FINAL

FEASIBILITY STUDY REPORT FOR RICOCHET AREA MUNITIONS RESPONSE SITE IN STATE GAME LANDS 211, PENNSYLVANIA

Contract No.: W9133L-09-F-0304

January 2012

Prepared for:

Army National Guard Directorate
Arlington, VA 22202-3231

Prepared by:

Weston Solutions, Inc.
West Chester, PA 19380

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WESTON PROJECT NO.: 12767.099.001.0095

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Final

Feasibility Study Report

For the Ricochet Area Munitions Response Site

In State Game Lands 211, Pennsylvania

WESTON – Technical Manager Ryan Steigerwalt, P.G.	01/11/2012 Date
WESTON – Project Manager John Gerhard	01/11/2012 Date

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
AMSL	above mean sea level
AP	armor piercing
APDS	armor piercing discarding sabot
ARAR	applicable or relevant and appropriate requirements
ARNG	Army National Guard Directorate
BIP	blow-in-place
BMP	best management practice
BRAC	Base Realignment and Closure
CENAB	U.S. Army Corps of Engineers, Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CTT	closed, transferred, and transferring
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DGPS	differential global positioning system
DMM	discarded military munitions
DoD	U.S. Department of Defense
E&S	erosion and sedimentation
EM	electromagnetic
EOD	explosive ordnance disposal
EPA	U.S. Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
FDEMI	Frequency-Domain Electromagnetic Induction
FIG	Fort Indiantown Gap Military Reservation
FS	feasibility study
GPR	ground penetrating radar
GPS	global positioning system
GSV	geophysical system verification
HE	high explosive
HEP-T	high explosive plastic tracer
HRR	Historical Records Review

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

HTRW	hazardous, toxic, and radioactive waste
IR	infrared
MC	munitions constituents
MD	munitions debris
MEC HA	munitions and explosives of concern hazard assessment
MEC	munitions and explosives of concern
MGFD	munition with the greatest fragmentation distance
mm	millimeter
MMRP	Military Munitions Response Program
MRA	Munitions Response Area
MRS	Munitions Response Site
MSC	medium-specific concentration
MSD	minimum separation distance
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
OB/OD	open burning/open detonation
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
PA	preliminary assessment
PAARNG	Pennsylvania Army National Guard
PA DCNR	Pennsylvania Department of Conservation and Natural Resources
PADEP	Pennsylvania Department of Environmental Protection
PGC	Pennsylvania Game Commission
PNDI	Pennsylvania Natural Diversity Inventory
PNHP	Pennsylvania Natural Heritage Program
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RAO	remedial action objective
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RSP	render safe procedures

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

RTS	robotic total station
SAM	Sub Audio Magnetics
SAR	synthetic aperture radar
SDZ	surface danger zone
SGL	State Game Lands
SHPO	State Historic Preservation Office
SI	site inspection
TBC	to be considered criteria
TDEMI	Time-Domain Electromagnetic Induction
TMV	toxicity, mobility, or volume
TNT	2,4,6-trinotrotoluene
TP	target practice
U.S.	United States
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USFWS	U. S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
VSP	Visual Sample Plan
WESTON®	Weston Solutions, Inc.

EXECUTIVE SUMMARY

The Army National Guard Directorate (ARNG) is conducting a feasibility study (FS) at the Ricochet Area (FTIG-003-R-01) Munitions Response Site (MRS) located within State Game Lands 211, Pennsylvania, to address munitions and explosives of concern (MEC) present at the MRS. The remedial investigation (RI) was conducted in 2010, and the results are presented in the *Final Remedial Investigation Report for the Ricochet Area Munitions Response Site, State Game Lands 211, Pennsylvania* (WESTON, 2011). The data collected and the conclusions drawn in the RI report were used to develop this FS report.

The Ricochet Area MRS is comprised of 8,002 acres of Pennsylvania State Game Land 211 in Dauphin and Lebanon Counties and is owned by the Commonwealth of Pennsylvania and managed by the Pennsylvania Game Commission (PGC). The MRS lies north of the Fort Indiantown Gap Military Reservation (FIG) boundary such that FIG's impact area forms the southwest boundary of the MRS. The current and future land use of the MRS is recreational, including hunting, fishing, and hiking. The area serves as a habitat for large and small game animals that are hunted in season. Visitors regularly fish in Stony Creek, a perennial stream that flows east to west through the MRS. Portions of the area are also used as herbaceous openings and for timber sales.

Based on the results of the RI, the Ricochet Area MRS was subdivided into the following two MRSs:

- **Ricochet Area MRS—**This MRS is approximately 3,262 acres and corresponds to a safety buffer/ricochet area of the FIG ranges where unexploded ordnance (UXO) and munitions debris (MD) were recovered during the RI. This MRS also includes the Cold Spring Firing Point where discarded military munitions (DMM) and MD were recovered during the RI.

- **Sharp Mountain MRS—**This MRS is approximately 4,740 acres extending from the northern Ricochet Area MRS boundary to the ridgeline of Sharp Mountain. There was no evidence of military munitions-related activities or material identified in this MRS during the RI.

The explosive hazard associated with MEC at the Ricochet Area MRS was determined to be moderate because of the surface and near surface MEC and MD and also because of the decreased number of contact hours by the public and maintenance personnel at this location. It was determined that there are no MEC hazards at the Sharp Mountain MRS because no MEC items were recovered during the RI and there is no suspected historical military munitions use at this location.

The purpose of this FS is to identify, develop, and perform a detailed analysis of potential remedial alternatives that would meet the remedial action objectives (RAOs) for MEC so that the decision-makers will have adequate information to select the most appropriate remedial alternative(s) for the Ricochet Area MRS. The selected alternatives are expected to mitigate, reduce, or eliminate unacceptable risks to human health and the environment from MEC, based on the future use of the property.

The following major steps were involved in the development of this FS:

- Identification of RAOs.
- Identification of Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered criteria (TBCs).
- Identification of general remedial actions.
- Identification and screening of potentially applicable remedial technologies and process options for the general response actions.
- Development and screening of a range of remedial alternatives for the site based on the combinations of the remedial technologies that were retained.
- Performance of a detailed analysis for each of the remedial alternatives using the evaluation criteria required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).
- Identification of the most appropriate/viable remedial alternative(s) that meet the RAOs.

The goal of a remedial action is to reduce explosives safety hazards or contaminants of concern to ensure protection of human health, public safety, and the environment in the Ricochet Area MRS. To achieve this goal, the FS evaluated the appropriateness and effectiveness of potential remedial actions for minimizing exposure pathways to MEC while maintaining the intended future land use for recreational activities, herbaceous opening maintenance, and timber harvesting at the Ricochet Area MRS. It was determined that there is no risk associated with

MEC at the Sharp Mountain MRS. Potential remedial actions were not evaluated for the Sharp Mountain MRS because no further action is warranted at this MRS.

The objectives established for remedial actions guided the development of alternatives for the Ricochet Area MRS and focused the comparison of acceptable remedial action alternatives, if warranted. These objectives also assisted in clarifying the goal of minimizing the explosive risk and achieving an acceptable level of protection for human health and the environment. These objectives are required to meet NCP criteria.

Three categories of ARARs (chemical-specific, location-specific, and action-specific) and TBCs were evaluated for the Ricochet Area MRS.

General remedial actions are those actions that will be evaluated to achieve the RAOs. General remedial actions that were considered for the Ricochet Area MRS include No Action, Containment and Controls, and MEC removal activities. MEC removal activities include technologies used for detection, positioning, removal, disposal, and waste stream treatment (if necessary). The various technologies currently available for MEC removal activities were screened for effectiveness, implementability, and cost to assess the viability of each technology at the Ricochet Area MRS and to provide additional information to future decision-makers.

The following remedial alternatives were developed from the general remedial actions identified above and were evaluated for the Ricochet Area MRS:

1. No Action—Required to be evaluated by the NCP.
2. Containment and Controls.
3. Surface Removal of MEC with Containment and Controls—Removal of MEC detected on the ground surface and breaching the ground surface across the entire Ricochet Area MRS. This alternative also includes containment and controls.
4. Focused Surface and Subsurface Removal of MEC with Containment and Controls—Removal of MEC detected on the ground surface and breaching the ground surface in the area identified with more than 0.5 MEC/MD per acre and along trails (estimated to be 1,334 acres of the Ricochet Area MRS). This alternative includes removal of MEC to detection depth at the herbaceous openings (estimated to be 10 acres of the Ricochet Area MRS). It also includes containment and controls, including UXO construction support for future intrusive activities at the MRS.

5. Removal of MEC to Detection Depth with Containment and Controls—Removal of MEC detected across 3,262 acres of the Ricochet Area MRS. The depth of detection varies based on the depth of MEC at the site and the detection technology used. This alternative also includes containment and controls.

Remedial alternatives deemed highly viable for use at the Ricochet Area MRS were assessed in a detailed evaluation against the evaluation criteria described in the NCP, Section 300.430. The evaluation criteria included:

1. Overall protectiveness of human health and the environment.
2. Compliance with ARARs and TBCs.
3. Long-term effectiveness and permanence.
4. Reduction of toxicity, mobility, or volume (TMV) of contaminants through treatment.
5. Short-term effectiveness.
6. Implementability.
7. Cost.
8. Regulatory agency acceptance.
9. Community acceptance.

Regulatory agency acceptance and community acceptance will be evaluated during the review of this FS and the Proposed Plan.

Based on the detailed analysis of remedial alternatives, the strengths and weaknesses of the remedial alternatives relative to one another were evaluated with respect to each of the NCP criteria. The results of this comparative analysis for the Ricochet Area MRS are summarized in **Table ES-1**. This approach to analyzing alternatives is designed to provide decision-makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for the MRS, and demonstrate satisfaction of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedy selection requirements in the Decision Document.

Alternative 4, Focused Surface and Subsurface Removal of MEC and Containment and Controls, is the recommended remedial action alternative. Although Alternative 4 was not ranked as favorably as Alternative 5, the detailed analyses for Alternatives 1, 2, and 3 have fewer criteria ranked as favorable. Alternative 4 was selected because it ranked favorably in the detailed analysis over the other alternatives in relation to the overall protectiveness of human health and the environment, compliance with ARARs, and implementability.

Table ES-1 Comparative Analysis of Remedial Alternatives for the Ricochet Area MRS

Alternative	Overall Protectiveness of Human Health and the Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants Through Treatment	Short-Term Effectiveness	Implementability	Cost	Regulatory Agency Acceptance
1 No Action	Alternative 1 would not be protective of human health because no action would be taken to prevent human exposure to MEC.	There are no regulations or criteria associated with Alternative 1.	Alternative 1 would not be effective or permanent.	Alternative l would not reduce the TMV of MEC.	Because there are no construction activities associated with Alternative 1, it would not present significant additional risk to the community or to workers at the MRS. Also, Alternative 1 would not cause damage to the environment because no clearing, grubbing, or excavation would be required.	Alternative 1 would be easily implemented because it requires no action.	$0	The criteria for regulatory agency acceptance cannot be fully evaluated and assessed until comments on the FS are received.
2 Containment and Controls	Alternative 2 would be more protective than Alternative 1 because the containment and controls would reduce unacceptable exposure to MEC.	Alternative 2 would be implemented to comply with all ARARs and TBCs.	Alternative 2 would be more effective and permanent than Alternative 1, assuming the cooperation and active participation of the existing powers and authorities of government agencies.	Alternative 2 would not reduce the TMV of MEC.	Because there are no construction activities associated with Alternative 2, it would not present significant additional risk to the community or to workers at the site. Also, Alternative 2 would not cause damage to the environment because no clearing, grubbing, or excavation would be required.	The containment and controls recommended as Alternative 2 could be easily implemented because they pose no technical difficulties and the materials and services needed are available.	$181,998	The criteria for regulatory agency acceptance cannot be fully evaluated and assessed until comments on the FS are received.
3 Surface Removal of MEC with Containment and Controls	Alternative 3 would be more protective than Alternative 2 because MEC would be removed. Alternative 3 would be less protective than Alternative 5 because it would remove only MEC located at the ground surface, but it would be more protective than Alternative 4 because it involves a larger area. Alternative 3 would address the immediate exposure risks of surface MEC only relative to the current land use and low contact hours by the public and maintenance personnel.	Alternative 3 would be implemented to comply with all ARARs and TBCs.	Alternatives 3, 4, and 5 would be more effective and more permanent than Alternative 2 because MEC would be removed permanently from the MRS. Alternative 3 would be more effective and less permanent over the long term as it covers a larger area than Alternative 4. Alternatives 3 and 4 are less effective and permanent than Alternative 5 because only MEC at the ground surface and subsurface at the herbaceous openings (Alternative 4) would be removed permanently from the MRS. MEC below ground surface could potentially move to the surface due to frost heave, soil erosion, or human disturbances.	Alternatives 3, 4, and 5 would reduce the TMV of MEC. Alternative 3 would reduce the TMV of MEC less than Alternative 5.	Alternative 3 would increase risk to the community and to workers at the MRS during removal of MEC. Risk to the community during removal of MEC would be reduced by the use of engineering controls and/or evacuations to maintain required minimum separation distances. Risks associated with Alternative 3 are less than risks associated with Alternative 5 because only MEC visible on the ground surface would be handled. Also, Alternative 3 would cause damage to the environment due to limited clearing, grubbing, and excavation during removal activities. Alternative 3 would cause less damage to environmental and cultural resources than Alternative 5 because limited intrusive activities would be required.	Removal of MEC on the surface and to various depths, similar to the activities proposed in Alternatives 3, 4, and 5, was implemented effectively at the Ricochet Area MRS during the RI. Specific activities, including plant survey, awareness training, and mitigation activities, will be required to protect natural resources and cultural resources, and it would be easier to meet the requirements with Alternative 3 than with Alternative 5.	$16,182,335	The criteria for regulatory agency acceptance cannot be fully evaluated and assessed until comments on the FS are received.

Table ES-1 Comparative Analysis of Remedial Alternatives for the Ricochet Area MRS (Continued)

Alternative	Overall Protectiveness of Human Health and the Environment	Compliance with ARARs and TBCs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants Through Treatment	Short-Term Effectiveness	Implementability	Cost	Regulatory Agency Acceptance
4 Focused Surface and Subsurface Removal of MEC with Containment and Controls	Alternatives 3, 4, and 5 would be more protective than Alternative 2 because MEC would be removed. Alternative 4 would be less protective than Alternatives 3 and 5 because it would remove only MEC located at the ground surface but within the areas where there is the highest probability for encountering MEC and along trails. Alternative 4 would address the immediate exposure risks of surface MEC and subsurface MEC at herbaceous openings relative to the current land use and low contact hours by the public and maintenance personnel. In addition, Alternative 4 would reduce exposure to MEC during future timbering activities by providing UXO construction support.	Alternative 4 would be implemented to comply with all ARARs and TBCs.	Alternatives 3, 4, and 5 would be more effective and more permanent than Alternative 2 because MEC would be removed permanently from the MRS. Alternative 4 would be less effective and permanent than Alternatives 3 and 5 because only UXO at the ground surface would be removed where there is the highest probability for encountering MEC, along trails, and in the subsurface at herbaceous openings. MEC below ground surface could potentially move to the surface due to frost heave, soil erosion, or human disturbances.	Alternatives 3, 4, and 5 would reduce the TMV of MEC. Alternative 4 would reduce the TMV of MEC less than Alternatives 3 and 5 as it involves removal over a smaller area but would include focused subsurface removals at herbaceous openings, which are not included in Alternative 3.	Alternative 4 would increase risk to the community and to workers at the MRS during the removal of MEC. Risk to the community during removal of MEC would be reduced by the use of engineering controls and/or evacuations to maintain required minimum separation distances. Risks associated with Alternative 4 are less than the risks associated with Alternatives 3 and 5 because only MEC in a smaller focused area would be handled. Alternative 4 would cause less damage to environmental and cultural resources than Alternatives 3 and 5 because limited intrusive activities would be required and a smaller area would undergo a surface and subsurface removal action.	Removal of MEC on the surface and to various depths, similar to the activities proposed in Alternatives 3, 4, and 5, was implemented effectively at the Ricochet Area MRS during the RI. Specific activities, including plant survey, awareness training, and mitigation activities, will be required to protect natural resources and cultural resources, and it would be easier to meet the requirements with Alternative 4 than with Alternative 5.	$6,757,826	The criteria for regulatory agency acceptance cannot be fully evaluated and assessed until comments on the FS are received.
5 Removal of MEC to Detection Depth with Containment and Controls	Alternative 5 would be most protective because it would remove all detectable MEC. However, Alternatives 3 and 4 would be similarly effective in that the immediate exposure risks of surface MEC would be reduced relative to the current land use and low contact hours by the public and maintenance personnel.	Alternative 5 would be implemented to comply with all ARARs and TBCs.	Alternative 5 would be most effective and permanent because all detectable MEC on the surface and in the subsurface would be removed permanently.	Alternative 5 would most reduce the TMV of MEC because all detectable MEC would be removed.	Alternative 5 would increase risk to the community and to workers at the MRS during removal of MEC compared to Alternatives 3 and 4. Risk to the community during removal of MEC would be reduced by the use of engineering controls and/or evacuations to maintain required minimum safe distances. Alternative 5 would cause more damage to environmental and cultural resources because more clearing, grubbing, and excavation during removal activities would be required than in Alternatives 3 and 4.	Removal of MEC on the surface and to various depths, similar to the activities proposed in Alternatives 3, 4, and 5, was implemented effectively at the Ricochet Area MRS during the RI. Specific activities including plant survey, awareness training and mitigation activities will be required to protect natural resources and cultural resources, and it would be easier to meet the requirements with Alternatives 3 and 4 than with Alternative 5.	$24,315,156	The criteria for regulatory agency acceptance cannot be fully evaluated and assessed until comments on the FS are received.

1. INTRODUCTION

The Army National Guard Directorate (ARNG) has contracted Weston Solutions, Inc. (WESTON®) to complete a feasibility study (FS) for the Ricochet Area (FTIG-003-R-01) Munitions Response Site (MRS) located in State Game Lands (SGL) 211, Pennsylvania. The Ricochet Area MRS is one of the sites included in the Defense Environmental Restoration Program (DERP) – Military Munitions Response Program (MMRP). This FS has been developed under the MMRP to address munitions and explosives of concern (MEC) present at the site. All MEC recovered at the site to date have been classified as unexploded ordnance (UXO) or discarded military munitions (DMM).

This FS has been prepared in relation to the U.S. Environmental Protection Agency (EPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, (EPA, 1988), and the U.S Army document, *Final Munitions Response Remedial Investigation/Feasibility Study Guidance*, November 2009 (U.S. Army, 2009). This work is being conducted under the General Services Administration Contract W9133L-09-F-0304. The funding for the FS is provided by ARNG, and technical support to ARNG is provided by the U.S. Army Corps of Engineers, Baltimore District (CENAB).

1.1 PURPOSE

The purpose of this FS is to identify, develop, and perform a detailed analysis of potential remedial alternatives that would meet the remedial action objectives (RAOs), so that the decision-makers will have adequate information to select the most appropriate remedial alternative(s) for the Ricochet Area MRS. The selected alternatives are expected to mitigate, reduce, or eliminate unacceptable risks to human health and the environment from MEC, based on current and intended future use of the property.

The following major steps are involved in the development of the FS:

- Identification of RAOs (Section 1.4).
- Identification of Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered criteria (TBCs) (Section 2).

- Identification of general remedial actions (Section 3).
- Identification and screening of potentially applicable remedial technologies and process options for the general response actions (Section 3).
- Development and screening of a range of remedial alternatives for the site based on combinations of the remedial technologies that were retained (Section 4).
- Performance of a detailed analysis for each of the remedial alternatives using the evaluation criteria as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Section 5).
- Identification of the most appropriate/viable remedial alternative(s) that meet the RAOs (Section 5).

1.2 PROJECT BACKGROUND

The Ricochet Area MRS comprises 8,002 acres of Pennsylvania State Game Land 211, which is owned by the Commonwealth of Pennsylvania and managed by the Pennsylvania Game Commission (PGC). The Ricochet Area MRS lies within East Hanover Township in Dauphin County and Cold Spring Township in Lebanon County. **Figure 1-1** shows the MRS location.

The southern boundary of the Ricochet Area MRS borders the Fort Indiantown Gap Military Reservation (FIG) property and follows the ridgeline of Second Mountain. The northern MRS boundary follows the ridgeline of Stony Mountain. The east and west boundaries correspond to the area documented as Restricted Airspace R5802A or as Restricted Area R5802A in the U.S. Army Garrison Safety Range Regulation (Army Regulation 385-1) for FIG (URS, 2008). This regulation describes the area as “a fall area for spent ordnance which ricochets north of Second Mountain” (U.S. Army Garrison, 1995).

In the early 1800s, the area was utilized for coal mining and timber harvesting. In the late 1800s, mining operations declined and recreational development (e.g., hiking, hunting, camping) increased through the early 1900s.

FIG was established in 1931 when the Commonwealth of Pennsylvania purchased approximately 18,000 acres as a military training facility for the Pennsylvania Army National Guard (PAARNG), with training maneuvers starting in 1933. Historical records indicate that surface danger zones (SDZs) extended from FIG into the current area known as the Ricochet Area MRS. The Cold Spring portion of the MRS was also used as a firing point and bivouac area.

The Ricochet Area MRS was not intentionally used as a target area for military activities conducted at FIG's operational range areas. The presence of munitions within the Ricochet Area MRS is the result of unintentional overshots and/or ricochets from former FIG operational ranges used from 1933 to 1998. Current FIG range designs incorporate firing angles that prevent ricochets into State Game Lands 211.

FIG remained the Army's responsibility until October 1998 when ARNG took control as part of the 1995 Base Realignment and Closure (BRAC). FIG then became an ARNG and Army Reserve training center. In 2003, the United States (U.S.) Congress established the MMRP under the DERP to address MEC and munitions constituents (MC) located on current and former defense sites. Properties classified as operational military ranges are not eligible for the MMRP. The DERP, including the MMRP, typically follows the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the NCP. ARNG conducted an inventory of closed, transferred, and transferring (CTT) military ranges and defense sites, which meets the requirements of a CERCLA Preliminary Assessment (PA). The CTT conducted at FIG in 2003 identified two MMRP-eligible areas: the Artillery Ricochet Area and the Cold Spring Range Fan. Both areas were categorized as artillery buffer areas for large caliber munitions and practice mortars.

The next phase of the CERCLA process at FIG was the site inspection (SI). The SI was completed in a two-phase approach. The Historical Records Review (HRR) (URS, 2007) was the initial step in the MMRP SI. During the HRR, records searches were performed to supplement the information gathered during the CTT and to help facilitate decision-making processes to determine the next step for the SI. Based on records reviews and overlapping range fans, the Artillery Ricochet Area and Cold Spring Range Fan were combined into a single MRS known as the Ricochet Area. Within the Ricochet Area MRS, four areas of concern (Areas A through D) were selected based on the approximate locations of previously observed and recovered MEC and munitions debris (MD). Field inspections were then performed at the four areas of concern. The field inspections were completed in 2008 (URS, 2008) and included magnetometer-assisted visual surveys and the collection of eight soil samples at pre-determined locations within the areas of concern. No MEC or MC were detected during the SI. However, based on the limited scope of the SI and Explosive Ordnance Disposal (EOD) Unit reports confirming that MEC has been previously recovered in the Ricochet Area MRS, a recommendation was made to further evaluate the Ricochet Area MRS for MEC during the remedial investigation (RI) phase of the CERCLA process. The SI report also recommended no further action (NFA) for MC unless MEC or MD is recovered.

The RI (WESTON, 2011) fieldwork was conducted between March 2010 and May 2010 to characterize the nature and extent of MEC and MC on the ground surface and subsurface of the Ricochet Area MRS. The data collected during the field investigation, and the conclusions drawn in the RI were used to develop the FS. A summary of the Ricochet Area RI is presented in the following sections.

1.3 SUMMARY OF REMEDIAL INVESTIGATION RESULTS

This section provides a summary of the environmental setting and results of the RI conducted at the Ricochet Area MRS, including the nature/ extent and the hazards associated with MEC. MC was determined not to have a significant risk to human health or the environment as indicated by the human health and ecological risk assessments. The results of the RI are discussed in greater detail in the *Final Remedial Investigation Report, Ricochet Area Munitions Response Site, State Game Lands 211, Pennsylvania* (WESTON, 2011).

1.3.1 Environmental Setting

1.3.1.1 Topography

The topography of the Ricochet Area MRS is that of the Valley and Ridge System. Inspection of the United States Geological Survey (USGS) Topographic Quadrangle (USGS, 1981) shows the study area is bounded to the north by Stony Mountain with ridgeline elevations between 1,610 and 1,670 feet above mean sea level (AMSL). Second Mountain, with ridgeline elevations between 1,200 and 1,400 ft AMSL, marks the southern boundary of the MRS. Stony Creek is at an approximate elevation of 700 ft and flows from northeast to southwest in the valley between the two mountains towards the Susquehanna River. **Figure 1-2** shows the topography of the area.

1.3.1.2 Geology

The Ricochet Area MRS is located within the Valley and Ridge physiographic province and for the most part underlain by Paleozoic age sedimentary rocks that have undergone extensive faulting and folding. The ridges within the Ricochet Area MRS are predominantly made up of weather-resistant rocks such as sandstone and conglomerates. The valleys between the ridges consist of the less weather-resistant rocks such as limestone and shale. The occurrence of bedrock within the valley is typically 5 to 8 ft bgs (USGS, 1981).

Four major geological formations are present at the site: the Pocono Formation, Mauch Chunk Formation, Pottsville Formation, and Llewllyn Formation. Second Mountain is formed by the Pocono Formation, consisting of conglomerates, massive sandstone, shale, and thin lenticular coal. Underlying Stony and Sharp Mountains is the Pottsville Formation that consists of conglomerate and sandstone. The Stony Valley consists of thin sandstone, siltstone, limestone, and red shales of the Mauch Chunk Formation. The valley between Sharp and Stony Mountain consists of shale, sandstone, conglomerates, and coal of the Llewellyn Formation (USDA, 2009).

1.3.1.3 Soil

Four major soil associations are present across the Ricochet Area MRS: Dekalb-Lehew, Calvin-Klinesville, Berks-Weikert-Bedington, and Laidig-Hazelton-Leck Kill. The soil in the area can be summarized as being generally thin and rocky. The soil on the steep slopes of the mountains consists mostly of very stony sandy loams with channery subsoil. The valleys contain alluvial materials—from the well-drained stony sandy loams on the foot slope to shaley silt loams found along the streams (USDA, 2009). Based on the U.S. Department of Commerce weather map, frost lines range from 20 to 25 inches bgs.

1.3.1.4 Hydrology

The Stony Creek watershed is primarily within the Ricochet Area MRS and contains three major tributaries to Stony Creek: Rausch Creek, which is not in the Ricochet Area MRS: Yellow Spring in the center; and Rattling Run on the west side of the MRS; Stony Creek flows from northeast to southwest and drains into the Susquehanna River approximately 10 miles to the west of the western boundary of the Ricochet Area MRS.

1.3.1.5 Hydrogeology

The Mauch Chunk Formation provides the most reliable source of groundwater with high yields capable of supporting public water suppliers and industry. Depths to adequate drinking water supplies for domestic use can usually be reached at less than 200 ft. Groundwater occurrence in the mountains may be associated with old coal mine workings and in the numerous fractures associated with the faults, folds, and jointing of the sedimentary rocks (PADER, 1979). Depth to the groundwater in this region averages 20 ft bgs.

1.3.1.6 Ecology

The Ricochet Area MRS contains a variety of conifer-dominated forests to mixed deciduous forests. Common conifer tree species found at the Ricochet Area MRS include Eastern white pine (*Pinus strobus*) and Eastern hemlock (*Tsuga canadensis*). The Eastern hemlock at the site is being threatened with hemlock woolly adelgid (*Adelges tsugae*). Common deciduous tree species found at the Ricochet Area MRS include oak (*Quercus* spp.) (chestnut [*Q. prinus*], white [*Q. alba*], and red [*Q. rubra*]) and maple [*Acer* spp.] (red [*A. rubrum*], silver [*A. saccharinum*], and striped [*A. pensylvanicum*]). Forested wetland areas are interspersed along many of the seeps and springs located throughout the Ricochet Area MRS and along the Stony Creek stream corridor.

During the RI, specific procedures were identified to protect sensitive plant and animal species. In accordance with the SOP "Minimizing Disruption of Special Plant and Animal Species," field staff were trained in the recognition, identification, and avoidance of special plant and animal species within the MRS. WESTON biologists and staff logged the locations of the special plant species so these areas could be avoided during intrusive operations. The only special plant species observed during the investigative work from March through May 2010 was the American holly, partly because the American holly is the easiest plant to identify based on physical appearance year round. The netted chainfern was not immediately recognizable in early spring 2010 activities. Minniebush also has a late spring budding process, which makes visual recognition by the untrained eye difficult. No netted chainfern or minniebush were observed during the RI fieldwork. Following completion of field work, WESTON provided Pennsylvania Department of Conservation and Natural Resources (PA DCNR) location data regarding the American holly found during the RI (see **Figure 1-3**).

A diverse mix of mammals, birds, reptiles, amphibians, insects, and benthic macroinvertebrates is supported by the habitat of the Ricochet Area MRS. Commonly observed species at the site were white-tailed deer (*Odocoileus virginianus*), Eastern wild turkey (*Meleagris gallopavo silvestris*), and ruffed grouse (*Bonasa umbellus*). Timber rattlesnakes (*Crotalus horridus*) were commonly found among the scattered boulder areas of the site. Stony Creek is routinely stocked with the following fish species: rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*).

Biological species that occur within the Ricochet Area MRS and are either considered as federally listed species or special status in Pennsylvania were determined using Pennsylvania Natural Heritage Program (PNHP) information. There are no known federally listed threatened or endangered plant or wildlife species that occur within the Ricochet Area MRS.

Other Potential Special Status Species (although not listed in the current Pennsylvania Natural Diversity Inventory [PNDI] request and response) are detailed in **Table 1-1**.

Table 1-1 Potential Special Status Species*

Insects	
Hand-Maid Moth	*Datana ranaeceps*
Pine Barrens Zale	*Zale sp. 1 nr. Lunifera*
Black Dash	*Euphyes conspicua*
Terrestrial Wildlife	
Indiana Bat	*Myotis sodalis*
Allegheny Wood Rat	*Neotoma magister*
Timber Rattlesnake	*Crotalus h. horridus*
Macroinvertebrates	
Allegheny Cave Amphipod	*Stygobromus allegheniensis*
Plant Species	
Minniebush	*Menziesia pilosa*
Netted Chainfern	*Woodwardia areolata*
American Holly	*Ilex opaca*

*Letters from PA DCNR, PA Fish and Boat Commission, PGC, and U. S. Fish and Wildlife Service (USFWS) as part of PNDI process conducted in winter-spring 2010.

1.3.1.7 Cultural Resources

Many prehistoric and historic archaeological cultural resources are located within the Ricochet Area MRS footprint. Based on available records, including the St. Anthony's Wilderness website (Via, 2011), these include, but are not limited to, the following:

- Eleven house foundations west of the Rattling Run tributary associated with the mining and railroad communities from the 1800s.
- An American Indian encampment near a spring on the south side of Sharp Mountain (artifacts dated to 4500-5500 BC).
- Rattling Run includes remnants of a stone inclined plane used for coal transport and structural foundations, including a well at the top and bottom of the incline. The mines at Rattling Run were in active use from about 1825 to 1850.
- Yellow Spring includes remnants of sawmill machinery near Stony Creek in the area of the Yellow Spring tributary. In addition, there is a stone tower/chimney at the top of a mine shaft. There is also a stone inclined plane used for coal transport. The minehead at Yellow Spring closed about 1859.
- Remnants of structural foundations associated with the historic Cold Spring resort. The Cold Spring Resort and facilities date back to 1800s. This area was also noted for its cold spring water.

As part of the RI planning effort, the Pennsylvania State Historic Preservation Office (SHPO) was contacted to identify historic places within the MRS worthy of preservation. The National Register of Historic Places listed the Fort Indiantown Gap Historic District as the closest place of historic significance. This historic district is located outside the MRS. In cooperation with the SHPO, field personnel avoided conducting field activities within identified areas of significant historical and/or cultural significance. During the field investigation, several man-made cultural items pertaining to the known cultural resources in the MRS were recovered. **Table 1-2** details the cultural items identified during the RI, and their locations within the MRS are shown in **Figure 1-4.** Cultural debris recovered during the field activities was inspected by cultural resource experts, including the PAARNG Cultural Resource Manager. Any items deemed by the cultural resource experts to be of historical significance were donated to local museums. The remaining items were brought to the Community Interest Group meetings to give the public the opportunity to claim cultural items before disposal at a metal recycler.

Table 1-2 Cultural Items and Locations

Item Description	Location on Figure 1-4	Coordinate Location	
		Easting	Northing
Bolt	1	1155630.38	14687243.63
Pipe	2	1155979.76	14687453.52
Bolt	3	1156597.49	14687859.25
Knife	4	1157466.79	14687763.82
Horseshoe	5	1159931.75	14689024.20
Spike	6	1160085.09	14688978.21
Horseshoe	7	1160326.01	14691064.05
Bolt	8	1161594.47	14690015.89
Bolt	8	1161580.70	14690023.44
Bolt	8	1161617.02	14690030.02
Bolt	8	1161611.60	14690037.41
Bolt	8	1161600.04	14690015.78
Knife	8	1161600.04	14690015.78
Railroad spike	8	1161589.19	14690030.56
Railroad spike	8	1161608.96	14690044.75
Railroad spike	8	1161622.80	14690040.84
Railway part	8	1161600.11	14690019.42
Cable bridge	9	1162188.69	14689679.33
Bolt	10	1162794.74	14689034.34
Horseshoe	10	1162805.87	14689034.12
Railroad tracks	11	1162280.30	14690038.24
Bolt	12	1162666.32	14690304.71
Chisel	12	1162665.68	14690271.93
Railroad spike	12	1162652.55	14690312.26
Railroad spike	12	1162652.55	14690312.26
Tape measures	13	1162439.53	14691525.99
Spikes	14	1164050.83	14690712.48
Spike	15	1164250.69	14690725.73
Chain	16	1164243.46	14691272.00
Knife	17	1164807.85	14691048.66
Rail spike	18	1165405.89	14691427.66
Cable crossing	19	1166140.55	14691675.06
Can	20	1166790.07	14691795.14
Horseshoe	21	1167560.23	14691313.97
Horseshoe	21	1167571.71	14691331.96
Horseshoe	21	1167571.71	14691331.96
Horseshoe	22	1170151.30	14692885.13
Horseshoe	23	1169747.85	14693285.60
Track plate and spike	24	1169808.61	14693406.13
Rail spike	25	1169740.54	14693528.75
Airplane debris	26	1169445.66	14696512.78
Airplane debris	27	1173343.45	14693589.68
Chain	28	1173717.86	14694544.39
Chain	28	1173717.86	14694544.39
Horseshoe	29	1172017.42	14697529.26
Pipe	30	1174563.55	14696986.80

Table 1-2 Cultural Items and Locations (Continued)

Item Description	Location on Figure 1-4	Coordinate Location	
		Easting	Northing
Survey nail	31	1175488.22	14696172.13
Survey nail	31	1175441.00	14696176.67
Horseshoe	32	1175810.00	14697586.91
Pipe	33	1176346.70	14697859.84
Fishing chains	34	1176928.14	14697938.85
Rail road track	35	1177281.71	14698964.30
Pipe	36	1175934.53	14701536.02
Bolt	37	1181506.34	14700713.51
Spike	38	1181874.42	14700621.38
Heavy nail (Old)	39	1181354.67	14701515.66
Muffler bolt	39	1181338.32	14701534.18
Horseshoe	40	1184342.79	14699122.49
Horseshoe	41	1186307.73	14702857.13
Foundation with stairs or spring outlet	42	1187215.62	14704305.63
Possible foundation	43	1187896.91	14704620.22
Bolt	44	1188522.86	14704876.46
Chain	44	1188549.66	14704821.31
Chain	44	1188581.06	14704864.45
Hinge	44	1188544.03	14704817.77
Horseshoe	44	1188536.23	14704847.06
Horseshoe	44	1188606.16	14704867.63
Knife	44	1188575.36	14704857.27
Pipe	44	1188560.45	14704802.90
Horseshoe	45	1188707.08	14704909.49
Bolt	46	1188650.55	14705012.54
Horseshoe	47	1190543.47	14705060.83

Note: Coordinates in NAD83, Universal Transverse Mercator (UTM) Zone 18N, U.S. Survey Feet.

1.3.1.8 Demographic Profile

The Ricochet Area MRS is located in Cold Spring Township, Dauphin County, and in East Hanover Township, Lebanon County in south-central Pennsylvania. Dauphin County consists of 525 square miles and 40 municipalities, one of which is the state capital, Harrisburg. The county is located 100 miles west of Philadelphia and 200 miles east of Pittsburgh. East Hanover Township is located approximately 12 miles east of Harrisburg and, with an area of 39.1 square miles, is the third largest township in Dauphin County. The population density is 133.4 persons per square mile as stated by the 2000 U.S. Census.

Lebanon County is located east of Dauphin County and consists of 362.9 square miles. Twenty-six municipalities are located in Lebanon County. Fort Indiantown Gap Reservation is the largest employer in Lebanon County and maintains a workforce of 2,000 full-time employees. Cold Spring Township is located in north Lebanon County and is bordered to the west by East Hanover Township. Cold Spring Township is 24.3 square miles and, according to the 2000 U.S. Census, has a population density of 2.0 persons per square mile.

No site-specific demographic information is available for SGL 211. The land is used for hunting, recreational, and forestry activities and is accessible to the general public with numerous entry and exit points. Census data for the year 2000 for Fort Indiantown Gap Census Tract 42043-0245.02, which overlaps SGL 211 somewhat, indicate a population density of 4.5 people per square mile. Approximately 26 inhabited structures are located up to 2 miles from the boundary of the MRS. Additional demographic information can be found in the project Community Relations Plan (WESTON, 2010).

1.3.1.9 Land Use

The Ricochet Area MRS is located in SGL 211. Current land use includes a number of recreational activities, such as fishing, hunting, hiking, running, bicycle riding, snow shoeing, dog sledding, cross-country skiing, snowmobiling, horseback riding, Fall-Drive-Thru, and bird watching. The Horse-Shoe Trail and Appalachian National Scenic Trail are adjacent to the MRS. Non-recreational activities within the MRS include trail, game, and forest maintenance performed by PGC employees or their contractors and organizations associated with the other trails.

The PGC plan for current and future land use includes continued recreational use, road construction and maintenance, special wildlife area management, timber management, prescribed burns, and preservation area maintenance. Regular maintenance is performed in herbaceous openings maintained for wild game such as turkey and deer. These herbaceous openings are located within the Cold Spring Firing Point area (approximately 7 acres) and an open area (approximately 3 acres) within the central portion of the MRS. The areas are prepared for planting by using agricultural tractors, plows, and disking. Intrusive depth for this work is estimated at 1 foot.

Timber harvests are also periodically conducted within SGL 211. In general, there is a timber harvest every 4 to 5 years, but the frequency or schedule can vary based on timber conditions.

The locations of harvests are selected based on timber surveys/inventories to identify manageable timber and areas where potential habitat improvement projects will be completed. Following the selection of harvestable areas, timber harvests are completed in a multiple-phase process.

Timbering plans are first developed to identify the boundaries of the harvestable areas, access roads, log landings, and potential skidding trails. The timber harvest area, if needed, is surface sprayed with herbicides to kill undesirable plant species in the understory. The spraying is usually performed 1 year in advance of timber harvesting. The next step is the construction of access roads to the designated timber harvest areas using heavy equipment, including bulldozers and excavators. These access roads are generally up to a maximum of 7,500 ft long and up to 12 ft wide. The roads are constructed with required erosion and sedimentation (E&S) controls, including a 2-ft shoulder on either side of the road for a total width of 16 ft. The actual placement of the road can vary up to 10 ft on either side of the centerline of the chosen pathway to avoid difficult terrain and other obstacles. The road construction is estimated to take two weeks. There may be four to six log landings up to 0.75 acre in size established to access and manage the harvestable timber. The log landings are graded with bulldozers to allow a level staging area to sort and load the harvested timber for transport. Subsurface disturbance is typically based on the terrain and the placement of access roads and log landings. The depth of intrusive work is based on the topography of the location. In some areas a cut and fill approach is used to create a log landing. On sites of that nature, the uphill side could have a 4-ft to as much as a 10-ft sloped bank, and the low side would be filled with the cut material. Water would be drained from the upslope side by use of a swale. All disturbed areas are seeded immediately following construction.

The last phase in the timber harvesting process is the actual timbering activities and loading of harvested timber. Timber is cut and dragged along established skidding trails to the designated log landings. Intrusive work associated with this phase is the cutting and dragging of trees by tracked vehicles along skidding trails to the designated log landings. The timber contract will run for approximately a 2-year time period, which is the window for the contractor to construct roads and landings, construct log landings, harvest the designated trees, and retire the harvest site. Retirement of the harvest site will include grading of the access roads (existing and new), grading of the log landings, grading and construction of water bars on the skid trails, and seeding of all designated log landings.

1.3.2 Munitions and Explosives of Concern

The term MEC distinguishes specific categories of military munitions that may pose unique explosive safety risks, including the following:

- **UXO—**Military munitions that fulfill the following criteria:
  - Have been primed, fuzed, armed, or otherwise prepared for action;
  - Have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and
  - Remain unexploded either by malfunction, design, or any other cause (U.S. Army, 2005).
- **DMM—**Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (U.S. Army, 2005).
- **MC—**The definition of MEC also includes chemicals such as TNT and RDX present in high enough concentrations to pose an explosive hazard (U.S. Army, 2005).

MC were also investigated during the RI. MC are any materials originating from MEC, discarded military munitions, or other military munitions, including explosive and non explosive materials, and emission, degradation, or breakdown elements of such munitions (U.S. Army, 2005). MD were investigated during the RI as evidence of potential MEC. MD are any remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization or disposal (U.S. Army, 2005).

1.3.2.1 Nature and Extent of Munitions and Explosives of Concern

A total of 374 acres of the Ricochet Area was investigated using a combination of visual, analog, and digital magnetic geophysical surveys to delineate the nature and extent of MEC. The geophysical survey coverage completed during the RI is presented in **Figure 1-5**. Thirteen MEC (9 UXO and 4 DMM) were identified and disposed of during RI activities, and 121 MD items and 594 non-MD items (manmade/cultural items like railroad spikes, nails, metal scrap, horseshoes, and wire) were identified and removed from the MRS. Locations of the MEC and MD recovered during the RI are presented in **Figure 1-6. Table 1-3** presents the UXO, DMM, and MD found during the RI. The UXO and DMM recovered include:

- Seven 75mm high explosives (HE) projectiles (UXO).
- One 155mm HE projectile (UXO).
- One 75mm armor piercing (AP) HE projectile (UXO).
- Four MK-2A4 Primers (DMM).

As shown in **Figure 1-6**, the highest density of UXO and MD was located on the north face of Second Mountain between the ridgeline and Stony Creek in the southcentral portion of the MRS. To support remedial alternative recommendations and to define and reduce MRS footprints, the UXO and MD were categorized into the following three groups:

- Category 1 – MEC only (**Figure 1-7**) – Eight UXO items were recovered south of the Rail Trail near the ridgeline of the Second Mountain. One UXO item (75mm HE projectile) was recovered approximately 500 ft north of the Rail Trail. Four DMM items were recovered at the Cold Spring Firing Point.

- Category 2 – MD items recovered that contained energetic components when fired and functioned as designed (e.g., training rounds, illumination projectiles), but no energetic components remained upon discovery (**Figure 1-8**). The majority of the MD items were located on the north side of Second Mountain and south of the Rail Trail.

- Category 3 – MD originating from items with no energetic components (**Figure 1-9**). This includes the majority of MD located in the southcentral portion of the MRS.

Table 1-3 Summary of UXO, DMM, and MD, Ricochet Area MRS, State Game Lands 211

Type of Munitions	Type UXO/DMM/MD	Quantity per Survey Type		Item Category	Depth (ft bgs)
		Transect	Grid		
37mm M55A1 Practice Projectile	MD	1	-	3	0
37mm M80 Armor Piercing Projectile	MD	8	-	3	0-0.5
57mm M70 Armor Piercing Projectile	MD	7	-	3	0-0.5
60mm Mortar M721 Illumination Projectile	MD	2	-	2	0-0.25
81mm M301A2 Illumination Mortar	MD	2	-	2	0
81mm M879 Practice Mortar	MD	5	-	2	0-0.5
81mm Mortar Parts	MD	1	-	2	0.75
75mm M339 Armor Piercing	MD	20	-	2	0-1.0
75mm HE Projectiles with M51A5 Fuze	UXO	2	-	1	0
75mm HE Projectiles	UXO	5	-	1	0-0.25
75mm Armor Piercing HE	UXO	-	1	1	0.25
105mm M467 Practice HEP-T (TP)	MD	8	-	3	0
105mm M392 Armor Piercing Discarding Sabot (APDS)	MD	2	-	3	0-0.25
105mm M490 and M490A1 Practice Anti-Tank Projectiles	MD	19	-	3	0-0.25
105mm M314 Illumination Projectile	MD	3	-	2	0
105mm M314 Illumination Canisters	MD	8	-	3	0
4.2 inch M335 Illumination Projectile (Mortar)	MD	2	-	2	0
155mm M107 Projectile (Empty)	MD	3	-	2	0-0.25
155mm HE Projectile	UXO	N/A*	N/A*	1	0
155mm Illumination Projectile	MD	3	-	2	0
155mm Illumination Canisters	MD	16	-	3	0
165mm M623 Practice HEP (TP)	MD	2	-	3	0
MK-2A4 Primers	DMM	4	-	1	1.0
Unknown fragmentation	MD	1	7	2	0-0.25

Notes:
UXO - unexploded ordnance
DMM - discarded military munitions
MD - munitions debris
HE - high explosive
HEP-T - high explosive plastic tracer
TP - target practice
APDS - armor piercing discarding sabot
Depths are top of items recovered.
N/A* not applicable; not recovered during grid or transect surveys

Item Category Description
Category 1 – UXO only
Category 2 – MD items originating from items with energetic components, but no energetic components remained upon discovery
Category 3 – MD originating from items with no energetic components

Item locations for each category were input into Visual Sample Plan (VSP) and used to calculate anomaly density maps for three combinations of the groups and are presented in the following figures:

- **Figure 1-10** is a contour map showing the density of Category 1 items across the MRS (MEC items only) as calculated in VSP. The map shows two small areas near the southern boundary of the MRS that have calculated densities greater than 0.5 MEC per acre, with a maximum value of 0.84 MEC per acre. The areas are illustrated on the map by blue as shown on the color scale. The two areas comprise 56.4 acres (0.7%) of the 8,002-acre MRS. The remainder of the MRS is calculated as being below 0.5 MEC per acre.

- **Figure 1-11** is a contour map showing the density of Category 1 and 2 items across the MRS as calculated in VSP. The map shows one large contiguous area and several small areas across the MRS that have calculated densities greater than 0.5 MEC per acre. The maximum calculated density is 5.7 anomalies per acre (MEC/MD), with a mean density of 1.34 anomalies per acre. The areas comprise 880 acres (11%) of the 8,002-acre MRS. The remainder of the MRS is calculated as being below 0.5 MEC per acre.

- **Figure 1-12** displays contoured density data of Categories 1, 2, and 3 combined. The contours indicate a large contiguous area of increased density in the southcentral portion of the site. The data indicate a maximum density of 8.8 items (MEC/MD) per acre, and is illustrated on the map by red, as shown on the color scale. Isolated areas of increased density up to approximately 3.5 items per acre are present throughout the southern portion of the MRS. The areas comprise 2,154 acres (27%) of the 8,002-acre MRS and have a mean anomaly density of 1.69 anomalies per acre.

- **Figure 1-13** displays contoured density data of the Category 1, 2, and 3 items recovered at the surface (top of item found at 0 inch). The contours indicate a large contiguous area of increased density in the southcentral portion of the site, primarily located on the north facing slope of Second Mountain. The data indicate a maximum density of 6.5 items (MEC/MD) per acre, as shown on the color scale. The areas comprise 1,334 acres (17%) of the 8,002-acre MRS and have a mean anomaly density of 1.69 anomalies per acre.

- **Figure 1-14** displays contoured density data of the Category 1, 2, and 3 items recovered beneath the surface (top of item found at 0.25 inch or deeper). The contours indicate isolated areas of increased density throughout the central valley portion of the site. Two UXO items and four DMM items were recovered within the subsurface. The data indicate a maximum density of 1.66 items (MEC/MD) per acre, as shown on the color scale. The areas comprise 748 acres (9%) of the 8,002-acre MRS and have a mean anomaly density of 0.76 anomalies per acre.

UXO and MD recovered during the RI were located on the surface or in the shallow subsurface soils between 0 inches and 12 inches. Approximately 95% of the UXO and MD were between 0 inches and 6 inches below ground surface. Sixty-six percent of the items recovered were at the ground surface, and 9% of the items were between 6 inches and 12 inches below ground surface. This information supports the conclusion that the release mechanism for UXO in the MRS is unintentional overshot and/or ricocheted munitions, where the munitions primarily deflected off rocks, thereby reducing their kinetic energy and depth of penetration.

Based on the field data, the highest density of UXO and MD is located between the ridgeline of Second Mountain and the Ricochet Area in the southcentral portion of the Ricochet Area. The UXO and MD density decreases farther north into the valley and up the southern slope of Stony Mountain. Two small areas near the southern boundary of the Ricochet Area have calculated densities greater than 0.5 UXO per acre, with a maximum value of 0.84 UXO per acre. The two areas comprise a total of 56.4 acres. The remainder of the MRS is calculated as having less than 0.5 UXO per acre. A large contiguous area of increased density in the southcentral portion of the Ricochet Area contains both UXO and MD. The data indicate a maximum density of 8.8 items (UXO or MD) per acre. Isolated areas of increased density up to approximately 3.5 items per acre are present throughout the southern portion of the MRS. The areas comprise a total of 2,154 acres and have a mean anomaly density of 1.69 items per acre.

The recovery of DMM (four MK-2A4 primers) and firing point/range related debris (e.g., fuze shipping containers, 155 mm rotating band covers, and 155 mm lifting lugs) confirms the location of the former Cold Spring Firing Point. The DMM were recovered at 12 inches below ground surface and were likely buried during training activities. Firing point debris was recovered on the ground surface.

The Ricochet Area MRS was subdivided into two separate MRSs based on the analysis of the density of UXO, DMM, and MD. The two MRS subsets include:

- **Ricochet Area MRS** (3,262 acres)—Comprised of the area from the ridgeline of Second Mountain to the Ricochet Area where the UXO and MD were recovered during the RI. This area also includes the former Cold Spring Firing Point, as evidenced by the recovered DMM and firing point/range related debris.

- **Sharp Mountain MRS** (4,740 acres)**—**The remaining portion of the Ricochet Area MRS where no munitions-related features were identified.

Table 1-4 summarizes the RI results. **Figure 1-15** presents the MRS locations. Additional details concerning the RI results can be found in Section 4 of the RI report (WESTON, 2011).

1.3.2.2 Munitions and Explosives of Concern Hazard Assessment

In October 2008, the Technical Working Group for Hazard Assessment, which includes representatives from the Department of Defense (DoD), Department of the Interior, EPA, and other officials, made available the technical reference document, *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) designed to be used as the CERCLA hazard assessment methodology for MRSs where there is an explosive hazard from the known or suspected presence of MEC. The MEC HA was used to assess the explosives hazards for the Ricochet Area MRS.

The MEC HA is structured around three components of a potential explosive hazard incident:

- **Severity—**The potential consequences (e.g., death, severe injury, property damage, etc.) of MEC detonating.
- **Accessibility—**The likelihood that a receptor will be able to come in contact with MEC.
- **Sensitivity—**The likelihood that a receptor will be able to interact with MEC such that it will detonate.

Each of these components is assessed in the MEC HA by input factors for each MRS. The sum of the input factor scores falls within one of four defined ranges, called hazard levels. Each of the four levels reflects site attributes that describe groups of sites and site conditions ranging from the highest to the lowest hazards. The MEC HA hazard levels are as follows:

- **Hazard Level 1—**Sites with the highest hazard potential. Instances of an imminent threat to human health from MEC may exist.
- **Hazard Level 2—**Sites with a high hazard potential. Surface MEC may exist at the site or intrusive activities being conducted may increase the risk of encountering MEC in the subsurface. The site have moderate or greater accessibility by the public.

Table 1-4 RI Results Summary

Objective of the RI	Munitions Response Site	Area (acres)	MEC/MC Source Description	Geophysical Survey Coverage	Investigation Results	MEC Hazard Assessment
Collect sufficient information to characterize the nature and extent of MEC and MC using a combination of visual, analog and digital geophysical mapping. Perform the necessary hazard and risk assessments to develop and recommend remedial action objectives.	Ricochet Area	3,262	The source and release mechanism for MEC is from historical training at the FIG operational range before 1998. Munitions burial during military training at the former Cold Spring Reservation prior to 1958.	161 total acres investigated during the RI. This includes: ▪ 159 acres of analog geophysical surveys. ▪ 2.5 acres of DGM surveys. ▪ 888 anomalies detected, reacquired, and investigated. Additionally 1.4 total acres were investigated during the RI at the Cold Spring Firing Point. This includes: ▪ One acre of analog geophysical surveys. ▪ 0.4 acre of DGM surveys. ▪ 317 anomalies were detected, reacquired, and investigated.	Results included: ▪ Seven 75mm HE projectiles (UXO). ▪ One 155mm HE projectile (UXO). ▪ One 75mm armor piercing (AP) HE projectile (UXO). ▪ 121 MD items. ▪ 594 non-MD/ cultural debris items. ▪ Cold Spring Firing Point: Four MK2 Primers (DMM) and 42 range debris items.	Hazard Level Category 3 (score 705) - moderate hazard potential.
	Sharp Mountain	4,740	No former military munitions use identified.	211 total acres investigated during the RI. This includes: ▪ 209 acres of analog geophysical surveys. ▪ Approximately 2 acres of DGM surveys. ▪ 21 anomalies detected, reacquired and investigated.	No MEC or MD recovered.	No indication that MEC or MD is present. MRS was not assessed for explosive hazards.

- **Hazard Level 3—**Sites with a moderate hazard potential. A site that would be considered safe for the current land use without further munitions responses, although not necessarily suitable for reasonable anticipated future use. Level 3 areas generally have restricted access and few contact hours. Typically MEC is present only in the subsurface.

- **Hazard Level 4—**Sites with a low hazard potential. The site is compatible with current and reasonably anticipated future use. Typically, a MEC cleanup has been performed at Level 4 sites.

The Ricochet Area MRS Hazard Level Category of 3 indicates that the site has a moderate hazard potential because of surface and near surface MEC and MD and due to a low number of contact hours by the public and maintenance personnel. Because there was no indication of the presence of MEC or MD at the Sharp Mountain MRS, this MRS was not assessed for explosive hazards. A summary of the MEC HA scoring for the Ricochet Area is provided in **Table 1-5**.

Table 1-5 MEC HA Scoring Summary

Site ID: Ricochet Area MRS, Safety Buffer Zone/Ricochet Area	Hazard Level Category	Score
Current Use Activities	3	705

Source: EPA MEC HA Worksheet V.1.0, 2006.

1.4 REMEDIAL ACTION OBJECTIVES

The goal of a remedial action is to reduce explosive safety hazards to ensure the protection of human health, public safety, and the environment. To achieve this goal at the Ricochet Area MRS, the appropriateness and effectiveness of potential remedial actions are evaluated in this FS to minimize exposure to MEC for the following land use activities:

- Minimizing the public's exposure to MEC while maintaining the intended future land use of public access for recreational activities;

- Minimizing the exposure of PGC personnel and their contractors to MEC at timber management areas; and

- Minimizing the exposure of PGC personnel to MEC at herbaceous openings maintained for turkey and deer.

Land use of the MRS is detailed in Section 1.3.1.9. As described in Section 1.3, it was determined that there is no hazard or risk associated with MEC or MC in the Sharp Mountain

MRS. Therefore, potential remedial actions are not evaluated for the MRS because no further action is warranted at this MRS.

The objectives established for remedial actions guided the development of alternatives for the Ricochet Area and focused the comparison of acceptable remedial action alternatives. These objectives also assist in clarifying the goal of minimizing the explosive risk and achieving an acceptable level of protection for human health and the environment. These objectives are required to meet NCP criteria.

SECTION 1

FIGURES

Legend

- Ricochet Area Boundary
- FIG Installation Boundary

Source: PA USGS 7.5 minute Topographic Maps, 1996

Figure 1-1
Ricochet Area and
Fort Indiantown Gap, Annville, PA

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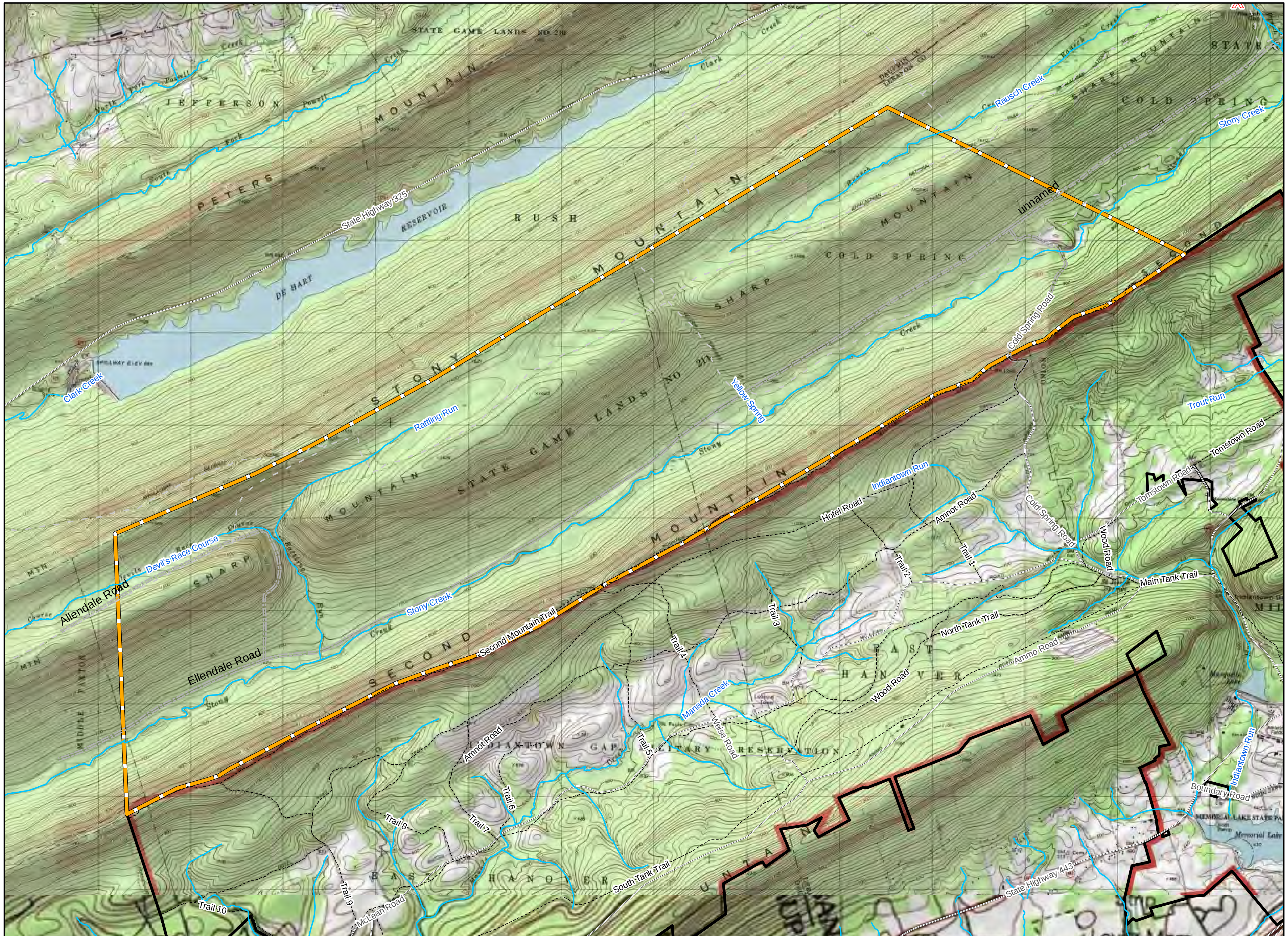


Legend

Ricochet Area MRS Boundary

FIG Installation Boundary

Source: Grantville and Indiantown Gap PA USGS 7.5 minute Topographic Map, 1996

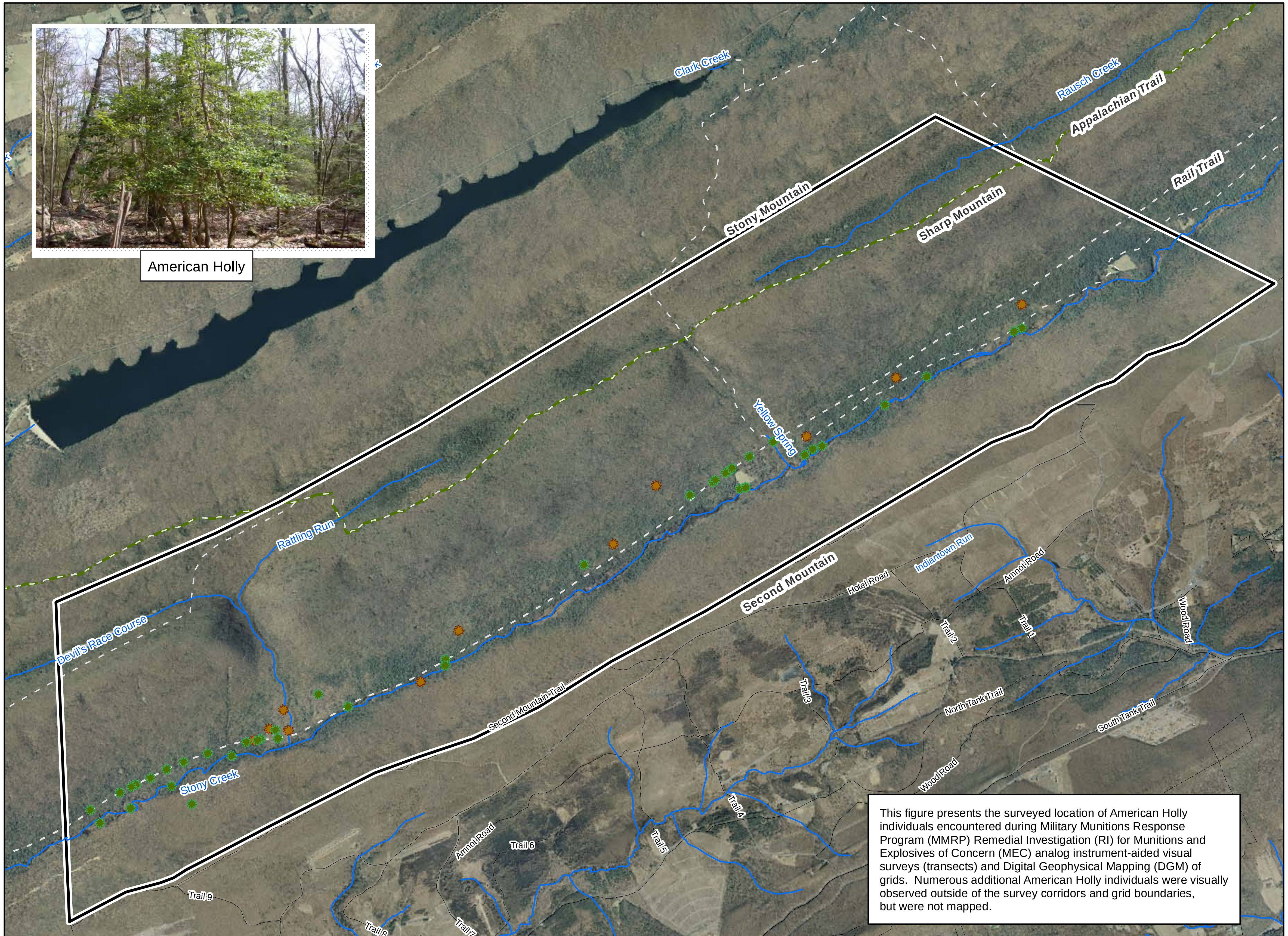
Note: The Ricochet Area MRS Boundary was designated based on topographic features to the north and south (Stony and Second Mountains) and the boundaries to the east and west correspond to Restricted Airspace R5802A.

N W E S

Feet
0 3,200 6,400

Figure 1-2
Topography and MRS Boundary

File: \\fsfed01\tig\FIG\mxd\MMRP_RIFS\RI\topography.mxd, 04-Oct-10 10:33, curtisf



This figure presents the surveyed location of American Holly individuals encountered during Military Munitions Response Program (MMRP) Remedial Investigation (RI) for Munitions and Explosives of Concern (MEC) analog instrument-aided visual surveys (transects) and Digital Geophysical Mapping (DGM) of grids. Numerous additional American Holly individuals were visually observed outside of the survey corridors and grid boundaries, but were not mapped.

WESTON SOLUTIONS

Legend

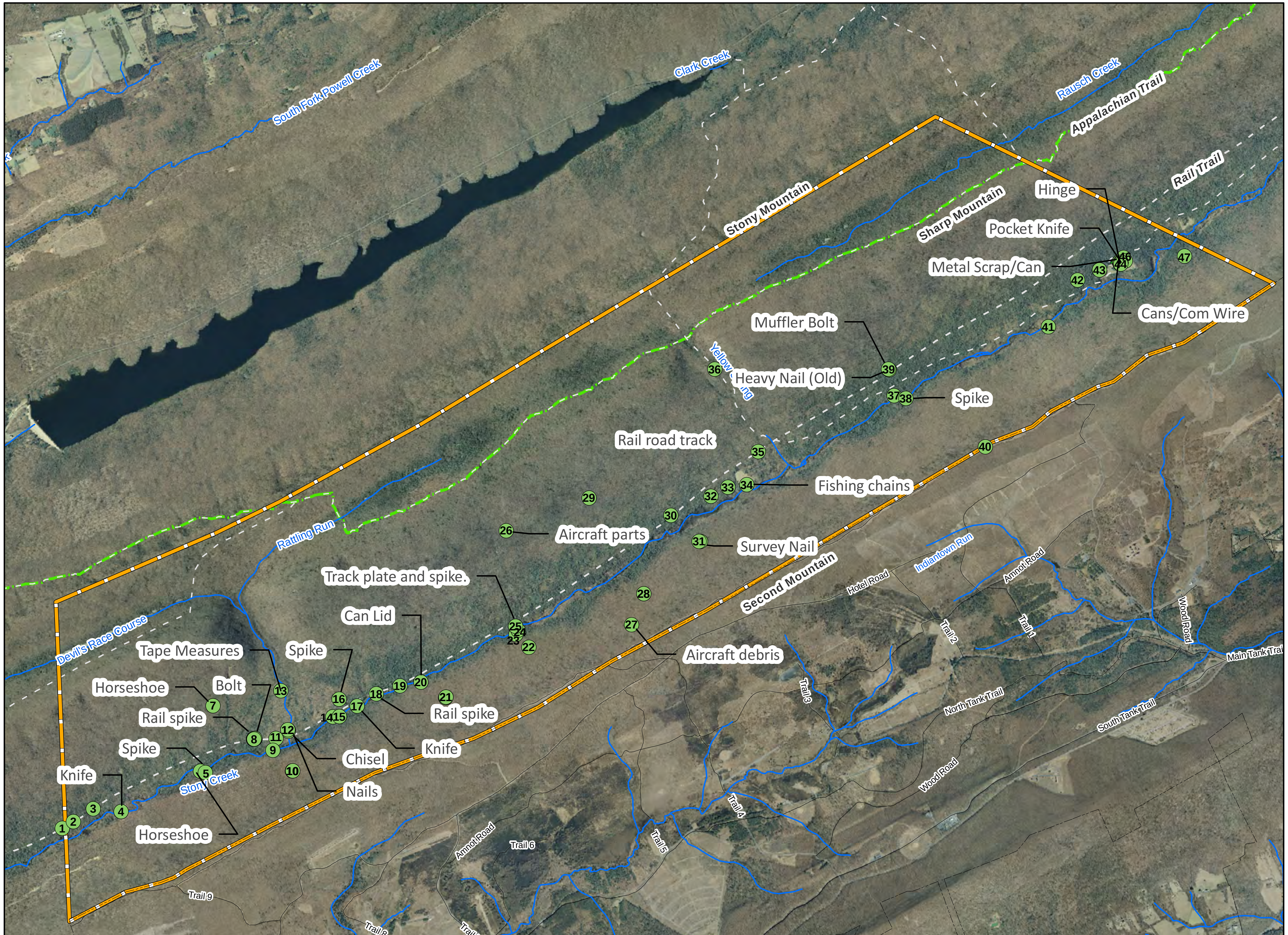
- Installation Boundary
- Ricochet Area MRS Boundary
- Trails
- American Holly
- American Holly (Approximate Location)

N
W E
S

0 3,250 6,500
Feet

Figure 1-3
American Holly
Location Map
Ricochet Area MRS
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\Field\Holly_070110.mxd, 9/12/2011 2:37:13 PM, johna



WESTON SOLUTIONS

Legend

- Cultural Items
- FIG Installation Boundary
- Ricochet Area MRS Boundary

Imagery Source: PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 2007.

N W E S

0 3,250 6,500
Feet

Figure 1-4
Cultural Items
Ricochet Area MRS
State Game Lands 211, PA

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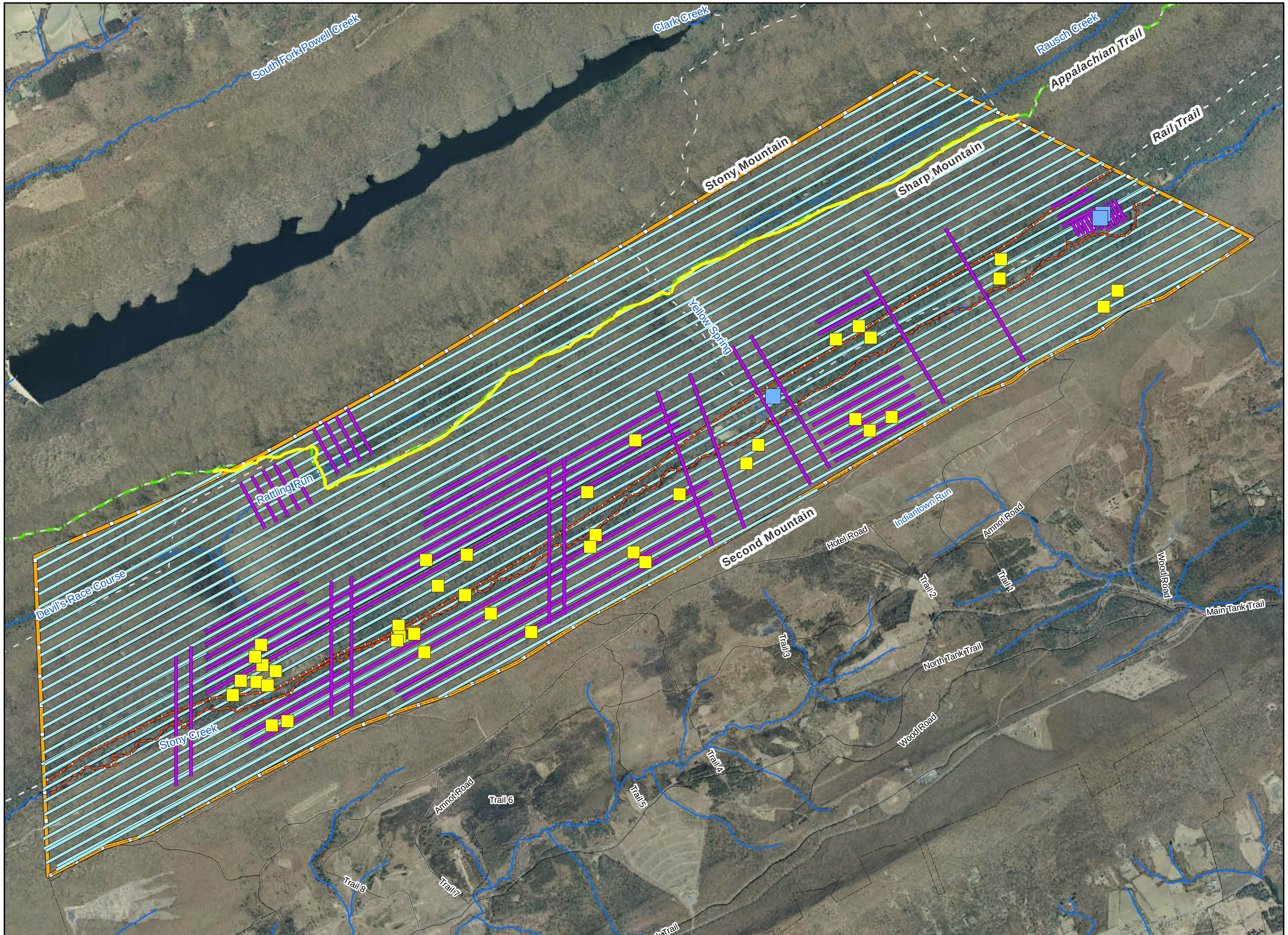


WESTON SOLUTIONS

Legend

- FIG Installation Boundary
- Ricochet Area MRS Boundary
- Analog Transects
- Visual Transects Using Analog Instruments
- DGM Transects
- Analog Work on Rail Trail and Stony Creek
- 100' x 100' DGM Grids
- 50' x 50' DGM Grids

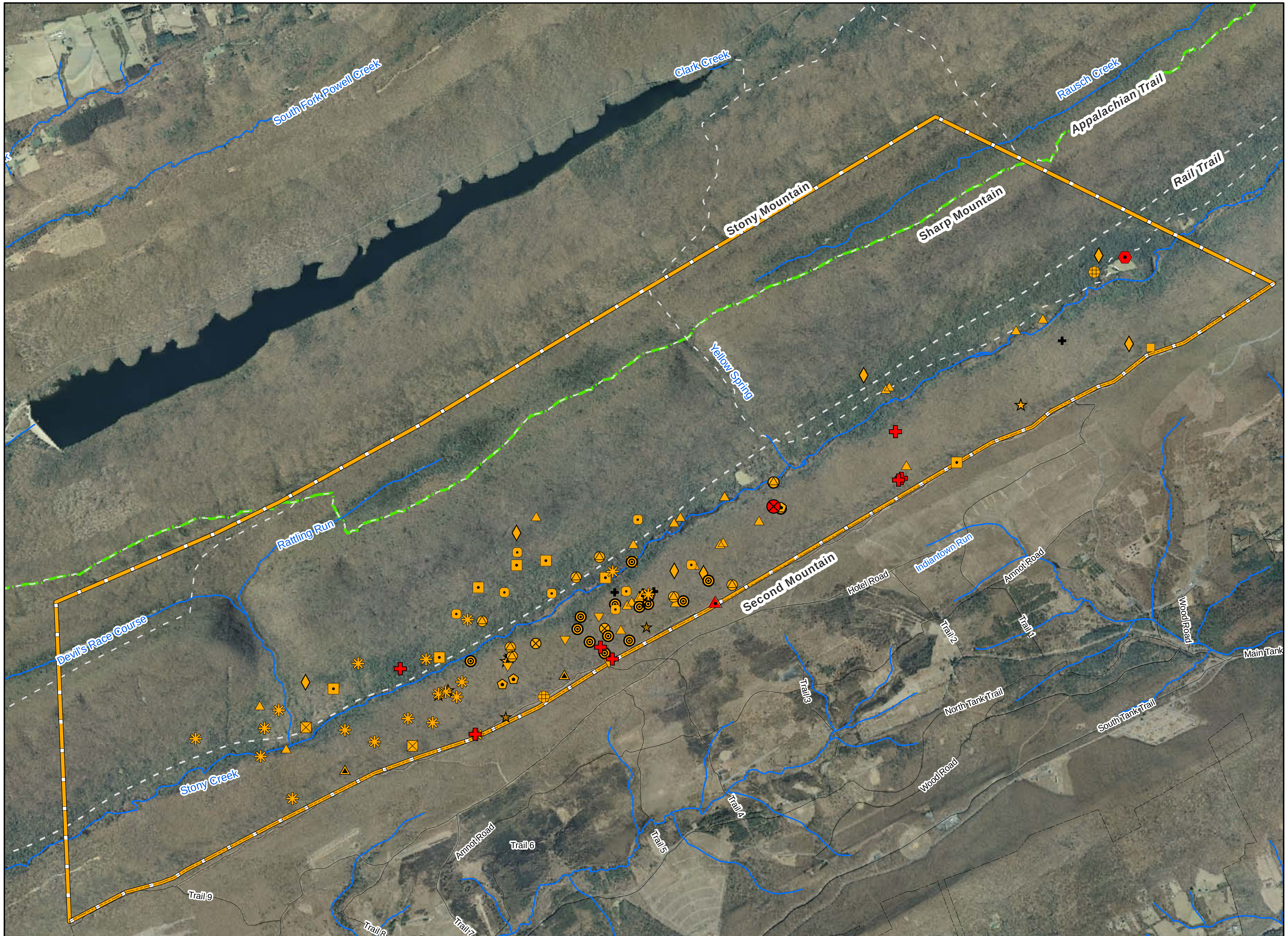
Imagery Source: PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 2007.

N W E S

0 3,250 6,500
Feet

Figure 1-5
RI Geophysical Survey Coverage
Ricochet Area
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\RI\DGM_Grids_Transects.mxd, 9/13/2011 9:51:48 AM, johna



WESTON SOLUTIONS

Legend

- FIG Installation Boundary
- Ricochet Area MRS Boundary
- 155mm HE Projectile (UXO)
- 75mm APHE Projectile (UXO)
- 75mm HE Projectile (UXO)
- MK-2A4 Primer(DMM)
- 105mm Anti-Tank (practice)
- 105mm Discarding SABOT
- 105mm HEP (practice)
- 105mm Illumination Canister
- 105mm Illumination Projectile
- 155mm Illumination Canister
- 155mm Illumination Projectile
- 155mm Projectile (empty)
- 165mm HEP (practice)
- 37mm AP
- 37mm Projectile (practice)
- 4.2" Projectile
- 57mm AP
- 60mm Illumination Projectile
- 75mm AP Rounds
- 81mm Illumination Mortar
- 81mm Mortar Tailfin
- 81mm Practice Mortar
- Frag

Note: If not noted as UXO or DMM, the items are munitions debris.

Imagery Source: PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 2007.

N W E S

0 3,250 6,500
Feet

Figure 1-6
UXO, DMM and MD Locations
Ricochet Area MRS
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\RI\UXOFinds.mxd, 9/14/2011 12:13:18 PM, johna

WESTON SOLUTIONS

Legend

- FIG Installation Boundary
- Ricochet Area MRS Boundary
- 155mm HE Projectile
- 75mm APHE Projectile
- 75mm HE Projectile
- MK-2A4 Primer

Imagery Source: PAMAP Program,
PA Department of Conservation and Natural Resources,
Bureau of Topographic and Geologic Survey, 2007.

N W E S

0 3,250 6,500
Feet

Figure 1-7
UXO/DMM (Category 1) Locations
Ricochet Area MRS
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\RI\Level1_Finds.mxd, 9/12/2011 3:13:02 PM, johna

WESTON SOLUTIONS

Legend

- FIG Installation Boundary
- Ricochet Area MRS Boundary
- 105mm Illumination Projectile
- 155mm Illumination Projectile
- 155mm Projectile (empty)
- 4.2" Projectile
- 60mm Illumination Projectile
- 75mm AP Rounds
- 81mm Illumination Mortar
- 81mm Mortar Tailfin
- 81mm Practice Mortar
- Frag

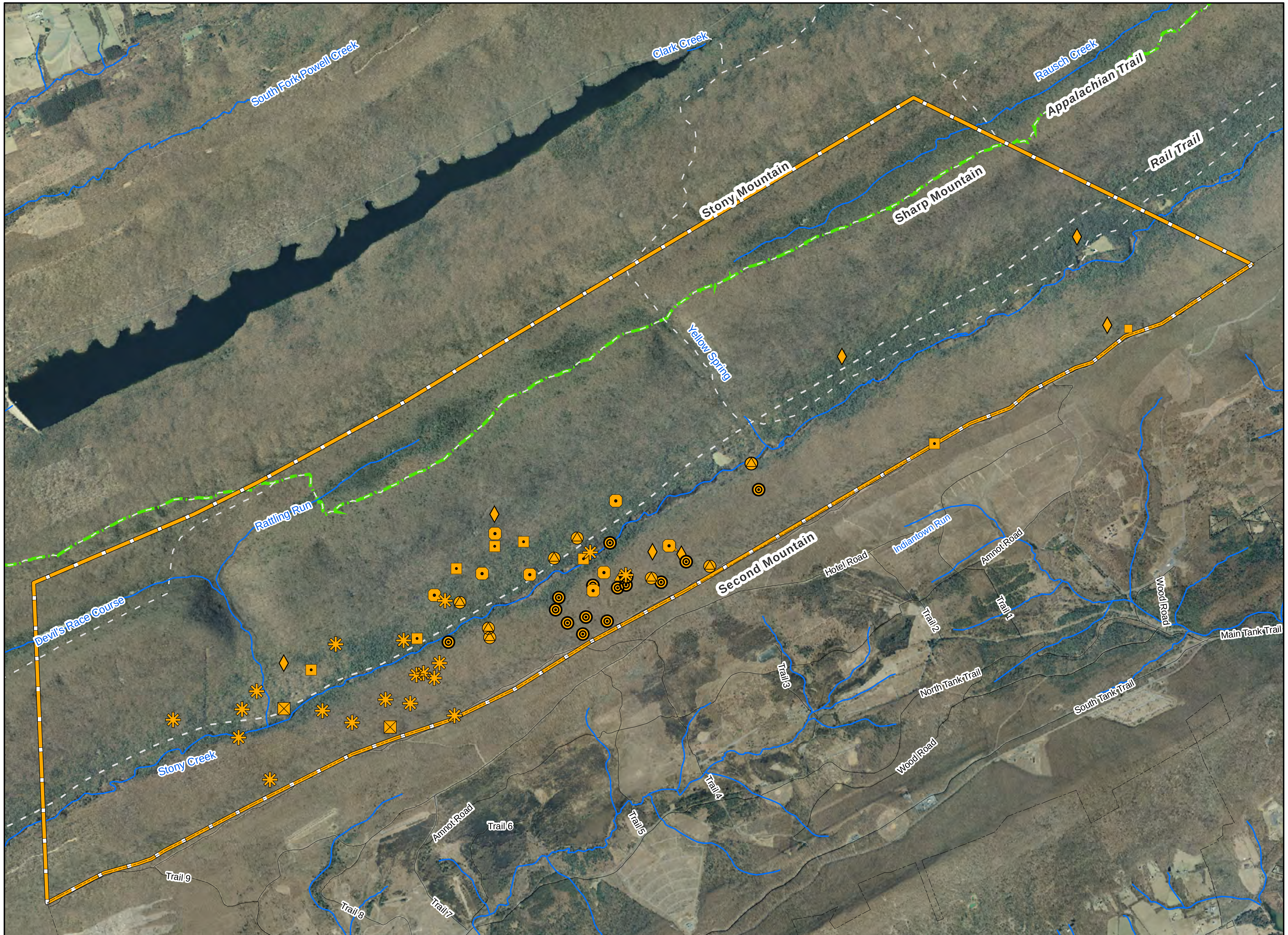
Imagery Source: PAMAP Program,
PA Department of Conservation and Natural Resources,
Bureau of Topographic and Geologic Survey, 2007.

N E S W

0 3,250 6,500
Feet

Figure 1-8
Munition Debris
(Category 2) Locations
Ricochet Area MRS
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\RI\Level2_Finds.mxd, 9/13/2011 9:58:51 AM, johna



WESTON SOLUTIONS

Legend

- FIG Installation Boundary
- Ricochet Area MRS Boundary
- 105mm Anti-Tank (practice)
- 105mm Discarding SABOT
- 105mm HEP (practice)
- 105mm Illumination Canister
- 155mm Illumination Canister
- 165mm HEP (practice)
- 37mm AP
- 37mm Projectile (practice)
- 57mm AP

Imagery Source: PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 2007.

N W E S

0 3,250 6,500
Feet

Figure 1-9
Munition Debris
(Category 3) Locations
Ricochet Area MRS
State Game Lands 211, PA

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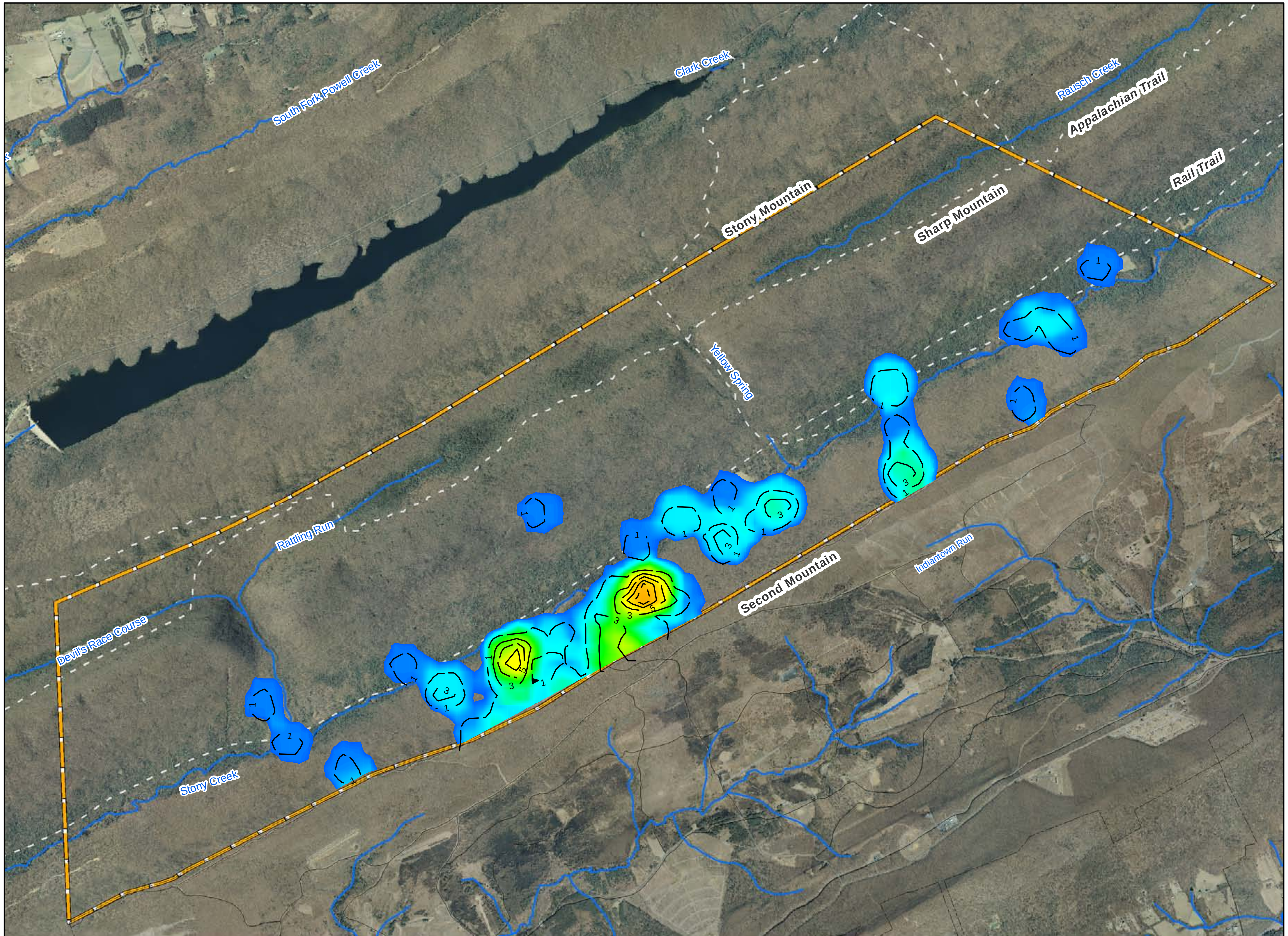
Figure 1-10
Calculated Densities
Category 1
Ricochet Area MRS
State Game Lands 211, PA

File: Y:\FIG\mxd\MMRP_RIFS\RI\Density_122910.mxd, 9/14/2011 9:21:00 AM, ricksc



WESTON SOLUTIONS

Legend

FIG Installation Boundary

Ricochet Area MRS Boundary

Anomaly Density Per Acre (From VSP)

<0.5 1 2 3 4 5 6 7 8 9

N E S W

0 3,250 6,500

Feet

Figure 1-11
Calculated Densities
Category 1-2
Ricochet Area MRS
State Game Lands 211, PA

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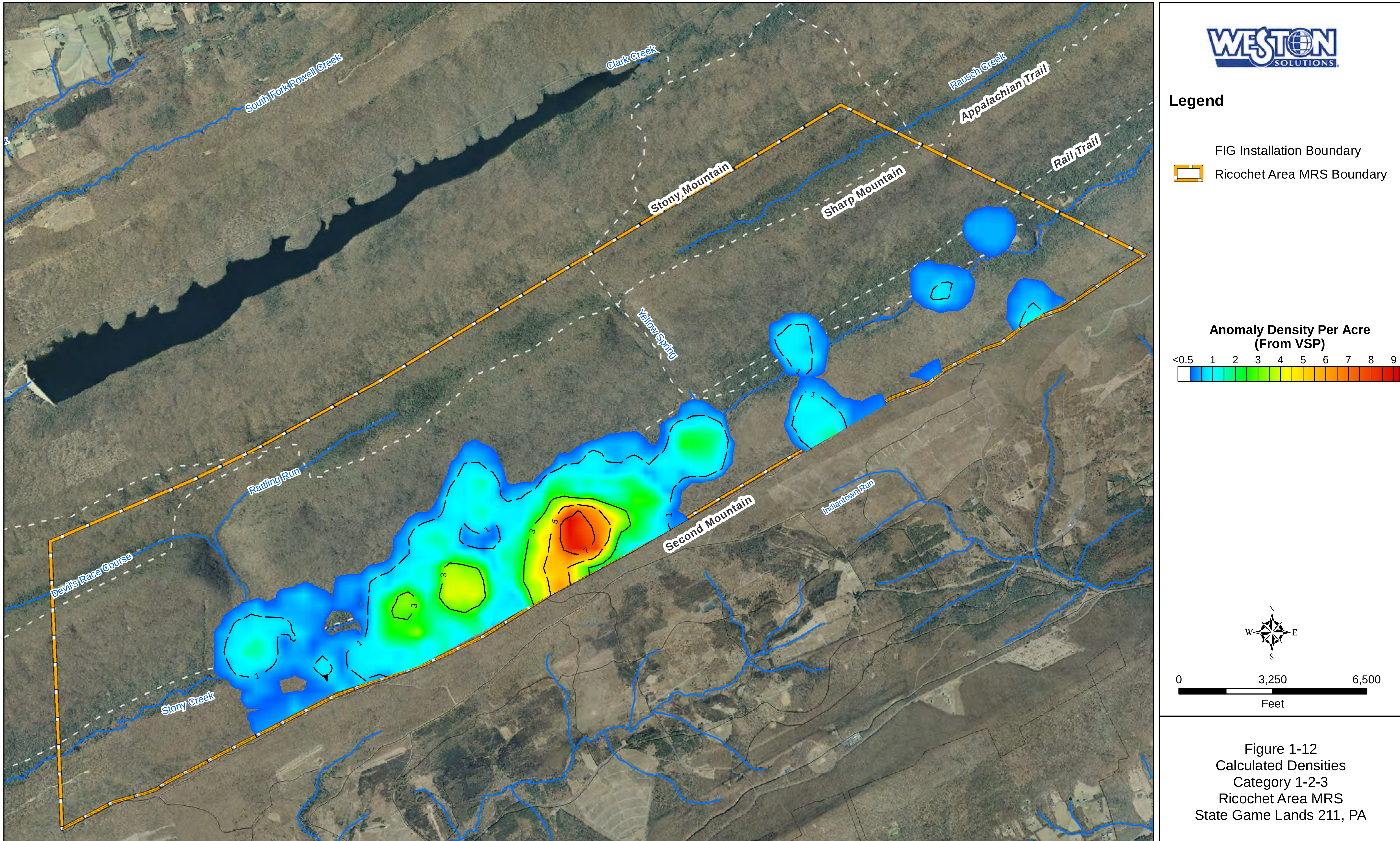

Figure 1-12
Calculated Densities
Category 1-2-3
Ricochet Area MRS
State Game Lands 211, PA

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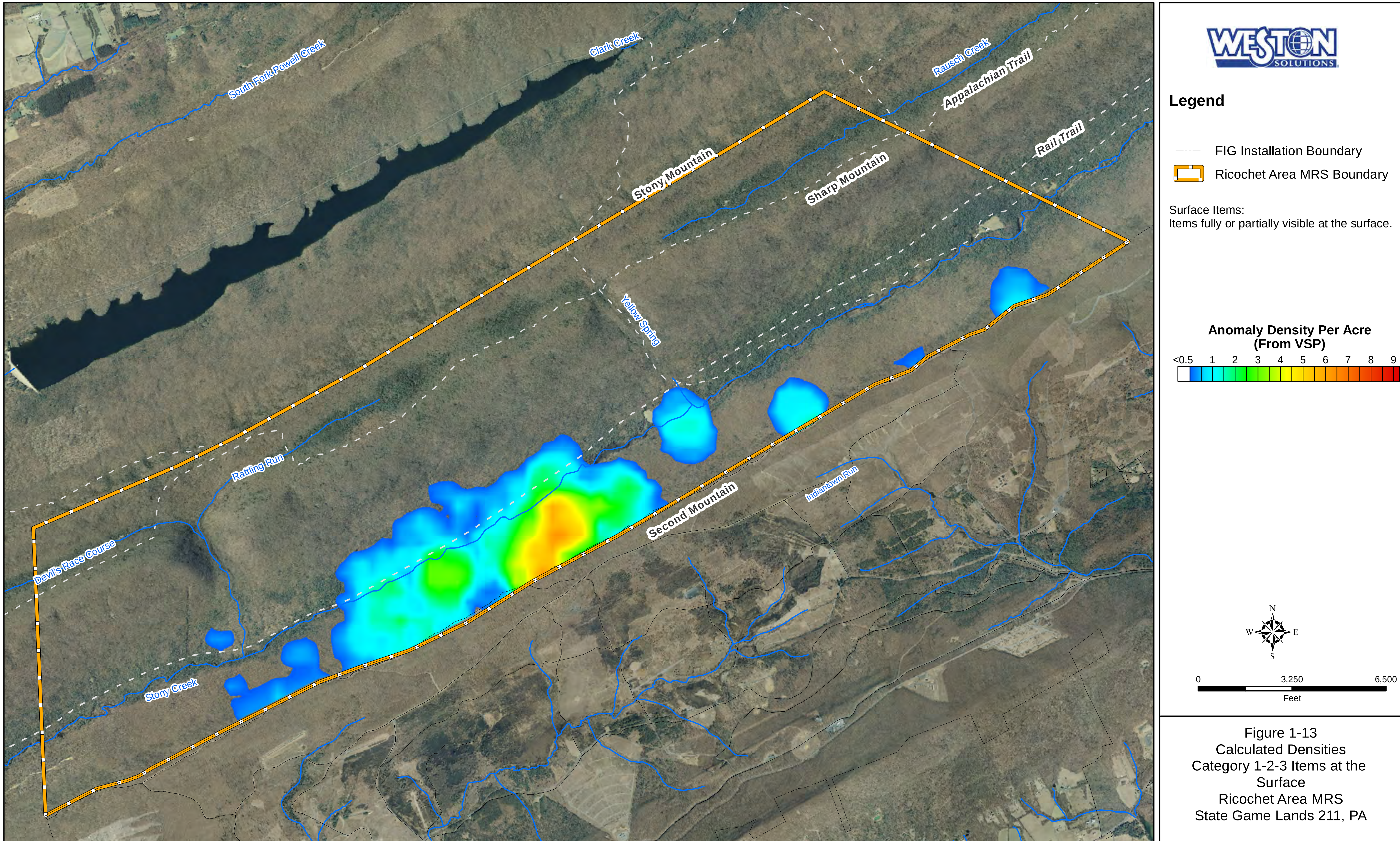

Figure 1-13
Calculated Densities
Category 1-2-3 Items at the Surface
Ricochet Area MRS
State Game Lands 211, PA

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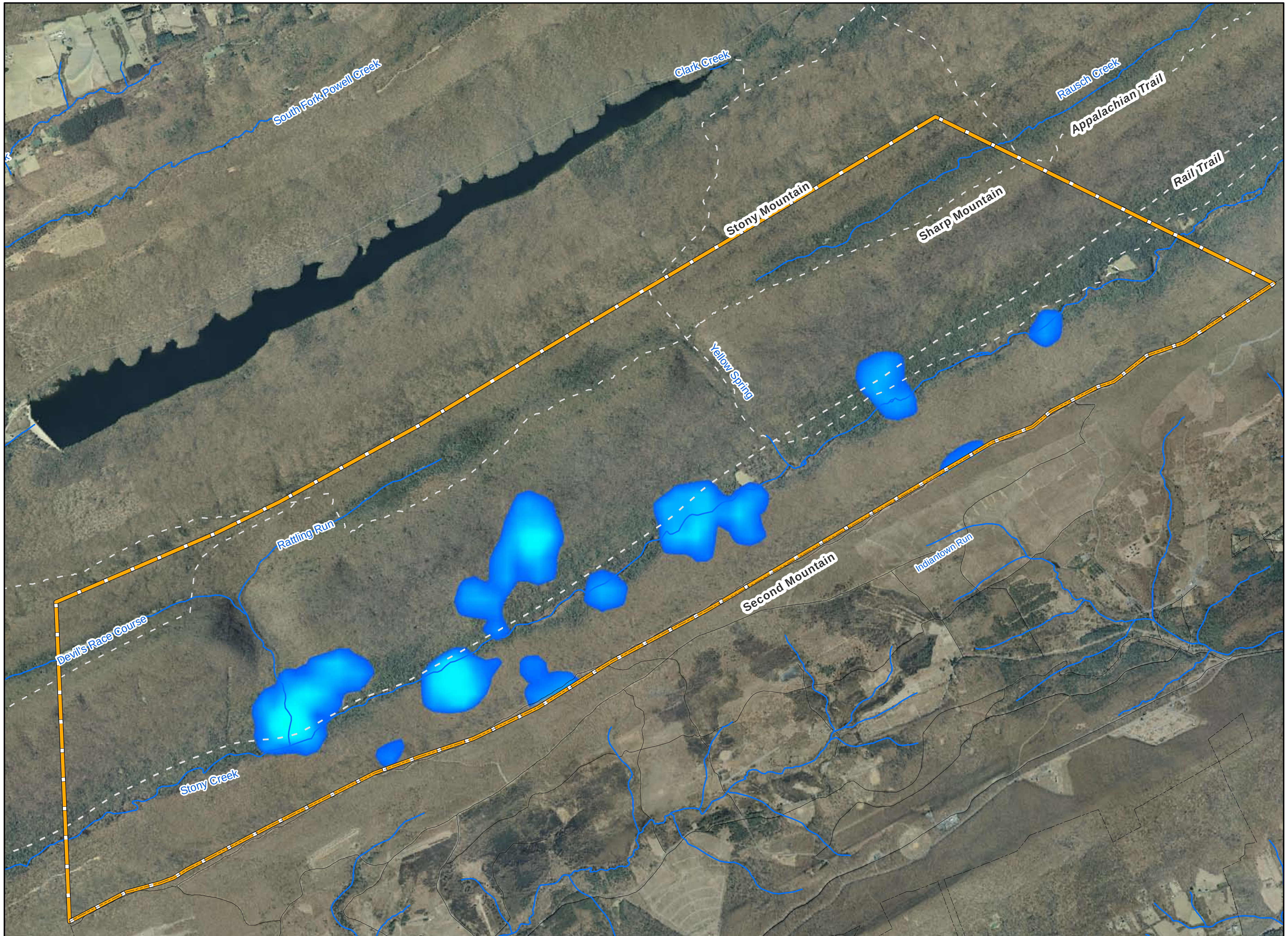

Figure 1-14
Calculated Densities
Category 1-2-3 Items in the Subsurface
Ricochet Area MRS
State Game Lands 211, PA

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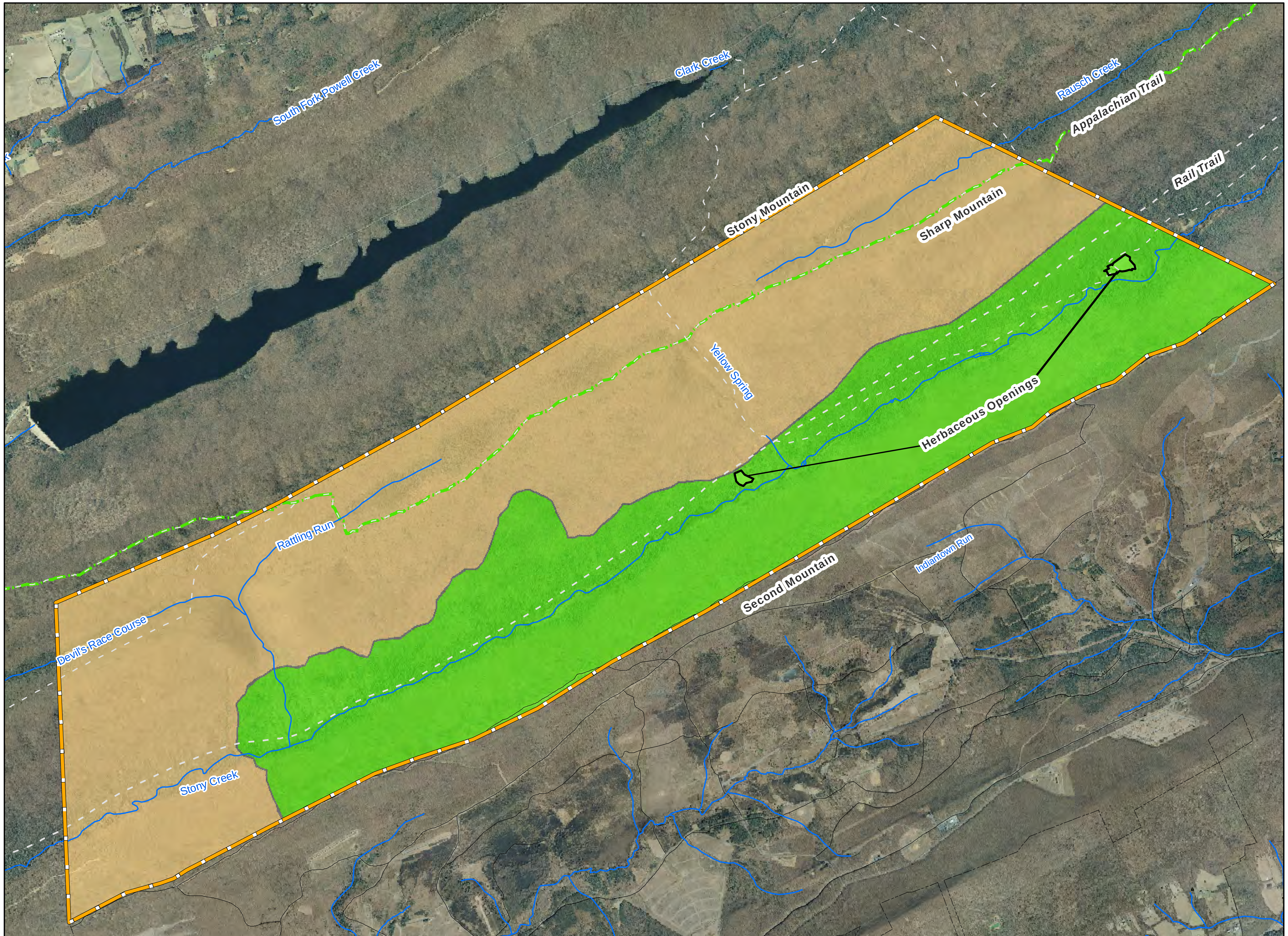

Legend

- Ricochet Area MRS Boundary
- FIG Installation Boundary
- Ricochet Area MRS (3,262 Acres)
- Sharp Mountain MRS (4,740 Acres)

Figure 1-15
Munitions Response Sites
Ricochet Area MRS
State Game Lands 211, PA

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2. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA

Three categories of ARARs are evaluated for the Ricochet Area MRS, along with TBCs. The ARAR categories are chemical-specific, location-specific, and action-specific.

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. Preliminary chemical-specific ARARs were identified in the RI to provide benchmarks with which to compare MC sampling results for metals and explosives at the Ricochet Area. The benchmarks were used in the human health and ecological screening level risk assessments in the RI. However, the results of the risk assessments indicated no specific MC associated with the Ricochet Area. Therefore, chemical-specific ARARs are not considered in this FS.

Location-specific ARARs generally are 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. Several location-specific ARARs have been identified. These location-specific ARARs will be reviewed prior to implementation of removal action alternatives at the Ricochet Area MRS. The location-specific ARARs include protection of historical and archaeological resources and protection of wildlife and habitat resources, including endangered species, fish, migratory birds, and wetlands.

Action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to removal actions or requirements to conduct certain actions to address particular circumstances at a site.

TBCs are used when there are no ARARs or when ARARs alone may not adequately protect human health and the environment.

ARARs and TBCs identified for the Ricochet Area are summarized in **Table 2-1.**

Table 2-1 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria

ARAR/TBC	Citation/Description	Applicability or Relevance
Chemical-Specific ARARs		
25 Pa. Code 250 – Administration of Land Recycling Program	Appendix A, Table 3a – Medium-Specific Concentrations (MSCs) for Organic Regulated Substances in Soil, Direct Contact Numeric Values, Residential (0-15 feet) and Non-Residential, Surface Soil (0-2 feet). Appendix A, Table 3b – MSCs for Organic Regulated Substances in Soil, Soil to Groundwater Numeric Values, Used Aquifers, Total Dissolved Solids (TDS) less than or equal to 2500, Residential (Generic Value) and Non-Residential (Generic Value). Appendix A, Table 4a – MSCs for Inorganic Regulated Substances in Soil, Direct Contact Numeric Values, Residential (0-15 feet) and Non-Residential, Surface Soil (0-2 feet). Appendix A, Table 4b – MSCs for Inorganic Regulated Substances in Soil, Soil to Groundwater Numeric Values, Used Aquifers, TDS less than or equal to 2500, Residential (Generic Value) and Non-Residential (Generic Value).	MSCs for organic and inorganic substances in soil were compared to results from soil and sediment samples collected at the Ricochet Area in order to evaluate risk associated with metals and explosives.
25 Pa. Code 16 – Water Quality Toxics Management Strategy-Statement of Policy	Appendix A, Table 1 – Water Quality Criteria for Toxic Substances.	Surface water samples were not collected as part of the RI.
Location-Specific ARARs		
36 Code of Federal Regulation (CFR) 800, Excluding Section 800.8 – Protection of Historic Properties (Section 106 of the National Historic Preservation Act, as amended)	(a) *Purposes of the Section 106 process.* Section 106 of the National Historic Preservation Act requires Federal agencies to take into account the effects of their undertakings on historic properties and afford the Council a reasonable opportunity to comment on such undertakings.	Historic properties/sites exist at the Ricochet Area. The procedures in 36 CFR 800 describe how Federal agencies meet these statutory responsibilities by identifying historic properties potentially affected by the undertaking; assessing the effects; and seeking ways to avoid, minimize, or mitigate any adverse effects on historic properties.

Table 2-1 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria (Continued)

ARAR/TBC	Citation/Description	Applicability or Relevance
Fish and Wildlife Coordination Act [16 Unites States Code (U.S.C.) 661 et seq.; 40 CFR Section 6.302(g); 33 CFR Part 320]	Requires Federal agencies involved in actions that will result in the control of structural modification of any stream or body of water for any purpose to take action to protect the fish and wildlife resources that may be affected by the action. EPA must consult with the Fish and Wildlife Service and the appropriate state agency to ascertain the means and measures necessary to mitigate, prevent, and compensate for project-related losses of wildlife resources and to enhance the resources.	No adverse impacts to fish and wildlife resources are anticipated.
Protection of Wetlands Executive Order No. 11990 [40 CFR Part 6, App. A]	Under this Order, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. If remediation is required within wetlands areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values.	Wetlands are present within the MRS. Only the margins of the wetlands were surveyed.
16 U.S.C. 1536 (Endangered Species Act of 1973, as amended)	2) Each Federal agency shall, in consultation with and with the assistance of the Secretary, ensure that any action authorized, funded, or carried out by such agency (hereinafter in this section referred to as an "agency action") is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical, unless such agency has been granted an exemption for such action by the Committee pursuant to subsection (h) of this section. In fulfilling the requirements of this paragraph each agency shall use the best scientific and commercial data available.	Pennsylvania Potential Special Status Species include three species of insects, three species of terrestrial wildlife, and three plant species (as described in Section 2 of the RI report). The purposes of this section of the Endangered Species Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section. This Act requires interagency cooperation to ensure that authorized actions do not jeopardize the continued existence of endangered or threatened species, or their habitats.

Table 2-1 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria (Continued)

ARAR/TBC	Citation/Description	Applicability or Relevance
Action-Specific ARARs		
25 Pa. Code 102.11 – Erosion and sediment control best management practices (BMPs); General requirements	(a) A person conducting or proposing to conduct an earth disturbance activity shall design, implement and maintain BMPs to minimize the potential for accelerated erosion and sedimentation in order to protect, maintain, reclaim and restore water quality and existing and designated uses. Various BMPs and their design standards are listed in the Erosion and Sediment Pollution Control Program Manual (Manual), Commonwealth of Pennsylvania, Department of Environmental Protection, No. 363-2134-008 (January1996), as amended and updated. (b) BMPs and design standards other than those listed in the Manual may be used when a person conducting or proposing to conduct an earth disturbance activity demonstrates to the Department or a county conservation district that the alternate BMP or design standard minimizes accelerated erosion and sedimentation to achieve the regulatory standards in subsection (a).	MEC removal activities may require excavation of some kind, mainly by using hand tools. 25 Pa. Code 102 requires persons proposing or conducting earth disturbance activities to develop, implement, and maintain BMPs to minimize the potential for accelerated erosion and sedimentation.
40 CFR 264 Subpart X – Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities; miscellaneous units	264.601- A miscellaneous unit must be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment.	It is anticipated that MEC disposal (by detonation) will be required as part of remedial alternatives discussed in this FS. Should the need for disposal/treatment arise, it could require the use of technologies defined as “miscellaneous units” in Subpart X, including open burning/open detonation (OB/OD) units, shredders, crushers, etc. Subpart X outlines procedures for issuing permits to miscellaneous units that treat, store, or dispose of hazardous waste. Miscellaneous units include OB/OD units, enclosed combustion devices, carbon and catalyst regeneration units, thermal desorption units, shredders, crushers, filter presses, and geologic repositories. Subpart X does not specify minimum technology requirements or monitoring requirements for miscellaneous units. Subpart X specifies an environmental performance standard that must be met through conformance with appropriate design, operating, and monitoring requirements.

Table 2-1 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria (Continued)

ARAR/TBC	Citation/Description	Applicability or Relevance
TBCs		
Memo, DoD and EPA, Interim Final, 7 March 2000 – "DoD and EPA Interim Final Management Principles for Implementing Response Actions at Closed, Transferring, and Transferred (CTT) Ranges"	A permanent record of the data gathered to characterize a site and a clear audit trail of pertinent data analysis and resulting decisions and actions are required. To the maximum extent practicable, the permanent record shall include sensor data that are digitally-recorded and geo-referenced.	This document provides interim guidance for ongoing response actions addressing MEC at the Ricochet Area.

3. IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies general remedial actions and potential MEC detection and removal technologies for the Ricochet Area MRS. The general remedial actions identified in this section are analyzed in the Development and Screening of Alternatives (Section 4) and Detailed Analysis of Alternatives (Section 5) sections of this report. Each technology identified in this section is screened for effectiveness, implementability, and cost to evaluate its viability at the Ricochet Area.

3.1 GENERAL REMEDIAL ACTIONS

General remedial actions are those actions that will achieve the RAOs. The following general remedial actions will be considered at the Ricochet Area MRS:

- **No Action—**The No Action alternative is evaluated to satisfy the NCP requirement of 40 CFR 300.430(e)(6), which requires consideration of this alternative as a baseline against which other alternatives may be compared.
- **Containment and Controls—**Containment and controls are considered a “limited” action alternative by EPA, and include components of access control and/or public education (EPA, 1988).
- **MEC Removal—**MEC can be detected and removed from the ground surface and/or below the ground surface. Alternatives for MEC removal will include technologies for MEC detection, positioning for the detection technologies, MEC removal, and MEC disposal.

3.2 IDENTIFICATION AND SCREENING OF MEC REMEDIAL TECHNOLOGIES

3.2.1 Screening Criteria

MEC remedial technologies are first evaluated against the three general categories of effectiveness, implementability, and cost to ensure that they meet the minimum standards of the criteria within each category in the FS process. The three general categories are first used to screen the technologies described in Section 3.2.2 and later used to screen the alternatives developed in Section 4.1. The three general categories are described below.

3.2.1.1 Effectiveness

Technologies or alternatives that have been identified should be evaluated further on their effectiveness relative to other processes within the same technology/alternative type. This evaluation should focus on: (1) the potential effectiveness of technology/alternative options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs; (2) the potential impacts to human health and the environment during the removal or implementation phase; and (3) how proven and reliable the technology/alternative is with respect to the MEC and conditions at the site (EPA, 1988).

3.2.1.2 Implementability

Implementability, as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative, is used during screening to evaluate the combinations of technology/alternative options with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for technology/alternative options until a remedial action is complete. It also includes operation, maintenance, replacement, and monitoring of technical components of a technology/alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services and capacity; and the requirements for, and availability of, specific equipment and technical specialists (EPA, 1988).

The determination that a technology/alternative is not technically feasible will usually preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination. Typically, this type of "fatal flaw" will be identified during technology screening, and an alternative consisting of infeasible technology will not be assembled. Negative factors affecting administrative feasibility will normally involve coordination steps to lessen the negative aspects of the technology/alternative but will not necessarily eliminate a technology/alternative from consideration (EPA, 1988).

3.2.1.3 Cost

Typically, technologies/alternatives will have been defined well enough before screening that some estimates of cost are available for comparisons among technologies/alternatives. However, because uncertainties associated with the definition of technologies/alternatives often remain, it may not be practicable to define the costs of technologies/alternatives with the accuracy desired for the detailed analysis (i.e., +50% to -30%) (EPA, 1988).

According to EPA guidance, a high level of accuracy in cost estimates during screening is not required. The focus should be to make comparative estimates for technologies/alternatives with relative accuracy so that cost decisions among technologies/alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process.

In the detailed analysis in Section 5, when the costs of remedial action alternatives are evaluated, both capital and operation and maintenance (O&M) costs are considered, where appropriate. The evaluation includes those O&M costs that will be incurred for as long as necessary, even after the initial remedial action is complete. In addition, potential future remedial action costs are considered during alternatives evaluation to the extent they can be defined. Present worth analyses are used during alternatives evaluation to evaluate expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different technologies/alternatives can be compared on the basis of a single figure for each alternative. Each cost calculation includes an estimate of the time to complete the proposed alternative.

3.2.2 Evaluation of Technologies

Various technologies and approaches exist for the remediation of MEC. MEC remediation activities include three steps: detection, removal, and disposal. A description of the technologies used in each step is presented in the following subsections. At the end of each subsection, the technologies are screened against the three screening criteria to determine their viability at the Ricochet Area.

3.2.2.1 MEC Detection

MEC detection includes those methods and instruments used to locate surface and subsurface MEC. The best detection method is selected based on the MEC properties such as the depth and size of the suspected UXO and DMM items, and the physical characteristics of the site (i.e., soil type, topography, vegetation, and local geology).

There are two basic forms of MEC detection. The first, visual searching, has been successfully used at a number of sites where MEC is located on the ground surface. When performing a visual search of a site, the area to be searched is typically divided into 5-foot lanes that are systematically inspected for MEC. A metal detector is sometimes used to supplement the visual search in areas where ground vegetation may conceal surface MEC. Typically, any MEC found during these searches is flagged or marked for immediate disposal.

The second form of MEC detection, geophysics, includes various detection instruments designed to locate subsurface MEC and is integrated with equipment and methods used for location positioning. Each piece of equipment has its own inherent advantages and disadvantages based on its operating characteristics, making the selection of the type of geophysical instrument paramount to the survey success. The instruments designed to locate subsurface MEC include magnetometers, electromagnetic instruments, and ground penetrating radar (GPR). Positioning technologies include various equipment and instruments that establish geo-referenced positions for subsurface anomalies detected using MEC detection technologies. Positioning technologies are impacted on-site primarily by terrain, tree canopy, and vegetation density.

MEC detection technologies and positioning technologies are described in **Table 3-1** and **Table 3-2**, respectively. **Table 3-1** and **Table 3-2** also include technologies that were tested and used at the Ricochet Area during the RI. The technologies described in **Table 3-1** and **Table 3-2** are screened against the three criteria of effectiveness, implementability, and cost for the Ricochet Area MRS. Only one detection technology listed in **Table 3-1**, the marine side-scan sonar, is designed for implementation in a marine environment. However, as noted in **Table 3-1**, the marine side-scan sonar detects only items on the surface of the water body floor, requires calm water, and vegetation can hinder acoustic signal propagation. Stony Creek is the major water body within the Ricochet Area MRS. It is accessible by handheld and digital instruments. Adjacent areas to Stony Creek are partially submerged, depending on precipitation amounts and frequencies. These areas are accessible by handheld and digital instruments. Technologies currently available for detection of MEC in marine environments would not be effective in the wet areas that exist at the Ricochet Area.

Table 3-1 MEC Detection Technologies

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at Ricochet Area MRS
Visual Searching	**Low - Medium:** Effective for surface removals in open areas with little ground cover. Not appropriate for subsurface removals.	**Medium - High:** Easily implemented by trained UXO qualified and sweep personnel. Minimal to no impacts to cultural or natural resources.	**Low:** Lower than other methods that require detection instrumentation and associated equipment.	NA	Typically supported with a flux-gate magnetometer or frequency-domain electromagnetic induction (FDEMI) metal detector.	**Low:** Most MEC items were found near the surface at the Ricochet Area during the RI, but the significant amount of ground cover and difficult terrain reduced visibility.
Flux-Gate Magnetometers: Flux-gate magnetometers measure the vertical component of the geomagnetic field along the axis of the sensor and not the total intensity of the geomagnetic field.	**Medium - High:** Flux-gate magnetometers have been used as the primary detector in traditional mag and dig operations. There is a high industry familiarization. Detects ferrous objects only. The Schonstedt GA-52Cx was proven effective during the Ricochet Area RI. The instrument was used effectively for mag and dig surveys.	**High:** Light and compact. Can be used in any traversable terrain. Costs, transportation, and logistics requirements are equal to or less than other systems. Widely available from a variety of sources. Minimal to no impacts to cultural or natural resources.	**Low:** A number of flux-gate magnetometers have a low cost for purchase and operation compared to other detection systems. Lower than other methods on most terrains.	Schonstedt GA-52Cx Schonstedt GA-72Cd Foerster FEREX 4.032 Ebinger MAGNEX 120 LW Vallon EL1202D1 Chicago Steel Tape (Magna-Trak 102)	Analog output not usually co-registered with navigational data.	**High:** This technology was proven effective at the Ricochet Area MRS during the RI.
Proton Precession Magnetometers: Proton precession magnetometers measure the total intensity of the geomagnetic field. Multiple sensors are sometimes arranged in proximity to measure horizontal and vertical gradients of the geomagnetic field.	**Medium:** Proton precession systems have similar sensitivities as flux-gate systems, but with a relatively slow sampling rate. There is a high industry familiarization. Detects ferrous objects only.	**Low:** Systems are similar to flux-gate systems in terms of operation and support. Generally is heavier and requires more battery power than flux-gate sensors. Sampling rate is low. Can be used in any traversable terrain. Is widely available from a variety of sources. Minor impacts to cultural or natural resources based on clearing of areas for data collection.	**Medium:** Costs are higher than flux-gate systems since proton precession systems often acquire digital data.	Geometrics G-856AX GEM Systems GSM-19T	Typically used as a base station for other digital magnetometer systems.	**Low:** This technology was used as a base station for the Geometrics G-858 system used effectively during the RI. Proton precession systems are not viable options as a standalone detector at the Ricochet Area MRS due to low implementability.
Optically Pumped Magnetometers: This technology is based on the theory of optical pumping and operates at the atomic level as opposed to the nuclear level (as in proton precession magnetometers).	**High:** This is the industry standard technology to detect MEC using magnetic data analysis. There is a high industry familiarization. Detects ferrous objects only. Geometrics G-858 was tested and proven effective during the geophysical system verification (GSV) process at the Ricochet Area. The system was used effectively for digital geophysical mapping (DGM) during the RI.	**Medium - High:** Equipment is digital, ruggedized, and weather resistant. Common systems weigh more than most flux-gate systems and are affected by heading error. Can be used in most traversable terrain. Widely available from a variety of sources. Processing and interpretation requires trained specialists. Anomaly classification possibilities are limited to positional accuracy, magnetic susceptibility/magnetic moment estimates, and depth estimates. Detection capabilities are negatively influenced by iron-bearing soils. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Medium – High:** Has high purchase cost compared to other technologies. More dependent on terrain than flux-gate magnetometers. Lower costs can be realized when using arrays of multiple detector sensors.	Geometrics G-858 Geometrics G-822 Geometrics G-880 Geometrics G-882 GEM Systems GSMP-40 Scientrex Smart Mag G-tek TM4	Digital signal should be co-registered with navigational data for best results.	**High:** This technology was proven effective at the Ricochet Area MRS during the RI.

Table 3-1 MEC Detection Technologies (Continued)

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at Ricochet Area MRS
Time-Domain Electromagnetic Induction (TDEMI) Metal Detectors: TDEMI is a technology used to induce a pulsed magnetic field beneath the Earth's surface with a transmitter coil, which in turn causes a secondary magnetic field to emanate from nearby objects that have conductive properties.	**High:** TDEMI technology is the industry standard for MEC detection using electromagnetic data analysis. There is a high industry familiarization. Detects both ferrous and non-ferrous metallic objects. Can be limited by terrain.	**Low - Medium:** Sensors are typically larger than digital magnetometers. Can be used in most traversable terrain. Most commonly used instrument and is widely available. Processing and interpretation are relatively straightforward. Anomaly classification possibilities exist for multi-channel systems. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Medium – High:** Has high purchase cost compared to other technologies. Dependent on terrain. Lower costs can be realized when using arrays of multiple detector sensors.	Geonics EM61-MK1 Geonics EM61-MK2 Geonics EM61-MK2 HP Geonics EM61 HH Geonics EM63 Zonge Nanotem G-tek TM5-EMU Vallon VMH3 Schiebel AN PSS-12	Digital signal should be co-registered with navigational data for best results. Detection depths are highly dependent on coil size and transmitter power.	**Medium:** This technology was proven effective at other MMRP projects but would be difficult to implement due to terrain at most of the Ricochet Area MRS.
Advanced EMI Sensors and Anomaly Classification: Emerging advanced sensors have the ability to precisely capture measurements from enough locations to sample all principal axis responses of an anomaly/item of interest. This provides the necessary information for analysis and classification of hazardous and non-hazardous items.	**Medium – High:** Some sensors may be used in production mode, but most require target locations from previous DGM survey to navigate to for static measurements. Greatest ability of all sensors for the classification of anomalies as either MEC or non-hazardous items. Detects both ferrous and non-ferrous metallic objects.	**Medium:** Most require the use of a vehicle to tow the sensor to the location of an anomaly, although some smaller, man-portable systems are in development. One-meter-wide coil width (or greater) limits accessibility in forested or steeply sloped areas. Advanced analysis is required to effectively use the data acquired by the sensors and accurately classify detected anomalies as MEC or non-hazardous material that will not be removed. Minor to moderate impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**High:** Use of the advanced systems often represents additional surveying and processing costs, which may be largely offset by the decrease in the intrusive investigation costs.	AllTEM Berkeley UXO Discriminator (BUD) Geometrics MetalMapper Geonics EM61-MK2 Geonics EM63 TEMTADS TEMTADS 2x2	Sensors have limited industry availability. Requires advanced training for operation, data processing, and analysis.	**Medium:** This technology has been demonstrated and validated by the DoD's Environmental Security Technology Certification Program (ESTCP). The technology would be generally difficult to implement due to the terrain at most of the Ricochet Area MRS.
Frequency-Domain Electromagnetic Induction (FDEMI) Metal Detectors: FDEMI sensors generate one or more defined frequencies in a continuous mode of operation.	**Medium - High:** Some digital units have been used as the primary detector in highly ranked systems. Demonstrates capability for detecting small items using handheld units. Is not optimum for detecting deeply buried objects. Lower industry familiarization than time-domain electromagnetic systems. Detects both ferrous and non-ferrous metallic objects. The technology is not good for detecting deeply buried, single items.	**High:** Hand-held detectors are generally light and compact. Can be used in any traversable terrain. Most are handheld systems. Widely available from a variety of sources. Minimal to no impacts to cultural or natural resources.	**Medium – High:** Instruments are slow and can detect very small items. Common handheld detectors are much lower cost than digital systems.	Schiebel ANPSS-12 White's All Metals Detector Fisher 1266X Foerster Minex Minelabs Explorer II Geophex GEM 2 Geophex GEM 3 Apex Max-Min	Analog output not usually co-registered with navigational data. Digital output should be co-registered with navigational data	**Medium:** This technology was not proven at the Ricochet Area MRS. Detects all metals, instead of only ferrous items. Relatively high cost to implement.
Sub Audio Magnetics (SAM): SAM is a patented methodology by which a total field magnetic sensor is used to simultaneously acquire both magnetic and electromagnetic response of subsurface conductive items.	**Medium - High:** Detects both ferrous and non-ferrous metallic objects. Capable tool for detection of deep MEC. Low industry familiarization. System has seen limited application.	**Low:** High data processing requirements. Available from a few sources. High power requirements. Has longer than average setup times. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**High:** Has higher than average operating costs and low availability.	G-tek SAM	Not commercially available. No established track record.	**Low:** Difficult to implement, high cost, not commercially available.

Table 3-1 MEC Detection Technologies (Continued)

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at Ricochet Area MRS
Magnetometer-Electromagnetic Detection Dual Sensor Systems: These dual sensor systems are expected to be effective in detecting MEC as magnetometers respond to large, deep ferrous targets and TDEMI sensors respond to nonferrous metallic targets.	**High:** Collects co-located magnetic and electromagnetic data to differentiate between ferrous and non-ferrous metallic objects. Has medium industry familiarization.	**Low – Medium:** Increased data processing requirements. Similar terrain constraints to time-domain electromagnetic systems. Available from few sources. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**High:** Costs are lower when using a towed array platform. Limited availability.	MSEMS (man-portable EM61-hh & G-822) VSEMS (vehicular EM61-hh & G-822)	Only available from a few sources.	**Low:** Difficult to implement, high cost, only available from a few sources. Towed array is not implementable at the Ricochet Area MRS.
Marine Side-Scan Sonar: This technology uses acoustic waves to locate objects and record water bottom structures in a swath on one or both sides of its sensors.	**Low:** Visualizes shapes of both metallic and non-metallic objects. Only detects items exposed on the water body floor. Has medium industry familiarization.	**Medium:** Requires trained operator and experienced field crew. Calm water may be needed. Vegetation can hinder acoustic signal propagation, and large floating vegetation mats and dense root growth are common in wetlands at the Ricochet Area. Would require removal of plants which would affect natural resources.	**Medium:** For marine investigations.	Klein 5500 EdgeTech DF-1000 Triton Elics Sonar Suite GeoAcoustics Fishers SSS-100K/600K Marin Sonic Technologies	Few have applied these technologies to detect MEC.	**Low:** Wetlands at the Ricochet Area MRS contain sufficient vegetation to hinder signal or reduce implementability.
Airborne Multi- or Hyper- Spectral Imagery: This airborne method uses unique spectral signatures produced by an item to determine the item composition and size. Multispectral techniques can be used because they provide more information than images from common broadband cameras.	**Low:** Detects both metallic and non-metallic objects. Only detects largest UXO or DMM. Low industry familiarization. Effectiveness increases when used for wide area assessment in conjunction with other airborne technologies.	**Low:** Requires aircraft and an experienced pilot. Substantial data processing and management requirements. Available from few sources. Minimal to no impacts to cultural or natural resources.	**High:** Aircraft and maintenance costs must be included. Processing costs are higher than other methods.	There are few multi/hyper spectral imagery providers.	Few have applied these technologies to detect MEC.	**Low:** Difficult to implement, high cost, only available from a few sources.
Airborne Synthetic Aperture Radar (SAR): This airborne method uses strength and travel time of microwave signals that are emitted by a radar antenna and reflected off a distant surface object.	**Low:** Detects both metallic and non-metallic objects. Only detects largest MEC on or near ground surface. Low industry familiarization. Effectiveness increases when used for wide area assessment in conjunction with other airborne technologies.	**Low:** Requires aircraft and an experienced pilot. Substantial data processing and management requirements. Available from few sources. Minimal to no impacts to cultural or natural resources.	**High:** Aircraft and maintenance costs must be included. Processing costs are higher than other methods.		Few have applied these technologies to detect MEC.	**Low:** Difficult to implement, high cost, only available from a few sources.

Table 3-1 MEC Detection Technologies (Continued)

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at Ricochet Area MRS
Airborne Laser and Infrared (IR) Sensors: IR and laser technologies can be used to identify objects by measuring their thermal energy signatures. UXO or DMM on or near the soil surface may possess different heat capacities or heat transfer properties than the surrounding soil, and this temperature difference theoretically can be detected and used to identify MEC.	**Low:** Detects both metallic and non-metallic objects. Low industry familiarization. Effectiveness increases when used for wide area assessment in conjunction with other airborne technologies.	**Low:** Requires aircraft and an experienced pilot. Substantial data processing and management requirements. Available from few sources. Minimal to no impacts to cultural or natural resources.	**High:** Aircraft and maintenance costs must be included. Processing costs are higher than other methods.		Few have applied these technologies to detect MEC.	**Low:** Difficult to implement, high cost, only available from a few sources.

Table 3-2 Positioning Technologies

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Differential Global Positioning System (DGPS): GPS is a worldwide positioning and navigation system that uses a constellation of 29 satellites orbiting the Earth. GPS uses these satellites as reference points to calculate positions on the Earth's surface. Advanced forms of GPS, like DGPS, can provide locations to centimeter accuracy.	**Medium**: Very effective in open areas for both digital mapping and reacquiring anomalies. Very accurate when differentially corrected. Not effective in wooded areas or around large buildings. Commonly achieves accuracy to a few centimeters, but degrades when minimum satellites are available.	**High**: Easy to operate and set up. Requires trained operators. Available from a number of vendors. Better systems are typically ruggedized and very durable. However, significant work time can be lost when insufficient satellites are available due to topography and tree canopy. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Medium**: Requires rover and base station units. Survey control points required for high accuracy results.	Leica GPS 1200 Trimble Model 5800 Thales Ashtech Series 6500	Recommended in open areas.	**Low – Medium:** This technology not effective in wooded areas with tree canopy. The Ricochet Area is heavily wooded.
Robotic Total Station (RTS): RTS is a laser-based survey station that derives its position from survey methodology and includes a servo-operated mechanism that tracks a prism mounted on the geophysical sensor.	**Medium - High**: Effective in open areas for both digital mapping and reacquiring anomalies. Effective around buildings and sparse trees. Is being used in heavily wooded areas with moderate success. Commonly achieves accuracy to a few centimeters.	**Medium**: Relatively easy to operate with trained personnel. Requires existing control. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Low**: Operates as a stand-alone unit. Typically requires survey control points but can be used in a relative coordinate system.	Leica RTS 1100 Trimble Model 5600	Recommended in open areas and in moderately wooded areas. Typically used with TDEMI metal detectors (like Geonics EM61-MK2) and digital magnetometers (like Geometrics G-858).	**Medium – High:** This technology was used for anomaly reacquisition during the RI. Can also be used for data positioning for digital detector systems in moderately wooded areas.
Fiducial Method: The fiducial method consists of digitally marking a data string with an indicator of a known position. Typically, markers are placed on the ground at known positions (e.g., 25 feet).	**Medium - High**: Medium to high effectiveness when performed by experienced personnel. Low effectiveness when used by inexperienced personnel. Commonly achieved accuracy is 15 to 30 centimeters. The fiducial method was tested and proven effective during the Ricochet Area RI.	**Medium**: Application requires a constant pace and detailed field notes. Can be used anywhere, with varying degrees of complexity in the operational setup. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Low - Medium**: Minimal direct costs associated with this method; however, poor results may negatively impact costs associated with target resolution. Fiducial method requires more "back-end" data processing than some other methods.	NA	Requires very capable operators. Useful method if digital positioning systems are unavailable.	**Medium – High:** This technology was tested and proven effective with atomic-vapor magnetometers during the RI.
Odometer Method: This method utilizes an odometer which physically measures the distance traveled.	**Medium**: Medium to high effectiveness when performed by experienced personnel. Low effectiveness when used by inexperienced personnel. Commonly achieved accuracy is 15 to 30 centimeters in line and 20 to 80 centimeters on laterals.	**Low**: Setup and operation affected by terrain/environment. Requires detailed field notes and setup times can be lengthy. Can be used anywhere, with varying degrees of complexity in the operational setup. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**Low**: Minimal direct costs associated with this method; however, poor results may negatively impact costs associated with target resolution.	NA	Requires very capable operators. Useful method if digital positioning systems are unavailable.	**Low:** Terrain could limit effectiveness and implementability.

Table 3-2 Positioning Technologies (Continued)

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Acoustic Method: This navigation system utilizes ultrasonic techniques to determine the location of a geophysical instrument each second. It consists of three basic elements: a data pack, up to 15 stationary receivers, and a master control center.	**Low – Medium**: Not very efficient in open areas due to substantial calibration and setup time. Effective in wooded areas although less accurate than other methods. Commonly achieves accuracy of 20 to 50 centimeters.	**Medium**: Difficult to set up and setup requirements are complex. (However, more easily set up and used by trained personnel.) Very little available support. Negatively affected by certain aspects of the environment. Transponders have very limited range, on the order of 75 to 150 feet. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**High**: Lengthy setup time can be reduced by using trained personnel. Requires more than one operator. Is expensive to purchase or rent.	USRADS	Requires trained operators. Has been used extensively in wooded areas with success.	**Medium**: Technology could be used in wooded areas at the Ricochet Area MRS. High costs limit its viability.
Inertial Navigation: This system measures the acceleration of an object in all three directions and calculates the location relative to a starting point. The starting point is input and periodically refreshed using another navigation system, typically DGPS.	**Low**: Very time consuming with below average accuracy. Accuracy of 4 to 6 centimeters (open area) is commonly achieved shortly after refreshing baseline data, but degrades quickly with time. Required frequency of refreshing baseline significantly reduces production rates.	**Low**: Difficult to operate, limited support. Limited range of use. Minor impacts to cultural or natural resources based on clearing of areas for high quality data collection.	**High**: Expensive to purchase or rent. Considerable time associated with refreshing baseline and operation.	Ranger	Still under development.	**Low**: This technology has a low viability at the Ricochet Area MRS because of limited range of use and high costs.

3.2.3 MEC Removal

When potential MEC is detected during either visual or geophysical methods, the removal of MEC can begin. Removal operations can take the form of a surface-only removal, an intrusive (subsurface) removal, or a combination of the two methods. The decision on the appropriate level of clearance operation is based on the nature and extent of the hazards as well as the current land use and intended future land use of the site.

During a surface removal operation, exposed MEC or suspected hazardous items are identified during the detection phase. The MEC are then inspected, identified, collected (if possible), and transported to a designated area for cataloging and eventual disposal. If it is determined during the inspection that the risk of moving an item is unacceptable, then it may be necessary to destroy the item in place.

Potential MEC identified during a subsurface removal operation by the geophysical survey or other detection methods require excavation for removal or detonation. Because the actual nature of the buried item cannot be determined without it being uncovered, nonessential personnel evacuations are necessary within a predetermined minimum separation distance (MSD). The MSD is based on the munition with the greatest fragmentation distance (MGFD) that may be present within the MRS. All non-essential personnel and the general public must be evacuated from and maintain their distance beyond the MSD during the intrusive operations. The MSD may be reduced if sufficient engineering controls are implemented. Excavation of the potential MEC takes place with either hand tools or mechanical equipment, depending on the suspected depth of the object. Once the item has been exposed, it is then inspected, identified, collected (if possible), and transported to a designated area for cataloging and disposal. If it is determined during the inspection that the item is MEC and the risk of moving the item is unacceptable, then it may be necessary to destroy the item in place. For intentional detonations, all personnel must observe the MSD. The MSD may be increased or decreased based on the actual item identified. The MSD may also be reduced if appropriate engineering controls are applied.

MEC removal technologies are described in **Table 3-3** and are screened against the three criteria of effectiveness, implementability, and cost for the Ricochet Area.

Table 3-3 MEC Removal Technologies

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Hand Excavation: Technique includes digging individual anomalies using commonly available hand tools.	**Medium - High**: This is the industry standard for MEC removal. It can be very thorough and provides an excellent means of data collection.	**High**: Hand excavation can be accomplished in almost any terrain and climate. Limited only by the number of people available. Minimal to no impacts to cultural or natural resources.	**Average**: Is the standard by which all others are measured.	Probe, trowel, shovel, pick axe.	Locally available and easily replaced tools.	**High:** This technology was successfully used during the Ricochet Area RI.
Mechanical Excavation of Individual Anomalies: This method uses commonly available mechanical excavating equipment to support hand excavations.	**Medium - High**: Used in conjunction with hand excavation when soil is too hard causing time delay during hand excavation. Method works well for the excavation of deep single anomalies to remove overburden.	**Low - High**: Equipment can be rented, is easy to operate, and allows excavation of anomalies in hard soil. Access to site may be limited in certain areas by terrain (trees, boulders/rocks). Mechanical excavation is not appropriate for items located on or near the surface because safety standards allow for mechanical excavation only to within 12 inches of a suspected MEC item. Moderate impacts to cultural and natural resources because roadways would be constructed and large-scale intrusion would take place to allow equipment into areas.	**Low**: In hard soil, this method has a lower cost than that of having the single anomalies hand excavated.	Tracked mini-excavator or wheeled backhoe. Multiple manufacturers.	Easy to rent and operate.	**High:** For deep subsurface anomalies not easily accessible by hand excavation. **Low:** For surface anomalies or shallow subsurface anomalies easily accessible by hand excavation.
Mass Excavation and Sifting: Armored excavation and transportation equipment to protect the operator and equipment from unintentional detonation. Once soil has been excavated and transported to the processing area, it is then processed through a series of screening devices and conveyors to segregate MEC from soil.	**High**: Process works very well in heavily contaminated areas. Can separate several different sizes of material, allowing for large quantities of soil to be returned with minimal screening for MEC.	**Low**: Earth moving equipment is readily available; however, armoring is not as widely available. Equipment is harder to maintain and may require trained heavy equipment operators. Not feasible for large explosively-configured munitions. Not feasible for heavily wooded areas with numerous ecosystems that must be protected. Major impacts to cultural and natural resources because roadways, stockpiles, and material laydown areas would need to be established for both earth moving and sifting equipment.	**High**: Earth moving equipment is expensive to rent and insure and has the added expense of high maintenance cost.	**Earth Moving Equipment**: Many brands of heavy earth moving equipment, including excavators, off-road dump trucks, and front-end loaders. **Sifting Equipment**: Trommel, shaker, rotary screen from varying manufacturers.	Can be rented and armor can be installed, and equipment delivered almost anywhere. Significant maintenance costs.	**Low:** Technology is effective, but would require clear cutting at the Ricochet Area. Technology is costly.
Magnetically Assisted Removal: Magnets are used to separate conductive material from soils.	**Low**: Primarily used in conjunction with mass excavation and sifting operations. Can help remove metal from separated soils, but does not work well enough to eliminate the need to inspect the smaller size soil spoils. Magnetic systems are also potentially useful to help with surface removal of MD and surface debris.	**High**: Magnetic rollers are easily obtained from the sifting equipment distributors and are designed to work with their equipment. Major impacts to cultural and natural resources because roadways, stockpiles and material laydown areas would need to be established for both earthmoving and sifting equipment which support magnetic operations.	**Low**: This method adds very little cost to the already expensive sifting operation.	Magnetic rollers or magnetic pick-ups are available from many manufacturers of the sifting equipment noted above.	Installed by sifting equipment owner.	**Low:** Primarily used in conjunction with mass excavation and sifting operations, which are not feasible for the Ricochet Area.
Remotely Operated Removal Equipment: this equipment has additional control equipment that allows the equipment to be operated remotely.	**Low**: Remotely operated equipment reduces productivity and capability of the equipment. Method is not widely used and is not yet proven to be an efficient means of MEC removal.	**Low**: Uses earth moving equipment, both mini-excavator type and heavier off-road earth moving equipment. Machinery is rigged with hydraulic or electrical controls to be operated remotely. Major impacts to cultural and natural resources because roadways, stockpiles, and material laydown areas would need to be established for earth moving equipment.	**High**: Has a combined cost of the base equipment plus the remote operating equipment and an operator. Remote operation protects the operator, but can create high equipment damage costs.	Many tracked excavators, dozers, loaders, and other equipment types have been outfitted with robotic remote controls.	EOD robots are almost exclusively used for military and law enforcement reconnaissance and render-safe operations. They were not evaluated for MEC applications.	**Low:** This technology is not viable at the Ricochet Area because of low effectiveness and low implementability in this type of terrain.

3.2.3.1 MEC Disposal

Disposal of recovered MEC can take one of two different forms: remote, on-site demolition and disposal; or in-place demolition and disposal. The decision regarding which of these techniques to use is based on the risk involved in employing the disposal option, as determined by the specific area's characteristics and the nature of the items recovered.

If a MEC item is determined to be safe to move, the item can be moved to a remote part of the project site where demolition and disposal can safely take place. For movable items, a countercharge can be used to destroy the item. Engineering controls, such as sandbag enclosures over and around the MEC, are often used to reduce fragmentation distances when an item is destroyed in this manner.

Alternatively, MEC may be blown-in-place (BIP). This method is typically employed when the risk of moving the item to a remote location is unacceptable. When BIP is required, procedures similar to those described above are used to detonate the MEC. Engineering controls are again often used to minimize the blast effects. All disposal technologies generate a waste stream, which must be addressed when determining which technologies are most viable. The waste streams generated by MEC disposal technologies include MC and/or MD. If the waste generated includes MC, then the waste stream may need to undergo additional treatment prior to final disposal. If the waste generated includes only MD, then additional treatment may not be necessary.

MEC disposal technologies are described in **Table 3-4** and screened against the three criteria of effectiveness, implementability, and cost for the Ricochet Area MRS. Treatment technologies for the waste streams generated by MEC disposal technologies are described in **Table 3-5** and screened against the three criteria of effectiveness, implementability, and cost for the Ricochet Area MRS.

3.2.4 Viable Technologies for the Ricochet Area MRS

The technologies deemed highly viable in **Tables 3-1** to **3-5** for the Ricochet Area MRS are summarized in **Table 3-6** and are included in the development of remedial alternatives in Section 4.

Table 3-4 MEC Disposal Technologies

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Render Safe Procedures (RSP): Procedures that enable the neutralization or disarming of mines and munitions to occur in a recognized and safe manner. RSPs are executed by EOD personnel.	**Low:** Hazardous components may remain intact after procedure. Some procedures may expose hazardous materials inadvertently or intentionally. Lower probability of success compared to other methods. Presents significant danger to performer. No MC or MD-related waste stream generated.	**Low:** Significant personnel exposure in implementation. Specialized tools and equipment commonly are required. Minimal to no impacts to cultural or natural resources.	**Medium – High:** Manpower intensive; specialized tools and equipment.	Manual disassembly, mechanical disassembly, explosive de-armer, cryofracture.	DoD policy allows RSP at MRSs only in cases of extreme emergency. RSPs are not allowed for the mere purpose of rendering a munitions item acceptable to move.	**Low**
Blow-in-Place (BIP): BIP is the destruction of MEC for which the risk of movement beyond the immediate vicinity of discovery is not considered acceptable. Normally, this is accomplished by placing an explosive charge alongside the item.	**High:** Each MEC item is individually destroyed with subsequent results individually verified using quality control/quality assurance (QC/QA). BIP yields unconfined releases of MC and MD, which can be restricted using engineering controls.	**High:** Field-proven techniques, transportable tools, and equipment; suited to most environments. Public exposure can limit viability of this option. Engineering controls can further improve implementation. Major impacts to cultural and natural resources if item cannot be moved away from sensitive cultural or natural resources. Trees and plants could be moved, but cultural resources would not be movable to mitigate impacts. Engineering controls may limit damages to these resources.	**Medium – High:** Manpower intensive. Costs increase in areas of higher population densities or where public access must be monitored/controlled. Limited accessibility to construct engineering controls increases costs.	Electric demolition procedures, non-electric demolition procedures.	Disposition of resultant waste streams must be addressed in BIP operations planning.	**High**
Consolidated Shots: Consolidated detonations are the collection, configuration, and subsequent destruction by explosive detonation of MEC for which the risk of movement has been determined to be acceptable either within a current working MRS or at an established demolition ground.	**Medium - High:** Limited in use to MEC that are deemed safe to move. BIP yields unconfined releases of MC and MD, which can be restricted using engineering controls.	**Medium – High:** Generally employs the same techniques, tools, and equipment as BIP procedures. Requires larger area and greater controls. Most approved engineering controls are not completely effective/applicable for these operations. Major impacts to cultural and natural resources if item cannot be moved away from sensitive cultural or natural resources. Trees and plants could be moved but cultural resources would not be movable to mitigate impacts. Engineering controls may limit damages to these resources.	**Medium:** Manpower intensive, may require materials handling equipment for large-scale operations.	Electric demolition procedures, non-electric demolition procedures, forklifts and cranes.	Disposition of resultant waste streams must be addressed. Increased areas require additional access and safety considerations.	**Medium**

Table 3-4 MEC Disposal Technologies (Continued)

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Contained Detonation Chambers (CDCs) – Stationary: CDCs involve destruction of certain types of munitions in a chamber, vessel, or facility designed and constructed specifically for the purpose of containing blast and fragments. CDCs can only be employed for munitions for which the risk of movement has been determined acceptable.	**Low – Medium:** CDCs successfully contain hazardous components. Current literature reviewed shows containment up to 40 pounds (lbs) (assume net explosive weight (NEW)). Commonly used for fuzes and smaller explosive components. May not be used for larger munitions items found at the Ricochet Area. Limited in use to munitions that are "acceptable to move." CDCs yield confined releases of MC and MD.	**Low – Medium:** Stationary facilities typically must meet regulatory and construction standards for permanent/semi permanent waste disposal facilities. Service life and maintenance issues. Such facilities are not commonly used in support of munitions responses. Produce additional hazardous waste streams. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**High:** Siting and construction required. Low feed rates equal more hours on-site. Significant requirements for maintenance of system.	Typically designed on case-by-case basis.	System cleaning and maintenance usually requires personal protective equipment (PPE) and worker training. Probable permitting issues with employment of technology.	**Low – Medium**
Contained Detonation Chambers (CDCs) – Mobile: CDCs involve destruction of certain types of munitions in a chamber, vessel, or facility designed and constructed specifically for the purpose of containing blast and fragments. CDCs can only be employed for munitions for which the risk of movement has been determined acceptable.	**Low – Medium:** CDCs successfully contain hazardous components. Current literature reviewed shows containment up to 40 NEW. Commonly used for fuzes and smaller explosive components. May not be used for larger munitions items found at the Ricochet Area. Limited in use to munitions that are "acceptable to move." CDCs yield confined releases of MC and MD.	**Low – Medium:** Designed to be deployed at the project site. Greatly reduced footprint compared to stationary facilities. Service life and maintenance are issues. Requires substantial additional handling and transport of MEC. Requires items to be safe to move. Flashing furnaces have low feed rates because of safety concerns. Produces additional hazardous waste streams. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**Medium – High:** Possible construction required (e.g., berms and pads). Low feed rates equal more hours on site. Significant requirements maintenance of system.	Donovan Blast Chamber, Kobe Blast Chamber.	System cleaning and maintenance usually requires PPE and worker training. Probable permitting issues with employment of technology.	**Low - Medium**
Laser Initiation: Portable (vehicle mounted) lasers are used from a safe distance to heat UXO or DMM lying on the surface, resulting in high or low order detonation of the munitions.	**Low – Medium:** Still in development, although currently deployed overseas for testing. Tests show positive results for 81 millimeter (mm) and below, with reported success on munitions up to 155 mm. Produces low order type effect; subsequent debris still requires disposition. Laser initiation yields unconfined releases of MC and MD, which can be restricted using engineering controls.	**Low:** MEC targets must be exposed/on surface for attack by directed beam. GATOR Laser System (Diode Laser Neutralization via Fiber-Optic Delivered Energy) does not require line-of-sight within approximately 100 meters. GATOR system does require approach and placement of fiber-optic cable at appropriate position of suspected item. Laser systems still addressing power, configuration, transportability, and logistics issues. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**Low – Medium:** Greatly reduced manpower; added equipment, transportability and logistics concerns; no explosives required by system.	ZEUS-HLONS GATOR Laser.	Offers added safety through significant standoff (up to 300 meters). (Note: acceptable safety standoffs must be evaluated for specific MEC types and location scenarios). ZEUS prototype deployed/employed in Afghanistan (2003).	**Low**

Table 3-5 Waste Stream Treatment Technologies

Technology	Effectiveness	Implementability	Cost	Representative Systems	Notes	Viability at the Ricochet Area MRS
Chemical Decontamination: Uses chemical processes to eliminate all explosives residues from MEC.	**Low – Medium:** Great variety in chemicals required to decontaminate various MEC fillers (e.g., propellants, pyrotechnics, explosives). Difficult to test for effectiveness. May generate additional waste streams (some hazardous).	**Low:** Requires containment of multiple hazardous materials. May require emissions controls. Worker training and PPE typically required. No mobile systems deployable to MRSs exist. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**High:** Specialized manpower, containment requirements, additional waste stream processing.	Supercritical water oxidation. Photocatalysis. Molten salt oxidation.	National Defense Center for Energy and Environment is working on a mobile system, but it treats only scrap metal, not UXO or DMM.	**Low:** System effectiveness not fully tested.
Shredders and Crushers: These technologies use large machines to deform metal components. This results in unusable remnants and overall reduced volume of scrap.	**Low:** Shredders are mainly used to render inert MD as unrecognizable if they still retain the shape of munitions. Limited use to date to shred MEC to make safe. Residue typically still requires additional treatment to achieve higher decontamination levels.	**Low:** Typically stationary facilities. Service life and very high maintenance are expected. Requires additional handling of MEC. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**Medium - High:** Specialized equipment and operators; high maintenance; additional waste stream processing.	Shred Tech ST-100H Roll-Off (vehicle mounted).	Disposition of resultant waste streams must be addressed.	**Low:** Technology would likely not be effective for handling known MEC at the Ricochet Area.
Thermal Treatment: Decontamination is achieved by exposing debris to high temperatures (between 600 and 1,400 degrees Fahrenheit) for specified periods of time.	**High:** Furnaces are designed to contain hazardous components. Methods are proven means of attaining high degrees (5X) of decontamination. Commonly used to destroy and decontaminate fuzes and smaller explosive components.	**Medium:** Typically stationary facilities. Service life and maintenance are issues. Requires additional handling of MEC. Flashing furnaces have low feed rates because of safety concerns. Produces additional hazardous waste streams. Major impacts to cultural and natural resources because roadways and staging areas would need to be established for equipment.	**High:** Possible construction required. Low feed rates equal more hours on-site. Maintenance of system.	Rotary kiln incinerator. Explosive waste incinerator. Transportable flashing furnace.	System cleaning and maintenance usually requires PPE and worker training. May require permit to deploy technology.	**Low - Medium:** Technology would likely not be effective for handling known MEC at the Ricochet Area.
Recycling: Required for MD and non-MD.	**High:** Very effective for MD and non-MD.	**High:** Easily implemented if there is a local metal recycler. No impacts to cultural or natural resources.	**Low – Medium:** Scrap metal may be accepted without cost.	NA		**High**

Table 3-6 Viable Technologies for the Ricochet Area MRS

<table>
<tr><th colspan="2">MEC Detection</th><th rowspan="2">MEC Removal</th><th colspan="2">MEC Disposal</th></tr>
<tr><th>Geophysical Detection</th><th>Positioning</th><th>Disposal</th><th>Waste Stream Treatment</th></tr>
<tr>
<td>▪ DGM, including TDEMI, optically pumped magnetic technologies, and advanced EMI sensors for anomaly classification. The sensors deemed viable for accessible herbaceous openings include the EM61-MK2, G-858, and MetalMapper.
▪ Analog (mag and dig), including flux-gate magnetometers. The instruments deemed viable for the Ricochet Area are the Schonstedt GA52cX or GA72cX.</td>
<td>▪ Robotic Total Station (with DGM).
▪ Fiducial Method (with DGM).
▪ Conventional Survey (with mag and dig).</td>
<td>▪ Hand excavation.
▪ Mechanical excavation to within 12 inches of anomalies followed by hand excavation.</td>
<td>▪ A combination of the following methods, based on MEC evaluation in the field by qualified UXO technicians:
– BIP.
– Consolidation.</td>
<td>▪ MD and non-MD material recovered from MEC removal and disposal will be sent to a local metals recycler.
▪ MC recovered from MEC disposal will be addressed as appropriate, and treated if necessary, using one of the following methods:
– Chemical decontamination.
– Shredding or crushing.
– Flash furnace.</td>
</tr>
</table>

4. DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section combines the technologies and general remedial actions deemed highly viable for use at the Ricochet Area MRS in Section 3 to form remedial alternatives. The remedial alternatives developed in this section and deemed highly viable for use at the Ricochet Area MRS will be evaluated against the NCP criteria in a detailed analysis that is presented in Section 5.

4.1 DESCRIPTION OF DEVELOPMENT AND SCREENING OF ALTERNATIVES

Remedial alternatives for the Ricochet Area MRS are described in the following subsections. It should be noted that CERCLA requires the review of remedial actions no less than every 5 years to assure that human health and the environment are being protected. Recurring reviews for MEC removal actions determine whether a remedial action continues to minimize explosives safety hazards and continues to be protective of human health, safety, and the environment, and provide an opportunity to assess the applicability of new technology for addressing previous technical impracticability determinations. Recurring reviews will be completed by ARNG and will include the following general steps:

- Prepare Recurring Review Plan.
- Establish project delivery team and begin community involvement activities.
- Review existing documentation.
- Identify/review new information and current site conditions.
- Prepare preliminary Site Analysis and Work Plan.
- Conduct site visit.
- Prepare Recurring Review Report.

4.1.1 Alternative 1 – No Action

Alternative 1 proposes that the government would take no action with regard to locating, removing, and disposing of any potential MEC present within the Ricochet Area MRS. In addition, no public awareness or education training would be initiated with regard to the risk of MEC. The No Action alternative assumes continued land use of the MRS in its present state. If the potential exposure and hazards associated with the MRS are compatible with current and future development in the area, as well as the MEC RAOs, then No Action may be warranted. It is important to note that the government will respond to any future MEC discoveries at the Ricochet Area MRS. The No Action alternative is a potential alternative for the Ricochet Area MRS.

4.1.2 Alternative 2 – Containment and Controls

Aside from conventional MEC removal actions, risks related to potential explosives hazards may be managed through a risk management/containment and controls alternative consisting of various access control and/or public awareness components. The implementation of containment and controls would provide a means for the Commonwealth of Pennsylvania and its representatives to coordinate an effort to reduce MEC exposure through behavior modification. Alternative 2 – Containment and Controls can be used in combination with MEC removal actions or in cases where it may not be possible or practical to physically remove MEC from the MRS. Successful implementation of containment and controls is contingent on the cooperation and active participation of the existing land users and authorities of the Commonwealth of Pennsylvania and other government agencies to protect the public from explosives hazards. The remedial design will specify steps to be put in place that will ensure that the containment and controls are maintained, thus ensuring long-term effectiveness and permanence.

In general, all organizations interviewed for this FS, including the PGC and Appalachian Trail Conservancy, expressed an interest/willingness to participate in containment and controls. Containment and controls recommended for the Ricochet Area MRS include the following:

- Signs.
- Notification during permitting and contracting.
- Brochures/fact sheets.
- Information packages to public officials and emergency management agencies.
- Awareness video.
- Classroom education.
- Internet website.
- Appalachian Trail Guidebook editorials.

4.1.2.1 Activities Affecting Containment and Controls

When activities are required that may affect the containment and controls established for the Ricochet Area MRS, UXO construction support activities would be provided by ARNG. UXO construction support would be used to ensure the safety of workers and the public in the event that MEC items were discovered during any future construction activities at the Ricochet Area MRS in areas where a MEC removal action was not performed. UXO construction support is provided by qualified UXO Technicians either on an on-call basis to respond to MEC that was incidentally encountered or on a standby basis to monitor construction activities onsite while they occur. The level of construction support changes in relation to the location and the probability for encountering potential MEC. UXO construction support activities would need to be performed during timber harvest operations in specific locations of the MRS based on the selected alternative. Discussions with the Pennsylvania Game Commission's Forester indicate timber harvests may occur one time every 4 to 5 years and include up to 150 acres, with road construction and other site preparation activities lasting approximately 2 weeks per event. As discussed earlier, the construction of access roads and the establishment of log landings would be the most intrusive soil moving events requiring UXO construction support.

4.1.3 MEC Removal Alternatives

The general remedial action of MEC removal has been broken down into two remedial alternatives for evaluation:

- Surface removal of MEC—Removal of MEC detected on the ground surface and breaching the ground surface (Alternatives 3 and 4).
- Removal of MEC to Detection Depth—Removal of detectable MEC. Depth of detection varies based on the depth of MEC at the site and the detection technology used (Alternative 5).

MEC and MD detected during the Ricochet Area RI were recovered between 0 inches and 12 inches below ground surface. Overall, 66% of the items recovered were at the surface and 9% were located between 6 inches and 12 inches below ground surface. All MEC removal alternatives will include a combination of disposal methods, recycling and/or waste stream treatment, and containment and controls.

4.1.3.1 Alternative 3 – Surface Removal of MEC with Containment and Controls

Surface removal of MEC includes removal of MEC detected on the ground surface and breaching the ground surface across 3,262 acres of the Ricochet Area MRS using analog detection instruments such as the Schonstedt magnetometer that uses flux-gate technology. The following general tasks would be included as part of Alternative 3, MEC surface removal:

- Mobilization.
- Survey/positioning.
- Brush clearing and grubbing (if needed).
- MEC detection.
- MEC removal.
- MEC disposal.
- MD and non-MD waste stream treatment.
- Demobilization.

Containment and controls (excluding UXO construction support for intrusive activities) will be implemented as described in Alternative 2 in Section 4.1.2.

4.1.3.2 Alternative 4 – Focused Surface and Subsurface Removal of MEC with Containment and Controls

Focused surface removal of MEC includes removal of MEC detected on the ground surface and breaching the ground surface using analog detection instruments like the Schonstedt magnetometer that uses flux-gate technology only in a focused area limited to portions of the MRS with MEC/MD densities greater than 0.5 surface item per acre (**see Figure 1-13**). This area is estimated to be 1,334 acres of the Ricochet Area MRS. In addition, all trails running through the MRS would have a surface removal completed. The following general tasks would be included as part of Alternative 4, MEC surface removal:

- Mobilization.
- Survey/positioning.
- Brush clearing and grubbing (if needed).
- MEC detection.
- MEC removal.
- MEC disposal.
- MD and non-MD waste stream treatment.
- Demobilization.

As part of Alternative 4, a focused subsurface removal action to detection depth would be performed at the herbaceous openings located within the Ricochet Area MRS (**see Figure 1-15**). The subsurface removal action includes the removal of MEC detected on the ground surface and to detection depth using DGM instrumentation like the EM61-MK2 that uses TDEMI technology. The subsurface removal action would total 10 acres. The following general tasks would be included as part of Alternative 4, MEC subsurface removal at the herbaceous openings of the MRS:

- Mobilization.
- Survey/positioning.
- Brush clearing and grubbing (if needed).
- DGM for MEC detection.
- Digital geophysical data analysis and anomaly selection.
- Anomaly reacquisition.
- MEC removal.
- MEC disposal.
- MD and non-MD waste stream treatment.
- Demobilization.

Containment and controls will be implemented as described in Alternative 2 in Section 4.1.2. This would include UXO construction support activities for the timber harvesting activities within the Ricochet Area, specifically the construction of access roads, building of log landings, and other soil moving activities. It is estimated that over the course of 30 years, six UXO construction support events would be needed to support timbering activities within the Ricochet Area MRS. Each UXO construction support event would last approximately 2 weeks and would support the construction of access roads, building of log landings, and soil moving activities.

4.1.3.3 Alternative 5 – Removal of MEC to Detection Depth with Containment and Controls

Alternative 5 includes removal of detected MEC. MEC detection using digital and analog instrumentation and methods is described separately in the following subsections.

4.1.3.3.1 Removal of MEC to Detection Depth Using Digital Instrumentation and Methods

Digital instruments would be used to detect MEC at the herbaceous openings of the MRS (**see Figure 1-15**) that total 10 acres. Digital instruments are a less viable option for the remaining portions of the MRS due to steep terrain, dense vegetation, and high tree canopy that reduces the effectiveness of some positioning systems. Based on the screening criteria evaluation results presented in **Table 3-1**, digital instruments will not be evaluated for areas outside of the herbaceous openings. The following general tasks would be included as part of Alternative 5 using digital detection instrumentation like the EM61-MK2 that uses TDEMI technology:

- Mobilization.
- Survey/positioning.
- Brush clearing and grubbing (if needed).
- DGM for MEC detection.
- Digital geophysical data analysis and anomaly selection.
- Anomaly reacquisition.
- MEC removal.
- MEC disposal.
- MD and non-MD waste stream treatment.
- Demobilization.

Containment and controls will be implemented as described in Alternative 2 in Section 4.1.2. UXO construction support is not required for this alternative as the subsurface removal action would mitigate explosive hazards associated with MEC in timber harvesting areas.

4.1.3.3.2 Removal of MEC to Detection Depth Using Analog Instrumentation and Methods

Analog instrumentation would be used to detect MEC in the remaining area (3,252 acres) of the MRS, not including the herbaceous openings. The following general tasks would be included as part of Alternative 5 using analog detection instrumentation such as the Schonstedt magnetometer that employs flux-gate technology and methods:

- Mobilization.
- Survey/positioning.
- Brush clearing and grubbing.
- Mag and dig surveys for MEC detection.
- MEC removal.
- MEC disposal.
- MD and non-MD waste stream treatment.
- Demobilization.

Containment and controls will be implemented as described in Alternative 2 in Section 4.1.2. UXO construction support is not required for this alternative as the subsurface removal action would mitigate explosive hazards associated with MEC in timber harvesting areas.

5. DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to allow decision-makers to select a site remedy, not the decision-making process itself. During the detailed analysis, each alternative is assessed against the NCP evaluation criteria described in Section 5.1 for the Ricochet Area MRS. The results of the detailed analysis are arrayed to compare the alternatives and identify their strengths and weaknesses relative to one another. This approach to analyzing alternatives is designed to provide decision-makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for each MRS, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Decision Document.

5.1 EVALUATION CRITERIA

Evaluation criteria are described in the NCP, Section 300.430. The criteria were developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that have proven to be important in selecting remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for subsequently selecting an appropriate remedial action. The evaluation criteria with the associated statutory considerations are described below.

The NCP calls the two factors described below "threshold factors" because each alternative must meet the two criteria:

1. **Overall protectiveness of human health and the environment—**Determines whether an alternative achieves the RAOs by eliminating, reducing, or controlling threats to public health and the environment through land use controls, engineering controls, or treatment. The evaluation is based on the three risk factors used in the MEC HA presented in Section 1.3 of this FS report: severity, accessibility, and sensitivity. An emphasis is placed on effectiveness in terms of worker safety issues during remedial actions and post-remedial action for local residents and workers based on future land use.
2. **Compliance with ARARs and TBCs—**Evaluates whether the alternative meets Federal and State environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified. ARARs and TBCs are summarized in Section 2.

The five "balancing factors" described below are weighed against each other to determine which remedies are cost effective and are "permanent" to the maximum extent practicable:

3. **Long-term effectiveness and permanence—**Considers the ability of an alternative to maintain protection of human health and the environment over time. For MRSs with potential explosives hazards, this will typically fall into categories associated with containment and controls that include signage, brochures, education/awareness programs, land use restrictions, and deed notifications. The long-term effectiveness and permanence of containment and controls will need to take into account the administrative feasibility of maintaining the land use controls and the potential risk/hazard should they fail, as well as mechanisms like the CERCLA Five Year Review process to evaluate on a periodic basis the long-term effectiveness and permanence, as well as protectiveness, of the alternative.

4. **Reduction of toxicity, mobility, or volume (TMV) of contaminants through treatment—**Evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present. For MRSs where the treatment options are generally limited to certain disposal options (BIP, consolidated shot, containerized version of these) the destruction of the MEC should be considered as constituting treatment that reduces the amount of MEC recovered. This is analogous to reduction in volume. Mobility in the context of hazardous, toxic, and radioactive waste (HTRW) treatment, where a hazardous substance is immobilized, does not have a direct analogy for MEC. Mobility may be considered a function of the ease of moving MEC. Transport mechanisms include: (1) picking up or moving of a potential MEC by a person(s); (2) disturbance of potential MEC during construction, excavation, or other soil moving activities; and (3) natural processes such as erosion/deposition, uptake or frost heave, gravity, hydrologic effects, or degradation. Each process may affect movement of MEC from its original depth or location. To the extent that MEC is detected, recovered, and disposed of, its ability to move is reduced. MEC remaining after a removal activity would maintain its ability to move, based on the physical processes described above, and should be accounted for.

5. **Short-term effectiveness—**Considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation. In addition, for MEC, safety considerations will include an evaluation of what is available from an administrative standpoint (e.g., access) and what is available from a technical standpoint (e.g., setbacks – are buildings too close for demolition; what will it take to bring the correct resources to the site to mitigate a demolition operation).

6. **Implementability—**Considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.

7. **Cost—**Includes estimated capital and annual O&M costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50% to -30%.

The last two criteria, the "modifying factors," are usually evaluated following comment on the FS, and should be completed after the Proposed Plan and public comment period on that plan in the Decision Document:

8. **Regulatory agency acceptance—**Considers whether the state (Pennsylvania Department of Environmental Protection [PADEP]) and EPA Region III agree with the Army's analyses and recommendations, as described in the RI/FS.
9. **Community acceptance—**Considers whether the local community agrees with the Army's analyses and preferred alternative.

5.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

Remedial alternatives will be evaluated based on the RI results, including MEC hazard assessments performed for the Ricochet Area MRS.

Based on the RI results, the following remedial alternatives will be evaluated for the Ricochet Area MRS against the NCP criteria in Sections 5.2.1.1 to 5.2.1.4:

- Alternative 1 – No Action.
- Alternative 2 – Containment and Controls.
- Alternative 3 – Surface Removal of MEC with Containment and Controls.
- Alternative 4 – Focused Surface and Subsurface Removal of MEC with Containment and Controls.
- Alternative 5 – Removal of MEC to Detection Depth with Containment and Controls.

MEC removal alternatives (Alternatives 3, 4, and 5) are described generally in Section 4.1.2. Specific remedial alternatives for the Ricochet Area MRS are described below.

5.2.1 Ricochet Area MRS

The Ricochet Area MRS is a total of 3,262 acres. The presence of UXO and MD in the Ricochet Area MRS is a result of unintentional overshot and/or ricochets from both direct firing from FIG historical ranges 24D and 27D and shortshot from indirect firing from the former Cold Spring Firing Point. The recovered DMM can be attributed to firing activities at the former Cold Spring Firing Point.

Approximately 161 acres of the Ricochet Area MRS was investigated during the RI. Approximately 2.5 acres were investigated using DGM methods and approximately 159 acres were investigated using mag and dig surveys. During the DGM surveys, 888 anomalies were detected by the digital instrumentation and subsequently reacquired and intrusively investigated.

Nine UXO and 121 MD items were recovered during the investigations. Two small areas comprising approximately 56.4 acres within the MRS have calculated UXO densities greater than 0.5 UXO per acre, with a maximum value of 0.84 UXO per acre. The remainder of the MRS is calculated as having less than 0.5 UXO per acre. The UXO recovered include:

- Seven 75 mm HE projectiles.
- One 155 mm HE projectile.
- One 75 mm AP HE projectile.

Field information collected during the RI indicates that the UXO and MD recovered in the Ricochet Area MRS were located on the surface or in the shallow subsurface soils between 0 inches and 12 inches below ground surface. In general, 95% of the items were recovered in the 0 inches to 6 inches below ground surface interval. Sixty-six percent the items were recovered at the surface while 9% of the items were located between 6 inches and 12 inches below ground surface. Only one UXO item was recovered at 12 inches below ground surface. This is likely due to the fact that munitions impacting this area were primarily deflected or ricocheted thereby greatly reducing kinetic energy and depth of penetration.

Additionally, the Cold Spring Firing Point is included in this MRS. A total of 1.4 acres were investigated during the RI. Approximately 0.4 acre was investigated using DGM methods, and approximately 1 acre was investigated using mag and dig surveys. During the DGM surveys, 317 anomalies were detected by the digital instrumentation and subsequently reacquired and intrusively investigated. The firing point location was confirmed during the RI based on the discovery of firing point/range-related debris, including fuze shipping containers, 155 millimeter (mm) rotating band covers, and 155 mm lifting lugs.

In addition, DMM were recovered during investigations. The DMM includes:

- Four MK-2A4 Primers.

Field information collected during the RI indicates that the DMM recovered were located at a depth of 12 inches below ground surface. All other firing point/range-related debris was recovered on the ground surface.

Based on the MEC HA, the Ricochet Area MRS has a Hazard Level Category 3, which indicates that the site has a moderate hazard potential because of the presence of MEC on the surface and in the shallow subsurface. The MRS has a low number of contact hours by the public and maintenance personnel. Because of the moderate hazard potential, this MRS will be evaluated for MEC removal alternatives. MEC removal activities would include detection, recovery, and disposal of MEC.

5.2.1.1 Alternative 1 – No Action

Alternative 1 – No Action can be evaluated relative to the NCP criteria for the Ricochet Area MRS as follows:

1. **Overall Protectiveness of Human Health and the Environment—**The Ricochet Area MRS was determined to have a moderate hazard potential because of the presence of UXO on the surface and UXO and DMM in the shallow subsurface. The MRS has a low number of contact hours by the public and maintenance personnel. Alternative 1 would not address the moderate hazard potential for human exposure to UXO and DMM; therefore, it would not be protective of human health. Alternative 1 would be protective of the environment because no clearing, grubbing, or excavation would be required. A MEC HA was conducted for each alternative and is provided in Appendix B. The MEC HA scoring for Alternative 1 is a Hazard Level 3 with a score of 705. This is consistent with the RI MEC HA presented in Section 1.3.2.2.
2. **Compliance with ARARs and TBCs—**There are no location- or action-specific ARARs associated with Alternative 1 because there are no active remedial actions associated with this alternative.
3. **Long-Term Effectiveness and Permanence—**The magnitude of risk is not expected to reduce significantly over the long term based on intended future land use. Alternative 1 requires no technical components and poses no uncertainties regarding its performance. Site reviews would be conducted once every 5 years as required by CERCLA to assess the site condition and the degree of protectiveness to human health and the environment.
4. **Reduction of TMV of Contaminants Through Treatment—**Alternative 1 would not reduce UXO or DMM volume or mobility because of human interaction or natural processes.

5. **Short-Term Effectiveness—**There would be no additional risk to the community or workers because there are no construction or operation activities associated with Alternative 1.

6. **Implementability—**Implementation of Alternative 1 poses no technical difficulties. Alternative 1 would be administratively feasible because it requires minimal contact or coordination with agencies to implement.

7. **Cost—**Because there is no action associated with Alternative 1, the total present-worth cost to perform Alternative 1 is $0.

8. **Regulatory Agency Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.2.1.2 Alternative 2 – Containment and Controls

Alternative 2 – Containment and Controls can be evaluated relative to the NCP criteria for the Ricochet Area MRS as follows:

1. **Overall Protectiveness of Human Health and the Environment—**The Ricochet Area MRS was determined to have a moderate hazard potential because of the presence of UXO on the surface and UXO and DMM in the shallow subsurface. The MRS has a low number of contact hours by the public and maintenance personnel. The institutional control components of containment and controls that are recommended would raise public awareness and modify public behavior related to the activities they perform in this area of State Game Lands 211, which would result in increased protection for human health. However, Alternative 2 would not completely address the moderate hazard potential and human exposure to UXO and DMM. Alternative 2 would be protective of the environment because no clearing, grubbing, or excavation would be required. The MEC HA scoring for Alternative 2 is a Hazard Level 3 with a score of 705.

2. **Compliance with ARARs and TBCs—**The Containment and Controls that are recommended based on discussions with State Game Lands 211 users would be implemented to comply with ARARs and TBCs.

3. **Long-Term Effectiveness and Permanence—**Alternative 2 is contingent on the cooperation and active participation of the existing powers and authorities of government agencies. The remedial design will specify steps and controls to be put in place that will ensure that the containment and controls are maintained, thus ensuring long-term effectiveness and permanence. The components of containment and controls that are recommended, as described in Section 4.1.2, require O&M of signs, printed media such as brochures and fact sheets, and audio/video media. Reviews would be conducted once every 5 years as required by CERCLA to assess the site condition and the degree of protectiveness to human health and the environment.

4. **Reduction of TMV of Contaminants Through Treatment—**Alternative 2 would not reduce UXO or DMM volume or mobility because of human interaction or natural processes.

5. **Short-Term Effectiveness—**There may be a slight increase in risk to workers, depending on where signs are posted. Otherwise, there would be no additional risk to the community or workers because there are no other construction or operation activities associated with Alternative 2.

6. **Implementability—**The majority of the components recommended in Alternative 2 can be easily implemented because there are no technical difficulties associated with this alternative and the materials and services needed to implement this alternative are available. O&M of signs and audio/video media can be performed easily.

7. **Cost—**The total present-worth cost to perform Alternative 2 at the Ricochet Area MRS is $181,998. This cost has been rounded to the nearest thousand dollars. Detailed cost estimates for Alternative 2 are provided in Appendix A.

8. **Regulatory Agency Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.2.1.3 Alternative 3 – Surface Removal of MEC with Containment and Controls

Alternative 3 – Surface Removal of MEC with Containment and Controls can be evaluated relative to the NCP criteria for the Ricochet Area MRS as follows:

1. **Overall Protectiveness of Human Health and the Environment—**The Ricochet Area MRS was determined to have a moderate hazard potential because of the presence of UXO on the surface and UXO and DMM in the shallow subsurface. The MRS has low contact hours by the public and maintenance personnel. In general, 95% of UXO and MD at this MRS were recovered in the 0 inches to 6 inches below ground surface interval during the RI. All DMM were recovered at 12 inches below ground surface. Sixty-six percent of the UXO and MD recovered in this MRS during the RI were located on the ground surface. Therefore, a surface removal would provide improved protection for human health.

   Alternative 3 would not completely address the moderate hazard potential and human exposure to UXO and DMM. Surface removal activities for UXO would not be protective of the environment because they require some clearing and grubbing and excavation at the site. UXO and DMM that is not acceptable to move would be BIP because this is the only viable method of disposal at this MRS. Consolidation is an efficient method of disposal for UXO and DMM that is acceptable to move. BIP demolition results in a less confined waste stream than consolidation, and is therefore less protective of human health and the environment. Demolition activities may also negatively impact cultural resources that cannot be moved. The waste stream could be reduced and protectiveness could be increased through the use of appropriate engineering controls. Engineering controls can also reduce impacts to cultural resources. Containment and controls would provide additional protection to human health, as discussed in Alternative 2. The MEC HA scoring for Alternative 3 is a Hazard Level 3 with a score of 575.

2. **Compliance with ARARs and TBCs—**Surface removal of UXO across the MRS would be performed to comply with all ARARs, including DoD and EPA guidance. Containment and controls would be implemented to comply with ARARs and TBCs, as discussed in Alternative 2. This Alternative would need to comply with requirements of working around sensitive natural resources, including plants and animals. Additionally, work would need to be conducted in a manner that would cause minimal to no impacts to cultural resources.

3. **Long-Term Effectiveness and Permanence—**Surface removal of UXO would provide long-term effectiveness by permanently removing approximately 66% of the remaining UXO items from the Ricochet Area MRS. However, UXO and DMM below the surface would remain in the MRS and could potentially move to the surface because of erosion or frost heave or human interaction. Containment and controls would provide additional long-term effectiveness and permanence by assisting in managing risk before, during, and after the removal activity has been conducted. Containment and controls are described in Alternative 2.

4. **Reduction of TMV of Contaminants Through Treatment—**Surface removal across the MRS followed by disposal of recovered UXO and DMM could reduce the number (or volume) of explosives hazards by up to 66%. The presence and mobility of UXO and DMM items deeper than 6 inches due to erosion or frost heave would not be reduced by a surface removal. Containment and controls would not reduce the volume or mobility of UXO and DMM in the area.

5. **Short-Term Effectiveness—**There would be an increase in risk to workers while the removal action is conducted. The increased risk to the community during the removal action would be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. The risk to workers and to the community associated with UXO and DMM that need to be BIP would be greater than the risk associated with consolidation because it is more difficult to control the area around an item. Items that are acceptable to move can be disposed of in a more controlled environment. The risk to the community during the disposal could be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. Containment and controls would probably not increase risk to workers or the public, as described in Alternative 2.

6. **Implementability—**Surface removals of UXO and DMM were implemented effectively at the Ricochet Area MRS during the RI. Specific activities, including plant surveys, awareness training, and mitigation activities, will be required to protect natural resources. Additionally, specific procedures will need to be developed to manage/minimize impacts to cultural resources. Regarding UXO and DMM disposal, BIP is more difficult to implement than consolidation because it is more difficult to control the area around an item. It may also be more difficult to transport engineering controls to the UXO and DMM for BIP demolition than to a consolidation area that

may be more accessible. Containment and controls could be implemented as described in Alternative 2.

7. **Cost—**The total present-worth cost to perform Alternative 3 at the Ricochet Area MRS is $16,182,335. Detailed cost estimates for Alternative 3 are provided in Appendix A.

8. **Regulatory Agency Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.2.1.4 Alternative 4 – Focused Surface and Subsurface Removal of MEC with Containment and Controls

Alternative 4 – Focused Surface and Subsurface Removal of MEC with Containment and Controls can be evaluated relative to the NCP criteria for the Ricochet Area MRS as follows:

1. **Overall Protectiveness of Human Health and the Environment—**The Ricochet Area MRS was determined to have a moderate hazard potential because of the presence of UXO on the surface and UXO and DMM in the shallow subsurface. The MRS has low contact hours by the public and maintenance personnel. In general, 95% of UXO and MD at this MRS were recovered in the 0 inches to 6 inches below ground surface interval during the RI. All DMM were recovered at 12 inches below ground surface. Sixty-six percent of the UXO and MD recovered in this MRS during the RI were located on the ground surface. Therefore, a focused surface removal in areas of high density, i.e., with greater than 0.5 MEC/MD per acre, and along trails would provide improved protection for human health. Subsurface removal activities at the herbaceous openings would provide additional protection since soil tilling and other subsurface related activities regularly occur. Surface removal activities for UXO would not be protective of the environment because they require some clearing and grubbing and excavation at the site; however, this alternative would be performed over a smaller area, thereby reducing widespread impacts.

   Subsurface removal activities for UXO and DMM at the herbaceous openings would not be protective of the environment because they require some clearing and grubbing and excavation at the site. UXO and DMM that is not acceptable to move would be BIP because this is the only viable method of disposal at this MRS. Consolidation is an efficient method of disposal for UXO that is acceptable to move. BIP demolition results in a less confined waste stream than consolidation, and is therefore less protective of human health and the environment. Demolition activities may also negatively impact cultural resources that cannot be moved. The waste stream could be reduced and protectiveness could be increased through the use of appropriate engineering controls. Engineering controls can also reduce impacts to cultural resources. Containment and controls would provide additional protection to human health, as discussed in Alternative 2. In addition, UXO construction support for intrusive activities associated with timber harvesting would increase human health protectiveness. The MEC HA scoring for Alternative 4 is a Hazard Level 3 with a score of 575.

2. **Compliance with ARARs and TBCs—**Focused surface removal of UXO across the MRS and subsurface removal of UXO and DMM at the herbaceous openings would be performed to comply with all ARARs, including DoD and EPA guidance. Containment and controls would be implemented to comply with ARARs and TBCs, as discussed in Alternative 2. This Alternative would need to comply with requirements of working around sensitive natural resources including plants and animals. Additionally work would need to be conducted in a manner that would cause minimal to no impacts on cultural resources.

3. **Long-Term Effectiveness and Permanence –** Focused surface removal of UXO would provide long-term effectiveness by permanently removing UXO items on the surface from the Ricochet Area MRS in the focused high density areas and trails. However, UXO and DMM below the surface and in areas of less density would remain and could potentially move to the surface because of erosion or frost heave or human interaction. Containment and controls would provide additional long-term effectiveness and permanence by assisting in managing risk before, during, and after the removal activity has been conducted. Containment and controls are described in Alternative 2 and, with the addition of UXO construction support, increases the effectiveness and permanence.

4. **Reduction of TMV of Contaminants Through Treatment—**Focused surface removal at areas with the highest probability for encountering UXO and subsurface removal at the herbaceous openings followed by disposal of recovered UXO and DMM could reduce the number (or volume) of explosives hazards in areas where they are more likely to be located. The presence and mobility of UXO and DMM items deeper than 6 inches due to erosion or frost heave would not be reduced by a surface removal in areas outside of the herbaceous openings. Containment and controls would slightly reduce the volume or mobility of UXO and DMM in the area during UXO construction support.

5. **Short-Term Effectiveness—**There would be an increase in risk to workers while the removal action is conducted. The increased risk to the community during the removal action would be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. The risk to workers and to the community associated with UXO and DMM that need to be BIP would be greater than the risk associated with consolidation because it is more difficult to control the area around an item. Items that are acceptable to move can be disposed of in a more controlled environment. The risk to the community during the disposal could be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. Containment and controls would probably not increase risk to workers or the public, as described in Alternative 2. Additionally, conducting the field work over a more focused area should result in shorter duration and less exposure for workers and the community.

6. **Implementability—**Focused surface and subsurface removals of UXO and DMM were implemented effectively at the Ricochet Area MRS during the RI. Specific activities, including plant surveys, awareness training, and mitigation activities, will be required to protect natural resources. Additionally, specific procedures will need to be developed to manage/minimize impacts to cultural resources. Regarding UXO and DMM disposal, BIP is more difficult to implement than consolidation because it is more difficult to control the area around an item. It may also be more difficult to transport engineering controls to the UXO and DMM for BIP demolition than to a consolidation area that may be more accessible. Containment and controls could be implemented as described in Alternative 2 and would include UXO construction support.

7. **Cost—**The total present-worth cost to perform Alternative 4 at the Ricochet Area MRS is $6,757,826. Detailed cost estimates for Alternative 4 are provided in Appendix A.

8. **Regulatory Agency Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.2.1.5 Alternative 5 – Removal of MEC to Detection Depth with Containment and Controls

Alternative 5 – Removal of MEC to Detection Depth with Containment and Controls can be evaluated relative to the NCP criteria for the Ricochet Area MRS as follows:

1. **Overall Protectiveness of Human Health and the Environment—**The Ricochet Area MRS was determined to have a moderate hazard potential because of the presence of UXO on the surface and UXO and DMM in the shallow subsurface. The MRS has low contact hours by the public and maintenance personnel. All of the UXO, DMM, and MD recovered in this MRS during the RI were located within 12 inches of the ground surface locatable by viable MEC detection technologies. Therefore, removal of UXO and DMM to detection depth would eliminate the risk related to detectable UXO and DMM below the ground surface and provide improved protection for human health. Removal activities for UXO and DMM would not be protective of the environment because they require clearing and grubbing and excavation at the site where anomalies are detected. UXO that is not acceptable to move will be BIP because this is the only viable method of disposal at this MRS. Consolidation is an efficient method of disposal for UXO that is acceptable to move. BIP results in a less confined waste stream than consolidation, and is therefore less protective of human health and the environment. Demolition activities may also negatively impact cultural resources that cannot be moved. The waste stream could be reduced and protectiveness could be increased through the use of appropriate engineering controls. Engineering controls can also reduce impacts to cultural resources. Containment and controls would provide additional protection to human health, as discussed in Alternative 2. The MEC HA scoring for Alternative 5 is a Hazard Level 4 with a score of 395.

2. **Compliance with ARARs and TBCs—**Removal of UXO and DMM to detection depth would be performed to comply with all ARARs, including DoD and EPA guidance. Containment and controls would be implemented to comply with ARARs and TBCs, as discussed in Alternative 2. This Alternative would need to comply with requirements of working around sensitive natural environment including plants and animals. Additionally work would need to be conducted in a manner that would cause minimal to no impacts on cultural resources.

3. **Long-Term Effectiveness and Permanence—**Removal of UXO and DMM to detection depth would provide long-term effectiveness by permanently removing the remaining detectable UXO and DMM items from the Ricochet Area MRS. Containment and controls would provide additional long-term effectiveness and permanence by assisting in managing risk before, during, and after the removal activity has been conducted. Containment and controls are described in Alternative 2.

4. **Reduction of TMV of Contaminants Through Treatment—**Removal and disposal of UXO and DMM to detection depth would reduce the number (or volume) of explosives hazards by up to 100% and eliminate the presence and mobility of UXO and DMM because of human interaction and natural processes such as soil erosion and frost heave. Containment and controls would not reduce the volume or mobility of UXO and DMM in the area.

5. **Short-Term Effectiveness—**There would be an increase in risk to workers while the removal action is conducted. The increased risk to the community during the removal action would be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. The risk to workers and to the community associated with UXO and DMM that need to be BIP would be greater than the risk associated with consolidation because it is more difficult to control the area around an item. Items that are acceptable to move can be disposed of in a more controlled environment. The risk to the community during the disposal could be mitigated, where possible, by the use of engineering controls and/or evacuations to maintain MSDs. Containment and controls would probably not increase risk to workers or the public, as described in Alternative 2.

6. **Implementability—**Removal of UXO and DMM has been implemented effectively at the Ricochet Area MRS during the RI. Specific activities, including plant surveys, awareness training, and mitigation activities, will be required to protect natural resources. Additionally, specific procedures will need to be developed to manage/minimize impacts to cultural resources. Regarding UXO and DMM disposal, BIP demolition is more difficult to implement than consolidation because it is more difficult to control the area around an item. It may also be more difficult to transport engineering controls to the UXO and DMM for BIP demolition than to a consolidation area that may be more accessible. Containment and controls could be implemented as described in Alternative 2.

7. **Cost—**The total present-worth cost to perform Alternative 5 at the Ricochet Area MRS is $24,315,156 Detailed cost estimates for Alternative 4 are provided in Appendix A.

8. **Regulatory Agency Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Based on the detailed analysis of remedial alternatives in Section 5.2, the strengths and weaknesses of the remedial alternatives relative to one another are evaluated with respect to each of the NCP criteria. Alternatives 1 through 5 are compared for the Ricochet Area MRS in the subsections below.

5.3.1 Ricochet Area MRS

1. **Overall Protectiveness of Human Health and the Environment—**UXO, DMM, and MD was recovered between 0 inches and 12 inches below ground surface in the Ricochet Area MRS. Ninety-five percent of UXO and MD at this MRS were recovered in the 0 inches to 6 inches below ground surface during the RI. Sixty-six percent of the UXO and MD recovered in this MRS during the RI were located on the ground surface. Nine percent of the items were recovered between 6 inches and 12 inches below ground surface. All DMM were recovered at 12 inches below ground surface. Alternative 1 is not protective because no action would be taken to prevent human exposure to UXO and DMM. Alternative 2 is more protective than Alternative 1 because the containment and controls would reduce unacceptable exposure. However, Alternative 2 is less protective than Alternatives 3, 4, and 5 because no UXO and DMM items would be removed. Alternatives 3 and 4 have a MEC HA Hazard Level of 3, with a score of 575, indicating greater protection than Alternatives 1 and 2. Alternative 5 is more protective than Alternatives 3 and 4 because it would remove all detectable UXO and DMM and is supported by the MEC HA Hazard Level of 4 with a score of 395. Alternative 3 would address the immediate exposure risks for surface UXO; however, it would not address the subsurface UXO and DMM at the herbaceous openings. Alternative 4 would be less protective than Alternative 3 because it would be performed over a smaller area but would focus on the locations where there is the highest probability of encountering UXO, and it would provide UXO construction support in all other areas of the MRS as warranted. Subsurface UXO and DMM would be removed in Alternatives 4 and 5, thereby reducing immediate hazards associated with intrusive activities at the herbaceous openings and the future timbering activities.

2. **Compliance with ARARs and TBCs—**There are no regulations or criteria associated with Alternative 1, and Alternatives 2 through 5 would be implemented and performed to comply with all ARARs and TBCs. Alternative 5 would be more intrusive in nature and would require further attention to impacts on cultural and natural resources.

3. **Long-Term Effectiveness and Permanence—**Alternative 1 is not effective or permanent. Alternative 2 is more effective and permanent than Alternative 1, assuming the cooperation and active participation of the existing powers and authorities of government agencies. The containment and controls recommended as Alternative 2 have been designed to provide effectiveness in the long term. Alternatives 3, 4, and 5 would be more effective and more permanent than Alternative 2 because UXO and DMM would be removed permanently from the MRS. Alternative 4 would be less effective and less permanent over the long term as it would cover a smaller surface area than Alternative 3, but would remove exposure to subsurface UXO and DMM by focused subsurface removals and UXO construction support for timbering activities. Alternative 5 would be the most effective and permanent alternative because all detectable UXO and DMM would be removed permanently, including items in the subsurface.

4. **Reduction of TMV of Contaminants Through Treatment—**Alternatives 1 and 2 will not reduce the TMV of UXO and DMM at the Ricochet Area MRS. Of Alternatives 3, 4 and 5, Alternative 4 would be less effective than Alternative 3 as it would be conducted over a smaller, more focused area and some surface UXO might be missed that would be covered under Alternative 3. Alternative 5 would be effective in reducing the TMV of UXO and DMM because all detectable UXO and DMM would be removed, including items in the subsurface. Subsurface UXO and DMM would be removed at the herbaceous openings and during UXO construction support under Alternative 4 and would be less effective than Alternative 5.

5. **Short-Term Effectiveness—**Because no construction activities are associated with either alternative, Alternatives 1 and 2 would not present significant additional risk to the community or to workers at the Ricochet Area MRS. Alternatives 3, 4, and 5 would increase risk to the community and to workers during removal of UXO and DMM. Increased risk to the community during removal of UXO and DMM would be reduced by the use of engineering controls and/or evacuations to maintain minimum safe distances. Alternatives 1 and 2 would not cause damage to the environment because no clearing, grubbing, or excavation would be required. Alternatives 3, 4, and 5 would cause damage to the environment because of those activities. Alternative 4 would cause less damage than Alternatives 3 and 5 because no or limited intrusive activities would be required as it would be performed over more focused surface and subsurface removal areas.

6. **Implementability—**Alternative 1 would be easily implemented because it requires no action. The containment and controls recommended as Alternative 2 could also be easily implemented because they pose no technical difficulties and the materials and services needed are available. Removals of UXO and DMM to various depths, like those proposed in Alternatives 3, 4, and 5, have been implemented effectively at the Ricochet Area MRS during the RI. Alternative 5 would take longer to implement as it would be performed over a larger area and would require intrusive work to instrument detection depth. Specific activities, including plant surveys, awareness training, and mitigation activities, will be required to protect natural resources and cultural

resources, and the requirements would be easier to meet with the less intrusive Alternative 4 approach.

7. **Cost—**The total present-worth cost to perform each alternative is as follows:
   - Alternative 1 = $0
   - Alternative 2 = $181,998
   - Alternative 3 = $16,182,335
   - Alternative 4 = $6,757,826
   - Alternative 5 = $24,315,156

   Note: Costs have been rounded to the nearest thousand dollars and do not include costs associated with recurring reviews.

8. **State Acceptance—**Regulatory agency acceptance will be evaluated following the review of this FS.

5.3.2 Recommended Remedial Action Alternative

Table 5-1 presents the summary of the detailed analysis of the alternatives for the Ricochet Area MRS. Alternative 4, Focused Surface and Subsurface Removal of MEC and Containment and Controls, is the recommended remedial action alternative. Although Alternative 4 was not ranked as favorably as Alternative 5, the detailed analyses for Alternatives 1, 2, and 3 have fewer criteria ranked as favorable. Alternative 4 was selected because it ranked favorably in the detailed analysis over other alternatives in relation to the overall protectiveness of human health and the environment, compliance with ARARs, and implementability.

Table 5-1 Summary of Detailed Analysis of Remaining Alternatives

	Screening Criterion	Alternative 1: No Action	Alternative 2: Containment and Controls	Alternative 3: Surface Removal with Containment and Controls	Alternative 4: Focused Surface and Subsurface Removal with Containment and Controls	Alternative 5: Subsurface Removal to Instrument Detection Depth with Containment and Controls
Threshold	Overall Protection of Human Health and Environment	○	◑	●	●	●
	Compliance with ARARs	○	○	●	●	●
Balancing	Long-Term Effectiveness	○	○	◑	◑	●
	Reduction of Toxicity, Mobility and Volume through Treatment	○	○	◑	◑	●
	Short-Term Effectiveness	●	●	◑	◑	◑
	Implementability	●	●	◑	●	◑
	-Technical Feasibility	●	●	●	●	●
	-Administrative Feasibility	●	●	●	●	●
	-Availability of Materials and Services	●	●	●	●	●
	Cost[1]	$0	$181,998	$16,182,335	$6,757,826	$24,315,156
Modifying[2]	Regulator Acceptance	TBD	TBD	TBD	TBD	TBD
	Community Acceptance	TBD	TBD	TBD	TBD	TBD
	Recommended					

● - Favorable (Yes for threshold criteria)
◑ - Moderately Favorable
○ - Not Favorable (No for threshold criteria)

1 – Costs are detailed in Appendix A.

2 – The Modifying criteria of regulator and community acceptance are 'To Be Determined' following review and input from these parties.

6. REFERENCES

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