Hazard Assessment for Munitions and Explosives of Concern: Workgroup Briefing Book

Section C: Table of Contents

Issue Paper #1: MEC Hazard Assessment versus Risk Assessment

1.0 Issue Statement

To what degree does the assessment of hazards at a Munitions Response Site adhere to the traditional risk assessment process. How can/ should a hazard assessment process be distinguished from the risk assessment process.

1.1 Purpose

This issue encompasses two questions that are critically important to the management of munitions and explosives of concern (MEC) in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process:[1]

- Should the term *hazard assessment* be used to describe a process that is similar, but not identical, to the traditional Superfund risk assessment and plays the required role of a risk assessment: "to collect data necessary to adequately characterize the site for purpose of developing and evaluating effective remedial alternatives"?
- How closely does the MEC hazard assessment process have to adhere to the traditional risk assessment process?

This paper describes the physical differences between an assessment for an explosive hazard and a traditional risk assessment, and presents an analysis of the NCP's risk assessment requirements addressed in the NCP.

1.2 Summary of Options

Not applicable.

1.3 Definitions

Remedial Investigation (RI) — An investigation conducted for the purpose of collecting the data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives. The RI includes field investigations, treatability studies, and a baseline risk assessment (National Contingency Plan, 300.430(d)(1)).

Baseline Risk Assessment — An assessment conducted based on the data collected during the RI to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain (NCP, 300.430(d)(4)).

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[1] The term *munitions and explosives of concern* (MEC) replaced the term *ordnance and explosives* (OE). MEC encompasses UXO, buried munitions, and explosive soils. It does not include munitions constituents that are not inherently explosive. Munitions constituents would continue to be addressed by the traditional Superfund risk assessment process.

Unacceptable Risk. For the release of hazardous substances to the environment, unacceptable risks may be determined for both carcinogens and non-carcinogens. These are determined by comparing the nature and extent of the release with access conditions for receptors. From this potential risk calculations are made based on site-specific conditions, and comparisons are made against regulatory numerical benchmarks (i.e. Hazard Index and/or Incremental Cancer Risk). Unacceptable risks are those that exceed such benchmarks.

No Action – means that no hazard is present that presents an unacceptable risk to human health and the environment.

Removal/Remedial Action. These are actions taken to reduce or eliminate the source and/or pathways of exposure to hazardous substances in response to unacceptable risks. Removal actions typically involved a smaller scale and more focused scope of action than remedial actions. Removal actions also do not require a baseline risk assessment. Both types of response actions can be taken at the same site in conjunction with the overall approach to management of site risks.

1.4 Background

As shown in the language in Attachment 1 and in the discussion below, the requirements for a risk assessment in the NCP are very general and suggest that the risk assessment should be tailored to the requirements of the site. The NCP, which is the implementing regulation for CERCLA, provides a framework for assessing and remediating releases or potential releases that could pose a threat to human health and the environment. Although the NCP comprises specific regulatory requirements for response actions, it also recognizes the variety and complexity of CERCLA responses and allows for flexibility in response actions.

The purpose of the RI "is to collect data necessary to adequately characterize the site for purposes of developing and evaluating effective remedial alternatives" that are protective of human health and the environment. The RI process comprises, as appropriate, the assessment of the factors listed below:

> "To characterize the site, the lead agency shall, as appropriate, conduct field investigations, including treatability studies, and conduct a baseline risk assessment. The RI provides information to assess the risks to human health and the environment and to support the development, evaluation, and selection of appropriate response alternatives."
>
> NCP, 300.430(d)(1)

- Physical characteristics of the site
- Characteristics or classifications of air, surface water, and groundwater
- The general characteristics of the waste
- The extent to which the source can be adequately identified and characterized
- Actual and potential exposure pathways through environmental media
- Actual and potential exposure routes
- Other factors…that pertain to the characterization of the site or support the analysis of potential remedial action alternatives (NCP, 300.430(d)(2))

The NCP requires that a risk assessment be conducted using these factors and that the results of the assessment be summarized in the Record of Decision (ROD) for the site. However, the requirements for the contents of risk assessments are flexible. The Preamble to the NCP emphasizes the program management principle of streamlining to determine which analyses are appropriate in the evaluation process at a particular site.

Analyses that do not aid in the development, evaluation, and design of the remedial alternative should not be conducted. For instance, although analyses addressing factors associated with carcinogenic and noncarcinogenic toxicity assessments are typically conducted during the risk assessment, they are not required by the regulation. If those analyses are not useful in the remedy selection process, they should not be conducted. Two tables provided in Attachment 1 summarize language in the NCP and the associated preamble that relate to the content of a risk assessment.

1.5 Discussion

An assessment of hazards from MEC is fundamentally different than an assessment of risks from chemical exposure. Under the traditional chemical risk assessment of the Superfund program, low levels of chemicals can result in risks that are acceptable under reasonable maximum exposure scenarios. The levels for carcinogens that are considered to be protective of human health and the environment are established using the target risk range of 1x10E-4 to 1x10E-6, and site-specific calculations of the potential incremental cancer risks to an exposed population above what is expected based on national cancer rates. Risks from exposure to MEC are very different. There is no accepted way of establishing the probability that a single encounter will occur or that such an encounter will result in an excess potential of death or injury. Instead, risks from MEC hazards are binary: they either exist or they do not. If there is the possibility of an encounter with MEC, there is also a likelihood that the encounter may result in death or injury. Therefore, if even one MEC item is present there is general agreement that some action will be required.

There are other ways in which hazard assessments differ from risk assessments. Different input factors are considered (see issue paper #7) given the nature of the hazard. Instead of chemical toxicity, the source of potential risk or hazards is the inherent hazard associated with the MEC. Instead of concentrations of chemicals, examples of information required for this inherent hazard include the type of munition, the nature of the fuze, and whether or not the munition is armed. Still another difference is that the hazard to human health and the environment from the MEC item will come from the interaction of people with the munitions item wherever it has fallen. Chemical risks to human health often are the result of migration of the substance to a receptor. While there is some potential for the environmental factors to move the MEC item, this is generally not the case.

When the characterization of the hazards at a munitions response site is called a risk assessment, some stakeholders and the public have certain expectations with regard to the nature of the assessment. Questions received in EPA training courses also show that participants are confused as to whether a hazard assessment can differ from a risk assessment, and whether they must assign some probability of an encounter and of resulting effects from that encounter. Using a different terminology than in the CERCLA process that provides equivalent "risk assessments" for MEC may allay some of that confusion by signaling the different approach.

Hazard assessments can, however, perform the same functions that a risk assessment is required to perform in the Superfund process. All of the characteristics of a site that are to be explored in the remedial investigation (see background above) are in fact fundamental to a hazard assessment. As seen in Issue papers 2 and 8, the functions of a hazard assessment can be identical to the functions of a risk assessment (e.g. action, no action, baseline assessment of hazards without actions, facilitation of the selection of alternatives). As shown in issue paper 7, although the specific input factors may be different (recognizing the different nature of risks to human health and the environment), they address similar categories. The sources of contamination, including the characteristics of the waste, the actual and potential exposure pathways, and actual and potential receptors are all considered.

1.6 Conclusions and Recommendations

The hazard assessment issues and functions that are outlined in various issue papers will perform the same functions required in the NCP for a risk assessment. The inputs to these functions will be different, as appropriate to the hazards for human health and the environment. The fundamental differences between the traditional risk assessment and the assessment of hazards from MEC are such that this paper recommends the use of the term *hazard assessment* instead of the use of the term *risk assessment.* The term has the advantage of recognizing the inherent differences of assessments conducted for MEC and those conducted for chemical risk, and assisting in the communication of these differences to the public and other stakeholders.

1.7 Discussion Items

Two issues are raised for discussion:

- Is the term hazard assessment more appropriate for the assessment at munitions response areas/sites?
- Can/should the hazard assessment process be slightly different than the risk assessment process and fulfill the same function?

Attachment 1: NCP Language Related to Risk Assessment

Table 1. NCP Preamble Language: Considerations for Components of a Baseline Risk Analysis

Exposure Assessment	Toxicity Assessment
• Magnitude of actual or potential human or environmental exposures • Frequency and duration of exposure • Exposure routes – Current exposure scenario – Reasonable maximum exposure including likelihood of maximum exposure occurring	• Types of adverse health or environmental effects • Relationship between magnitude of exposures and adverse effects • Related uncertainties

Note. Assessment language is from the *Federal Register*, December 21, 1988, p. 51425.

Table 2. Language from the Preamble and NCP on the Content of a Risk Assessment

Risk Assessment Language	Associated Language
Preamble	
"The RI should be focused so that only data needed to develop and evaluate alternatives and to support design are collected."* (p. 51405)	"EPA's primary consideration in CERCLA response actions is that remedies be protective of human health and the environment. The variety of releases and threats encountered, however, makes it necessary that specific response actions and cleanup levels be determined on a site-by-site basis." (p. 51404)
"The RI/FS remedy selection process is portrayed in the following specific steps: …(2) a remedial investigation that typically includes gathering basic site data for site characterization and the baseline risk assessment, and conducting treatment studies." (p. 51424)	
"The RI includes: …(ii) the characterization of current and potential risks through a baseline risk assessment." (p. 51425)	"Today's proposed revisions emphasize that the program management principle of streamlining will be applied to determinations of what is necessary to adequately characterize a site." (p. 51425)
"The Superfund baseline risk assessment process may be viewed as consisting of an exposure assessment component and a toxicity assessment component." (p. 51425)	"As indicated above, these assessments are site-specific and therefore my vary in both detail and the extent to which qualitative and quantitative analyses are utilized, depending on the complexity and particular circumstances of the site." (p. 51425)
National Contingency Plan (NCP) Regulatory Language	
"An RI/FS generally includes the following activities: project scoping, data collection, risk assessment." (300.430(a)(2))	"The investigative and analytical studies should be tailored to site circumstances so that the scope and detail of the analysis is appropriate to the complexity of site problems being addressed." (300.430(b))

Risk Assessment Language	**Associated Language**
"To characterize the site, the lead agency shall, as appropriate, conduct field investigations, including treatability studies, and conduct a baseline risk assessment. The RI provides information to assess the risks to human health and the environment and to support the development, evaluation, and selection of appropriate response alternatives." (300.430(d)(1))	"The purpose of the remedial investigation (RI) is to collect data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives." (300.430(d))
"The lead agency shall characterize the nature and threat … by conducting, as appropriate, field investigations to assess the following factors: (i) Physical characteristics of the site…; (ii) Characteristics or classifications of air, surface water, and groundwater; (iii) The general characteristics of the waste…; (iv) The extent to which the source can be adequately identified and characterized; (v) Actual and potential exposure pathways through environmental media; (vi) Actual and potential exposure routes…; (vii) Other factors…that pertain to the characterization of the site or support the analysis of potential remedial action alternatives." (300.430(d)(2))	
"Using the data developed under paragraphs (d)(1) and (2) of this section [i.e., the previous two cites], the lead agency shall conduct a site-specific baseline risk assessment to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain." (300.430(d)(4))	

* NCP 300.430(d)(4)) calls for the risk assessment to be conducted as part of the remedial investigation.
Note. Risk assessment and associated language is from the *Federal Register*, December 21, 1988, and from the National Contingency Plan.

Issue Paper #2. Purpose of an MEC Hazard Assessment

2.0 Issue Statement

What is the purpose of a hazard assessment at sites containing munitions and explosives of concern (MEC)? What must a hazard assessment consist of in order to provide information of sufficient quality and quantity to be useful to the project team and other stakeholders?

2.1 Purpose

This issue paper discusses several potential purposes for a hazard assessment and describes the level of data and certainty required for each of those. The purposes addressed are the following:

- The decision to take action or not take action
- The initial baseline of the hazards of the site
- Hazard data input for analysis of alternatives
- Input into the risk management decision for the prioritization of MEC response sites within a munitions response area (MRA)
- Effective communication of the process and results to the project team and stakeholders

This issue paper does not consider options; however, it discusses each of the purposes that are listed above to show how they influence the data requirements and function of an MEC hazard assessment.

2.2 Summary of Options

Not applicable.

2.3 Definitions

Munitions response area (MRA) – An area such as a former range or a munitions burial site that may contain UXO, discarded military munitions, or munitions constituents with explosive properties (collectively called munitions and explosives of concern – MEC). May contain one or more munitions response sites.

Munitions response site (MRS) – A discrete location within a munitions response area that is known to require a munitions response.

Conceptual site model (CSM) – A “model” of a site developed initially at scoping with readily available data, and revised as more data is gathered. Used to identify all potential or suspected sources of contamination, types and concentrations of contaminants detected at the site, potentially contaminated media, and potential exposure pathways, including receptors.

2.4 Background

Other papers discuss the function and attributes of hazard assessments and the differences between hazard assessments and risk assessments (issue paper #1). This paper explores the various purposes of hazard assessments and the implications of those purposes for the types of data collected, the level of certainty required, and the national prioritization tool currently under development.

Because hazard assessments play a very similar role in the CERCLA process as risk assessments, understanding that role is useful. The risk assessment process is part of the remedial investigation (it is also part of a removal investigation but tends, in general, to be more qualitative). The purpose of the remedial investigation "is to collect data necessary to adequately characterize the site for purposes of developing and evaluating effective remedial alternatives" that are protective of human health and the environment. The remedial investigation process comprises, as appropriate, the assessment of the factors listed below:

- Physical characteristics of the site
- Characteristics or classifications of air, surface water, and groundwater
- The general characteristics of the waste
- The extent to which the source can be adequately identified and characterized
- Actual and potential exposure pathways through environmental media
- Actual and potential exposure routes
- Other factors…that pertain to the characterization of the site or support the analysis of potential remedial action alternatives (*National Contingency Plan*, 300.430(d)(2))

The National Contingency Plan (NCP) requires that a risk assessment be conducted using these factors and that the results be summarized in the Record of Decision (ROD) for the site. However, the requirements for the content of the risk assessment are flexible. The Preamble of the NCP emphasizes the expectation that the program management principle of streamlining will be applied to determine which analyses are appropriate in the evaluation process at a particular site. Analyses that do not aid in the development, evaluation, and design of the remedial alternative should not be conducted.

2.5 Discussion

A methodology is needed for performing hazard assessments of sites with munitions and explosives of concern (MEC) so that a clear distinction can be made between the analysis of MEC hazards and the risk management decisions made by the project team. The methodology must explicitly require that information on site conditions and characteristics be of sufficient quality and quantity. The methodology must also state the implications of using data inputs of different quality and quantity for making risk management decisions at each step in the munitions response. The more uncertain the information is at any point in the process, the more significant are the implications for the reliability of the decisions, additional costs of response and analysis, and more importantly, the public or environmental hazards of the munitions response area (MRA).

2.5.1 Action and No-Action Decisions

The methodology can enable a project team and stakeholders to assess potential hazards in an MRA, and in munitions response sites (MRS), to determine whether or not action is required. This decision can be assessed at various stages in the investigative process. The hazard assessment framework can allow a project team to reassess the hazard status of the MRA and associated MRS, as more data are gathered, until the investigation and the remedy decision steps are complete. In this process, the hazard assessment can result in changes in the conceptual site model (CSM) on a continuing basis.

In all investigations, more information, with a higher level of certainty, is required for no-action decisions than for decisions to take action at a site. This is because an action decision moves the site into the next stage of investigation or response, whereas a no-action decision means that the site is considered to be safe for its intended use, such that not even institutional controls are required.

The first stage at which the action versus no-action decision can be made is early in the process of collecting data, when an Archive Search Report (ASR) is collected, perhaps in association with a site inspection (which is sometimes conducted with instrument-aided reconnaissance). This stage provides the potential (unverified) MRA site characteristics, conditions, and MEC hazards. The quality and quantity of information required to support a response decision[2] may not be very comprehensive at this stage. However, at early stages in an investigation, the information supporting a no-action decision must be very strong, since the project team may be dealing only with ASR and site reconnaissance data.

Documenting the certainty or uncertainty criteria of the information at this point is critical. For each stage at which a decision is made, the project team should document the following:

- The sufficiency of the quality and quantity of information, including any uncertainties, used to determine that the area was not used for munitions-related-activities.
- The inadequacy of information, so that a clear determination cannot be made and further investigation is required. In this instance the MRA will undergo further investigation to search for MEC, or if such an investigation is impracticable, move into the risk management process.
- The information used to make a determination that MEC is present. In this case the MRS will move into either further investigation necessary to identify alternatives, or directly into the response.

2.5.2 The Baseline of Site Hazards

If at any point in the process a decision is made that additional information is required, a CSM is developed that will provide the initial site characteristics and conditions of the site, and what is known about the sources, pathways, and receptors. The CSM is used to identify additional information needed to fill potential data gaps in the site characteristics and conditions. As additional information is gathered at various stages of the investigation, the CSM is updated until a remedy decision is complete.

[2] This can be part of an initial prioritization process for further action(s) at the site.

Like the baseline risk assessment, the hazard assessment can provide the information on the conditions at the MRA/MRS without any action. The information documented in the CSM is collected and organized into the various input factors that go into a hazard assessment and used to complete the ranking, either qualitatively or quantitatively.

The quality and quantity of data used to document baseline hazards varies depending on the next step in the process. In a decision to take action, sufficient certainty of information will be required to contribute to the comparative analysis of alternatives (e.g., degree of removal required, boundaries of the removal action, cost, and protectiveness). As discussed above, the requirements for quality, quantity and certainty of data will be much stronger for a no-action decision.

2.5.3 Hazard Data Input for Analysis of Alternatives

As discussed in issue paper #8, the hazard assessment can feed into the comparative analysis of alternatives conducted using the nine CERCLA criteria of the remedial program, or in the alternatives analysis of removals using the Engineering Evaluation/Cost Analysis (EE/CA). The comparative analysis can examine how the baseline hazard of the site is reduced by the change to input factors that results from the completion of the remedy.

2.5.4 Input for Prioritizing Munitions Response Sites within an MRA

The hazard assessment can be used to assist in prioritizing the MRA and subsequently MRSs. The more hazardous and accessible an MRS, the higher the site's priority in any response action. The quality and certainty of data for those sites should be quite high, making the response decisions transparent. In this case, the site-specific hazard assessment is part of a facility-specific prioritization of potential MEC areas based on high quality data, and should not be confused with the national prioritization that is also under development.

2.5.5 Effective Communication of the Hazard Assessment Results

As discussed in issue paper #9, a key role for hazard assessment is the communication of results to the project team and other stakeholders, such as the public. If the hazard assessment is updated regularly as information is gathered to update the CSM, then this tool can show what is going on at the facility on an ongoing basis and assist the communication and understanding of priorities.

2.6 Conclusions and Recommendations

The MEC hazard assessment can serve a purpose similar to the human health risk assessment conducted at sites with hazardous substances. That is, the MEC hazard assessment can facilitate an understanding of site conditions and the potential hazards associated with coming in contact with MEC items. This understanding will be beneficial on several levels, starting with the scoping of project investigations as part of the systematic planning process, prioritization of response actions, analysis of response alternatives, as well as helping to communicate site conditions and focus hazard management decisions.

2.7 Discussion Items

Two issues are raised in the discussion below that may warrant further, specific discussion:

- To what degree will the hazard assessment be a dynamic tool, that is, one that is updated regularly so it remains consistent with the CSM? This dynamism increases the tool's potential to help set priorities and to communicate with stakeholders. However, it could require frequent updating of the MRS hazard scoring, based on new information.

- How should site prioritization using information from a hazard assessment be used in coordination with the national prioritization tool currently under development?

Issue Paper #3: The Role of Uncertainty

3.0 Issue Statement

What is the role of uncertainty in the assessment of MEC hazards? How should uncertainty be addressed in an MEC hazard assessment?

3.1 Purpose

This paper describes sources of uncertainty in the munitions response process and discusses the role that uncertainty can play in the assessment of explosive hazards. It also recommends a conceptual framework for the relationship between past use, future use, and uncertainty. This framework will be useful in considering the big question: "How much do we need to know before we can be sure that our land is safe enough for current or reasonably anticipated future use?"

3.2 Summary of Options

Not applicable.

3.3 Definitions

Not applicable.

3.4 Background

The munitions response process can be described in five steps: (1) initial identification of the munitions response area (MRA), using historical evidence; (2) identification of individual munitions response sites (MRSs) within the larger MRA, using historic research and site investigation; (3) determination of the boundaries of the MRSs, using site investigation techniques; (4) decision about response (e.g., no further action, institutional controls (ICs) only, or cleanup plus ICs); and (5) implementation of the selected response. Uncertainty is inherent in every step of the process, including the accuracy of the boundaries of an MRA, the completeness of the historical research used to identify MRSs, and the representativeness of the sample design used during the investigation. In addition, the site-specific capability of the geophysical detection process is a well-known, often-debated source of uncertainty for both the investigation and any cleanup actions that might be undertaken.

Uncertainty is not unique to munitions responses, and there are parallels with hazardous waste investigation and cleanup activities.[3] Quality control and quality assurance (QA/QC) procedures are used to manage, though not eliminate, uncertainty associated with hazardous waste response activities. QA/QC techniques appropriate to munitions responses have been under development for several years and are applied with varying degrees of rigor at many sites. Again, the goal of

[3] There is one significant difference between hazardous waste and munitions responses: When a munitions item is found, there is no question of its existence. There is no parallel to the gap between detection limit and quantitation limit in chemical analyses.

these techniques is to manage the uncertainty associated with a munitions investigation or cleanup, not to eliminate it.

3.5 Discussion

If it were possible to make MEC risk management decisions with complete information, the relationship between the past munitions-related use of the land and the future use of the land would resemble that depicted in Figure 1. Sites that have been rendered most hazardous[4] by past munitions-related use would be put to only the least intensive[5] uses in the future. If a more intensive future use were desired, then activities would first be undertaken (e.g., cleanup) to reduce the hazards at the site. Of course, even if it were technically possible to acquire complete information before making a decision, limitations on project resources would probably prevent that acquisition.

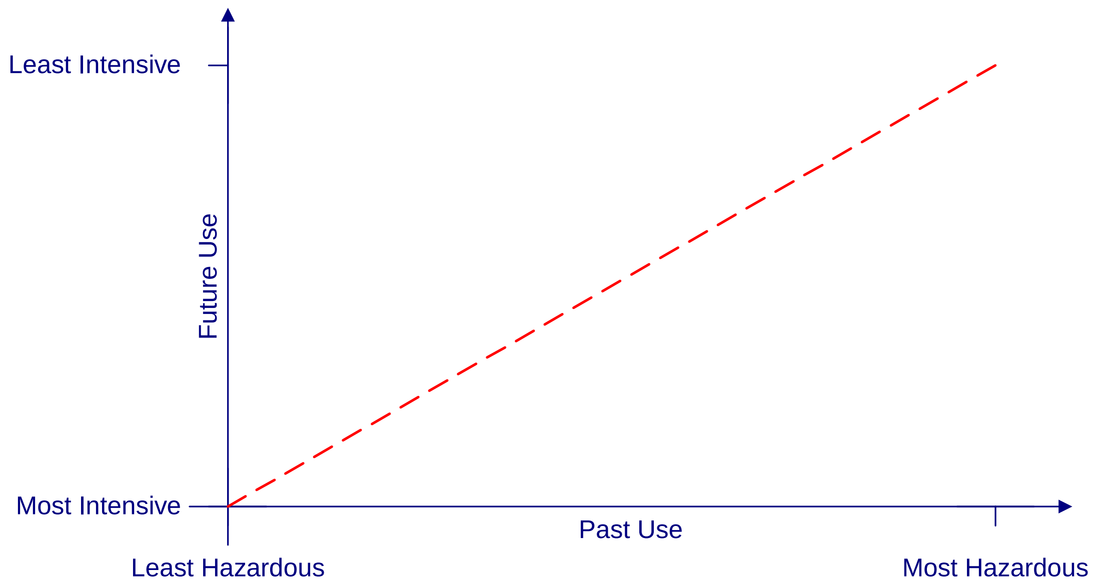


Figure 1. Ideal Relationship Between Past Use and Future Use, Given Complete Information

Figures 2 and 3 provide idealized representations of the relationships between uncertainty and the past and future uses of an MRS. For each scenario, the desired level of certainty increases with the increase in the potential for an explosive event, due to either the hazard of the past use or the intensity of the future use.

[4] Not to presuppose how the working group may define hazard, but it is likely that some combination of munition and fuze type, past activity (e.g., firing or disposal), amount of use, and site dynamics will be used to define how hazardous a site might be due to its past munitions-related use.
[5] Intensity of future use can be thought of as some combination of number of users, ages of users, and intrusiveness of their activity

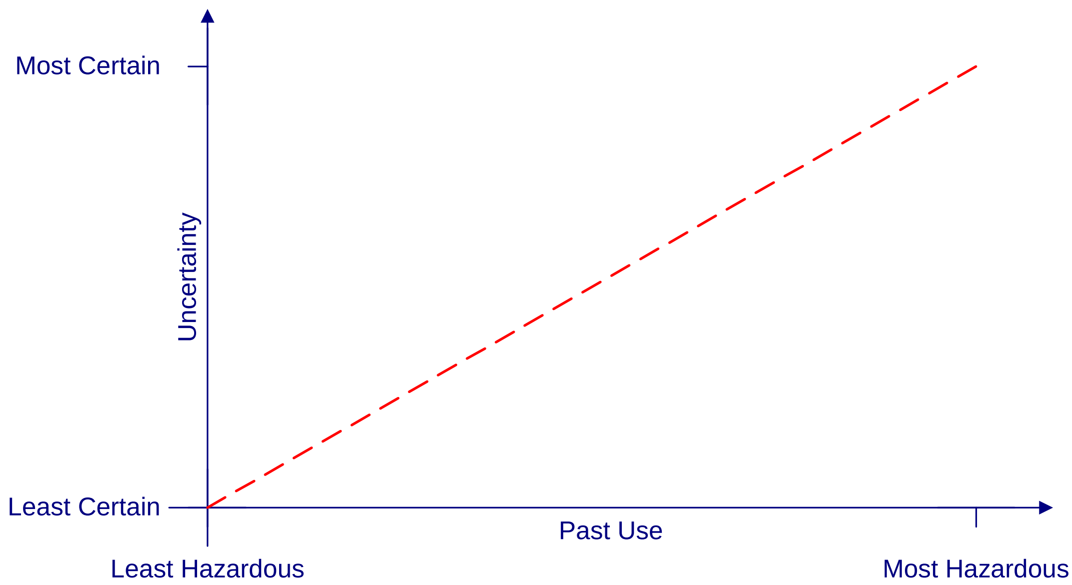


Figure 2. Ideal Relationship Between Uncertainty and Past Use

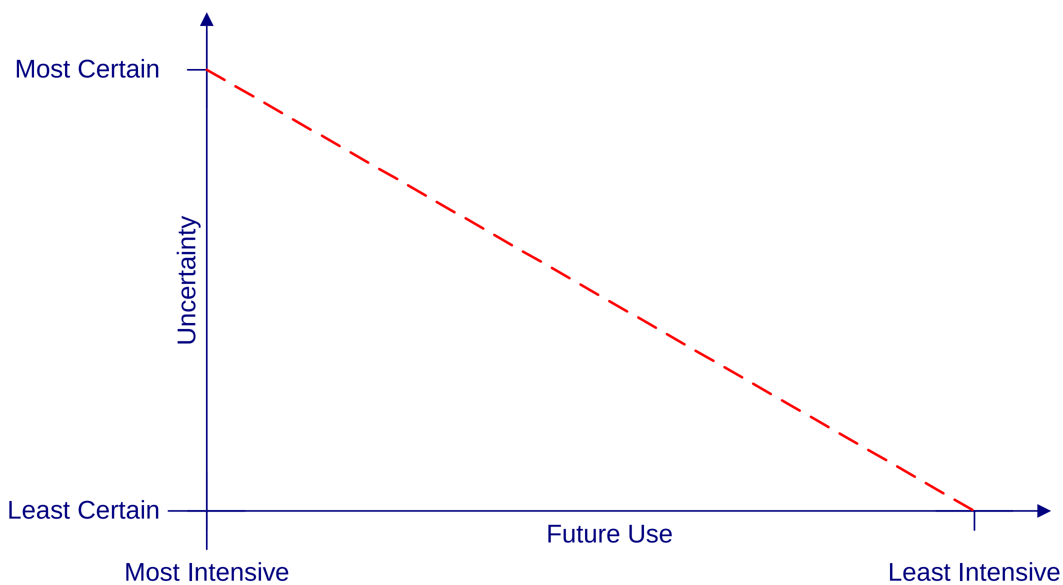


Figure 3. Ideal Relationship Between Uncertainty and Future Use

The question implied in Figures 2 and 3 is: "How certain does one need to be that the land in question is suitable for its future use?" This is different from asking "How clean is clean?" It is, rather, the fundamental question that is asked, either explicitly or implicitly, at every decision point in the munitions response process, as in the following examples:

- "Given that we plan to build a day care center there, how certain do we want to be that the cantonment area was never used in ways that could lead to the presence of MEC?"

- "Given that the site will be part of a scouting camp, how certain do we want to be that the time-critical removal action completely removed all MEC?"
- "Given that the range will be used as a wilderness area, how certain do we want to be that all of the target areas on the range have been located?"
- "Given that we are not certain that we have located all the target areas on the range, how certain do we need to be that the range will be used only as a wilderness area?"

3.6 Conclusions, Recommendations and Discussion Items

Lack of understanding among lead agencies, regulators, and stakeholders, and lack of agreement about the acceptable level of uncertainty in decisions at MRSs, have in many cases led to the erosion of trust within project teams, not to mention wasted project resources. A strong argument could be made that this lack of mutual understanding is almost always one of the primary causes of delays in site closures.

To help ensure the defensibility of the decisions made using the MEC hazard assessment framework, the role of uncertainty in the decision-making process should be explicitly incorporated into the framework. How uncertainty is incorporated into the framework will greatly depend on how the working group decides to structure the framework. However, some general principles are suggested by the discussion above:

- Uncertainty must be acknowledged, managed, and communicated throughout the munitions response process, including in the assessment of MEC hazards.
- The criteria for determining whether the available information is sufficient and adequate (i.e., the quantity and quality of the data are suitable) to make a decision may depend in part on how hazardous the land is or might be.
- The criteria for determining whether the available information is sufficient and adequate to make a decision may also depend in part on how intensive the future use of the land might be.
- The MEC hazard assessment framework can provide a communication tool to aid project teams' and stakeholders' understanding of the role that uncertainty has in the decision-making process.

Issue Paper #4: Estimate of Probabilistic Risk of Exposure or Death

4.0 Issue Statement

Is it necessary or useful to estimate a probabilistic risk of exposure or death for MEC?

4.1 Purpose

The purpose of this paper is to examine whether and how an estimate of probabilistic risk might fit into an MEC HA framework. It addresses specific recommendations within the RAND 2004 report *Unexploded Ordnance: Critical Review of Risk Assessment Methods* regarding the desirability of developing a method to calculate site-specific, quantitative, probabilistic risks to the public of death or injury from the functioning of UXO.

4.2 Options

Not applicable.

4.3 Definitions

Not applicable.

4.4 Background

The RAND report recommends that probabilistic approaches "…used by the Army Chemical Stockpile Disposal Program, NASA, FAA, and the NRC provide possible models for…"[6] a site-specific risk assessment method. These approaches involve: the identification of basic events that, for the case of a UXO risk assessment, might lead to death or injury of a member of the public by a UXO detonation; assigning probabilities to those basic events; using a fault-tree methodology to map out ways those basic events might combine in what are basically exposure scenarios; and, combining probabilities of the basic events (based on the fault tree map of how those events interact) to lead to a detonation. An example of the fault-tree approach, as applied to the demilitarization of chemical weapons, is provided in Figure 4-7 on page 114 of the report. That figure has been provided as an attachment to this paper.

On pages 136 and 137, the report describes several advantages to using this approach to UXO risk assessment, including[7]:

- The approach requires analysts to "decompose elements of risk" at a site and construct a formal structure to analyze the risk.
- It facilitates the identification of the "dominant sources of risk" to optimize risk mitigation planning.
- "The logical structure and graphical presentation facilitate stakeholder input and communication."

[6] Page 135.
[7] All quotes are directly from pages 136-137 of the report.

- The results of the risk assessment can be compared directly to risks of adverse health impacts from munitions constituents, "because the approach quantifies risk values as explicit probabilities, rather than as dimensionless rankings…".

The report also acknowledges potential difficulties in applying the approach, including that the method is easiest to use for engineered systems, for which large amounts of prior information about system component performance exist, whereas there is significant uncertainty about not only the explosive characteristics (e.g., munitions types, fuze conditions, depths, locations, etc.) of munitions response sites, but also about human behavior in the event of contact with a munitions item.

4.5 Discussion

To summarize the posited benefits of the approach recommended in the report, it would provide a structured, systematic way of analyzing site-specific UXO related risk and identifying mitigation strategies. This structured approach, combined with a graphical presentation, would facilitate communication with stakeholders. And the output from the analysis – a quantified risk of injury or death from a detonation – can be compared to the risk of health adverse health effects from munitions constituents.

The desirability of using a structured systematic approach to assessing risk (or MEC hazard), probably needs no argument. A structured approach enhances the chances that sites are assessed in a consistent and thorough manner. Furthermore, the desirability of enhancing stakeholder communication through the use of a structured, systematic approach that lends itself to graphical presentation is also unarguably a desirable goal.

It is not as clear whether being able to compare quantified explosive risks with risks of adverse health effects is desirable or even useful. There may be some utility in making the comparison in an abstract sense – for example, factoring information like exposure to RDX in drinking water can lead to 1 excess cancer incident per 10,000 water consumers, while use of a former bombing range as a park can lead to 2 excess deaths per 10,000 park visits into a cost/benefit prioritization of different responses. However, from a risk communication standpoint, it can cause problems. An individual may have a hard time comparing a small increase in the risk that his or her child may develop a health condition, which may or may not prove fatal, at some point in the future, to what may be an even smaller chance that the child will die tomorrow from playing with a mortar round.

There is a question as to whether the approach recommended by RAND is actually possible to implement. All of the examples of the application of the probabilistic risk, fault-tree based assessment approaches described in the RAND report were applied to engineered systems. While the report acknowledges this, it may be understating the challenges in applying the approach to the MEC risk problem.

One factor in this possible understatement is due to the fact that in analyzing engineered systems, the human behavior of concern is the behavior of trained workers who presumably are well aware of the dangers in the work they are doing, and are following detailed procedures in accomplishing that work. Predicting mistakes or physical mishaps under those circumstances may be challenging, but the argument can be made that the estimates have some relationship to what might actually happen. It is hard to make the same argument when one is attempting to predict the behavior of the public at large, and children and adolescents in particular.

Another factor is the level of site investigation that would be required in order to develop a defensible estimate of the risk of exposure to MEC. In order to do so, it would be necessary to develop a valid estimate of the amount of MEC in an MRS. Issue paper 6 goes into some detail regarding the difficulties in calculating such an estimate.

4.6 Conclusions and Recommendations

A critical question is whether the benefits of a structured, systematic, and logical assessment of MEC risk (or MEC hazard) can be realized given the uncertainties associated with even a rigorous a level of site investigation and the difficulties in predicting the behavior of the general public. A second question is whether it is necessary to calculate a probabilistic risk of death or injury from the detonation of a MEC item in order to make systematic, logical and defensible risk management decisions for MRSs?

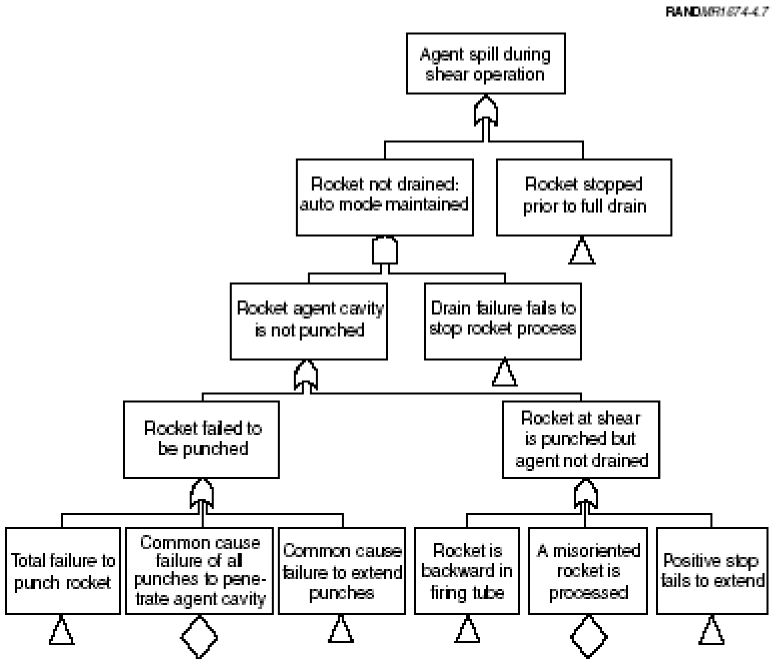
There are several other approaches that can support structured, systematic and logical assessment of MEC hazard and in a manner that communicates with stakeholders and the general public. In particular conceptual site model (CSM) concepts can be used to structure an MEC HA. CSMs serve to document the source-pathway-exposure scenarios that apply to a site. They also serve as a tool to assist in communicating site conditions to stakeholders in logical, graphical ways.

4.7 Discussion item:

Three discussion questions are posed:

- Should a hazard assessment attempt to estimate a probabilistic risk of exposure, injury, or death for MEC?
- If the answer to the first question is yes, what are the necessary components of such an estimate?
- If the answer is no, are other qualitative measures useful or appropriate? (e.g. low medium, high “likelihood” of encounter based on site specific factors).

Attachment: Figure 4.7 from page 114 of RAND report-example fault tree analysis



SOURCE: National Research Council (1997b).

Figure 4.7—Example of a Fault Tree Used in Assessing Risks at the Tooele Chemical Agent Disposal Facility

Issue Paper #5: Input Factors to MEC Hazard Assessment

5.0 Issue Statement

What are the characteristics of hazard assessment tools for munitions and explosives of concern, and what should their specific input factors be?

5.1 Purpose

The purpose of this paper is to present the input factors that have been developed in the past and the issues associated with their use to assist the working group in the evaluation and selection of input factors that will support the desired functionality of the MEC Hazard Assessment.

This paper does not discuss issues that are addressed in other papers, such as the use of a hazard assessment in a response decision process, and the degree to which such a hazard assessment will be quantitative or qualitative.

5.2 Summary of Options

Commonly used input factors fall into three categories: source/explosive hazard, pathways, and receptors. Different methodologies often use very different measures and different groupings of these measures. Some of these measures (or input factors) are controversial. The discussion below presents specific options for input factors in relationship to three categories in which they are typically grouped. Controversies surrounding the use of specific factors are identified.

5.3 Definitions

- **Hazard assessment input factor categories—**A way of organizing inputs into the hazard assessment to structure an understanding of the potential for the hazard or risk. These groupings are similar to the traditional risk assessment. However, explosive hazard is typically substituted for the toxicity category of a chemical risk assessment. It is typically agreed that all three categories (explosive hazard, pathway, and receptors) must be present for a potential explosive hazard to exist.
- **Hazard assessment input factors —** The specific elements of a category (e.g., depth of MEC) that are evaluated to determine the characteristics of that category.
- **Source/explosive hazard —** The inherent hazard associated with the specific MEC.
- **Pathways —** The potential route by which people can reach the explosive hazard. This category typically includes factors such as physical barriers, depth of the ordnance, site dynamics (e.g., erosion) and overall accessibility of the ordnance.
- **Receptors** — Factors that affect the probability that people will come into contact with the explosive hazard. These factors typically include the level and frequency of human activity, as well as current and future land use.

5.4 Background

There has been an ongoing debate in the range management and regulatory community about how to characterize the explosive hazards in areas where MEC are present. Because no single, nationally accepted methodology exists, a number of tools or methodologies have been created to meet site-specific needs. In addition, the use of each of these tools within the process varies considerably (for characterization, prioritization, evaluation of alternatives, etc.), so the input factors also differ considerably.

5.5 Discussion

The potential for a hazard associated with MEC depends on the presence of all of the following:

- A source of contamination (MEC)
- A pathway
- A receptor

Without these, a potential risk or hazard does not exist. A MEC hazard may be based on the characterization of the source, the reasonableness of the potential pathway, and the ease or frequency of exposure to MEC by a receptor. These concepts drive the evaluation of potential MEC hazards at a site. To effectively evaluate potential hazards, the correct inputs need to be identified that will evaluate source, pathway, and receptor characteristics of the MEC site.

The input factors can be divided into three broad categories: overall explosive hazard (source), potential accessibility of receptors to MEC (pathway), and likelihood of exposure (receptor).

Table 1 describes how input factors are used in different hazard/risk assessment models for MEC. The most commonly used factors as documented in the table are:

- **Source/explosive hazard —** Munitions type, fuze sensitivity
- **Pathways —** Depth, migration/erosion potential
- **Receptors/Exposure —** Frequency of entry, and UXO Density.

TABLE 1

	Input Factor	RAC	NAVEODTECHDIV	QRE	SRE	IR3M	OE-CERT	OERIA	Fort Ord	Adak	Kaho`olawe	Fort Meade
		Methodology										
Source/Hazard (inherent hazard of the UXO/MEC)	MEC type	✓		✓	✓	✓		✓	✓	✓		✓
	Fuze sensitivity		✓			✓		✓			✓	
	Amount of energetic material					✓				✓		
	Distribution of UXO contamination						✓			✓		
	UXO location	✓										
Pathway (accessibility/activity)	Site accessibility	✓						✓				
	Current or future land use						✓			✓		
	Range features (vegetation, topography)		✓		✓		✓					
	Distance to buildings and neighbors	✓										
	Types of buildings nearby	✓										
	Total size of the area				✓							✓
	UXO depth		✓			✓	✓		✓	✓		✓
	Migration/erosion					✓		✓	✓	✓		
	Intensity of activity					✓			✓	✓		
	Activity		✓					✓				
	Presence of fauna						✓					
	Site barriers	✓										
Receptor (probability of encounter)	Frequency of entry			✓		✓			✓	✓		
	Intrusion level of activity					✓			✓	✓		
	Probability of encountering hazard										✓	
	UXO density		✓	✓	✓	✓	✓		✓			✓
	Population							✓				
	Portability					✓				✓		

KEY:
RAC=Risk Assessment Code
NAVEODTECHDIV=Naval Explosive Ordnance Disposal Technology Division
QRE=Draft R3M Qualitative Risk Evaluation Methodology
IR3M=Interim Range Rule Risk Methodology
SRE=Draft IR3M Streamlined Risk Evaluation Methodology
The Term UXO is the term used in the models.
MEC is a new term, and therefore is not used in this table

OE-CERT=Ordnance and Explosives Cost-Effectiveness Risk Tool
OERIA=Ordnance and Explosives Risk Impact Assessment
Fort Ord=Fort Ord Ordnance and Explosives Risk Assessment Protocol
Adak=Adak Island OU B Explosives Safety Hazard Assessment Methodology
Kaho'olawe=Kaho'olawe UXO Site Characterization Risk Assessment Methodology
Fort Meade=Fort Meade Risk Assessment Methodology

5.5.1 Source/explosive hazard (inherent explosive hazard)

The source/explosive hazard factor characterizes the MEC contamination itself, such as the type of MEC or the type of fuzing (more sensitive fuzing is more hazardous). Although other inputs may be used, as shown in Table 1, the inputs below are typically used to characterize overall hazard:

- MEC type
- Fuzing
- Amount of energetic material

Every methodology for assessing risks or hazards of MEC includes at least one, and usually several, of these overall hazard inputs. Fuzing and MEC type are generally straightforward, although the methodologies tend to use different scales to score the inherent hazard of the MEC. The fuzing input factor is simply a way to categorize an ordnance item with a more sensitive fuze (e.g., piezoelectric). An ordnance item with this type of fuzing, if live, can be triggered to detonate more easily.

Although there has been less controversy regarding some of these factors, and particularly about the importance of them, inputs that involve quantity (such as amount of energetic material) have been criticized. The consequences of a single encounter with unexploded ordnance can be catastrophic (serious injury or death). The purpose of quantifying the amount of energetic material present in the IR3M was to determine if it was sufficient for detonation. However, this intent was not well documented in the method. This lack of documentation has led to the factor being interpreted as a way to place a lower risk value on "smaller items" that still have the potential to do harm. This controversy ties into a larger debate on using the quantification of MEC risk as a starting point to set an "acceptable threshold limit" for explosive devices, as in the case of hazardous chemicals.

5.5.2 Pathway (accessibility/activity)

The pathway involves the potential receptors' access to contamination and the availability of the MEC if the receptors' activity brings them in contact with it. The questions posed in relation to this factor are: where is the contamination today, and what is the potential that the contamination can move, making it accessible to receptors in the future (migration or erosion). The inputs below typically characterize accessibility:

- Depth below land surface
- Migration or erosion
- Intrusion level of activity
- Intensity of activity
- Site barriers
- Range and site features (such as vegetation or slope)

The following debates are associated with these input factors:

- Site barriers — Issues associated with this measure are determining what constitutes a barrier. Can it be a man-made barrier such as a fence? Is an area that is owned and operated by the military considered to be inaccessible because of physical control by the military?
- Migration and erosion potential — Issues associated with this measure are derived from the basic understanding that, unlike chemical munitions, in general, people go toward the MEC. MEC will not move significantly; however, site-specific circumstances may cause this conventional wisdom to be incorrect. Therefore, how this set of issues should be treated in a hazard assessment framework is being debated.

5.5.3 Receptor Exposure

The receptor exposure factor involves the likelihood of a receptor encountering the hazard (through a pathway). When an encounter occurs, all three elements of a hazard exist. The inputs below typically characterize exposure:

- Frequency of entry
- MEC density
- Intensity of activity
- Portability (facilitated migration)

This category of input factors has been criticized in the past because of the controversy involved in calculating UXO (now called MEC) density and the uncertainty involved in calculating the frequency of entry, the intensity of the activity, and portability (facilitated migration).

Using the input factor of MEC density is criticized because areas with a higher density of UXO have been designated as having more risk to receptors, whereas one item of MEC (in the right place, with the right receptor) can cause injury or death. In other words, the density of MEC present cannot necessarily be directly correlated to the amount of risk present. Another argument associated with the use of density is that reasonably accurate density data are not always available. The data sets for calculating MEC density are not always complete and many times not enough site investigation has been conducted to estimate density with any certainty. In addition, many of the tools for estimating MEC density use the erroneous assumption of homogeneous distribution.

Finally, factors that link risks and hazards to receptors are inherently filled with uncertainty, as it is difficult to predict human behavior. Typically, these factors have been quantified with a large range of values (e.g., number of times a month the site is accessed), which is then linked to a semi-quantitative output. Any uncertainty in the data can lead to inaccurate output. Also, these factors are generally estimates based on current land use, as data on future land use are not available. In addition, as with density of MEC, frequency of activity may undervalue the potential hazard associated with a single encounter. Intensity of activity is a fairly straightforward input involving current land use, with residential and construction activities being assigned a higher hazard value.

5.6 Conclusions and Recommendations

Although various considerations affect the selection of input factors, the two issues below dominate the debate:

- The desired use of the hazard assessment model — Will it be used to prioritize responses, to determine which sites undergo a more intensive study (e.g., RI/FS), or to facilitate a risk management decision under the CERCLA nine criteria?
- The degree of complexity of the model — A simple model may be easier to understand and have fewer features. The simplicity alone may make outputs less reproducible. A more complex model may be deemed more comprehensive and defensible. It also may be more data intensive and be more difficult to explain to the public.

A key consideration for the development of a hazard assessment methodology will be flexibility in the application of inputs to allow for the variability in MRA/MRS conditions. It will also be critical that the methodology contains sufficient information and guidelines to assist project teams in the evaluation and application of inputs such that meaningful and reproducible results are achieved.

5.7 Discussion Items

- What input factors will support the functionality desired in the MEC HA?
- Considering the use for this tool, what quantity and quality of data are necessary to adequately determine the input factor values?
- Is the output to be quantitative, semi-quantitative, or qualitative? What are the pros and cons to each with regard to stakeholder communication and acceptance? What are the implications for data needs?
- Considering that the output is to be __________ (fill-in from the outcome of the above discussion), what type of data is needed to answer the decision question identified above, and what are the most relevant inputs (related to accessibility, exposure, and hazard)?
- Considering the answers to the previous questions, is it more important to develop a simple streamlined methodology, with fewer inputs, or a more complex methodology with more inputs?

Issue Paper #6: Input Factor for the Amount of MEC

6.0 Issue Statement

What is the most useful way to represent amount of MEC in the MEC hazard assessment (HA)? How quantitative should the input factor be?

6.1 Purpose

An approach to indicating the amount of MEC within a munitions response site (MRS) is necessary if an MEC HA is to be used to assist in the analysis of response alternatives and/or to prioritize actions among different MRSs within a munitions response area (MRA). This paper discusses the advantages and disadvantages of different approaches to representing amount of MEC in the MEC HA.

6.2 Summary of Options

The following options are three different ways that the amount of MEC can be represented in an MEC HA:

- Option 1: Use a binary approach: MEC is either present or absent.
- Option 2: Use the past munition-related use of a site as an indicator of the amount of MEC relative to other sites within an MRA, e.g., target areas score more highly than firing points.
- Option 3: Use a valid numeric estimate of MEC amount.

6.3 Definitions

Not applicable.

6.4 Background

This discussion purposely uses the term MEC amount, rather than MEC density. Use of the term density has several pitfalls, including:

- *The sensitivity of the results of MEC density calculations to the amount of land included in the calculation.* For example, a 2000-acre impact area may contain 5 heavily used 10-acre target areas, each containing approximately 250 UXO items (for 1250 items total), while the buffer areas surrounding the target areas may contain few, if any, MEC items. The MEC density in the target areas is 25 UXO/acre, but the UXO density calculated for the impact area as a whole is 0.625 UXO/acre. Depending on the how the density term is used in assessing hazards, this could grossly understate the potential hazard in the target areas, while somewhat overstating the potential hazard in the buffer areas of the impact area.
- *The term density implies a uniform distribution.* If 0.625 UXO/acre have been reported for an MRS, then it would be reasonable to expect that any one acre within that MRS would not contain significantly more than 1 UXO. The situation

described in the previous bullet helps to demonstrate density does not do a particularly good job of representing the MEC "hot spots" that are the norm at MRSs.

- *The term complicates hazard communication.* It is difficult to explain to the public how to interpret a density like 0.625 UXO/acre. The implication of uniform distribution can lead to a cognitive disconnect between the understanding that any one MEC item can cause severe injury or death and a "fractional" item implied in a density calculation. The information that is inherent in the density calculation – that there is probably some amount of MEC present in the area, and that therefore it is important that people using the land take appropriate precautions – is obscured by the implied precision of a fractional UXO density.

Because of the drawbacks described above, coupled with the difficulties in developing a valid estimate of MEC amount to be used to calculate MEC density (see discussion in Section 6.5.3), this paper recommends that the term not be used during the development of the MEC HA.

6.5 Discussion

The input factor for MEC amount will help to characterize the explosive hazard of an MRS by serving as one indication of how likely it is that a receptor in the MRS will come into contact with an MEC item. In selecting an approach to representing MEC amount in a MEC HA, the working group will need to consider the following factors:

- Required rigor of data gathering to support the input factor
- Ability to prioritize among MRSs
- Ability to reflect results of response alternatives
- Transparency and ease of communication

Three options for representing amount are described below, and their advantages and disadvantages are discussed. One idea to keep in mind is that any representation of amount is based on an assumption or an estimate – the actual amount of MEC within an MRS is not known until it is cleaned up, and even then, there is the uncertainty associated with performance of the detection process used in the cleanup.

6.5.1 Option 1: MEC Present/MEC Absent

An input factor based solely on the presence or absence of MEC within an MRS would seem to be the simplest approach to take. But care must be taken in defining the conditions for both presence and absence. For example, to assign "MEC absent" to an MRS that has not been cleaned up, either users must agree before hand, or the MEC HA guidance must define, what constitutes sufficient information to conclude that MEC is absent from the MRS.[8]

[8] The summary of the Adak ESHA provides an example of definitions for a present/absent input factor.

If set up as a purely binary choice, then the input factor will not allow the MEC HA to differentiate between an area that never contained MEC and one that did contain MEC but was cleaned up, which might limit the usefulness of the MEC HA in assessing the effect of remedial action alternatives. One way to mitigate this is to create a three-level input factor: MEC not present; MEC present but cleaned-up; and, MEC present.

Another drawback is that even as a three-level factor, this approach does not allow distinctions between heavily and lightly used MRSs within an MRA, and may therefore not support using the MEC HA as a prioritization tool in regard to amount present.

6.5.2 Option 2: Past Munitions-Related Use as Indicator of MEC Amount

To use past munitions-related use as an indicator of MEC amount, the value assigned to the input factor would be based on the past use, for example:

Past Use	MEC Amount Hazard Score
Target Area	A
OB/OD Area	A
QA Function Test Range	B
Maneuver Areas	B
Storage	C
Firing Points	C
Range Fans/Buffer Areas	C
No munitions-related use	D

Where A is the higher hazard score and C the lower. This factor could be modified by incorporating site-specific information regarding the length of use, or intensity of use. For example, if there are two QA function test ranges on an installation, one used for 50 years, and the other for 10, then the score for the older range might be increased from B to A.

Like the previously discussed (MEC present/MEC absent) approach, this approach does not distinguish between sites that have and have not been cleaned up. However, this shortcoming could be addressed by adding a category for cleaned MRSs, perhaps scoring them above the "No munitions-related use" category, but below all the other ones. Also like the previously discussed approach, requirements for information sufficient to classify an area in the "No munitions-related use" category would need to be defined.

6.5.3 Option 3: Valid Numeric Estimate of MEC Amount

The manner in which this approach could be implemented would depend on the past use of the MRS. For target areas, and perhaps OB/OD areas, an estimate could be calculated using some kind of spatial interpolation technique (e.g., inverse distance weighting or kriging), given sufficient sampling[9]. Another approach for target areas would be to estimate the number of UXO by first estimating the number of live rounds fired at the area each year, then, developing a composite "dud rate" for each year, and finally estimating the number of resulting UXO per year and summing over the years the area was used. This kind of approach would have to be fully developed and demonstrated before it could be shown to provide valid estimates.

For past uses other than target areas and OB/OD areas, the approach becomes more problematic. The release of MEC in most other types of areas was either unintentional (e.g., loss or mishandling at an ammunition transfer point) or unsanctioned (e.g., burial or abandonment at a firing point), and any MEC in range safety fans will be sporadic; none of these circumstances are amenable to the successful application of sample-based statistical estimates of amount.

Use of a numeric estimate would allow direct comparison of the value of this input factor between MRSs, and so could simplify prioritization. Reductions in amount due to cleanup activities could also be directly estimated for analyzing response alternatives, although the procedure used to produce this estimate would need to be developed and demonstrated. However, rigorous sampling may be required to generate a numeric estimate, and there is a lack of developed estimation methods for many types of past munitions-related activities. In addition, it would be necessary for a numeric factor to include some measure of the uncertainty associated with the estimate, and the MEC HA would have to be structured to address that uncertainty.

6.6 Conclusions/Recommendations

The following table summarizes how the three options address the evaluation factors listed in Section 6.4.

Evaluation Factors	Option 1: MEC Present/ MEC Absent	Option 2: Base on Past Use	Option 3: Numeric Estimate
Rigor of data gathering	Seemingly simple, but may require significant effort to demonstrate "MEC Absent"	In most cases, could be only enough data required to confirm past-use, although, like option 1, the need to demonstrate "No munitions-related use" in a suspected MRS may require significant effort	Rigorous data gathering required to support valid calculations

[9] Sandia National Laboratory is currently exploring the application of geostatistics to the characterization of UXO sites, under SERDP/ESTCP funding.

Evaluation Factors	Option 1: MEC Present/ MEC Absent	Option 2: Base on Past Use	Option 3: Numeric Estimate
Prioritization among MRSs	Does not distinguish between heavily used and lightly used MRSs	Implies differences in amount of MEC based on past use; can be modified to reflect relative differences in length or intensity of use	MEC amounts can be directly compared
Reflect response alternatives	If made a three-level factor, it can reflect difference between a site that has been cleaned up and one that has not	A category for cleaned up sites could be incorporated into the approach	A procedure to estimate the reduction in MEC amount due to cleanup could be developed and demonstrated
Transparency and ease of communication	Although seemingly simple, care should be taken in communicating the meaning of “present”, and especially “absent”	Once the types of past-use are defined, the concept is very straightforward to communicate	Effort must be made to communicate the level of certainty associated with any estimates

Of the options presented in this paper, Option 2 probably provides the best approach for representing MEC amount in an MEC HA. It is almost as simple as Option 1, but more useful in discerning differences between MRSs. The question to be asked and answered regarding Option 3 is whether the extra effort in developing and communicating the meaning of numeric estimates is outweighed by the benefit of having a number to work with in the MEC HA.

Issue Paper #7: Consistent Framework for Analysis

7.0 Issue Statement

To what degree should national guidance developed for an MEC hazard assessment result in a consistent framework for data analysis and format for data presentation?

7.1 Purpose

This issue paper poses the following questions about policy regarding the content and use of the guidance:

- To what degree should the input factors, and the process for putting them together, be specified to a level that encourages a consistent approach to hazard assessment at each site?
- To what degree should the manner in which the factors are organized and evaluated encourage a reproducible outcome, such that different project teams will make the same decisions when presented with the same information?
- To what degree should the structure and organization of the hazard assessment be a requirement of national guidance?

For the purpose of discussing, it is assumed that some level of consistency is a desirable feature of a hazard assessment process. This paper poses the question of what level of consistency is desired.

This paper does not address the degree to which a consistent set of algorithms can be developed that given the same information will yield results that are reproducible.

7.2 Summary of Options

Three options for the level of consistency required by the guidance are presented for consideration:

- Option 1. The guidance presents a general framework for approaching a hazard assessment, including input factors and a suggested process for interpreting data. It is left to the individual project teams (the "users") to implement a process that meets the general requirements of the guidance at their sites.
- Option 2. The guidance is very specific as to the process and the rules for data interpretation, but it leaves the individual project teams with the decision of how best to organize and present the information.
- Option 3. The guidance not only specifies the process and the rules for data interpretation, it also includes detailed tools (e.g., tables to fill out using specific procedures) that support a consistent format in the development and presentation of information.

Note: All three options assume that the implementation of any hazard assessment process will allow for site-specific deviations, as appropriate for the level, complexity, and type of site.

7.3 Definitions

Consistency of process. Involves specified stepwise procedures for conducting a site-specific hazard assessment. The framework includes general categories of factors to be addressed (e.g., hazard of ordnance, accessibility), the input factors to be addressed in each of those categories, and a process for evaluating those factors. The approach also includes direction on how the output of the hazard assessment feeds into the CERCLA nine criteria evaluation process.

Consistency of content. Goes a step beyond consistency of process to include direction on how input factors are to be evaluated against each other. Data interpretation requirements tell the user of the guidance document what elements to consider and how to consider them (e.g., what ordnance items in what conditions are ranked as a high hazard).

Consistency of presentation. Describes an organized manner for presenting information gathered in the hazard assessment, such that the results of hazard assessments are presented consistently across multiple sites in different parts of the country (e.g., in a table that summarizes results).

Systematic Planning Process. A consistent, logic-based process used to plan the collection and use of environmental data. It is based on the scientific method and includes concepts such as objectivity of approach and acceptability of results. Systematic planning is based on a commonsense, graded approach to ensure that the level of detail in planning is commensurate with the importance and intended use of the work and the available resources. The data quality objectives (DQO) process used by the U.S. Environmental Protection Agency (EPA), and the Technical Project Planning Process used by the U.S. Army Corps of Engineers are types of systematic planning processes.

7.4 Background

CERCLA guidance documents address the issues of consistency in process, content, and presentation in a variety of ways. Typical CERCLA guidance outlines specific processes and procedures that are to be used. Those processes and procedures are qualified by language that says “as appropriate to the needs of the site.” Early guidance paid little attention to a consistent format for assessment documents. However, over the years the frequent result was documents that generally addressed the same subject and processes but organized and presented information unique to the site (and in most cases, the author). This often made it challenging for reviewers to locate information in a consistent manner from site to site.

In recent years, CERCLA guidance has recognized this problem. The risk assessment guidance, for example, added RAGS part D, which outlines a series of standard tools (tables) to be completed when developing a risk assessment, to improve the transparency and consistency of risk assessments. The use of these tools is mandatory. The 1999 revised Record of Decision (ROD) guidance similarly encouraged the use of specific tables and formats to address the requirements for a ROD. The draft *Uniform Federal Policy for Quality Assurance Project Plans*, currently being revised for final publication, uses a series of worksheets that walks the preparer of site-specific QAPPs through the entire systematic planning process. Although the use of worksheets is optional, the guidance asks the QAPP preparer to address each requirement of the guidance or explain why that requirement is not appropriate for the site.

CERCLA guidance documents vary widely in how specifically they address content and process. The risk assessment guidance, as it has evolved, has very specific processes and procedures for calculating and evaluating risk. The ROD guidance is very specific as to how the nine criteria are to be evaluated in relation to each other. However, the judgment of the project team plays a significant part in how the data are interpreted and weighed in that evaluation.

7.5 Discussion

Each of the three options presented in Section 7.2 has different aspects to consider. The options are not mutually exclusive, and each could be adopted as a feature of a consistent hazard assessment tool.

Option 1. The guidance presents a general framework for approaching a hazard assessment, including input factors and a suggested process for interpreting data. It is left to the individual project teams (the "users") to implement a process that meets the general requirements of the guidance at their sites.

In this option, project teams are provided with the information they need on the definition of a hazard assessment (and its role in the CERCLA process), how to develop a hazard assessment, how to evaluate the information they gather, and how to use the information. However, this option recognizes that the project team can change the framework (including the input factors). This gives the project team flexibility if they either do not understand an element of the hazard assessment process or feel that some elements are not applicable to their situation. This option offers ideas on how to categorize and interpret the data that go into the hazard assessment process but leaves decisions on how to weight different factors to the judgment of the project team. Maximized flexibility also presents the risk that the user will skip important steps that are integral to a logic-based systematic planning process. The existing *Interim Guidance Ordnance and Explosives Risk Impact Assessment*, published by the U.S. Army Engineering and Support Center in Huntsville, Alabama, reflects this approach. (See background materials in Tab D for description.)

Although this option provides for a consistent framework and maximizes the flexibility of the project team, it could allow for unjustified deviation from the guidance. Important elements could be modified or left out by project teams that the developers of the hazard assessment process feel should not be left out under any circumstances. This overall approach runs the risk that different project teams provided with the same information will make very different decisions. In addition, this option might run the risk that the departure of a team member and their replacement by someone else, would result in reopening previous discussions.

Option 2. The guidance is very specific as to the process and the rules for data interpretation, but it leaves the individual project teams with the decision of how best to organize and present the information.

This option is not really one single option but a series of potential options on a continuum that begins with somewhat specific definitions and guidance and advances to very specific direction. A decision to implement this option will require careful consideration of how much flexibility to give project teams in building a model that works for their sites.

This option builds on the first option, but it includes very specific rules for how the process is to be conducted, what elements are to be considered, and how data are to be interpreted. In addition, this option would include clear definitions and explanations of what is to be considered with regard to the set of input factors. In this option, the project team could have the flexibility to not address a particular feature of the process (or element of the analysis) but would be asked to justify why that feature is not applicable. The advantage of this option is that it requires a consistent approach to decision-making, and makes it more likely that teams dealing with similar problems will come to similar conclusions.

This option maintains the graded approach of the systematic planning process by providing the project team with the flexibility to tailor the approach to its needs; however, project teams may not really understand their level of flexibility. Their interpretation may be such that they believe a forced march through the guidance is essential. The guidance can address this interpretation by carefully identifying the circumstances (in the form of examples) in which the project team may find it necessary to make changes. However, it may be still be difficult to get this message of flexibility across.

Option 3. The guidance not only specifies the process and the rules for data interpretation, it also includes detailed tools (e.g., tables to fill out using specific procedures) that support a consistent format in the development and presentation of information.

This option can be used in conjunction with option 1 or option 2. The guidance would develop outlines, tables, and structures (collectively called tools) for the analysis that would ensure that hazard assessments look the same. Use of these tools could be either optional (e.g., encouraged, but not required) or mandatory. If implemented by project teams, the tools would ease the review of the hazard assessment by all members of the project team. The use of the tools could facilitate communication with the public by providing consistent documentation of hazard assessments. In addition, use of the tools can help ensure that the project team goes through the entire process without skipping steps. Finally, consistent use of tools and tables can facilitate collection of data from individual hazard assessment in an automated format.

Voluntary use of the tools will accomplish all of the positive objectives identified in the paragraph above, if in fact they are used. However, a number of project teams (perhaps most) might not use them initially. Mandatory use of the tools, however, might frustrate the project team and undercut the project flexibility and the graded approach, which should be part of a systematic planning process.

7.6 Conclusions and Recommendations

The options presented above are driven by the fundamental question of how much consistency is desirable in implementation of a hazard assessment framework. The answer to this question will affect the manner in which the hazard assessment framework is written and the level of detail on the framework

7.7 Discussion Items(s)

- To what degree is it desirable that different teams reviewing the same information would be expected to come to the same conclusion?
- To what degree is it desirable to ensure consistency of output?

Issue Paper #8: Analysis of Response Alternatives

8.0 Issue Statement

How should an MEC hazard assessment support the analysis of response alternatives?

8.1 Purpose

The purpose of this paper is to outline the manner in which the output of a hazard assessment process may facilitate the nine criteria evaluation, including an understanding of remaining hazards on the site. This paper does not explore options, but rather describes the integration of a hazard assessment process with the nine criteria evaluation.

8.2 Summary of Options

Not applicable.

8.3 Definitions

Remedy (or Remedial Action) — Those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment (National Contingency Plan, 300.5).

Remedial Alternatives — Potential remedies evaluated during the feasibility study that may include the following:

- One or more alternatives that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants, through engineering controls, for example, containment, and, as necessary, institutional controls.
- For source control actions, an alternative in which treatment that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants is a principal element.
- For ground-water response action, a limited number of remedial actions that attain site-specific remediation levels within different restoration time periods. (CERCLA, 101 (24))

8.4 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) established five overarching requirements for selected remedies at Superfund sites:

- The selected remedy is protective of human health and the environment.
- The applicable, or relevant and appropriate requirements of Federal and State laws are attained (or if not, a waiver must be obtained).
- The selected remedy is cost-effective.
- The selected remedy uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.
- The selected remedy employs treatment that permanently and significantly reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants as a principal element to the maximum extent practicable. (Section 121 CERCLA)

CERCLA directed the NCP to establish criteria to ensure that these overarching requirements are attained. In response, the NCP established nine criteria for performing the detailed analysis of remedial alternatives. The NCP requires that the actual remedy selected meet the *threshold* (minimum) criteria, be compared with other potential remedies using the *primary balancing* criteria, and reflect any changes that result from consideration of the *modifying* criteria. Attachment 1 provides a more complete discussion of the nine criteria of the CERCLA process.

8.5 Discussion

Various existing hazard assessment methodologies assess the existing hazards at munitions response sites. Using different input factors, these methodologies "score" the hazard associated with MEC at the site using quantitative and qualitative measures. The site or sites are then assigned a hazard assessment level. The inputs used to assign this level are described in issue paper #5 and include information related to the inherent hazard of the source (e.g., the types of munitions and fuzing), the availability of a pathway for receptors, and the intensiveness of activities of existing or potential receptors.

Different remedial alternatives may involve different depths to which a response action will remove MEC, different approaches to anomaly acquisition and removal, different boundaries of this removal action, different levels of certainty associated with removal, different types of disposal or treatment actions (e.g., blow-in-place, consolidated detonation, or blast chamber). Each of these differences affects the original assessment of some of the input factors. For example, a decision to completely remove all MEC items to a 1-foot depth in an impact area will remove that source for recreational receptors. A reassignment of the site hazard assessment level using new information will change the score of the hazard. This lowered score can demonstrate the impact of the action on the hazard at the site.

Each alternative is to be evaluated in accordance with the nine criteria (see Attachment #1 for a description of the nine criteria). The potential change in the input factor (e.g., quantity of MEC present) can be described in the nine criteria comparative analysis.

Some examples of the nine criteria evaluation using the information from the hazard assessment are provided below:

- The criterion of protectiveness addresses the degree to which exposures to MEC are controlled by a combination of removal and institutional controls, to support the reasonably anticipated future land use. The comparison of the different alternatives and how they reduced the ranking of the hazard at the site (described above) would be discussed here.
- The criterion of long-term effectiveness is used to compare the degree of removal of different alternatives and the anticipated effectiveness of institutional controls. Again, the comparison of the hazard ranking of different alternatives could be considered here.
- The criterion of reduction of toxicity, mobility, or volume of the principal threat is used to compare the removal and destruction of MEC under various options.

8.6 Conclusions and Recommendations

A hazard assessment framework can be used to facilitate analysis of alternative remedies under the nine criteria – one of the fundamental purposes of a risk assessment in the National Contingency Plan. This could be accomplished by providing a consistent set of tools that provide a common baseline understanding of the conditions at the site, and the change in conditions if particular alternatives are undertaken. A requirement for accomplishing this objective is that the framework provide sufficient consistency in results that the comparative analysis can be well understood.

Issue Paper #8: Attachment 1

Statutory Requirements

CERCLA established five overarching requirements for selected remedies at Superfund sites:

- The selected remedy is protective of human health and the environment.
- The applicable or relevant and appropriate requirements of Federal and State laws are attained (or if not, a waiver must be obtained).
- The selected remedy is cost-effective.
- The selected remedy uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.
- The selected remedy employs treatment that permanently and significantly reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants as a principal element to the maximum extent practicable.

CERCLA directed the NCP to establish criteria to ensure that these overarching requirements are attained. In response, the NCP established nine criteria for the detailed analysis of remedial alternatives.

Evaluation Using the Nine Criteria

The NCP requires that the actual remedy selected meet the **threshold** (minimum) criteria, be compared with other potential remedies using the **primary balancing** criteria, and reflect any changes that result from consideration of the **modifying** criteria.

Threshold Criteria

Protection of Human Health and the Environment

The basic CERCLA requirement is that all remedies must be protective of human health and the environment. The NCP defines protection of human health using reasonable maximum exposure scenarios and the maximum exposed individual. In other words, the CERCLA program concerns itself with the *individual* most likely to be exposed to risks under a reasonable set of assumptions. For carcinogenic waste, an acceptable risk is one within the range of 10^{-4} to 10^{-6}, with a preference for the low end of the risk range (10^{-6}). For acute risks, no individual should be exposed to a hazard index of more than 1. Environmental risks are examined qualitatively based on site-specific species and habitats.

Compliance with ARARs

All remedies selected must comply with ARARs (applicable, or relevant and appropriate requirements of State and Federal environmental laws). All remedies selected must comply with such laws or establish the basis for an ARARs waiver. There are three types of ARARs:

- **Action-specific –** ARARs that may prescribe the manner in which blow-in-place or incineration must be carried out (e.g., RCRA Subpart X or its State equivalent).
- **Location-specific –** ARARs that may prohibit blow-in-place activities from taking place in a sensitive ecological environment.
- **Chemical-specific –** In the traditional Superfund arena, ARARs that specify cleanup levels in (for example) groundwater or soil.

The remedial process requires identification of the ARARs for each remedy. Each remedial alternative must comply with the substantive requirements of these ARARs or include in the remedial decision document a rationale for an ARAR waiver.

Primary Balancing Criteria

The five balancing criteria — long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost — are used in evaluating the selected remedial alternatives. The purpose of the evaluation is to determine the remedies' ability to achieve the statutory goals of Superfund.

The NCP suggests that the first two of the five balancing criteria — long-term effectiveness, and reduction of toxicity, mobility, or volume through treatment — should be weighted most heavily. However, the statute also requires that remedies be cost-effective. The balancing process is designed in part to identify one or more remedies that are cost-effective and that reflect achievement of the other criteria. Cost-effectiveness is determined by "comparing the costs and overall effectiveness of alternatives to determine whether the costs are proportional to the effectiveness achieved." The outcome of this process is the selection of an alternative that is effective over the long-term; permanently and significantly reduces the toxicity, mobility, or volume to the maximum extent practicable; and is cost-effective.

Long-Term Effectiveness and Permanence

This criterion is an extension of the threshold requirement that a remedy be protective of human health and the environment. The alternatives should be assessed "for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful." The evaluation should consider the magnitude of residual risk and the adequacy and reliability of controls (e.g., containment and institutional controls).

Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the statutory requirement interpreted in the NCP "that gives a preference to treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume" of the hazardous substance. In general, when evaluating the effectiveness of different treatment technologies in reducing toxicity, mobility, or volume of waste, consideration should be given not only to the reductions achieved in treatment, but also to the amount of residual waste that would remain, and the management of that waste. For MEC sites, these residual wastes could come from low-order detonations associated with blow-in-place and consolidated detonations, as well as from the donor charges that are used to effect the required detonations.

Short-Term Effectiveness

This criterion requires that the impacts of implementing the remedial alternative be evaluated. Cross-media transfers, such as air or water pollution, as well as the safety of workers and the surrounding communities during remedy implementation, are examined. The development and detailed analysis of each remedial alternative must explicitly consider the explosive risks associated with the clearance process, and any mitigating actions that will be taken to reduce those risks.

Implementability

The implementability criterion focuses on the technical and administrative feasibility of the proposed remedial action. Implementability of engineered remedies often involves assessment of costs. Complete cleanup of a site may be safely accomplished if there is no limit on cost. However, this criterion only considers costs to the degree that the costs of implementing the remedy are extraordinary. In such instances, the remedy may be "implementable" but technically impracticable due to extraordinary costs.

Cost

The fifth balancing criterion to be considered in selecting a remedy is cost. By statutory requirement, any alternative selected must be cost-effective. The cost of the remedy must be in proportion to its effectiveness. More than one remedy can be considered cost-effective. Key aspects of the evaluation of costs in remedy selection are outlined below:

- The cost analysis should consider all appropriate costs (e.g., mobilization, mitigation measures, monitoring, ICs, and replacement costs).
- The proportionality of cost is further defined as "whether an alternative represents a reasonable value for the money." For this reason, more than one remedy may be cost-effective.
- Decision makers are asked to compare the costs and effectiveness of each alternative.

Modifying Criteria: State and Community Acceptance

Although State acceptance and community acceptance, the two modifying criteria, are treated separately in the NCP, their functions are similar. The views of the States, Native American and Native Alaskan Tribes, and the public may modify or otherwise alter the proposed plan. However, during the feasibility-study stage in the process, information may not be available on State, Tribal, or community acceptance, because until the proposed plan is published, there may be little feedback from the State, Tribes, or the public. As described by the NCP, since the full level of State, Tribal, and community acceptance will generally not be known until after the proposed plan is published, those criteria are not considered primary balancing criteria.

Issue Paper #9: MEC Hazard Assessment as a Communication Tool

9.0 Issue Statement

To what degree should the hazard assessment framework reflect the goal of enhancing communication with the public?

9.1 Purpose

Development of a formal hazard assessment tool can provide a foundation for common understanding of hazards associated with response actions at munitions response sites. This paper explores the degree to which a hazard assessment framework may be adjusted to reflect that purpose. The paper also discusses how different approaches of a framework affect the project team's ability to use the tool to communicate with the public.

9.2 Summary of Options

This paper explores the following two options:

- Option 1. The framework is developed with the overarching goal of enhancing communications with the public.
- Option 2. The framework is developed with the goal of communication with the public as one of many goals, but one that does not drive the structure of the framework.

A working assumption is that for most MEC areas and sites, effective communication networks, both within a project team and with stakeholders and the affected community, are critical components of risk and hazard assessments, communications, and the risk management decision-making processes. This paper focuses on the degree to which communication with the public is an overarching goal in designing the hazard assessment framework.

9.3 Definitions

Not applicable.

9.4 Background

Experience with the traditional Superfund risk assessment process for hazardous chemicals has shown that communicating risk is one of the most complex communication challenges when providing information to public groups. The complexity of these issues falls into two spheres:

- Numeric equations that define a risk range that is protective for exposure to carcinogens are difficult to explain. When a site is declared to be "protective" at a

10^{-5} risk level, a lot of words must be used to explain a concept that may be well understood by the project team but very confusing to the public.

- The Superfund process frequently leaves chemicals on site at levels that are considered to be protective – either after remedy completion or for a certain land use, so long as that particular use is maintained. Even when the levels of risk are understood, the stakeholders may not accept that an incremental cancer risk of 1 in 100,000 is "protective."

A hazard assessment may necessarily be quite different from a risk assessment (see earlier issue papers); however, lessons learned from the communication of risk in the traditional Superfund risk assessment program may be useful to consider with regard to the degree to which a process is designed to facilitate communication with the public. First, the hazard assessment framework will likely combine several factors to develop either a qualitative or a quantitative view of the hazard at the site (see Issue paper number 5). The nature of the factors, and the transparency with which they are put together, may either help or hinder public understanding of the hazards at the site and the project team's decisions. Second, in many cases a decision is made to stop response actions on a site when there is still a substantial amount of uncertainty (or even a high likelihood) that not all MEC has been located. This decision will be part of the hazard/risk management process that involves evaluation of the remedy using the CERCLA nine criteria. In those cases, the nature of the remaining hazard, the likelihood that the hazard is real, and the risk management choices that lead to the decision that the response action is complete are a critical part of the project team's communication with the public.

9.5 Discussion

The design of the hazard assessment framework can be substantially influenced by the degree to which communication is a goal. Although both options assume that communication with the public is a desirable goal of the framework, option 2 recognizes that it may not be possible to optimize equally all the desired attributes of a hazard assessment framework. Option 2 also recognizes that, in developing the framework, some attributes or criteria may make it more complex and difficult to communicate.

9.5.1 Option 1. The framework is developed with the overarching goal of enhancing communications with the public.

In this option, it is likely that the framework will be substantially simplified to ensure that all parties understand how it is put together. The U.S. Army Corps of Engineers OERIA (See Tab D) framework asserts that this is a goal and achieves this simplicity to some degree. A simplified approach that communicates well with the public may also produce less consistent or less reproducible results (see issue paper #7). In addition, simplifying a framework to ease public understanding may require that the framework not address some issues that the developers feel are important.

9.5.2 Option 2. The framework is developed with the goal of communication with the public as one of many goals, but one that does not drive the structure of the framework.

In this option, communication with the public is not an overarching goal that drives the structure of the framework. Prior to completion of the framework, substantial efforts are put into ensuring that the guidance product can be understood and that outputs are as transparent as possible. However, as shown in the risk assessment process, this is not always a completely achievable objective, given other factors. As noted in the discussion of option 1, with communication one of many goals, the framework may be both more complex and have more reproducible results.

9.6 Conclusions and Recommendations

The hazard assessment can serve a similar purpose as a human health risk assessment for sites where there was a release of hazardous substances. That is, information from the MEC hazard assessment will improve the public's understanding of site conditions and the potential hazards associated with coming in contact with MEC items. This understanding will be beneficial from the beginning, starting with the scoping of the project investigation as part of the systematic planning process.

9.7 Discussion Item

- To what level should communication with the public be an overarching goal for design of the hazard assessment framework?