US Army Corps
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EM 200-1-12
28 December 2012

ENVIRONMENTAL QUALITY

CONCEPTUAL SITE MODELS

ENGINEER MANUAL

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EM 200-1-12

CEMP-CE

Manual
No. 200-1-12

28 December 2012

Environmental Quality
CONCEPTUAL SITE MODELS

1. Purpose. This Engineer Manual (EM) provides U.S. Army Corps of Engineers (USACE) and other personnel with procedural guidance to develop Conceptual Site Models (CSMs) at sites potentially containing munitions and explosives of concern (MEC), munitions constituents (MC), and/or hazardous, toxic, and radioactive waste (HTRW) environmental contamination. The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources and receptors, and the interactions that link these. It assists the team in planning, interpreting data, and communicating. The CSM will provide a planning tool to integrate information from a variety of resources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process for further data collection or action. The target audience is the project delivery team.

2. Applicability. This manual applies to all Headquarters, U.S. Army Corps of Engineers (HQUSACE) elements, USACE Divisions, Districts, and field operating activities having responsibilities for military programs and/or civil works with MEC, MC and/or HTRW-related issues.

3. Distribution Statement. Approved for public release, distribution is unlimited.

4. Discussion. This guidance is provided to assist any organization or team involved in evaluation and decision-making. The CSM development process in this manual is applicable to any phase of a project, including investigation, design, response, and operation and maintenance of remedial systems with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Five-Year Reviews.

FOR THE COMMANDER:

4 Appendices
(See Table of Contents)

DIONYSIOS ANNINOS
Colonel, Corps of Engineers
Chief of Staff

This manual supersedes EM 1110-1-1200, dated 3 February 2003.

	DEPARTMENT OF THE ARMY U.S. Army Corps of Engineers	EM 200-1-12
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CHAPTER 1
Introduction

1-1. Purpose.

a. This document provides teams with procedural guidance to develop Conceptual Site Models (CSMs) at sites where unexploded ordnance (UXO), discarded military munitions (DMM), munitions constituents (MC), and/or hazardous, toxic, and radioactive waste (HTRW) are known or suspected to be present. The CSM is an integral part of the U.S. Army Corps of Engineers (USACE) Technical Project Planning (TPP) process (EM 200-1-2) and the U.S. Environmental Protection Agency (USEPA) systematic planning process as described in the Uniform Federal Policy for Quality Assurance Project Plans Manual (USEPA 2005). The target audience is the Project Team (hereinafter referred to as the team).

b. This guidance addresses munitions and HTRW environmental responses conducted by USACE under various Military Programs activities or at USACE managed or operated Civil Works facilities. A response to munitions and explosives of concern (MEC) (see textbox) addresses the explosive hazards associated with the presence of UXO, DMM or MC.

> MEC distinguishes specific categories of military munitions that may pose unique explosives safety risks; (a) Unexploded Ordnance (UXO), as defined in 10 U.S.C. 2710(e)(9); (b) Discarded military munitions (DMM), as defined in 10 U.S.C. 2710(e)(2); or (c) Munitions constituents (e.g., TNT, RDX) present in high enough concentration to pose an explosive hazard.

c. A response to MC that is not in sufficient concentrations to pose an explosive hazard is the same as an HTRW response. A common goal for response actions is to achieve site closeout in a safe, environmentally responsible, and fiscally responsible manner. It is critical to coordinate efforts to attain this goal of site closeout. The Project Manager (PM) is the leader of the team who must seamlessly integrate efforts to deliver the best possible solution for the site. The team members must coordinate with each other to ensure data collection meets project objectives. Team composition is discussed in paragraph 2-3. The PM must ensure that data collection supports the data quality objectives (DQOs) (see below). Development of a CSM should assist the team in designing the required environmental data collection and response actions, allowing for a more efficient use of resources, ensuring response actions are protective of human health and the environment, and providing for faster closeout of sites.

d. This guidance should be used together with other DoD and relevant guidance for execution. Development of a CSM is an integral component of planning and data collection activities described in TPP and systematic planning. TPP and systematic planning provide a framework for identifying project objectives to undertake the appropriate level of site investigation, characterization, and cleanup to achieve site closeout. TPP and systematic planning help to determine data needs and develop DQOs to support those data needs through a step-wise series of problem identification, analysis, and response. It encourages the team to determine data gaps, to ensure data collected are appropriate for the project objectives, and to consider the end use of data before they are collected. This process results in more efficient and cost-effective investigation, cleanup, and monitoring.

e. The foundation of Corps of Engineers environmental work is the Environmental Operating Principles as specified in ER 200-1-5. These seven tenets serve as guides and must be applied in all Corps business lines as we strive to achieve a sustainable environment.

1-2. Applicability. This manual applies to all Headquarters, U.S. Army Corps of Engineers (HQUSACE) elements, USACE Divisions, Districts, and field operating activities having responsibilities for military programs and/or civil works where MEC, MC and/or HTRW are known or suspected to be present. This guidance is provided to assist any organization or team involved in evaluation and decision-making. The CSM development process in this manual is applicable to any phase of a project, including investigation, design, response, and operation and maintenance of remedial systems with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Five-Year Reviews.

1-3. Distribution Statement. Approved for public release, distribution is unlimited

1-4. References. Appendix A contains a list of references used in this pamphlet.

1-5. Scope. The CSM development process outlined in this manual is applicable to any phase (e.g., investigation, removal, design, operation/maintenance, five-year reviews) of an environmental response. The CSM is not usually a separate deliverable, but a component of existing documents such as work plans, site characterization reports, final removal/remedial action reports, or similar documents as determined by the team. While this process is primarily used in connection with a CERCLA response action, it may be applied under any regulatory framework.

CHAPTER 2

Description of a Conceptual Site Model

2-1. Introduction. This chapter presents an overview of the CSM, describing the ways it can be depicted and how it should be used. It also describes when the CSM should be developed and updated, and who should be involved in the process.

2-2. Conceptual Site Model Defined.

> The CSM is a description of a site based on existing knowledge. It describes sources and receptors, and the interactions that link these. A CSM assists a project team in its planning, data interpretation, and communication.

a. A CSM is a description of a site and its environment, both natural and man-made, that is based on existing knowledge. It describes sources of UXO, DMM, MC, and/or HTRW known or suspected to be present at a site. It also describes complete, potentially complete, or incomplete exposure pathways; current, determined, or reasonably anticipated future use of property; and potential receptors. The CSM serves as a planning instrument, a modeling and data interpretation aid, and a communication device for the team (see Paragraph 2-3). The CSM can be viewed as a tool to assist the team in communicating with the public, integrating information and making informed decisions. These decisions can range from sampling strategies to cleanup actions. A CSM provides a structure to summarize and display information about a site and identify additional information needed to develop technically sound decisions.

> CSM development is an iterative process that reflects the progress of activities at a site from initial assessment through site closeout. The CSM is refined to help focus objectives throughout the life of the project.

b. The team should initiate CSM development during the site inspection (SI) phase and refine it as the team fills data gaps during subsequent phases (see Paragraph 2-8 for CERCLA phases and their relationship to CSM development). Potential source areas, receptors and media of concern should be documented in the initial CSM. Later versions of the CSM may be used to evaluate the effectiveness of sampling, help focus design efforts, record results of response actions and implement long-term management actions. The CSM can help focus general regulatory objectives to more site-specific project objectives. Data collection should be focused on complete or potentially complete exposure pathways that are based on current, determined, or reasonably anticipated future land use.

c. The basic CSM development process applies to both environmental and Munitions Response Sites (MRSs). The CSM is developed through analysis of site profile information that the project team collects and integrates to illustrate the interaction between the receptors that may be affected and the potential source areas. Through this illustration, the team conducts a pathway analysis to show how site conditions function as a system. As more data are generated, the understanding of this system becomes more refined allowing greater focus for subsequent project phases.

2-3. MEC vs. Environmental Contamination. The threats presented by MEC and MC/HTRW are different, and for the purposes of this document are differentiated by the terms “hazard” and “risk.” MEC presents a hazard of direct physical injury resulting from the blast, heat, fragmentation, or acute chemical effects of a munition or munition component. MC and HTRW are contaminants which present a risk to human health and the environment through exposures. The degree of risk posed by MC and HTRW is usually proportional to the toxicity of the contaminants, as well as the amount and duration of exposure. A single site may have threats of MEC hazards and/or MC and HTRW risks that must be considered.

2-4. Team Composition. Team composition will vary with the complexity of the site and the nature of the hazards or risks present. The PM leads a team that consists of technical experts, regulatory personnel, and other stakeholders who provide various planning perspectives. An effort should be made early in the process to identify special challenges or interests that require input from specific disciplines or groups. Each group will have a set of data needs that may contain differences and over-laps. One aspect of CSM development for a site that may contain both explosive hazards and chemical risks is the importance of early and ongoing coordination between technical experts on the team.

> The team will include the PM, technical experts (e.g., explosives safety specialist, geologist, risk assessor), contracting specialist, counsel, consultants, contractors, stakeholders and representatives from regulatory and other state or federal agencies, that are needed to develop and complete a project. Early identification of team members, their continuous involvement in the process, and the identification of project goals and objectives are important during a CSM’s development.

2-5. Profiles Needed to Develop a CSM.

a. An effective CSM presents known or suspected conditions about receptors and potential source areas, and the interactions between them. The team must be able to recognize the type of information relevant to the development of a CSM. In most cases, the needed information may be categorized into five “profile types” that address specific, yet overlapping types of information. These include:

(1) Facility Profile—describes man-made features and potential sources at or near the site.

> The quality of existing data must be evaluated before being included in the CSM. Some data may not meet quality standards for all uses. For example, data that are inadequate to evaluate risk may be acceptable for another use. The decision to use the data should be based on its applicability to the project’s object-tives. However, all data sources should be described, copied, and archived for future reference.

(2) Physical Profile—describes natural factors that may affect release, fate and transport, or access.

(3) Release Profile—describes the movement and extent of contaminants in the environment; bounds the locations where munitions may be present.

(4) Land Use and Exposure Profile—provides information used to identify and evaluate applicable exposure scenarios, receptors, and receptor locations.

(5) Ecological and Cultural Resources Profile—describes the natural habitats and ecological receptors present on and around the site.

b. The team can collect profile information from a variety of resources. The team should review all relevant historical and current documentation, conduct interviews, and perform a site visit, if needed, to gather profile information. Information from similar sites may also be useful.

c. Examples of the types of information typically associated with each profile type are presented in Table 2-1. Because site specific conditions vary, a project team may determine that different or additional information is needed for any given site.

Table 2-1. Profile Types and Information Needs

Profile Type	Typical Information Needs
Facility Profile	• All structures, sewer systems, process lines, underground utilities • Physical boundaries (past and current), fencing, administrative controls, etc. • Current and historical process and manufacturing areas • Operation procedures and history • Storage and waste disposal • Location of Munitions Response Area (MRA) or MRS (e.g., impact areas, range areas, storage areas, munitions manufacturing, disposal areas, firing points, target locations) • Historical features that indicate potential source areas (landfills or lagoons, ground scars, impact craters, stained soils or stressed vegetation)
Physical Profile	• Topographic and vegetative features and other natural barriers • Surface water features and drainage pathways • Surface and subsurface geology, including soil type and properties • Meteorological data • Geophysical data • Hydrogeological data for depth to ground water and aquifer characteristics • Physical site factors that affect site activities • Soil boring or monitoring well logs and locations • Naturally occurring phenomena (e.g., tidal action, erosion) that may cause subsurface munitions (e.g., UXO) to surface or move • Development, construction (e.g., grading) that may have occurred after transfer from DoD.
Release Profile	• Munitions-related activities that occurred • Determination of contaminant movement from source areas • Contaminants and media of potential concern, including chemical properties (e.g., solubility, volatility, adsorption coefficient, tendency to bioconcentrate) of any environmental contaminants, including MC • Impact of chemical mixtures and co-located waste on transport mechanisms • Locations and delineation of confirmed releases with sampling locations • Migration routes and mechanisms (HTRW and MC) • Modeling results

Profile Type	Typical Information Needs
Land Use and Exposure Profile	• Receptors associated with current, determined or reasonably anticipated future land use (e.g., residential, recreational, commercial, agricultural, industrial, public forest) on or near the facility • Types of current or future activities at the facility, including frequency and nature of activity (intrusive or non-intrusive) • Zoning, Master planning, community interests, and any government restrictions such as safety fly zones or noise zone near airports • Beneficial resource determination (aquifer classification, natural resources, wetlands, cultural resources, etc.) • Resource use locations (e.g., water supply wells, recreational swimming, boating, or fishing areas, hiking trails, grazing lands, burial grounds) • Demographics, including subpopulation types and locations (e.g., schools, hospitals, day care centers, site workers)
Ecological and Cultural Resources Profile	• Description of the environment at the facility, including habitat type (wetland, forest, desert, pond, etc.), quantity and quality • Primary use of the area and degree of disturbance, if any • Identification of any ecological receptors in relation to habitat type (endangered or threatened species, migratory animals, fish, etc.) • Relationship of any releases to potential habitat areas (locations, contaminants or hazards of concern, sampling data, migration pathways, etc.)

2-6. Pathway Analysis. The team uses information from the profiles to identify all complete, potentially complete, or incomplete pathways (sources, receptors and the interactions between them), for both current, determined, or reasonably anticipated future land uses for a site. Each pathway for MEC must include a source, access, activity, and receptor. For HTRW and MC, regardless of its concentrations, the pathway must include a source, an exposure medium, an exposure route, and a receptor. These pathways may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. Pathway analysis will guide data collection activities and can be used to inform stake-holders of site conditions.

> Source–receptor interaction for MEC requires two components: Access and Activity.

> Source-receptor interaction for MC or HTRW requires two components: an Exposure Medium and an Exposure Route. A release mechanism and transport medium may also be present.

a. Source. Sources are those areas where UXO, DMM, MC or HTRW have entered (or may enter) the physical system. The project team collects information about sources and source areas when it generates the Facility, Physical, and Release Profiles. Even though a source (e.g., impact area or a landfill) may be easily labeled, it is extremely important that the entire team understand as much about the source as possible, including probable munitions or contaminants. Although many details about the source may not be known, the team needs to determine what is known and what is assumed about the source early in the project.

b. Interaction. Interaction describes ways that receptors come into contact with a source. Information from all profiles will assist in identifying source–receptor interactions. Typically, movement of munitions (i.e., UXO, DMM) is not significant, and interaction will occur only at the source area, limited by the receptor's access and activity. However, natural processes (e.g., erosion, flooding) may cause subsurface munitions to surface or may cause some movement of munitions within or from the MRS. Additionally, munitions may get moved as a result of human activity. HTRW and MC often undergo various processes (e.g., volatilization, migration) such that media other than the source area can become contaminated. Therefore, the team must consider all potentially contaminated media (exposure media) as well as all exposure routes (ingestion, inhalation, and dermal contact) in evaluating the source–receptor interactions for MC and HTRW.

c. Receptors. A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider current, determined, or reasonably anticipated future land use, as receptors are determined on that basis. Human and ecological receptors are identified in the Land Use and Exposure, and Ecological Profiles. Human receptor subcategories can include residents, site workers, construction workers, recreational users, and trespassers.

2-7. Representation of the CSM. The CSM can vary in content and detail, depending on complexity of the site as well as available or needed information. A simple figure or narrative may depict a CSM for a simple site. However, for most sites, the CSM is more complex and typically documented by a written narrative that is supported by maps, cross-sections, diagrams, or other graphics to form the entire model. For MEC, the CSM depicts the source of munitions (i.e., the munitions-related activities that occurred at the MRS), access to the source (i.e., whether munitions are on the surface or in the subsurface) by a receptor, and the activity performed by the receptor. For MC and HTRW, the CSM focuses on the source, exposure routes through environmental media, and exposure of receptors. Regardless of what format is chosen to illustrate the model, all CSMs should provide an accurate representation of the source–receptor interactions present at the site. See Appendix D for examples of various CSM representations.

> A CSM illustrates the sources and receptors present at a site, and the interactions that may result in exposure. For munitions responses, a CSM will aid in determining whether explosive or chemical agent hazards are present. Similarly, for environmental contaminants (MC, HTRW), the CSM will help determine whether the contamination poses a potential risk to human health and the environment.

a. Narrative Description. A narrative is a written description of site conditions, based on profile information. The level of detail will vary based on the complexity of the site and the information available. Narrative descriptions should include a summary of information on sources, receptors and interactions.

> In some cases, a narrative may be all that is needed to document site condition in a CSM.

b. Pictorial Presentation. A pictorial presentation includes the necessary elements of a CSM, including the sources, receptors, and interactions between them. This format is useful for presenting the CSM to a wide range of stakeholders. Figure 2-1 provides an example of a pictorial CSM for an MRS. Figure 2-2 provides a similar example for environmental contamination (MC, HTRW).

c. Graphical Representation. The graphical representation provides a concise summary of complete or incomplete exposure pathways. It is commonly used for MC and HTRW and may also be used for MEC. However, the potential interactions between sources and receptors are assessed differently, as described below.

(1) A graphical representation of a CSM for an HTRW project or munitions response to MC is shown in Figure 2-3. This example focuses on a single contamination source in soil. Secondary sources or secondary pathways may also be identified, and can be represented by the addition of these components to the diagram.

(2) Interaction between the source and receptors involves a release mechanism for the contaminant, an exposure medium that contains the contaminant, and an exposure route that places the receptor into contact with the contaminated medium. Additional pathways can be added to the model as necessary. For example, for sites with a radioactive source area, an exposure pathway could be added for external radiation for both the soil pathway and the air pathway.

d. Other Representations. A CSM is a summary of the existing body of knowledge for a project presented in one or more illustrations or narratives. Specific data users may require this information to be presented in different formats. For instance, a hydro-geologist may prefer a cross-sectional subsurface diagram to conceptually view the source areas and possible ground water impacts. A risk assessor or land use planner may prefer the graphic representation to consider present or future risk issues. A person more interested in MEC-related issues might opt for a range map depicting firing points and impact areas and the potential for human interaction with these.

e. Geographical Information Systems (GIS). The data collected and stored for a project may be complex and immense. The team is strongly encouraged to use GIS as a tool to store, manipulate, and present these data in a CSM.

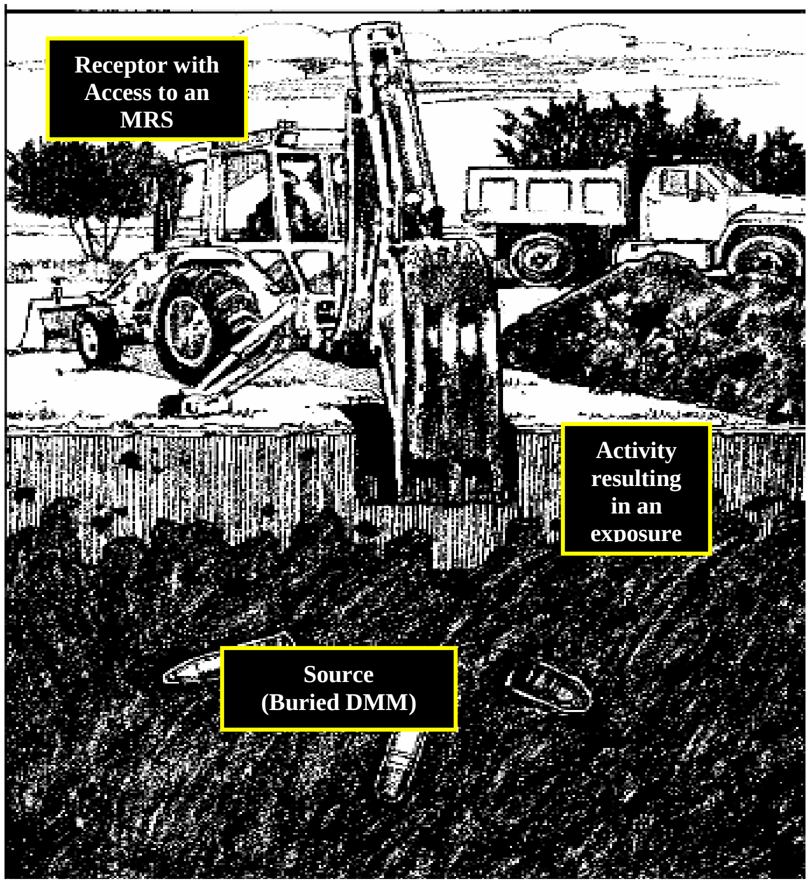

Figure 2-1. Pictorial CSM for an MRS

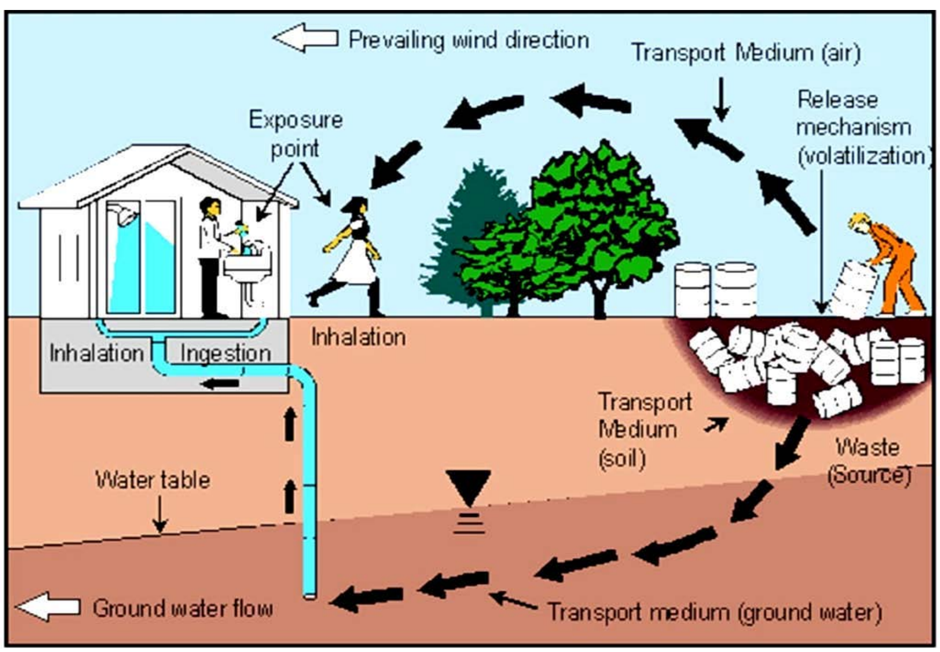

Figure 2-2. Pictorial CSM for Environmental Contamination (MC, HTRW)

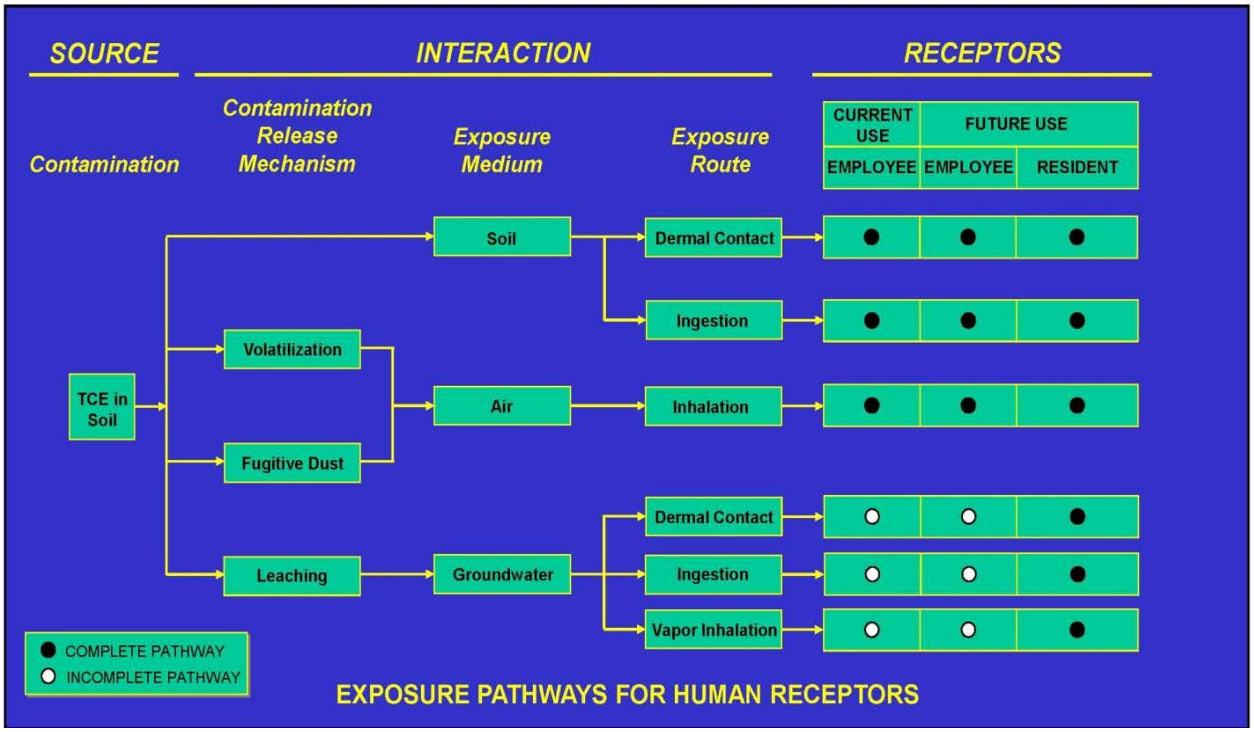

Figure 2-3. Graphic Presentation of an HTRW/MC CSM

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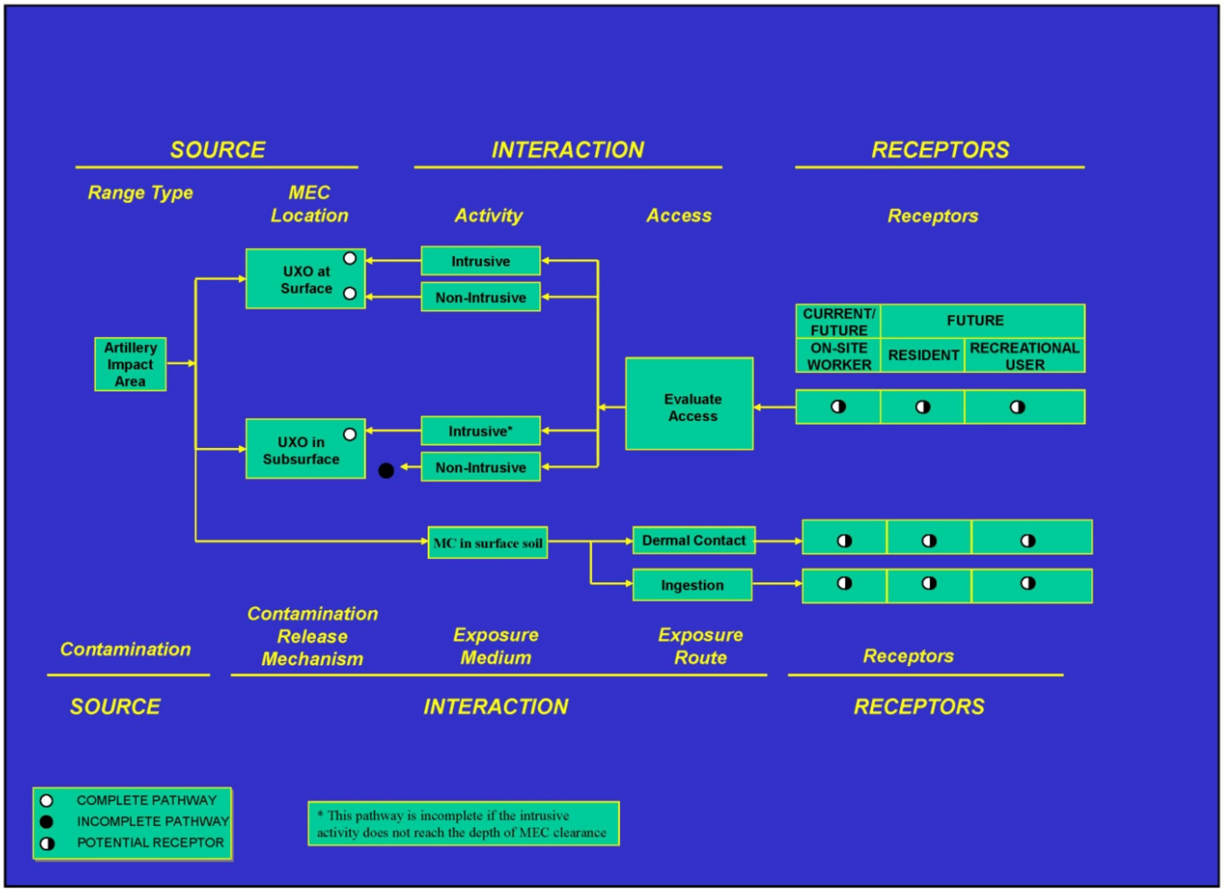

Figure 2-4. Graphic Presentation of an MRS CSM

2-8. Development and Refinement of a CSM.

a. Just as knowledge and understanding of a site will change as additional data are collected, the model used to represent that information should also change. A CSM requires continual refinement during the CERCLA process (see Paragraph 2-9). A CSM can help a team to identify data gaps in each phase of the project. In addition, completion of project phases should also be reflected in the CSM.

b. The development and refinement process is as shown in Figure 2-5. Site profiles are developed from the existing data to document an initial CSM. The team must then create reasonable hypotheses regarding potential for exposure. For example, analysis of the ground water pathway will usually entail some hypotheses about ground water flow velocity or direction relative to potential receptors. If these parameters are not known, they can be measured through sampling or interpreted through modeling or professional judgment. If the results from data collection confirm the predicted model, the CSM is updated to show that the hypothesis is correct. However, if results do not support the predicted outcome, it may indicate the hypothesis was incorrect and should be restated. This will require revision to the existing CSM.

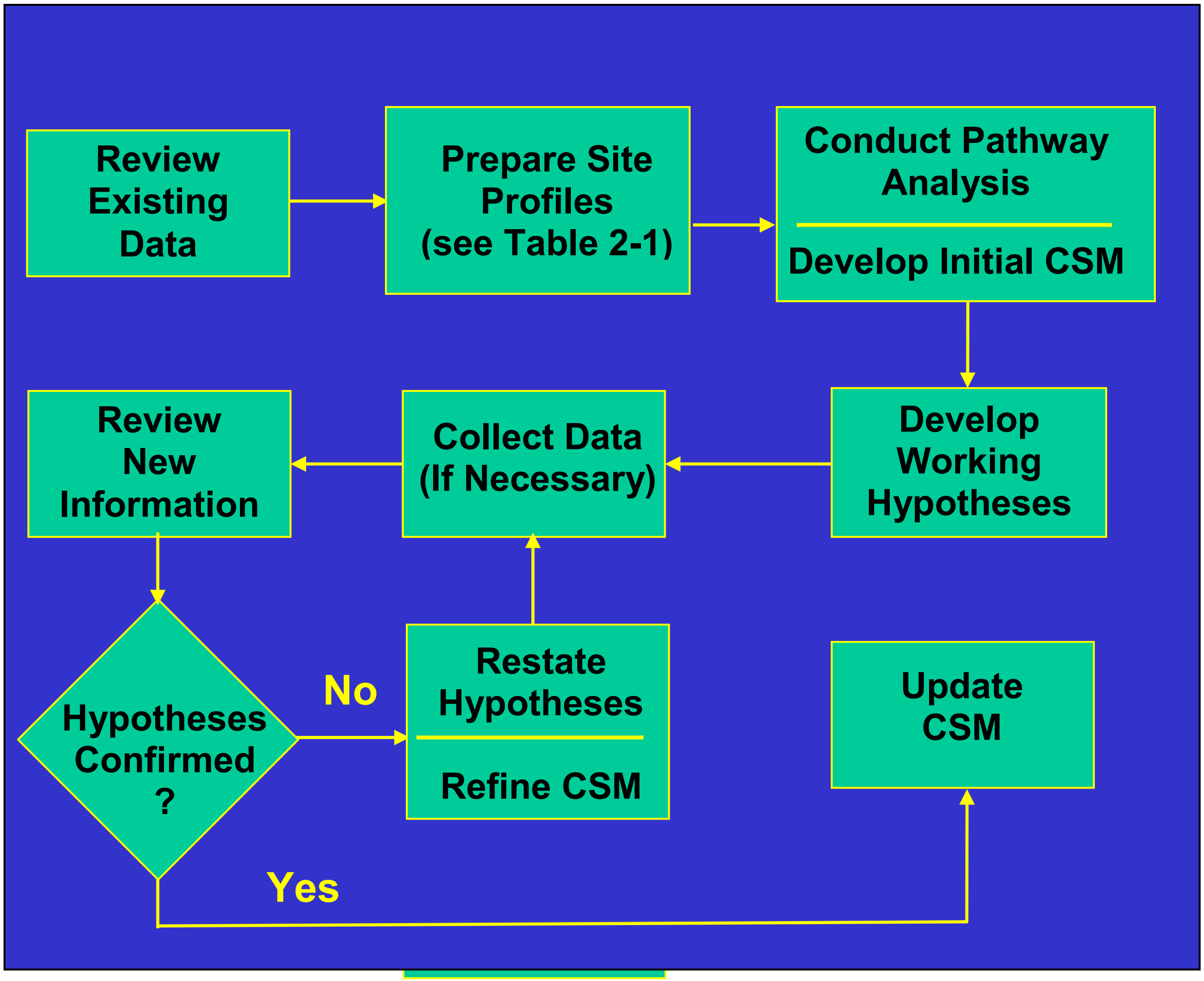

Figure 2-5. CSM Development/Refinement Process

c. A CSM can be developed during any phase of a project. In addition, site characterization or other response actions may reveal unanticipated contamination, the presence of unexpected munitions, or other sources. As an example, UXO, DMM, or MC might be discovered during investigation of an HTRW site. Although not expected during the initial phase of the investigation, the CSM should now be refined to address such a discovery. Additionally, the project's objectives should be reviewed and revised as needed.

2-9. <u>CERCLA Phases and CSM Development</u>. The following sections address development of a CSM and its uses in the CERCLA phases. Per the FUDS Program Policy (Engineer Regulation (ER) 200-3-1), the CSM should be initiated during the site inspection phase and refined throughout the response process as new information becomes available.

a. <u>Site Inspection (SI)</u>.

(1) A CSM is usually initiated at the SI phase using information from the Preliminary

Assessment (PA) report. Typical information sources include the Archive Search Report or Historical Records Review, aerial photography, site usage history, and interviews. The CSM is used to identify data gaps to support the SI objectives to:

> Per the FUDS ER the CSM should be initiated during the Site Inspection (SI) phase and refined throughout the response process as new information becomes available.

(a) Eliminate from further consideration those releases that pose no significant threat to public health or the environment;

(b) Determine the potential need for removal action (time critical or non-time critical);

(c) Collect or develop data to support Hazard Ranking Score (HRS) scoring by USEPA;

(d) Characterize the release for effective and rapid initiation of the RI/FS;

(e) Collect data to apply the DOD Relative Risk Site Evaluation (RRSE) and/or Munitions Response Site Prioritization Protocol (MRSPP).

(2) A CSM contains the most current information available to describe potential source areas, receptors and the interactions between the two. These source areas and pathways are then "tested" during the SI phase to determine whether a remedial investigation (complete or potentially complete pathways) or a removal action is required.

b. Engineering Evaluation/Cost Analysis (EE/CA). A CSM is used with information gathered during a PA/SI and/or subsequent investigation to identify exposure pathways or explosives safety hazards that should be addressed when developing an EE/CA for a removal action.

c. Remedial Investigation/Feasibility Study (RI/FS).

(1) A CSM is a document that should be refined as new information is gathered. A CSM is used to identify data gaps to support the RI objectives to:

(a) Determine nature and extent of contamination

(b) Collect information to bound an MRS;

(c) Determine if there are unacceptable risks or hazards associated with site-related contamination or the presence of UXO, DMM or MC;

(d) Collect sufficient information to allow development and evaluation of remedial alternatives.

(2) Initially, in the RI, the potential sources, interactions and receptors are evaluated against existing data for the site to identify data gaps. Filling these data gaps forms the basis for the RI field effort. DQOs are developed to address the data gaps. New data on sources, interactions and receptors are compared to the current

CSM, with the CSM refined as necessary. This in turn may result in new or revised data gaps that may impact DQOs and the design of site characterization. The CSM may also be used to identify modeling that may be required to determine potential exposure points, exposure point concentrations and whether there is an unacceptable risk to receptors.

(3) At the FS phase, the CSM is used to assist designers in identifying source areas, any media, and pathways or exposure routes that must be addressed by the remediation. Remedial Action Objectives (RAOs) are created to address the sources, media, and/or pathways identified as posing a risk or hazard. Proposed remedies are compared to the RAOs and the CSM to determine their relative effectiveness at addressing UXO or DMM known or suspected to be present, eliminating or controlling contamination, including MC, in a given medium, and determining their effectiveness at breaking an exposure pathway.

d. Remedial Design/Remedial Action (RD/RA). The CSM drives the remedial design process by identifying sources, contaminated media, or exposure pathways that require remedial action to eliminate risks. Multiple media may need to be addressed, or multiple institutional controls may need to be placed on a site to address accessibility or exposure scenarios described in the CSM. Design features are compared to the CSM to determine their ability to eliminate unacceptable risk or hazard.

e. Operation and Maintenance (O&M) and Long-Term Monitoring (LTM). During the O&M phase of a project, the CSM may be used to identify or adjust any long-term monitoring that may be required. Pathways and receptors may change during the conduct of a response, or contaminant concentrations may change, requiring related changes in LTM goals and programs. As source areas and media are remediated, features of a remediation system are adjusted or shut off based on exposures and pathways described in the CSM. The CSM is refined to reflect any changes in exposure pathways or routes and contaminated media.

f. Five-Year Reviews. During a five-year review, RAOs used at the time of remedy selection are compared against the current CSM to determine if they are still valid. Remedial measures are compared against the CSM to determine if the measures remain protective of human health and the environment. Current pathways and media contamination are evaluated to determine if remedial measures are controlling or eliminating a pathway or to see if remedial measures continue to be effective in controlling or preventing contaminant migration. The CSM is refined to reflect any changes in exposure pathways, exposure routes and/or contaminated media.

CHAPTER 3

Development of a Conceptual Site Model for a Munitions Response to MEC

3-1. Introduction. This chapter describes the CSM development process for an MRS that is known or suspected to contain MEC, defines key terms, and provides examples for each step of the development process. The primary focus of a CSM for an MRS known or suspected to contain MEC is to illustrate how receptors may be affected by the presence of MEC on an MRS. For a receptor to be potentially affected by MEC on an MRS, the receptor must have access to the MRS and the receptor must conduct an activity that would result in direct contact with MEC. A CSM is developed through collection of the profile information (see Paragraph 2-4) and subsequent pathway analysis.

> MEC distinguishes specific categories of military munitions that may pose unique explosives safety risks; (a) Unexploded Ordnance (UXO), as defined in 10 U.S.C. 2710(e)(9); (b) Discarded military munitions (DMM), as defined in 10 U.S.C. 2710(e)(2); or (c) Munitions constituents (e.g., TNT, RDX) present in high enough concentration to pose an explosive hazard.

3-2. Profile Information Resources. The first step in development of a CSM for an MRS known or suspected to contain MEC is to collect profile information for the MRS. For most MRSs, a PA that includes a historical records search (e.g., Archival Search Report (ASR), Munitions Response Historical Records Review) provides useful profile information. However, these alone should not be viewed as presenting a comprehensive understanding of an MRS's conditions. Additional records searches, a site visit, and personnel interviews are other recommended resources. For military installations, the base historian as well as real property and range managers should also be contacted. Local safety officials (e.g., law enforcement, fire department) will typically have information about any explosives or munitions emergencies that may have occurred within the MRS or local area. Additionally, historical ground and aerial photographs may be obtained from the installation or military archives. A detailed military photogrammetric analysis should be conducted if not already done. Other methods (e.g., light detection and ranging (LIDAR) and geophysical maps) can also be useful in developing a CSM. The team should review the applicable Common Operations, Range Operations, and Installation Reports that the USACE Environmental and Munitions Center of Expertise (EM CX) developed. These reports:

> A historical records search is an evaluation of past military activities at an installation. Its purpose is to assemble historical records about activities, including munitions-related activities that occurred at a site, and available data to assess whether MEC may be present.

a. Provide a historically documented discussion of how the military conducted operations (e.g., vehicle maintenance, aircraft maintenance, training ranges) with potential for releases to the environment.

b. Eliminate the need for redundant research of these operations.

c. Are supported by the technical manuals for the various time periods.

3-3. Facility Profiles. Facility Profiles focus on identifying potential source areas. A source area is a location where MEC will most likely be found as a result of munitions-related activities (e.g., production, live-fire training and testing, disposal operations).

MC as an environmental contaminant must also be considered (see Chapter 4).

a. Source areas may include, but may not be limited to ranges and demilitarization sites (i.e., open burning/open detonation (OB/OD)), including any associated safety buffer zones, production or renovation areas, burial sites, storage locations. Accumulations of munitions debris and range-related debris on operational or former ranges may also be determined to be a source area. It should be noted that small arms ammunitions (see definitions), which are not considered to pose a unique explosive hazard, and DMM may be found anywhere on an installation; however they will most likely be found where munitions-related activities occurred. Table 3-1 lists types of source areas, the possible activities that may have occurred, and the potential MEC for each area. See Appendix C, Range Operations Overview, for a discussion of design, operation and maintenance of training ranges.

Table 3-1. Common Range Types, Possible Activities, and Potential MEC

Types of Source Areas	Possible Munitions-Related Activities	Expected MEC Category
Grenade Court/Range	Hand grenade training/testing Rifle grenade training/testing	UXO (hand or rifle grenades)
Small Arms Range	Pistol, rifle, machine gun and skeet firing ranges	Not Applicable. Small Arms Ammunition is not considered MEC
Artillery Range	Anti-aircraft, tank, recoilless rifle ranges	UXO (projectiles, submunitions)
Bombing Target	Aircraft bombing	UXO (bombs and submunitions)
Air-to-Air Gunnery Range	Air-to-air firing	UXO (projectiles, rockets, guided missiles)
Air-to-Ground Gunnery Range	Strafing and other air to ground firing	UXO (projectiles, rockets, guided missiles)
Ground-to-Air Gunnery Range	Anti-aircraft firing	UXO (projectiles, rockets, guided missiles)
Ground-to-Ground Range (Rocket Range)	Rocket and missile firing	UXO (rockets, guided missiles)
Multiple/Combined Use training area	Multiple training activities	UXO (projectiles, grenades, rockets, bombs)
Training/Maneuver Areas	Tactical training	DMM and some UXO (simulators, signals, pyrotechnics, and other training devices)

Types of Source Areas	Possible Munitions-Related Activities	Expected MEC Category
OB/OD Areas	Disposal of munitions	DMM, MC (e.g., TNT, RDX) present in high enough concentration to pose an explosive hazard
Ammunition Plants (e.g., building voids, piping, settling ponds, soil)	Production of explosives and munitions	MC (e.g., TNT, RDX) present in high enough concentration to pose an explosive hazard
Storage Areas/Transfer Points	Storage and handling of munitions	Possibly DMM
Firing Points	Preparation and firing of authorized weapons systems	Possibly DMM
Impact Area	Multiple training activities	UXO (projectiles, grenades, rockets, bombs)
Burial Pits	Mass burial of large quantities of DMM	DMM
Bivouac Areas	Troop encampments	Possibly DMM

b. Common indicators of source areas include, but are not limited to:

(1) Historical records of munitions use.

(2) The presence of munitions or range-related debris.

(3) Scarring:

(a) Land scarring (e.g., depressions, craters).

(b) Rock scarring resulting in fresh rock face, and rubble.

(c) Tree scarring or lack of or an unusual abundance of vegetation.

(4) Manmade or land features indicating munitions related activities (e.g., concrete pads, berms, mounds).

(5) Incident reports of explosives or munitions emergencies (e.g., Explosive Ordnance Disposal (EOD), local bomb squad).

(6) Eyewitness accounts of munitions use.

Such indicators can help the team focus on areas where there is a medium to high probability of encountering MEC. (Figures 3-1 and 3-2 are photographic examples of some indicators of munitions-related use.)

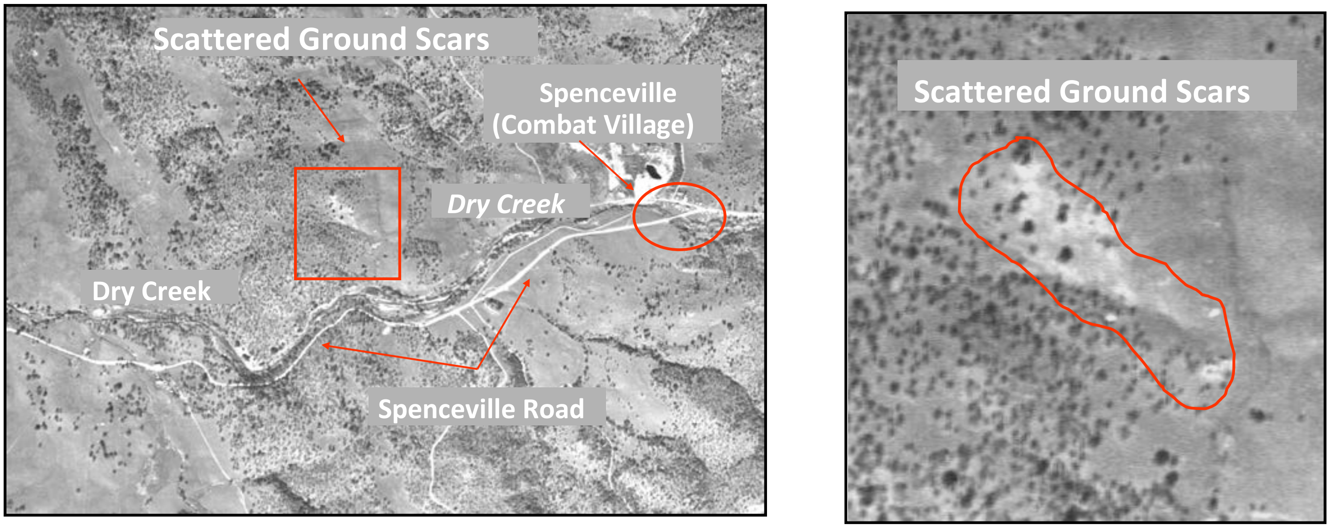

Figure 3-1. Ground Scars Indicating Potential Munitions Use

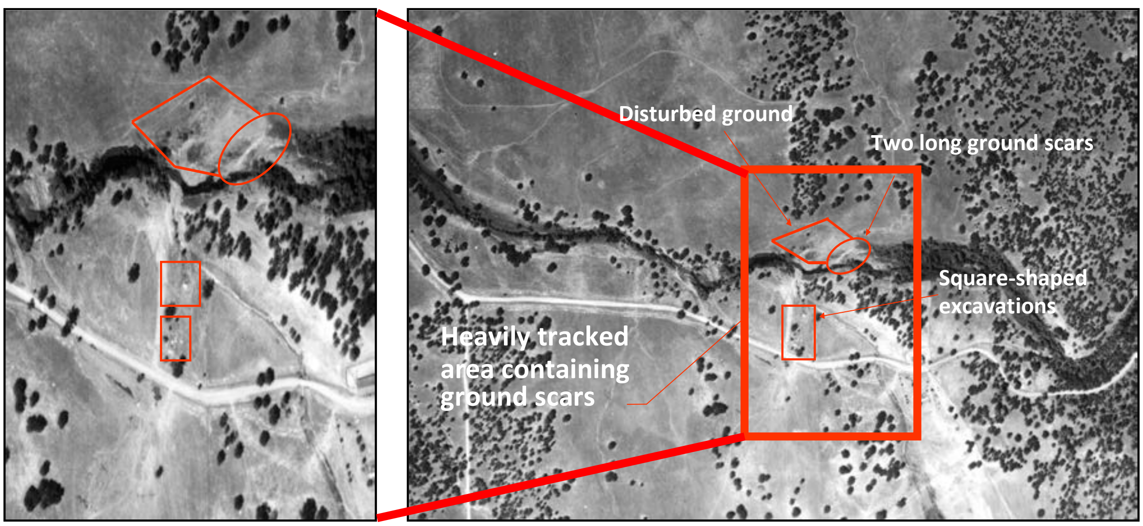

Figure 3-2. Tracked Areas and Ground Scars Indicating Past Range Activities

c. The military's use of a site may change over time. The same range may be used for several different munitions-related or live-fire training activities. Therefore, multi-use ranges may contain a variety of munition types and different categories of MEC. Range dimensions and orientations may change as a result of target relocation (Figure 3-3). The team must consider the potential for both such changes in use and a variety of munitions and different categories of MEC being present.

d. Define target areas. The type of weapons systems and munitions used, and their respective range limits will usually provide a basis for the areal distribution of MEC within an impact area, and its associated buffer zones. Standard layouts for range boundaries may be used to help determine the probable location of MEC.

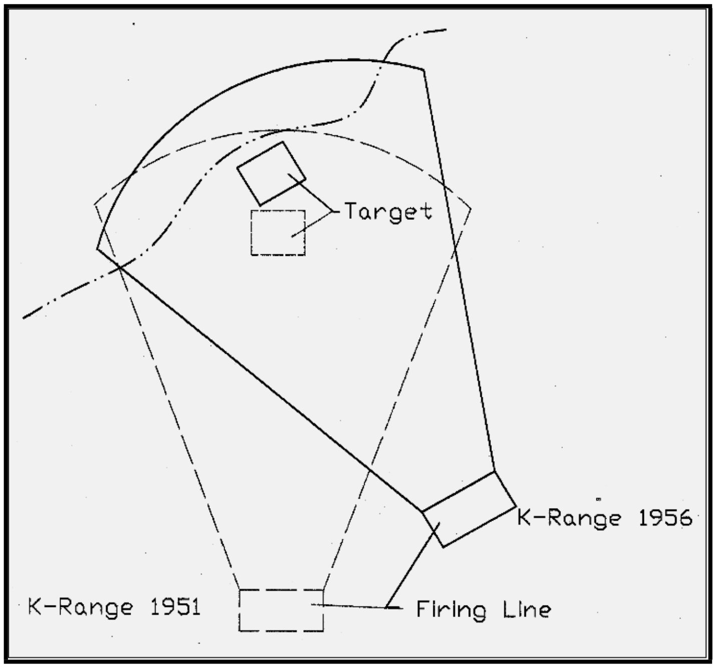

Figure 3-3. Range Orientation over Time

3-4. Physical Profiles. The Physical Profile for an MRS will provide a description of an MRS's physical properties that could affect the location, movement, detection, and recovery of UXO and DMM.

a. Location of UXO. Location refers to the areal extent and the potential depth of subsurface UXO.

(1) Areal Extent. This is related to the distribution of UXO from any munitions-related activities that occurred at that site. When using standard layouts for range boundaries, terrain or man-made features may be important to determining the areal extent of any UXO present. Certain terrain features can limit the use of portions of a range, potentially impacting the areal extent of UXO. Natural or man-made features will produce a "shadow effect" on the distribution of UXO near a target with a terrain feature as a backstop. (Figure 3-4 provides an illustration of a "shadow effect.")

(2) Standard Layout. The standard layout for a range is shown in both design and as-built drawings for a former military installation. As shown on the as-built drawing, the total area of the range is reduced by the terrain feature. This effect is more applicable to direct fire (e.g., bazooka) than indirect fire (e.g., mortar, artillery) weapons.

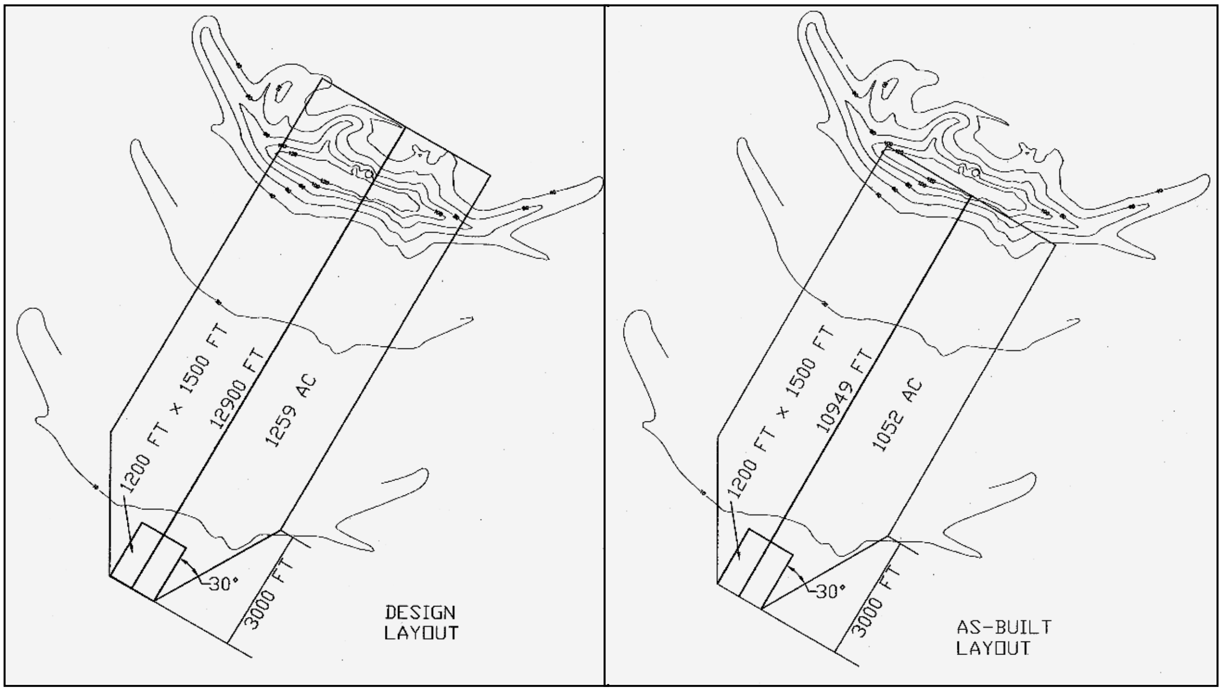

Figure 3-4. Terrain Effects on Range Dimensions

(3) Potential Depth of Subsurface UXO. Subsurface conditions can affect the potential depth at which UXO may be found. For instance, soil type, soil moisture, topography and vegetation are important physical factors in determining the penetration depth of certain munitions. The team should attempt to determine the probable depth of penetration by the munitions types known or suspected to have been used. This information is important when determining the potential explosive hazards present, the ability to detect and remove UXO, and the cost of munitions response activities. Information about a weapons system normally includes the munitions used, including their design characteristics (geometry, weight, fuzing) striking velocity, and angle of entry. The team should be aware that dramatic differences in penetration depth by the same type of munitions may exist. For example, loose, sandy soil will typically allow less penetration of similar munitions than will moist clay. Site-specific conditions and the potential depth of any subsurface munitions should be available when developing response objectives for the current, determined, or reasonably anticipated future land use.

b. Location of DMM. Location refers to the areal extent and the potential depth of subsurface DMM.

(1) Areal Extent. Unlike UXO which was fired, launched, dropped, or placed in a target area, DMM was intact munitions that were left over after range operations were completed. Consequently, the team should expect to find DMM in one or more discrete locations very close to the firing or storage location.

(2) Potential Depth of Subsurface DMM. DMM in some cases were thrown in ditches, streams, or small bodies of water close to the firing point or during the travel back to the barracks or bivouac site. At some artillery and mortar firing locations, the troops would dig fighting positions as a part of their training. When these fighting positions were closed out, they would sometimes put left over munitions, rations cans, and other debris in the bottom before filling in the position with dirt. That is why at these sites, the buried DMM and debris is normally located about 4 feet below the ground surface. At other locations, the troops would dig shallow holes and bury the DMM before leaving. The team needs to plan their characterization of firing points with this in mind.

c. Underwater UXO and DMM. Munitions may have been projected, launched or dropped in the water portion of ranges. These water bodies may be ponds, lakes, marshes, streams, rivers, harbors, bays, seas, and oceans. Working underwater presents unique challenges for both characterizing the site or for performing removal or remedial actions.

(1) Areal Extent. For water ranges, UXO would have been fired or dropped at targets on the water or fired at airborne targets flown over the water. The team should review the historical documentation of the activities that caused the munitions to be located at their site to help in determining the extent of MEC.

(2) Potential Depth of Underwater Munitions. At some sites the bottom conditions (mud, muck, sand) suggest the munitions will be buried. Other sites munitions may be encrusted in coral and be readily visible on the water bottom. In rivers and streams that contain a large amount of sediment, UXO or DMM may be covered from years of sediment buildup. In some underwater environments the sand will bury or uncover munitions depending on the underwater dynamics. The team must learn their site dynamics to better plan site activities.

d. Movement. The team needs to evaluate any naturally occurring phenomena (e.g., tidal activity, flooding, frost heave, erosion) or physical activities (e.g., farming, construction, and development) that may have caused or could cause surface or subsurface MEC to move or be moved or subsurface MEC to surface over time. Data related to the geology, geomorphology, and hydrology of a site, as well as activities that have occurred at the site should be collected to assess this potential.

(1) Subsurface UXO and DMM. Subsurface UXO or DMM can rise to the surface through frost heave if certain site conditions exist. These conditions are more prevalent in the Northeast portion of the country. In the west, wind erosion is a more common occurrence that can cause UXO and DMM to become exposed to the surface. The most common cause of UXO and DMM to be moved, however, is for people to pick it up and move it from one location to another. This is especially true where old munitions sites are being cleared for agriculture or development. There are many reports of farmers uncovering old munitions and munitions debris when plowing, moving it off to the side and reporting it to authorities.

(2) Underwater UXO and DMM. UXO and DMM underwater can be moved through naturally occurring events (e.g., storms, tidal action, underwater currents) or the result of man's activities (e.g., fishing, dredging). At some locations munitions will be buried as sand moves one direction and then be uncovered as sand moves in the other direction. Project teams have to perform historical research to learn the dynamics applicable to the site

e. Detection. Naturally occurring conditions can affect the detection of subsurface anomalies when using geophysical instruments and methods. These conditions and the physical characteristics of the munitions may affect the various types of detection instruments in different ways. Terrain and geology features may introduce electronic noise, making detection difficult. Dense vegetation may affect the ability to get an instrument's sensor close enough to the surface, thereby limiting its effectiveness. Such vegetation may also limit choices for positioning technologies. Soil composition and moisture content are key elements to be collected. These same instruments can also be used underwater to detect anomalies. However, the underwater environment presents a whole new set of challenges such as crab pots, outboard motor boat engines, large coral deposits, critical habitat, large rocks, etc. The project team must evaluate these potential problems when planning their mapping strategy.

f. Accessibility. Certain terrain features (e.g., impassable or rough terrain, such as steep cliffs; fast moving water; wetlands; tidal plains; water depth) and locations (e.g., wilderness areas, distance from shore) limit a receptor's access to an MRS; therefore, reduce the potential risk. Such terrain features may also limit potential response actions. This information should be collected.

3-5. Land Use and Exposure Profiles.

a. The land use and exposure profiles are used to identify on-site and surrounding off-site land uses and provide an idea of the frequency of access and those activities that could result in receptor exposure to MEC. The Land Use and Exposure Profile identify the human activities (e.g., hiking, hunting, playing, farming, construction) that may result in a potential contact with any MEC present. The potential for contact must also consider the location of MEC (surface or subsurface) and the intrusiveness, intensity and frequency of those activities at the MRS. Population densities and demographic information, which can normally be based on the most recent census, should also be included.

b. The development of a land use and exposure profile should also be performed for any determined or reasonably anticipated future land use. Zoning, master planning, and community interest are important as the team agree upon an MRS's reasonably anticipated land use. These profiles will assist in determination of the appropriate receptors to be evaluated in the pathway analysis.

3-6. Ecological and Cultural Resources Profile. The presence of ecological or cultural resources on an MRS should be considered in development of the CSM. Although humans are typically considered as the primary and often the only receptor to MEC, the presence of ecological or cultural resources on an MRS should be known to avoid or mitigate response actions (e.g., vegetation removal) that could adversely impact such resources

3-7. Pathway Analysis. Careful analysis of the profile information should allow the team to identify potential source–receptor interactions for MEC. The CSM will illustrate all potential pathways (see Paragraph 2-6 for various CSM representations). For MEC, a complete pathway must include the presence of MEC (a source), access to an MRS, activity that provides for a potential encounter with MEC, and a receptor. Generally, some interaction (e.g., touching, disturbing, moving), either intentional or unintentional, between the receptor and MEC is required.

a. Sources. Source areas are identified during generation of the Facility, Physical, and Release Profiles from archival research or direct evidence compiled during a site visit. A source area is described by the following components: the type of area, the location and dimensions of the area, and the type and distribution (including depth) of MEC within the area. If the location or distribution of MEC has changed over time because of physical process or human activity, this movement can increase the potential for human interaction.

b. Interaction. Information from all profiles will assist in identifying source–receptor interactions. Interaction is the direct physical contact with MEC. Such interaction requires two closely connected elements: access and activity. Access is the ability of a receptor to enter a source area (e.g., MRS). Activity is any action by a receptor that may result in direct physical contact (intentional or unintentional) with MEC.

> Interaction between the receptor and MEC has two components: access and - activity. Access is the ability of a receptor to enter the area. Activity is any action by a receptor that results in direct contact with MEC. Activity considers intrusiveness, intensity and frequency of those actions.

(1) Access. The ability of a receptor to enter an MRS is affected by both natural and man- made features. All such features must be analyzed to determine if the access component of a pathway is currently complete or could become complete with the reasonably anticipated future land use for the MRS. Terrain, vegetation and other natural features (e.g., sheer cliffs, crevices, fast running or deep water) in the physical profile for an MRS may provide natural barriers that limit access to an MRS. Additionally, man-made features (e.g., buildings, concrete pads) identified in the facility profile can also limit access. Although access is generally defined in terms of access to an MRS, the location of MEC (i.e., on the surface, in the sub-surface) may also limit access. The populations near an MRS and potential for transient populations (e.g., hikers, boaters) to visit an MRS during specific periods of time should also be evaluated.

(2) Activity. The hazard presented by MEC is caused by direct contact as a result of some human activity. Site access without such activity does not present a hazard.

Identification of MEC pathways should focus on current or future activities that bring humans into contact with the MEC. The activity component of the pathway should analyze current activities and future activities associated with determined or reasonably anticipated land use. Information from all profiles will be used in establishing the activities of the receptors. Different activities are associated with each receptor and it is important to clearly describe the actions that may result in direct contact with individual MEC items in the source area. It is also important to evaluate the depth of intrusive activity against the depth of MEC. Contact with MEC cannot occur where the depth of intrusive activity does not reach the depth of the MEC, and the pathway would not be complete. Future use of property containing MEC may result in intrusive activities (e.g., construction or agriculture) that also increase the potential for contact. The intensity and frequency of activities should also be evaluated.

c. Receptors. Receptors (human and ecological) were identified in the Land Use and Exposure Profile. Both current and future receptors must be considered. Human receptors are categorized by their ability to access a site combined with the activities that potentially allow for contact (i.e., interaction) with MEC. Construction workers, ranchers, recreational users, trespassers, and residents are examples of potential receptors.

CHAPTER 4

Development of a Conceptual Site Model for MC and HTRW Responses

4-1. Introduction. This chapter describes the steps in developing the MC and/or HTRW portions of the CSM. As with MEC, the primary focus of the CSM is to illustrate the interaction between contaminant sources and receptors. This is accomplished through development of profile information (see Paragraph 2-4) and subsequent pathway analysis.

4-2. Profile Information Resources.

a. Identifying MC and HTRW profile information available for a site is one of the most critical steps in developing the initial CSM. For most sites, a Preliminary Assessment including a historical records search such as an ASR or similar document provides useful profile information. Historical and current site information may be obtained from maps, aerial photographs, existing reports, cross sections, land surveys, environmental studies, or laboratory analytical data. Procurement contracts or inventory records provide information about what items or materials were purchased and used by various departments. Operational manuals or procedures are also essential resources for information relating to how an activity was performed in the past. Landfill or burial pit disposal records, when available, offer valuable data on what wastes may be present. The team should also consider the applicability of a series of Common Operations, Range Operations, and Installation Reports developed by the USACE EM CX. These reports provide a general historical discussion of military guidance on the conduct of certain types of operations such as vehicle maintenance, aircraft maintenance, training ranges and other operations of interest with potential for releases to the environment. They are not a substitute nor may they be relied upon to accurately depict what happened at a particular site. They may provide insight as to what to look for and what might be expected as to how an operation may have been carried out. Certain Installation Reports were also developed for installation types, such as Ground Forces Training installation, Army Airfields, Atlas missile sites and other installations that were numerous or had specific narrow missions. None of these materials may be relied upon as site specific. Implementation at individual sites may have varied from the standard operating procedures

b. Interviews with current or former site personnel may provide anecdotal information or process knowledge about the site or specific activity. For military installations, the base historian, real property manager, and range managers should also be contacted. Local officials with the fire or law enforcement offices would typically have information if there have been responses to chemical spills, incidents or MEC discoveries indicating the possible presence of MC.

> Sources of contaminants should be described in terms of locations where the known or suspected contamination exists and the types and concentrations of contaminants present.

Figure 4-1. Example of Large Scrap Yard Layout (1966)

c. Site visits are highly recommended to identify significant features from all profile types for inclusion in the initial CSM. Local archives are often the best resource for information, and a site visit allows the opportunity to verify much of the written information. Visual evidence, such as soil staining, stressed vegetation or one of the common indicators listed in 3-3(b), can directly indicate that HTRW contaminants or MC are present.

4-3. Facility Profiles.

> A contaminant is usually defined as any substance that is potentially hazardous to human health or the environment and is present at concentrations above background levels.

a. Facility profiles provide information to determine the potential source areas at a site. The source area should be identified based on the presence or suspected presence of a contaminant. The team should be familiar with the historical operations at a site to recognize potential unauthorized disposal sites or areas with likelihood for incidental spills or releases. Potential HTRW source areas typically include landfills, surface impoundments, scrap yards (Figure 4-1), fire training areas, process buildings, and underground storage tanks. Potential MC source areas are the same as MEC source areas (see Table 3-1). All suspected source areas should be marked clearly on a site map, including the relationship to property boundaries.

b. Historical site operations (e.g., firing points, impact areas) and site physical characteristics (e.g., impact craters, berms, ground scars) provide initial clues to the location of potential source areas for MEC and MC. Sampling data, if available, are typically the most reliable indicator of HTRW source areas. In the absence of adequate sampling data, other methods may be used to develop reasonable hypotheses regarding potential HTRW source areas. Known burial sites, soil stains, or stressed vegetation located during site visits or from review of historical aerial photos are signs of potential source areas and should be included in the profile information.

c. Investigation at an artillery range would be considered as an MMRP project. The team would, in the course of their investigation, define the range boundaries to focus their investigation. For example, the geophysics investigation may result in a map showing UXO density (Figure 4-2). Although this information would be reflected in the MEC portion of the CSM, this information would be critical to the MC or HTRW portion of the CSM as well. It would allow that project phase to focus investigations in those areas most likely to be a source of subsurface environmental/chemical contamination from the MC (Figure 4-3).

d. Some locations with MEC also have a potential for other than MC environmental/chemical contamination. For example, fuels were often used at OB/OD areas as accelerants when excess munitions were destroyed. Similarly, the manufacture of explosives at ammunition plants generated large quantities of waste rinse water that was retained in impoundments and often released contaminants to other media.

e. Changes in the chemical composition of MC may occur over time and from exposure to the environment. Explosive D (ammonium picrate), for instance, degrades to picric acid and other constituents when exposed to moisture, and can produce explosive picric salts that are extremely shock sensitive.

4-4. <u>Physical Profiles</u>.

a. The factors that affect the fate and transport of the contaminants are identified in the Physical Profile. This information includes soil type, soil properties, precipitation data, surface and ground water characteristics, and topography. Soil type and soil properties (moisture content, corrosivity, pH, etc.) are important for evaluation of depth of MEC and therefore, can affect the fate and transport of MC and HTRW chemical contamination.

b. Physical profiles also describe site conditions important in determining exposure potential. Excessive topographic relief, dense vegetation, water bodies, or other physical characteristics may prevent or deter access to some sites, which limits potential for exposure.

c. Physical profiles are also important for identifying constraints to field activities and evaluating potential response actions.

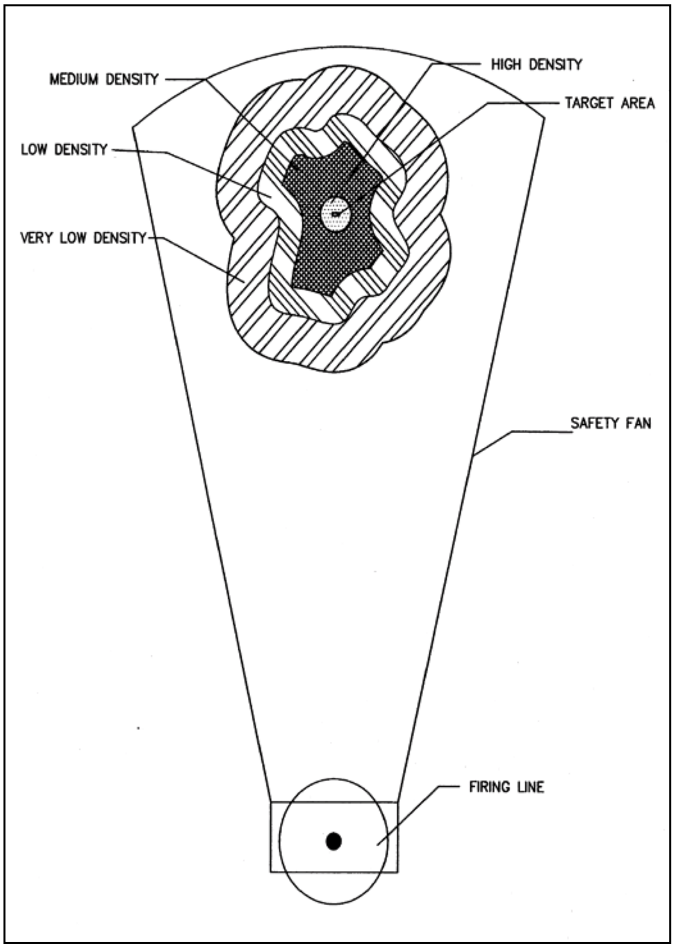

Figure 4-2. Estimating UXO Density

4-5. Release Profiles.

a. A contaminant is rarely immobile in the physical system; therefore, pathway analysis for contaminants will usually require identification of a release mechanism. Release mechanisms include those physical processes that contribute to the introduction and distribution of a contaminant in the environment. This often leads to migration from the source area to another exposure medium.

> Release mechanisms should be identified for each source present at the site. Multiple release mechanisms may exist for each source area.

b. Multiple release mechanisms may exist for the same source. A drum of liquid contaminant may leak to soil as a primary release, then create a secondary release through percolation or infiltration. Volatilization of that contaminant from the soil may also occur, which adds another release mechanism from the primary source. Contaminated soil or sediment may become airborne or migrate through erosional processes to contaminate another medium. All potential release mechanisms and resulting contaminated media must be carefully evaluated.

c. Exposure media contain the source or become contaminated through migration of the contaminant from the source area. Examples of exposure media are surface soil, subsurface soil, ground water, sediments, surface water, air, and biota. The biotic medium can exist through uptake, accumulation, or concentration of contaminants by organisms and subsequent transport of that contaminant through the food chain.

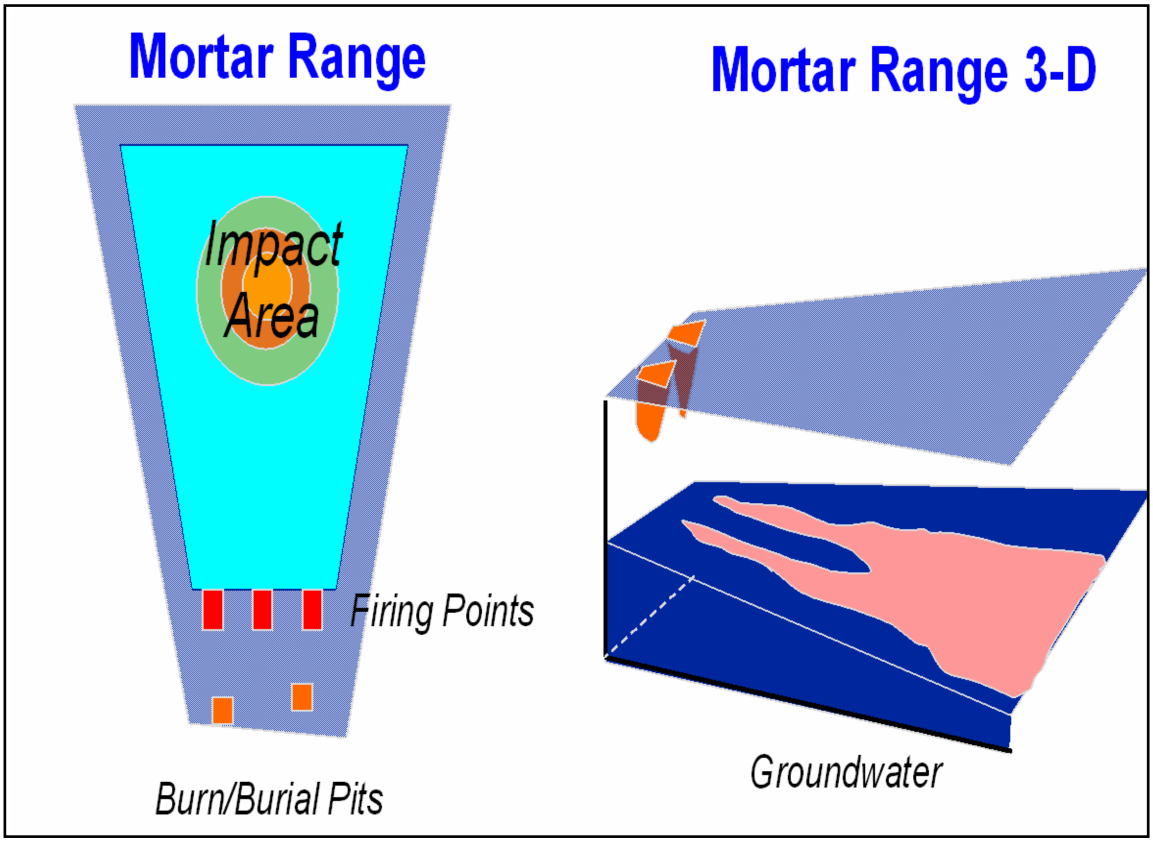

Figure 4-3. Areas of Potential MEC and MC Distribution at a Mortar Range

4-6. Land Use and Exposure Profiles.

a. The Land Use and Exposure Profiles are used to identify on-site and surrounding off- site land use and associated receptors. These profiles should also include locations of natural resources and how they are used.

b. The team should determine current use of the property and surrounding land. Demographic as well as sensitive subpopulation information is included in this profile. Any beneficial resources at the site must also be identified. This will aid in determining the appropriate receptors to be evaluated in the pathway analysis. Although the source–receptor interactions may differ, understanding receptor populations and their activities is necessary for either MEC or MC/HTRW investigations and remedial actions.

c. The exposure profile identifies the available receptors at and near a site. A receptor is a person or population that is or may be exposed to a release. Both current and potential future receptors must be identified. Zoning, master planning, and community interest are critical to determining and defending determined or reasonably anticipated future land use.

4-7. Ecological and Cultural Resources Profiles. The Ecological Profile includes a description and use of the natural habitats at and surrounding the site. Identification of receptors is usually enhanced by use of maps that show the ecological profile and land use surrounding the facility and contaminant migration routes from the source. Ecological receptors may include individual organisms, populations, communities, or habitats and ecosystems. Threatened and endangered species, as well as migratory species, must be identified if they are present. Special use areas (e.g., fisheries) potentially impacted by the site should also be described.

4-8. Pathway Analysis. Careful analysis of the profile information should allow the team to identify all source–receptor interactions, for both current, determined, or reasonably anticipated future land use. The CSM will illustrate all potential pathways (see Paragraph 2-6 for various CSM representations). Each pathway must include a source, an exposure medium, an exposure route, and a receptor. The pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. It is important to remember that certain activities, such as soil excavation, can create a complete exposure pathway where one does not currently exist.

> Source–receptor interaction for MC or HTRW requires two components: an Exposure Medium and an Exposure Route. A release mechanism and transport medium may also be present.

a. Sources. Source areas are identified when the Facility, Physical, and Release Profiles are generated, and will be used for the pathway analysis. For MC, potential source areas are the same as those identified for MEC in Chapter 3. Source areas are described by the following components: area use (e.g., Burn-and-Cover Operations, Figure 4-4), type and concentrations of contaminants, and lateral and vertical extent within media.

b. Interaction. The source–receptor interaction requires that exposure media and exposure routes be evaluated. Information from all profiles will assist in identifying these interactions.

(1) Exposure Media. Exposure media are those that contain the source, or those media that become contaminated through migration of the contaminant from the source area.

(a) Exposure to soil (surface and subsurface) is important where there is potential for receptor contact with contamination or for contaminant migration into another medium. The team must determine the depth of contamination, the potential for human or biotic contact with the contamination, and the migration potential of the contaminant.

(b) Exposure to groundwater is important when contaminated groundwater is used for or may be used for domestic purposes. Contaminants are rarely released directly into groundwater. Groundwater is usually contaminated by migration from another medium. The team must consider factors that affect the likelihood of a contaminant reaching groundwater, such as depth to the aquifer and permeability of the overlying strata. Contaminant migration within the aquifer must consider transmissivity of the water-bearing unit as well as fate and transport properties of the contaminant.

(c) Exposure to sediments is most important to ecological receptors, as sediment-dwelling organisms typically serve as a food source for higher trophic level organisms. Human receptors can be exposed under certain conditions, such as through wading or swimming.

(d) Exposure to surface water is important when contamination is released directly to the surface water body, or through contaminant migration from another medium (e.g., surface soil or ground water). Human receptors can be exposed through recreational activities (e.g., swimming, wading, or fishing) or domestic uses of the surface water.

(e) Exposure to air is important when particulate dispersion of contaminated soils or sediments, release of volatile compounds from soils or sediments, or volatilization of contaminants from surface water is possible. Prevailing wind directions should be determined to measure potential for receptor exposure to this medium.

(f) The biotic medium is important when considering the potential for transfer of contaminants through the food chain. Additionally, bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations.

(2) Exposure Routes. Exposure routes are those processes by which a contaminant or physical agent comes in contact with a receptor. For most contaminants, these processes include ingestion, inhalation, and dermal contact. More than one exposure route may exist for any single pathway. For example, a receptor may be exposed to contaminants in surface water through dermal contact and incidental ingestion while swimming. Inhalation of volatile compounds released from water are a third potential exposure route in this scenario, depending on the properties of the contaminant. Multiple receptors may be, and typically are, exposed through a single exposure route. Ingestion of contaminated surface water is as much a concern for terrestrial or aquatic wildlife as for humans.

c. Receptors. Receptors were identified in the Land Use and Exposure Profile, as well as the Ecological and Cultural Resources Profile. The team must consider both human and ecological receptors. Evaluation of actual and potential receptors will consider both current, determined, or reasonably anticipated future land use. In addition, human receptors are typically subdivided into several categories to represent varying degrees of potential exposure. These may include residents, site workers, construction workers, recreational users, and trespassers. The probability, frequency, and duration of each receptor's exposure to the contaminant are assessed in this manner.

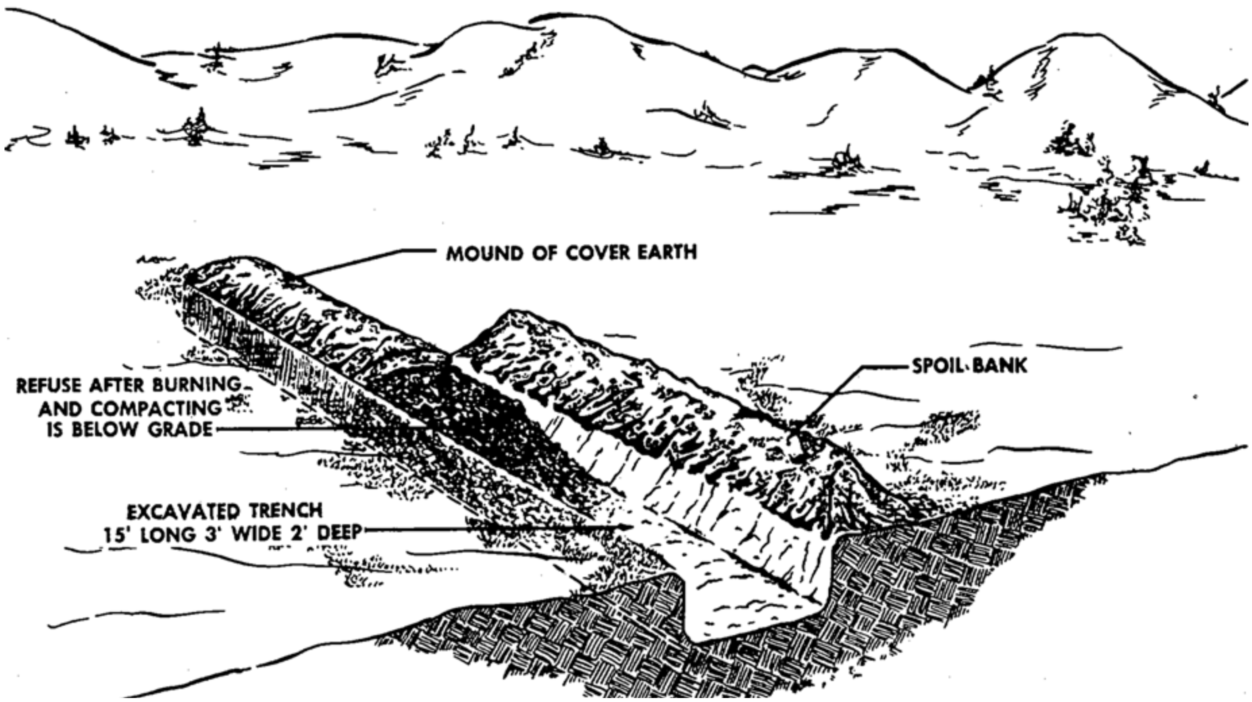

Figure 4-4. Burn-and-Cover Disposal Method (1946, 1958)

APPENDIX A

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A-1. Required References.

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APPENDIX B

Range Operations Overview

B-1. General. When developing a CSM for a former military site it is important for the team to understand the basics of design, operation, and maintenance of training ranges. Different parts of ranges were used for different operations with distinctly different hazards existing at each of these locations. This section presents only an overview of the most important elements of range operations.

B-2. Storage Areas. These are typically located near, but not within, a range. Types of storage areas include permanent or temporary facilities for stockpiling munitions and munitions components. These facilities can include warehouses, bunkers, magazines, or vehicles. Munitions stored in these facilities are normally in their shipping containers or configurations and are seldom fuzed. They represent very little hazard of inadvertent detonation. Though not a normal practice, unwanted or unserviceable munitions were occasionally buried in or near storage areas.

B-3. Firing Points. These are fixed locations or areas where munitions are prepared for use and then fired. Munitions come in many different configurations, but normally include the filler (typically explosive) and a fuzing system to initiate the explosive. In addition, many munitions include a propellant charge designed to propel them to their target. For most munitions, at least two, and often all three of these main components were stored separately. They were only combined and configured for use at the firing point. In many instances, there were excess components, especially propellant, resulting from the use of munitions at firing points. Excess propellants were typically burned near the firing point, and other excess components were either returned to storage, destroyed through burning or detonation, or buried.

B-4. Targets. These are particular locations within a larger impact area where munitions are intended to land and function. Targets can consist of almost anything, including excess military or civilian vehicles, old appliances, wooden or cardboard structures, geographic features, or map coordinates with no defining features. Most munitions fired at a target functioned as intended, and therefore represent no further safety hazard. However, a significant percentage—typically from 1 to 20%—did not function as intended. Either the munitions did not explode at all, or only a part of the filler was consumed when the munitions functioned. When munitions were fired but inadvertently did not function as designed, they are categorized as UXO. UXO can be extremely dangerous and must never be touched by anyone other than trained personnel. Impact areas containing UXO should be regarded as extremely hazardous sites. At many larger range complexes, several ranges may share a common impact area. As indicated by the example in Figure B-1, determination of the MEC hazards in an impact area can be quite complex. Numerous weapons systems firing different types of ammunition over a time have resulted in an impact area that is difficult to characterize. Both MEC hazards and environmental contaminants must be evaluated. UXO (armed or fuzed) and residual MC are likely to be present.

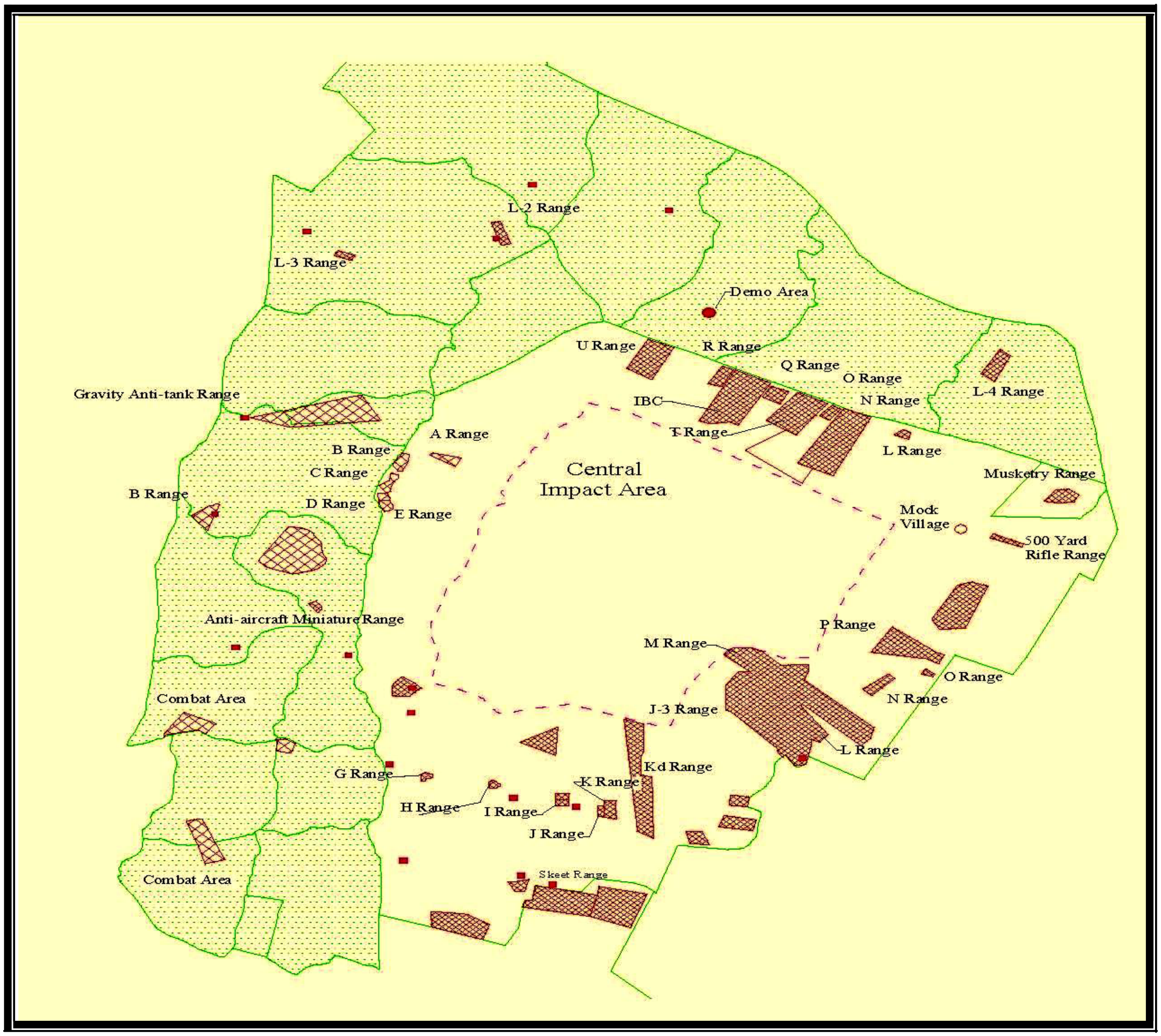

Figure B-1. Typical Range Complex Impact Area

B-5. <u>OB/OD Areas</u>. These are locations where munitions are destroyed. Typically, excess military munitions were destroyed at OB/OD areas. However, UXO from target and impact areas are sometimes moved to OB/OD areas for destruction as well. Basically, UXO can be divided into two groups: those that trained personnel determine are moveable, and those that are determined unsafe to move. Those that are unsafe to move are destroyed where they are found by detonating in place. UXO and other munitions that are determined to be safe to move can be either detonated in place or moved to another location, often an OB/OD facility, for destruction. Because of safety concerns, UXO, whether “safe to move” or not, are never disassembled and their components recovered. Demolition operations are not always effective. Entire munitions, as well as dangerous components, can remain. Like target areas, demolition areas should be regarded as extremely hazardous sites.

APPENDIX C

Development of a Conceptual Site Model for an MRS or HTRW Site

C-1. Introduction. The following is a hypothetical example for demonstration only. It is intended to illustrate how a team might begin the process of developing a CSM for a site with both MMRP and HTRW concerns. The reader is cautioned that CSM development should be based on site-specific parameters and information. For purposes of this Appendix, assume all other FUDS policies and procedures have been followed, there are no concerns regarding releases by other parties, and the following discussion only concerns the development of a CSM. All examples should be assumed to follow all applicable laws, regulations, and DoD, DA, and USACE policies and guidance. Any mistakes or deviations are unintentional.

C-2. Background.

a. Former Camp Swampy was a World War II facility for training of U.S. Army troops. The facility was declared excess in 1956, and in 1957, the property transferred to the local township Industrial Development Authority (IDA). The IDA transferred a small parcel in the southeast corner to a private landowner 2 years later. The remaining property has been subsequently leased to several commercial enterprises for various uses. An ASR conducted in 1993 identified a mortar range and OB/OD area at the former camp (see Figure C-1). Surface clearance had been conducted prior to transfer, and no MEC items were known to remain at the site. In 2001, several explosions were heard during a prescribed burn in a forested area of the former installation. The detonations were suspected to be from mortar rounds on the property. Presented with this information, the IDA contacted the local district of the USACE for assistance.

b. A PM from the geographic District was assigned overall management of the former Camp Swampy investigation. The MMRP project will precede the HTRW investigation. To initiate the project, the PM assembled a team consisting of Ordnance and Explosives safety specialists (OESS), HTRW specialists, state and federal regulators, and representatives from the IDA, business owners, and local landowners at the site. The team's first order of business was to establish goals and objectives of the investigation to follow. One of the objectives was to develop a CSM to capture the source–receptor interactions to guide future data collection efforts. The team gathered all historical information available for the site, including aerial photographs from the operating period of the facility. The team then organized the available information into the following profiles.

C-3. Facility Profile.

a. The team was able to determine current use and ownership of former Camp Swampy from existing information and a site visit. The majority of the 18,000-acre facility is leased from the IDA by a timber products company and used to grow pine trees. The timber products company also sub-leases this land to a local hunting club, which has a cabin on the northern boundary of the property. The acreage is not fenced, but there are locked gates across access roads through the property. The industrial area (the former cantonment area) still has several buildings that are in use at the site, also leased through the IDA. A metal fabrication shop occupies one building, and a grocery storage company uses two warehouses and an office building. A 6-foot tall security fence surrounds the industrial area.

b. An existing map from 1943 for former Camp Swampy revealed the location of both the mortar firing line and the OB/OD area. The actual mortar range dimensions, however, were not documented. The map was updated with information the team had uncovered and is shown as Figure C-1. Because the detonations occurred during a controlled burn at the tree farm, the team hypothesized that cultivation and harvesting of the trees over the years resulted in relocation of MEC items through disturbance of the soil. This activity, and the presence of the planted pines, had obliterated any ground scars that may have once existed at the site.

c. The team obtained a standard range layout for mortar ranges for the 1943–1945 period to establish approximate dimensions for this potential source area (Figure C-2). The team also noted that the standard layout was typically modified to meet site conditions. A typical mortar range has three areas of concern, the firing point (firing line), the impact area, and the danger area. The firing line is assumed to be 75 feet (25 yards) wide and the impact area (target area) is assumed to begin a minimum of 1800 feet (600 yards) from the firing point, continuing downrange the maximum distance of the mortars fired. These dimensions were estimated using an 81-mm HE, M43 mortar as worst case, which has a maximum range of 11,700 feet (3,300 yards). Regulations require that an additional 1800-foot (600-yard) danger area be applied to each side and to the downrange distance. The area of the explosions appeared to be consistent with the range impact area identified by the standard layout.

d. The OB/OD area was defined by operating manuals as a 400-foot diameter circle at the crest of a small hill. During the site visit, the team noted an area of bare, disturbed soil and stressed vegetation in this area. Five distinct mounds were visible that indicated munitions debris burial from the OB/OD operation. The team hypothesized that the potential MEC items included mortars, small arms, smokes, flares, and simulators as both broken and unfunctioned rounds. Munitions debris was noted across the entire area. An accelerant, either gasoline or diesel fuel, was assumed to have been used to initiate the burns.

C-4. Physical Profile.

a. The facility is located in an area of gently rolling hills, with topographic relief of not more than 50 feet. Coastal plain sediments dominate this area, with well-sorted sand being the dominant strata and major component of the soil. The rapid drainage characteristics of this soil make it an excellent medium for growing pine trees, a major industry of the area. In addition to the dense rows of pine trees, most of the acreage also supports thick underbrush that is periodically burned to allow better access to the trees.

b. The team reviewed available state records of residential drinking water wells in the surrounding area and determined that ground water averaged 20–25 feet below ground surface. There are no wells in the former cantonment area, but it was discovered that a shallow water well exists at the cabin, presumably used during the hunting season.

c. A small creek originates about 150 feet southeast of the OB/OD area. Some red staining, thought to be iron oxide, was noted seeping from the creek bank downhill of the OB/OD area. The creek joins a river about 1.5 miles west of the facility. Despite the former camp's name, there are no wetland areas located at the property.

C-5. Release Profile. Using the Facility Profile information, the team identified the source areas as the former mortar range and the OB/OD area. The mortar range was further divided into two areas based on typical use, the hazards associated with that use, and potential source materials. These two areas are the firing line and the impact/target area. The probable locations of all source areas were placed on the site map for later confirmation.

C-6. Land Use and Exposure Profile.

a. The team documented use of the former mortar range as managed forest lands, and the former OB/OD area as currently unused. The on-site population includes workers at the industrial area, but interviews with these personnel indicated that they do not utilize either area during work hours. Timber company workers occupy the areas of concern on those occasions when planting, harvesting, or the controlled burns occur. Recreational use (hunting and hiking) was also noted, although the team has not yet identified the extent of this site use.

b. The surrounding land use is agricultural, with 12 single-family homes located within a 3-mile radius of the property. These residents rely on private wells for their drinking water. The industrial area, however, is serviced by the municipal water supply system. The small creek traversing the site discharges to a river that is used extensively for recreation (boating, swimming, and fishing).

C-7. Ecological and Cultural Resources Profile. The Ecological Profile for former Camp Swampy includes a description of the managed pine forest habitat that occupies most of the acreage. Ecological receptors include game animals (e.g., deer, turkeys) and other terrestrial animals. Fish and other aquatic organisms inhabit the down-stream river, which serves as a popular recreation area. No threatened or endangered species are known to utilize the area and no cultural resources are known or suspected to be on-site.

C-8. Pathway Analysis. Analysis of the profile information should allow the team to identify all source – receptor interactions (exposure pathways) for the site. For MEC, a pathway must include a source, access, activity, and a receptor. Each pathway for HTRW must include a source, an exposure medium, an exposure route, and a receptor. The pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air), if the point of exposure is not at the same location as the source. In preparation for the CSM, the team compiled the following.

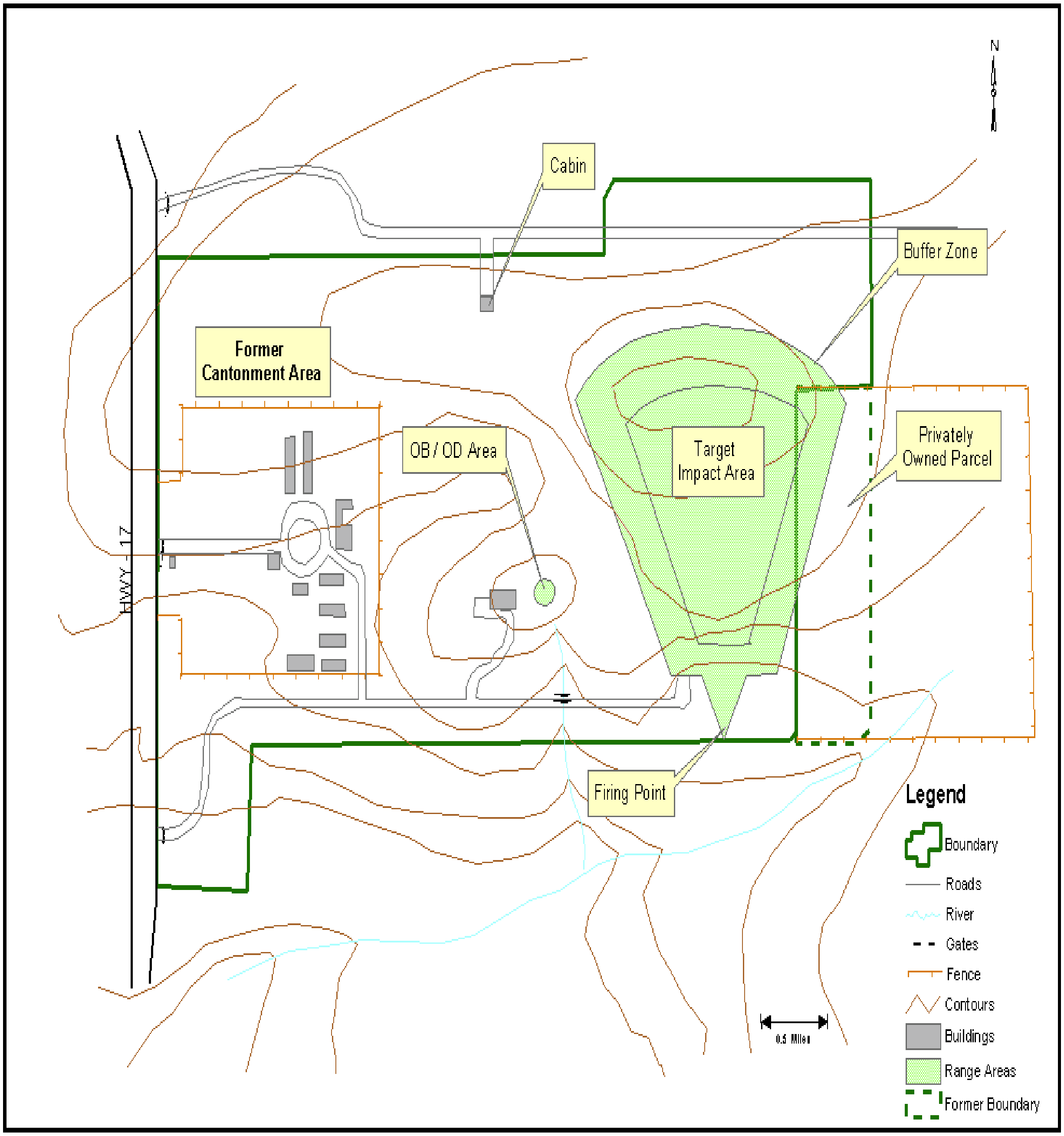

Figure C-1. Preliminary Site Map

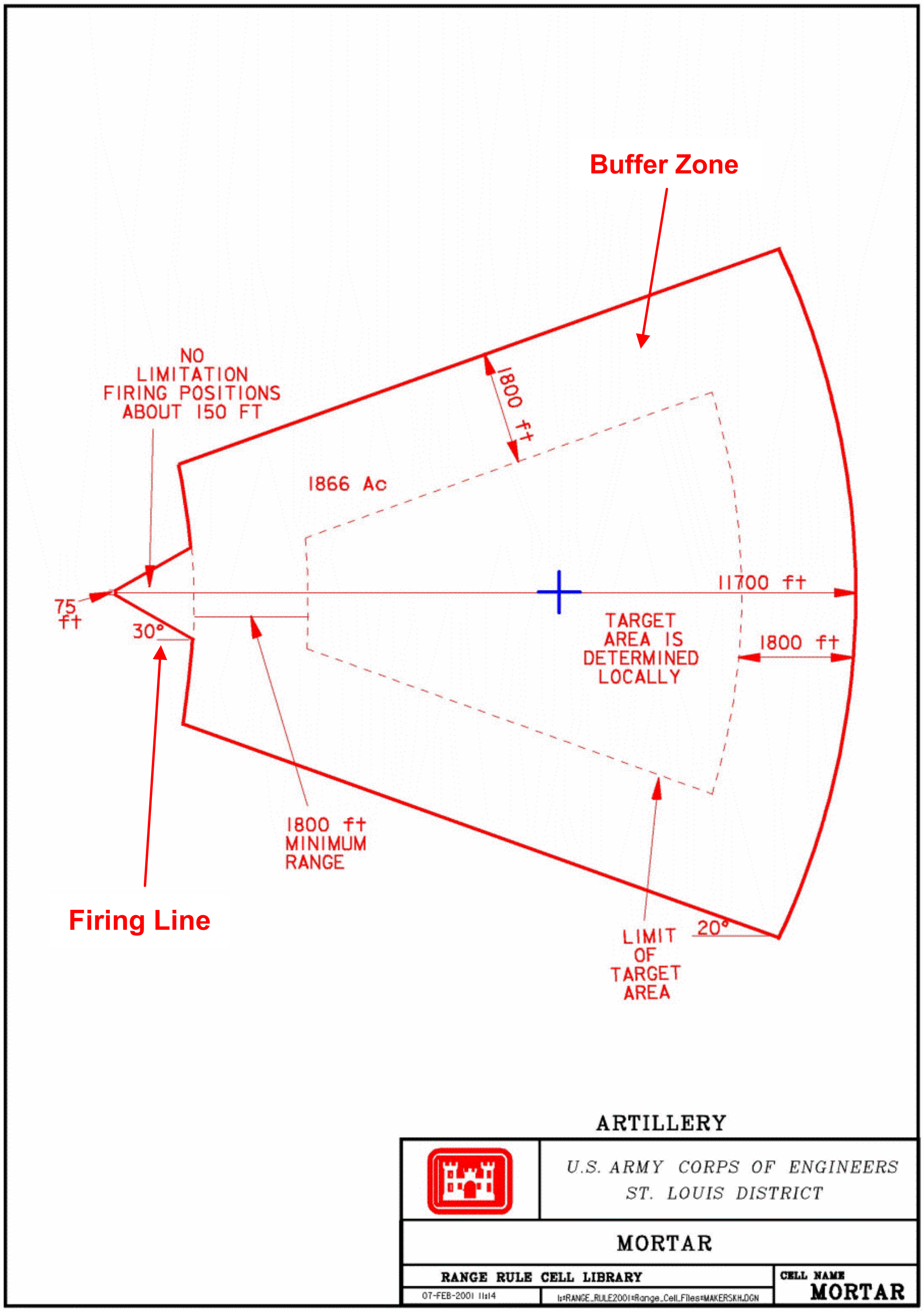

Figure C-2. Mortar Range

C-9. MEC Sources. Three source areas were identified. They are the firing line at the mortar range, the mortar impact area, and the OB/OD area. DMM may have been buried at the firing point, and is expected in both surface and subsurface soils at the impact area and OB/OD area. The exposure media for the mortar range areas are expected to include surface and subsurface soils, as well as ground water from leaching of the MC and accelerants. The same exposure media are expected for the OB/OD area. Additionally, the bare soils at this area make releases to air a potential, as well as releases to surface water and sediments in the nearby creek.

I

The firing line was hypothesized to potentially contain a burn area and burial pits. A burn area was common during training to dispose of excess propellant charges from the mortars. Disposal pits were another concern to the team. An uncommon but potential practice was to bury unused munitions near the firing point, rather than return these to the Ammunition Supply Point. This type of unsanctioned burial usually would occur near the firing point. The potential for DMM buried at the firing line to function is low because the expected items are probably unfuzed, and if fuzed, would not have been subjected to the forces required to arm the fuzes.

II

The impact area is suspected of having a serious explosive safety hazard from UXO resulting from dud-fired rounds or incomplete detonation. The team will evaluate site conditions to determine the expected depth of penetration of MEC at the impact area.

III

The OB/OD area is identified as a third source area at the site. Probable source materials at this area include all types of munitions used at the installation (e.g., mortars, small arms rounds, smokes, and flares), due to kick-outs during operations. The potential for MEC items functioning was also noted as low because the expected items are probably unfuzed, and if fuzed, would not have been subjected to the forces required to arm the fuzes.

a. Interaction*.* The source–receptor interactions for an MRS requires access and activity.

(1) Access. Currently, access to the source areas is unlimited. Future access restrictions are unlikely as well, as the reasonable future site use is expected to remain the same.

(2) Activity. Current and future activities that can bring receptors into contact with MEC are tree farm activities (cultivation/planting of trees, harvesting of the trees, and conduct of the occasional controlled burns), as well as recreational site use, whereby hunters could contact MEC at the ground surface.

b. Receptors. On-site tree farm workers have the greatest exposure potential since their jobs entail intrusive work. On-site recreational users and off-site residents have the potential for exposure; however, their on-site activities would make it less likely for direct contact with MEC.

C-10. MC and HTRW Sources. Potential MC at the firing line of the mortar range area includes trinitrotoluene (TNT), nitrocellulose, nitroglycerin, dinitrotoluene, as well as fuels and metals. There is the potential for release of HTRW (probably diesel fuel) into the surface and subsurface soils, if any burns were conducted there. The expected contaminants at the impact area include TNT and its breakdown products. The primary HTRW source area is the OB/OD area. Both surface and subsurface soil are expected to contain fuel contamination from an accelerant used to facilitate burns. The team also documented the red staining at the creek so that future site investigations can verify its composition.

a. Interaction*.* The source–receptor interactions at an HTRW site require an exposure medium (or media) and an exposure route.

(1) Exposure Media. Exposure media are those that contain the source, or those media that become contaminated through migration of the contaminant from the source area. The team identified the exposure media to be:

(a) Surface and subsurface soils at the source areas.

(b) Surface water and sediments at the creek (via the red staining at the bank).

(c) Air (via volatilization from surface soils). This would be a minor pathway as the expected accelerants would not be highly volatile.

(d) Ground water (via leaching from surface and subsurface soils).

(e) Food chain (via plant uptake from soils, contaminated fish and wildlife consumption, and contaminated domestic animal consumption).

(2) Exposure Routes. Exposure routes are those processes by which a contaminant or physical agent comes in contact with a receptor. For most environmental contaminants, these processes include ingestion, inhalation, and dermal contact. Ingestion is applicable to all exposure media except air. Dermal contact is applicable to all exposure media except air and food chain. Inhalation is applicable to air, soils, and ground water.

b. Receptors. Current receptors to HTRW contamination are tree farm workers and recreational users (hunters at the cabin).

C-11. Conceptual Site Model. Once the pathway analysis was completed, the team developed a graphic CSM component that integrated the profiles to illustrate all source-receptor interactions at the site. Figure C-3 provides a graphic representation of these interactions for the OB/OD unit, one of the three source areas. This graphic, along with the accompanying profile narrative and maps, form the CSM for this source area.

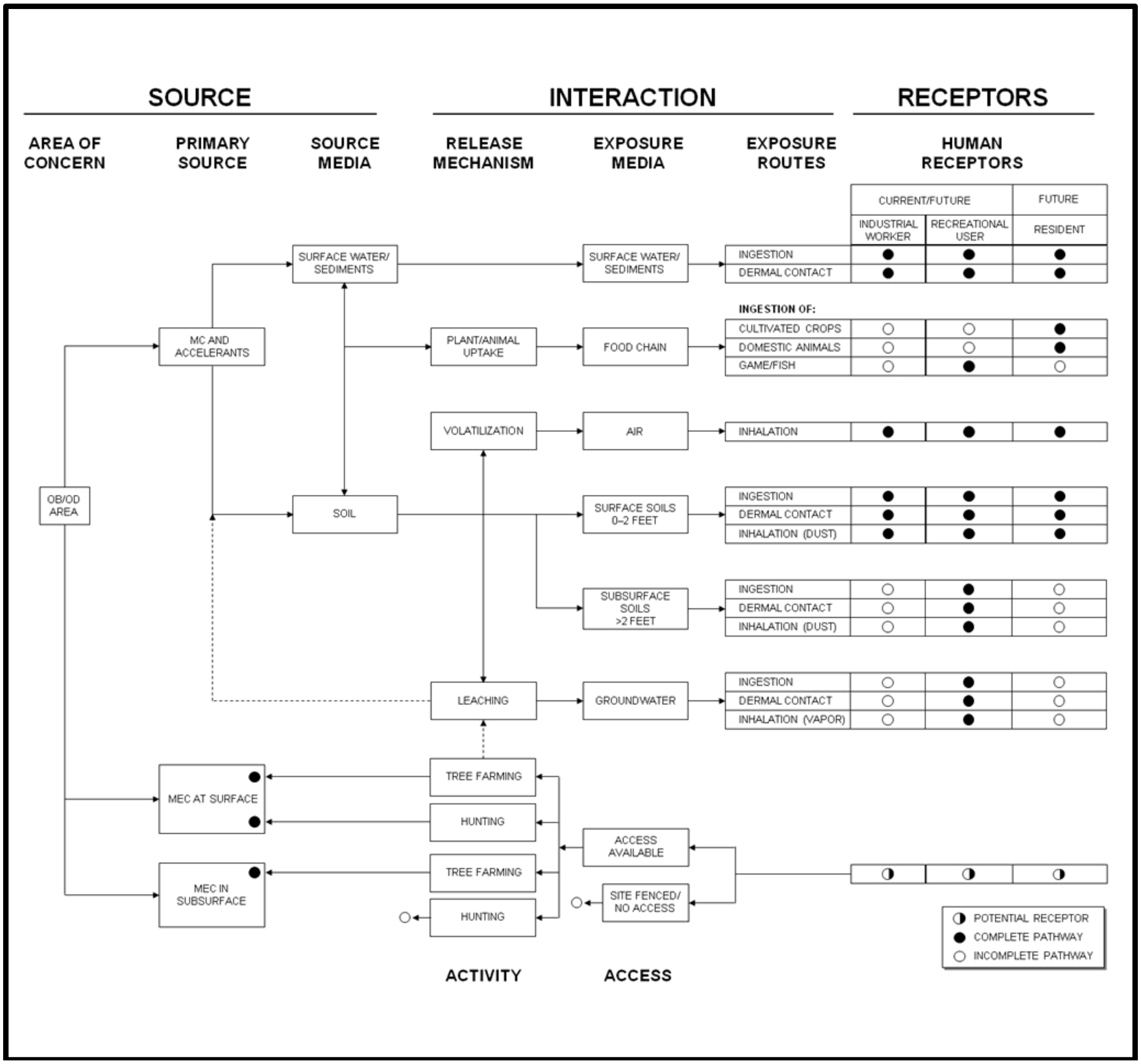

Figure C-3. Source Receptor Relationships for an MRS and HTRW Site

APPENDIX D

Example CSMs

NOTE: All examples should be assumed to follow all applicable laws, regulations, and DoD, DA, and USACE policies and guidance. Any mistakes or deviations are unintentional.

As noted in Section 2-6, the CSM for a site can be represented in various ways. Several examples have been shown throughout the document and several others are shown in this appendix. The first example is a narrative presentation for a site inspection for MEC/MC. The examples that follow show various exposure/migration routes and many will need to be supported to a certain extent by narrative descriptions to provide the complete source- receptor interactions necessary. The following CSMs are provided:

Example 1. Air to Ground Gunnery Range; Narrative Description.

Example 2. Groundwater Contaminant Plume; Degradation Zone Delineation; Pictorial Presentation.

Example 3. Vapor Intrusion; Pictorial Presentation.

Example 4. Geologic CSM; Three-Dimensional Pictorial Presentation.

Example 5. Groundwater Treatment Train CSM; Pictorial Presentation.

Example 6. Potential Impacted Areas; Map Presentation.

Example 7. Benzene Groundwater Plume; Three-Dimensional Pictorial Presentation.

Example 8. Formerly Utilized Sites Remedial Action Program (FUSRAP) Site, Human Health Exposure Model; Graphical Representation.

Example 9. MMRP MEC and MC; Graphical Representation.

Example 10. Human Health Exposure Model; Graphical Representation.

Example 1
Air to Ground Gunnery Range; Narrative Description

Conceptual Site Model – Air to Ground Gunnery Range

Overview:

A site-specific conceptual site model (CSM) summarizes available site information and identifies relationships between exposure pathways and associated receptors. A CSM is used to determine the data types necessary to describe site conditions and quantify receptor exposure, and discusses the following information:

Current site conditions and future land use;

Potential munitions and explosives of concern (MEC) and munitions constituents (MC) sources (e.g., lead projectiles in an impact berm);

Affected media;

Governing fate and transport processes (e.g., surface water runoff and/or groundwater migration);

Exposure media (i.e., media through which receptors could contact site-related MEC and MC);

Routes of exposure (e.g., inhalation, incidental ingestion, and dermal contact); and

Potential human and/or representative ecological receptors at the exposure point. Receptors likely to be exposed to site MEC or MC are identified based on current, determined, or reasonably anticipated future land uses.

The CSM is evaluated for completeness and further developed as needed through Technical Project Planning (TPP) meetings and additional investigation.

Background:

The CSM is based on information presented in the Archives Search Report (ASR) (U.S. Army Corps of Engineers [USACE], 1995) and ASR Supplement (USACE, 2004). The CSM was updated with information obtained during the Site Inspection (SI).

History of Use:

The AGGR was in use from 1942 to 1945. The gunnery range, which was a 2-mile by 6-mile rectangle, was used strictly for target machine-gun firing by bombers. Landowners reported that the site was never used as a bombing range and indicated that Department of Defense (DoD) personnel conducted machine-gun practice from B-17 and B-24 aircraft toward wood frame and canvas covered targets located on ridges and flat pastures.

A typical air-to-ground gunnery range would have aircraft flight paths parallel to the lengthwise property boundary. Targets would be located in the interior of the Formerly Used Defense Site (FUDS) on flat lands or on hill tops. Munitions debris (MD) associated with the flight lines of the bomber aircraft would typically consist of bullet casings, bullet links, and unfired rounds. The 1995 ASR reports a series of nine targets (including a cement stock tank) was established in a line beginning in the southeast corner and extending northward (including one target location outside the FUDS boundary) over a length of approximately 7 miles. Landowners reported that machine-gun strafing occurred throughout the site and up to 1 or 2 miles outside the site boundary. Real estate records indicate that no DoD-installed improvements were constructed on the site. According to landowners, DoD-installed improvements were limited to wood frame targets for machine-gun practice. A local newspaper described a B-24 crash during a training flight over the target area. The area north-east of the FUDS was cleaned up before being disposed of as excess government property. On March 10, 1945, the installation was declared surplus by the War Department. The ASR reports that research and interviews revealed no evidence of chemical warfare material activity or contamination on the AGGR.

Overview of Site Characteristics:

The FUDS site is located within the High Plains section of the Great Plains physiographic province. The upper surface of the site consists of Quaternary deposits consisting of alluvium, loess, and eolian sand that are shaped into complex hills and valleys. The soils of the site are loose fine sand that has rapid permeability, low available water capacity, and low organic matter content. Local vegetation consists of mixed to short prairie grasses.

The site is primarily drained by an intermittent stream that flows generally south and west. The area is quite sandy and significant runoff in surface streams is uncommon.

The former AGGR is underlain by the High Plains aquifer. The High Plains aquifer is a water table aquifer consisting mainly of near-surface sand and gravel deposits of Tertiary and Quaternary age. Current depth to groundwater in wells at the FUDS ranges from 18 to 85 feet (ft) below ground surface (bgs).

Munitions and Associated MC:

The munitions associated with the air-to-ground gunnery range consisted of .50-caliber small arms ammunition, which generally included a combination of ball and tracer rounds. Projectiles from an air-to-ground gunnery range are generally concentrated within the vicinity of the former gunnery targets, although projectiles can be found beyond the target areas. Spent casings, bullet links and unfired rounds would typically be found under the flight lines on the northern and southern boundaries of the FUDS.

Previous MEC Finds:

The only reported previous MEC finds at the FUDS were unfired .50-caliber rounds (including a partial belt found by a landowner and one live round in a field) observed during the 1995 ASR site visit. Landowners and USACE personnel have observed MD in the form of .50-caliber casings.

Previous MC Sample Results:

No prior sampling for MC at the FUDS is known.

Current and Future Land Use:

The current, determined, or reasonably anticipated future use for the former AGGR is for agriculture. All of the properties are owned by private individuals. The typical fencing and “No Trespassing” signs provide a degree of restriction to access by the public. Parcels outside of the southeast area of the FUDS are part of the Nebraska Conservation Reserve Program- Management Access Program, which is a wildlife/game management program.

Sensitive Environments:

Two small wetlands are present within the AOC, qualifying the site as an Important Ecological Place (IEP), based on a review of the Army Checklist for Important Ecological Places (USACE, 2006). Therefore, ecological receptors are considered potential receptors for migration pathways at the AGGR. Land outside of the southeast area of the FUDS is part of a wildlife/game management area.

MEC Evaluation:

This section provides an evaluation of the potential MEC associated with the munitions formerly used at the range.

Types of MEC:

Historical evidence indicates that .50-caliber (ball and tracer type) small arms ammunition was used at the range.

Human Receptors:

The FUDS has been privately owned since the DoD terminated leases and relinquished the land. Some residential homes are located within or adjacent to the property. Individual land parcels are segregated by barbed-wire fencing, primarily to control the movement of livestock. Gates are not locked and do not provide an effective barrier preventing human access. Potential human receptors include agricultural workers, ranchers, and hunters.

Route of Exposure:

The potential routes of human exposure to MEC or MD would be by digging activities such as drilling, trenching, road building, or soil tilling.

MEC Risk Assessment:

There is no explosive hazard associated with MD derived from the .50-caliber ammunition used at this range. The projectiles contain no explosive components, and, therefore, pose no explosive risk. The tracer mixture associated with .50-caliber tracer projectiles is not explosive.

Complete .50-caliber rounds contain smokeless powder propellant charges and primers. Tampering with complete cartridges could result in injury as a result of firing of primers, which could cause burns. Considerable force would be necessary to discharge a live round, if found. Therefore, although some unfired small arms ammunition may be found, it is not considered to present a significant explosive hazard.

MC Pathway Evaluation:

This section provides an evaluation of the potential MC associated with the munitions formerly used at the range. Small arms munitions are considered to be the source of MC of potential concern at the AOC. In addition, other constituents associated with the former munitions activity that lack the potential for a significant release that would threaten human health or the environment are discussed below.

Potential exposure media at the air-to-ground gunnery range include soil/sediment and groundwater.

Types of MC:

This section provides an evaluation of the potential MC associated with the munitions formerly used at the range.

Metals:

The projectiles, casings, and tracer, igniter, and primer compositions of the ammunition used contain several metals. The highest concentrations of source metals from munitions activity are anticipated where projectiles and/or casings may have accumulated at the ground surface. The metals potentially constituting a significant source include lead and antimony (from the alloy forming the body or point filler of various .50-caliber projectiles) and copper and zinc (from brass cartridge casings).

Other metals associated with ammunition are unlikely sources of a release. Iron, the principal constituent of steel in some projectiles and casings, is non-hazardous and relatively immobile. Nickel may have been a minor constituent of the jacketing material on some projectiles but would be present in small quantities in comparison to other metals (lead, antimony, and copper). Other metals, present in primer, tracer, and igniter compositions, were present in small quantities and widely dispersed from scattered aerial firing positions.

Perchlorate:

Perchlorate may have been present in some tracer compositions used with .50-caliber ammunition at the range. Therefore, the potential presence of perchlorate was addressed in the SI.

Explosives:

The propellant used in .50-caliber rounds consisted primarily of nitrocellulose. Small amounts of nitrogen-based explosive compounds, such as dinitrotoluene or nitroglycerine, were present in some formulations that may have been used. Some primers contained pentaerythritol tetranitrate in addition to metallic compounds. However, fixed small arms ammunition discharged from aerial firing positions or occasionally dropped to the ground surface poses little possibility for a significant release of propellant. Therefore, a significant source of explosives is not considered to be present at the AOC.

Soil Exposure (Terrestrial) Pathway

Sources of MC:

Aircraft fired .50-caliber rounds at wood- or canvas-covered targets on the ground. The MC from this operation include metals associated with .50-caliber munitions, which may have included steel and/or lead core bullets.

Potential MC of concern in bullets and casings include lead, copper, antimony, and zinc. Tracer rounds used with .50-caliber ammunition may have contained small amounts of perchlorate. Surface soil sample results from the SI indicate that zinc and copper exceeded background threshold levels at some biased sample locations. Perchlorate was not analyzed in surface soils; perchlorate was not expected to persist in surface soils due to high mobility.

Exposure Pathway:

Soil is the medium directly affected by munitions activity. Metals are likely to remain sorbed to soil at high concentrations. Perchlorate is likely to have migrated due to its mobility in water.

Land Use and Access:

Most of the site is used for grazing livestock. A portion of the site is used for raising crops. Access to the lands is limited somewhat by fencing and gates. Wetlands areas are located within the AOC boundary. It is anticipated that the land use in the future will remain the same.

Human Receptors:

Potential human receptors of MC are property owners, agricultural workers, and hunters who may be exposed to contaminated soil from dermal contact, ingestion, and inhalation of soil particles during intrusive work. For purposes of human health risk screening, residential screening values are used as the most conservative case, since the objective of the SI is to evaluate the MRS for NDAI with no land use restrictions.

Human Health Assessment:

Because there are potential human receptors, and metals have been found in soil at concentrations above background, the soil exposure pathway is considered to be complete. The results from sampling do not exceed human health screening values.

Ecological Assessment:

Area wildlife comprise potential ecological receptors, particularly at two small wetlands located within the AOC. The soil exposure pathway for ecological receptors is potentially complete due to the presence of metals in soil at concentrations exceeding background and ecological screening values. However, stakeholders have agreed that the scattered and isolated soil exceedances do not pose a significant MC hazard to ecological receptors.

Surface Water Pathway

Sources of MC:

The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) from soil to the surface water pathway. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting surface water transport media.

Migration Pathway:

The creek is an intermittent stream that runs in a north and south direction through the site. The area is composed of deep excessively drained, permeable soils where surface runoff is uncommon.

Surface Water Use and Access:

Surface water is not used for drinking water within or near the FUDS.

Human Receptors:

Human exposure to surface water and sediment would generally be limited to incidental contact along the intermittent stream. Because the stream is intermittent, exposure to sediment is more likely than exposure to surface water. Therefore, potential exposure of human receptors (property owners, agricultural workers, and hunters) is limited to sediment.

Human Health Assessment:

Surface water was not observed in either sediment sample location, thus no surface water samples were taken. The surface water pathway is considered to be incomplete.

Ecological Assessment:

Ecological receptors are potentially present because wetlands are present on the site. Surface water was not observed in either sediment sample location, thus no surface water samples were taken. The surface water pathway is considered to be incomplete.

Sediment Pathway

Sources of MC:

The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) from soil to the sediment pathway via surface water flow. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting sediment.

Migration Pathway:

The creek is an intermittent stream that runs in a north and south direction through the site. The area is composed of deep excessively drained, permeable soils where surface runoff is uncommon.

Sediment Use and Access:

Sediment in the bed of the intermittent stream is accessible but is not used for any known purposes.

Human Receptors:

Human exposure to sediment would generally be limited to incidental contact along the intermittent stream. Because the stream is intermittent, exposure to sediment is more likely than exposure to surface water. Therefore, potential exposure of human receptors (property owners, agricultural workers, and hunters) is limited to sediment.

Human Health Assessment:

Sediment sample results did not exceed background threshold levels, and the sediment pathway is considered to be incomplete.

Ecological Assessment:

Ecological receptors are potentially present because wetlands are present on the site. Sediment sample results did not exceed background threshold levels, and the sediment pathway is considered to be incomplete.

Groundwater Pathway

Sources of MC:

The SI evaluated potential migration of metals (lead, copper, antimony, and zinc) and perchlorate from soil to the groundwater pathway. The presence of zinc and copper in soil at concentrations above background indicates a source potentially impacting the groundwater transport medium.

Migration Pathway:

Depth to groundwater is approximately 18 to 85 ft bgs at the FUDS. The direction of groundwater flow is to the southwest. Groundwater samples were not collected in the vicinity of the soil source area.

Groundwater Use and Access:

Registered agricultural wells are located on the FUDS. Registered domestic groundwater wells are located within 1-2 miles southwest (downgradient) of the FUDS. Additional unregistered wells may be present in the area.

Human Receptors:

Exposure of property owners and agricultural workers to groundwater from agricultural wells would be very limited. The potential human routes of exposure are ingestion, direct contact, and Residents using domestic wells as a water supply are the potential human receptors near the site.

Human Health Assessment:

Groundwater samples were collected for the SI from three domestic wells located downgradient of potential source soils. Groundwater sample results did not exceed background threshold levels. Because the potential points of human exposure were unaffected, the groundwater pathway is incomplete.

Air Pathway:

Inhalation of MC in vapor form is not a pathway of concern for non-volatile MC under normal environmental conditions, and the air migration pathway is incomplete. Potential inhalation of soil particles is considered in the development of health-based screening values for soil, which were not exceeded.

Summary

Presence of MEC:

No significant explosive hazard is posed by former use of the range for air-to-ground gunnery involving small arms ammunition.

Presence of MC:

No surface soil sample results exceeded human health screening values, and no sediment or groundwater samples collected exceeded background threshold levels. Surface soil sample results indicate that zinc and copper exceeded background threshold levels and ecological screening levels. Stakeholders have agreed that the scattered and isolated soil exceedances do not pose a significant MC hazard to ecological receptors.

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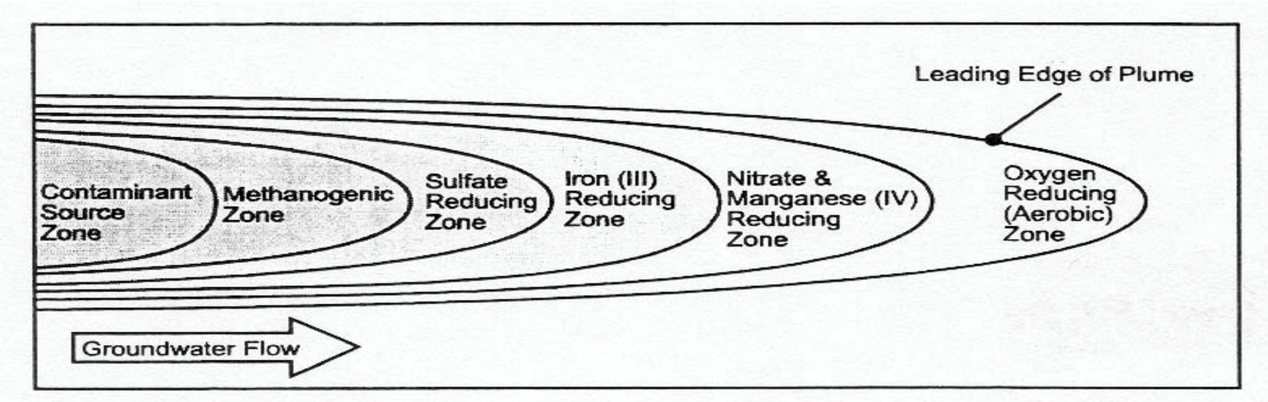
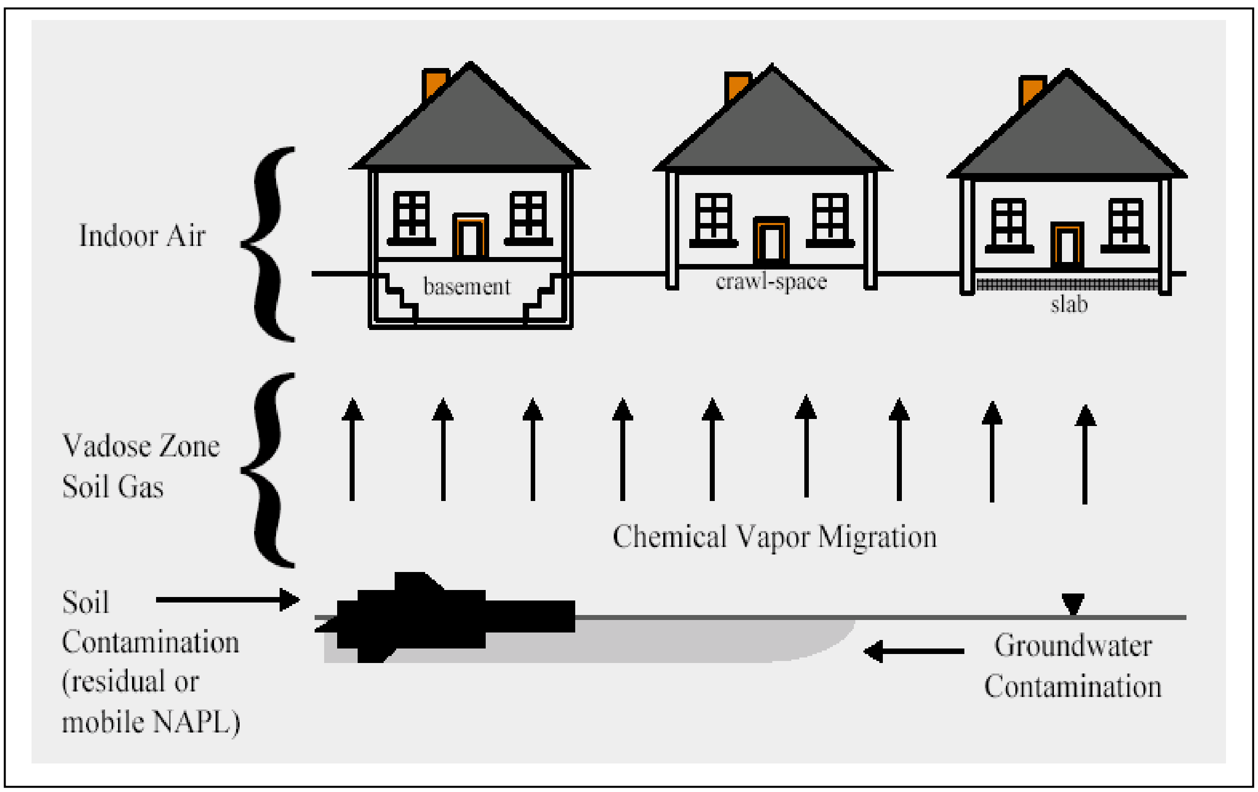
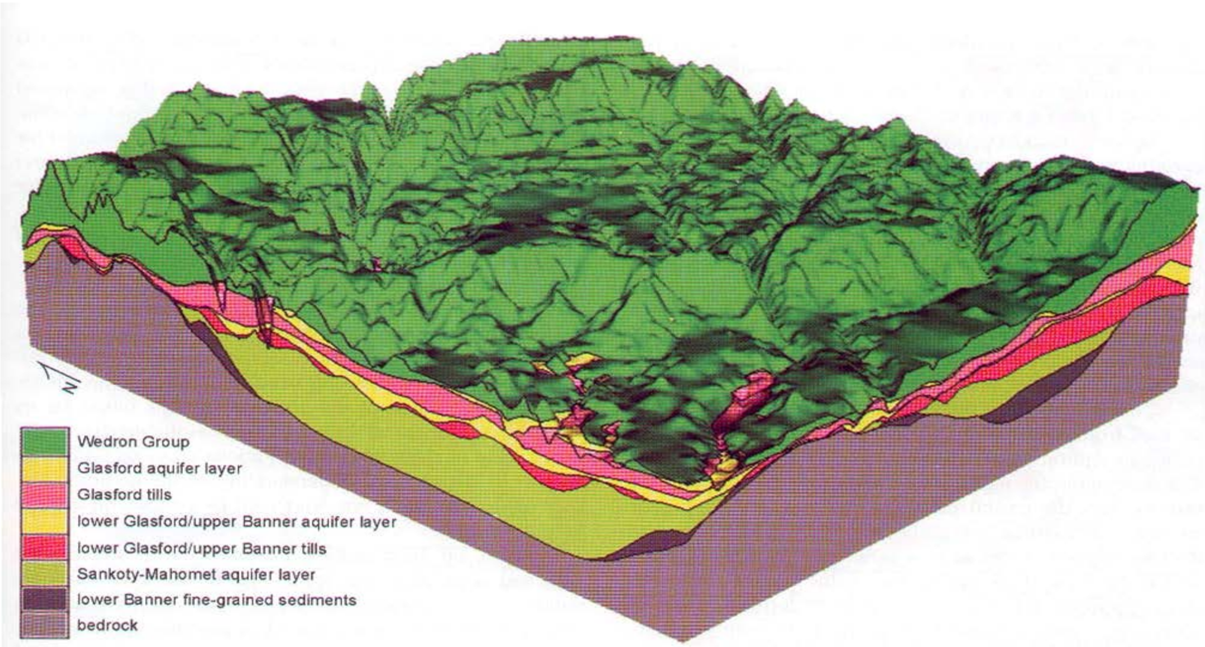


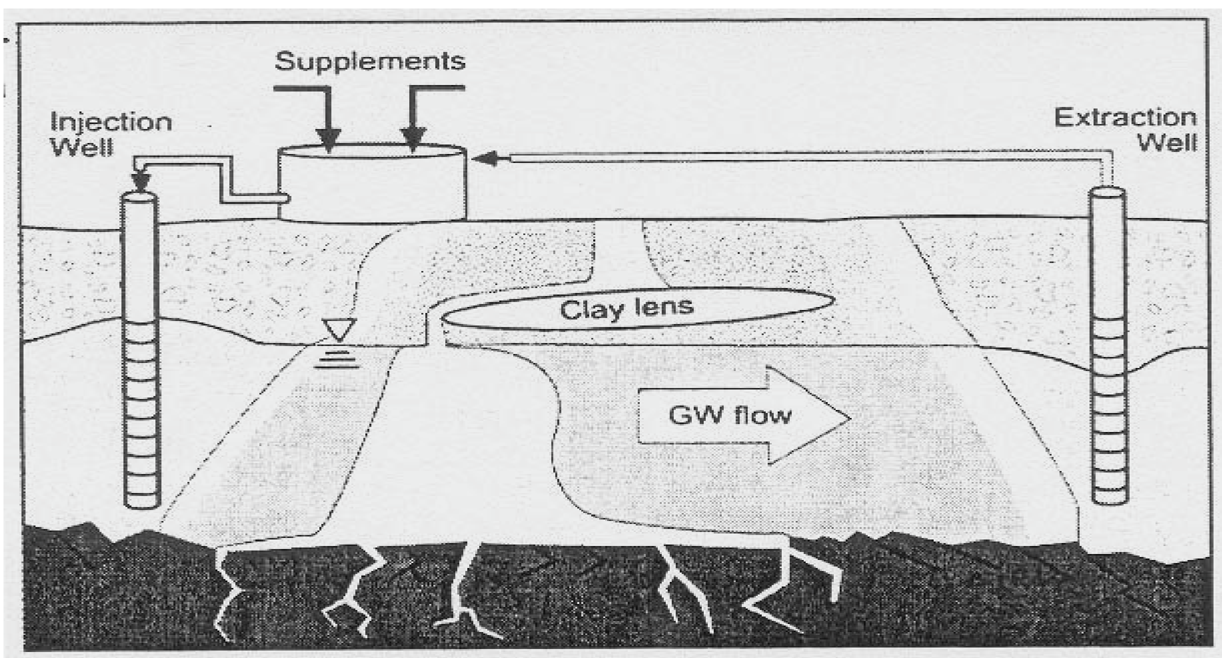
Example 2. Groundwater Contaminant Plume, Degradation Zone Delineation; Pictorial Presentation



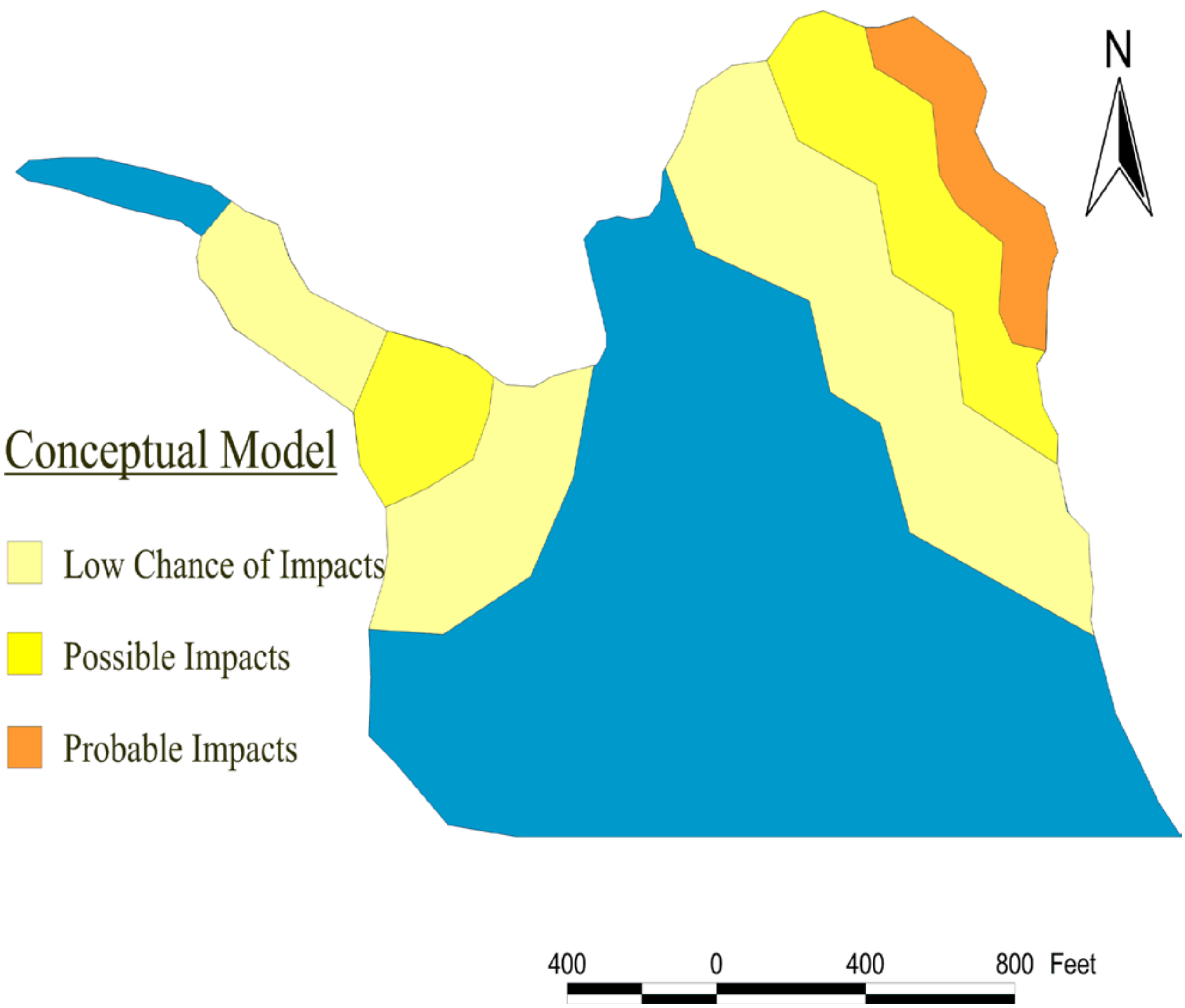
Example 3. Vapor Intrusion CSM; Pictorial Presentation



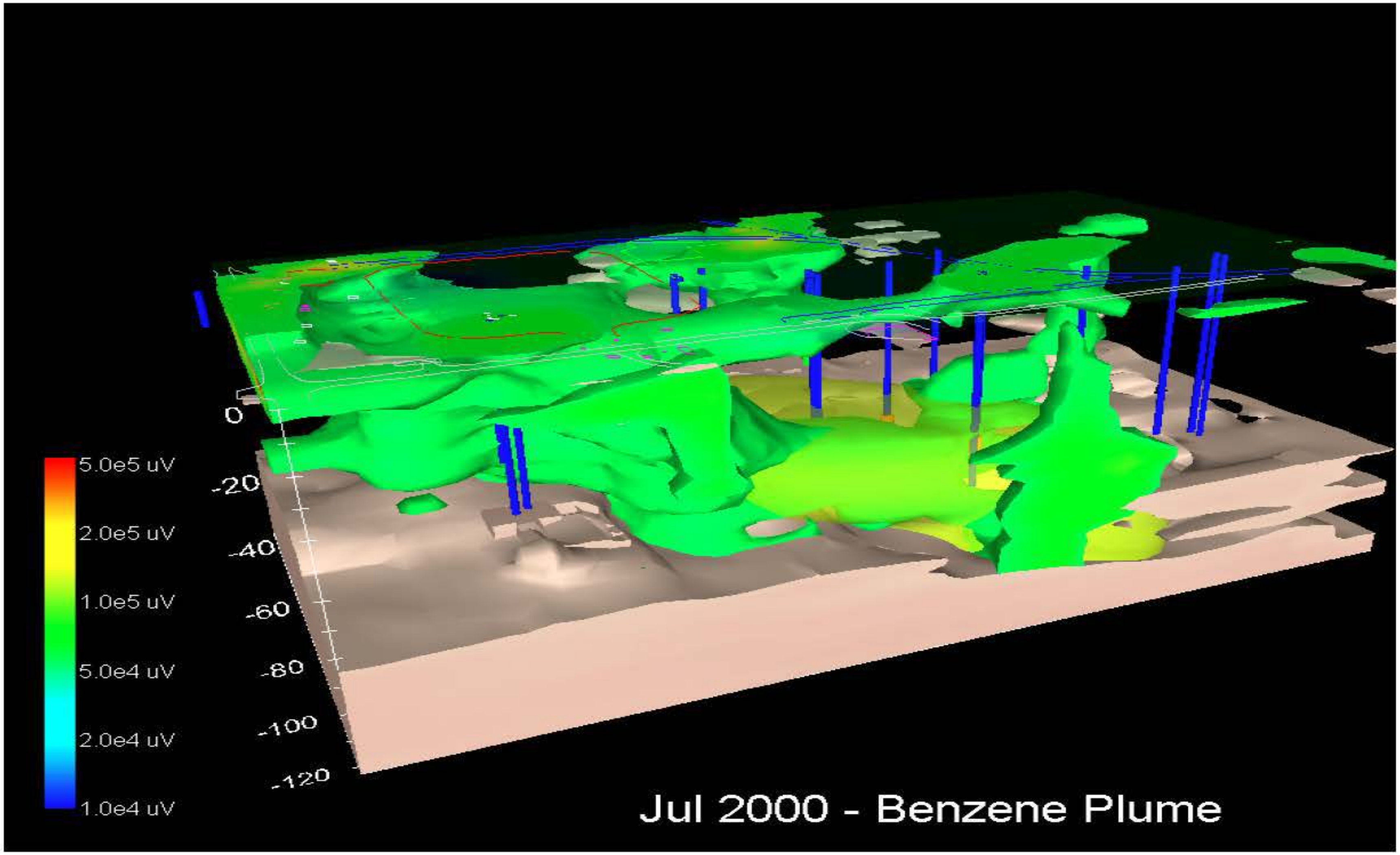
Example 4. Geologic CSM; Three-Dimensional Pictorial Presentation



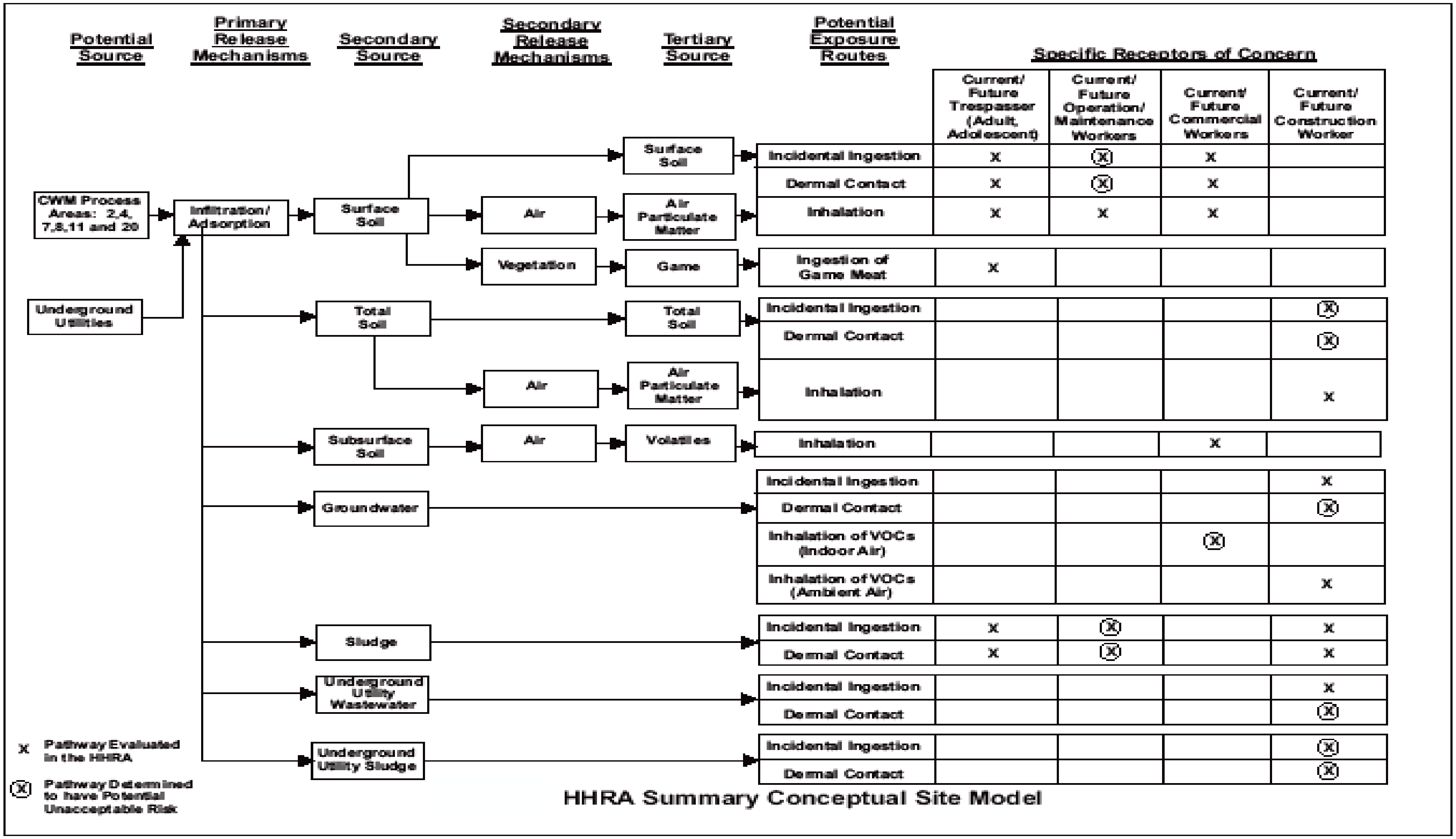
Example 5. Groundwater Treatment Train CSM; Pictorial Presentation



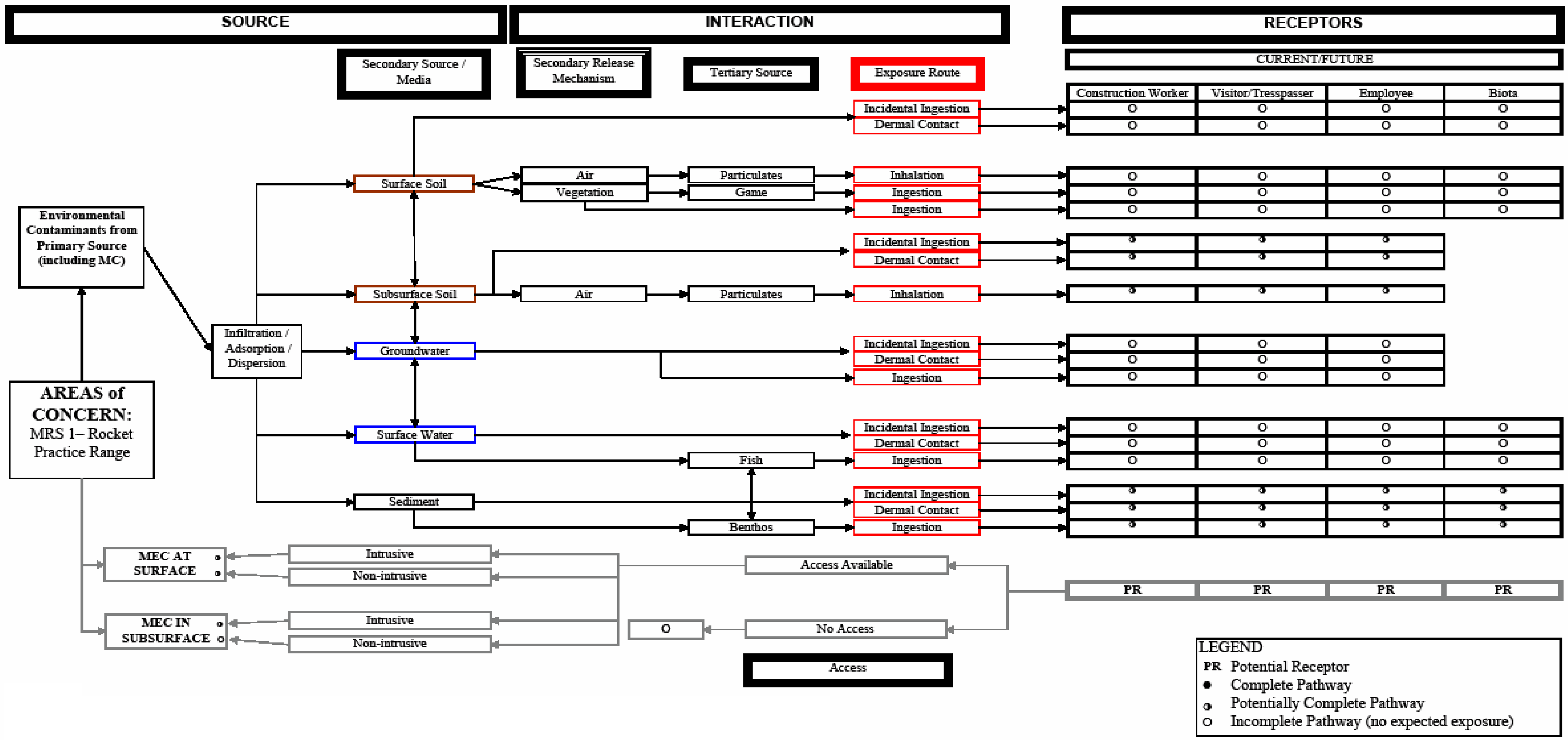
Example 6. Potential Impacted Areas CSM; Map Presentation



Example 7. Benzene Groundwater Plume; Three-Dimensional Pictorial Presentation



Example 8. Formerly Utilized Site Remedial Action Program (FUSRAP) Site, Human Health Exposure Model; Graphical Representation



Example 9. MMRP MEC and MC CSM, Graphical Representation

Potential Sources	Primary Release Mechanism	Environmental Transport Medium	Exposure Pathways	Potential Receptors: Commercial/ Industrial Worker	Construction/ Utility Worker	Maintenance Worker	Recreational/ Trespasser	Resident (Adult and Child)
Contaminated Soil	Infiltration/ Percolation	Ground Water	Ingestion	✓				✓
			Inhalation					✓
			Dermal					✓
	Surface Runoff	Surface Water	Inhalation				✓	✓
			Dermal				✓	✓
		Sediment	External Gamma	✓		✓	✓	✓
			Ingestion	✓			✓	✓
			Inhalation	✓			✓	✓
			Dermal	✓			✓	✓
		Direct Contact	Ingestion	✓	✓	✓	✓	✓
			Dermal	✓	✓	✓	✓	✓
			External Gamma	✓	✓	✓	✓	✓
	Particulate/ Gaseous Emission	Air	Inhalation	✓	✓	✓	✓	✓
Contaminated Building Surface			External Gamma	✓	✓			✓
	Particulate/ Gaseous Emission	Air	Inhalation	✓	✓			✓

Example 10. Human Health Exposure Model; Graphical Representation

GLOSSARY

Section I
Abbreviations

ASR	Archives Search Report
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSM	Conceptual Site Model
DMM	Discarded Military Munitions
DoD	U.S. Department of Defense
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EM	Engineering Manual
EM CX	USACE Environmental and Munitions Center of Expertise
EOD	Explosive Ordnance Disposal
ER	Engineer Regulation
FUDS	Formerly Used Defense Site
GIS	Geographical Information Systems
HRS	Hazard Ranking System
HQUSACE	Headquarters U.S. Army Corps of Engineers
HTRW	Hazardous, Toxic, and Radioactive Waste
IDA	Industrial Development Authority
LIDAR	Light Detection and Ranging
LTM	Long-Term Monitoring
MC	Munitions Constituents
MEC	Munitions and Explosives of Concern
MMRP	Military Munitions Response Program
MRA	Munitions Response Area
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
O&M	Operation and Maintenance
OB/OD	Open Burning/Open Detonation
OESS	Ordnance and Explosives Safety Specialist
PA	Preliminary Assessment
PM	Project Manager
RAO	Remedial Action Objective
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study

RRSE	Relative Risk Site Evaluation
SI	Site Inspection
SPP	Systematic Planning Process
TNT	Trinitrotoluene
TPP	Technical Project Planning
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance

Section II
Terms

Access

The ability of a receptor to enter a source area.

Activity

Any action by a receptor that may result in direct contact with individual MEC items in the source area. Activity considers intrusiveness, intensity and frequency of those actions

Archives Search Report (ASR)

An ASR is an evaluation of past munitions activities at an installation. The purpose of an ASR is to assemble historical records and available data and assess potential ordnance presence. Will be no longer a stand-alone document, and will be part of the preliminary assessment.

Conceptual Site Model (CSM)

The CSM is a description of a site and its environment that is based on existing knowledge. It describes sources of MEC or HTRW at a site; actual, potentially complete, or incomplete exposure pathways; current, determined, or reasonably anticipated future land use; and potential receptors. The source–receptor interaction is a descriptive output of a CSM. The CSM serves as a planning instrument, a modeling and data interpretation aid, and a communication device among the team.

Data Quality Objective (DQO)

DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. They are project-specific statements that describe the intended data use(s), the data need requirements, and the means to achieve them (sampling and analysis) for each data point. DQOs become the formal documentation of the data quality requirements. (EM 200-1-2, EPA/240/B-06/001)

<u>Discarded military munitions (DMM)</u>

Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(2))

<u>Exposure</u>

Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, organs) and available for absorption. (EPA/540/1-89/002)

<u>Exposure Pathway</u>

The course a chemical or physical agent takes from a source to an exposed organism. An expo sure pathway describes a unique mechanism by which an individual or population is exposed to chemical or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air), or media, also is included. (EPA/540/1-89/002)

<u>Exposure Point</u>

A location of potential contact between an organism and a chemical or physical agent. (EPA/540/1-89/002)

<u>Exposure Route</u>

The way a chemical or physical agent comes into contact with an organism (e.g., ingestion, inhalation, dermal contact). (EPA/540/1-89/002)

<u>Interaction</u>

Ways that receptors come into contact with a source. Interaction between the receptor and a MEC item has two components access and activity. Access is the ability of a receptor to enter the area. Activity is any action by a receptor that may result in direct contact with individual MEC items in the source area. The source–receptor interaction for MC or HTRW requires two components an Exposure Medium and an Exposure Route. A release mechanism and transport medium may also be present if exposure occurs at other than the source area.

<u>Light Detection and Ranging (LIDAR)</u>

Surveying performed from an aircraft platform. LIDAR surveying allows generation of digital terrain models. With proper processing, the elevation data collected by a LIDAR survey may identify targets and range areas that may not be discernible on standard aerial photography. Surveying is possible during day or night or at any sun angle, and may even be flown during overcast conditions if the ceiling is above the aircraft. Surveys may be performed over large areas in a much shorter time frame than on-the-ground survey crews. Data can be collected on active range and training areas without requiring access to the range.

Material Potentially Presenting an Explosive Hazard (MPPEH)

Material potentially containing explosives or munitions (e.g., munitions containers and packaging material; munitions debris remaining after munitions use, demilitarization, or disposal; and range-related debris); or material potentially contaminated with a high enough concentration of explosives such that the material presents an explosive hazard (e.g., equipment, drainage systems, holding tanks, piping, ventilation ducts) associated with munitions production, demilitarization or disposal operations. Excluded from MPPEH are munitions within DoD's established munitions management system and other hazardous items that may present explosion hazards (e.g., gasoline cans, compressed gas cylinders) that are not munitions and are not intended for use as munitions. (OASA(I&E) Memorandum, 28 October 2003, Subject: Definitions Related to Munitions Response Actions.)

Media

Air, surface water, sediment, soil, and ground water are the most common types of environmental media at a site. Media can be any naturally occurring environmental material that can be affected by contamination at a site.

Military Munitions

All ammunition products and components produced for or used by the U.S. armed forces for national defense and security, including ammunition products or components under the control of the Department of Defense, the Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes and incendiaries, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. The term does not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components, except that the term does include non-nuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under the Atomic Energy Act of 1954 (42 USC 2011, et seq.) have been completed. (10 USC 2710(e)(3)(A))

Military Range

Designated land and water areas set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas. (Military Munitions Rule, 40 CFR 266.201).

Munitions and Explosives of Concern (MEC)

This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means:

(a) unexploded ordnance (UXO), as defined in 10 USC 2710 (e)(9);

(b) discarded Military Munitions (DMM), as defined in 10 USC 2710 (e)(2); or

(c) Munitions constituents (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard.

Munitions Constituents (MC)

Any materials originating from unexploded ordnance, discarded military munitions, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 USC 2710(e)(4))

Munitions Debris

Remnants of munitions (e.g., penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization or disposal. (OASA(I&E) Memorandum, 28 October 2003, Subject: Definitions Related to Munitions Response Actions.)

Munitions Response

Response actions, including investigation, removal and remedial actions to address the explosives safety, human health, or environmental risks presented by UXO, DMM, or MC. (32 CFR Part 179)

Munitions Response Area (MRA)

Any area on a defense site that is known or suspected to contain UXO, DMM, or MC. Examples include former ranges and munitions burial areas. A munitions response area is comprised of one or more munitions response sites. (32 CFR Part 179)

Munitions Response Site (MRS)

A discrete location within a MRA that is known to require a munitions response. (32 CFR Part 179)

Munitions Response Site Prioritization Protocol (MRSPP)

The Munitions Response Site Prioritization Protocol (MRSPP) is in 32 CFR Part 179. The MRSPP implements the requirement established in section 311(b) of the National Defense Authorization Act for Fiscal Year 2002 for the DoD to assign a relative priority for munitions responses to each location in the Department's inventory of defense sites known or suspected of containing UXO, DMM, or MC. The rule was effective October 5, 2005.

Project Objectives

Project objectives are the short- and long-term site issues to be addressed and resolved at a site. Satisfying or resolving the project objectives, based on the underlying regulations or site decisions, is the purpose of all site activities. Most project objectives are a consequence of the governing statutes and applicable regulations. (EM 200-1-2)

Range-Related Debris

Debris, other than munitions debris, collected from operational ranges or from former ranges (e.g., targets). (OASA(I&E) Memorandum, 28 October 2003, Subject: Definitions Related to Munitions Response Actions.)

Receptor

A receptor is an organism (human or ecological) that contacts a chemical or physical agent.

Source

Sources are those areas where MEC, MC or HTRW has entered (or may enter) the physical system.

Stakeholders

Individuals and organizations that are involved in or may be affected by the project.

Systematic Planning Process

Systematic planning is a planning process that is based on the scientific method. It is a common sense approach designed to ensure that the level of detail in planning is commensurate with the importance and intended use of the data, as well as the available resources Systematic planning is important for the successful execution of all activities at HTRW and MEC sites. The Data Quality Objectives process is one of the formalized processes of systematic planning.)

Technical Project Planning (TPP) Process

The process for designing data collection programs at MMRP and HTRW sites. The TPP process helps ensure that the requisite type, quality, and quantity of data are obtained to satisfy project objectives that lead to informed decisions and site closeout. The four-phase TPP process is a comprehensive and systematic planning process that will accelerate progress to site closeout within all project constraints. The TPP process can be used from investigation through closeout at small, simple sites, as well as large, complex sites. The TPP process is a critical component of the USACE quality management system that meets the American National Standard Institute for planning collection and evaluation of environmental data. The TPP process is documented in EM 200-1-2, Technical Project Planning (TPP) Process.

Unexploded Ordnance (UXO)

Military munitions that (a) have been primed, fused, armed, or otherwise prepared for action; (b) have been fired, dropped, launched, projected or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and (c) remain unexploded either by malfunction, design, or any other cause. (10 USC 2710 (e)(9))