DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

JAN 03 2017

CEMP-CED

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Trial Period for Risk Management Methodology at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects

1. PURPOSE: This memorandum establishes as guidance and implements a 2-year trial of the process described in the Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites (MRS). (Enclosure 1).

2. APPLICABILITY: This guidance is applicable to all USACE elements engaged in FUDS MMRP projects.

3. REQUIREMENTS: In accordance with 40 CFR Part 300.175(d) (4), *"...the Lead Agency shall conduct a site specific baseline risk assessment to characterize the current and potential threats to human health and the environment..."* For unacceptable risks, and in accordance with 40 CFR Part 300.430(e) (i), the Lead Agency shall *"Establish Remedial Action Objectives (RAOs) specifying contaminants and media of concern, potential exposure pathways, and remediation goals."* The methodology in Enclosure 1 is intended to satisfy the requirement for a risk assessment for FUDS MMRP projects. RAOs are established to define the acceptable end state for a MRS.

4. IMPLEMENTATION: Although application of this risk methodology is first intended for use at the end of Remedial Investigations, it is also intended to support remedy selection decisions and post Remedial Action data assessment.

a. The methodology will be used to:

(1) Provide information to support risk management decisions upon completion of site characterization;

(2) Develop remedial action objectives; and

(3) Provide a basis for assessing achievement of remedial action objectives relative to acceptable end states.

b. Implementation will avoid disruption of service contracts or site remedy implementation, where possible. For circumstances where ongoing work is not able to transition to the new methodology and be conducted in compliance with this Memorandum, efforts will be made to include consideration of the risk assessment criteria discussed in Enclosure 1 and provide feedback to address how other approaches compare to the process described in the Study Paper. This information will be submitted to the EM CX in lieu of Enclosure 2.

5. DATA MANAGEMENT: Information regarding use for this methodology during the 2-year trial will be collected by the EM CX. Project teams will submit the attached Feedback Form (Enclosure 2), at the time draft reports are submitted for EM CX review. The methodology will be assessed at the end of two years from the date of this memorandum. The EM CX, at the end of the trial, will prepare a report of assessment.

6. TRAINING: Project teams are encouraged to enroll in the FUDS training course #428 to learn how to use the methodology, or engage the EM CX to assist in project specific application.

7. EFFECTIVE DATES: The requirements and procedures set forth in this interim guidance are effective immediately. They will remain in effect for 2 years, unless superseded by other policy or regulation.

8. POINT OF CONTACT: For additional information, please contact Mr. Julian Chu, FUDS National Program Manager, at 202-761-1869.

Karen J. Baker

KAREN J. BAKER
Chief, Environmental Division
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2 Encls
1. Study Paper
2. Feedback Form

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7 December 2016

Final
Study Paper:
Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites

Abstract

A framework of logic is presented to evaluate hazards at Munitions Response Sites (MRS) such that a systematic assessment of the associated site specific human health risks can be determined, and remedial action objectives (RAOs) can be established. This paper is presented as a consistent methodology for these determinations which depend on site-specific characterization data and specific land use conditions at each MRS. These data are processed similar to the Department of Army Pamphlet for Risk Management (DA Pam 385-30), but the framework utilizes MRS characteristics of Accessibility, Sensitivity and Severity to illustrate site specific conditions, and assign acceptable versus unacceptable scenarios at an MRS. Acceptable end states as presented in Figure A3-1 achieve negligible risk scenarios for an MRS and can be A) Acceptable, where unlimited use unrestricted exposure (UU/UE) is supported, B) Acceptable without additional land use controls (LUCs), where UU/UE may not be supported, or C) Acceptable with LUCs, where UU/UE is not supported.

1 Purpose

The purpose of this paper is to provide U.S. Army Corps of Engineers (USACE) Formerly Used Defense Sites (FUDS) Project Delivery Teams (PDT) with decision logic to differentiate acceptable versus unacceptable site conditions at Munitions Response Sites (MRSs), to establish a systematic approach for developing remedial action objectives (RAOs), and to assist in developing acceptable response alternatives to meet the RAOs. This paper establishes a parallel to the Department of the Army Pamphlet defining the process of Risk Management (DA Pam 385-30), by defining factors more appropriate for Military Munitions Response Program (MMRP), to include specific site conditions and munitions sensitivities. The strength in the Army risk assessment approach is that it is intended to address potentially acute hazard scenarios by factoring real site conditions to establish risk.

- Section 2 provides the applicability of this paper.
- Section 3 introduces CERCLA regulatory requirements for risk assessment and defining remedial action objectives, and limitations to available tools.
- Section 4 addresses the requirement for risk assessment at Munitions Response Sites (MRSs) by providing considerations for site characterization and a framework that allows PDTs to define the current state of an MRS as acceptable or unacceptable based on specific site conditions and information gathered through characterization.
- Section 5 addresses the requirements for developing the RAO by utilizing the framework for MRS risk assessment in Section 4 to identify one or more site scenarios that are

considered acceptable and therefore would constitute a protective end state. These scenarios provide the basis for determining the RAO(s) for the MRS.

- Section 6 presents an exit strategy using post remedy data assessments to evaluate confidence in the remedial action and support achievement of the RAOs for an acceptable end state.

2 Applicability

This study paper methodology may be applied by all USACE organizations conducting FUDS MMRP CERCLA response actions.

3 Background

3.1 NCP Requirement for a Risk Assessment

In accordance with 40 CFR Part 300.175(d)(4), *"...the Lead Agency shall conduct a site specific baseline risk assessment to characterize the current and potential threats to human health and the environment..."* The methodology described in this paper is intended to meet the NCP requirement for a risk assessment, and be consistent with the risk management decision process described in DA Pam 385–30, which establishes a framework for risk management in accordance with Department of Defense Instruction (DODI) 6055.1 and Army Regulation (AR) 385–10.

3.2 NCP Requirement for Remedial Action Objectives

For unacceptable risks, and in accordance with 40 CFR Part 300.430(e)(i), the Lead Agency shall *"Establish Remedial Action Objectives (RAOs) specifying contaminants and media of concern, potential exposure pathways, and remediation goals."*

Similar to a chemical contaminant, defining a measureable and achievable RAO for munitions response sites will be dependent upon a defensible characterization[1] to result in clear identification of the munitions and explosives of concern (MEC), as well as the exposure pathways to receptors. Identification of MEC for a munitions project must first be supported by the nature of the specific munitions known or suspected to exist at a MRS. The specific nature of the munitions present is a significant consideration in defining the presence of a hazard.[2]

[1] Although there are different goals for cleanup of munitions than for HTRW, CERCLA is generally the regulatory framework that DoD has determined will be used for the MMRP. The term "characterization" is used broadly to foster the iterative development of a robust, high quality Conceptual Site Model (CSM) through investigative response actions, such as the CERCLA Preliminary Assessment (PA), Site Inspection (SI) and Remedial Investigation (RI) phases collectively, but generally irrespective of the regulatory framework under which a project is being conducted. At the end of the RI under CERCLA, the site is "characterized" and data is used for assessment of risk.

[2] Variability in explosive nature (sensitivity) of specific munitions, and variance in the anticipated result of an incident (severity) is acknowledged in determining an acceptable versus unacceptable risk on an MRS (e.g., small spotting charge vs. high explosive, fuzed munitions).

With these considerations applied to the 40 CFR Part 300 requirement for developing a measureable RAO, development of measureable and achievable RAO for a MRS requires:

A	a. Identification of specific munitions and explosives of concern (MEC) and media of concern. b. Identification of exposure pathways to receptors, and c. Identification of acceptable remediation goal.

3.3 *Current Tools for Assessment of Explosive Hazards*

Currently, there are tools available to assist in prioritization, and qualitative assessment of hazard reduction for MRSs. These tools have specific programmatic functions, but have limitations at the project level regarding initial determination of acceptable versus unacceptable risk at an MRS. Without this initial assessment of risk supported by the conceptual site model (CSM), it is difficult to establish RAOs for a MRS. A summary of these tools and how they were assessed in support of the approach described in this paper is provided at Attachment 1.

4 **Assessing Risk at Munitions Response Sites**

The following section is intended to assist project teams to initially define and defend determinations of acceptable versus unacceptable risk at munitions response sites. Section 5 builds on this logic to identify acceptable site scenarios as RAOs that will achieve one of the acceptable end states.

4.1 *Defining Risk after MRS Characterization*

Characterization is critical to define the presence of MEC hazards and exposure pathways to receptors that are used to create the baseline risk determination.[3] At the completion of successful characterization, the project team must be able to determine whether the conditions at the site are "acceptable" or "unacceptable," such that only unacceptable risks require remedial action. *For determination of an unacceptable risk and to develop the RAO, the likely presence of MEC with a reasonably anticipated current or future exposure scenario must be clearly supported by MRS specific information.*

B	Presence of Site Munitions with a Specific Explosive Nature and Site Specific Receptor and Exposure Pathway → Determination of Risk

[3] See Attachment 4.

The general expression for risk, shown in block B, is derived from items a and b in block A, and is directly related to the CSM[4] resulting from characterization. The determination of an explosive risk must include a) likely presence of *specific munitions* having an explosive nature at the MRS; it cannot be solely dependent on historical suspicion or general observance of uncharacterized munitions debris (MD). The known explosive component characteristics of the specific munitions present are a critical consideration in assessing and defining the sensitivity and severity of site risks.[5] Additionally, the determination of unacceptable risk in block B must also be supported by accessibility, specifically b) site-specific current or reasonably anticipated future land use scenarios, defining receptors and a pathway that would result in a likelihood of exposure.

C	"Unacceptable Explosive Risk" is determined if the CSM indicates presence of munitions having a specific explosive nature, as well as the accessibility supported by the specific land use, such that the likelihood of encounter, sensitivity of the munitions items, and severity of a potential incident are collectively unacceptable.

Multiple lines of evidence are required to define the presence and nature of specific munitions, receptors and pathways that will support a qualitative risk assessment and development of the RAO. As these data typically rely heavily on observation, geophysical data, and qualified experts to determine likely presence and nature of explosive munitions, additional lines of evidence that need to be considered whenever available are historical records identifying type of ordnance used and operational context (nature of operations, when, where, how much, etc.). Additionally, details such as the horizontal and vertical spatial distribution information resulting from characterization, as well as topography and terrain, vegetation, and geology are the types of information collectively used to support a determination of the potential of an explosive risk based on current and future land use.

In section 4.3, information from the CSM is used to assess the accessibility, severity and sensitivity of the site scenario. The section provides decision logic that supports a determination of whether there is an ***unacceptable explosive risk***.[6]

4.2 MRSs with Undefined Risk

Similar to response for chemical contamination, a remedial action that results in "zero risk" remaining on the site is ***not*** possible or required. A Feasibility Study (FS) is only conducted to

[4] See Engineer Manual 200-1-12 for CSM development. Additional assistance with development of the CSM (lateral and vertical) is available through the EM CX.

[5] For HTRW, without definition of the specific chemical, concentration, toxicity, and an assessment of exposure, it is impossible to define (even relatively) the severity of risk or to assess an appropriate response. Similarly in MMRP, without defining the specific munition, the scale to the explosive nature of specific munitions, and assessment of site specific exposure pathways, it is impossible to assess and define risk at a MRS (See footnote 12).

[6] This is consistent with HTRW response process, conducting the risk assessment subsequent to defining hazards resulting from RI site characterization. It is also consistent with the Department of the Army Pamphlet 385-30, Safety: Risk Management, such that the CSM conditions define the presence of a hazard.

address an unacceptable risk. It is critical to note that a RAO cannot be developed for an unknown or unlikely risk.

- If there is an "unknown" risk, then characterization is not complete.

- If there is a determination that a site risk is so small (often seen in reports described as "unlikely" or "negligible") that response would result in a residual risk equal to the initial risk, then there is no further reduction possible such that a more acceptable level of protectiveness can be defined.[3]

Therefore, it is not appropriate to conduct a FS, nor can a remedial action be conducted to reduce an "unknown," "negligible," or "unlikely" risk.

D	A remediation goal cannot be defined for an unknown or unlikely risk.

4.3 Approach to Assessing Acceptable versus Unacceptable Risk at MRSs

For each MRS, the project team is encouraged to develop data and structure for differentiating an acceptable versus unacceptable risk. By defining unacceptable versus acceptable using site specific characteristics of severity, accessibility, and sensitivity, a project team can more effectively communicate the risks and associated requirements for remedial action, develop a RAO, and facilitate the achievement of response complete (RC) for the Site.

A simple approach for this logic is to employ matrices using site-specific CSM data to relate accessibility, munitions sensitivity, and severity of an explosive event if it were to occur, to determine baseline risks.[7] The purpose of each matrix is introduced here, and then presented in detail in section 4.4 to support unacceptable risk determinations for a site.

- ***Matrix 1,*** *the Likelihood of Encounter*, relates the site characterization data for amount of MEC potentially present to site use, including *accessibility*, in order to determine the likelihood of encountering MEC at a specific site.

- ***Matrix 2,*** *the Severity of an Incident*, assesses the likelihood of encounter from Matrix 1 as related to the *severity* of an unintentional detonation.

- ***Matrix 3,*** *the Likelihood of Detonation,* relates *sensitivity* of the MEC items to the likelihood for energy to be imparted on an item during an encounter by specific land users.

- ***Matrix 4*** combines the results of the above categories to differentiate *Acceptable and Unacceptable Site Conditions.* A site which results in an unacceptable initial condition will

[7] Accessibility, Sensitivity and Severity are the same factors used in the MEC HA. This methodology requires that data elements for these hazard components result from the site specific characterization data. It is anticipated that individual site circumstances will require different levels of the severity, accessibility, or sensitivity determinations. Decision logic used to select particular levels in the matrices must be justified and well-supported by facts presented in the CSM.

proceed to the next phase of the CERCLA response process. This matrix identifies acceptable conditions, which become possible remedial action goals that are ultimately achievable (via remedial response actions) for all portions of the MRS. Section 5 discusses these acceptable conditions as RAOs.

4.4 The Risk Matrices

4.4.1 *Matrix 1.* In Matrix 1, below, the "Likelihood of Encounter" is dependent on two factors, the amount of MEC items known or suspected to exist, and access conditions (e.g., accessibility and frequency of use). Either or both of these factors can be modified as a result of the selected remedial action to reduce or eliminate the likelihood of encounter.

"Amount of MEC" is determined using site specific characterization data or anticipated or completed results of a remedial action.[8] Although the scale emphasizes the results of distribution, the selection may also include consideration of available historical information, such as development history.[9] "Access Conditions" are selected based on considerations of the access and frequency of use for the MRS.

The selection considers "Accessibility" as similarly defined by the MEC Hazard Assessment (MEC HA); but also considers other relevant conditions, such as topography, terrain, specific land use, and specific potential receptors via defined pathways to establish access conditions as a frequency of use.[10] As such, site specific circumstances may result in different access conditions, which should be supported and documented by the CSM.

[8] The "Amount of MEC" selection in Matrix 1 differs from the MEC HA's input factor for "Amount of MEC" which is based solely on the MRS "type" historically identified. Instead, the "Amount of MEC" in Matrix 1 is initially dependent on the results of characterization data regarding MEC and MD distribution. The Matrix is then used to assess anticipated or completed results of a remedial action (physical removal of MEC) to a "reduced" amount.

[9] For example, historical information indicating an area has been extensively developed and used for years with no MEC encounters, in many cases, will be evidence to support a low determination for "Amount of MEC" in the table, and therefore support a lower "Likelihood of Encounter."

[10] A site may be accessible but may have relatively low frequency of use due to the difficult terrain, which results in lower possible contact hours or "access" for the MRS. This scale of "access conditions" may include several factors, including number of visitors or receptor hours per year, nearby population, or residential versus industrial use. Each of these factors may have different justifications depending on the facts at the site. The concept of calculation of "receptor hours per year" is provided in the MEC HA document.

Matrix 1. Likelihood of Encounter

Likelihood of Encounter, Matrix 1: Amount of MEC vs. Access Conditions		**Access Conditions (frequency of use)[10]**			
		Regular (e.g., daily use, open access)	**Often** (e.g., less regular or periodic use, some access)	**Intermittent** (e.g., some irregular use, or access limited)	**Rare** (e.g., very limited use, access prevented)
Amount of MEC [8,9]	• MEC is visible on the surface and detected in the subsurface.	**Frequent**	**Frequent**	**Likely**	**Occasional**
	• The area is identified as a Concentrated Munitions Use Area (CMUA) where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.	**Frequent**	**Likely**	**Occasional**	**Seldom**
	• MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not a CMUA, or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).	**Likely**	**Occasional**	**Seldom**	**Unlikely**
	• MEC presence is based on isolated historical discoveries (e.g., EOD report) prior to investigation, or • A DERP response action has been conducted to physically remove MEC and known or suspected hazard remains to support this selection, (e.g., surface removal where subsurface not addressed) or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.5/acre at 95% confidence).	**Occasional**	**Seldom**	**Unlikely**	**Unlikely**
	• MEC presence is suspected based on historical evidence of munitions use only, or • A DERP response action has been conducted to physically remove surface and subsurface MEC (evidence that some residual hazard remains to support this selection), or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.25/acre at 95% confidence).	**Seldom**	**Seldom**	**Unlikely**	**Unlikely**
	• Investigation of the MRS did not identify evidence of MEC presence, or • A DERP response action has been conducted that will achieve UU/UE.	**Unlikely**	**Unlikely**	**Unlikely**	**Unlikely**

Matrix 2. Severity of Incident

Severity of Explosive Incident, Matrix 2: Severity vs. Likelihood of Encounter		**Likelihood of Encounter**[11]				
		Frequent: Regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent, rare occurrences	**Unlikely:** Not probable
Severity Associated with Specific Munitions items[12]	**Catastrophic/Critical:** May result in 1 or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in 1 (or more) injury resulting in emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in 1 or more injuries requiring first aid or medical treatment	B	C	C	C	D
	Improbable: No injury is anticipated	D	D	D	D	D

"A" indicates conditions most likely to result in determination of an unacceptable risk.
"D" indicates conditions most likely to result in determination of an acceptable risk.

4.4.2 *Matrix 2.* Matrix 2, "The Severity of Incident," relates "Likelihood of Encounter" from Matrix 1 to the severity of an unintentional detonation. Unlike the two factors affecting the likelihood of encounter in Matrix 1, the "Severity" factor in Matrix 2 is a static characteristic of each of the munitions known or suspected to exist at the property. This is consistent with the MEC HA application for munitions identified for the property. Therefore, in order to improve the Category in Matrix 2, either the items are physically treated and/or removed (reducing the amount of MEC), land use or conditions are altered, or both of these factors are improved in Matrix 1.[11]

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[11] Note that with data collected from physical remediation, it is possible to support an unlikely determination for Matrix 1 and 2, (Attachment 3).
[12] This paper recognizes there is currently no scale for ranking the explosive nature of munitions, and it therefore requires coordination with qualified UXO professionals, per TP-18 requirements (reference 15), on the project team. Initiatives are underway to evaluate these considerations of scale. There must be a defined munitions item having an explosive nature and a defined exposure scenario. Additionally, the degrees of hazards differentiate between intact UXO and munitions components such as rocket motors, fuzes, discarded military munitions (DMM), and explosive soils. Decision logic to support the selection on this scale must be supported by the CSM, and documented in the project reports. Additional research in this subject area in the future may allow for additional refinement within these categories so site specific conditions will be the primary factor for project team determination once MEC types on site have been determined.

Matrix 3. Likelihood of Detonation

Likelihood of Detonation, Matrix 3: Munitions Sensitivity vs. Likelihood of Energy to be Imparted		**Likelihood to Impart Energy on an Item[14]**		
		High e.g., areas planned for development, or seasonally tilled	***Modest*** e.g., undeveloped, wildlife refuge, parks	***Inconsequential*** e.g., not anticipated, prevented, mitigated
Sensitivity:[13] Susceptibility to Detonation	***High*** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., high explosive (HE) or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

4.4.3 *Matrix 3.* Matrix 3, "The Likelihood of Detonation," relates the sensitivity of site specific munitions items to the likelihood for energy to be imparted on an item, such that the interaction results in detonation (incident). MEC sensitivity and the likelihood for energy imparted during an encounter are both specific to the site CSM. The "sensitivity" of a munitions item is alone a static component, inherent to the known or suspected munitions present at the site. The selection for sensitivity is similar to the sensitivity scale in Table 1 of the Military Munitions Response Site Prioritization Protocol (MRSPP).[13] The "Likelihood to Impart Energy" is selected from the known activities at the site that may cause an interaction that results in energy being imparted on a munitions item by human activity.[14] The "Likelihood to Impart Energy" can be affected by behavioral modifications or by altering land use, specifically to prevent accessibility or particular activities to reduce the likelihood or ability of imparting energy on a munitions item.

[13] The Sensitivity categories are scaled highest to lowest, similar to the MRSPP Table 1: Munitions Type Data Elements Table. While the scale of sensitivity in Matrix 3 is similar to MRSPP Table 1, the matrix must have the flexibility to consider the inclusion of unlisted or undefined items, such as fuzes having small amounts of primary charge and not attached to a booster charge, which may be less sensitive than fuzes with large amounts of primary charge or any fuze connected to a booster charge. Therefore, the PDT should build from this baseline structure in Matrix 3 to include additional considerations, and provide justification for the sensitivity selection for the specific item. Selections must be supported by identifying the specific munitions on the MRS (listed with correct nomenclature).

[14] The likelihood to impart energy on an item can be high for farmed land that is regularly tilled, or areas where development is planned. Moderate areas may include parks or areas where digging is manual or limited. Areas that are Inconsequential will include areas where digging is not anticipated, or otherwise mitigated to prevent imparting energy on an item. The project team will consider land use, specifically types and amount of energy imparted at the site that will result in an interaction with a munitions item. The project team will document the justification for selection on the scale.

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result From Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Note: Multiple conditions may exist within an MRS, such that unique baselines risks can be established for the multiple explosive hazards that are present within the same property. Acceptable conditions indicate input factors are collectively determined to support a negligible risk. Project teams shall consider the nature of the specific item within the MRS and the probability to encounter in order to support the selection on the scale.

4.4.4 *Matrix 4.* Matrix 4 represents the overall risk for the site, and differentiates "acceptable" from "unacceptable" conditions. This is determined based on the likelihood of an encounter (Matrix 1), with consideration given to the severity of the incident (Matrix 2), combined with the likelihood of an interaction that results in detonation (Matrix 3). For example: The result of A-3 in Matrix 4 indicates "unacceptable" as depicted above. The overall risk for the selection is driven by the "frequent" or "likely" encounter (Matrix 1) with a potentially catastrophic munitions item (Matrix 2), even though the likelihood of a detonation (Matrix 3) is low (3) based on sensitivity and likelihood to impart energy on the item.

At the end of characterization, the result of Matrix 4 is used to differentiate unacceptable from acceptable conditions. Where an unacceptable scenario is identified, this matrix is then used during the feasibility study to identify acceptable conditions that are ultimately achievable via remedial response actions for all portions of the MRS. Finally, the matrices are used in a post remedy data assessment to evaluate the achievement of risk reduction for a given remedy (Attachment 3).

4.5 *Addressing Multiple Risk Scenarios*

The risk management matrices will be applied to all portions of an MRS. Multiple conditions may exist within an MRS, such that unique baseline risks can be established for the multiple explosive hazard scenarios that are present within the same MRS. If separate remedial actions for different locations of an MRS are anticipated, the matrices may be applied separately to support the risk management decisions in each location. Multiple entries (or multiple matrices) should be used when:

1) accessibility or land use conditions vary across the MRS (e.g. industrial vs. camping or hiking vs. residential),

2) when munitions types and and/or MEC characteristics vary within an MRS, and /or

3) when the distribution of MEC differs across the MRS (e.g., target center, identified as a concentrated munitions use area (CMUA) vs. buffer or safety zones, identified as non-concentrated munitions use areas (NCMUAs)).

Therefore, multiple RAOs may be required where multiple site conditions exist. These multiple conditions may be illustrated in a tabular form. An example of multiple risk scenarios is provided in Attachment 2.

5 Defining the RAO

A RAO must establish the acceptable condition(s) for the MRS which no longer poses an unacceptable risk.[15] Project teams must carefully consider available data and logic to support assessment of any remedial action against the RAO, such that remedial actions can be developed to feasibly take a site which currently poses an unacceptable risk to one which no longer poses an unacceptable risk.

5.1 Planning Risk Reduction to the RAO

After an unacceptable risk has been defined for an MRS, teams can identify conditions that are acceptable in Matrix 4 as RAOs, where remedial actions can be identified that will result in reduction of an unacceptable risk to one of these acceptable conditions.

Once Matrix 4 establishes the unacceptable baseline risk condition, the RAO can then be developed to achieve one of the acceptable conditions of Matrix 4. ***The Remedial Action Objective(s)*** can be written *"to reduce the unacceptable risk due to presence of [name specific munitions of explosive nature or components using appropriate nomenclature] within [specified horizontal MRS boundary] to a depth of [defined depth related to current and future land use, or depth of MEC determined during characterization if less than land use] below surface to address likelihood of exposure to [receptors] via [pathway] such that an acceptable condition (as defined by Matrix 4) is achieved."*

E	"The **Remedial Action Objective(s)** can be written *"to reduce the unacceptable risk due to presence of [name specific munitions of explosive nature or components using appropriate nomenclature] within [specified horizontal MRS boundary] to a depth of [defined depth related to current and future land use, or depth of MEC determined during characterization if less than land use] below surface to address likelihood of exposure to [receptors] via [pathway] such that an acceptable condition of negligible risk (as defined by Matrix 4) is achieved."*

Multiple RAOs may be required where multiple site conditions exist, for example, for different MEC characteristics or components within an MRS, for different land uses within the MRS, and/or for areas having different distribution characteristics, (e.g. target area and buffer area).

[15] For many traditional chemical analyte targets, there is either an established acceptable level on which the RAOs are based, or where there are no levels, there are standard processes used to establish project acceptable limits. For explosive hazard, however, there is no promulgated standard, nor are there standard processes to establish acceptable limits. This paper provides general guidelines as a process for defining an acceptable state for a MRS.

These multiple conditions may be illustrated in a tabular form. An example is provided in Attachment 2.

5.2 Achieving the RAO

The RAO is met by changing the unacceptable baseline risk conditions to one of the possible acceptable conditions in Matrix 4. This is achieved by moving to the right within Matrix 2, Matrix 3, or both.

- ***Moving to the right in Matrix 2.*** Risk is reduced by establishing remedial alternatives that reduce the "Likelihood of Encounter" which results in moving to the right on Matrix 2. This is accomplished either by reducing the amount of MEC, altering the frequency of access, or both in Matrix 1.

- ***Moving to the right in Matrix 3.*** Risk is reduced by establishing remedial alternatives to address likelihood of energy imparted to a munitions item as a result of specific activities at the MRS, which will result in moving to the right on Matrix 3. This can be accomplished by implementation of land use controls.

For example, if an MRS baseline is unacceptable, resulting from a "B" category of Matrix 2 and a "2" category from Matrix 3, the remedial alternatives can be established to reduce "B" in Matrix 2 to a "C" or "D", reduce "2" in Matrix 3 to a "3", or affect both matrices to reach any of the "Acceptable" risk levels.

Where multiple site conditions are present on a MRS, e.g., multiple accessibility parameters based on differing land use, or when locations of multiple explosive types and sensitivities can be differentiated from one another, different hazard matrices for these areas may be required. An example presenting multiple acceptable conditions where differing site scenarios are present is included at Attachment 3.

6 Exit Strategy Using Post Remediation Data Assessments

6.1 Defining an Acceptable End State for a MRS

The achievement of one of the "Acceptable" scenarios in Matrix 4 can result in one of the following "end states" to support a Response Complete (RC) determination, as illustrated in Attachment 3 (Figure A3-1):

a. Acceptable, where UU/UE is supported[16], or

[16] DODM 4715.20, Enclosure 3, 4.b.(5)(b)1. The assessment of remedial alternatives to meet the remediation goal must include an action to remediate the site to a condition that provides for a UU/UE alternative, and an alternative that achieves protectiveness with LUCs. Upon achievement of the RAO, information should be developed which supports achievement of the acceptable hazard level and an assessment of a UU/UE determination. Project teams must keep in mind that after any site remedy is complete, if the contamination left behind does not allow for UU/UE, 5- year reviews will be required.

b. Acceptable without LUCs, where UU/UE is not supported[17], or

c. Acceptable with LUCs, where UU/UE is not supported.

6.2 *Supporting the Acceptable End State Using Post Remedy Data Assessment*

Where a physical removal is a component of the selected alternative, the data collected during the physical removal supplements the CSM such that one of the three exit conditions for RC above can be confidently supported. The project team is encouraged to develop "if-then" statements within the proposed plan and decision document that provide the decision logic for these conditions.

Data assessment at the completion of any physical remediation can be used to support the achievement of the RAO, to support the RC determination, and to provide additional confidence in decisions at the site. This includes determination of whether additional actions, such as LUCs, are necessary. It separately includes the determination of whether UU/UE is supported. Teams must plan for data acquisition during the response action to support this decision logic. An example of a post remedy data assessment is included at Attachment 3.

7 Summary and Considerations of Exit Strategy at MRSs

This paper provides decision logic to define and defend decisions on acceptable versus unacceptable conditions at an MRS such that remedial action objectives can be established. These RAOs must be established so the remedial action will mitigate an unacceptable risk to an acceptable one. Furthermore, a RAO cannot be established to reduce an unknown or unlikely risk.

The following recommendations are made to differentiate acceptable and unacceptable risk conditions for each site based on magnitude of evidence collected through site characterization and/or during collection of data during implementation of physical response actions to support achievement of an acceptable end state, shown in Figure A3-1.

1) The project team is encouraged to utilize the matrices presented in this paper as a site-specific risk assessment structure to differentiate acceptable and unacceptable conditions at an MRS.

    a. The likelihood of encounter must account for the characterized distribution, and specific land use scenario. Together, these data reflect the likelihood of encounter, shown in Matrix 1. The matrix may be used pre and post remedy to assess changes to the likelihood of encounter.

[17] LUCs are additional components of a remedy that further reduce risk where the RAO is not achieved by physical remedy alone. Although UU/UE is not supported, this does not specifically necessitate LUCs. It does, however, necessitate 5-year reviews. Pre-existing site conditions may impose restrictions that are not part of the remedy and will be considered in making the remedial decision, but a site might not achieve UU/UE after RC.

b. Through the assessment of Severity and Sensitivity Matrices 2 and 3, acceptable conditions may be differentiated from unacceptable ones, thereby supporting the development of a site specific RAO.

2) At completion of characterization (or post remedy) where likelihood of exposure is not reasonably anticipated and has been described, based on combined magnitude of evidence, as "negligible" or "unlikely," then an acceptable condition already exists for which no additional remedial response is required.

3) Project teams performing physical response actions to reduce risk levels, must plan to acquire data needed to describe the residual risk post response to evaluate achievement of the RAO. These data are used to determine if an additional remedial action (such as implementation of LUCs or additional treatment or removal) is necessary to achieve the RAO.

4) Furthermore, data acquired during a remedial action in which a physical removal is conducted may be of quality to support a UU/UE determination, if data gathering is planned and the necessary data is acquired during implementation of the remedy. Project teams are encouraged to include "if-then" statements when assessing remedial alternatives that consider potentially different results of remedial data as applicable to the determination of UU/UE.

5) Where multiple site scenarios are present on a site, (for example, multiple accessibility parameters based on differing land use, or when locations of multiple explosive types and sensitivities can be differentiated from one another), different hazard matrices for these areas may be required.

8 References

1) National Oil and Hazardous Substances Pollution Contingency Plan, (NCP). 40 CFR Part 300, Sections 1-7 and 400-525 March, 1990.

2) DoD Ammunition and Explosives Safety Standards: Criteria for Unexploded Ordnance, Munitions Response, Waste Military Munitions, and Material Potentially Presenting an Explosive Hazard (Department of Defense MANUAL NUMBER 6055.09-M, Volume 7, February 29, 2008. Administratively Reissued August 4, 2010).

3) Defense Environmental Response Program (DERP), Department of Defense Instruction Number 4715.07

4) USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. EPA/540/G-89/004. OSWER Directive 9355.3-01. October.

5) Technical Guidance for Military Munitions Response Actions, Environmental and Munitions Center of Expertise Interim Guidance Document (IGD) 14-01, 20 December 2013. EM 200-1-15.

6) ESTCP studies. https://www.serdp-estcp.org/Featured-Initiatives/Munitions-Response-Initiatives/Classification-Applied-to-Munitions-Response

7) USEPA, 2001. Comprehensive Five Year Review Guidance, EPA-540-R-01-007, OSWER Number 9355.7-03B-P, June.

8) USEPA, 2007. Interim guidance for Munitions of Explosive Concern Hazard Assessment (MEC HA).

9) Office of the Secretary of Defense (OSD) Munitions Response Site Prioritization Protocol (MRSPP) Primer, 32 CFR Part 179, April 2007.

10) Office of the Secretary of Defense (OSD). DoD Evaluation of MEC HA. November 2014.

11) USACE Munitions Safety, Engineer Manual (EM) 385-1-97. Chapter III Probability Assessments

12) Department of the Army, Safety: Risk Management, DA PAM 385-30, 2 December 2014.

13) USACE Engineer Manual (EM) 200-1-12.

14) USACE Memorandum dated January 2007, RE: UFP QAPP Implementation

15) DDESB Technical Paper 18: Minimum qualification standards for personnel who support MEC related activities, 16 July 2015.

Attachment 1: Current Tools for Assessment of Hazard

A1.1 Consideration of the MEC Hazard Assessment (MEC HA)

The MEC HA is intended to provide a qualitative assessment of alternatives given a baseline MRS condition. The output for the MEC HA (baseline and alternatives) is hazard levels 1 through 4, with 1 having the highest hazard, and 4 being the lowest. Each remedial alternative receives a reduced score relative to the baseline score. The score is calculated by additive characteristics of the CSM, specifically the "accessibility" to the explosive items at the MRS, "sensitivity" of the items to function, and the "severity" of an incident, should it occur.

In consideration of MEC HA tool, the "munitions classification", "type", and "energetic material" components of the score are, understandably, static characteristics. These components (accounting for ~32% of the baseline) are never reduced, no matter what remedy is selected. However, because the MEC HA score is an additive calculation, where these factors are not changed, the score cannot efficiently account for a reduced "probability of encounter", which should be a multiplicative determination founded on the "amount of MEC" and "accessibility" conditions.

Other limitations identified by the DoD memorandum, dated November 2014, are related to the rigid selection factors of the tool which do not lend flexibility for the multitude of scenarios of site specific CSMs in the MMRP. For instance, the "Amount of MEC" selection for the MEC HA tool relies on the area category, similar to the type of range that is known or suspected, rather than the period and frequency of use, or actual anomaly distribution resulting from characterization.[18] Understanding or estimating the "Amount of MEC" should be more representative of the findings of the CSM and have direct relation to the calculation of the likelihood of encounter. By selecting a "type" of use as currently provided in the MEC HA tool, the resulting score is in no way reflective of the actual distribution data resulting from the completed characterization, and therefore cannot adequately represent differences between a highly used target areas of several years versus sites with limited use having very little findings to support presence as a result of characterization.

Based on the multiple findings of the DoD (reference 10 in Section 8 above), the probability of encounter cannot be appropriately represented by the current MEC HA tool. In this way, there are limitations to the qualitative value presented by the MEC HA score, and thus is not helpful in establishing the acceptable level of risk or in communicating a likelihood of encounter with a munitions item. It is therefore not an appropriate tool to help a project team in differentiating acceptable from unacceptable risk, or in developing a RAO. A project team is left to make these

[18] Note the use of "anomaly" here is a general representation of information resulting from characterization. The "hazard" is the result of the explosive nature of specific munitions that may remain partially or fully intact, not the clutter or debris that may be included in this anomaly distribution. The potential for some of those anomalies to present an explosive concern for specific site receptors is the basis of the unacceptable risk determination. It is those specific items presenting an explosive concern that are the "targets of interest" at the MRS, and for which the RAO is focused to reduce risk by implementing a remedial action.

assumptions and considerations outside of the tool in order to support development of a site specific RAO.

Therefore, while utilizing MEC HA to assess different remedial alternatives could be useful for sites where an unacceptable risk is clearly evident, it is not recommended for use to establish an acceptable site scenario or to define an acceptable amount of reduction for an MRS.

A1.2 Consideration of the Munitions Response Site Prioritization Protocol (MRSPP)

The Munitions Response Site Prioritization Protocol (MRSPP) is specifically used as a funding prioritization, not a hazard or risk assessment. However, data acquired during the project life cycle is used to develop sensitivity, accessibility and severity components of the MRSPP score. Therefore, it may be useful to look at the structure of MRSPP when identifying the MRS hazards, specifically the structured scale for the munitions explosive nature, Tables 1-3 of the MRSPP. The information in the MRSPP tables may be pertinent, and should ultimately be comparable to the methods established in this paper, such that the accessibility, sensitivity, and severity components are reflected similarly. Although the MRSPP is completed annually for each MRS, or as new information is available, it is important to recognize that once a remedial process has been completed, the MRSPP score becomes "no longer required" indicating funding is no longer planned. As a result, the MRSPP is not used to determine the reduction of risk once a remedy has been implemented.

A1.3 MEC Probability Assessment

The Engineer Manual (EM) 385-1-97, Safety and Health Requirements Manual, provides planning requirements for military construction projects having a current scale of "no," "low," and "moderate to high" probability determinations of an explosive hazard defined in a Probability Assessment. Though most of EM 385-1-97 does not apply to FUDS, this Probability Assessment is instructive as to how other programs assess explosives safety. Both "low" and "moderate to high" determinations require planning for MEC construction support (MEC standby or onsite support, respectively) on military installation construction projects.

Prior to Errata sheet No 1, dated 12 April 13 for this EM, "negligible probability" was included as the lowest probability, rather than the current word "no". In consideration of defining a similar scale for an MRS, rather than a construction site, though, the change in this terminology is significant. The word "no" constitutes a zero probability, which ***cannot*** be supported by any characterization effort; however the term "negligible" can be supported, with a specified degree of confidence. Conceptually, by this scale historically in EM 385-1-97, either "no" or "negligible" would support an "acceptable" condition, as no construction support would be required for sites where "negligible" (now "no") probability of encounter is determined.

Further, there is ambiguity in the relative definition of "low" probability, and there is no definition to the former term "negligible". While these general terms can provide a qualitative scale to establish the baseline probability of a hazard that may be found at a site, based on historic use and observation, there is no established logic in these terms that supports the determination of acceptable versus unacceptable risk at a site for purposes of CERCLA response.

In considering these terms for MMRP, this team recommends the term "negligible" probability because it can be defined using this RAO methodology such that an acceptable risk for an MRS can be established. In the absence of generally accepted definitions for acceptable risk levels for munitions response sites, project teams are currently encouraged to define "negligible" or "low" as acceptable risk levels, depending on specific physical and land use conditions at a MRS. This paper provides a framework of logic to support these determinations of probability, or "likelihood of encounter", relative to acceptability.

A1.4 Army Risk Management

Department of Army Pamphlet for Risk Management (DA Pam 385-30) is used to identify mission-related hazards and conduct a risk assessment for these conditions. It is generally tailored for active military missions. It does not clearly relate to environmental hazards related to MMRP; however, it focuses generally on probability and severity as key input factors for the evaluation of risk. This paper establishes a parallel to this Army process of Risk Management, using more appropriate matrix categories and factors pertinent to MMRP, to include specific site conditions and munitions sensitivities, while incorporating appropriate elements of the MEC HA, MRSPP, and the Probability Assessment. The strength in the Army risk assessment approach is that it is intended to address potentially acute hazard scenarios by assessing real site conditions to establish risk.

Attachment 2. Example RAO Acceptable Conditions

The table below gives examples of unacceptable baseline conditions and resultant acceptable conditions the remedial alternatives can seek to achieve.

MRS Scenario	Horizontal Boundary	Receptors	Pathways	Required remedial response depth[19]	UXO and DMM	Baseline Risk Condition (from Matrix 4)	Acceptable Condition(s) (from Matrix 4)	Baseline Acceptable or Unacceptable? U→FS required A→no action
Target Area	Trails plus 15m buffer that are within Target Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	A-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, D-2, C-3 or D-3	U
				0.2 meter	M48 Fuze	B-2	C-2, D-2, C-3, D-3	U
	All other portions of Target Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	B-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, D-2, C-3, or D-3	U
				0.2 meter	M48 Fuze	C-2	C-2, D-2, C-3, or D-3	A
Buffer Zone	Remaining Buffer Zone Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	B-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, C-3, D-2 or D-3	U
				0.2 meter	M48 Fuze	C-2	C-2, C-3, D-2 or D-3	A

[19] Characterization must provide data to suggest a horizontal as well as depth distribution of the TOI (with indication of confidence). The response depth is built from that distribution, with relative consideration of land use and instrument detection capabilities. See Attachment 3 to illustrate the significance of this data and how the post removal assessment is used to determine need for additional response (LUCs) or whether UU/UE can be supported.

Attachment 3: Example Post Remedy Data Assessment

This attachment illustrates the decision logic that may be performed post-remedy, using data collected during the remedial action to support the decision. Decision logic for this type of assessment is provided in the decision tree at Figure A3-1. The example is based on the tabulated RAO for acceptable conditions, which was developed using the matrices presented in this document:

EXAMPLE: Acceptable Conditions that Achieve the RAO

MRS Scenario	Horizontal Boundary	Receptors	Pathways	Required remedial response depth	UXO and DMM	Baseline Risk Condition	Acceptable Condition(s)= RAOs
Target Area	MRS01 boundary	Recreational users	Interaction during hiking, camping, hunting	0. 65 meter	81mm Mortar	A-1	B-3, D-1 D-2, or D-3
				0.3 meter	37mm projectile	A-1	B-3, D-1 D-2, or D-3

37mm and 81mm mortars are the targets of interest (TOI) based on historic use and confirmed presence of explosives use during characterization. Assumptions resulting from characterization are that:

- *37mm exist from the surface to 30cm*
- *81mm exist from the surface to 65cm*
- *These items are easy to detect and classify in any orientation within those depth intervals.*
- *Items can be detected and recovered at deeper depths when a signal-to-noise ratio is predicted for a given depth and orientation that is equal or greater than the project-specific detection threshold required to detect a horizontal 37mm at 30cm or a horizontal 81mm at 65cm.*

Details of the remedial action will be specified and executed in accordance with the site specific Uniform Federal Policy for Quality Assurance Project Plan (UFP QAPP).[20] Once the remedial action is complete, post remedy data is used at the Post Remedy Decision Points, indicated at Figure A3-1.

In this example, data were collected during remedy implementation to support post remedy evaluation of the residual risk, confirm the CSM and achievement of the RAO, to determine

[20] The Office of the Under Secretary of Defense Memorandum of April 11, 2006, first recommended use of UFP QAPP for DoD. USACE echoed recommendation in Memo dated January 2007. UFP QAPP, has since been implemented into the EM 200-1-15, 30 October 2015. *The DoD Environment, Safety, and Occupational Health Network and Information Exchange* provides the UFP QAPP worksheets at: http://www.denix.osd.mil/edqw/Documents.cfm

whether UU/UE can be supported, and/or to determine whether additional response, such as LUCs, may be required. If the RAO is satisfied, then RC is achieved.

POST-REMEDY DECISION POINTS: Confidence in the CSM and achievement of the RAO is supported when:

- All quality control criteria as specified in the site specific UFP QAPP for the remedial action are met,
- The CSM resulting from the characterization is still true, to include:
  - Identities of the items recovered were anticipated as a result of the characterization CSM.
  - The vertical distribution resulting from characterization reflects the actual vertical distribution of UXO recovered during the remedial response; and
  - All areas within the MRS Scenario (lateral and vertical boundary specifications of the RAO) have been searched for TOI.
    - Partial search (e.g., due to areas of difficult terrain, lack of ROE or other access issues) may result in considerations for additional response at the MRS (such as LUCs), or delineation of the unsearched area for further response while the searched area remedy is considered complete.

Post Remedy Decision Point 1: The Remedial Action work plan (UFP QAPP) defines the data quality objectives (to support achievement of the RAO). The Post Remedy Decision Point 1 assesses whether the conditions of response action met the requirements of the RAO as planned.

NO: For Remedial Responses that do not meet the criteria as specified in the remedial action UFP QAPP, there is reason to suspect the RAO has not been met. The project team must determine whether the deficiencies impact the achievement of the RAO, whether for the whole MRS Scenario, partial MRS Scenario, or if achievement of the RAO can still be supported. Justification for the decision must be provided. For instance, difficult terrain encountered during remedy prevented search of 100% of the MRS. MEC was encountered throughout the remedy of the areas immediately surrounding and within difficult terrain areas of the MRS. The PDT must determine if the reduction of the amount of MEC, with consideration of the confidence in the data can support achievement the RAO. A selection of "No" in the decision tree indicates the physical remedy did not achieve the RAO, where the likelihood of encounter, severity and sensitivity is still unacceptable, and therefore further remedial action is required. (See Post Remedy Decision Point 2b below.)

YES: For physical responses that meet the RAO, additional remedial actions (e.g., LUCs) will not be required to support an acceptable end state. In Figure A3-2, the data supports that the remedial response above the detection depth of the instrument and within the boundaries for the MRS was successful to meet the RAO. All assumptions and quality control data were met, supporting high confidence in remedy implementation. After the remedy is implemented at 100% of the MRS Scenario, the amount of MEC is confidently reduced to support selection of "unlikely" in Matrix 1, resulting in a D determination in Matrix 2. The reduction of items within the depth interval for current and reasonably anticipated future land users also supports selection of "Inconsequential" in Matrix 3.

For MRS scenarios where the physical response achieves the RAO, the project team must then assess whether UU/UE can be supported. Examples at Figures A3-2 and A3-3 are used to illustrate this subsequent post remedy data assessment for UU/UE considerations. (See ***Post Remedy Decision Point 2a*** below.)

Post Remedy Decision Point 2a: If the result of Decision Point 1 is "YES", the team must consider the achievement of UU/UE. Figures A3-2 and A3-3 are used as an example to illustrate how a post remedy data assessment can be used to support the consideration of UU/UE.

- *Outcome A: UU/UE Supported.* In further evaluation of the data, a significant gap exists below the lowest item found during implementation of the physical response and the known detection depth of the instruments used. The gap provides confidence that residual MEC at the MRS is "unlikely" to be present. In this case, a UU/UE determination is supported by the post remedy data assessment.

  Additional considerations: Another consideration for UU/UE is the limits of physical remedy imposed by site-specific limitations, such as bedrock. Removal to shallow bedrock over 100 % of the MRS Scenario, with appropriate quality data in the UFP QAPP may also be used to support a UU/UE determination.

- *Outcome B: UU/UE Not Supported.* In this example, two TOI were found near or just below the detection depth of the instrument, categorized as "catastrophic" in the severity Matrix 2. Both were identified as an explosive hazard. Based on the distribution of TOI in the subsurface, primarily in the 0-20 cm interval, the single detection of the 37mm at 30 cm, and the single detection of the 81mm at 70 cm are atypical of the remaining data set. However, because the items detected were "live", there is less confidence that residual presence of MEC below the RAO boundaries is "unlikely." If UU/UE is not supported, Five-Year Reviews will be required to assess long term protectiveness of the remedy to ensure the remedy remains protective.

  Consider, though, if the items at these depths were identified as inert fragments, the determination of UU/ UE may further be supported, as the dataset may suggest that MEC was limited to within 20cm of the surface.

Post Remedy Decision Point 2b: When the result of Decision Point 1 is "NO", the Decision Tree provides consideration of the existing data to re-assess the MRS Scenario and determine whether further remedial actions (e.g., LUCs) may be implemented to further support an Acceptable end state, according to Matrix 4.

- *Outcome C: UU/UE Not Supported.* If LUCs can be implemented to support achievement of the RAO, Outcome C is achieved, and response is complete.[21] Five Year Reviews will be required to assess long term protectiveness; however, if inclusion of LUCs does not support an acceptable end state, the project team must consider additional response actions, and return to the Remedial process.

[21] Consideration of LUCs at this decision point should be included as a discussion in the Feasibility Study, and Proposed Plan/Decision Document. Consideration of LUCs as part of a remedial alternative may occur if the physical remedy alone is not anticipated to achieve the RAO, and these measures will further reduce Matrix 4 to an acceptable end state. Alternatively, (post physical remedy) there may be cases where the physical remedy alone is anticipated to achieve the RAO, and if after the physical remedy is complete this is not the case, a decision document amendment or an explanation of significant differences (ESD) may be required to include LUCs or include additional remedial measures. The DERP Manual requires consideration of a remedial alternative that includes LUCs. The implementation of a LUC is (or may be part of) a remedial action, so a determination that LUCs are necessary after completion of a remedy that does not include LUCs should be infrequent.

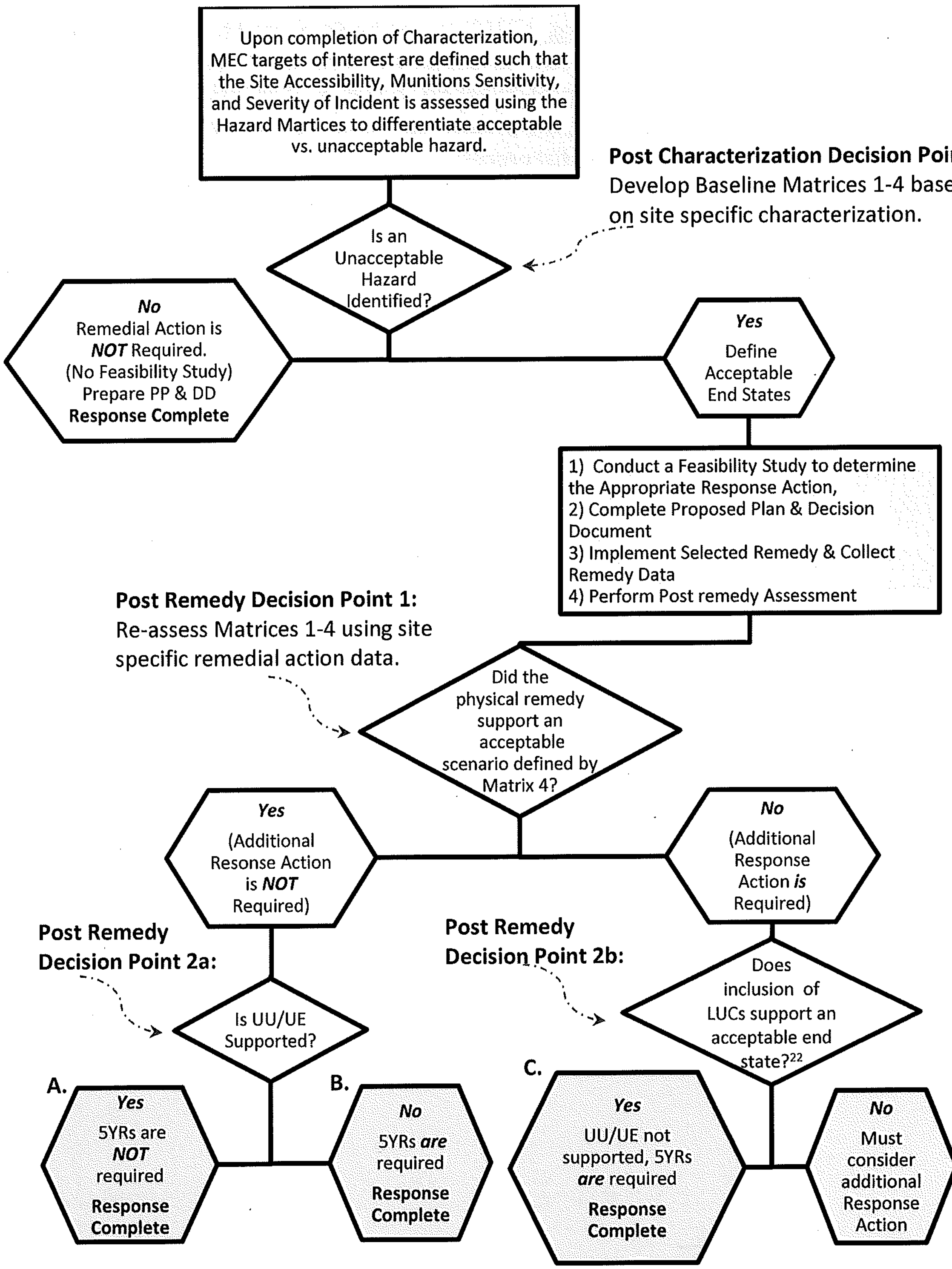

Figure A3-1. Decision Logic for post-Remedial Action data assessment, where a physical remedy is conducted. End States A, B, or C are the potential outcomes of a remedial action. Figures A3-2 and A3-3 illustrate additional consideration of UU/UE for outcome of A vs. B, where the RAO is achieved.

As illustrated below, achievement of the RAO when physical remediation is conducted should be assessed post remedy in order to determine whether the RAO is met or if additional response is required to meet the RAO. Furthermore, if the RAO is met, then assessment of UU/UE is evaluated separately from the remedial process, also conducted post remedy. If UU/UE cannot be supported by the data, Five-Year Reviews will be required.

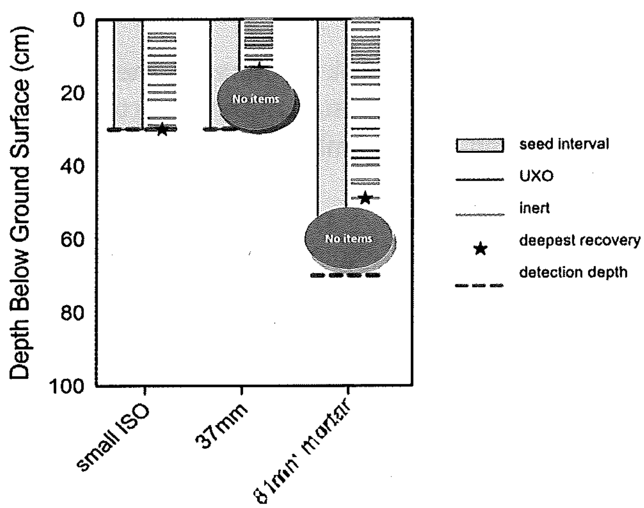

Figure A3-2. Example Outcome A. After a physical response action for 100% of the MRS, the data assessment shows that all targets of interest (TOI) were recovered from the MRS and all were well within the detection capabilities of the instrument such that there is high confidence that any potential residual presence of UXO is negligible. The end state for the MRS from Matrix 4 is 3-D. This is defined by the "Unlikely" resulting from Matrix 1, and "Inconsequential" rating in Matrix 3. There are no detections below 50 cm down to the instrument detection depth of 65 cm for the 81mm, nor below 15 cm down to the instrument detection depth of 30 cm for the 37mm. This "buffer" in the detection data versus instrument capability provides confidence that UU/UE can be reasonably supported for the MRS.

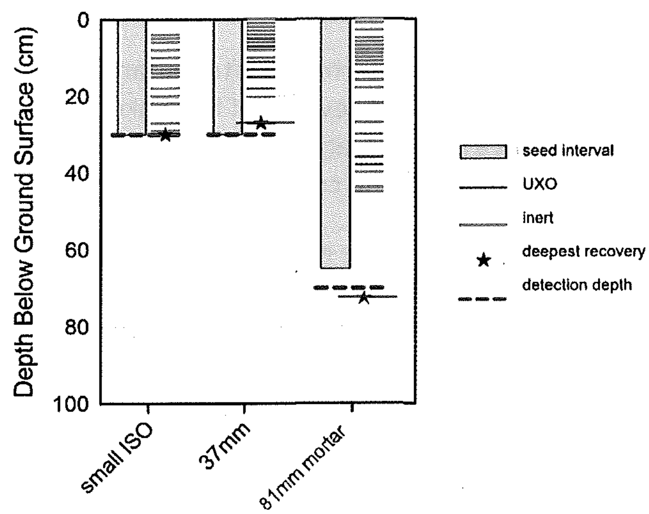

Figure A3-3. Example Outcome B. After a physical response action for 100% of the MRS, the data assessment shows that all detectable targets of interest were recovered from the MRS, but few TOI were recovered near the limits of the detection capabilities of the instrument. Like Outcome A, the supported end state within the recovery area for the MRS, Matrix 4, is 3-D. In this case, there is lower confidence in accepting the residual presence of TOI below detection depth for the MRS. UU/UE may not be supported if there is some evidence of residual hazard remaining on the MRS with some likelihood of exposure. If UU/UE is not supported, Five-Year Reviews will be required.

Attachment 4: Glossary- (Hazard versus Risk)

Definitions of Terms Found in DA Pam 385-30:[22]

Hazard. Hazard is a condition with the potential to cause injury, illness, or death of personnel; damage to or loss of equipment or property; or mission degradation. Therefore, a hazard can have several possible negative outcomes or losses (for example, injury, death, damage, mission failure, mission degradation, increased resource(s) expenditures, and adverse public relations).

Risk. Risk is determined after hazards are identified and analyzed. Risk is defined as the probability and severity of loss linked to hazards. It is simply the measure of the expected loss from a given hazard or group of hazards, usually estimated as the combination of the likelihood (probability) and consequences (severity) of the loss.

Residual risk. The risk associated with a hazard that remains after implementing all planned countermeasures or controls to eliminate, reduce, or control the impact of the hazard. The residual risk may be equal to the initial risk, especially when the initial risk is so low that the hazard does not warrant expenditure of funds to mitigate.

Probability. An approximation of the likelihood of a hazard scenario or mishap occurring. Probability is assessed as frequent, likely, occasional, seldom, or unlikely.

Severity. An approximation of the amount of potential harm, damage, or injury associated with a given mishap.

Additional definitions added to this study for purposes of munitions risk management:

Sensitivity. An approximation of the likelihood that a human receptor will be able to interact with a MEC item such that it will detonate.

[22] The DA Pam 385-30 definition for "hazard" includes some aspects, such as "damage, mission failure, mission degradation," etc., that have no specific application for the MMRP conducted under CERCLA. As such, the definitions were used as a benchmark for this study, and are included here only as a guide to users in making risk management evaluations to recognize the presence of MEC as the "hazard", but to separate the term from the determination of "risk" as the *probability* of an incident and severity of loss due to a hazard and conditions around it. It is not intended to expand CERCLA response authority past death or injury. Additionally, these definitions recognize cases where some "residual hazard" may be determined to be acceptable, as discussed in section 4.2.

Attachment 5: Acronyms

AR	Army Regulation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMUA	Concentrated Munitions Use Area
DA Pam	Department of the Army Pamphlet
DD	Decision Document
DMM	Discarded Military Munitions
DODI	Department of Defense Instruction
EM	Engineer Manual
FS	Feasibility Study
HE	High Explosive
HTRW	Hazardous Toxic and Radioactive Wastes
LUCs	Land Use Controls
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
MEC HA	MEC Hazard Assessment
MMRP	Military Munitions Response Program
MRS	Munitions Response Sites
MRSPP	Munitions Response Site Prioritization Protocol
NCMUA	Non Concentrated Munitions Use Area
PA	Preliminary Assessment
PDT	Project Delivery Team
PP	Proposed Plan
RAO	Remedial Action Objective
RC	Response Complete
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RIP	Response in Place
SI	Site Inspection
TOI	Targets of Interest
UFP QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	U.S. Army Corps of Engineers
UU/UE	Unlimited Use, Unrestricted Exposure
UXO	Unexploded Ordnance

NEW RISK MANAGEMENT METHODOLOGY FEEDBACK FORM

Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites

FUDS Property/Project Number:
Property Name:
Project Name:
MRSPP Overall Score:

1. List historically known or suspected munitions and specify what evidence of MEC was found during characterization. (If multiple munitions exist, and or different areas are identified, these areas may be presented separately):

Amount of MEC Justification: ______________________________

____

Sensitivity Justification: ______________________________

____

Severity Justification: ______________________________

____

2. Specify Land Use and Site Receptors. (If multiple Land Use/Receptors exist as different areas, these areas may be identified separately):

Access Condition Justification: ______________________________

____

Likelihood to Impart Energy Justification: ______________________________

____

3. For each area having separate conditions above, indicate the Risk Management Results for the following:

Matrix 1:	Frequent	Likely	Occasional	Seldom	Unlikely
Matrix 2:	A	B	C	D	
Matrix 3:	1	2	3		

Matrix 4: (result of combining Matrices 2 and 3 above, e.g., A-2, B-1, etc.)
Risk Determination: Acceptable Unacceptable

4. Other Comments, (Please identify limitations or suggestions, if any.):

____

____

5. Compare of use of RAO methodology to MEC HA, if applied:

____

____