks and non-cancer hazards for each receptor and exposure scenario.

Assuming RME conditions, the cancer risks estimated for all receptors were less than the risk range of 10^{-6} (i.e., 1E-06 or 1 in 1,000,000) to 10^{-4} (i.e., 1E-04 or 1 in 10,000) established by the NCP. Non-cancer HIs were less than the target HI of 1 for all receptors, except the future construction worker (HI = 10) and hypothetical future resident child (HI = 3). Under CTE scenarios, the non-cancer HI for the construction worker was 5, and the non-cancer HI for the resident child was still 3. For the construction worker, the potential for adverse, non-cancer health effects was attributable to inhalation exposure to manganese in outdoor air. For the

resident child, the potential for adverse, non-cancer health effects was attributable to ingestion exposure to manganese in surface soil.

However no further action to address manganese in surface soil at the Former Operational Areas MRS is warranted, considering the following observations:

- The future construction worker scenario assumed inhalation exposure to uncontrolled particulate emissions generated by vehicle traffic on temporary, unpaved roads. This scenario is overly protective given that fugitive emissions during future construction work at PTA would likely be minimized through engineering controls.
- The PEF used to estimate COPC concentrations in outdoor air was 2.23E+06 m^3/kg. In contrast, the default PEF used to generate the EPA RSLs for soil is 1.4E+09 m^3/kg (EPA, 2013a). Use of this EPA default PEF for the Former Operational Areas MRS risk assessment would result in a construction worker inhalation HQ of 0.02 for manganese (vs. HQ of 10 using the PEF for vehicle traffic on unpaved roads) under the RME scenario and a receptor-specific HI of 0.7, which is less than the target HI of 1 established by the NCP.
- The EPA default PEF is used to generate the EPA RSL for manganese in industrial soil (23,000 mg/kg), which is being applied as the soil cleanup level for manganese at PTA sites evaluated under the IRP.
- The hypothetical future residential exposure scenario is also overly protective, given there are no known future land use changes for the Former Operational Areas MRS and residential development of the Former Operational Areas MRS is not included in PTA's master plans (Parsons 2007a, 2007b).
- The EPC for manganese (5,156 mg/kg) likely over-estimated average exposure conditions throughout the Former Operational Areas MRS, as the majority of detected concentrations (79 of 103 or 76%) were less than the site-specific background value of 1,250 mg/kg.
- The EPC for manganese was influenced by concentrations detected in step-out samples around two surface soil samples (PTA-2011-FOAG-SS23 and PTA-2011-FOAG-SS71) with relatively elevated concentrations in the Former Operational Areas MRS. The mean concentration of an alternate data set excluding these nine samples would be 648 mg/kg, and the 95% UCL concentration would be 1,148 mg/kg. Use of 1,148 mg/kg as an alternate EPC to evaluate potential construction worker exposures to manganese would yield a non-cancer HI of 2 under the RME scenario and a non-cancer HI of 1 under the CTE scenario. An EPC of 1,148 mg/kg would result in a non-cancer HI of 0.6 for the resident child under both the RME and CTE scenarios.
- The alternate EPC for manganese is less than the background value of 1,250 mg/kg, indicating even background manganese concentrations would yield non-cancer hazards greater than 1 under the RME scenario for the construction worker.

- Both EPCs for manganese (5,156 mg/kg and 1,148 mg/kg) are less than the EPA RSL for industrial soil of 23,000 mg/kg, which is being applied as the soil cleanup level for manganese at PTA sites evaluated under the IRP.
- Only two (FOAG-SS223 and FOAG-SS523) of the 103 surface soil samples (or 2%), located within 150 feet of each other, had detected manganese concentrations greater than 23,000 mg/kg.
- PTA-2011-FOAG-SS23 and PTA-FOAG-SS71 are located on opposite sides of the Former Operational Areas MRS, in wooded areas that are not continuously occupied under the current land use scenario.
- Even under a future site redevelopment scenario, it is not likely that construction workers or resident children would be exposed to the most elevated manganese concentrations to the extent assumed by the exposure models used in this risk assessment. Repeated exposures would more likely be to MC in soil across a larger geographic area. Therefore, the alternate EPC of 1,148 mg/kg and background value of 1,250 mg/kg are most representative of manganese concentrations to which humans would be routinely exposed.
- Following a review of historical use areas within PTA, concentrations of manganese are not likely associated with former use of MEC at the Former Operational Areas MRS.

Based on the above considerations and to be consistent with the approach being applied at PTA sites evaluated under the IRP, no further action based on the potential for human health risk is warranted.

9.1.3.2 Summary of SLERA

EPA (1997) guidance indicates that following the screening-level risk calculation, a decision point is reached where it is determined which of these three statements applies:

- The potential for adverse health effects in ecological receptors is negligible and there is no need for remediation on the basis of ecological risk.
- There is inadequate information and the ecological risk assessment process should continue.
- There is the potential for adverse ecological effects and a more thorough assessment is warranted.

The following summarizes the results of the SLERA and states the conclusions.

Community-Based Assessment

Aluminum

The PTA background value for aluminum exceeds both plant and invertebrate TRVs by orders of magnitude. While concentrations of aluminum exceeded the TRV in all samples, exceedance of the PTA background value only occurs in 13 locations. Exceedances of background occurred at three locations on the northern portion (PTA-2011-FOAG-SS-03, PTA-2011-FOAG-SS-71, and PTA-2011-FOAG-SS-82) and four locations on the southern portion (PTA-2011-FOAG-SS-14, PTA-2011-FOAG-SS-23, PTA-2011-FOAG-SS-46, and PTA-2011-FOAG-SS-61) of the Former Operational Areas MRS. These locations are not localized to one area nor necessarily adjacent to one another. Aluminum concentrations in five of the six step-out samples collected adjacent to PTA-2011-FOAG-SS-71 also exceeded background. However, the concentration of aluminum in all background samples (975 mg/kg to 20,500 mg/kg) also exceed the TRV (50 mg/kg). It seems likely that the distribution of aluminum across the Former Operational Areas MRS is likely due to natural variability. Aluminum in soils may be more or less bioavailable depending on soil pH, however, it is unlikely that aluminum is related to toxicity under background conditions. As indicated in Section 9.1.2.1.1.1, the majority of the Former Operational Areas MRS is covered by forested uplands and wetlands. Concentrations of aluminum detected in soil are likely not associated with former use of or with MEC at the Former Operational Areas MRS.

Manganese

The PTA background value for manganese exceeds both plant and invertebrate TRVs. As described previously in Section 9.1.1.4 (Risk Characterization for the HHRA), the majority of manganese concentrations (79 of 103 or 76%) were less than the PTA background value of 1,250 mg/kg. When the most elevated manganese samples detected in PTA-2011-FOAG-SS23 (9,300 mg/kg), PTA-2011-FOAG-SS71 (27,000 mg/kg), and associated step-out samples are removed, the mean concentration of this alternate manganese data set would be 648 mg/kg, and the 95% UCL concentration would be 1,148 mg/kg. While still above the plant and invertebrate TRVs, these average concentrations are below the PTA background value. It should be noted that the manganese background value also exceeds the plant and invertebrate TRVs. As indicated in Section 9.1.2.1.1.1, the majority of the Former Operational Areas MRS is covered by forested uplands and wetlands. With the possible exception of the most elevated samples, concentrations of manganese detected in soil are likely not associated with former use of or with MEC at the

Former Operational Areas MRS.

Other Metals

Both plant and invertebrate HQs for barium, copper, lead, and zinc were below 10 in the conservative scenario, were 2 or less in the refined scenario, and exceed the TRVs in approximately 20% or fewer locations and exceed the PTA background values in approximately 30% or fewer locations. The spatial distribution of the exceedances is discussed below for each metal.

Barium

Barium exceeded the plant and invertebrate TRVs at PTA-2011-FOAG-SS71 on the northern portion of the Former Operational Areas MRS and some of the associated step-out samples and at PTA-2011-FOAG-SS23 on the southern portion of the Former Operational Areas MRS and some of the associated step out samples. Barium also exceeded the invertebrate TRV at PTA-2011-FOAG-SS19. PTA-2011-FOAG-SS19 is adjacent to PTA-2011-FOAG-SS23.

Copper

Copper exceeded plant and invertebrate TRVs in three of the 90 samples (one location on the northern portion and two, non-adjacent, locations on the southern portion of the MRS).

Lead

On the northern portion of the Former Operational Areas MRS, lead exceeded the plant TRV at three locations, including one step out sample associated with PTA-2011-FOAG-SS71. These locations are not adjacent to one another. On the southern portion of the Former Operational Areas MRS, lead exceeded the plant TRV at 10 locations. Several of these locations are adjacent to one another PTA-2011-FOAG-SS36, PTA-2011-FOAG-SS41 and PTA-2011-FOAG-SS35, PTA-2011-FOAG-SS43, PTA-2011-FOAG-SS49, and PTA-2011-FOAG-SS53.

Zinc

On the northern portion of the Former Operational Areas MRS, zinc exceeded the plant and invertebrate TRVs at five locations, including PTA-2011-FOAG-SS71 and some of the

associated step out samples. With the exception of PTA-2011-FOAG-SS71 and the associated step out locations, the locations are not adjacent to one another. On the southern portion of the Former Operational Areas MRS, zinc exceeded the plant TRV in six locations, including one step out location associated with at PTA-2011-FOAG-SS23. However, none of these locations are adjacent to one another. Zinc also exceeded the invertebrate TRV at six non-adjacent locations on the southern portion of the Former Operational Areas MRS.

Exceedances of plant and/or invertebrate TRVs that are not adjacent to one another may represent only localized areas with the potential for adverse health effects. However, exceedances of plant and/or invertebrate TRVs that are adjacent to one another may represent more wide-spread areas with the potential for adverse health effects.

Based on these considerations, it is unlikely that concentrations of barium, copper, lead, and zinc are associated with widespread adverse effects in plants and invertebrates at the Former Operational Areas MRS, with the following exceptions:

- Invertebrate TRV exceedances for barium in the vicinity of PTA-2011-FOAG-SS19 and PTA-2011-FOAG-SS23.
- Plant TRV exceedances for lead in the vicinity of PTA-2011-FOAG-SS36, PTA-2011-FOAG-SS41 and PTA-2011-FOAG-SS35, PTA-2011-FOAG-SS43, PTA-2011-FOAG-SS49, and PTA-2011-FOAG-SS53.

However, as indicated in Section 6 of the RI Report, no evidence of potential disposal areas or firing points were observed during investigations at the majority of the Former Operational Areas MRS (i.e., excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24, where MC is being addressed under the IRP). Also, the majority of the Former Operational Areas MRS is covered by forested uplands and wetlands, as indicated in Section 9.1.2.1.1.1.

Although intact MEC was found, mainly in the southern portion of the Former Operational Areas MRS, there was no evidence of a release from the MEC. Thus, concentrations of barium, copper, lead, and zinc are likely not associated with MEC or its former use at the Former Operational Areas MRS.

Population-Based Assessment

For the conservative scenario (Step 2), HQnoaels were less than 1 for the eastern gray squirrel, red-tailed hawk, and bobcat. HQnoaels were greater than 1 for the deer mouse (cadmium), the American woodcock (cadmium, copper, lead, and zinc), and the northern long-eared bat (cadmium, copper, lead, and zinc). HQnoaels were less than 10 except for cadmium (17) and lead (17) for the American woodcock and cadmium (22) for the northern long-eared bat.

For the refined scenario (Step 3a), HQnoaels were less than or equal to 1 for the eastern gray squirrel, deer mouse, red-tailed hawk, and bobcat. HQnoaels were greater than 1 but less than 10 for the American woodcock (cadmium, lead, and zinc) and the northern long-eared bat (cadmium).

Based on the results of food web modeling, there may be a potential for adverse effects in individual insectivorous birds and mammals associated with bioaccumulation of cadmium, lead, and zinc into invertebrates consumed as dietary items. However, the use of bioaccumulation factors from the literature leaves uncertain the extent to which soil invertebrates within the Former Operational Areas MRS may actually be bioaccumulating these metals. Additionally, it is likely overly conservative to assume COPECs are present at the maximum detected concentration or even the 95% UCL concentration throughout the entire home range/feeding territory of the American woodcock and northern long-eared bat. In addition, it is likely that exposure at the Former Operational Areas MRS may be limited for these receptors because the American woodcock at PTA, being at the northern boundary of their year-round range, may migrate south during the winter and northern long-eared bats migrate up to 56 kilometers from summer habitat to winter hibernacula.

It should also be noted that even background values for copper, lead, and zinc result in conservative HQs greater than 1 for the American woodcock the background value for cadmium results in a conservative HQ greater than 1 for the northern long-eared bat. More than 75% of the zinc concentrations and more than 50% of the lead concentrations are below the PTA background value. Based on these considerations it is unlikely that the survival, growth and reproduction of insectivorous bird and mammal populations at PTA are at risk from soil impacted by MEC or historical use at the Former Operational Areas MRS. However, the bioavailability of these metals in soil at the Former Operational Areas MRS and the extent to

which they bioaccumulate into invertebrates is unknown.

The results of the refinement step (Step 3a) of the SLERA support that there is adequate information to conclude that, for most of the COPECs in surface soil, adverse impacts to terrestrial receptors are unlikely or are not ecologically significant. There is a potential for more wide-spread adverse health effects in plants and invertebrates associated with exposure to barium (invertebrates only) in the vicinity of PTA-2011-FOAG-SS19 and PTA-2011-FOAG-SS23 and associated with exposure to lead (plants only) in the vicinity of PTA-2011-FOAG-SS36 and PTA-2011-FOAG-SS41 and PTA-2011-FOAG-SS35, PTA-2011-FOAG-SS43, PTA-2011-FOAG-SS49, and PTA-2011-FOAG-SS53. **Figures 9-3** and **9-4** show the exceedances of plant and invertebrate TRVs for the northern and southern portions of the Former Operational Areas MRS and the sample locations where the exceedances occur in relation to the historical use areas identified from the *DoD Executive Order 11508 Installation Survey Report, Picatinny Arsenal, Dover, New Jersey*, January 1973. As shown on **Figure 9-3**, PTA-FOAG-SS71 and the associated step out locations PTA-FOAG-SS107, PTA-FOAG-SS108, and PTA-FOA-SS109 are within areas historically identified as technical areas (i.e., labeled "Code 300 – Technical" on **Figure 9-3**). Based on the figure, location PTA-FOAG-SS25 may also be within the former technical area. As shown on **Figure 9-4**, locations PTA-2011-FOAG-SS19, PTA-FOAG-SS20, PTA-2011-FOAG-SS35, PTA-2011-FOAG-SS43, PTA-2011-FOAG-SS49, PTA-2011-FOAG-SS23, and step out samples PTA-FOAG-SS105 and PTA-FOAG-SS106 associated with PTA-FOAG-SS23 are within or at the boundary of areas historically identified as training areas (i.e., labeled "Code 100 – Training" on **Figure 9-4**). Also shown on **Figure 9-4**, PTA-FOAG-SS61 is at the boundary between the former training area and an area of unknown historical use, and PTA-FOAG-SS-22 is at the boundary of the former technical area. However, as indicated in Section 6 of this RI Report, no evidence of potential disposal areas or firing points was observed during investigations at the majority of the Former Operational Areas MRS (i.e., excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24 where MC is being addressed under the IRP). In addition, intact MEC was found, but mainly in the southern portion of the Former Operational Areas MRS (excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24, where MC is being addressed under the IRP). Thus, it seems unlikely that barium concentrations are associated with former use of the Former Operational Areas MRS. Further evaluation on the basis of the potential for

ecological risk is not warranted.

9.2 INACTIVE MUNITIONS WASTE PIT MRS

Prior to the RI, sampling conducted to evaluate MC at the Inactive Munitions Waste Pit MRS consisted of surface water and sediment samples collected to support a 1989 SI for the MRS (Malcolm Pirnie, 2006). Based on the significant amount of filling and earthwork conducted in the Inactive Munitions Waste Pit MRS around the time of and following the collection of these samples, the data are not considered reflective of current conditions.

During the field investigation portion of the RI, biased subsurface soil samples were collected from potentially impacted media observed in direct contact with buried DMM. Based on the current use scenario for the Inactive Munitions Waste Pit MRS, and given the depth of the samples that were collected to characterize the bulk of buried debris containing MEC (greater than 10 feet bgs), there is likely no direct contact risk for PTA personnel and no exposure potential for ecological receptors. However, because PTA is dynamic with an evolving mission focus, risk assessment activities were conservatively initiated for human health receptors in the event that buried debris is encountered.

The first step in the risk assessment process was to perform a point-by-point comparison of the analytical results to the screening levels selected for each compound. To develop appropriate screening levels, the current and future uses of the Inactive Munitions Waste Pit MRS property were considered. Currently, the Inactive Munitions Waste Pit MRS is a restricted access area (fully fenced) within PTA that abuts operational ranges to the northeast and southwest with the PTA boundary forming the western extent of the MRS. The Inactive Munitions Waste Pit MRS is only accessible to authorized personnel, who currently use the center portion of the MRS for material and equipment staging (e.g., vehicles, sand, and gravel). Recreational use within the Inactive Munitions Waste Pit MRS is allowed for hunting in a regulated manner. Hunting is permitted only on Saturdays and holidays and is restricted to only five hunting individuals at one time within the Robinson Enclosure area. The current use is not anticipated to change in the future, and the Inactive Munitions Waste Pit MRS is not included in any future overall redevelopment plans for PTA because of its proximity to operational ranges. The Code 300 Area also overlaps with the MRS.

9.2.1 Human Health Risk Assessment

The basis for the RI was historical information collected during the Inactive Munitions Waste Pit HRR that indicated a suspect burial pit(s) for munitions may be present, which could be a source for an MC release(s), and included a recommendation for an RI following the SI (Malcolm Pirnie, 2008). The human health evaluation performed to assess potential risks from MC at the Inactive Munitions Waste Pit MRS was initiated to first confirm the potential presence/absence of contamination using the analytical data from the biased samples collected during the RI and project screening levels for human health. The level of effort was appropriate based on the limited amount of pre-existing analytical data, and no risk assessment results previously documented for the Inactive Munitions Waste Pit MRS.

To employ a conservative approach to the point-by-point comparison and in accordance with the UFP-QAPP developed as part of the Final RI Work Plan (WESTON, 2012), screening levels for human health were based on the latest revision to Oak Ridge National Laboratory Regional Screening Levels for residential soil exposure (EPA, 2013a) and the NJ Department of Environmental Protection Residential Direct Contact Soil Remediation Standard (NJDEP, 2009), (the most conservative screening level was selected) and applied uniformly to the data set to identify potential MC COPC.

Data collected during the RI field investigation consisted of surface DGM to identify features indicative of a burial pit(s), in addition to visual inspection, field screening with a PID, and analytical sampling of subsurface impacted soil from a test trench excavated at the Inactive Munitions Waste Pit MRS. Sampling activities were performed concurrently with ongoing IRP investigations in the MRS for a potential trichloroethylene release. The collocated data and information generated by the IRP contractor during the test trench investigation was also considered during the human health evaluation to include multiple lines of evidence to the extent practical.

Based on the surface DGM performed at the Inactive Munitions Waste Pit MRS, a burial pit is present and laterally encompasses approximately 0.24 acre. During the trench investigation DMM was identified underlying fill material in debris at 4.5 feet bgs; the majority of debris, including MD, was encountered between 10 feet and 20 feet bgs. Native soil was observed below the debris, and bedrock was encountered at the bottom of the trench, approximately 24 feet bgs. Discrete samples were collected for off-site laboratory analysis from subsurface soil at the top

and bottom of the observed debris layer, in addition to the native soil at the bottom of the trench. During the test trench investigation, DMM was identified (see Section 6.8.2). Several observations were recorded of associated soil staining and/or faint odors indicating the potential for a release to soil in contact with the debris.

The Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M** illustrates the comparison of validated data results to selected screening levels.

9.2.1.1 Data Evaluation

As shown on the Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M**, the majority of constituents analyzed by the laboratory yielded non-detect results or low level detections at quantitation limits that were below project screening levels. Only one explosive exceedance of the selected screening levels was noted during data evaluation that warranted further review in accordance with the risk evaluation procedure detailed in the Final RI Work Plan (WESTON, 2012). Field data, collocated data collected under the IRP, and toxicology information was reviewed to facilitate a weight of evidence approach while determining if the screening level exceedance warranted selection of a COPC for the Inactive Munitions Waste Pit MRS.

All metal analytes, except for antimony, were positively detected in the four samples collected from the Inactive Munitions Waste Pit MRS as shown in the validated analytical data provided in the Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M.** Only aluminum, cadmium and zinc were observed at concentrations above initially selected screening levels for the RI and/or PTA-specific background values for soil.

Several explosive compounds were positively detected in the samples collected associated with buried debris as shown in the Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M**. However, all results except for one were below project screening levels. Sample PTA-2012-IMWP-004 collected from soil below the observed debris and above bedrock at the bottom of the trench at 14 ft bgs, contained 2,4-DNT reported by the laboratory at a concentration of 8.3 mg/kg, which exceeds the project screening level for human health of 01.6 mg/kg.

9.2.1.1.1 Data Usability and Quality Assessment

Subsurface discrete soil samples from the Inactive Munitions Waste Pit MRS were analyzed and validated according to the methods described in the Final RI Work Plan (WESTON, 2012). Measurement performance criteria evaluated during validation include precision, accuracy, representativeness, comparability, detection limit verification, and completeness. As shown on the validation reports, overall the data are of acceptable quality, subject to the data validator's qualifying marks. Data assigned qualifiers (e.g., indicating the numerical value is an estimated quantity) were treated the same as data without such qualifiers.

Subsurface discrete soil samples from the Inactive Munitions Waste Pit MRS were analyzed by an NJDEP and NELAP certified laboratory and were validated according to the methods described in the MMRP Final RI Work Plan (WESTON, 2012). Measurement performance criteria evaluated during validation in accordance with the Final RI Work Plan included precision, accuracy, representativeness, comparability, and completeness.

- Precision - is a measure of the reproducibility of an analysis under a given set of conditions. Precision was evaluated through a review of field duplicate and laboratory duplicate samples. As discussed in the validation reports in **Appendix M**, none of the data were qualified as estimated or rejected due to issues with precision.

- Accuracy – is a measure of the bias that exists in a measurement system. Accuracy was evaluated through a review of system calibration, laboratory control samples, matrix spike samples, rinsate blanks, method blanks, and serial dilutions. As discussed in the validation reports in **Appendix M**, some of the data were qualified as estimated, "J", due to out of control matrix spike, matrix spike duplicate, or post-digestion spike recoveries and/or out of control differences for serial dilution samples. In addition, perchlorate was qualified as non-detect "U" in several samples since perchlorate was found in the method blank. None of the data were qualified as rejected due to accuracy issues.

- Representativeness – is a qualitative measure that expresses the degree to which data accurately and precisely reflects a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness was evaluated through a review of field observations, in addition to sampling and analysis procedures that were employed compared to the proposed sampling plan. Either a statistical-based sampling plan developed using VSP and/or a biased sampling approach were was proposed for use in the April 2012 Addendum to the UFP-QAPP based on field conditions. In accordance with the UFP-QAPP, only discrete biased sampling was employed due to the definitive identification of potential MC source in form of MEC (i.e., buried DMM) which warranted biased sampling, and due to safety concerns within the excavation which precluded

personnel from entering the trench. The planned field and analytical procedures were adhered to in light of the discrete sampling method used. Samples were considered representative of site conditions and potential MC impacts from the observed MEC source because they were collected from soil in direct contact with buried DMM, and soil that may have been impacted (stained soil, and soil with faint odors), as discussed above, and in accordance with the Final RI Work Plan (WESTON, 2012).

- Comparability – is a measure of the degree of confidence with which two data sets can be compared to each other. Comparability was evaluated through an assessment of whether appropriate and acceptable sampling and analytical methods were used compared to historical studies and on-going IRP activities (WESTON, 2012). As established in the Final RI Work Plan, discrete biased sample collection similar to that performed is the stipulated procedure for sample collection in the *Final Picatinny Arsenal Facility-Wide Field Sampling Plan,* September 1998 and the *Final Facility-Wide Field Sampling Plan, US Army Garrison, Picatinny Arsenal, NJ*, May 2007 based on NJDEP requirements. Additionally, an IRP investigation was performed concurrent with RI activities in the MRS. Co-located discrete samples were collected by both WESTON and the IRP contractor at the same time and analyzed using the same methods, thus the data can be reliably compared.

- Completeness – is a measure of the amount of valid data obtained. Completeness was evaluated through an assessment of how many data results were qualified as rejected as a result of the data validation process and how many valid samples were collected in relation to the number of samples needed to meet the intended use of the data. None of the results were qualified as rejected; therefore, the percentage of data rejected is insignificant.

As shown on the validation reports, overall the data are of acceptable quality, subject to the data validator's qualifying marks and all analytical data obtained were considered useable. All data qualified as estimated "J" were treated the same as data without such qualifiers since the small degree of uncertainty for the estimated quantities had no substantial impact on data interpretation. All data are considered usable from the field perspective. Because sample collection activities met the requirements outlined in the Final RI Work Plan (WESTON, 2012), and the data collected satisfied the requirements of precision, accuracy, representativeness, comparability, and completeness, the data effectively satisfy the DQOs outlined in the Final RI Work Plan.

9.2.1.2 Selection of Chemicals of Potential Concern

Based on the data evaluation and screening level assessment, a further determination was made (refer to the following section) whether screening level exceedances warranted selection as COPCs and quantitative risk assessment to establish baseline risks. In accordance with EPA's

Risk Assessment Guidance for Superfund (RAGS): Volume I Human Health Evaluation Manual Part A, (RAGS Part A) (EPA, 1989), if no COPCs are identified, then the risk assessment process ends.

The detection of zinc in sample PTA-2012-IMWP-002 of 190 mg/kg exceeds the PTA background value of 77 mg/kg, but is below the project screening level of 23,000 mg/kg. It should be noted that sample PTA-2012-IMWP-002 was collected from soil approximately 10 to 11 bgs and directly below DMM and a drum observed in the field to be leaking liquid contents; therefore, this biased sample was considered the "worst-case" assessment sample. In accordance with the Final RI Work Plan (see UFP-QAPP Worksheet #10), zinc was not considered for COPC selection based on its background exceedance as the result was significantly below the project screening level.

Aluminum was detected in all four samples at a concentration of 11,000 mg/kg exceeded the project screening level of 7,700 mg/kg, but is below the PTA background value of 20,500 mg/kg. The detection of cadmium in sample PTA-2012-IMWP-002 at a concentration of 29 mg/kg exceeds the project screening level of 7 mg/kg, and PTA-specific background value of 0.7 mg/kg. Therefore, aluminum and cadmium were considered for COPC selection and are further evaluated below.

Sample PTA-2012-IMWP-004 collected from soil below the observed debris and above bedrock at the bottom of the trench, contained 2,4-DNT reported by the laboratory at a concentration of 8.3 mg/kg, which exceeds the project screening level for human health of 01.6 mg/kg. Therefore, 2,4-DNT was further evaluated for selection as a COPC as reported below.

9.2.1.2.1 Aluminum

Aluminum was detected in all four samples at a concentration of 11,000 mg/kg, which exceeded the project screening level of 7,700 mg/kg, but is below the PTA background value of 20,500 mg/kg. In accordance with the Final RI Work Plan (WESTON, 2012), the screening level for aluminum was initially selected to assess a target HQ of 0.1 to account for potential additive effects on noncarcinogens affecting the same endpoint. The target organs for aluminum exposure include the nervous system, lungs and bone (ATSDR, 2008). Although several noncarcinogens were detected by the laboratory, the concentrations were primarily below the conservative

screening levels and available PTA-specific background values, and thus indicate that the screening level reduction is likely over conservative. Therefore, the screening level can be adjusted upwards to assess a target HQ of 1.0, equivalent to the published value of 77,000 mg/kg for aluminum. In this case, the detections of 11,000 mg/kg observed in all samples meets the human health screening level. Given the published background value for PTA and alternative screening level employed during the RI, aluminum was not selected as a COPC for further quantitative assessment

9.2.1.2.2 Cadmium

Cadmium was positively detected at an estimated concentration of 29 mg/kg in the "worst-case" biased sample that was collected from the Inactive Munitions Waste Pit MRS from soil associated with buried, potentially leaking, DMM. As a noncarcinogen, the screening level for cadmium was initially selected to assess a target HQ of 0.1 to account for potential additive effects on noncarcinogens affecting the same endpoint. The primary target organ for cadmium exposure are the kidneys (ATSDR, 2012b). As noted in Section 9.2.1.2.1, the screening level reduction is likely over conservative. Therefore, the screening level can be adjusted upwards to assess a target HQ of 1.0, equivalent to the published value of 70 mg/kg for cadmium. In this case, the detection of 29 mg/kg observed in sample PTA-2012-IMWP-002 meets the human health screening level and cadmium was not selected as a COPC for further quantitative assessment.

9.2.1.2.3 2,4-Dinitrotoluene

Field screening conducted during sampling indicated that sample PTA-2012-IMWP-004 was associated with elevated readings on the PID and faint odors but neither of these field observations would be expected to be associated with 2,4-DNT. Available toxicology information for 2,4-DNT indicates that it is has low volatility (ATSDR, 1998). The compound 2,4-DNT was not detected by the laboratory in any of the remaining samples, including sample PTA-2012-IMWP-002, which based on field observations, represents the "worst-case" included in the biased characterization sampling effort as it was collected from soil directly below a leaking drum and DMM.

The IRP contractor performing the trench investigation collected samples in the same locations that RI samples were collected, and also analyzed for MC in addition to volatile contaminants to

address IRP concerns. Review of the IRP data indicates that none of the collocated samples had detectable concentrations of MC above the selected screening levels, although elevated levels of several volatile compounds were present (Shaw, 2013).

The toxicological profile for 2,4-DNT also indicates that its water solubility is high, and that if leached to groundwater without elements such as light, oxygen and/or biota acting on the system to stimulate breakdown or subsequent uptake, 2,4-DNT would be expected to persist in the environment (ATSDR, 1998). As such persistence could be applicable to the Inactive Munitions Waste Pit MRS because of the depth of discovery above bedrock, further evaluation of the potential for groundwater impacts was performed.

The potential for MC to have leached over time and affect human health receptors for the aquifer downgradient of the MRS was evaluated by the collection of IRP data to assess groundwater in the 600 Area, located south (hydraulically downgradient) of the Inactive Munitions Waste Pit MRS. Based on the data, last collected in 2008, the only explosive detected was cyclotrimethylenetrinitramine (RDX) in one well (Shaw, 2009). The source for which is being addressed under the IRP (currently proposed for No Further Action (NFA)) and is not believed to be associated with the Inactive Munitions Waste Pit MRS. The laboratory did not detect 2,4-DNT in any samples (Shaw, 2009).

Based on the lack of detections of 2,4-DNT in the biased soil samples collected adjacent to observed DMM the non-detect 2,4-DNT result observed in the co-located IRP sample, the extremely low potential for exposure resulting from sample depth and the lack of evidence indicative of a release to groundwater, the one estimated sample exceedance for 2,4-DNT relative to human health screening criteria that was observed in native soil was not determined significant to warrant selection of a COPC for further quantitative assessment.

9.2.1.3 Uncertainty Analysis

The quality and robustness of sample data can be key factors in risk uncertainties. If exposure areas are not well characterized (i.e., samples are not collected randomly or insufficient samples are taken), or if data are not validated according to EPA guidelines, the resulting risks may be questionable or uncertain.

The Inactive Munitions Waste Pit MRS has been delineated to extend laterally over 0.24 acres,

and assuming an even distribution of buried debris containing DMM is present to bedrock (~24.5 ft bgs), the maximum volume of waste estimated to be present is 257,201 cubic feet (9,526 cubic yards) based on the results of the RI. Sample collection was biased towards assessment of soil observed in direct contact with buried debris; therefore, these samples represented a "worst case scenario" to confirm the presence of potential contamination. Biased sampling of this nature is conservative and tends to overestimate risk. Four, discrete samples were collected for this purpose (one was a field duplicate). Neither the number nor location of samples collected were determined to be large sources of uncertainty in this risk assessment, given the biased nature of the field investigation; however, increasing the number and spatial coverage of the sampling program would provide further definition.

To reduce the risk of uncertainty due to analytical processing, results were validated in accordance with EPA protocol prior to incorporation into the risk assessment. Potential biases within the data results were identified and considered during the screening exercise; therefore, data quality is not likely to contribute to uncertainty for this risk assessment.

The last potential source of uncertainty associated with this analysis is the non-selection of 2,4-DNT as a COPC in light of its screening level exceedance. However, as noted above, 2,4-DNT was not detected in any other soil samples collected, including co-located samples collected under the IRP by separate contractor. The depth of the sample which yielded the elevated detection was approximately 24 ft bgs, directly above bedrock. Based on the depth of detection and potential for groundwater transport, a further review of available IRP reports was conducted to assess downgradient groundwater quality. No detections of 2,4-DNT have been identified in groundwater sampling conducted under the IRP indicative of a potential source from the Inactive Munitions Waste Pit MRS. Therefore, the uncertainty associated with nonselection of 2,4-DNT as a COPC is considered low.

9.2.2 Ecological Risk Assessment

An Ecological Risk Assessment was not performed or warranted based on the data collected as the bulk of buried debris was observed, and biased soil samples collected, from depths between 10 and 24 feet bgs, and typical ecological exposure occurs within the top 2 feet of soil bgs.

9.2.3 Risk Assessment Summary and Conclusions

The risk assessment evaluated the potential for adverse human health effects from exposure to explosives and metals detected in subsurface soil (greater than 10 feet bgs) at the Inactive Munitions Waste Pit MRS. Current EPA risk assessment guidance and screening levels were used, in addition to State soil standards and PTA-specific background concentrations (for metal analytes in soil).

9.2.3.1 Summary of Human Health Evaluation

Evaluation of the available analytical data collected during the RI and co-located IRP investigation, in addition to field notes and observations made during intrusive investigation of the Inactive Munitions Waste Pit MRS, indicate that risks to human health are not present from MC associated with the buried debris. No metals were selected as COPCs given that the two analytes observed in excess of initially selected screening levels were found to be below PTA-specific background values, and/or below alternative screening levels (adjusted upwards to assess a target HQ of 1.0). All explosives compounds analyzed in the biased soil samples, except for one, were found to be below project screening levels. The one exceedance was an estimated detection of 2,4-DNT in soil collected from 24 feet bgs at the very bottom of the test trench and below the observed debris. As 2,4-DNT was not detected in the co-located IRP sample, or any other of the biased samples collected from soil in contact with buried debris, and has negligible potential for exposure due to depth and no confirmed groundwater impacts, it was not selected as a COPC and no risks were identified.

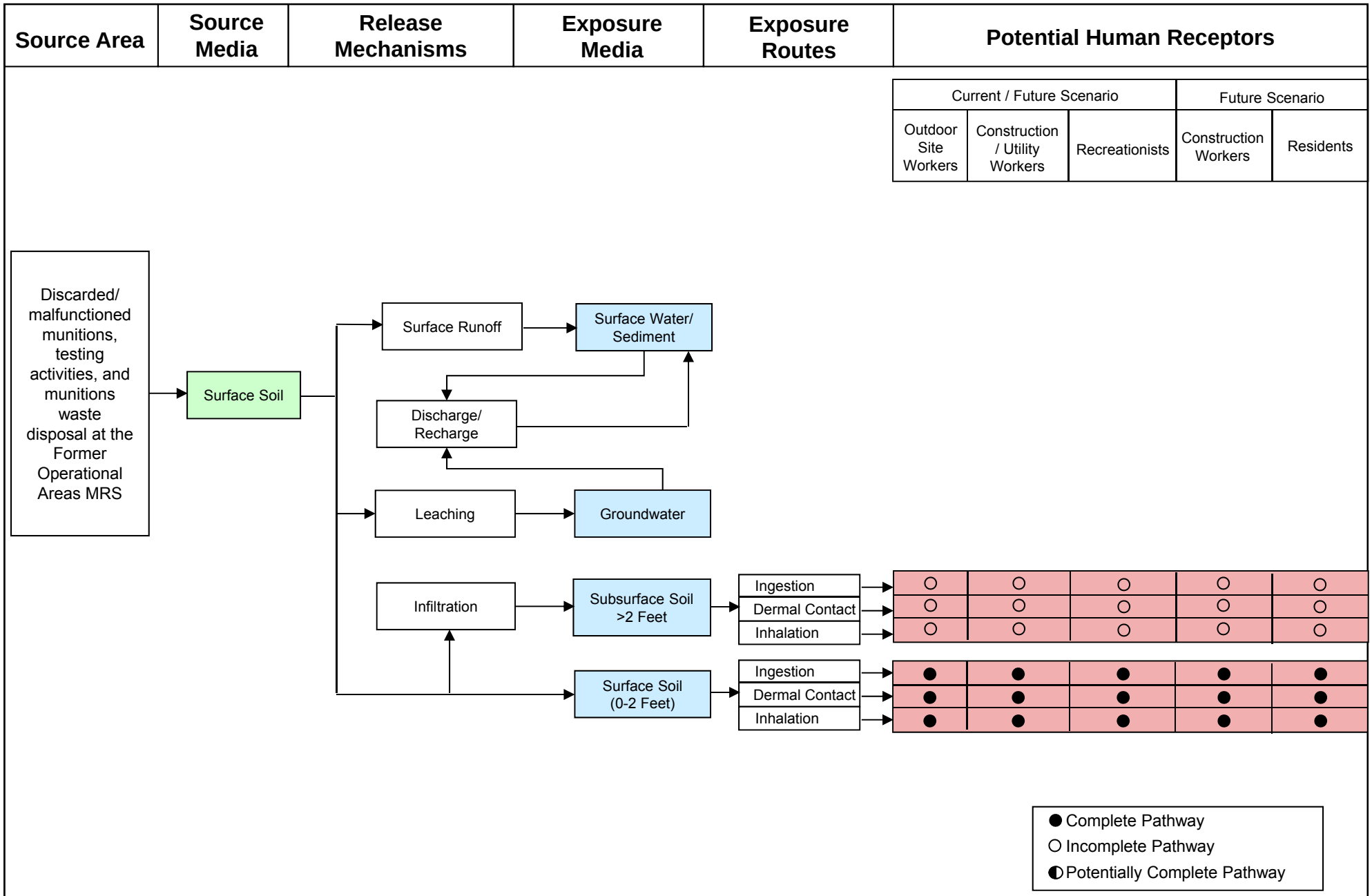


Figure 9-1
Human Health Conceptual Site Model – Former Operational Areas MRS
Remedial Investigation Picatinny Arsenal
Morris County, New Jersey

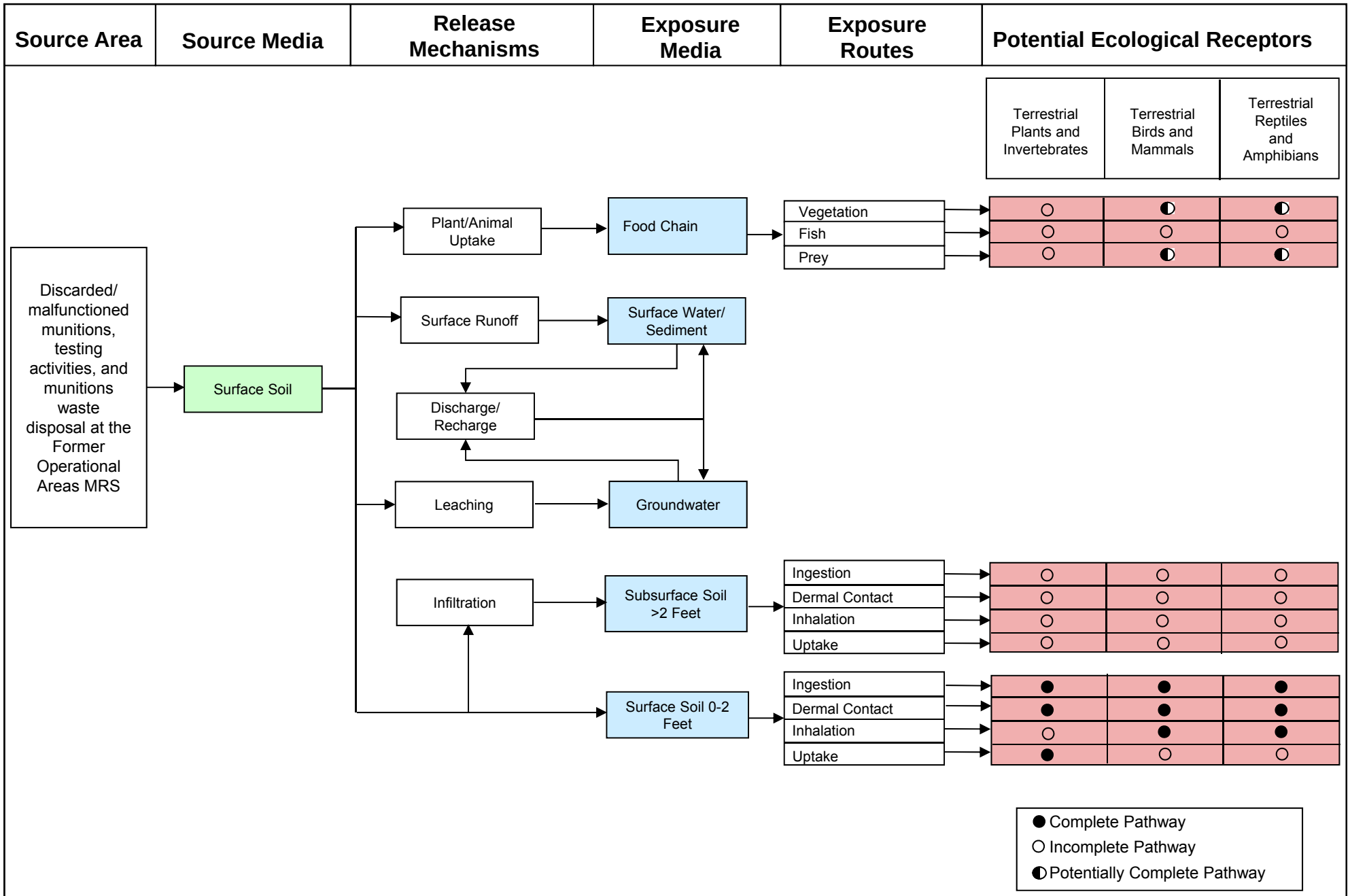
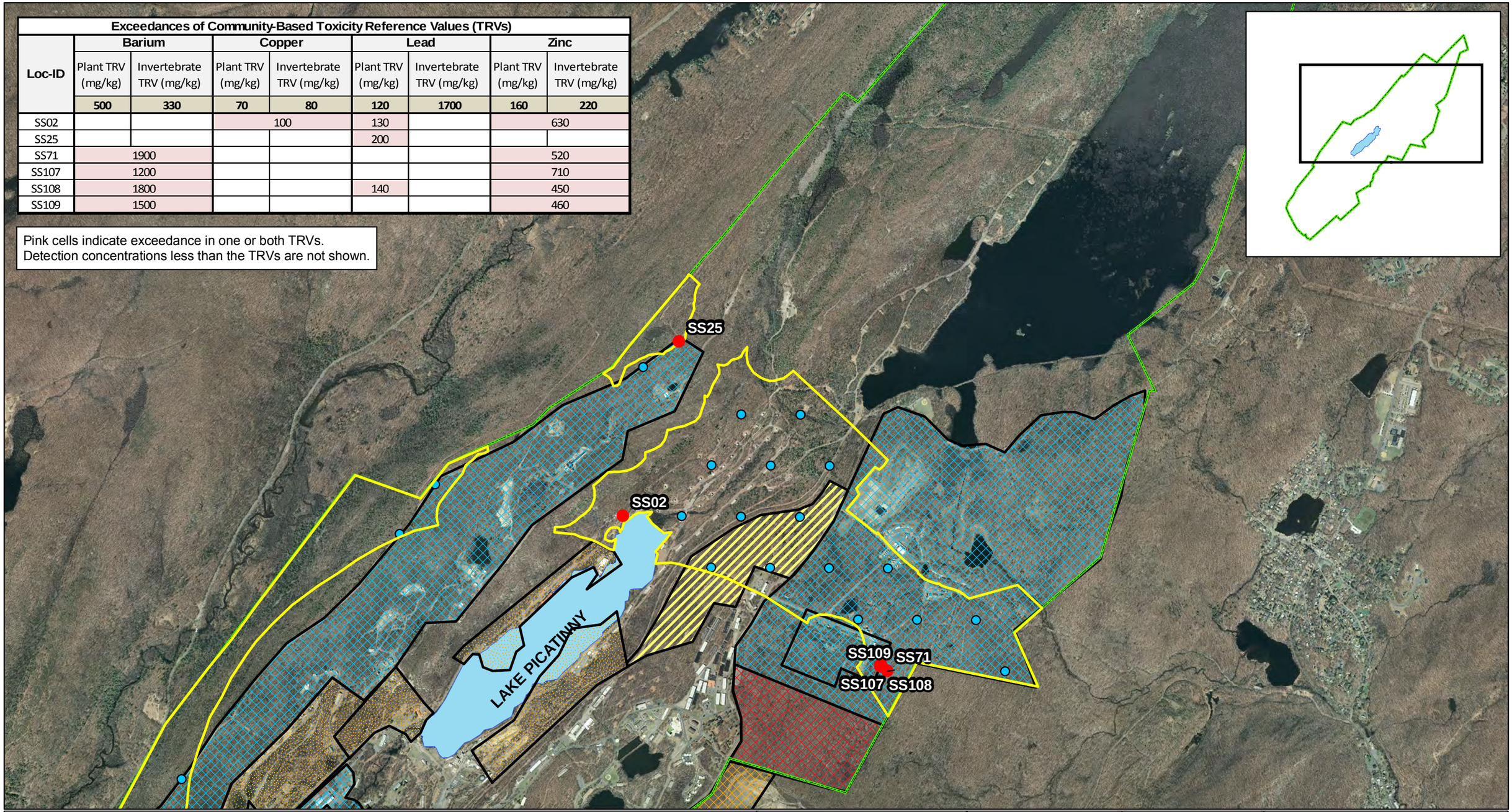


Figure 9-2
Ecological Conceptual Site Model – Former Operational Areas MRS
Remedial Investigation Picatinny Arsenal
Morris County, New Jersey

Exceedances of Community-Based Toxicity Reference Values (TRVs)

Loc-ID	Barium		Copper		Lead		Zinc	
	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)
	500	**330**	**70**	**80**	**120**	**1700**	**160**	**220**
SS02			100		130		630	
SS25					200			
SS71	1900						520	
SS107	1200						710	
SS108	1800				140		450	
SS109	1500						460	

Pink cells indicate exceedance in one or both TRVs.
Detection concentrations less than the TRVs are not shown.



Legend

- Plant/Invertebrate TRV Exceedance
- Former Operational Areas
- Installation Boundary
- Sample Location

1973 Code Area Installation Survey

- Code 100 - Training
- Code 200 - Industrial
- Code 300 - Technical
- Code 900 - Easement
- Unknown

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 1,000 2,000 Feet

0 250 500 750 Meters

Created By: CEP

Verified By: XXX

Approved By: XXX

Figure 9-3
Plant and Invertebrate Toxicity-Based Reference Values
Former Operational Area North

7/1/2013

Contract # W912DR-09-D-0006
DO 0002

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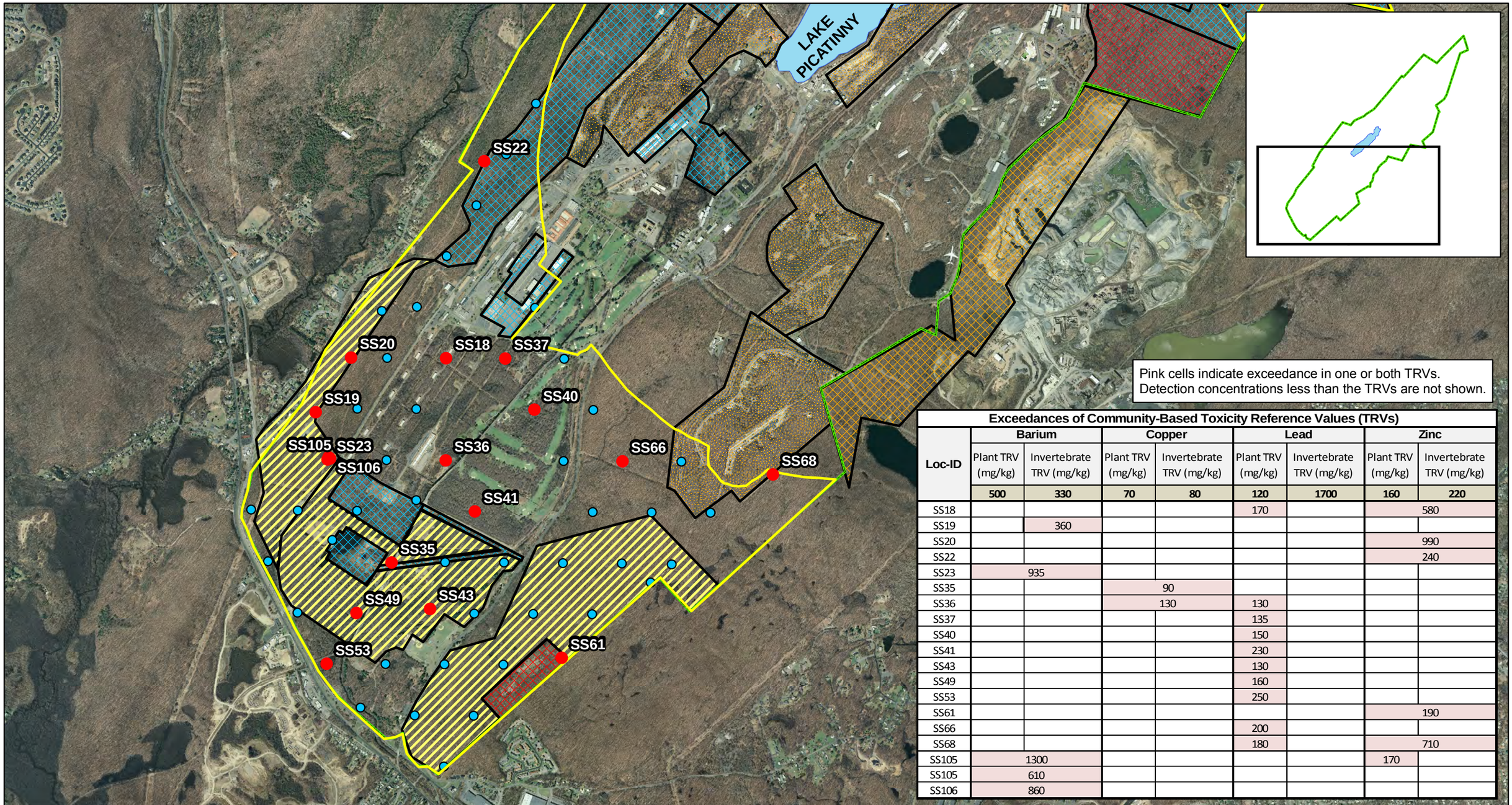

Pink cells indicate exceedance in one or both TRVs.
Detection concentrations less than the TRVs are not shown.

Exceedances of Community-Based Toxicity Reference Values (TRVs)

Loc-ID	Barium		Copper		Lead		Zinc	
	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)	Plant TRV (mg/kg)	Invertebrate TRV (mg/kg)
	500	330	70	80	120	1700	160	220
SS18					170		580	
SS19		360						
SS20							990	
SS22							240	
SS23	935							
SS35			90					
SS36			130		130			
SS37					135			
SS40					150			
SS41					230			
SS43					130			
SS49					160			
SS53					250			
SS61							190	
SS66					200			
SS68					180		710	
SS105	1300						170	
SS105	610							
SS106	860							

Legend

- Plant/Invertebrate TRV Exceedance
- Former Operational Areas
- Installation Boundary
- Sample Location

1973 Code Area Installation Survey

- Code 100 - Training
- Code 200 - Industrial
- Code 300 - Technical
- Code 900 - Easement
- Unknown

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: New Jersey State Plane
Datum: NAD83. Units: Feet

N

0 1,000 2,000 Feet

0 250 500 750 Meters

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 9-4
Plant and Invertebrate Toxicity-Based Reference Values
Former Operational Area South

Created By: CEP

Verified By: XXX

Approved By: XXX

7/1/2013

Contract # W912DR-09-D-0006
DO 0002

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10. PRELIMINARY IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section presents a discussion of the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs) and other "to be considered" (TBC) information regarding potential response actions, based solely at this point on results of the RI. .

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

A preliminary list of ARARs and other TBC information is developed as part of the RI to identify requirements applicable or relevant and appropriate to the release or remedial action contemplated and to support the CERCLA process going forward. The ARARs and TBCs are used as a "starting point" in determining the protectiveness of a remedy during design and analysis in an FS.

Pursuant to Section 300.400(g) of the NCP, a list of ARARs and other TBC information is developed to identify requirements applicable to the release or remedial action contemplated based upon an objective determination of whether the requirement specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at an MRS. CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP require that the development and evaluation of remedial alternatives must attain ARARs and ensure protection of public health and the environment as the minimum threshold criteria that must be met during selection of a future response action.

ARARs are defined as follows:

- Applicable requirements—Those cleanup standards, standards of control, and other substantive environmental protection requirements promulgated under federal or state environmental law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements—Those cleanup standards, standards of control, and other substantive environmental protection requirements promulgated under federal or state environmental law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site.

It is first determined whether an ARAR is applicable for the CERCLA site. If it is not applicable,

then it is determined whether the ARAR is relevant and appropriate. The procedure for determining whether a requirement is relevant and appropriate is a two-step process. First, to determine relevance, it is evaluated whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the CERCLA site. In some cases, only a portion of a requirement would be both relevant and appropriate. When a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR.

"Applicable requirements" and "relevant and appropriate requirements" are considered to have the same weight under CERCLA. Section 121(d) of CERCLA, as amended by SARA, requires the attainment of federal ARARs and of state ARARs, if the state environmental or facility siting laws are promulgated, are more stringent than federal laws, and are identified by the state in a timely manner.

CERCLA and the NCP also identify a TBC category, which includes non-promulgated (not enforceable) federal and state criteria, strategies, advisories, and guidance documents, which is also considered. The TBCs do not have the same status as ARARs; but, if no ARAR exists for a substance or particular situation, TBCs may be used to ensure that a remedy is protective.

As the RI/FS process continues, the list of ARARs is further defined, particularly as guidance is issued by state and federal agencies and with respect to data collected during the RI (e.g., protection of endangered species may be not applicable if RI findings indicate no endangered species are present). The ARARs are used to establish the appropriate extent of cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies and remedial alternatives; and to govern the implementation and operation of the selected remedial alternative. The results of the preliminary identification of potential ARARs and TBCs for the MRSs at PTA are summarized in **Table 10-1**.

Table 10-1 Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Information

Standard, Requirement, Criteria, or Limitation	Citation Potentially Germane to Remedial Actions at Picatinny	Description of Requirement	Comment
Action-specific			
New Jersey Stormwater Management and Erosion Control	N.J.A.C. 7:8-1.6 Per N.J.S.A. 13:9A-1 et seq., and N.J.S.A. 58:16A-50 et seq., Erosion and Sediment Control Act Chapter 251, P. L. 1975 Federal regulations as per 33 USC 1251-1387 Chapter 26 (CWA, Section 402): See NPDES below	Establishes requirements governing "major development" (over 1 acre of disturbance). Establishes water quality standards, including classifications of waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into State waters. Specific requirements in N.J.A.C. 7:8 for areas adjacent to waterways designated Category 1 or their upstream tributaries, including observing a 300 ft Category 1 buffer (Special Water Resource Protection Area) and not allowing discharging stormwater outside of special protection area. Act Requires the implementation of soil and erosion and sediment control measures for activities disturbing over 5,000 square feet of surface area of land.	*Applicable* because addresses contaminants that may become mobile as a results of remedial action. To any future response actions involving over 1 acre of excavation, grading, or other soil disturbance activities for example, when removing MEC. Potentially applies to Lakes MRS, 1926 Explosion Radius MRS, and Former Operational Areas MRS since these sites may require response actions that will involve land disturbance. More stringent than federal requirements since it has requirements for erosion and sedimentation control expanded coverage beyond the federal requirements.
New Jersey Water Pollution Control Act - New Jersey Pollutant Discharge Elimination System and National Pollutant Discharge Elimination System (NPDES)	NJAC 7:14A and 40 CFR Part 122.26	Discharge of pollutants to surface water and groundwater from remediation sites is regulated via NJPDES requirements. NJPDES requirements include obtaining a discharge to surface water or groundwater permit equivalent and meeting substantive requirements of the permit. Requirements include effluent limitations, water quality based limitations, monitoring, and monitoring techniques. NJ administers the federal program.	*Relevant and Appropriate* because soil disturbance activities can result in point discharge, which is regulated, but this would need to meet the substantive requirements of the permit program for stormwater discharge.
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.

Table 10-1 Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Information (Continued)

Standard, Requirement, Criteria, or Limitation	Citation Potentially Germane to Remedial Actions at Picatinny	Description of Requirement	Comment
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	Solid/Hazardous Waste Regulations: 40 CFR, Subparts A, B, C, and D and 40 CFR 263, Subparts A, B, and C Directive #9330.2-07,49 NJAC 7:26G NJDEP - Division of Waste Management: NJAC 7:26G	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements. NJ incorporates 40 CFR and lists additional requirements related to violations and penalties. Hazardous waste must be labeled properly, a manifest generated, and vehicles shipping hazardous must be properly registered to handle and transport the waste to a regulated facility. In addition, waste must be properly packed and accompanied with proper emergency response spill procedures and manifests.	Applicable in the event that hazardous waste is generated and/or shipped off-site as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Location-Specific			
Freshwater Wetlands Protection	Clean Water Act Section 402, 40 CFR 320.4 and NJ Freshwater Wetlands Protection Act: N.J.A.C. 7:7A-1.1, -1.4, -2.2, -2.5, -2.6, -12.2 N.J.A.C. 7:7A-4.3 per N.J.S.A. 13-9B-13 N.J.S.A. 13:9B-17 NJDEP has assumed responsibility for the Federal 404 program in most NJ freshwater wetlands.	Establishes requirements that need to be considered when performing activities in and adjacent to wetlands; regulates alteration or disturbance in and around freshwater wetland areas. NJ assumed responsibility for administering the Federal wetlands program in 1994. Action must be taken to the extent possible to avoid degradation or destruction of wetlands. Discharges for which there are practicable alternatives with less adverse impacts or those that would cause or contribute to significant degradation are prohibited. If adverse impacts are unavoidable, then action must be taken to enhance, restore, or create alternative/replacement wetlands.	*Relevant and Appropriate* To any future response actions including removal, excavation, or disturbance of soil, or destruction of plant life within wetlands and transition areas (150 ft of a freshwater wetland of exceptional resource value, and, or within 50 ft of a freshwater wetland of intermediate resource value). Potentially applies to Lakes MRS, 1926 Explosion Radius MRS, and Former Operational Areas MRS.

Table 10-1 Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Information (Continued)

Standard, Requirement, Criteria, or Limitation	Citation Potentially Germane to Remedial Actions at Picatinny	Description of Requirement	Comment
Flood Hazard Area Control	40 CFR 320.4 N.J.A.C. 7:13-1.1, -9.2,- 9.5, -10.2, -10.3 -11.2, and -11.3 per N.J.S.A. 58:16A-50 et seq.,	NJ requirements are more stringent than federal since there are added requirements for riparian zones. NJ establishes requirements governing human disturbance to the land and vegetation in flood hazard areas of regulated water (defined in N.J.A.C. 7:13-3) and riparian zones of a regulated water (defined in N.J.A.C. 7:13-4); individual permit required for disturbance within the riparian areas, for which the substantive portions must be met defined in N.J.A.C. 7:13-9.2 and 9.5, 10.2 and 10.3 and 11.2 and 11.3. Requirements could include (to be determined by NJ) limiting areas of vegetation removal, not impeding stormwater flows, stabilization for slopes greater than 50%, and providing information normally required in a permit application including but not limited to project maps, details of planned activities, details of erosion and sedimentation controls, methods of construction, areas where vegetation will be cleared, and schedule.	*Relevant and Appropriate* To any future response involving disturbance and/or impacts within flood hazard or 300 ft Riparian Zone. Potentially applies 1926 Explosion Radius MRS, and Former Operational Areas MRS since there are flood hazard areas associated with portions of these sites wherein Green Pond Brook passes through the sites.
Chemical-Specific			
New Jersey non-residential direct contact soil remediation standards	N.J.A.C 7:26D-4.2 and 7:26D-4.3 per N.J.S.A. 58:10B-12	Establishes minimum standards for remediation of surface water and minimum residential and non-residential direct contact soil remediation standards. These are promulgated standards and there are no federal promulgated soil standards. ARAR only applies for MRS determined to have an unacceptable level of risk.	*Relevant and Appropriate* For any future MC assessment related to MEC response actions for soil media.

Table 10-1 Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Information (Continued)

Standard, Requirement, Criteria, or Limitation	Citation Potentially Germane to Remedial Actions at Picatinny	Description of Requirement	Comment
Toxicity Reference Values from published literature	Human health and ecological screening number references; See next column.	Values representing the threshold above which effects are expected and below which either no effect or a low effect is expected. Human Health: EPA Regional Screening Levels (RSL) for Resident Soil (EPA, 2012a Ecological: -EPA Ecological Soil Screening Levels (Eco-SSLs) (accessed online at: http://www.epa.gov/ecotox/ecossl/), -Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants (Efroymson et al., 1997a) -Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson et al., 1997b). -ESLs from the Los Alamos National Laboratory (LANL) ECORISK Database Release 3.0 (October 2011) (LANL, 2011). -EPA Region 5 ESLs (accessed online at: http://www.epa.gov/reg5rcra/ca/edgl.htm), ESLs from the LANL ECORISK Database Release 3.0 (LANL, 2011).	*To be considered* For any future MC assessment related to MEC response actions.

Notes:
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR = Code of Federal Regulations
CWA = Clean Water Act
MRS = Munitions Response Site
UFP-QAPP = Unified Federal Policy-Quality Assurance Project Plan

Generally, ARARs pertain to either contaminant levels or to performance or design standards to ensure protection at all points of potential exposure. ARARs are divided into three general categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs. Throughout the RI/FS phase, ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the MRS.
- Chemical analysis performed or scheduled to be performed.
- Types of media (air, soil, groundwater, surface water, and sediment).

- Geology and other MRS characteristics.
- Use of MRS resources and media.
- Potential contaminant transport mechanisms.
- Purpose and application of potential ARARs and TBCs.
- Remedial alternatives considered for MRS cleanup.

Action-specific ARARs are usually technology or activity-based requirements or limitations placed on actions taken with respect to cleanup actions, or requirements to conduct certain actions to address particular circumstances at an MRS. The preliminary ARARs are summarized in **Table 10-1**. Based on the findings of the RI, it is anticipated that the remedial alternatives will not include on-site storage (greater than 90 days), or on-site disposal of hazardous waste since mechanisms already exist to handle MEC waste at PTA; therefore, certain potential ARARs related to these activities were not considered applicable at this time.

Location-specific ARARs are generally restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. Location-specific ARARs are summarized on **Table 10-1**. Most of the state regulations pertaining to permitting/waivers for which substantive requirements may be applicable and achieved for disturbances in floodplains, wetlands, and stormwater management have been categorized as potentially appropriate and relevant following the RI. Applicability will be considered during the FS based on MRS-specific characteristics and remedial alternative designs, and based on coordination with NJDEP. Flood hazard areas at Picatinny are associated with Green Pond Brook. Federal Emergency Management Agency (FEMA) mapping has not been prepared for a large portion of PTA, thus it is difficult to determine exact 100-year floodplain areas. FEMA mapping does cover a small portion of PTA and shows an area of undetermined, but possible flood hazards. However, there is one floodplain located within PTA near several MRSs. The Green Pond Brook floodplain is located at the southern end of PTA. (LBG and VanDeVenter, 2004).

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs identified on **Table 10-1** are used to provide benchmarks with which to compare environmental sampling results for metals

and explosives. Currently, NJ Department of Environmental Protection Residential and Non-residential Direct Contact Soil Remediation Standard (SRS) (NJDEP, 2012) have been identified as chemical-specific TBC criteria for MC in soil at PTA. Additionally, should a future MEC response be implemented that requires monitoring to ensure surface water bodies present at PTA are not adversely affected, the New Jersey Surface Water Quality Standards have been identified as an ARAR to establish criteria for MC parameter monitoring. Published toxicity reference values and risk screening levels are TBC for any further MC assessment conducted related to MEC. See Section 9 of the RI Report for details on human health screening levels and ecological benchmarks selected to support risk assessment at the time of the RI. No chemical-specific ARARs have been identified pertaining to MC in groundwater for the MMRP RI/FS because groundwater present at PTA is being addressed under the IRP program for all pollutants, including MC.

The ARARs will be further refined during future phases of work at PTA for each MRS as needed.

11. SUMMARY AND CONCLUSIONS

This section summarizes the significant results obtained and the conclusions reached as a result of the RI activities conducted at PTA. Only the most significant findings are presented in this section and are reproduced directly or abstracted from information contained in this report. The overall goal of the RI was to determine the nature and extent of MEC and MC and subsequently to determine the potential hazards and risks posed to human health and the environment by MEC and MC for each MRS. The RI also provides additional data to assist in determining if a FS are necessary for each MRS. As a result of the characterization activities conducted at PTA, the objectives of the RI have been met.

11.1 1926 EXPLOSION RADIUS MRA

This section summarizes the results of the RI activities conducted at the 1926 Explosion Radius MRA located at PTA. This MRA is composed of the 1926 Explosion Radius MRS (PICA-003-R-01) and the newly discovered Fuze Area MRS. The RI objective was to determine the density and depth of MEC within the inner and out radii and to determine whether a MEC release was present within the AOI Code 300 area.

The 1926 explosion radius consists of two separate MRSs, the 1926 Explosion Radius MRS (PICA-003-R-01) and 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01). Because the primary release mechanism was assumed to be the same for the two MRSs, they were investigated as one site and are discussed as one in the following section.

It should be noted that during the RI the Former Green Pond MRS and the AOI Former DRMO Yard, which are wholly located within the 1926 Explosion Radius MRS, had a different sampling approach and were investigated separately from the 1926 Explosion Radius MRS. The separation of the Former Green Pond MRS from the 1926 Explosion Radius MRS was made during the SI. However, during the RI, a release mechanism different from the release mechanism for the 1926 Explosion Radius was not discovered for these two areas. Therefore, the Former Green Pond MRS and the AOI Former DRMO Yard have been incorporated into the 1926 Explosion Radius MRS.

11.1.1 Summary of RI Activities

The preliminary CSM for the 1926 Explosion Radius MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4 of the RI Report. In general, the data needs and DQOs focused on detecting and assessing the MEC identified within the decision units of the MRS and determining the source. UXO Estimator was used to determine the area requiring investigation within the two decision units in the combined 1926 Explosion Radius MRS and the 1926 Explosion Radius – Off-Post MRS.

Sampling for MC was not conducted in the 1926 Explosion Radius MRS during the SI or RI because MEC items with soil staining, or visible evidence of a potential MC release were not found in the MRS.

11.1.1.1 AOI Code 300 Area

In the AOI Code 300 Area, the output from VSP's geostatistical mapping of anomaly density tool indicated the presence of six high anomaly density areas within the 1926 Explosion Radius MRS. A total of eleven grids were investigated within these six high anomaly density areas to determine whether they were potential target areas. Two additional areas, one within the Former Operational Areas MRS and one within the Inactive Munitions Waste Pit MRS, were added to the list of analog grids to be investigated to ensure that a potential target area was not missed as a result of an edge effect in the VSP analysis.

The analog grid surveys within the AOI Code 300 Area were conducted between September 24 and 27, 2012, and 669 anomalies were identified and investigated within the 13 grids. Refer to **Figure 5-5** for the locations of the grids for the entire AOI Code 300 Area (i.e., within the 1926 Explosion Radius MRS, Inactive Munitions Waste Pit MRS, and the Former Operational Areas MRS).

In the 1926 Explosion Radius MRS, 541 anomalies were selected for intrusive investigation within the AOI Code 300 Area and no MEC or MPPEH was found. Eighteen of the targets were cultural debris such as barbed wire and metal scrap, while four targets, from four different grids, were MD, consisting of three fragments, and a 105mm Projectile empty shell. Due to no MEC or MPPEH being identified, an impact area was not identified during the RI in this portion of the AOI Code 300 Area. Note that no MEC or MPPEH were identified outside the 1926 Explosion

Radius MRS portion of the AOI Code 300 Area either; one MD (a M42 empty body) was identified in the Inactive Munitions Waste Pit MRS. Therefore no impact areas have been identified in any portions of the AOI Code 300 Area.

11.1.1.2 Former Green Pond MRS and AOI Former DRMO Yard

Using an EM31-MK2, 2,703 linear feet of DGM transect surveys were performed along the east and west banks of Green Pond Brook. Based on a review of the DGM data, 32 targets consisting of individual anomalies and high density areas were chosen for reacquisition and intrusive investigation. Of the 32 targets selected for intrusive investigation 125 items classified as cultural debris and seven items classified as geologic "hot rocks" were identified. These items were recovered between 0 and 8 inches bgs.

Analog transects were performed using a White's MXT all-metals detector along 0.37 acres of the banks of Green Pond Brook, and 0.87 acres were 100% investigated in the southwest portion of the AOI Former DRMO Yard for a total of 1.24 acres. Analog transects were conducted wherever accessible along the inner banks of Green Pond Brook. Transects were not able to be collected along the entire inner banks or within the water of the brook, as specified in the Final Work Plan, due to safety concerns with the water depth, depth of silt/sediment along the bottom, and steepness and instability of the banks. No MEC was identified within the former Green Pond MRS but 57 MD items were recovered at depths ranging between 0 and 30 inches bgs.

A total of 430 anomalies were intrusively investigated along the analog transects within the AOI Former DRMO Yard. No MEC was initially observed, but one MPPEH (a 75mm shrapnel projectile) and one MD (a 2.36-inch Ballistic Rocket Nose Cane) were recovered at depths ranging between 0 and 3 inches bgs. After demolition, the 75mm Shrapnel Projectile was determined to be an explosive hazard and was designated as MEC in the final dig lists in **Appendix H**. The MEC item was identified at 3 inches bgs.

For the Former Green Pond MRS and AOI Former DRMO Yard, the DGM surveys and analog transects detected a total of 562 anomalies. Only one MEC items was observed, a 75mm Shrapnel Projectile, within the AOI Former DRMO Yard. A total of 58 MD were detected in the combined Former Green Pond MRS and AOI Former DRMO Yard. The remaining anomalies in the Former Green Pond MRS and AOI Former DRMO Yard, included 496 items designated as

cultural debris, and eight geologic "hot rocks". Items were recovered at depths ranging between 0 and 33 inches bgs, with the MD being identified up to 30 inches bgs. Based on a review of the investigation data it was determined that no large burial areas, posing an explosive risk, were present in the Former Green Pond MRS.

11.1.1.3 1926 Explosion Radius MRS including the AOI

Geophysical surveys and intrusive investigations were conducted in one hundred twenty-one grids randomly placed across the combined 1926 Explosion Radius MRS and 1926 Explosion Radius – Off-Post MRS, consisting of 39 DGM grids, and 82 analog grids. An additional 11 analog grids were conducted in the portion of the 1926 Explosion Radius MRS overlapping with the AOI Code 300 Area (described above), which is in the Outer Radius Decision Unit. A total of 2,664 anomalies were investigated (i.e., 1,182 anomalies within the analog grids and 1,482 anomalies within the DGM grids that were above the anomaly selection threshold, a Channel 2 response of 7.2 mV).

A total of 132 grids, covering approximately 7.6 acres, were investigated within the 1926 Explosion Radius On-Post and Off-Post MRSs during the RI.

Fourteen MEC were found in the 1926 Explosion Radius MRS during the RI; five in the Fuze Area, which is located within the Inner Radius, and nine in the Outer Radius. All items were identified within six inches bgs except for five fuzes identified within a burn pit at 12 inches bgs. The items recovered in the 1926 Explosion Radius MRS, split by decision unit are described below:

- **Fuze Area Decision Unit** - Three MK2 Base Detonating (BD) fuzes and two MK2 Point Detonating (PD) fuzes were found within grid 26IR-010. This grid was part of a larger area with a significant number of fuzes on the ground surface (shown on **Figure 6-2**). Based on field observations, it appears that the fuzes are related to the 1926 explosion and not to a later burial. The fuzes found within grid 26IR-010 are not included in the analysis of the Inner Radius Decision Unit results (refer to Section 6.2.2.2.1) because the release mechanism appears to be different than the release mechanism for the rest of the Inner Radius. These fuzes were determined to be an explosive hazard and were designated as DMM.

- **Outer Radius Decision Unit** - The nine DMM found within the Outer Radius Decision Unit included the following:

    - Munitions associated with the 1926 Explosion - included one 6-inch naval projectile (Grid 26OR-003) and one 5-inch armor-piercing round (Grid 26OR-

064). Both items were determined to be an explosive hazard and were designated as DMM.

- Munitions potentially associated with the 1926 Explosion – including the base of one BD fuze, found in Grid 26OR-022. This item was determined to be an explosive hazard and was designated as DMM.

- Munitions not associated with the 1926 Explosion:

  - Five fuze components found within a burn pit in Grid 26OR-016. The source of these fuzes is unknown. These items were determined to be an explosive hazard and were designated as DMM.
  - One 37mm projectile was found in Grid 26OR-024. In addition to this one DMM, five practice munitions were also found within this grid: one 37mm projectile; two 3-inch MK1 practice Stokes mortars; and two World War I 75mm projectiles. None of these items are associated with the 1926 explosion. It is likely that they are associated with activities that occurred on Picatinny Lake (i.e., range activities and/or operations associated with munitions manufacturing/testing that occurred in the buildings surrounding the lake). Unconfirmed reports have indicated that firing used to occur across Picatinny Lake into the hillside to the northwest of this grid. Therefore, it is possible that munitions fired into the hillside could have rolled down the hill into this grid.

In addition to the MEC found during the RI, 973 MD items totaling 1,173 pounds were found in 69 grids, consisting mainly of fragments, flash tubes and fuzes, with various other items. In addition, 62 small arms were found, consisting mainly of 7.62mm blanks, 5.56mm blanks, shotgun primers and various others. All MD was recovered between the surface and 24 inches bgs, with 98% of items recovered between the surface and 12 inches bgs.

Because the Inner Radius Fuze Area was identified during the RI, there was no original sampling design to delineate the area. During the RI, the extent of the high density Fuze Area was delineated using a GPS and is shown on **Figure 6-2**. The total area of the site was determined to be approximately 1.63 acres and, five DMM were found within Grid 26IR-010.

A data analysis was performed to determine the potential number of MEC present in the Inner Radius Fuze Area associated with the 1926 explosion. This analysis evaluates the findings from Grid 26IR-010 that was investigated during the RI. The results of this analysis are shown below and in **Table 6-5**.

- Hypothesis - 95% confidence that there are less than 173.006 MEC/acre (between 0 and 272 total MEC associated with the 1926 explosion within the Fuze Area).

Table 6-5 summarized the quantitative estimates at the 95% CL of the upper bound of residual MEC within the Fuze Area, as well as the average amount of residual MEC within the Fuze Area decision unit. It should be noted that the total amount of residual MEC can be anywhere between 0 and the upper bound of calculated MEC.

Based on the RI intrusive investigation results within the Outer and Inner Radii Decision Units, the H_0 established in the Final RI Work Plan (WESTON, 2012) must be rejected for both the Inner and Outer Radius Decision Units, for the following reasons:

- **Inner Radius** – An area in the Inner Radius with a high fuze density was split out from the Inner Radius Decision Unit as a separate decision unit. Therefore, the area for Grid 26IR-010, which is associated with the Fuze Area, was removed from the analysis. As a result, the area of investigation for the Inner Radius Decision Unit was reduced so the area required to meet the H_0 was not investigated, resulting in a statistical CL that is slightly less than 95% (94.32%).
- **Outer Radius** – H_0 was not met because MEC associated with the 1926 explosion were identified during the investigation. Given that the original MEC density used in the sampling design was an estimate (i.e., the PDT did not know what the actual MEC density was throughout the Inner And Outer Radii at the time of the sampling design), and because three DMM/MEC associated with the 1926 explosion were found in the Outer Radius Decision Unit during the RI, it is likely that the actual density of MEC associated with the 1926 explosion within the Outer Radius Decision Unit is higher than 0.5 MEC/acre.

According to EM 200-1-15, existing information may be used, together with the RI data, to meet the project DQOs without the collection of additional data. Although the previous investigation data is not statistically random (and therefore cannot be used to obtain a statistically valid, quantitative estimate of the residual MEC), it can be used as a qualitative guide to whether the residual amount of MEC is closer to zero or the upper bound.

Although UXO Estimator is designed to be used with randomly collected data, the information from the EE/CA and TCRA II for the Outer Radius Decision Unit were input into this tool and the total amount of data (including the RI data) were analyzed to determine what affect these additional data would have on the CL. While it is understood that these results cannot be used quantitatively, they can be used qualitatively to obtain additional insight regarding the likely residual UXO hazard within the Outer Radius Decision Unit. Note that only munitions from the 1926 explosion were used, and the inputs used included 49.22 acres investigated and three DMM identified.

Table 6-5 summarized the qualitative estimates at the 95% confidence level of the upper bound of residual MEC within the Outer Radius Decision Unit. It should be noted that the total amount of residual MEC can be anywhere between 0 and the upper bound of calculated MEC. For qualitative analysis of the Outer Radius Decision Unit, there is 95% confidence that there is less than 0.161 MEC/acre (between 0 and 233 total MEC associated with the 1926 explosion within the Outer Radius Decision Unit). Based on this evaluation, even with the addition of previous investigation data, it cannot be definitively stated that there are zero residual MEC from the 1926 explosion remaining in the Outer Radius Decision Unit.

For the Inner Radius Decision Unit as well as the Outer Radius Decision Unit, the information from the previous investigations were input into UXO Estimator and the total amount of data (including the RI data) was analyzed to determine what affect these additional data would have on the confidence levels. While it is understood that these results cannot be used quantitatively, they can be used qualitatively to obtain additional insight regarding the likely residual UXO hazard within the Inner Radius Decision Unit. The revised input for evaluation includes the following:

- Data from the RI and previous investigations within the Inner Radius Decision Unit were included and all MEC/MPPEH associated with the 1926 explosion were used. Therefore, the inputs used included 79 acres investigated and 107 DMM identified.

Table 6-5 summarized the qualitative estimates at the 95% confidence level of the upper bound of residual MEC within the Inner Radius Decision Unit. It should be noted that the total amount of residual MEC can be anywhere between zero and the upper bound of calculated MEC. For qualitative analysis of the Inner Radius, there is 95% confidence that there are less than 1.487 MEC/acre (between 0 and 905 total MEC associated with the 1926 explosion within the Inner Radius Decision Unit).

11.1.2 Munitions and Explosives of Concern Hazard Assessment

The 1926 Explosion Radius MRS has a Hazard Level Category of 1 and the Fuze Area MRS has a Hazard Level Category of 2. Refer to **Appendix O**.

11.1.3 Summary of Risk Assessments

No additional characterization activities were required during the RI to assess MC within the 1926 Explosion Radius MRA based on munitions-related findings. There was no evidence that a

potential MC release had occurred, therefore no samples were collected in the MRA. As a result, the project team determined that a Risk Assessment was not warranted for the 1926 Explosion Radius MRA.

11.1.4 Revised Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified, the MC exposure conclusions are provided in Section 11.1.4.6.

11.1.4.1 Source

During previous intrusive investigations within the 1926 Explosion Radius On and Off-Post MRSs, including TCRA I, II, III, and several EE/CA's, 110 MEC were identified. Intrusive operations during the RI discovered an additional fifteen MEC items and 1,031 MD items. Confirmed MEC discovered at the MRSs consists of one 75mm shrapnel projectiles, one 6-inch naval projectile, one 5-inch armor-piercing round, one 37mm projectile, three MK2 BD fuzes, two MK2 PD fuzes, the base of a PD fuze, and five fuze components.

The 1926 Explosion Radius MRA is 1,544.13 acres and covers a large portion of the south-central part of PTA, including the majority of the downtown area. The AOI Code 300 Area, which covers approximately 400 acres on the western portion of the 1926 Explosion Radius MRA, is located on mainly undeveloped land adjacent to an operational range. The AOI Former DRMO Yard was primarily used for the storage of waste materials, including materials used in manufacturing and testing explosives, pyrotechnics and munitions. The HRR also indicated that flashed and unflashed shells were reportedly located behind Building 314 in dumpsters. According to the HRR, buried UXO was discovered during the installation of a fence post in the AOI Former DRMO Yard, in 1993. Subsequent investigation activities were performed; however, the results and the locations of the activities are not known. In 2009, a TCRA was performed (under the MMRP for PICA-007-R-01 Former DRMO Yard) over a 0.5 acres area of the AOI Former DRMO Yard. In total, 192 MEC/MPPEH were disposed of by detonation and 283 MD items were removed as part of the TCRA. The TCRA MEC/MPPEH items identified within the AOI Former DRMO Yard included BLUs, 40mm, 105mm, 6-inch, and 37mm projectiles; PD fuzes, and M525 fuzes. Surface and subsurface removal activities in support of

IRP activities at the AOI Former DRMO Yard were conducted concurrently. A total of 208 MEC/MPPEH were disposed of by detonation and 14,950 lbs of MD was recovered during the TCRA (ARCADIS, 2010). The RI field activities resulted in one MEC (a 75mm Shrapnel Projectile Body) and one MD being found within the DRMO Yard. Fifty-seven MD were identified within the former Green Pond MRS.

11.1.4.2 Access

Access to Picatinny Arsenal is restricted to two entrances (Main Gate and Mount Hope Entrance) although access to the majority of the 1926 Explosion Radius MRA, including the AOI Code 300 Area and the AOI Former DRMO Yard, is not restricted once on PTA. Once within the MRS boundary, potential receptors would have access to any MEC in surface or subsurface soil.

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s). A LUC Plan, which addresses the interim actions at MRSs, is currently being prepared for PTA under a separate program.

11.1.4.3 Activity

The 1926 Explosion Radius MRA has approximately 800 buildings used for various purposes, including manufacturing, storage, testing, R&D, administration, and housing. The MRA also contains parking lots, recreational areas, and undeveloped property. Portions of the MRA contain habitat used by state and/or federal threatened and/or endangered species.

For the purposes of this RI, there are no anticipated changes in land use at the 1926 Explosion Radius MRA; however, a significant amount of development is planned for PTA in both the short and long term. Because large portions of downtown PTA are located within the 1926 Explosion Radius MRA, it is assumed that much of the proposed development, detailed below, will also occur within this area (Parsons, 2007a, 2007b).

- Over 200 existing buildings will be demolished and numerous new buildings will be constructed throughout the PTA.
- Selected roads in the downtown area will be improved and widened.
- Additional general improvements will occur (e.g., pave roads, add curbs, and improve parking lots).

The potential future use of the AOI Code 300 Area and the AOI Former DRMO Yard is not expected to change from the current use. LUCs in the form of soil and asphalt caps cover much of the AOI Former DRMO Yard, excluding the southern portion of the site, where the land is undeveloped.

11.1.4.4 Receptors

Human receptors identified for the 1926 Explosion Radius MRA include both current and anticipated future land users. Human receptors include PTA personnel, residents, contractors (sampling, utility and construction workers), visitors, recreational users, and trespassers as current human receptors.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the 1926 Explosion Radius MRA and based on the MRS physical setting (detailed in Section 3) are reasonably anticipated to be present on either a permanent or transient basis. The MRA contains patches of forest, wetlands, and lakes used by state threatened and endangered plants and animals. The 1926 Explosion Radius MRA is also located in both the Highlands Preservation Area and the Highlands Planning Area. According to the NJDEP i-Map Landscape Project layer, the former Green Pond MRS contains habitat with at least one occurrence of a state-threatened species (bog turtle).

11.1.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete, because MEC has been found within the 1926 Explosion Radius MRA. Complete exposure pathways exist for PTA personnel, PTA residents, and contractors/visitors who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments of the water bodies within the 1926 Explosion Radius MRA. Complete exposure pathways exist for biota that may contact MEC in surface soil or surficial sediments and that may nest or burrow at the site and thereby contact MEC in subsurface soil. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil or may perform intrusive work during future construction activities.

11.1.4.6 Munition Constituents of Concern Exposure Conclusions

Sampling for MC was not conducted in the 1926 Explosion Radius MRS during the SI or RI because MEC items with soil staining, or visible evidence of a potential MC release were not found in the MRA. Therefore, exposure pathways for human and ecological receptors to contact MC are considered incomplete because it has not been established that MC is present at concentrations of concern. In addition, MC at the former Green Pond MRS is being addressed under the IRP. Surface water and sediment samples have been collected and analyzed for explosives and metals from the area known as IRP Site PICA-193 under the IRP. The ROD was completed in 2004 for IRP site PICA-193, and chemical and biological monitoring began in 2007 and will continue until 2021 (Picatinny Arsenal, 2013).

11.1.5 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the 1926 Explosion Radius MRA is associated with the statistical calculations performed using UXO Estimator.

During the TPP process, the upper limit of the MEC density at the combined 1926 Explosion Radius MRSs was assumed to be 3 MEC/acre in the Inner Radius Decision Unit and 0.5 MEC/acre in the Outer Radius Decision Unit. Characterization coverage of 1 acre in the Inner Radius Decision Unit and 6 acres in the Outer Radius Decision Unit was needed to be 95% confident that there are less than or equal to 3 MEC/acre in the Inner Radius Decision Unit and 0.5 MEC/acre within the MRSs. Given that the original MEC density used in the sampling design was an estimate (i.e., the PDT did not know what the actual MEC density was throughout the inner and outer radii at the time of the sampling design), and because three DMM/MEC associated with the 1926 explosion were found in the Outer Radius Decision Unit during the RI, it is likely that the actual density of MEC associated with the 1926 explosion within the Outer Radius Decision Unit is higher than 0.5 MEC/acre.

According to the UXO Estimator calculations, at a 95% confidence that there are less than 1.175 UXO/acre (between 0 and 1,705 total MEC associated with the 1926 explosion within the Outer Radius Decision Unit). To reduce uncertainty following the investigation, data from previous investigations was included in the UXO Estimator data analysis to qualitatively calculate the statistical upper bound of the MEC density, which was found to be 0.159 MEC/acre (between 0 and 231 total MEC associated with the 1926 explosion within the Outer Radius Decision Unit) at

a 95% confidence level. The qualitative average MEC density within the MRS was calculated to be 0.082 UXO/acre associated with the 1926 explosion within the Outer Radius Decision Unit. Based on this evaluation, even with the addition of previous investigation data, it cannot be definitively stated that there are zero residual MEC from the 1926 explosion remaining in the Outer Radius Decision Unit.

According to the UXO Estimator calculations, the upper bound of the MEC density at a 95% confidence within the Inner Radius Decision Unit was calculated at 3.151 MEC/acre (between 0 and 1,918 total MEC associated with the 1926 explosion within the Inner Radius Decision Unit). To reduce uncertainty following the investigation, data from previous investigations was included in the UXO Estimator data analysis to qualitatively calculate the upper bound of the MEC density, which was found to be 1.577 MEC/acre (between 0 and 959 total MEC associated with the 1926 explosion within the Outer Radius) at a 95% confidence level in the Outer Radius Decision Unit. The qualitative average MEC density within the MRS was calculated to be 1.366 UXO/acre associated with the 1926 explosion within the Inner Radius Decision Unit. Based on this evaluation, even with the addition of previous investigation data, it cannot be definitively stated that there are zero residual MEC from the 1926 explosion remaining in the Inner Radius Decision Unit.

An additional uncertainty concerns the source of MEC within the MRS. Sources of MEC within the 1926 Explosion Radius MRS include the 1926 explosion, and in the northern portion of the MRS, unconfirmed reports of munitions being fired over Picatinny lake into the side of a hill. Munitions would then have the potential of rolling down the slope to enter the MRS, and undershots could have landed within Picatinny Lake.

During the RI intrusive results for Picatinny Lake, a 37mm smoke Projectile was recovered which is no associated with the 1926 explosion. Additionally, west of Picatinny Lake, in the 1926 Explosion Radius MRS Grid 26OR-024, one MEC was identified (a 37mm projectile); and five practice munitions were found: one 37mm projectile, two 3-inch MK1 practice Stokes mortars; and two World War I 75mm projectiles. None of these items are associated with the 1926 explosion either. It is possible that they are associated with activities that occurred on/over Picatinny Lake. Unconfirmed reports have indicated that firing used to occur across Picatinny Lake into the hillside to the northwest of the grid. Therefore, it is possible that munitions fired

into the hillside could have rolled down the hill into this grid and further into Picatinny Lake. Although the exact release mechanism is not known; the intrusive investigation within grids and the additional handheld EM sensor-assisted visual surveys only identified one DMM within this area. These findings do not indicate that there is a release mechanism which would result in a higher or lower probability of encountering DMM than in other parts of the Outer Radius Decision Unit; therefore, this area is evaluated as part of the Outer Radius Decision Unit instead of being evaluated as a separate decision unit.

11.1.6 Conclusions and Recommendations

Based on the results of the RI it is recommended that the 1926 Explosion Radius MRS become one MRA with two MRSs; the Fuze Area MRS and the 1926 Explosion Radius MRS. The amount of investigation within the 1926 Explosion Radius MRS exceeded the amount proposed in the RI Work Plan. Grid 26IR-10 was located within the Inner Radius Decision Unit; however, it was located in an area with a high concentration of fuzes that was later delineated as a separate decision unit (i.e., the Fuze Area Decision Unit). Because grid 26IR-10 is evaluated with the Fuze Area Decision Unit as opposed to the Inner Radius Decision Unit, the decreased acreage in the Inner Radius Decision Unit no longer meets the amount proposed in the Final RI Work Plan. However, the decreased acreage doesn't significantly alter the results of the Inner Radius Decision Unit investigation because the only effect is that the statistical confidence level is decreased from 95% to 94.23% as a result of the decreased amount of investigation. No investigation was planned in the Fuze Area Decision Unit, since it was unknown that this area existed until the RI was conducted.

Based on the results of the RI, there is a 95% confidence level that less than or equal to 0.159 MEC/acre remains within the Outer Radius Decision Unit and 1.577 MEC/acre in the Inner Radius Decision Unit within the 1926 Explosion Radius MRS. Qualitative evaluations of the RI results indicate a low probability of encountering MEC in the Outer Radius Decision Unit of the 1926 Explosion Radius MRS. There is 95% confidence that less than or equal to 173.006 MEC/acre within the Fuze Area MRS.

Based on the results of the RI field activities, the following conclusions can be made for the 1926 Explosion Radius MRA:

- MEC was encountered in all three decision units, therefore an explosive safety hazard is present.
- Complete pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRA.
- Sampling for MC was not conducted in the 1926 Explosion Radius MRA during the SI or RI because MEC items with soil staining, or visible evidence of a potential MC release were not found. Therefore, pathways for MC are considered incomplete.

It has been determined that DQOs for the 1926 Explosion Radius MRS have been satisfied and the nature and extent of MEC has been adequately characterized. It is recommended that the 1926 Explosion Radius MRA (AEDB-R-ID: PICA-003-R-01) be further evaluated in an FS for potential action to address hazards because of the presence of MEC.

11.2 1926 EXPLOSION RADIUS – OFF-POST MRS

11.2.1 Summary of RI Activities

As mentioned in Section 11.1.1, the 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01) was investigated in conjunction with the 1926 Explosion Radius MRS (PICA-003-R-01) because the division between the two MRSs is based on the physical location of the PTA boundary and is not due to differentiation between the potential source and the release mechanisms. Thus, the two MRSs were investigated together and divided into decision units for characterization based on the available historical information and real-time RI data. Refer to Section 11.1.1 for details regarding activities conducted at the 1926 Explosion Radius MRS.

Note, no MEC and only 2 MD (a fragment and a 5-inch base plate) were recovered from the 1926 Explosion Radius – Off-Post MRS during RI activities. Additional items recovered consisted of 297 items designated as cultural debris, 6 small arms (civilian 12 gauge shotgun shell base), and 15 geologic "hot rocks".

Sampling for MC was not conducted in the 1926 Explosion Radius – Off-Post MRS because MEC items with soil staining, or visible evidence of a potential MC release were not found in the MRS.

11.2.2 Munitions and Explosives of Concern Hazard Assessment

The 1926 Explosion Radius – Off-Post MRS has a Hazard Level Category of 3, which indicates the MRS has moderate hazard potential for current use activities. Refer to **Appendix O.**

11.2.3 Summary of Risk Assessments

No additional characterization activities were required during the RI to assess MC within the 1926 Explosion Radius – Off-Post MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS. As a result, the project team determined that a Risk Assessment was not warranted for the 1926 Explosion Radius – Off-Post MRS.

11.2.4 Revised Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The MC exposure conclusions are provided in Section 11.2.3.

11.2.4.1 Source

Based on the available historical information, MEC including UXO and DMM, and MD have been released in the 1926 Explosion Radius Off-Post MRS from the 1926 Explosion Radius – Off-Post MRS.

Prior to any TCRA activities, 16 MEC were found by quarry workers at Mount Hope Quarry; these finds were reported to the PTA EOD. During TCRA activities to date, 64 MEC have been found at the quarry. MEC have been found only during TCRAs I and III, which were conducted at locations much closer to the explosion center than the area cleared under TCRA II. During the RI, no MEC was found within the 1926 Explosion Radius – Off-Post MRS.

11.2.4.2 Access

The 1926 Explosion Radius – Off-Post MRS is located outside the secured PTA boundary. With the exception of the quarry, which has a guarded gate at the main entrance and signs posted along the perimeter of the property, the off-post property is not secured.

11.2.4.3 Activity

The 1926 Explosion Radius – Off-Post MRS covers 836 acres and is located outside the eastern boundary of PTA. Mount Hope Pond and portions of Mount Hope Lake are located within the MRS boundary. The MRS contains vacant land and several businesses, including Mount Hope

Quarry, which comprises approximately 80% (634 acres) of the MRS. Structures located within the 1926 Explosion Radius – Off-Post MRS include commercial businesses and their associated buildings including those structures associated with the operations of Tilcon at Mount Hope Quarry. In addition, public utility towers, large piles of cultural debris, and a stone wall were observed during this and previous investigations.

The current land use is industrial and recreational with some vacant land. During the RI, the property owners indicated there are no future plans to change the current land use.

11.2.4.4 Receptors

Human receptors identified for the 1926 Explosion Radius – Off-Post MRS include both current and anticipated future land users. Human receptors include quarry personnel, other workers (e.g., workers associated with other businesses, contractors, utility workers), visitors, recreationists (e.g., hunters, fishermen), and trespassers. Recreational use on Mount Hope Lake includes camping and fishing.

Ecological receptors (biota) for the purposes of the revised MEC CSM is identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and 1926 Explosion Radius – Off-Post MRS and based on the MRS physical setting (detailed in Section 3) are reasonably anticipated to be present on either a permanent or transient basis. Both forested and wetland areas are present in the MRS. No specific ecological receptors are identified; however, according to NJDEP's i-Map Landscape Project layer, the MRS contains habitat with at least one occurrence of a state-threatened species, shown on **Figure 3-6**. The MRS is also located in the Highlands Preservation Area.

11.2.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete, because MEC has been found within the 1926 Explosion Radius – Off-Post MRS. Complete exposure pathways exist for the Tilcon personnel at Mount Hope Quarry who may contact, via handling/treading underfoot, MEC in the surface and subsurface soil. Complete exposure pathways exist for the workers/visitors and the recreationists/trespassers who may contact MEC in surface soil or surficial sediment and in the subsurface soil or sediment for contractors or utility workers performing intrusive work. The exposure pathways are complete for biota that may contact MEC in the surface soil during

feeding and nesting activities and in subsurface soil during burrowing. Potentially complete exposure pathways exist for the aquatic and semi-aquatic ecological receptors that may contact MEC in the surficial sediments of Mount Hope Lake or Mount Hope Pond.

11.2.4.6 Munition Constituents of Concern Exposure Conclusions

Sampling for MC was not conducted in the 1926 Explosion Radius – Off-Post MRS during the SI or RI because MEC items, soil staining, or visible evidence of a potential MC release were not found in the MRS. Exposure pathways for human and ecological receptors to contact MC are considered incomplete, because it has not been established that MC is present at concentrations of concern.

11.2.5 Uncertainties

As mentioned in Section 11.1.1, the 1926 Explosion Radius – Off-Post MRS (PICA-004-R-01) was investigated in conjunction with the 1926 Explosion Radius MRS (PICA-003-R-01) because the division between the two is based on the physical location of the PTA boundary and is not due to differentiation between the potential source and the release mechanisms. Thus, the two MRSs were investigated together and divided into decision units for characterization based on the available historical information and real-time RI data. The primary uncertainty related to the evaluation of the RI results at the combined 1926 Explosion Radius MRSs is associated with the statistical calculations performed using UXO Estimator. Refer to Section 11.1.5 for details regarding uncertainties at the 1926 Explosion Radius MRA.

11.2.6 Conclusions and recommendations

Based on the results of the RI, there is a 95% confidence level that less than or equal to 0.159 MEC/acre remains within the Outer Radius Decision Unit and 1.49 MEC/acre in the Inner Radius Decision Unit within the 1926 Explosion Radius – Off-Post MRS. Qualitative evaluations of the RI results indicate a low probability of encountering MEC in the Outer Radius Decision Unit of the 1926 Explosion Radius – Off-Post MRS.

Based on the results of the RI field activities, the following conclusions can be made for the 1926 Explosion Radius — Off-Post MRS:

- Though no MEC was recovered from the 1926 Explosion Radius – Off-Post MRS during the RI, MEC has historically been encountered.

- MEC has been encountered in both decision units in the adjacent 1926 Explosion Radius MRA, therefore an explosive safety hazard is deemed to be present.
- Complete pathways for MEC were identified for surface and subsurface soils for all receptors having access to the MRS.
- Sampling for MC was not conducted in the MRS during the RI because MEC items with soil staining, or visible evidence of a potential MC release were not found. Therefore pathways for MC are considered incomplete.

It has been determined that DQOs for the 1926 Explosion Radius – Off-Post MRS have been satisfied and the nature and extent of MEC has been adequately characterized. It is recommended that the 1926 Explosion Radius – Off-Post MRS (AEDB-R-ID: PICA-004-R-01) be further evaluated in an FS for potential action to address hazards because of the presence of MEC.

11.3 SHELL BURIAL GROUNDS MRS

This section summarizes the results of the RI activities conducted at the Shell Burial Grounds MRS (PICA-010-R-01) located at PTA. The RI objective was to determine the horizontal and vertical extent of the subsurface material and subsequently verify that existing institutional controls (ICs) are adequate.

11.3.1 Summary of RI Activities

The preliminary CSM for the Shell Burial Grounds MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4.3.2 of the RI Report. In general, the data needs and DQOs focused on detecting and assessing subsurface features assumed to be munitions-impacted material. Historical information, and geophysical survey data was used to evaluate whether the existing ICs (i.e., chain link fencing with warning signs) are adequate to demarcate the extent of subsurface material.

In order to delineate the horizontal boundaries of both burial areas, a total of 7,153 linear feet (3,490 feet in the Shell Burial Grounds - East and 3,663 feet in the Shell Burial Grounds - West) of DGM transect surveys were performed using a man-portable EM31-MK2. A total of 8,160 linear feet (2,368 feet in the Shell Burial Grounds - East and 5,791 feet in the Shell Burial Grounds - West) of DGM transect surveys were performed using a man-portable G-858 magnetometer.

ER imaging surveys were performed, from February 6 through 9, 2012 using an AGI SuperSting/Swift R8 Earth resistivity imaging system, to delineate the vertical extents of the burial areas and to delineate the lateral extents. ER survey lines, two each, along the long and short axes, were placed across each burial area to profile the varying subsurface conditions by measuring the voltage drop between various combinations of paired electrodes.

A 3D conceptual model was constructed using the Shell Burial Grounds - West and Shell Burial Grounds - East ER transect profile sections for the purpose of estimating the lateral and vertical extents of 1926 Explosion craters and the disposal material contained within.

The Shell Burial Grounds - West consists of two individual burial areas resulting from two simultaneous explosions creating overlapping craters. Both interpreted burial areas extend slightly beyond the current fence line, shown on **Figure 6-9**. Pit 1 is approximately 30-feet deep and contains 33,000 cubic yards (20 acre-feet) of material. The cap material averages 4 to 5-feet thick and makes up ~25% of this volume. The fill above the cap comprises ~15% of the volume. The remaining 60% of the volume is a mix between moderate and highly conductive materials and is inferred to be the transition zone between backfill material and the deeper shell burial deposits. Pit 2 is approximately half as deep as Pit 1 and contains approximately 15% of the volume of Pit 1. The relative composition of Pit 2 is approximately the same as Pit 1.

The Shell Burial Grounds - East consists of a single large burial area that is approximately 40-feet deep and contains 80,000 cubic yards of material (50 acre-feet). The Shell Burial Grounds - East volume is approximately double the combined volume of the Shell Burial Grounds - West. The Shell Burial Grounds - East extends slightly beyond the current fence line, shown on **Figure 6-10**. The Shell Burial Grounds - East contains a basal zone of material that is extremely conductive. The presence of this zone, combined with anecdotal evidence regarding the large size of the eastern crater (known as Shell Burial Grounds – East), helped define the base of the burial area. The high and low conductivity debris zones were modeled as separate layers for the purpose of volume estimation. The high conductivity zone, inferred to be shell burial deposits, occupies 10,000 cubic yards, which accounts for 16% of the total volume of the Shell Burial Grounds - East burial area material. The remainder of the volume of material in the high conductivity zone of the Shell Burial Grounds - East burial area pit is inferred to be a mix of construction debris and reworked native material.

11.3.2 Munitions and Explosives of Concern Probability Assessment

No MEC were identified at the MRS during the RI. Due to the high potential for MEC to be present (based on historical reports), a probability assessment was conducted and is included in **Appendix O** and detailed in Section 7.2.

The Shell Burial Grounds MRS has a "moderate to high probability" for encountering MEC (refer to Table 7-8). In accordance with the U.S. Army Corps of Engineers, Explosives – Safety and Health Requirements Manual EM 385-1-97, a "moderate to high probability" of encountering MEC means any activity within the MRS must be conducted using anomaly avoidance techniques or UXO-qualified personnel must attempt to identify and remove any explosive hazards prior to any intrusive activities. Before the removal action begins, a Department of Defense Explosives Safety Board approved Explosives Safety Submission will be required prior to additional soil disturbance activities that cannot be achieved using anomaly avoidance techniques.

11.3.3 Summary of Risk Assessments

Co-located IRP investigations that include MC parameters in their scope of remedial objectives are occurring and/or have already occurred at the Shell Burial Grounds MRS; therefore, further assessment of MC under the MMRP was not warranted for the MRS and was not included in the scope of RI field activities. As a result, the project team determined that a Risk Assessment was not warranted for the Shell Burial Grounds MRS.

11.3.4 Revised Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted; due to MC being addressed under IRP Site PICA-162.

11.3.4.1 Source

The Shell Burial Grounds MRS was used for disposal and burial of MEC and explosives released from the 1926 explosion. The MRS was also used for munitions disposal until 1945 by the Navy. Records on the amounts or types of explosive devices buried at the site were not kept. No intrusive field activities have been conducted at the Shell Burial Grounds MRS to date, but potential munitions may include mines, depth charges, fuzes, projectiles, explosives, small arms

ammunition, and propellants, based on the HRR (Malcolm Pirnie, 2006). MEC density is unknown, but the MRS was used for the disposal of up to 25 tons of MEC and the density is assumed to be very high. It is also probable that MD associated with the 1926 explosion is contained within the burial areas.

11.3.4.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, providing UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

Currently, ICs (i.e., 6 1/2-foot tall chain-link fencing with warning signs) restrict access to the MRS and the fenceline is thought to be the horizontal extent of the burial areas. Once on the MRS, receptors would have limited or no access to any MEC in surface soil due to the depth of fill (0-10 feet of fill on top of debris, varying across the two burial grounds), therefore most MEC would be present in the subsurface. As shown during the geophysical surveys, a portion of each burial area extends beyond the current fence line; therefore, receptors could have limited access to MEC present in the subsurface. The future land use for the MRS is considered not to include activities that will access surface and subsurface soils.

11.3.4.3 Activity

The Shell Burial Grounds MRS is not currently being used and access is restricted. There are no planned land use changes for the Shell Burial Grounds MRS. The MRS is comprised mainly of deciduous forest.

11.3.4.4 Receptors

Human receptors identified for the Shell Burial Grounds MRS include both current and anticipated future land users.

The revised MEC CSM in this RI identifies PTA personnel, residents, and contractors (utility workers, maintenance and construction workers) and visitors as current human receptors, but because the Shell Burial Grounds MRS has restricted access, the potential for the human receptors to access the MRS is low. Ecological receptors (biota), for the purposes of the revised MEC CSM, are identified as the listed and unlisted mammals, and birds known to be present at

PTA and the Shell Burial Grounds MRS and based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. There are no known ecological receptors identified at the Shell Burial Grounds MRS. The potential access and activities were considered in evaluating the source-receptor interactions at the MRS.

11.3.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete in the subsurface, because it has historically been used for disposal of approximately 25 tons of explosives from the 1926 explosion. In addition, it was determined during the ER transect surveys that debris extends beyond the boundaries of the ICs (fenceline), which could provide access for receptors to contact munitions in the subsurface. A potentially complete pathway could exist for PTA personnel and contractors who may perform intrusive work during potential future IC installation/movement activities. Incomplete exposure pathways exist for PTA personnel, residents, and contractors for MEC in surface soil, given that buried debris containing possible MEC has been detected deeper than 5 feet bgs where environmental factors (e.g., frost) may bring subsurface MEC to the surface in the Shell Burial Grounds MRS. The exposure pathways are incomplete for biota that may contact MEC in the subsurface soil during burrowing based on the possible location of MEC source material at depth in subsurface soil. The pathway to ecological receptors is possibly present, but incomplete as no MEC source material was confirmed within 2 feet of ground surface where biota activity is most likely.

11.3.4.6 Munition Constituents of Concern Exposure Conclusions

In accordance with the Final Work Plan (WESTON, 2012), no MC sampling was performed at the Shell Burial Grounds MRS because MC is being addressed under the IRP. Groundwater, surface, and subsurface soil samples were collected and analyzed for explosives and metals from the area known as IRP Site PICA-162 under the IRP. MC is being addressed under the IRP; therefore, the exposure pathways for MC were not determined for the Shell Burial Grounds MRS.

11.3.5 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Shell Burial Grounds MRS is associated with the interpretation of the DGM transects in relation to the incomplete record of the historical operations at the MRS since the 1926 explosion and subsequent burial activities.

Review of the HRR indicated the craters created during the 1926 explosion were subsequently used as two burial grounds to dispose of approximately 25 tons of explosives released during the 1926 explosion and used for disposal of material by the Navy until 1945, after which time the craters were backfilled/covered with as much as 20 feet of fill material. The burial areas are estimated at 25 to 35 feet deep (Malcolm Pirnie, 2006).

Additionally potential munitions disposed of at the Shell Burial Grounds MRS may include projectiles, mines, depth charges, fuzes, explosives, small arms ammunition, propellants, and possibly rocket fuels. It was also reported that the MRS potentially contained acids, pickling liquors, cyanide, and phenol (Malcolm Pirnie, 2008). No records of the types of materials or amounts of material disposed of in the burial grounds were maintained. Therefore the nature of the potential risk posed by the presence of MEC within the Shell Burial Grounds MRS cannot be fully determined.

The approved Work Plan DGM survey coverage for the RI was performed to determine the horizontal extent of the subsurface material and to verify that the current ICs (fencing) bound the two burial areas using a non-intrusive investigative approach. DGM surveys were also performed to determine the vertical extent of the subsurface material as much as was possible without intrusive investigation. EM31-MK2 transect surveys were performed to delineate the lateral boundaries of the burial areas and ER imaging surveys were then performed to delineate the lateral and vertical extents of the burial areas.

After analysis of the EM31-MK2 data, it was noted that no clearly defined anomalous areas indicative of burial features were observed. To supplement the EM31-MK2 data, a G-858 magnetometer survey was also conducted. However, no clearly defined areas indicative of burial features were observed within the G-858 magnetometer survey data either. Subsequently, ER imaging surveys were performed using an AGI SuperSting/Swift R8 ER imaging system to delineate the vertical extents of the burial areas were also used to delineate the lateral extents.

After an analysis of the ER transect profiles a 3D conceptual model was constructed using the Shell Burial Grounds - West and Shell Burial Grounds - East ER transect profile sections for the purpose of estimating the lateral and vertical extents of 1926 Explosion craters and the disposal material contained within. The burial area dimensions were based upon WESTON's analysis of geophysical data collected by both WESTON and Enviroscan. Therefore the burial areas were

emplaced in a two-layer (bedrock and overburden) geologic model constructed from both site-specific and regional data to augment regional information with site-specific data. The regional data consisted of both bedrock and topographic surfaces downloaded from the NJDEP website. The Digital Elevation Model (DEM) was then adjusted to account for topographic detail provided by three site monitoring wells (DM6-1 through -3) and topographic field data collected along the eight surveyed ER transects. The adjustment process warps the regional DEM such that its general shape is maintained but the revised surface honors the additional site-specific data. The bedrock surface used in the model was also developed in a similar multistep process that merged both regional and site-specific data.

Therefore, while the dimensions of the burial areas are estimated from the 3D model, the data was augmented with site-specific data, both geologic and topographic, which was used to diminish the uncertainty associated with the interpretation of the data.

As stated in section 6.4.1 the modeling results state that the burial grounds extend slightly beyond the current ICs (fence line), therefore; it is possible that burial debris may be present at the surface of the Shell Burial Grounds MRS despite the fact that no confirmed discoveries have been made to date. However, as the DQOs were met and no MEC/MD was discovered during the RI field activities the uncertainty that MEC is present at the surface of the Shell Burial Grounds MRS is low.

11.3.6 Conclusions and Recommendations

Based on the results of the RI field activities, the following conclusions can be made for the Shell Burial Grounds MRS:

- No MEC or MD were observed during the DGM surveys performed in the Shell Burial Grounds MRS.
- The lateral extent of each burial area within the Shell Burial Grounds MRS was determined to extend beyond the current fenceline.
- The vertical extent of both burial areas was determined; the Shell Burial Grounds – West has an approximate depth/thickness of less than 30 feet, while the Shell Burial Grounds – East has an approximate depth/thickness of 40 feet.
- Historically, MEC was disposed of within the burial areas, and a highly conductive layer (assumed associated with burial of 1926 explosion munition debris) was determined to exist at both burial areas, therefore an explosive safety hazard is

deemed to be present.

- Incomplete pathways were identified for surface and complete pathways were identified for subsurface soils outside the MRS because debris extends beyond the boundaries of the ICs (fenceline). A potentially complete pathway could exist for PTA personnel and contractors within the MRS who may perform intrusive work during potential future IC installation/movement activities.
- Sampling for MC was not conducted in the MRS during the RI because MC is being addressed under the IRP.

It has been determined that DQOs for the Shell Burial Grounds MRS have been satisfied and the vertical and horizontal extent of the burial areas has been adequately characterized. It is recommended that the Shell Burial Grounds MRS (AEDB-R-ID: PICA-010-R-01) be further evaluated in an FS for potential action to address hazards because of the presence of MEC.

11.4 FORMER OPERATIONAL AREAS MRS

This section summarizes the results of the RI activities conducted at the Former Operational Areas MRS (PICA-006-R-01) located at PTA. The RI objective was to determine whether a MEC release was present within the MRS and/or AOI Code 300 Area, and approximate the MEC density. The RI objectives within the additional AOI were to delineate the horizontal extent of the subsurface material at the AOI Former Sanitary Landfill/ Dredge Pile, and AOI Waste Burial Area and evaluate the extent of MEC. Within the AOI Site 20/24 the RI objective was to determine whether MEC burial sites were present and determine the nature and extent.

11.4.1 Summary of RI Activities

The preliminary CSM for the Former Operational Areas MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4.5.2 of the RI Report. In general, the data needs and DQOs focused on detecting and assessing a MEC release and delineating the extent of MEC within the AOIs.

The main body of the Former Operational Areas MRS and the AOIs are discussed separately throughout the section.

11.4.1.1 Former Operational Areas (Non-AOI Areas)

EM61-MK2 transects were collected in two regions of the Former Operational Areas MRS that consisted of the developed portions of the MRS. In the northern half of the MRS, DGM transects

were completed north of Picatinny Lake, and in the southern half of the MRS, DGM transects were completed west of the golf course. Along these DGM transects, several high-density areas were observed, where focused DGM grids were placed to further investigate the area. Seven EM61-MK2 (50 by 50 foot) grids were surveyed (four in the southern area and three in the northern area (**Figures 5-19** and **5-20**)).

A total of 433 anomalies were selected for intrusive investigation along the DGM transects in the Former Operational Areas MRS, excluding the DGM transects conducted in the AOIs. No MEC was identified but 14 MD were identified consisting of fragments, fuzes, flares, 60mm Mortar parts and a 40mm Armor-Piercing Projectile. The remaining items consist of 393 items identified as cultural debris (wire, nails, pipe, etc.), 22 items identified as geologic "hot rocks", and 4 No Contacts. Items were recovered at depths ranging between 0 and 8 inches bgs, with the MD being identified up to 6 inches bgs.

In the seven DGM grids within the Former Operational Areas MRS no MEC was identified but five MD were identified, in only two of the grids, (FOA-03: 60mm Mortar Tailboom and a Fragment, FOA-04: two Hand Grenade Smoke Bodies and a 60mm Mortar Illumination Body). The remaining anomalies investigated in the DGM grids consist of 1 small arms (shotgun shell) in FOA-04, 76 items identified as cultural debris (wire, nails, etc.), 9 seeds, two anomalies identified as geologic "hot rocks", and 38 No Contacts. Items were recovered at depths ranging between 0 and 24 inches bgs, with the MD being identified up to 18 inches bgs.

Analog transect surveys along 218,910 linear feet (41.5 miles) were performed using a White's XLT all-metals detector in the Former Operational Areas MRS, outside the AOI and areas where DGM was performed. A total of 306 anomalies were intrusively investigated along the analog transect surveys in the MRS. MEC items recovered during intrusive investigations consisted of one DMM consisting of a M302 60mm White Phosphorous Projectile and 55 UXO (48: 81mm Practice Mortars, four 60mm Practice Mortars, wax filled, two rifle grenades [fuze and body], and a 3.5" rocket fuze well). The remaining anomalies included 901 items classified as cultural debris (cans, cables, aluminum, nails, bolts and others).

A total of 100 MD items were recovered at depths ranging between 0 and 33 inches bgs. The MD items identified in the Former Operational Areas MRS, excluding the AOIs, include: 28 Fragments, three 81mm Practice Mortars parts (two tail booms and spacer); twelve 60mm

Mortars, (point detonating, illumination, and parts); sixteen 22mm Sub Calibers; six 3.5-inch Rocket parts; five 75mm Projectiles; one M26 AP fragmentation mine, wax filled; several grenades, flares, mines and various others. 70 Small Arms were observed including; 23 Shotgun Primers, 41 Blank Ammunitions such as a 7.62mm, 4 casings, 1 Shotgun Shell, and 1 Ball Ammunition. The remaining non-MD related material included 901 items classified as cultural debris. These items were recovered between the surface and 39 inches bgs.

11.4.1.2 AOI Code 300 Area

A total of 13,443 linear feet of density transects were conducted in the area of the Former Operational Areas MRS overlapping with the AOI Code 300 Area as shown on **Figure 5-18**. This transect length exceeded the minimum VSP requirements of 2.1 miles (11,088 feet) listed in **Table 5-9**. After the density transects were completed, an analog grid, Code300-13 (50 by 50 feet), was placed to characterize a potential high-density area. Only one item was identified and was classified as cultural debris consisting of barbed wire, which was identified at the ground surface.

A MEC release was not identified within the AOI Code 300 Area and the potential for MEC items from a Code 300 Area source is considered to be low.

11.4.1.3 AOI Former Sanitary Landfill/Dredge Pile

EM31-MK2 transect data were collected across the AOI Former Sanitary Landfill and after a review of the DGM data, an area of elevated response was designated for anomaly reacquisition with the EM61-MK2 and eventual intrusive investigation. EM61-MK2 transect surveys were then conduced in the designated high-density region to evaluate the high-density areas. 4,644 linear feet of DGM transects were collected across the AOI Former Sanitary Landfill.

As a result of the steep terrain in the AOI Dredge Pile, analog investigations were performed in accessible areas using a White's MXT all-metals detector instead of the planned DGM transect approach using the EM31-MK2. The mag & dig transect survey approach was more effective than DGM transect surveys due to the intermingled metallic debris that may have masked subsurface anomalies. Surface debris was removed during the transect surveys to determine if subsurface anomalies were present. Surface and subsurface anomalies were investigated to determine the anomaly source and evaluate the presence of munitions related material. No

munition related items were identified within the AOI Dredge Pile.

A total of 17 anomalies were identified within the AOI Former Sanitary Landfill and Dredge Pile portion of the Former Operational Areas MRS. Eight UXO were identified in the AOI Former Sanitary Landfill, all BLU-36 submunitions, as well as 13 items identified as MD (BLU-36 pieces, 155mm powder can, rocket pieces, fragments, etc.). The remaining items identified within the AOI consist of 29 small arms (shotgun primers and casings), 133 items identified as cultural debris (fencing, nails, foil, wire, etc.), and 4 No Contacts. Items were recovered at depths ranging between 0 and 39 inches bgs, with the MD being identified up to 15 inches bgs. The MEC, were identified up to 18 inches bgs.

It was determined that the horizontal extent of the AOI Former Sanitary Landfill and Dredge Pile were adequately delineated and the extent of the anomalies identified were determined to be within the current boundaries of the AOI.

11.4.1.4 AOI Waste Burial Area

EM31-MK2 transects were surveyed across the AOI Waste Burial Area and after a review of the DGM data, the area of elevated response along the DGM transects were designated as distinct regions for anomaly reacquisition using the EM61-MK2 and intrusive investigation. EM61-MK2 transect surveys were then conducted in the designated region to evaluate the high-density areas. 4,407 linear feet of DGM transects were collected across the AOI Waste Burial Area.

A total of 399 anomalies were identified within the AOI Waste Burial Area portion of the Former Operational Areas MRS. No MEC was identified but, 210 MD; consisting of flash tubes, 37mm Projectile parts, 40mm and 60mm Mortar parts, as well as 2.36-inch and 2.75-inch rocket components, were identified within the AOI. The remaining anomalies were 5 small arms (shotgun primers and blank ammunitions), 182 items identified as cultural debris (pipes, nails, concrete, etc.), 1 geologic "hot rock", and 1 No Contact. Items were recovered at depths ranging between 0 and 30 inches bgs, with the MD being identified up to 30 inches bgs.

It was determined that the horizontal extent of the AOI Waste Burial Area was adequately delineated and the extent of the anomalies identified were determined to be within the current boundaries of the AOI.

11.4.1.5 AOI Site 20/24

EM31-MK2 transects were surveyed across the AOI Site 20/24 and after a review of the DGM data, the area of elevated response along the DGM transects were designated as a distinct region for anomaly reacquisition and investigation. EM61-MK2 transect surveys were then conducted in the designated region to evaluate the high-density area. Additional EM61-MK2 transect surveys were conducted over an area north of the AOI border because of an UXO item consisting of an 81mm mortar identified on the ground surface during the EM31-MK2 transect survey. 12,704 linear feet of DGM transects were collected across the AOI Site 20/24.

A total of 320 anomalies were identified within the AOI Site 20/24 portion of the Former Operational Areas MRS. Nine UXO were identified within the AOI Site 20/24 consisting of a Fuzed 60mm, White Phosphorous Mortar, five Fuzed 81mm Practice Mortars, two Fuzed 60mm Practice Mortars, and a BLU-26 submunition. In addition to the UXO were two DMM, a 60mm HE Mortar and a 40mm HE Projectile identified within the AOI. A total of 121 MD consisting mainly of flares, and 60mm and 40mm illumination Mortar parts (bodies, casing, tailbooms, etc.) were identified within the AOI Site 20/24, as well as three small arms. The remaining items consisted of 144 items identified as cultural debris (foil, nails, wire, etc.), 31 geologic "hot rocks", and 10 No Contacts. Items were recovered at depths ranging between 0 and 24 inches bgs, with the MD being identified up to 15 inches bgs. The UXO, and DMM were identified up to 8 inches bgs.

No evidence of a burial site was identified within the AOI Site 20/24 which was the objective of the investigation. However, historical use also identified a mortar range overlapping the AOI Site 20/24. A MEC impact area was detected and delineated as an approximately 183-acre mortar range. The nature of the MEC items within the mortar range was determined to be 81mm and 60mm Mortars (White Phosphorus, HE, and Practice). Additional items identified within the AOI are assumed to have a source of other historical activities within the AOI and southern portion of the Former Operational Areas MRS such as the pyrotechnic and flare areas, as well as reported disposal within Landfill Pond. The extent of the munitions (MEC and MD) associated with the mortar range fan is shown on **Figure 11-1**.

11.4.1.6 Summary of MEC RI Activities

A total of 289,559 linear feet of transect surveys were conducted within the Former Operational Areas MRS, including a combination of 218,910 linear feet of analog transect surveys, and

70,650 linear feet of DGM transect surveys. Seven DGM grids were also surveyed totaling 175,000 square feet. Additionally, 13,443 linear feet of density transect surveys and one analog grid survey totaling 2,500 square feet were conducted in the portion of the AOI Code 300 Area that falls within the Former Operational Areas MRS boundary. For the entire Former Operational Areas MRS, the DGM surveys and analog transects consisted of 3,195 anomalies. Within the MRS 75 MEC items (three DMM and 72 UXO), 443 MD and 187 small arms were identified.

Based on the results of the data collected for the RI, which were collected to supplement previous information provided in the SI report and the HRR, it is proposed that the Mortar Range impact area (described in Section 11.4.1.5) be split from the Former Operational Areas MRS and becomes a separate Former Operational Areas – Mortar Range MRS due to differences in CSMs.

11.4.1.7 Summary of MC Sampling Activities

Random gridded soil samples collected for MC analysis were collected from the Former Operational Areas MRS. Between December 12-21, 2011, 89 gridded soil samples, 84 environmental samples and five field duplicates, were collected from 0 to 6 inches bgs and analyzed for the MC list, consisting of metals and explosives, provided in **Table 5-5**. Analysis of these samples indicated the presence of metals at three locations at concentrations above the PTA-specific background concentrations as well as the human health screening levels. Metals were also detected at several locations at concentrations greater than the PTA-specific background concentrations and the ecological screening levels. Refer to **Table 6-14** for additional information regarding the analytical results. No explosive compounds were detected at concentrations greater than the screening levels. The location of samples with the presence of analytes above screening levels, and their analytical results are presented on the Former Operational Areas MRS Analytical Results figure in **Appendix M**. Detailed information for all samples can be found in the Former Operational Areas MC Sampling Summary Table in **Appendix M**.

To delineate the horizontal and vertical extent of contamination, step-out samples were collected in May and September 2012 from locations where concentrations above the human health screening levels were found. Each location is discussed below:

- **Location P-1** – Soil sample FOAG-SS71 was collected in December 2011. Manganese was detected above the NJDEP residential soil remediation standard

(SRS, 11,000 mg/kg.) at a concentration of 27,000 mg/kg. Step-out samples were collected in May and September 2012.

- Six step-out soil samples were collected from three locations approximately 20 feet north, south, and west of sample FOAG-SS71. Two samples were collected from each location; one from 0 to 6 inches bgs and one from 1.5 to 2 feet bgs. Manganese was present in all three samples collected from 0 to 6 inches at concentrations above the NJDEP residential SRS. None of the deeper samples exhibited manganese concentrations above the NJDEP residential SRS. Manganese was found at a maximum concentration of 21,000 mg/kg.

- Nine additional step-out soil samples, eight environmental samples and one field duplicate, were collected and analyzed for manganese only Analysis of these samples, which were all collected from 0 to 6 inches bgs, did not indicate the presence of manganese at concentrations above the NJDEP residential SRS.

- **Location P-45** – Soil sample FOAG-SS42 was collected in December 2011. Two analytes, lead and antimony, were detected at concentrations of 27,000 and 67 mg/kg respectively, that are above the NJDEP residential SRSs of 400 mg/kg and 31 mg/kg, respectively. Location P-45 will be included in the Former Skeet Range cleanup and will not be addressed under the MMRP because it was determined that due to proximity and an analysis of samples collected under the IRP, that the antimony and lead detected in the soil samples could be related to activities on the Skeet Range.

- **Location P-61** – Soil sample FOAG-SS23 was collected in December 2011. The only analyte detected above the NJDEP residential SRS was manganese, which was detected at a concentration of 12,000 mg/kg. Step-out samples were collected in May, September, and October 2012.

- Seven step-out soil samples, six environmental samples and one field duplicate, were collected from three locations approximately 20 feet north, south, and east of sample FOAG-SS23. Two samples were collected from each location; one from 0 to 6 inches bgs and one from 1.5 to 2 feet bgs. Analysis of these samples, indicated the presence of manganese in only two samples, both collected from 0 to 6 inches bgs, at concentrations above the NJDEP residential SRS. Manganese was detected at a maximum concentration of 15,000 mg/kg.

- Five additional step-out soil samples were collected and analyzed for manganese only. Two soil samples were collected approximately 50 and 115 ft north of FOAG-SS23, two soil samples collected approximately 70 and 220 ft east, and one collected approximately 280 ft northwest. Analysis of these samples, which were all collected from 0 to 6 inches bgs, indicated the presence of manganese in two samples at concentrations above the NJDEP residential SRS. Manganese was found in samples FOAG-SS223 and FOAG-SS523 at concentrations of 31,000 mg/kg and 37,000 mg/kg, respectively.

11.4.2 Munitions and Explosives of Concern Hazard Assessment

The Former Operational Areas MRS has a Hazard Level Category of 1, which indicates the MRS

has the highest potential hazard for current use activities. Refer to **Appendix O**.

The Former Operational Areas–Mortar Range MRS also has a Hazard Level Category of 1, which indicates the MRS has the highest potential hazard for current use activities. Refer to **Appendix O**. An MRSPP priority score was also assigned to the new MRS with a score of 3 Refer to **Appendix P**.

11.4.3 Summary of Risk Assessment

The risk assessment evaluated the potential for adverse human and ecological health effects from exposure to explosives and metals detected in surface soil (0 to 2 feet bgs) at the Former Operational Areas MRS. Current EPA risk assessment guidance, screening levels, and recommended exposure equations and parameter values were used.

11.4.3.1 Summary of HHRA

COPCs for the Former Operational Areas MRS HHRA were identified by comparing maximum detected constituent concentrations to the lower of NJDEP SRSs and EPA RSLs for resident soil and, for metals, to site-specific background threshold values. The COPCs identified in surface soil were the following metals: aluminum, antimony, barium, cadmium, and manganese. EPCs in surface soil were calculated as the 95% UCL concentration, and EPCs in outdoor air were estimated using calculated PEFs. Ingestion, dermal contact, and inhalation exposures were modeled for the following potential human receptor populations: current/future outdoor site workers, construction/utility workers, recreationists (adults and children), future construction workers, and hypothetical future residents (adults and children). Exposure estimates were combined with chemical-specific toxicity values to calculate incremental lifetime cancer risks and non-cancer hazards for each receptor and exposure scenario.

Assuming RME conditions, the cancer risks estimated for all receptors were less than the risk management range of 10^{-6} (i.e., 1E-06 or 1 in 1,000,000) to 10^{-4} (i.e., 1E-04 or 1 in 10,000) established by the NCP. Non-cancer HIs were less than the target HI of 1 for all receptors, except the future construction worker (HI = 10) and hypothetical future resident child (HI = 3). Under CTE scenarios, the non-cancer HI for the construction worker was 5, and the non-cancer HI for the resident child was still 3. For the construction worker, the potential for adverse, non-cancer health effects was attributable to inhalation exposure to manganese in outdoor air. For the

resident child, the potential for adverse, non-cancer health effects was attributable to ingestion exposure to manganese in surface soil.

However, considering the following observations, no further action to address manganese in surface soil at the Former Operational Areas MRS is warranted:

- The future construction worker scenario assumed inhalation exposure to uncontrolled particulate emissions generated by vehicle traffic on temporary, unpaved roads. This scenario is overly protective given that fugitive emissions during future construction work at PTA would likely be minimized through engineering controls.
- The PEF used to estimate COPC concentrations in outdoor air was 2.23E+06 m^3/kg. In contrast, the default PEF used to generate the USEPA RSLs for soil is 1.4E+09 m^3/kg (EPA, 2013a). Use of this USEPA default PEF for the Former Operational Areas MRS risk assessment would result in a construction worker inhalation HQ of 0.02 for manganese (vs. HQ of 10 using the PEF for vehicle traffic on unpaved roads) under the RME scenario and a receptor-specific HI of 0.7, which is less than the target HI of 1 established by the NCP.
- The USEPA default PEF is used to generate the USEPA RSL for manganese in industrial soil (23,000 mg/kg), which is being applied as the soil cleanup level for manganese at PTA sites evaluated under the IRP.
- The hypothetical future residential exposure scenario is also overly protective, given there are no known future land use changes for the Former Operational Areas MRS and residential development of the Former Operational Areas MRS is not included in PTA's master plans (Parsons 2007a, 2007b).
- The EPC for manganese (5,156 mg/kg) likely over-estimated average exposure conditions throughout the Former Operational Areas MRS, as the majority of detected concentrations (79 of 103 or 76%) were less than the site-specific background value of 1,250 mg/kg.
- The EPC for manganese was influenced by concentrations detected in step-out samples around two surface soil samples (PTA-2011-FOAG-SS23 and PTA-2011-FOAG-SS71) with relatively elevated concentrations in the Former Operational Areas MRS. The mean concentration of an alternate data set excluding these nine samples would be 648 mg/kg, and the 95% UCL concentration would be 1,148 mg/kg. Use of 1,148 mg/kg as an alternate EPC to evaluate potential construction worker exposures to manganese would yield a non-cancer HI of 2 under the RME scenario and a non-cancer HI of 1 under the CTE scenario. An EPC of 1,148 mg/kg would result in a non-cancer HI of 0.6 for the resident child under both the RME and CTE scenarios.
- The alternate EPC for manganese is less than the background value of 1,250 mg/kg, indicating even background manganese concentrations would yield non-cancer hazards greater than 1 under the RME scenario for the construction worker.

- Both EPCs for manganese (5,156 mg/kg and 1,148 mg/kg) are less than the EPA RSL for industrial soil of 23,000 mg/kg, which is being applied as the soil cleanup level for manganese at PTA sites evaluated under the IRP.
- Only two (FOAG-SS223 and FOAG-SS523) of the 103 surface soil samples (or 2%), located within 150 feet of each other, had detected manganese concentrations greater than 23,000 mg/kg.
- PTA-2011-FOAG-SS23 and PTA-FOAG-SS71 are located on opposite sides of the Former Operational Areas MRS, in wooded areas that are not continuously occupied under the current land use scenario.
- Even under a future site redevelopment scenario, it is not likely that construction workers or resident children would be exposed to the most elevated manganese concentrations to the extent assumed by the exposure models used in this risk assessment. Repeated exposures would more likely be to MC in soil across a larger geographic area. Therefore, the alternate EPC of 1,148 mg/kg and background value of 1,250 mg/kg are most representative of manganese concentrations to which humans would be routinely exposed.
- Following a review of historical use areas within PTA, concentrations of manganese are not likely associated with former use of MEC at the Former Operational Areas MRS.

Based on the above considerations and to be consistent with the approach being applied at sites evaluated under the IRP, no further action based on the potential for human health risk is warranted.

11.4.3.2 Summary of SLERA

EPA (1997b) guidance indicates that following the screening-level risk calculation, a decision point is reached where it is determined which of these three statements applies:

- The potential for adverse health effects in ecological receptors is negligible and there is no need for remediation on the basis of ecological risk.
- There is inadequate information and the ecological risk assessment process should continue.
- There is the potential for adverse ecological effects and a more thorough assessment is warranted.

The following summarizes the results of the SLERA and states the conclusions for the Former Operational Areas MRS.

Community-Based Assessment

Aluminum

While concentrations of aluminum detected in samples from the MRS exceeded the TRV in all samples, exceedance of the PTA background value only occurs in 13 out of 89 locations. The PTA background value for aluminum exceeds both plant and invertebrate TRVs by orders of magnitude. Exceedances of background occurred at three locations on the northern portion and four locations on the southern portion of the Former Operational Areas MRS. These locations are neither localized to one area nor necessarily adjacent to one another. Aluminum concentrations in five of the six step-out samples collected for delineation also exceeded background. However, the concentration of aluminum in all background samples (975 mg/kg to 20,500 mg/kg) also exceed the TRV (50 mg/kg). It seems likely that the distribution of aluminum across the Former Operational Areas MRS is likely due to natural variability. Aluminum in soils may be more or less bioavailable depending on soil pH; however, it is unlikely that aluminum is related to toxicity under background conditions. Concentrations of aluminum detected in soil are likely not associated with former use of or with MEC at the Former Operational Areas MRS.

Manganese

The PTA background value for manganese exceeds both plant and invertebrate TRVs. As described previously in Section 9.1.1.4 (Risk Characterization for the HHRA), the majority of manganese concentrations (79 of 103 or 76%) were less than the PTA background value of 1,250 mg/kg. When the most elevated manganese samples detected in PTA-2011-FOAG-SS23 (9,300 mg/kg), PTA-2011-FOAG-SS71 (27,000 mg/kg), and associated step-out samples are removed, the mean concentration of this alternate manganese data set would be 648 mg/kg, and the 95% UCL concentration would be 1,148 mg/kg. While still above the plant and invertebrate TRVs, these average concentrations are below the PTA background value. It should be noted that the manganese background value also exceeds the plant and invertebrate TRVs. With the possible exception of the most elevated samples, concentrations of manganese detected in soil are likely not associated with former use of or with MEC at the Former Operational Areas MRS.

Other Metals

Both plant and invertebrate HQs for barium, copper, lead, and zinc were below 10 in the

conservative scenario, were 2 or less in the refined scenario, and exceed the TRVs in approximately 20% or fewer locations and exceed the PTA background values in approximately 30% or fewer locations. The spatial distribution of the exceedances is discussed below for each metal.

Barium - Barium exceeded the plant and/or invertebrate TRVs at one location within the northern portion of the Former Operational Areas MRS, and at two adjacent locations within the southern portion of the MRS.

Copper - Copper exceeded plant and invertebrate TRVs in three of the 90 samples (one location on the northern portion and two, non-adjacent, locations on the southern portion of the MRS).

Lead - On the northern portion of the Former Operational Areas MRS, lead exceeded the plant TRV at three locations, including one step out sample associated with PTA-2011-FOAG-SS71. These locations are not adjacent to one another. On the southern portion of the Former Operational Areas MRS, lead exceeded the plant TRV at 10 locations. Several of these locations are adjacent to one another.

Zinc - On the northern portion of the Former Operational Areas MRS, zinc exceeded the plant and invertebrate TRVs at five locations, including PTA-2011-FOAG-SS71 and some of the associated step out samples. With the exception of PTA-2011-FOAG-SS71 and the associated step out locations, the locations are not adjacent to one another. On the southern portion of the Former Operational Areas MRS, zinc exceeded the plant TRV in six locations, including one step out location associated with at PTA-2011-FOAG-SS23. However, none of these locations are adjacent to one another. Zinc also exceeded the invertebrate TRV at six non-adjacent locations on the southern portion of the Former Operational Areas MRS.

Exceedences of plant and/or invertebrate TRVs that are not adjacent to one another may represent only localized areas with the potential for adverse health effects. However, exceedences of plant and/or invertebrate TRVs that are adjacent to one another may represent more wide-spread areas with the potential for adverse health effects.

Based on these considerations, it is unlikely that concentrations of barium, copper, lead, and zinc are associated with widespread adverse effects in plants and invertebrates at the Former Operational Areas MRS, with the following exceptions:

- Invertebrate TRV exceedences for barium in the vicinity of PTA-2011-FOAG-SS19 and PTA-2011-FOAG-SS23.
- Plant TRV exceedences for lead in the vicinity of PTA-2011-FOAG-SS36, PTA-2011-FOAG-SS41 and PTA-2011-FOAG-SS35, PTA-2011-FOAG-SS43, PTA-2011-FOAG-SS49, and PTA-2011-FOAG-SS53.

However, as indicated in Section 6 of the RI Report, no evidence of potential disposal areas or firing points were observed during investigations at the majority of the Former Operational Areas MRS (i.e., excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24, where MC is being addressed under the IRP). Although intact MEC was found, mainly in the southern portion of the Former Operational Areas MRS, there was no evidence of a release from the MEC. Thus, concentrations of barium, copper, lead, and zinc are likely not associated with MEC or its former use at the Former Operational Areas MRS.

Population-Based Assessment

Based on the results of food web modeling, there may be a potential for adverse effects in individual insectivorous birds and mammals associated with bioaccumulation of cadmium, lead, and zinc into invertebrates consumed as dietary items. However, the use of bioaccumulation factors from the literature leaves uncertain the extent to which soil invertebrates within the Former Operational Areas MRS may actually be bioaccumulating these metals. Additionally, it is likely overly conservative to assume COPECs are present at the maximum detected concentration or even the 95% UCL concentration throughout the entire home range/feeding territory of the American woodcock and northern long-eared bat. In addition, it is likely that exposure at the Former Operational Areas MRS may be limited for these receptors because at PTA the American woodcock is at the northern boundary of their year-round range, may migrate south during the winter and northern long-eared bats migrate up to 56 kilometers from summer habitat to winter hibernacula.

It should also be noted that even background values for lead and zinc result in conservative HQs greater than 1 for the American woodcock. More than 75% of the zinc concentrations and more than 50% of the lead concentrations are below the PTA background value. Based on these considerations it is unlikely that the survival, growth and reproduction of insectivorous bird populations at PTA are at risk from soil impacted by MEC or historical use at the Former Operational Areas MRS. However, the bioavailability of these metals in soil at the Former

Operational Areas MRS and the extent to which they bioaccumulate into invertebrates is unknown.

The results of the refinement step (Step 3a) of the SLERA support that there is adequate information to conclude that, for most of the COPECs in surface soil, adverse impacts to terrestrial receptors are unlikely or are not ecologically significant. There is a potential for more wide-spread adverse health effects in plants and invertebrates associated with exposure to barium (invertebrates only) in the vicinity of two samples collected, and associated with exposure to lead (plants only) in the vicinity of several samples. However, as indicated in Section 6 of this RI Report, no evidence of potential disposal areas or firing points) was observed during investigations at the majority of the Former Operational Areas MRS (i.e., excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24 where MC is being addressed under the IRP). In addition, intact MEC was found, but mainly in the southern portion of the Former Operational Areas MRS (excluding the AOI Former Sanitary Landfill/Dredge Pile, AOI Waste Burial Area, and AOI Site 20/24, where MC is being addressed under the IRP). Thus, it seems unlikely that barium concentrations are associated with former use of the Former Operational Areas MRS. Further evaluation on the basis of the potential for ecological risk is not warranted.

11.4.4 Revised MEC Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. Based on the results of the data collected for the RI, which were collected to supplement previous information provided in the SI report and the HRR, it is proposed that the Mortar Range impact area be split from the Former Operational Areas MRS and becomes a separate Former Operational Areas – Mortar Range MRS due to differences in CSMs. The only difference is due to MEC sources and MEC density, presented in Section 11.4.4.1. An MC CSM was developed and provided in Section 11.4.5.

11.4.4.1 Source

The Former Operational Areas MRS was identified from the UXO Finds Map that was found in the PTA Safety Office (**Appendix B**). The UXO Finds Map documents the numerous MEC and MD recovered throughout the Former Operational Areas MRS between 1986 and 1998. In addition, a PTA Survey report (DoD, 1973) documents several areas within the Former Operational Areas MRS as being allocated for former R&D activities.

Throughout the Former Operational Area MRS, intrusive survey activities during the RI resulted in 75 MEC finds consisting of 9 fuzed 60mm mortars, 53 fuzed 81mm mortars, a 40mm HE Projectile, 9 BLU submunitions, a grenade rifle HEAT body and fuze, and a rocket fuze well. The majority of these items were identified within the southern portion of the Former Operational Areas MRS. Only one item, a 3.5-inch rocket fuze well, was found within the northern portion of the MRS.

Observed on the surface and in the subsurface were 444 MD—flares; flare components; fragments; fuzes; rifle grenades; hand grenades; 60mm mortars; 81mm mortars; 4.2-inch mortar; 3.5-inch rockets and their components; various 37mm, 40mm, 75mm, 20mm, 105mm projectiles; an AP wax filled fragmentation mine, 22mm subcalibers; M42 submunitions; and BLU-36 submunitions, consistent with historical training records and historical Former Operational Areas MRS activities as an R&D area.

Based on the RI, MEC density is known to vary across the MRS. During the RI, 75 MEC associated with the activities within the MRS were found and a total of 64.68 acres were investigated. MEC were typically found within the southern portion of the MRS, only one item, a 3.5-inch rocket fuze well, was found within the northern portion of the MRS. Based on data from the RI, the area with the highest density of MEC recovered was located in the southern portion of the Former Operational Areas MRS with the MEC density within this area calculated as more than 2 MEC per acre. Outside the high-density area shown on **Figure 6-13 and 11-1**, the MEC density decreased to less than 0.1 MEC per acre. Characterization coverage of 2.71 acres was performed to ensure a 95% probability of traversing and detecting a MEC impact area.

MEC identified within the Former Operational Areas MRS have been found at depths to 18 inches bgs; however, the majority of the MEC items (58 of 75 or 77%) were found at a maximum depth of 9 inches bgs.

Also in the 1973 Survey Report, a pyrotechnic testing area was identified near AOI Site 20/24. No pyrotechnic items were identified as MEC, but 89 MD items were identified as flares, a 60mm illumination canister, 40mm smoke canisters, flare bodies, flare caps, flare canisters, and casings.

During an interview conducted post-RI field activities (included in **Appendix C**), a mortar range was identified in the southern portion of the Former Operational Areas MRS. The mortar range

was discovered to have three separate firing points and a target area near the safe haven in AOI Site 20/24. The munitions tested at the range consisted of 60mm and 81mm mortars with 120mm practice rounds being fired from one of the firing points near the present day skeet range. No 120mm rounds have been identified within the MRS. It was determined that firing was conducted along line of site from near the intersection of Moody Rail Rd and Shinkle Rd. The size of the range was identified by personnel on a map; the length of the mortar range was limited by Phipps road and an observation point that was present to observe the firing. It was stated that controls were used to limit the length of firing. This information was confirmed during the RI by no evidence of mortars being identified on the other side of Phipps road.

A total of 62 MEC items consisting of 60mm and 81mm mortars were identified either within/near the target area or along the line of sight from the firing points to the target area. Additionally, 27 MD items consisting of 60mm and 81mm mortars and mortar pieces were also identified within the surrounding area as well as other MD. The historical mortar range boundary was modified to include MEC and MD associated with its former use (60mm and 81mm mortar training/testing) shown on **Figure 11-1**. MD not potentially associated with the former use as a mortar range was excluded. Note that outside the range, only nine MEC items were identified, one UXO consisting of a 3.5-inch Rocket Fuze Well, and eight blu-3b submunitions in the AOI Former Sanitary Landfill.

During the RI investigation no MEC was recovered from the area identified as the target area. However, during a 2002 investigation of Site 20/24 numerous MEC and MD were recovered. A soil cap was then constructed in 2002 over this portion of the site where elevated levels of PCBs and lead were identified and a smaller secondary cap was placed nearby over terminated excavations sites where munitions were found. It is likely that the majority of MEC and MD from former the target area would have been removed during the investigation or covered during the construction of the soil caps. However, MEC and MD along the line of fire and within the range boundaries were observed.

11.4.4.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, providing UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

There is currently unrestricted access to the Former Operational Areas MRS for current authorized receptors after entering PTA. After entering the MRS, receptors would have access to any MEC in surface soil by walking. A receptor may contact MEC in the subsurface performing intrusive activities. Maintenance activities in the Former Operational Areas MRS may disturb surface and subsurface soils.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

11.4.4.3 Activity

Current activities at the Former Operational Areas MRS include manufacturing, storage, testing, R&D, administration, and recreation. Included within the MRS boundary are also parking lots, recreational areas, and portions of a golf course. Undeveloped areas are used for hunting (including the AOI Waste Burial Area). The AOI Site 20/24 is currently the site of a "safe haven" for trucks transporting explosives on interstate highways. Biota activities at the MRS may include surface movement or burrowing activities.

For the purposes of this RI, the anticipated future land use at the Former Operational Areas MRS is the same as the current land use but includes short-term and long-term development and redevelopment. The potential future use of the AOI Code 300 Area is the same as the current use.

11.4.4.4 Receptors

Human receptors identified for the Former Operational Areas MRS include both current and anticipated future land users. The potential receptors include PTA personnel, residents, contractors (utility workers, construction workers), visitors, recreational users, and trespassers.

Ecological receptors (biota) for the purposes of the revised MEC CSM is identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the Former Operational Areas MRS and based on the MRS physical setting (detailed in Section 3) are reasonably anticipated to be present on either a permanent or transient basis. The majority of the MRS is undeveloped and consists of deciduous forests, ponds, streams and wetlands. Several sensitive species are known to inhabit the Former Operational Areas MRS, including the veery

(Catharus Fuscescens), barred owl (Strix varia), and American woodcock (Scolopax minor). A habitat with at least one occurrence of a state-listed threatened species is present at the MRS, according to the NJDEP i Map Landscape Project layer.

11.4.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete; because MEC was found within the Former Operational Areas MRS, shown on **Figure 6-15**. Complete exposure pathways exist for the PTA personnel who may contact, via handling/treading underfoot, MEC in the surface and subsurface soil. Complete exposure pathways exist for the workers/visitors and the recreationists/trespassers who may contact MEC in surface soil or surficial sediment and in the subsurface soil or sediment for contractors or utility workers performing intrusive work. The exposure pathways are complete for biota that may contact MEC in the surface soil during feeding and nesting activities and in subsurface soil during burrowing. Potentially complete exposure pathways exist for the aquatic and semi-aquatic ecological receptors that may contact MEC in the surficial sediments of Landfill pond or Green Pond Brook. While Landfill Pond or Green Pond Brook were not investigated, the exposure pathways for aquatic and semiaquatic ecological receptors are considered complete because of the amount of MEC items identified in the near vicinity of Landfill pond and a portion of Green Pond Brook. As shown on **Figure 6-13**, the extrapolated MEC density denotes a high probability of MEC existing within these water features.

11.4.5 Revised MC Conceptual Site Model

The exposure pathways analysis describes MC source areas, the source media and potential exposure media, release and transport mechanisms, and exposure routes for potential receptor populations. For an exposure pathway to be complete, all of the following elements must be present: a source and mechanism of MC release, a retention and/or transport medium, a point of contact with the exposure medium, and an exposure route at the contact point. If any one of these elements is missing, the pathway is considered incomplete. A pathway is considered potentially complete when the presence of MC is suspected but has not been confirmed, and receptors may be exposed while engaging in some activity that results in contact with the exposure medium.

11.4.5.1 Source

The primary source of MC at the Former Operational Areas MRS is through site usage, including discarded or malfunctioned munitions, testing activities, and munitions waste disposal. MC was detected at concentrations of concern in RI surface soil samples from the Former Operational Areas MRS; therefore, **Figure 6-18** depicts MC in surface soil as the source medium.

MC may also be found in association with MEC at the Former Operational Areas MRS. No evidence of a potential release from MEC encountered during the RI was observed; therefore, biased soil samples for MC were not collected during the RI. However, random gridded soil samples were collected across the MRS to determine if MC is present through historical site usage.

11.4.5.2 Release Mechanisms, Exposure Media and Routes

Primary release mechanisms constitute any soil disturbance that may cause redistribution of contamination. The current degree of disturbance at the Former Operational Areas is relatively low because a large portion of the MRS is undeveloped. The primary exposure medium is surface soil. Exposure routes for human and ecological receptors are ingestion, dermal contact, and inhalation, and for ecological receptors only, uptake or assimilation of MC into plants and invertebrates in direct contact with soil.

Release mechanisms from surface soil include infiltration/percolation of precipitation through soil, leaching from soil to groundwater, surface runoff to nearby water bodies, and uptake of MC into plants and invertebrates in direct contact with soil. MC migration via infiltration or leaching is likely, because a large portion of the Former Operational Areas MRS is undeveloped and not covered with impermeable surface. However, migration of dissolved MC is a minor migration pathway as the MC is relatively immobile and has low water solubilities.

Secondary release mechanisms include discharge of groundwater to a surface water body or recharge of groundwater from a surface water body and biotransfer of bioaccumulative constituents through the food web. A potential exposure route for ecological receptors is ingestion of food items that have assimilated MC. Activities at the Former Operational Areas may have also impacted surface water bodies directly. However, surface water, sediment, and groundwater at the Former Operational Areas MRS are being addressed under the IRP.

11.4.5.3 Receptors

Current activities at the Former Operational Areas MRS include manufacturing, storage, testing, R&D, administration, and recreation. The majority of the MRS is undeveloped and consists of deciduous forests, ponds, streams, and wetlands. Parts of the Former Operational Areas MRS also contain parking lots, recreational fields, and portions of the PTA golf course. Hunting is permitted in undeveloped areas. There are no housing areas located within the MRS, and future residential development is not currently planned as all housing areas are proposed to be located within the 1926 Explosion Radius MRS. For the purposes of this RI, the anticipated future land use at the Former Operational Areas MRS is the same as current land use but includes short-term and long-term development and redevelopment.

Based on the current and most likely future land uses at the Former Operational Areas MRS, potential human receptor populations include site workers (including indoor workers, outdoor workers, construction/utility workers, and future construction workers), visitors, and recreationists. Access within the Former Operational Areas MRS, once on PTA, is unrestricted.

Potential ecological receptors at the Former Operational Areas MRS include terrestrial plants, soil invertebrates, small and large birds and mammals, and reptiles and amphibians. Aquatic and semi-aquatic ecological receptors were not identified for the Former Operational Areas MRS, because surface water and sediment are being addressed under the IRP.

11.4.5.4 Munition Constituents of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MC CSM for the Former Operational Areas MRS and to identify complete, potentially complete, or incomplete exposure pathways, as presented on **Figure 6-18.**

Exposure pathways for surface soil are considered complete because MC is present at concentrations of concern and human and ecological receptors may be exposed through ingestion, dermal contact, inhalation (e.g., metals that are adsorbed onto respirable particulates where dust is generated), or uptake/assimilation (ecological receptors only). Exposure pathways for terrestrial biota through the food web are potentially complete because detected MC are bioaccumulative (i.e., cadmium, copper, lead, and zinc) and the potential for ecological exposure exists. Exposure pathways for subsurface soil are incomplete. No subsurface soil samples were

collected at the Former Operational Areas MRS because constituent concentrations detected in step-out samples collected from 1 to 1.5 feet bgs were less than human health risk-based screening levels and vertical delineation was not performed. Surface water, sediment, and groundwater exposure pathways were not evaluated because the exposure media are being addressed under the IRP.

11.4.6 MEC Uncertainties

The primary uncertainty for the RI results at the Former Operational Areas MRS is related to the statistical calculations performed using VSP. The transect spacing was planned using VSP to ensure a 95% probability of traversing and detecting a potential MEC target area in the Former Operational Areas MRS. Based on the VSP computations, analog and DGM surveys were performed across the MRS at a 250-foot spacing to achieve the statistical requirements for survey coverage.

DGM grids were placed at anomaly cluster areas identified during the DGM transect surveys for subsequent survey and anomaly investigation. A DGM grid was placed at each anomaly cluster to determine the source of the anomalies and to reduce the characterization uncertainty following the RI. Three MD items were recovered during the intrusive investigations in the 7 grids. One MEC item and 45 MD items were recovered during the intrusive investigations of the analog transects, confirming that only low concentrations of MEC and MD are present within the majority of the Former Operational Areas MRS.

The transect spacing planned using VSP was successful in detecting a MEC target area in the Former Operational Areas MRS during the RI investigation. A high density impact area was identified within/surrounding the AOI Site 20/14, delineated on **Figure 11-1**. However, during the RI investigation no MEC was recovered from the area identified as the mortar target area within the AOI Site 20/24. However, during a 2002 investigation of Site 20/24 numerous MEC and MD were recovered. A soil cap was then constructed in 2002 over this portion of the site where elevated levels of PCBs and lead were identified and a smaller secondary cap was placed nearby over terminated excavations sites where munitions were found. It is likely that the majority of MEC and MD from the former target area would have been removed during the investigation or covered during the construction of the soil caps. However, MEC and MD along the line of fire and within the range boundaries were observed.

An additional uncertainty for the Former Operational Areas MRS was regarding the types of munitions that could be identified in the MRS. Numerous MEC items have been historically identified in the MRS, of a variety of types and sizes. To mitigate some of the uncertainty during DGM investigation a low anomaly threshold was chosen, 7.2mv, to select the initial target list. Approved by the USACE QA geophysicist, this threshold was based upon seed item responses and noise levels observed at the IVS during initial pre- and post-seeding surveys which would be indicative of potential munitions within the MRS. The low anomaly threshold resulted in several No Contacts identified during intrusive investigations. No Contacts are anomalies that were identified during geophysical surveys but registered no audible response during reacquisition using analog instrumentation. The procedures for conducting reacquisition were followed as detailed in the Final RI Work Plan.

11.4.7 Conclusions and recommendations

Based on the results of the RI field activities, the following conclusions can be made for the Former Operational Areas MRS:

- A MEC impact area was detected and delineated as an approximately 183-acre range that includes the high MEC density area in the southern portion of the MRS, and an explosive safety hazard is present. (74 MEC consisting of (62) 60mm and 81mm Mortars, (9) BLU submunition, (2) rifle grenades and a 40mm Projectile.)

- The horizontal extent of the subsurface material at the AOI Former Sanitary Landfill, Dredge Pile, and AOI Waste Burial Area was delineated by the use of geophysical transects and visual observations to determine that the current AOI boundaries sufficiently bound the subsurface material.

- The extent of MEC at the AOI Former Sanitary Landfill, Dredge Pile, and AOI Waste Burial Area was evaluated and no MEC was identified within the AOI Waste Burial Area, or Dredge Pile, while 8 MEC (BLU-36 submunitions) were identified within the AOI Former Sanitary Landfill.

- No burial sites were identified at the AOI Site 20/24; however a MEC impact area was identified, consisting of a 60mm and 81mm training/testing area, the extent of which is shown on **Figure 11-1.**

- Complete MEC pathways were identified for surface and subsurface soils for all receptors having access to this portion of the MRS within the high density range area.

- One MEC was identified (a 3.5 inch rocket fuze near a rocket testing operational range) and less than 50 MD were identified in the remaining 1,689.5-acre portion of the MRS during RI field activities, and an explosive safety hazard is anticipated to be

low.

- Complete MEC pathways were identified for surface and subsurface soils for all receptors having access to the portion of the MRS outside the high density area.

- MC is present at concentrations of concern in surface soil. The HHRA indicated the potential for adverse, non-cancer health effects from exposure to manganese in surface soil. The manganese EPC was biased by relatively elevated concentrations detected in nine samples. Average and 95% UCL concentrations calculated on a manganese data set excluding these nine samples would be less than site-specific background. The SLERA indicated the potential for adverse ecological effects from exposure to aluminum, barium, cadmium, copper, lead, manganese, and zinc. However, detected metals concentrations in the majority of samples were less than site-specific background values, which in some cases also exceed ecological TRVs or would result in HQs greater than 1.

- Complete MC pathways were identified for human and ecological receptors that may contact surface soil. Pathways for subsurface soil are incomplete. No subsurface soil samples were collected, as MC concentrations in step-out samples collected from 1 to 1.5 feet bgs were less than human health risk-based screening levels and vertical delineation was not performed.

- Detected MC concentrations in surface soil are not associated with observed MEC and are not likely reflective of historical site operations. Biased soil samples were not collected from the Former Operational Areas MRS, as the MEC and MD items discovered during the RI did not present any evidence of a release. In addition, no evidence of potential disposal areas or firing points was observed during the RI. Therefore, it is most likely that detected MC concentrations reflect background conditions and natural variability therein.

It has been determined that DQOs for the Former Operational Areas MRS have been satisfied and the nature and extent of MEC and MC have been adequately characterized. It is recommended that the approximately 183-acre high MEC density portion of the Former Operational Areas MRS be separated from the 1,689.5-acre portion of the Former Operational Areas MRS to reflect the results of the RI. The recommendation is as follows and is further documented in **Table 11-1** and **Figure 11-2**:

- Revise the Former Operational Area MRS to 1,689.5 acres associated with the area outside/surrounding the range fan that includes the high MEC density area.

- Create a new MRS called Former Operational Areas – Mortar Range MRS that is 183 acres that includes the high MEC density area and delineates the range fan.

Table 11-1 Former Operational Areas MRS Recommendations

Current Configuration		Configuration Following Recommendations	
MRS Name	**Area (acres)**	**MRS Name**	**Area (acres)**
Former Operational Areas MRS (PICA-006-R-01)	1,880 acres	Former Operational Areas (PICA-006-R-01)	1,689.5 acres
		Former Operational Areas – Mortar Range (PICA-006-R-02)	183 acres

- It is recommended that the Former Operational Areas MRS (PICA-006-R-01) be further evaluated in an FS for potential action to address hazards because of the presence of MEC. It is recommended that the Former Operational Areas – Mortar Range MRS (PICA-006-R-02) also be further evaluated in an FS for potential action to address hazards because of the presence of MEC.

11.5 LAKES MRS

This section summarizes the results of the RI activities conducted at the Lakes MRS (PICA-008-R-01) located at PTA. The RI objective at Picatinny Lake was to determine the release mechanism for MEC detected along the shoreline and in the water of Picatinny Lake and to determine the nature and extent of MEC if present in burial areas at the 3-inch projectile Barbette gun firing point. The RI objective at Lake Denmark was to determine whether a MEC release from the mortar and 20mm ranges had occurred on the land portions of the area, to delineate the Lake Denmark mortar range impact area with additional underwater geophysical transect surveys, to determine whether MEC burial features are present at the firing points, and to determine the nature and extent of MEC at the burial sites.

11.5.1 Summary of RI Activities

The Lakes MRS (PICA-008-R-01) consists of both Picatinny Lake and Lake Denmark and the shoreline area surrounding the lakes. Each lake has a different military-munitions-related history, and therefore, a different investigative approach was employed for each area as discussed separately in the following sections.

11.5.1.1 Picatinny Lake

The preliminary CSM for the Lakes MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4 of the RI Report. In general,

the data needs and DQOs for the Picatinny Lake portion of the Lakes MRS focused on detecting and assessing a MEC release and detecting MEC within potential burial areas at the firing point.

A 0.59-acre DGM grid survey (PL-01) was performed on January 19 and 25, 2012 using an EM61-MK2 in cart mode at the 3-inch Barbette Gun firing point. As it was not possible to place a single 100- by 100-foot grid survey for data collection because of excessive vegetation, DGM data were collected in accessible areas near the original firing point location. It was determined that several anomalous features appeared to be present within the DGM grid that could be indicative of burial features. The potential burial features were observed to contain construction debris, such as a concrete slab, reinforced concrete and metal rebar. No MEC or MD items were observed; the anomalies only included items classified as cultural debris.

In May 2012, a total of 3.18 acres of analog surveys were performed using a White's MXT all-metals detector. Analog transects were conducted along 14,297 linear feet (2.7 miles) of Picatinny Lake shoreline. A total of 131 anomalies were intrusively investigated along the Picatinny Lake analog transects. One MEC was identified, a 37mm Smoke Subcaliber, recovered near Building 813, and 39 MD items were recovered between 0 and 12 inches bgs during the intrusive investigations. The remaining anomalies included 140 items classified as cultural debris (pipes, railroad debris, cans), and 2 geologic "hot rocks". Items were recovered at depths ranging between 0 and 12 inches bgs, with the MEC being at 6 inches bgs. The slug butt/impact area for the 3-inch Barbette gun was traversed during the analog transects and no items were identified.

On 27 July 2012, a total of 15 DGM transect surveys were conducted across the water portion of Picatinny Lake in areas where potential data gap were identified in the historical geophysical data set (Blackhawk, 1995). A total of 15,177 linear feet (2.82 miles) was surveyed using a Marine EM61-MKII in high-power mode. A total of 63 anomalies were detected in Picatinny Lake. A total of 25 anomalies (consisting of both single anomalies and anomaly clusters) were chosen for intrusive investigation. From the existing DGM data (1995), 16 targets were identified for investigation (12% of the anomalies from the existing DGM data), and 9 targets were identified for investigation from the RI DGM data (2012) based on a threshold of 30MV in Channel 3. One MEC item was identified as a supplemental charge for a 155mm projectile. MD consisting of an expended smoke canister at target PL-21 and a 3-inch flare base was identified at an additional anomaly (PL-23*) that was selected and investigated to replace the original

target PL-23 (deemed unsafe to dive on due to its location, which was too close to the spillway/dam for safe dive operations). The remaining anomalies consisted of eight items designated as cultural debris, two anomalies were considered geologic "hot rocks", ten anomalies were No Finds, and fourteen anomalies were No Contacts. Due to safety issues Anomaly LP-25 was not investigated due to concerns with the anomaly being located within outfall from the Dam.

11.5.1.2 Lake Denmark

The preliminary CSM for the Lakes MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4 of the RI Report. In general, the data needs and DQOs for the Lake Denmark portion of the Lakes MRS focused on detecting and assessing a MEC release, delineating the mortar range impact area with underwater DGM surveys, and determining the nature and extent of MEC within potential burial areas at the firing point.

A 0.23-acre (200-foot by 50-foot) DGM grid survey (LD-01) was performed on January 24, 2012 using an EM61-MK2 in cart mode at the Lake Denmark 20mm Cannon Firing Point. The Lake Denmark 20mm Cannon Firing Point DGM grid was used to detect potential burial features at the firing point. A total of 64 anomalies were selected from the geophysical data for intrusive investigation within the DGM grid.

Detected anomalies from the 20mm Cannon Firing Point grid (LD-01) were investigated to determine the anomaly source. No MEC or MD items were observed, but 25 Small Arms were identified; two Shotgun Primers, one Blank Ammunition and 22 casings. The remaining anomalies included 59 items classified as cultural debris (foil, wire, cans and others), 3 geologic "hot rocks", and one seed item. Items were recovered at depths ranging between 0 and 6 inches bgs.

Although two additional grids were proposed at the Mortar Range firing points shown on the 1947 map in the HRR, they were not surveyed because the southern end of Lake Denmark had been extensively reworked during dam construction and upgrades in 2011. The area had been leveled and overlain with fill, and concrete had been poured as part of the construction activities. UXO construction support was used during dam construction and three UXO items were recovered. On December 8, 2010 two UXO items, consisting of a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an

M302A1 60mm WP mortar and M527B1 fuze and WP filler. The 60mm WP mortar was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD.

In April and May 2012, analog surveys were conducted along 64,581 linear feet of 14.37 acres of land surrounding Lake Denmark, using a White's MXT all-metals detector. Analog transect surveys were conducted only in accessible areas. The analog transects in the central portion of the northwestern side of Lake Denmark were unable to be surveyed because of swampy terrain and the extent of the water. Of the 17 acres proposed by VSP, only 14.37 acres were able to be surveyed because a small section of the eastern land portion of Lake Denmark east of 25th Avenue was found to be inaccessible for investigation because of the presence of wetlands consisting of swampy terrain and pools of water.

A total of 102 anomalies were intrusively investigated along the Lake Denmark analog transects. No MEC was observed, but a total of two MD items, a fragment and a 152mm Practice Projectile, were recovered at depths ranging between 0 and 6 inches bgs. The remaining anomalies included 119 items classified as cultural debris such as cables, wires, and cans and seven items classified as geologic "hot rocks". These items were recovered between 0 and 12 inches bgs.

A total of 3.08 miles of underwater DGM transect surveys were performed on July 25 and 26, 2012. Data from two linear transects and one meandering transect were collected in the open water portion of the lake north of the area of data collection in the 1999 underwater DGM survey. The meandering transect was used to penetrate as far into the wetland area as possible to maximize coverage. The northern wetland area was not accessible for further surveys during the RI. From the existing DGM data (1999), five targets were identified for investigation, and five targets were identified for investigation from the RI DGM data (2012) based on a threshold of 30MV in Channel 3. After a review of the DGM data 10 targets were chosen for further investigation.

On 11 November 2012, nine underwater targets in Lake Denmark were intrusively investigated. One additional anomaly, LD-03 was unable to be investigated due to safety issues within the location (vegetation was too thick). Anomaly LD-10 was inaccessible; (too shallow for diving) therefore another anomaly location was determined in the field and investigated, LD-10*. No MEC was identified, but one MPPEH item identified as a M49/A28 60mm Mortar (Fuzed/Fired).

The 60mm mortar was designated as safe (expended) and classified as MD. The remaining anomalies consisted of one item designated as cultural debris (can), three No Finds, and four anomalies were No Contacts.

11.5.2 Munitions and Explosives of Concern Hazard Assessment

The MEC HA does not address locations where military munitions are known or suspected to be present underwater, therefore only the land portion of the Lakes MRS was included in the scoring. However, the one MEC item recovered from Picatinny Lake, a supplemental charge for a 155mm projectile, was included in the Munitions, Bulk Explosives Info Worksheet, due to the potential for the item to be present on the land portion of the Lakes MRS.

The land portion of the Lakes MRS has a Hazard Level Category of 1, which indicates the MRS has the highest hazard potential for current use activities.

11.5.3 Summary of Risk Assessments

As co-located IRP investigations that include MC parameters in their scope of remedial objectives are occurring and/or have already occurred at the water portion of the Lakes MRS, further assessment of MC under the MMRP was not warranted for the MRS and was not included in the scope of RI field activities. As a result, the project team determined that a Risk Assessment was not warranted for the water portion of the Lakes MRS.

No additional characterization activities were required during the RI to assess MC within the land portion of the Lakes MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS. As a result, the project team determined that a Risk Assessment was not warranted for the Lakes MRS.

11.5.4 Revised Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted, due to MC in the water being addressed under IRP and a release was not identified, MC exposure conclusions are provided in Section 11.5.4.4.

11.5.4.1 Picatinny Lake

11.5.4.1.1 Source

The Picatinny Lake portion of the Lakes MRS was used as the location of a 3-inch Barbette gun range, and for storing smokeless powder and explosives underwater. Additional sources are munitions dumped in the lake, munitions from the 1926 explosion, building explosions along the banks of the lake, and shortfalls from an experimental mortar range. Unconfirmed reports have indicated that firing used to occur across Picatinny Lake into an operational range on the hillside to the northwest of the Lake. Therefore, it is possible that munitions fired into the hillside could have rolled down the hill into/near Picatinny Lake.

Two MD items were identified at Picatinny Lake during upgrades at the Picatinny Dam; a 3-inch Empty Brass Ball was identified on May 9, 2011 and a M51A1 75mm Cartridge Case was identified on October 10, 2011.

Intrusive investigations during the RI resulted in two MEC being identified, a supplemental charge for a 155mm in the water portion of Picatinny Lake, and a 37mm smoke Projectile identified along the northwestern shoreline. MD consisting of grenade fuzes, grenade lever, fuze adaptor, 57mm base plate, and a practice BLU-26 were identified onshore, while an expended smoke canister and a 3-inch flare base were also identified in the water.

Based on the RI, MEC density is known to vary across the Picatinny Lake portion of the Lakes MRS. During the RI, two MEC were identified within 300 feet of each other on the northwestern side of the lake (one within the water, and one on land). The MD was located either on the peninsula where the 3-inch Barbette gun firing point was located, the peninsula where the slug butt and several building explosions were located, or in the water near Flare Island, see **Figure 6-16**. As shown on the UXO Finds maps in **Appendix B**, MEC and MD have historically been found along the southeastern portion of the shoreline, and on the peninsula where the slug butt and several building explosions were located.

MEC identified within the Picatinny Lake portion of the Lakes MRS have been found at depths up to 4 inches bgs along the shoreline; however, the depth of MEC within the lake is unknown.

11.5.4.1.2 Access

Once on PTA, there is currently unrestricted access to the majority of the Picatinny Lake portion of the Lakes MRS for current authorized receptors. Portions of the Lake have limited access because of fencing. The lake is accessible for various recreational activities including fishing and boating. Fishing is allowed from the lake shore (except certain areas, which are restricted due to site activities, such as buildings where propellant mixing occurs), by boat, or, during the winter fishing is allowed from the ice. Engineering controls, including warning signs are present at the major access points of Picatinny Lake describing restrictions of site use. Due to state-wide mercury, PCB, and dioxin contamination, a fishing advisory is in place to control consumption of Picatinny Lake fish. Both gasoline-powered boats and nonmotorized boats are allowed on the lake, but the speed of gasoline-powered boats is limited such that wake generation is not permitted. Under the existing program, boats may be launched from permissible areas, which are not limited to ramps/docks. No swimming or sail boarding is allowed in Picatinny Lake (ARCADIS, 2012).

A receptor may contact MEC that is on the ground surface simply by walking. A receptor may contact MEC in the subsurface by performing intrusive activities. Maintenance activities near the dam, boat docks, or buildings around Picatinny Lake may disturb surface and subsurface soils. It is unlikely that a receptor would contact MEC within the water portion of the lake because of access restrictions on swimming and wading.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

11.5.4.1.3 Activity

Current activities at the Picatinny Lake portion of the Lakes MRS include being used as a nonpotable water source for firefighting and production purposes, fishing, and recreational boating. LUCs are in place that ban swimming/wading in the water. Fish consumption advisories are in effect because of elevated contaminant levels in fish tissue. There no current plans to change the land use.

11.5.4.1.4 Receptors

Human receptors identified for the Picatinny Lake portion of the Lakes MRS include both current and anticipated future land users. The revised MEC CSM in the RI identifies PTA

personnel, residents, contractors, visitors, and recreationists.

Ecological receptors (biota) for the purposes of the revised MEC CSM are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the Picatinny Lake portion of the Lakes MRS and, based on the MRS physical setting (detailed in Section 3), reasonably anticipated to be present on either a permanent or transient basis. Picatinny Lake is considered to be an open-water wetland. The northern end of Picatinny Lake is dominated by scrub/shrub wetland with smooth alder (Alnus serrulata) and swamp azalea (Rhodendron viscosum). Ecological receptors known to be present at the Picatinny Lake portion of the Lakes MRS include fish, birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors, reptiles, amphibians, and mammals.

11.5.4.2 Lake Denmark

11.5.4.2.1 Source

The Lake Denmark portion of the Lakes MRS was used for experimental testing of 60mm and 81mm mortars and 4.2-inch inert mortars. The firing point for the mortar testing was located on the southern end of the lake with impact areas at the north and northwest end of the lake. A 20mm cannon range was also present across the lake, with the firing point located near the current softball field, and the target area on the western side of Lake Denmark near the Lakes MRS boundary. Also during an interview a Sagger Missile Firing point was identified for the Lake Denmark Range (**Figure 1-12**). During the interview it was detailed that the missiles were designed to float once the motors were expended and the missiles were recovered using boats after each firing.

On December 8, 2010 two UXO items were identified during upgrades at the Denmark dam, a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an M302A1 60mm WP mortar with a M527B1 fuze and WP filler. The 60mm WP mortar was discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD.

Intrusive investigations during the RI for the Lake Denmark portion of the Lakes MRS resulted in no MEC being found, but three MD (one in the water portion and 2 on land). The MD item identified in the southwestern water portion of Lake Denmark, a 60mm mortar, was,

approximately 1,200 feet from the firing point. The 60mm mortar was initially classified as MPPEH, but was then designated as safe (expended) and is classified as MD in the dig list provided in **Appendix H**. The two additional MD items identified on the land portion were a 152mm Practice Projectile and a fragment.

Between December 2012 and January 2013, MEC consisting of two 60mm mortars (one was inert with a PD fuze and the other HE) were identified by REMTEC, one on the west side of Lake Denmark and one on the east side of the lake near the Lakes MRS north boundary, as work was being conducted along the PSE&G electrical tower right-of-way. Note the 60mm HE mortar was identified just outside the Lakes MRS boundary and near/possibly outside of the installation boundary.

Based on the RI, MEC density is known to vary across the Lake Denmark portion of the Lakes MRS. During the RI, two MEC associated with the activities within the MRS were found by REMTEC. One of the MEC items, a 60mm HE mortar, was identified near/outside the northern MRS boundary. Overall two UXO items have been identified within the Lake Denmark portion of the Lakes MRS, both 60mm mortars (inert with a PD fuze and WP), shown on **Figure 6-18**. The second mortar (60mm WP) was recovered during a USACE site walk in 2010 near the 20mm cannon firing point. Based on data from the RI, the MEC density within the Lakes MRS was determined to be low and to vary across the MRS.

MD identified within the Lake Denmark portion of the Lakes MRS has been found at depths of 12 inches bgs on land; however, the depth of the MEC is unknown since the mortars were not identified during the RI.

11.5.4.2.2 Access

PTA has existing ICs and LUCs in place, including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support as required during intrusive work, and requiring appropriate personnel to attend a safety course(s).

After entering PTA, there is currently unrestricted access to the Lake Denmark portion of the Lakes MRS for current authorized receptors. Additionally, a portion of Lake Denmark, to the east, bordering the installation boundary is not fenced, therefore unauthorized receptors (trespassers) could have to access to the Lake Denmark portion of the Lakes MRS. The lake is

accessible for various recreational activities including fishing and boating. Fishing is allowed from the lake shore (except certain areas, which are restricted due to site activities, such as the western shore of the lake), by boat, or, during the winter fishing is allowed from the ice. Engineering controls, including warning signs are present at the major access points of Lake Denmark describing restrictions of site use (ARCADIS, 2012)

A receptor may contact MEC that is on the ground surface simply by walking. A receptor may contact MEC in the subsurface by performing intrusive activities. Maintenance activities in the vicinity of the dam, boat docks, softball field, or buildings around Lake Denmark may disturb surface and subsurface soils. It is unlikely that a receptor would contact MEC within the water portion of Lake Denmark due to access restrictions on swimming and wading.

The future land use for the MRS is considered to be authorized activities that will access surface and subsurface soils.

11.5.4.2.3 Activity

Current activities at the Lake Denmark portion of the Lakes MRS include being used for recreational boating and fishing. LUCs are in place that ban swimming/wading in the water. Fish consumption advisories are in effect due to elevated contaminant levels in fish tissue. Former ranges at Lake Denmark and surrounding upland forested areas are designated as other than operational range. There no current plans to change the land use.

11.5.4.2.4 Receptors

Human receptors identified for the Lake Denmark portion of the Lakes MRS include both current and anticipated future land users. The revised MEC CSM in this RI identifies PTA personnel, residents, contractors, visitors, recreationists, and trespassers.

Ecological receptors (biota) for the purposes of the revised MEC CSM is identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the Lake Denmark portion of the Lakes MRS and based on the MRS physical setting (detailed in Section 3) are reasonably anticipated to be present on either a permanent or transient basis. The northern portion of Lake Denmark is dominated by scrub/shrub wetland with smooth alder (Alnus serrulata) and swamp azalea (Rhodendron viscosum). Undeveloped, forest surrounds the

lake with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present at the Lake Denmark portion of the Lakes MRS include fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, including featherfoil (Hottonia inflate), Robbin's pondweed (Potamogeton robbinsii), small bur (Sparganium minimum), and lesser bladderwort (Utricularia minor). Lake Denmark is also located adjacent to Area J (shown in **Appendix B**), which is a summer roosting area for the federally endangered Indiana bat. Gravel Dam Cove, located in the southern end of Lake Denmark, is a unique pond habitat that supports breeding populations of the New England bluet, a rare damselfly.

11.5.4.3 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete, because MEC was identified within both portions of the Lakes MRS. Complete exposure pathways exist for PTA personnel, residents, contractors/visitors, and recreationists/trespassers who may contact, via handling or treading underfoot, MEC in surface soil or surficial sediments. Residents and personnel who work in the buildings close to the lakes may have access to the shorelines. Swimming is banned, but it is possible that recreationists/trespassers and children could still try to swim in the lake and may contact MEC in the sediments. Complete exposure pathways also exist for contractors who may need to access underground utilities in the subsurface soil and sediment or who may perform intrusive work during future construction or otherwise intrusive activities. Complete exposure pathways exist from MEC in surface soil and surface sediment to terrestrial and aquatic vegetation and wildlife and from MEC in subsurface soil to biota that burrow or nest in the subsurface soil.

11.5.4.4 Munition Constituents of Concern Exposure Conclusions

In accordance with the Work Plan (WESTON, 2012), a MEC release was not observed during the intrusive investigation, therefore no MC characterization was warranted. The water portions of the Lakes MRS, along with the land portion of Picatinny Lake, are being addressed under the IRP. Lake Denmark (Site 54) is known as IRP Site PICA-015, and Picatinny Lake is IRP Site PICA-057. The production buildings around Picatinny Lake are known as PICA-135. The FS for both water sites was submitted in October 2009. Surface water and sediment samples were

collected and analyzed for explosives and metals under the IRP. The RI/FS for the land portion of Picatinny Lake that included the collection of groundwater, soil, and sediment samples, which were analyzed for explosives and metals, was submitted in December 2009.

Although complete exposure pathways for MC exist, MC is addressed under the IRP.

11.5.5 Uncertainties

11.5.5.1 Picatinny Lake

The primary uncertainty related to the evaluation of the RI results at the Picatinny Lake portion of the Lakes MRS is associated with the incomplete record of the historical operations at the Picatinny Lake portion of the Lakes MRS.

Review of the HRR indicated a 3-inch projectile Barbette gun firing range, constructed between 1919 and 1922, was operated over Picatinny Lake until 1931 with a firing point located on the southeastern shore and a sand butt (i.e., impact area) located across the lake to the west, near Buildings 810 and 824 (Malcolm Pirnie, 2006). Historical reports also document smokeless powder and explosives being stored underwater in the southern portion of the lake between 1910 and 1960 for protection from lightning, spontaneous ignition, and heat. Although pyrotechnic and/or flare testing was conducted on Flare Island (a peninsula sometimes referred to historically as Whiley's Island), there is no historical documentation of former munitions testing on the other island located on Picatinny Lake, commonly known as Picnic Island. Several explosive-related accidents occurred in the back room of Building 800, which is located along the southwestern portion of the lake. These explosions could have potentially caused MEC releases into the lake. During IRP investigations, MEC was encountered during test pitting near several of the former production buildings along the southwestern portion of the lake (Malcolm Pirnie, 2008).

Additional sources of MEC within the Picatinny Lake portion of the Lakes MRS include the 1926 explosion, because a majority of the MRS is within the explosion radius, and unconfirmed reports of munitions being fired over the lake into an operational range on the side of the hill. Munitions would then have the potential of rolling down the slope to enter the MRS, and undershots could have landed within Picatinny Lake.

During the RI intrusive results for Picatinny Lake, only 2 MEC items were identified, a 37mm

smoke Projectile and a supplemental charge of a 155mm projectile, only the 155mm is associated with the 1926 explosion. Additionally, west of Picatinny Lake, in the 1926 Explosion Radius MRS Grid 26OR-024, one MEC was identified; a 37mm projectile. This item is not associated with the 1926 explosion therefore, it is possible that it is associated with activities that occurred on Picatinny Lake (i.e., range activities and/or operations associated with munitions manufacturing/testing that occurred in the buildings surrounding the lake). Unconfirmed reports have indicated that firing used to occur across Picatinny Lake into the hillside to the northwest of this grid. Therefore, it is possible that munitions fired into the hillside could have rolled down the hill into this grid and into/near Picatinny Lake. Although the exact release mechanism is not known; the intrusive investigation within grids and the additional visual surveys only identified one DMM within the survey area. These findings do not indicate there is a release mechanism that would result in a higher or lower probability of encountering MEC than in other parts of the Lakes MRS or 1926 Explosion Radius MRS; therefore, this area is evaluated was part of the Outer Radius Decision Unit instead of being evaluated as a separate decision unit.

Additional uncertainty for the Lakes MRS is in regards to the underwater intrusive investigations. During intrusive investigation within the water portions of the Lakes MRS, at both Picatinny Lake and Lake Denmark, several target anomalies were identified as No Finds. No Finds are defined as an anomaly that was detected by an audible response through an analog geophysical instrument but could not be visually seen or physically located. In this scenario, the diver widened the search radius from the buoy in increments of 1 foot to a maximum radius of 10 feet from the marker buoy. Intrusive operations commenced again after the diver had audible contact. No Find anomalies could be related to geology, similar to geologic "hot rock" anomalies on land or an anomaly at greater depth than possible to investigate during the underwater intrusive operations.

11.5.5.2 Lake Denmark

The primary uncertainty for the RI results for the Lake Denmark portion of the Lakes MRS is related to the statistical calculations performed using VSP. The transect spacing was planned using VSP to ensure a 95% probability of traversing and detecting a potential MEC target area in the Lake Denmark portion of the Lakes MRS. Based on the VSP computations, analog transect surveys were performed across the eastern half of the Lake Denmark portion of the Lakes MRS

at a 120-foot spacing, and analog transect surveys were performed across the western half of the Lake Denmark portion of the Lakes MRS at a 225-foot spacing to achieve the statistical requirements for survey coverage.

Two MD items were recovered during the intrusive investigations on land and one MD item was recovered during the intrusive investigations within the Lake, confirming that only low concentrations of MEC and MD are present within the Lake Denmark portion of the Lakes MRS. Two UXO have been identified within the Lake Denmark portion of the Lakes MRS, both 60mm Mortars (inert with a PD fuze and WP). The first was a 60mm WP mortar was recovered during a USACE site walk in 2010, near the 20mm Cannon Firing Point. Two 60mm Mortars (one was inert with a PD fuze and the other HE) were identified by REMTEC in December 2012 and January 2013. One mortar was on the western side of the lake and one mortar was of the eastern side of the lake near the northern MRS boundary, as work was being conducted along the PSE&G electrical tower right-of-way. Note the 60mm HE mortar was identified outside but near the northern MRS boundary. By assessing the intrusive investigations and comparing to previous MEC finds, it was determined that high concentrations of MEC and MD associated with a target area were not detected in the Lake Denmark portion of the Lakes MRS.

Additional uncertainty for the RI results for the Lake Denmark portion of the Lakes MRS is related to performing DGM grid surveys and intrusive investigations at the firing point locations as necessary to detect burial features. A 0.23-acre DGM grid survey (LD-01) was performed on January 24, 2012 using an EM61-MK2 in cart mode at the Lake Denmark 20mm Cannon Firing Point. Two additional grids were proposed at the Mortar Range firing points shown on the 1947 map in the HRR. However, they were not surveyed because the southern end of Lake Denmark had undergone significant development during dam construction and upgrades in 2011. The area had been leveled and overlain with fill, and concrete had been poured as part of the construction activities.

Although no characterization work was performed at the Mortar Range Firing Points because of the dam, three MEC items had already been recovered by construction support during dam upgrades. On December 8, 2010 two UXO items, consisting of a 60mm Mortar with Fuze and a 60mm Mortar Fuze with Booster. An additional UXO item was identified on June 13, 2011 as an M302A1 60mm WP mortar and M527B1 fuze and WP filler. The 60mm WP mortar was

discovered by a member of the public outside of work hours and was recovered and disposed of by PTA EOD. Based on the RI results and the amount of development that has occurred at the firing points of the Lake Denmark portion of the Lakes MRS, concentrations of MEC and MD, have been removed during construction and are no longer present. Therefore the uncertainty based on the firing points investigation is considered to be low.

11.5.6 Conclusions and recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Lakes MRS:

- No MEC target area was detected; however, the presence of MEC and MD suggests that a potential MEC source, and thus an explosive hazard, is present in the Lakes MRS.
- Although there is a low potential for additional MEC or MD to be present in the subsurface throughout the MRS, the pathways for MEC are complete for all receptors with access to the MRS.
- No MEC burial features were identified at the firing points within the MRS.
- Sampling for MC was not conducted in the MRS during the RI because the water portion is addressed under the IRP and MEC items with soil staining, or visible evidence of a potential MC release were not found.

It has been determined that DQOs for the Lakes MRS have been satisfied and the nature and extent of MEC and MC have been adequately characterized for the Lakes MRS. Based on these conclusions, an FS is recommended to assess possible response action alternatives for addressing MEC that has the potential to remain in the Lakes MRS (AEDB-R-ID-PICA-008-R-01).

11.6 LAKE DENMARK – OFF-POST MRS

No intrusive field activities have been conducted within the Lake Denmark – Off-Post MRS, due to access restrictions for intrusive investigations. Because the property is in receivership, the New York Army Corps of Engineers Real Estate Office would need to petition the New Jersey court system through the Department of Justice (DoJ) to acquire access agreements. However, the petition process would likely take longer than the period of performance associated with the MMRP RI contract. Attempts to gain access for intrusive work through other avenues were unsuccessful. Therefore, the intrusive work planned as part of the MMRP RI, and detailed in the Final RI Work Plan, will not be permitted. However, instrument assisted non-intrusive visual

surveys were possible at the MRS through an access agreement with Sterigenics. The Amendment to the Final Work Plan, submitted June 12, 2013, detailed the field approach change and revised DQOs. The original and revised DQO's are also provided in Section 4.7.2. It has been agreed that if the DQO's are not met by the instrument assisted non-intrusive visual surveys; a FS Data Gap Study will be conducted under a separate contract.

This section summarizes the results of the RI activities conducted at the Lake Denmark – Off-Post MRS (PICA-012-R-01) located at PTA. The RI objective was to determine whether a MEC release had occurred and the MEC nature and extent.

11.6.1 Summary of RI Activities

Lake Denmark – Off-Post MRS has been the focus of numerous previous investigations and sampling events. All of these investigations were pre-RI activities and did not definitively assess the nature and extent of contamination at the MRS. The RI results will use all of the previously compiled information to evaluate the presence or absence of MEC within the Lake Denmark – Off-Post MRS.

Using a White's MXT, 30,817 feet (5.84 miles) of visual surveys were traversed across the portions of the Lake Denmark – Off-Post MRS that constituted the investigation areas, shown on **Figure 4-1**. Within the two non-contiguous investigation areas, 78 anomalies were identified and logged; 15 anomalies were identified within the northern investigation area and 63 anomalies were identified within the southern investigation area. Three anomaly locations were identified as non-munitions related trash pits because of the quantity of surface debris in these areas. No MEC, MD or munitions related features such as cratering were observed. The proposed and actual transects as well as the anomaly locations are presented on **Figure 5-37**.

The anomaly locations were further assessed using VSP to determine the anomaly density and distribution across the MRS. The anomaly density plot is presented in **Figure 6-22**. VSP was used to analyze the non-intrusive visual survey data collected at the Lake Denmark – Off-Post MRS to identify anomaly cluster areas that may suggest the location of concentrated munitions use such as an impact area (represented by high density areas). The northern portion of the MRS was determined to have an anomaly density of approximately 11 anomalies per acre while the southern portion of the MRS has an anomaly density of approximately 24 anomalies per acre.

Two areas in the southern portion of the MRS were identified as having elevated anomaly densities relative to the low background anomaly density. These elevated anomaly density areas consist of approximately 54 anomalies per acre across an area of approximately 3 acres and 1.5 acres. The location of these elevated anomaly density areas are presented on **Figure 6-22**. While these two areas have anomaly densities greater than the background density of 24 anomalies per acre, the anomaly densities are substantially lower than what would be anticipated at a typical impact area. In addition, no MEC or MD was observed on the ground surface in these anomaly density areas or anywhere in the MRS. MEC and MD would typically be visible on the ground surface at an impact area.

In accordance with the revised DQO's presented in Section 4.7.2.2, no intrusive activities were planned or conducted at the Lake Denmark – Off-Post MRS.

11.6.2 Munitions and Explosives of Concern Hazard Assessment

No MEC has been observed at the Lake Denmark – Off-Post MRS during the SI, RI, or on any other occasion; therefore, a MEC HA was not conducted.

11.6.3 Summary of Risk Assessment

No characterization activities were required during the RI to assess MC within the Lake Denmark – Off-Post MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS. As a result, the project team determined that a Risk Assessment was not warranted for the Lake Denmark – Off-Post MRS.

11.6.4 Revised Conceptual Site Model

The following sections present the revised CSM for MEC at the Lake Denmark – Off-Post MRS based on the results of the data collected for the RI to supplement information provided during previous investigations, and previous information in the SI report and the HRR. The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The revised CSM for MEC is depicted on **Figure 6-23** for the Lake Denmark – Off-Post MRS as a flow chart summarizing the pathway and exposure analysis discussed below.

11.6.4.1 Munitions and Explosives of Concern Exposure Pathway Analysis

This section summarizes the cumulative data collected across the Lake Denmark – Off-Post MRS during the MMRP SI and RI fieldwork in addition to coverage from environmental investigations performed as part of the RTI Superfund site in order to make MEC exposure analysis conclusions.

11.6.4.2 Source

The Lake Denmark – Off-Post MRS is a 113 acre portion of a mortar range safety fan centered in Lake Denmark. MEC may be present in the MRS due to misfires or overshoots from the Lake Denmark mortar range. These activities could have resulted in MEC occurring at low densities located sporadically across the MRS, unlike heavily concentrated areas within an impact area. An example of this sporadic occurrence could be the 60mm HE mortar recovered north of the MRS boundary. Mortars may be on the ground surface or in the subsurface and may occur at such low densities that they would not have been observed during the numerous environmental sampling activities. However, it is unlikely that the Lake Denmark – Off-Post MRS would have been impacted due to the location of an observation point for the Lake Denmark mortar ranges, shown on **Figure 1-12**. In order to impact the MRS, mortars would need to have been fired near and/or beyond the observation point, which would have posed a safety hazard to personnel.

The majority of the Lake Denmark – Off-Post MRS has been traversed during environmental sampling activities as part of the RTI Superfund site. Intrusive mag & dig surveys have been completed south and east of the MRS, in the Lake Denmark portion of the Lakes MRS on Picatinny Arsenal. SI and RI visual surveys have also been performed in the Lake Denmark – Off-Post MRS. The locations of the historical sampling and SI transects are shown on **Figure 2-4**. No MEC or MD has been reported in the Lake Denmark – Off-Post MRS to date. Since no MEC or MD have been discovered in the MRS during previous investigation at the MRS and the results of the RI fieldwork suggest a low subsurface anomaly density that is not consistent with impact areas, it is not expected that a MEC source or explosive safety hazard is present at the Lake Denmark – Off-Post MRS.

11.6.4.3 Activity

The Lake Denmark – Off-Post MRS is in receivership and is currently leased by Sterigenics. The

majority of the MRS is part of the RTI Superfund site. A small portion of the MRS is owned by Rockaway Township. Current activities at the MRS include environmental remediation and sampling work. Most of the activities involve foot traffic; however, the sampling and remedial activities may include disturbing surface and subsurface soils. For the purposes of this RI, the anticipated future land use at the Lake Denmark – Off-Post MRS is not anticipated to change.

11.6.4.4 Access

Access to a portion of the Lake Denmark – Off-Post MRS, consisting of the RTI Superfund Site, is restricted by a perimeter fence. ROEs are also required for access to the privately owned property. The remaining portion of the MRS does not have any physical boundaries, and is open to recreational use. Once on the MRS, receptors would have access to MEC on surface and in subsurface soil if they exist.

11.6.4.5 Receptors

Human receptors identified for the Lake Denmark – Off-Post MRS include both current and anticipated future land users. Human receptors include Sterigenics workers, utility workers, contractors, and visitors. Additional receptors could include recreationists including hunters and hikers.

Ecological receptors (biota) for the purposes of the revised MEC CSM at the Lake Denmark – Off-Post MRS are identified as the listed and unlisted mammals, birds, and wetland species known to be present at PTA and the vicinity, based on the MRS physical setting, reasonably anticipated to be present on either a permanent or transient basis. Undeveloped, forest exists within the MRS with a dominant canopy forest species belonging in the red oak subgroup. Ecological receptors known to be present, in the vicinity of the MRS, at the Lake Denmark include fish; birds, including waterfowl, wading birds, piscivorous birds, songbirds, and raptors; reptiles; amphibians; and mammals. Four state-listed endangered aquatic plant species occur in Lake Denmark, including featherfoil (Hottonia inflate), Robbin's pondweed (Potamogeton robbinsii), small bur (Sparganium minimum), and lesser bladderwort (Utricularia minor). The Lake Denmark – Off-Post MRS is also located near a summer roosting area for the federally endangered Indiana bat.

11.6.4.6 Munitions and Explosives of Concern Exposure Conclusions

Given that no MEC source has been identified and an explosive safety hazard is not anticipated to exist at the Lake Denmark – Off-Post MRS, there are no activity/access/receptor interactions ongoing or anticipated under current or future land use where the receptor may come in contact with MEC. As a result, the revised CSM for MEC identifies incomplete pathways for surface and subsurface soils for all receptors having access to the MRS.

11.6.5 Uncertainties

The primary uncertainty for the RI results for the Lake Denmark – Off-Post MRS is related to the areas that were able to be investigated during the RI. The investigation area and several transects extended beyond the MRS boundary. The investigation was conducted outside the MRS boundary because of the 60mm mortar that was encountered along the PSE&G power line right of way near PTA boundary. This was the first known MEC item recovered near the Lake Denmark – Off-Post MRS and it was therefore deemed prudent to extend the investigation to as near as the mortar location as possible. However, as shown on **Figure 5-37** (areas where the visual survey transects do not overlap the proposed transects), transects were unable to be collected in this area as well as other areas that were identified as inaccessible by the field team. Transects along the northern MRS boundary were unpassable because of water and vegetation making visual surveys ineffective. The northeastern most corner of the MRS was turned into a parking area for PSE&G power line right of way activities. A small area in the southern portion of the MRS was inaccessible because of the Lake Denmark cove and associated wetlands. Therefore it is possible that additional subsurface anomalies, with the potential to be MEC, could be present in the areas that were unable to be investigated. However, it is unlikely that the Lake Denmark – Off-Post MRS would have been impacted by mortars fired from the Lake Denmark mortar range, due to the location of an observation point for the Lake Denmark mortar ranges, shown on **Figure 1-12**. In order to impact the MRS, mortars would need to have been fired near and/or beyond the observation point, which would have posed a safety hazard to personnel. Therefore the uncertainty related to potential MEC items within the areas unable to be investigated is low.

11.6.6 Conclusions and Recommendations

The following conclusions for the Lake Denmark – Off-Post MRS based on the results of the RI

field investigations:

- A total of 5.84 miles were investigated at the MRS during the RI and exceeds the proposed coverage of 4.88 miles. In addition to the RI field work, a significant majority the MRS was traversed and covered (surface and subsurface) during previous environmental studies associated with the RTI Superfund site.
- No evidence of MEC or MD was identified during the RI field activities or other activities associated with the MRS.
- The nature and extent of MEC and MD has been adequately defined at the MRS. One 60mm mortar, documented as high explosive (HE), has been recently encountered along the PSE&G power line right of way, approximately 500 ft north of the MRS, near (and possibly outside of) the installation boundary. The exact origin of the 60mm mortar recovered to the north of the MRS is unknown but its location does not appear to be consistent with the RI results.
- MC sampling was not warranted since no MEC or MD was found at the MRS during the RI field activities.

After evaluating the RI results and coverage of previous studies, it is determined that the DQOs for the Lake Denmark – Off-Post MRS have been satisfied and the MRS has been adequately characterized. Based on these conclusions, an FS is recommended to assess a No Further Action response alternative for the Lake Denmark – Off-Post MRS (AEDB-R-ID: PICA-0012-R-01).

11.7 INACTIVE MUNITIONS WASTE PIT MRS

This section summarizes the results of the RI activities conducted at the Inactive Munitions Waste Pit MRS (PICA-013-R-01) located at PTA. The RI objective was to define the nature and extent of MEC burial areas and determine whether a MEC release had occurred.

11.7.1 Summary of RI Activities

The preliminary CSM for the Inactive Munitions Waste Pit MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4 of the RI Report. In general, the data needs and DQOs focused on detecting and assessing whether a MEC release existed in the MRS.

A total of 6,163 linear feet of EM31-MK2 transects were surveyed within the Inactive Munitions Waste Pit MRS. No intrusive investigations for MEC were performed along the DGM transects employed to define the lateral extent of buried debris, as the presence of MEC and MD is

considered to be confirmed based on the available historical information. However, limited intrusive investigation within the Inactive Munitions Waste Pit MRS was performed during the co-located IRP trench excavation including visual inspection and characterization sampling for MC, which is described in Section 5.9.2.

Based on the 6,163 linear feet of DGM transects conducted within the MRS, the lateral and vertical extent of a large waste pit has been determined and is presented in **Figure 6-24**. The waste pit area is estimated to extend laterally over 0.24 acre (10,498 square feet) from ground surface down to bedrock, approximately 24.5 feet bgs. Assuming an even distribution of buried material, the approximate maximum volume of the waste pit is 257,201 cubic feet (9,526 cubic yards).

No anomalies were detected that warranted intrusive investigation during the 830 linear feet of analog transects performed within the Inactive Munitions Waste Pit MRS, around the periphery of the burial site identified via DGM and not overlapping with the AOI Code 300 Area.

A total of 3,020 linear feet of density transects were conducted in the area of the Inactive Munitions Waste Pit MRS overlapping with the AOI Code 300 Area. After the density transects were completed an analog grid Code300-12 (50 by 50 feet) was placed to characterize a potential high density area. A total of 14 anomalies were identified within the grid; only one item was identified as MD, an M42 submunition body, which was recovered from 3 inches bgs. The remaining 13 items were classified as cultural debris. The items were recovered between 0 and 3 inches bgs.

11.7.1.1 Summary of Non-RI Intrusive Investigation

Shaw E & I completed an intrusive investigation, consisting of trenching activities, under the IRP to investigate the source of a TCE plume (Shaw, 2010) at the former testing area at the center of the Inactive Munitions Waste Pit MRS. The trench was intended to be a 60- ft trench with a depth extending into clean native soil or top of bedrock, the loose gravel nature of the fill material resulted in the final excavation of a test pit with an approximate 40-ft diameter opening at the surface and a final depth of 24.5 ft bgs terminating at the bedrock interface. The location of the trench is shown on **Figure 6-24**. During the intrusive investigation, MEC and MD were confirmed at the MRS. Only one MEC item was identified during the investigation, a CDU-10 (T-1)/B Canister with XM39E and XM44 (Gravel Mines) recovered during the 2011 phase of work. MD recovered during the trenching activities are listed below (Shaw, 2013):

Quantity	Description
1	Cartridge, Photoflash: Practice, M121, Expended
13	M72 Rocket Launcher for 66mm Rocket (LAW), Empty - no sights
1	XM31 Anti Tank Land Mine, Expended
1	155mm Fragment (ogive)
1	Aircraft Flare, MK45, Expended
1	PD Fuze, Expended
1	BLU 3/B plate
1	CDU-10 canister cover
3	BLU 39/B Skitters, CN/CS Tear Gas, Inert
7	40mm Grenade Cartridge Cases, Expended
1	Electric Blasting Cap, Expended
12	Fuzes M48, M51, M81 Series, M557 Series, and M572

11.7.1.2 Summary of MC Sampling Activities

As a result of both safety concerns and field observations of a potential for a release, MC sampling was conducted in a biased manner in conjunction with IRP sampling activities. RI samples were co-located with the IRP samples during trenching. Safety concerns regarding the loose nature of gravel fill encountered during excavation precluded entry into the trench to collect random samples. Additionally, clear visual observations during excavation of potentially impacted soil associated with buried debris indicated a need to collect biased samples.

Between May 22-24, 2012, three soil samples and one field duplicate, were collected and analyzed for the MC list given in **Table 5-5** and perchlorate. Samples were collected in accordance with the Final RI Work Plan (WESTON, 2012). Field sheets and photographs for the sampling event are provided in **Appendix M**. The samples were collected at various depths from soil associated with buried debris, as well as from soil below the observed burial area. The sample locations and depths are shown on **Figure 6-24**. Sample PTA-2012-IMWP-002 was collected from soil directly below a drum which was observed to contain MD in the form of various fuzes and leaking fluids, and represented the most impacted soil that was assessed based on field observations (i.e., “worst case scenario”). Refer to **Table 6-16** for additional details. Only one explosive compound, 2,4-dinitrotoluene, in one sample was detected at a concentration (8.3 mg/kg) above the project screening level selected to assess human health (1.6 mg/kg). Aluminum was detected in all samples at a concentration of 11,000 mg/kg, which was slightly above the project screening of 7,700 mg/kg selected to assess a target HQ of 0.1. Cadmium was detected in one sample (PTA-2012-IMWP-002) at a concentration of 29 mg/kg, which slightly exceeded the project screening level of 7 mg/kg, which was also selected to assess a target HQ of

0.1. Zinc was the only other metal analyte detected at notable concentration, which was 190 mg/kg in one sample (PTA-2012-IMWP-002) and slightly above the PTA-specific background value of 77 mg/kg, but well below the project screening level of 2,300 mg/kg. Detailed information for all these samples can be found in **Appendix M**.

11.7.2 Munitions and Explosives of Concern Hazard Assessment

The Inactive Munitions Waste Pit MRS has a Hazard Level Category of 3, which indicates the MRS has a moderate potential explosive hazard condition.

11.7.3 Summary of Risk Assessments

Evaluation of the available analytical data collected during the RI and co-located IRP investigation, in addition to field notes and observations made during intrusive investigation of the Inactive Munitions Waste Pit MRS, indicate that risks to human health are not present from MC associated with the buried debris. No metals were selected as COPCs given that the two analytes observed in excess of initially selected screening levels were found to be below PTA-specific background values, and/or below alternative screening levels (adjusted upwards to assess a target HQ of 1.0). All explosives compounds analyzed in the biased soil samples, except for one, were found to be below project screening levels. The one exceedance was an estimated detection of 2,4-DNT in soil collected from 24 feet bgs at the very bottom of the test trench and below the observed debris. As 2,4-DNT was not detected in the co-located IRP sample, or any other of the biased samples collected from soil in contact with buried debris, and has negligible potential for exposure due to depth and no confirmed groundwater impacts, it was not selected as a COPC and no risks were identified.

11.7.4 Revised MEC Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate if the development of an MC CSM was warranted. An MC CSM was developed and provided in Section 10.8.5.

11.7.4.1 Source

Confirmed MEC discovered at the Inactive Munitions Waste Pit MRS consists of one gravel mine canister (Shaw, 2013). Intrusive operations during the IRP activities recovered MD at the former testing area in the center of the Inactive Munitions Waste Pit MRS consisting of: M72

Rocket Launcher for 66mm (LAW) rockets, CN/CS teargas canisters (inert), expended 40mm grenade cartridge cases, an exploded XM31 antitank landmine, 155mm fragments, expended MK45 aircraft flare, and expended PD fuzes (Shaw, 2013). Outside the former testing area in the remainder of the MRS, one MD item was identified, in the AOI Code 300 grid Code300-12 as an M42 submunition body.

Consistent with the historical information reviewed, the findings of IRP intrusive investigations performed during the RI, and the one MD identified during the RI, positively identified MD and DMM comingled with other debris (e.g., drums) as waste buried from 10 to 20 feet bgs. The debris layer was observed below unconsolidated fill material, and terminated approximately 4.5 feet above where bedrock was encountered at 24.5 feet bgs within the excavated test trench. Based on surface DGM performed during the RI, the lateral extent of debris was observed to encompass approximately 0.24 acres within the Inactive Munitions Waste Pit MRS boundary.

Although the IRP trench investigation identified debris located primarily below 10 feet, intrusive operations performed elsewhere within the former burial pit during the IRP trench investigation have discovered MD and MEC within 10 feet of ground surface. Specifically, one DMM item, a gravel mine canister, was encountered at 4.5 feet bgs (Shaw, 2013). Assuming an average distribution of debris is buried within the Inactive Munitions Waste Pit MRS, the volume of the source area for residual MEC at the MRS is calculated to be 257,201 cubic feet (9,526 cubic yards).

In the AOI Code 300 Area, only one MD item was identified in Grid Code300-12 during the RI, an empty M42 submunition body at 3 inches bgs. No MEC was identified within the AOI Code 300 area, including the portions in the Former Operational Areas MRS and 1926 Explosion Radius MRS. As previously discussed in Section 5.9.1.2, surveying in the AOI Code 300 Area was completed to meet VSP input and coverage parameters and exceeded the minimum requirements defined in the Final Work Plan for RI characterization (WESTON, 2012).

Based on the weight of evidence obtained during the RI, the MEC density in the former testing area/burial pit is considered high compared to the surrounding portions of the Inactive Munitions Waste Pit MRS where no MEC was identified. There is evidence that MEC remains at the former testing area/burial pit at the center of the Inactive Munitions Waste Pit MRS comingled with debris in subsurface soil, and MD at ground surface in the portion that overlaps with the AOI Code 300 Area. Based on RI observations, the bulk of buried debris containing potential

MEC is located from 10 to 20 feet bgs, although activities document one MEC discovery in the Inactive Munitions Waste Pit MRS at 4.5 feet bgs. Based on the 0.24-acre lateral extent of the burial pit characterized via DGM and assuming and even distribution of debris down to bedrock, the estimated quantity of waste material remaining containing MEC, and MD is 257,201 cubic feet (9,526 cubic yards).

11.7.4.2 Access

PTA has existing ICs and LUCs in place including, but not limited to, issuing safety permits for work on PTA, conducting UXO construction support, as required, during intrusive work, and requiring appropriate personnel to attend a safety course(s).

Currently, the Inactive Munitions Waste Pit MRS is a restricted access area (fully fenced) within PTA that abuts operational ranges to the east and south, with the installation boundary forming the northwestern extent of the MRS. The Inactive Munitions Waste Pit MRS is only accessible to authorized personnel. Control measures maintained by PTA for the Robinson Enclosure area, which encompasses the MRS, include fencing, guarded access points, pre-authorization requirements for access, and escorts for visitors. The current access restrictions are not anticipated to change in the future, and the Inactive Munitions Waste Pit MRS is not currently included in any future overall redevelopment plans for PTA because of its proximity to operational ranges.

Once within the MRS boundary, potential receptors would have access to any MEC in surface or subsurface soil outside the burial area. Within the burial area potential receptors would have access to any MEC in the subsurface only, but is highly unlikely to occur given the depth of confirmed MEC (at least 4.5 feet bgs), and the observed depth of the bulk of debris characterized during the RI, which was found to contain MEC at depths equal to and greater than 10 feet bgs. However, personnel/contractors attempting to remediate the TCE (reason for IRP trenching) could come in contact with any MEC in the subsurface.

11.7.4.3 Activity

Authorized PTA personnel and/or contractors currently use the center portion of the Inactive Munitions Waste Pit MRS for material and equipment staging (e.g., vehicles, sand, and gravel), The current use is not anticipated to change in the future, and the Inactive Munitions Waste Pit

MRS is not currently included in any future overall redevelopment plans for PTA because of its proximity to operational ranges. Intrusive activities may be required by authorized PTA personnel or contractors. Visitors may be authorized to enter the MRS and would potentially engage in the same activities described for PTA personnel/contractors. Recreational use within the Inactive Munitions Waste Pit MRS is allowed for hunting in a regulated manner. Hunting is permitted only on Saturdays and holidays and is restricted to only five hunting individuals at one time within the Robinson Enclosure area.

Although trespassers were considered as potential human receptors based on information available when the SI was performed, the findings of the RI do not support this potential category of receptors and trespassers are not being carried forward as receptors in the revised CSM. The control measures observed to be maintained by PTA for the Robinson Enclosure area, which encompasses the Inactive Munitions Waste Pit MRS, include fencing, guarded access points, pre-authorization requirements for access, and escorts for visitors. Thus, the potential for trespassers to be exposed to residual MEC is highly unlikely.

As a result of the restricted access provided by the fence around the Inactive Munitions Waste Pit MRS, the current use of the property for equipment/material staging, and the largely open ground surface where the burial pit has been delineated based on DGM, biota activities are expected to be limited within the MRS at the burial site primarily to activity in soil located within 2 feet bgs. Sparse forested areas, including some shrubby habitat, surround the Inactive Munitions Waste Pit MRS but none of the natural communities occupy land where the former burial pit has been delineated. The NJDEP i-Map Landscape Project layer indicates that the MRS contains habitat with at least one occurrence of a state-listed threatened species.

11.7.4.4 Receptors

Authorized PTA personnel and/or contractors currently use the center portion of the Inactive Munitions Waste Pit MRS for material and equipment staging (e.g., vehicles, sand, and gravel). The current use is not anticipated to change in the future, and the MRS is not currently included in any future overall redevelopment plans for PTA due to its proximity to operational ranges. Intrusive activities may be required by authorized PTA personnel or contractors. Visitors may be authorized to enter the Inactive Munitions Waste Pit MRS and would potentially engage in the same activities described for PTA personnel/contractors. Recreational use within the MRS is

allowed for hunting in a regulated manner. Hunting is permitted only on Saturdays and holidays and is restricted to only five hunting individuals at one time within the Robinson Enclosure area.

Although trespassers were considered as potential human receptors based on information available when the SI was performed, the findings of the RI do not support this potential category of receptors and trespassers are not being carried forward as receptors in the revised CSM. Observations of the control measures maintained by PTA for the Robinson Enclosure area make the potential for trespassers to be exposed to residual MEC highly unlikely.

Due to the restricted access provided by the fence around the Inactive Munitions Waste Pit MRS, the current use of the property for equipment/material staging, and the generally open ground surface where the burial pit has been delineated based on DGM, biota activities are expected to be limited within the MRS at the burial site to primarily activity in soil located within 2 feet bgs. Sparse forested areas, including some shrubby habitat, surround the Inactive Munitions Waste Pit MRS but none of the natural communities occupy land where the former burial pit has been delineated. The NJDEP i-Map Landscape Project layer indicates the MRS contains habitat with at least one occurrence of a state threatened species.

Human health receptors identified for the Inactive Munitions Waste Pit MRS include both current and anticipated future land users. At this time, current and future users are considered to be coincident and consist of authorized PTA personnel, contractors, visitors (e.g., regulatory personnel), and recreational users. Unauthorized trespassers are highly unlikely given the controlled access to the Inactive Munitions Waste Pit MRS.

For the Inactive Munitions Waste Pit MRS, potential ecological receptors (biota) for the purposes of the revised MEC CSM were identified as the listed and unlisted mammals, birds, and vegetation species known to be present at PTA and based on the MRS physical setting (detailed in Section 3), which could be present on either a permanent or transient basis. The NJDEP i-Map Landscape Project layer indicates the MRS contains habitat with at least one occurrence of a state threatened species. Sparse forested areas, including some shrubby habitat, surround the Inactive Munitions Waste Pit MRS, but none of the natural communities occupy land where the former burial pit was delineated employing DGM during the RI. Although present within the MRS, an exposure pathway to confirmed MEC at the Inactive Munitions Waste Pit MRS to ecological receptors is highly unlikely to occur given the depth of confirmed MEC (at least 4.5

feet bgs) and the observed depth of the bulk of debris characterized during the RI, which was found to contain MEC in the form of DMM at depths equal to and greater than 10 feet bgs.

11.7.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC are considered complete because MEC was found within the burial area of the Inactive Munitions Waste Pit MRS. Complete exposure pathways exist for the PTA personnel who may contact, MEC in the subsurface soil. Complete pathways for the confirmed subsurface MEC source were identified for authorized human health receptors engaging in intrusive activities in the Inactive Munitions Waste Pit MRS, because of the restricted access and current use/activities ongoing within the MRS, neither of which is expected to change based on the proximity to operational ranges. Surface MEC related to historical burial of munitions or use pertaining to the AOI Code 300 Area was not observed during the RI. MD was only discovered at ground surface in the AOI Code 300 Area overlap area. Surface MEC exposure pathways are not anticipated to be present to human receptors given that buried debris containing confirmed MEC has been detected deeper than 4 feet bgs where environmental factors (e.g., frost) may bring subsurface MEC to the surface in the Inactive Munitions Waste Pit MRS.

The exposure pathways are incomplete for biota that may contact MEC in the subsurface soil during burrowing based on the confirmed location of MEC source material at depth in subsurface soil. The pathway to ecological receptors is probably present, but incomplete as no MEC source material was confirmed within 2 feet of ground surface where biota activity is most likely.

11.7.5 Revised MC Conceptual Site Model

This section summarizes the RI data results for the MC exposure pathway analysis for the Inactive Munitions Waste Pit MRS. Each pathway includes a source, release mechanisms, exposure routes, media, and receptors, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MC) is known to exist and when receptors have access to the Inactive Munitions Waste Pit MRS while engaging in some activity that results in contact with the source. A pathway is considered potentially complete when a source (MC) has not been confirmed but is suspected to exist and when receptors have access to the MRS while engaging in some activity that results in contact with the source. Last, an incomplete pathway is any case where one of the four components (source, access, activity, or receptors) is missing from the MRS.

Historical data collection has included surface soil and sediment evaluation for MC as reported in the HRR and included in the pathway analysis developed following the SI (Malcolm Pirnie, 2008). Although no COPCs or COPECs were identified following the SI, potentially and/or complete pathways were identified to both human health and ecological receptors for some of the pathways evaluated based on historical data therefore, additional MC characterization was completed during the RI at the Inactive Munitions Waste Pit MRS. Based on the characterization efforts, the findings of the RI were used to update the preliminary CSM for MC to determine whether the pathway for MC is complete or incomplete for potential human health and ecological receptors at the Inactive Munitions Waste Pit MRS.

11.7.5.1 Source

Potential MC was assessed at the Inactive Munitions Waste Pit MRS in soil found directly in contact with DMM intermingled with other debris. Although the bulk of the debris was observed at depths between 10 and 20 feet bgs during the RI in 2012, the 2011 discovery of a gravel mine canister (identified as MEC) occurred at a depth of 4.5 feet bgs (Shaw, 2013). Geophysical data acquisition during the RI indicates that the burial pit is present over a 0.24 acre portion of the Inactive Munitions Waste Pit MRS with a conservative volume of approximately 257,201 cubic feet (9,526 cubic yards), assuming the depth of debris extends to bedrock (approximately 24.5 feet bgs).

Historical information regarding the type of munitions that may have been buried at the Inactive Munitions Waste Pit MRS is inconclusive The list of MEC and MD identified during the IRP trenching activities is included in Section 6.8.2.1.3. Therefore, MC sampling evaluated perchlorate and the baseline list of explosives and metals, which were identified in the UFP-QAPP prepared for the RI based on munitions typically associated with historical PTA activities (WESTON, 2012).

Discrete sampling conducted during the MMRP RI and during collocated IRP activities at biased locations associated with discovered munitions-related debris has not indicated elevated concentrations of MC above selected screening levels are present (see Section 6.8.4 and Shaw, 2013). During the RI, various compounds, including all metals analyzed and several explosives compounds, were positively detected by the laboratory in the biased samples (see the Inactive Munitions Waste Pit MRS MC Summary Table in **Appendix M**), but only one sample analyzed by

the laboratory yielded results that indicated a screening level exceedance. The compound 2,4-dinitrotoluene was detected at a concentration of 8.3 mg/kg, which exceeds the selected screening level of 1.6 mg/kg in the sample collected from native soil just above bedrock and approximately 4 feet below the bulk of buried debris observed during the RI. The 2,4-dinitrotoluene was only detected in one sample at the greatest depth sampled (24-24.5 ft bgs) and was not detected in the groundwater, surface water, or sediment sampling conducted for the 600 Area. Therefore, based on a weight of evidence approach that incorporates both exposure potential and supplement data from collocated IRP activities, inferring that a hazardous release of MC is not present from potential source material, and 2,4-dinitrotoluene was not selected as a COPC.

All metals analytes, except for antimony, were positively detected by the laboratory. However, only aluminum, cadmium, and zinc were detected at levels that warranted further review for COPC selection. Aluminum was detected in all samples at a concentration of 11,000 mg/kg, which was slightly above the project screening level of 7,700 mg/kg selected to assess a target HQ of 0.1. Cadmium was detected in one sample (PTA-2012-IMWP-002) at a concentration of 29 mg/kg, which slightly exceeded the project screening level of 7 mg/kg selected to assess a target HQ of 0.1. Adjusting the screening levels upwards to assess a target HQ of 1.0 equivalent to the published value resulted in nonselection as a COPC because the observed concentrations were well below the alternative screening levels. Zinc was the only other metal analyte detected at notable concentration, which was 190 mg/kg in one sample (PTA-2012-IMWP-002) and slightly above the PTA-specific background value of 77 mg/kg, but well below the project screening level of 2,300 mg/kg. Neither aluminum, cadmium, nor zinc was identified as a COPC for further quantitative analysis.

11.7.5.2 Release Mechanisms, Exposure Media and Routes

Release of MC to environmental media occurs initially through direct contact at the munitions impact/disposal site. The potential source area for MC at the Inactive Munitions Waste Pit MRS is buried munitions-related debris, the bulk of which was observed at depths between 10 and 20 feet bgs; therefore, the primary release mechanism is adsorption to adjacent soil. Based on biased analytical sampling of soil in direct contact with buried debris including DMM, a direct release of MC to soil was not observed. When present, MC in soil has the potential for secondary release via infiltration within soil or leaching to groundwater; however, the lack of an identified MC

source in soil infers that this potential transport mechanism is not contributing concentrations of MC to groundwater at the Inactive Munitions Waste Pit MRS. Groundwater at PTA is regulated under the IRP and was not assessed within the MRS as part of the MMRP RI (see Section 9.2).

Sediment and air are not anticipated to be primary or secondary release exposure media for MC associated with historical munitions burial in the Inactive Munitions Waste Pit MRS based on the depth of debris observed during the RI. Exposure routes for MC to affect potential receptors include ingestion, incidental ingestion, inhalation, and direct contact based on specific media to receptor pathways. There are no surface water bodies present in the Inactive Munitions Waste Pit MRS.

When biota are exposed to elevated concentrations of MC in environmental media, uptake via food chain interactions has the potential to bioaccumulate and affect human receptors engaging in hunting/consumption of contaminated organisms.

11.7.5.3 Receptors

MC exposure receptors are the same as MEC exposure receptors within the PTA boundary:

- Authorized PTA personnel and contractors.
- Visitors and recreational users.
- Biota.

All potential release mechanisms, exposure routes, and media were considered in evaluating the MC source-receptor interactions at the MRS based on the available information for the Inactive Munitions Waste Pit MRS following the RI.

11.7.5.4 Munitions Constituents Exposure Conclusions

As shown on **Figure 6-26**, all considered pathways in the exposure analysis for MC at the Inactive Munitions Waste Pit MRS were determined to be incomplete.

Based on the location of observed debris with MEC in subsurface soil, primary or secondary release to sediment/surface water and air is not anticipated to be exposure pathways of concern as there is no source impacting the media. Similarly, no source for exposure to potential ecological receptors is probable based on the depth of buried debris. Therefore, the exposure pathways are incomplete on **Figure 6-26**.

For the Inactive Munitions Waste Pit MRS, current conditions within the MRS boundary limit access (direct-contact exposure) to any potential subsurface MC to authorized PTA personnel, including visitors, or contractors conducting construction/maintenance activities, and regulated recreational use for hunting. Currently, use of the MRS by authorized personnel is limited to ground surface activities, although intrusive work could be required.

Although analytical sampling did detect some MC compounds in biased samples collected adjacent to discovered munitions-related debris, the concentrations were not found to be indicative of a release that would present a source of MC contamination that would adversely affect potential receptors. Low levels of MC are present, the subsurface soil pathway for MC exposure to human health receptors within the Inactive Munitions Waste Pit MRS was found to be incomplete for all receptors except authorized PTA personnel or contractors that may perform a removal action in accordance with the proposed alternative for the 600 Area Groundwater Plume FS (Shaw, 2013). For these receptors the pathway is considered potentially complete because the removal action alternative has yet to be chosen at the preferred alternative.

Within the MRS boundary, groundwater is not currently extracted/used and was not observed in direct contact with buried debris. Therefore, the groundwater pathway for MC exposure to human health receptors within the Inactive Munitions Waste Pit MRS was found to be incomplete. However, the potential for MC to leach over time and affect human health receptors from the aquifer downgradient of the MRS was additionally evaluated employing IRP data being collected to assess groundwater associated with the 600 Area. Based on the data, last collected in 2008, the only explosive detected was RDX in one well (Shaw, 2009). The source is being addressed under the IRP (the recommendation of NFA has since been approved) and is not believed to be associated with the Inactive Munitions Waste Pit MRS. The chemical 2,4-dinitrotoluene, which was the only MC compound detected at concentrations greater than the screening level in RI soil samples, was not detected by the laboratory at any concentration greater than the method detection limits (Shaw, 2009).

11.7.6 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Inactive Munitions Waste Pit MRS is associated with the incomplete record of the historical operations at the MRS.

Although the Inactive Munitions Waste Pit MRS name suggests that materials might have been buried in pits, there was no site feature or other evidence in either historical report indicating that burial of munitions took place in the area. Additionally, the 2006 IAP Report indicates that collected anecdotal information shows that after 1965, all material generated from munitions testing was removed and transported to the Picatinny Burning Ground.

Additional historical research was performed as part of the RI during work plan development for the Inactive Munitions Waste Pit MRS because of recent IRP studies and their findings of DMM, consisting of a CDU-10/B gravel mine canister and numerous MD. Part of the additional research included historical aerial photograph analysis as well as meeting with the IRP contractor to discuss its findings.

Observations from aerial photographs show that the former testing area has been used as a disposal site for the last 40 years. Layers of fill and debris have been stacked at the former testing area and periodically leveled since the early 1960s. Recent intrusive work shows that debris is scattered throughout the former testing area. Although MD has been recovered, the MEC density has been found to be low, consisting of only one DMM (CDU-10/B gravel mine canister). The boundary of the former testing area is clearly defined by the aerial photographs. Overall cultural debris, munitions debris, and MEC have been found to be intermixed throughout the entire former testing area.

Historical records and aerial photography also indicate that the potential testing area in the center of the Inactive Munitions Waste Pit MRS was filled with up to 12 feet of sand, gravel, and rock during the 1980s and 1990s (Malcolm Pirnie, 2006). The fill work has most likely obscured any surface signs of former use as a disposal or burial area. It was also reported that metal objects have been found partially buried at the Inactive Munitions Waste Pit MRS, but none of the objects identified constituted MEC or munitions debris (Malcolm Pirnie, 2006).

Prior to the discovery of DMM, consisting of a gravel mine canister during IRP trenching activities, no MEC had been identified within the Inactive Munitions Waste Pit MRS, and the MRS was unconfirmed as a burial area, with only metallic non-munition related debris identified at ground surface.

MEC, including DMM and MD, have been released in the Inactive Munitions Waste Pit MRS from former testing activities and munitions disposal. Confirmed MEC discovered at the MRS

consists of one gravel mine canister identified as DMM (Shaw, 2013). IRP intrusive trenching operations have also discovered MD at the Inactive Munitions Waste Pit MRS, consisting of LAW rocket tubes, M72 Rocket Launcher for 66mm (LAW) rockets, CN/CS Teargas canisters, expended 40mm grenade cartridge cases, an exploded XM31 Antitank landmine, 155mm fragments, expended MK45 aircraft flare, and expended PD fuzes. The nature of MEC within the burial area is potentially incomplete, however a large list of munitions were identified during the IRP trenching activities. Based on the RI results, munitions types existing within the former testing/burial area could be anything used at PTA prior to the 1960s. The extent has been well defined during DGM surveys and IRP trenching activities.

11.7.7 Conclusions and Recommendations

The following conclusions can be made for the Inactive Munitions Waste Pit MRS based on the results of the RI field activities:

- A burial pit feature was confirmed to be present based on DGM performed at ground surface extending over 0.24 acre laterally within the MRS boundary.
- Previous site investigations and intrusive investigations performed during the RI confirm that MD and MEC are present, comingled with other debris containing constituents being addressed under the IRP.
- MEC identified during the RI intrusive investigation was limited to DMM, which was identified in subsurface soil at 4.5 ft bgs, however the majority of the debris was between 10 and 20 feet bgs.
- MD was recovered at ground surface from the portion of the MRS that overlaps with the AOI Code 300 Area only.
- An estimated volume of 257,201 cubic feet (9,526 cubic yards) of fill material with debris containing MEC and MD remains within the MRS boundary.
- An explosive safety hazard may exist at the Inactive Munitions Waste Pit MRS, based on the discovery of MEC.
- The extent of buried debris containing DMM and MD present as a result of past munitions testing/burial within the Inactive Munitions Waste Pit MRS has been adequately defined and the nature of the buried debris has been determined to the extent that intrusive investigation was practical.
- The extent of MD present as a result of artillery firing and fragmentation pattern testing within the AOI Code 300 Area has been adequately defined.
- MEC pathways to potential receptors with subsurface exposure potential at the MRS

have been determined to be complete.

- MEC pathways to potential receptors with surface exposure only at the Inactive Munitions Waste Pit MRS have been determined to be incomplete for lack of a confirmed source for MEC at ground surface or within the subsurface at depths that are likely to be susceptible to transport to the surface.
- All MC pathways to potential receptors at the MRS have been determined to be incomplete for lack of a confirmed release/source.

It has been determined that the DQOs for the Inactive Munitions Waste Pit MRS have been satisfied and that the MRS has been adequately characterized. Although no MEC was found during the RI investigation, and although access is tightly restricted/regulated within the MRS, future risk management is likely warranted regarding the significant quantity of DMM and MD identified during IRP activities, in the Inactive Munitions Waste Pit MRS. Authorized users may engage in subsurface activities within the MRS; therefore, a Feasibility Study is recommended to address future management of MEC and MD present in the Inactive Munitions Waste Pit MRS.

11.8 INACTIVE MUNITIONS WASTE PIT – OFF-POST MRS

This section summarizes the results of the RI activities conducted at the Inactive Munitions Waste Pit – Off-Post MRS (PICA-014-R-01) located at PTA. The RI objective was to determine whether MEC was present in the MRS and approximate the density. The RI also provides additional data to assist in determining what remedial alternatives, if any, are necessary.

11.8.1 Summary of RI Activities

The preliminary CSM for the Inactive Munitions Waste Pit – Off-Post MRS aided in the development of data needs and DQOs as documented in the Final RI Work Plan and summarized in Section 4 of the RI Report. In general, the data needs and DQOs focused on determining the nature and extent of MEC.

A total of 6,780 linear feet (1.51 acres) of analog surveys were performed using a White's MXT All-Metals detector in the Inactive Munitions Waste Pit – Off-Post MRS as depicted on **Figure 5-40**.

Based on the 6,780 linear feet (1.51 acres) of analog transects completed in the Inactive Munitions Waste Pit – Off-Post MRS, a total of six anomalies were intrusively investigated, which are depicted on **Figure 6-27**. Four MD were identified, a 37mm projectile and three

fragments, as well as two cultural debris items. The MD was identified just below ground surface between 2 and 4 inches bgs and all items were determined to be MDAS prior to final transfer to PTA. The two cultural debris items were identified as a piece of scrap metal and a metallic bolt and were discovered at 1 inch bgs.

11.8.2 Munitions and Explosives of Concern Hazard Assessment

No MEC has been observed at the Inactive Munitions Waste Pit – Off-Post MRS during the SI, RI, or on any other occasion; therefore, a MEC HA was not conducted.

11.8.3 Summary of Risk Assessments

No characterization activities were required during the RI to assess MC within the Inactive Munitions Waste Pit – Off-Post MRS based on munitions-related findings. There was no evidence that a potential MC release had occurred, therefore no samples were collected in the MRS. As a result, the project team determined that a Risk Assessment was not warranted for the Inactive Munitions Waste Pit – Off-Post MRS.

11.8.4 Revised Conceptual Site Model

The information collected during the RI field activities was used to update the MEC CSM and evaluate whether the development of an MC CSM was warranted. It was determined during the RI that an MC CSM was not warranted because a release was not identified. The MC exposure conclusions are provided in Section 11.8.4.6.

11.8.4.1 Source

Based on the available historical information, MEC and MD could have been released in the Inactive Munitions Waste Pit – Off-Post MRS as it falls within the SDZ for the on-post Inactive Munitions Waste Pit MRS. The previous munitions use at the Inactive Munitions Waste Pit MRS was undocumented. Potential uses may have included the evaluation of munitions and static testing of explosives and propellants, which could have resulted in munitions being kicked-out from the testing area into the Inactive Munitions Waste Pit – Off-Post MRS. MD discovered at the MRS during the RI was limited and consisted of one 37mm projectile and three fragments, all found within 6 inches of ground surface. All MD was determined to be MDAS and is likely associated with a release from the testing conducted at the Inactive Munitions Waste Pit MRS.

The highest density of anomalies that was detected occurred in the southwestern portion of the MRS, and although MD was confirmed to be present, no MEC was discovered. Based on the DQOs and RI objectives established in the Final Work Plan and discussed in Section 4.9, intrusive investigations achieved the RI objective for coverage and did not identify a MEC source.

11.8.4.2 Access

No MEC was identified within the Inactive Munitions Waste Pit – Off-Post MRS; therefore, potential receptors would not have access to MEC. However MD was identified and would be accessible to any potential receptors within the MRS. MD was discovered during the RI within 6 inches of ground surface, making transport from subsurface to surface possible over time from fate and transport dynamics such as frost heave. The Inactive Munitions Waste Pit – Off-Post MRS does not have any physical boundaries, is owned by the State, and is open to recreational use.

As no change to the current land use is anticipated at this time, no modifications to access were contemplated for future use regarding MD exposure for any receptors that will access the Inactive Munitions Waste Pit – Off-Post MRS.

11.8.4.3 Activity

The Inactive Munitions Waste Pit – Off-Post MRS occupies land designated within a state-owned (NJDEP Division of Fish & Wildlife) Wildlife Management Area, that is vacant, steeply sloped and heavily forested (WESTON, 2012). Due to the steep topography, and limited accessibility because the nearest roadway is more than 0.5 mile away, this land is left unmaintained as a natural habitat. Recreational use (e.g., hunting, hiking) is permitted, but use for such purposes, if any, is believed to be extremely low.

All potential ecological receptors for PTA (see Section 3.1.7), except those associated with water bodies as there are none present within the MRS, are anticipated to be present and engage in activities within the MRS because it is an unmaintained forest within a Wildlife Management Area.

11.8.4.4 Receptors

Human health receptors identified for the Inactive Munitions Waste Pit – Off-Post MRS include both current and anticipated future land users and consist of State employees/contractors, PTA personnel/contractors, visitors, and recreational users. The potential for exposure to residual MD

for any human receptor is very low for the MRS because of its poor accessibility and steep topography.

All potential ecological receptors for PTA (see Section 6.8.3.1.4), except those associated with water bodies as there are none, are anticipated to be present and engage in activities within the Inactive Munitions Waste Pit – Off-Post MRS because it is an unmaintained forest within a Wildlife Management Area and falls within the Highlands Preservation Area. A habitat with at least one occurrence of a state-listed threatened species is present at the MRS, according to the NJDEP i-Map Landscape Project layer (WESTON, 2012).

11.8.4.5 Munitions and Explosives of Concern Exposure Conclusions

Exposure pathways for MEC at the Inactive Munitions Waste Pit-Off-Post MRS were determined to be present, but incomplete based on the lack of a confirmed MEC source.

11.8.4.6 Munitions Constituents Exposure Conclusions

As only four MD items were recovered during the geophysical survey conducted in the Inactive Munitions Waste Pit – Off-Post MRS, analytical sampling to assess MC was not warranted in accordance with the decision logic provided in the UFP-QAPP in the Final Work Plan (WESTON, 2012). The MC sampling and assessment for the on-post Inactive Munitions Waste Pit MRS did not identify a release of MC associated with the bulk of MEC, including DMM and MD; therefore, it is assumed that MC hazards are also not present off-post. The findings of the RI support the conclusion that pathways for MC are incomplete for the Inactive Munitions Waste Pit – Off-Post MRS.

11.8.5 Uncertainties

The primary uncertainty related to the evaluation of the RI results at the Inactive Munitions Waste Pit – Off-Post MRS is associated with the spatial coverage used to assess the extent of MEC at the MRS. The northwest portion of the MRS is steeply sloped, with limited accessibility for UXO technicians to perform surveys. To reduce uncertainty, mag and dig surveys were performed in all accessible areas at the top of the ridge and bottom of the slope in the northwest portion of the Inactive Munitions Waste Pit – Off-Post MRS. Mag and dig transects surveys were also conducted at 300-foot spacing in the remaining portions of the Inactive Munitions Waste Pit to detect potential MEC releases. Refer to **Figure 5-40** for locations of the transect surveys.

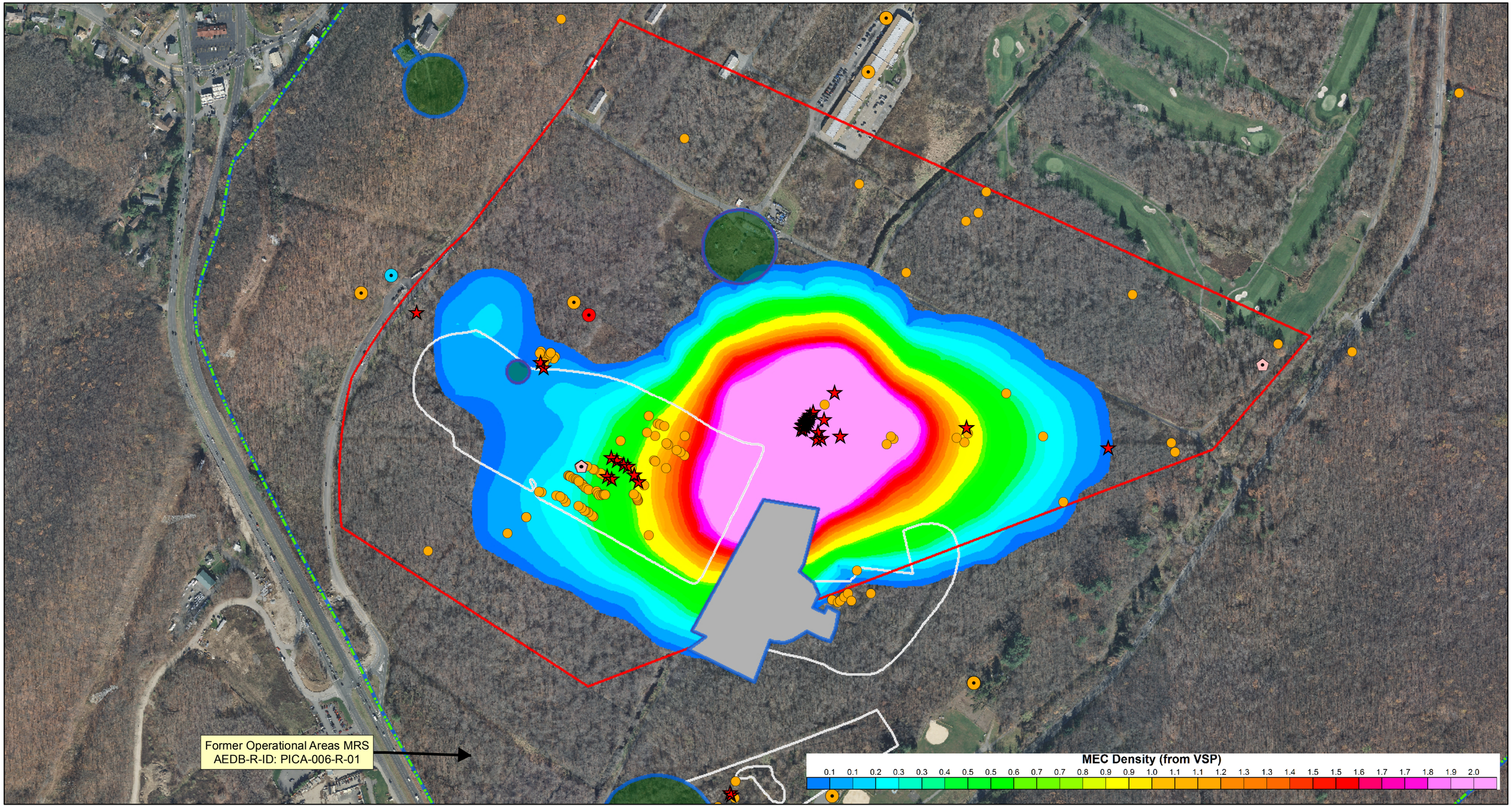
No MEC was identified within the MRS and only limited MD consisting of a 37mm projectile and three fragments were recovered near the PTA boundary. The Inactive Munitions Waste Pit – Off-Post MRS consists of 39 acres of the 1,250-foot SD centered on an area reportedly used as a former munitions test area and waste pit within the on-post Inactive Munitions Waste Pit MRS. No MEC was identified within the Inactive Munitions Waste Pit MRS either, excluding the former burial area. Based on the RI results at the Inactive Munitions Waste Pit – Off-Post MRS, combined with the results of the Inactive Munitions Waste Pit MRS, which was adequately delineated within the PTA boundary, the uncertainty that MEC is present at the Inactive Munitions Waste Pit – Off-Post MRS is low.

11.8.6 Conclusions and recommendations

The following conclusions can be made for the Inactive Munitions Waste Pit – Off-Post MRS based on the results of the RI field activities:

- No features indicative of the identified burial pit delineated on-post extend into the Inactive Munitions Waste Pit- Off-Post MRS.
- No MEC was identified during the SI or RI, and only four MD items have been recovered during the RI intrusive investigation.
- No MD has been identified at ground surface and the maximum depth of MD recovered during the RI was 4 inches bgs.
- An explosive safety hazard is not anticipated to exist at the Inactive Munitions Waste Pit – Off-Post MRS because a source for MEC has not been identified.
- All MEC and MC pathways to potential receptors at the Inactive Munitions Waste Pit – Off-Post MRS have been determined to be incomplete for lack of a confirmed source.

It has been determined that the DQOs for the Inactive Munitions Waste Pit – Off-Post MRS have been satisfied and that the MRS has been adequately characterized. Based on these conclusions, an FS is recommended to assess a No Further Action response alternatives for the Inactive Munitions Waste Pit – Off-Post MRS (AEDB-R-ID: PICA-014-R-01).



Legend

- Installation Boundary
- Military Response Sites
- Operational Range Areas
- Ineligible Area - Burning Ground
- Munitions Response Sites
- Former Operational Areas
- Mortar Range MRS
- DMM
- UXO
- Munitions Debris

UXO Finds Map Items

- Munitions Debris
- MEC
- Small Arms

NOTES:
Base Imagery: NJ 2012 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

WESTON SOLUTIONS

Figure 11-1
Former Operational Areas MRS
Range Fan and MEC Density

0 450 900 Feet
0 110 220 330 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

10/2/2014

Contract # W912DR-09-D-0006
DO 0002

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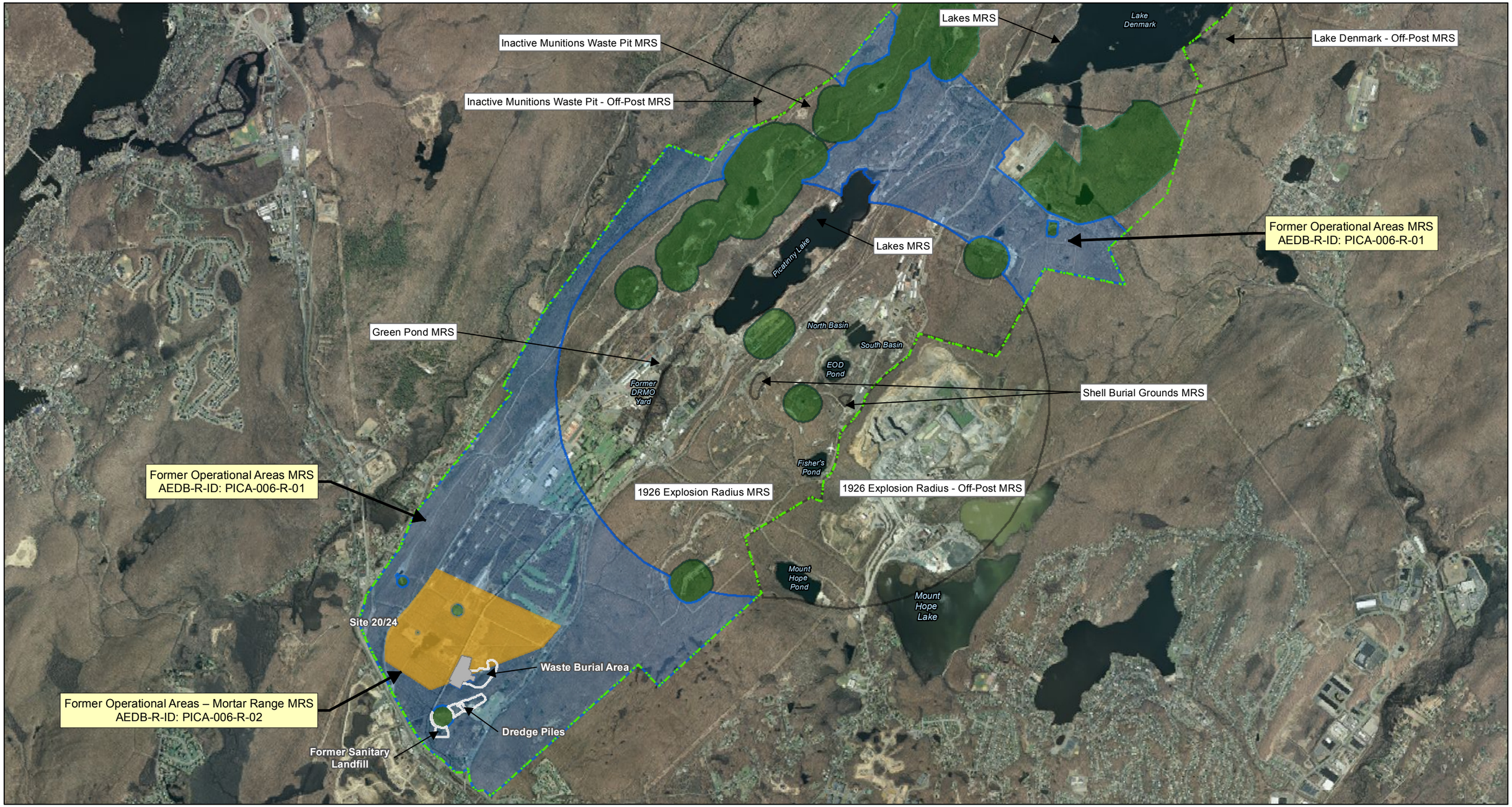

Legend

- Installation Boundary
- Operational Range Areas
- Munitions Response Sites
- Former Operational Areas
- Mortar Range MRS
- Ineligible Area - Burning Ground

NOTES:
Base Imagery: NJ 2007 Natural Color Imagery
Data Source: Army GIS Layers (August 2011)

Coordinate System: UTM Zone 18N
Datum: WGS84. Units: Feet

Picatinny Arsenal
Morris County,
New Jersey

N

0 2,500 5,000 Feet

0 620 1,240 1,860 Meters

Created By: CLR
Verified By: NAS
Approved By: RSS

Figure 11-2
Recommended MRS Division
PICA-006-R-01 and PICA-006-R-02

11/15/2013

Contract # W912DR-09-D-0006
DO 0002

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