PRINCIPLES OF ENVIRONMENTAL RESTORATION AND THEIR APPLICATION TO STREAMLINING INITIATIVES

U.S. Army Environmental Center

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Principles of Environmental Restoration
and Their Application
to Streamlining Initiatives

Introduction

◆Introduction to workshop, instructors, and logistics

◆This workshop is presented in a series of modules built around focused lectures, illustrative site examples, small group exercises

◆Workshop materials format:

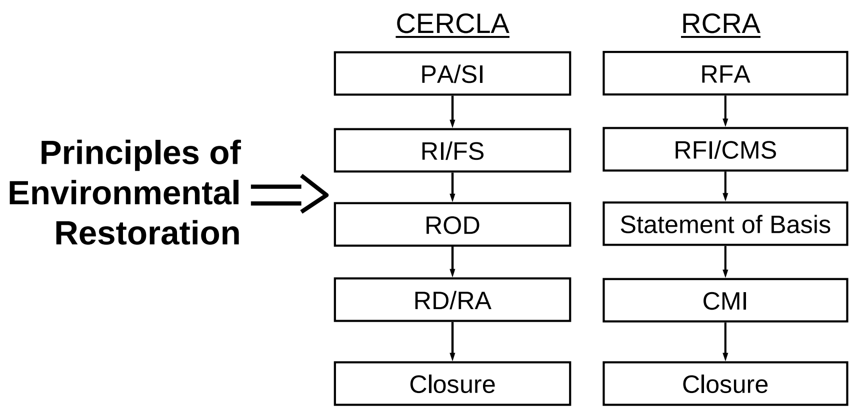
✓The top half of the pages present the main concepts of this workshop and are copies of the slides shown during the workshop

◆Students notes, presented on the bottom half, provide additional detail and information on the main concepts

Agenda

- Introduction
- Principles of Environmental Restoration
  - ✓ Communication and Cooperation
  - ✓ Problem Identification and Definition
  - ✓ Identification of Likely Response Actions
  - ✓ Uncertainty Management
- Developing Exit Strategies
- PER Workshops

An Approach, Not A Process



◆The principals apply throughout the remediation process, regardless of regulatory framework.

◆This course does not intend to ignore the existing processes; rather to enhance them and use them to benefit rather than hinder progress at your installation.

Genesis

- Pilot demonstrations of streamlining initiatives
  - ✓ SACM
  - ✓ SAFER
- Distillation of Principles from successes and failures
- Data Quality Objectives Guidance
- Development of joint DOE/EPA training and manuals
- Lessons learned from ITRT have distilled into present course

◆The principles have developed over a number of years, and are applicable to a variety of settings: Decontamination and Decommissioning facilities and closing out sites.

◆Incorporating the principles into your work will help you achieve rapid, cost-effective site closeout.

◆Information on DOE training initiatives is available from the National Environmental Training Office at www.em.doe.gov/neto/

Common Approaches Encountered

- Assume ARAR Exceedance Necessitates Remediation
- Use PRG to Screen for Removal Actions
- Characterize Incomplete Pathways
- Define PTM with Risk Threshold

Cost/Benefit Analysis

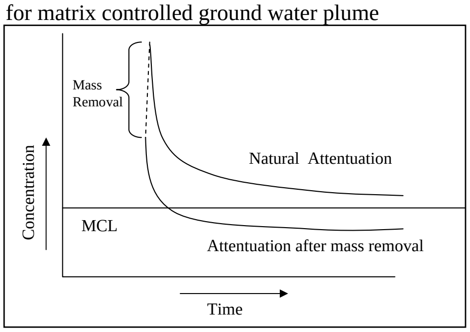
- 7/27 Redundant Plume Studies vs Watershed
- 13/27 DQO Process
- Confuse Data Gaps with Data Needs
- 6/27 Remedy Cost More Than Resource Value
- 9/27 Amenable to MNA
- 12/27 Require Exit Strategy

Risk-Based Decision Making

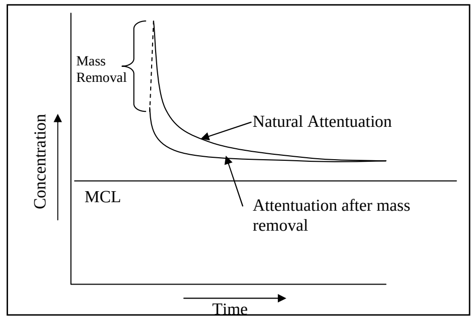
- 9/27 Risk Calculated for Scenarios not in Future Use Plan
- 10/27 CSM Developed as Product, Not Planning Tool
- 8/27 Risk Based on Background Metal Concentrations

Mass Removal Does Not Ensure Accelerated Resource Restoration

Model assumed when mass removal is proposed for matrix controlled ground water plume



Actual response to mass removal. Matrix controls position of asymptote regardless of starting inventory



Other Recommendations

- Need to Identify Legal Drivers in Advance
- Need Top Down, Tiered Approach to Ecological Risk Assessment
- Need to Document and Communicate Decisions Earlier

Four Principles of Environmental Restoration

- Developing effective communication and cooperation with a project management team is essential
- Clear, concise, and accurate problem identification and definition are critical
- Early identification of likely response actions is possible, prudent, and necessary
- Uncertainties are inherent and will always need to be managed

◆Incorporating these four principles will help to ensure effective and efficient site closeout.

◆This workshop will focus on these four principles. Although the principles themselves are not new, effectively applying them together in restoration projects is not always done.

◆These principles are the basis for effective problem solving under any environmental restoration regulatory authority.

◆These principles apply throughout the environmental restoration process - from scoping to implementation, with a focus on implementation.

◆Using these principles will better focus projects and lead to better recognition of streamlining opportunities by the project team.

◆These same principles are an excellent basis for organizing information to communicate with, and involve stakeholders, including the public, to achieve earlier decisions and consensus, leading to better projects.

Key Assertions

- Principles are implicit in the NCP and RCRA corrective action policies
- Adherence to the principles saves time and reduces costs
- Traditional "barriers" to streamlining can be overcome through teamwork and early agreement
- Proper focus of environmental restoration is implementing response actions
- All stakeholders want to achieve acceptable levels of risk

◆These assertions are the basis for the streamlining approaches advocated.

◆We recognize both RCRA corrective action and CERCLA allow, without further regulatory or statutory modification, flexibility in what can be done assuming certain basic steps are followed. The emphasis of both is to decide whether to take action to solve problems, not conduct investigations. Collecting data should be done when it fills clearly defined data needs (not all data gaps).

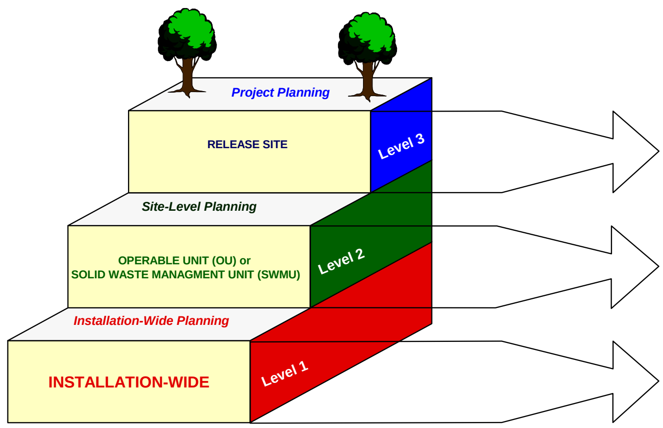
◆Historically, this regulatory and policy flexibility that now exists has not been well used. FFAs traditionally have focused on deliverables (e.g., RI reports) and not on actions.

◆Why? Regardless of type or magnitude of problem, nearly all characterization and assessment activities are seen as extensive processes, often because existing FFAs require many documents to be completed.

◆Every stakeholder's ultimate objective is to achieve acceptable levels of risk. Differences traditionally arise in defining acceptable levels of risk, and in determining the level of confidence in alternative approaches to achieving acceptable levels of risk. The latter relates to our ability to identify and manage uncertainty.

◆The PMT’s willingness to utilize this inherent flexibility is the ultimate key to success.

Applying the Principles at Different "Activity" Levels



Outcomes /Objectives

- Rapid decision on whether to take action and what kind of action
- Rapid identification of data needs

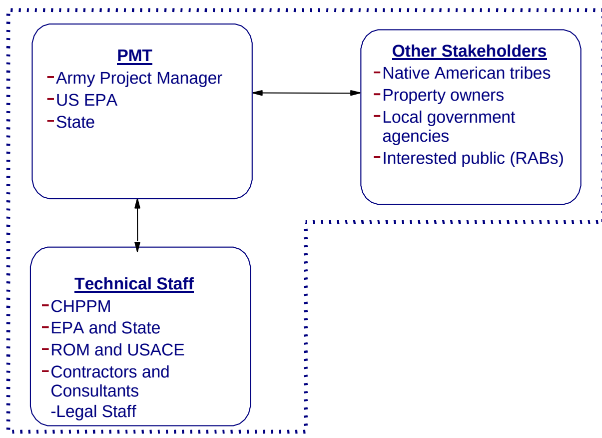
- Cost/schedule reduction
- Efficiencies of scale

- Coordination with other programs
- Strategic use of site resources

Principles of Environmental Restoration

Principle: Developing Effective Communication and Cooperation with a Project Management Team is Essential

Proposed Paradigm: Project Management Team Approach



◆Environmental restoration is not merely a technical project done by a team of Army personnel, with occasional review by outside parties. Under the proposed paradigm, the Army extends involvement beyond its own personnel so that their regulators become active members of the PMT, fully engaged and responsible for the scope, direction, objectives, and results of the project.

◆This paradigm does not limit in any way a regulatory enforcement authority or sovereign immunity, but provides an opportunity for regulatory agencies to use their authorities to move the project forward. What they will and will not agree to are known sooner.

◆This paradigm involves sharing information, planning, and decision criteria at the outset of a project, ensuring all decision-making authorities are aware of factors that will impact for moving the project forward, and have an opportunity to develop early consensus, if possible.

◆This new paradigm also means that the PMT is informed of all progress throughout a project. For example, the PMT is aware of major uncertainties that could jeopardize achieving objectives and understands/agrees on those contingencies that will counteract negative impacts to the degree that the response objectives are met when contingencies are implemented. When there are surprises, they should be a surprise to all parties. Presumably, if everyone agrees to the methods being applied and the meaning of the data, there will be little argument about results after the fact, and therefore, few instances of redoing work or second guessing the efficacy of methods after their application (i.e., if we all agree two numbers are additive, and we agree on their value, it is hard to refute their sum after addition is performed).

◆While there will be variability in their level of involvement, under the new paradigm, other stakeholders are kept abreast of the entire process through frequent, clear, concise, and open communication.

◆A key example of early involvement and other dialogue should be the development of an exit strategy. In this paradigm, closure is identified as the primary objective and the development of an exit strategy to achieve close-out quickly is an important element of all PMT discussions.

Project Management Team

- Includes those with the responsibility to represent their agencies interests (roughly equates to BCT or the TRC)
- Owns the process as well as the product
- Discusses all major aspects of the project
- Each member represents the public's best interests

◆At a minimum, the project management team will need to include the Army (as lead agency), EPA, state regulators, and any local regulators (such as water control boards).

◆PMT's actual responsibility will vary according to installation conditions; however, the goal is to steer /influence the decisions made.

◆Those people with decision-making responsibility include those that represent the organization that has authority to make decisions.

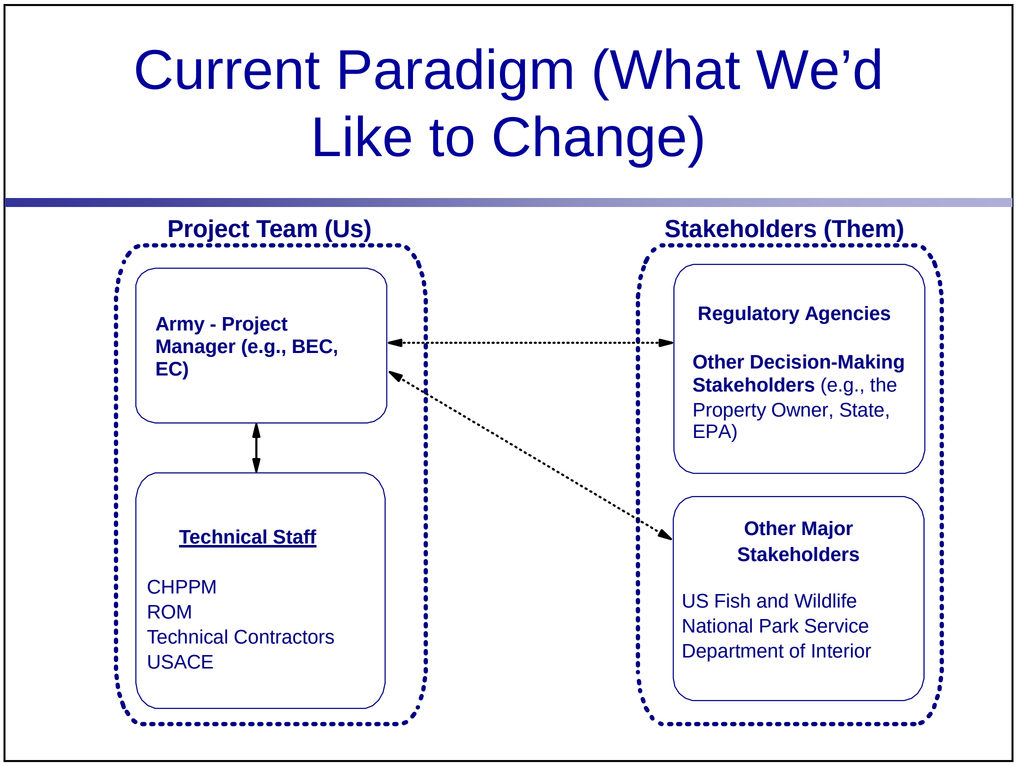
◆The level of decisions made by PMT will depend on the complexity and profile of the problem, the installation, and the PMT.

◆PMT needs to work together and, when possible, reach consensus, on the major aspects of the project. All members must be fully engaged and responsible for the project's scope, direction, objectives, and results.

◆Each team member is responsible for making important contributions to the project's success: Army provides technical resources and money; EPA provides technical support and regulatory interpretation; State-regulatory agencies provide interpretation and representation of local concerns.

◆The project management team operates by meetings or conference calls in which decisions are at issue. Army staff and their consultants do all the technical "leg work" necessary to facilitate analysis and decision making by the project management team during meetings.

◆Each member of the project management team represents the public's best interest, albeit from different perspectives. Moving ahead requires proper alignment to assure that all perspectives are adequately addressed.



◆Under the current paradigm, the Army and contractors develop the strategies and plans, do the work, and write the reports separately from stakeholders. Regulatory agencies are consulted sporadically and infrequently and review the work when it is finished.

◆In this paradigm, the stakeholders are not included in the decision making process as much as they should be.

◆Any stakeholder tends to be more rigid in their positions when not given early and frequent opportunities to provide input and express their needs/desires.

◆The lessons learned are to involve stakeholders early in the decision-making process, as frequently as possible.

PMT's Key Activities

- Planning:
  - ✓ What are the decisions to be made?
  - ✓ What are the decision criteria?
  - ✓ What data support making the decisions?
  - ✓ What confidence level does the decision require?
  - ✓ What are the consequences of a decision error?

◆Planning activities curtail the development of the framework from which all investigations are designed. They focus on identification of the decision logic to be followed, that is, the PMT needs to identify what decisions will be made, what criteria will be used to make the decisions, and what the consequences are for yes or no answers to a decision. These activities will be discussed in more detail in Module 6.

PMT's Key Activities (cont'd)

- Communication
  - ✓Upward to management
  - ✓Outward to stakeholders
- Documentation
  - ✓Formalize agreements
  - ✓Ensure knowledge management

◆The PMT is responsible for communicating both upward to senior management and outward to other stakeholders. Communication should indicate the scope of activities, the decision being made, the criteria and rationale for decisions, and their consequences.

◆Furthermore, the PMT must document decisions and the basis for them. This will preserve programmatic progress in light of personnel changes. It will also ensure that knowledge is passed on to future stakeholders and those ultimately responsible for stewardship as discussed in Module 8.

Documentation

- Documents / Reports Are:
  - ✓ A vehicle to archive decisions and logic
  - ✓ A means of managing knowledge for future stakeholders
  - ✓ A complement to other means of communication with stakeholders
- Documents / Reports are Not:
  - ✓ Milestones or endpoints
  - ✓ A supplement or primary mode of communication with stakeholders

◆It is key to remember that although we document the process and results, we're not striving for documentation in itself as the endpoint.

◆A document is only a communication tool.

The New Paradigm

- Common Approach
  - ✓ Use DOCUMENTS
  - ✓ To COMMUNICATE
  - ✓ In hopes of reaching AGREEMENT
- Preferred Approach
  - ✓ COMMUNICATE
  - ✓ To reach AGREEMENT
  - ✓ Memorialize in DOCUMENT

◆Traditionally, parties have used documents to communicate. Many times the documents ultimately became the medium of negotiation. This is an inefficient means of reaching agreement and often leads to misunderstandings even when all parties think they can agree on a document because they interpret it differently.

◆The desired model is to communicate openly and in person until agreement is reached. The document is then used to memorialize that agreement. In this mode, the document is not the milestone, the agreement is.

Challenges to an Effective Project Management Team

Challenges:

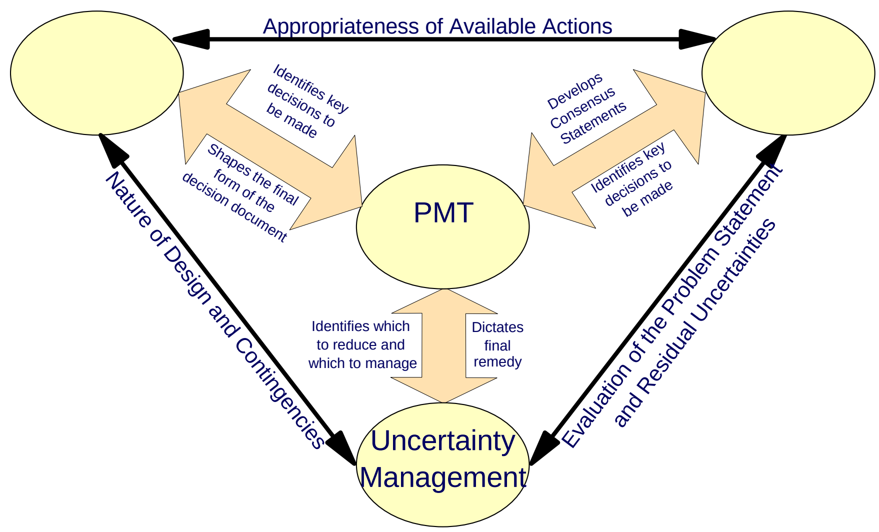
- ✓ Lack of empowerment
- ✓ Budget constraints
- ✓ Fear of sharing (and taking) responsibility
- ✓ Existing relationships

- The best approach to meeting these challenges is to develop a working PMT and jointly make decisions

◆DOD, EPA, and States have undertaken several initiatives to help meet these challenges, including:

✓Federal Facilities Streamlined Oversight Directive - EPA published a policy directive to streamline oversight at federal facilities in a systematic, planned manner. This directive was published November 29, 1996 (OSWER directive # 9230.0-75).

PMT Implements the Other Three Principles



◆The level of success in implementing the other three principles effectively is directly related to the effectiveness of the project management team.

◆How project management teams apply these principles will vary from installation to installation and from project to project.

◆It is the project management team's responsibility to integrate these principles.

Principle: Clear, concise, and accurate problem identification and definition are critical to successful closeout

Environmental Restoration is Driven by Two Key Questions

- Do we have a problem?
- If yes, what should we do about it?

◆This module focuses on the first question.

◆The next module focuses on the second question.

What is a Problem?

- A problem is a condition posing real *or potential* unacceptable risk, or a condition that requires a response.

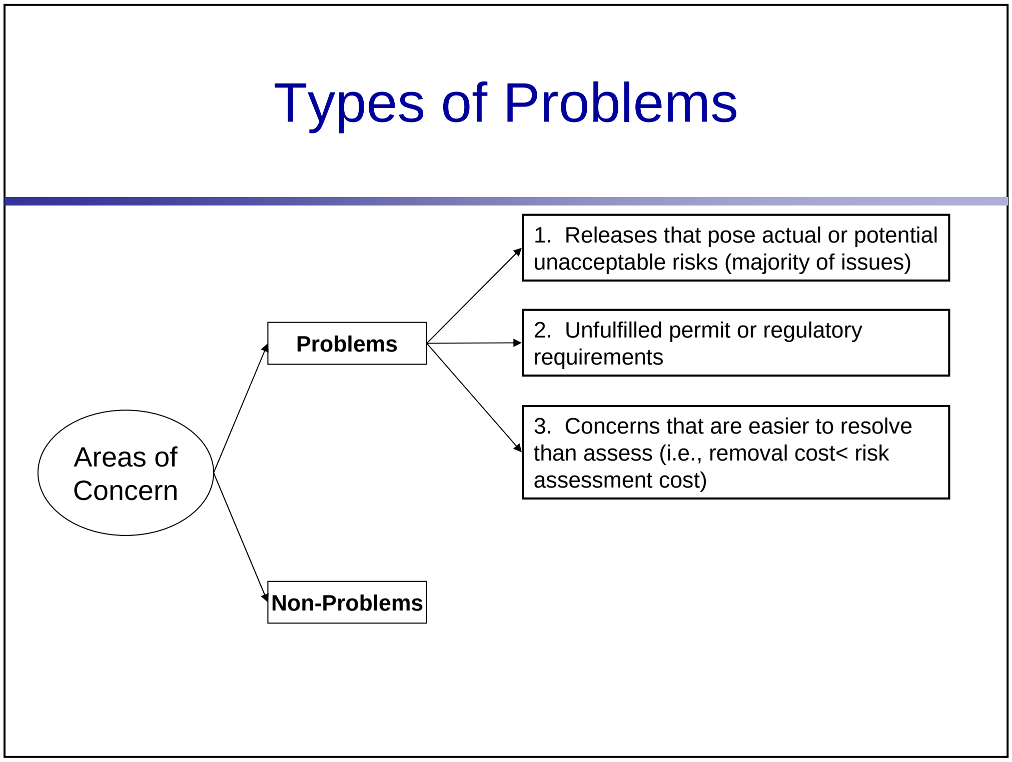
◆Problems, by our definition, require a response - some action, either interim or final, taken to reduce/eliminate the potential for exposure

◆Situations that PMTs determine do not require a response are not problems. Note that uncertainty may exist as to whether a problem exists. However, defining whether a problem exists is a critical initial activity and often the focus of investigation activities.

◆A problem may be an actual risk to human health or the environment (e.g., evaluations may indicate that a health-based standard has been exceeded), or a perceived risk (e.g., dioxin in subsurface soils even if no chance of exposure exists). Once specific legal requirement beyond CERCLA are found to exist, all future work should be focused on meeting the requirements, not on assessing risk.

◆There are thresholds that define the conditions under which a current or potential exposure pathway poses an unacceptable risk

◆An unacceptable condition is a situation that regulations, agreements, or public perceptions delineate as unacceptable, regardless of the actual degree of risk posed



◆Types of Problems:

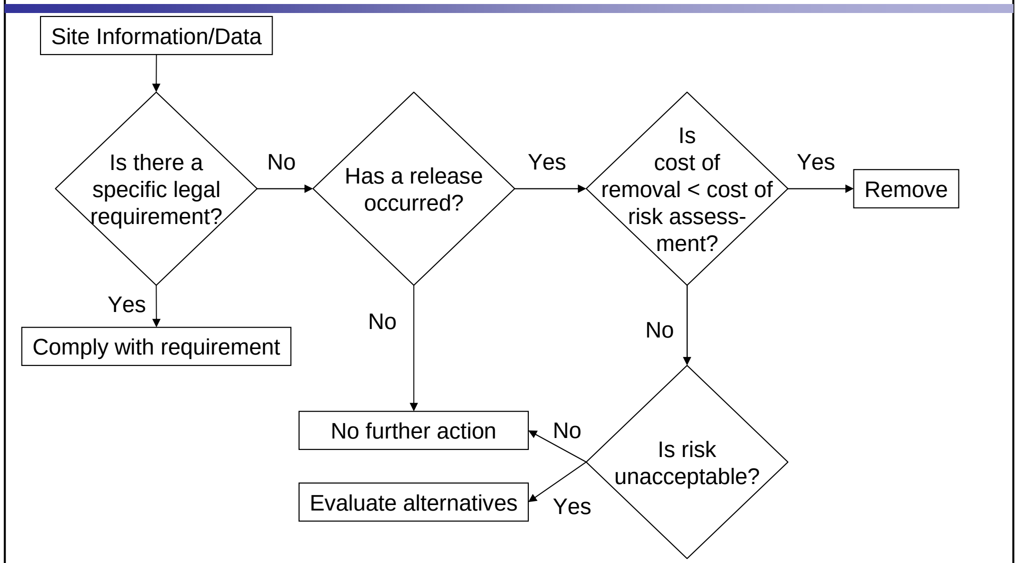
✓Problem Type #1: The majority of all problems to be addressed arise from releases of contaminants that pose an actual or potential risk to human health or the environment. This is particularly true of restoration efforts being conducted under CERCLA. These problems must be characterized sufficiently to substantiate the risk (i.e., demonstrate a problem exists) and evaluate alternatives for resolution. In general, some degree of investigation activities are needed to provide the data for defining a problem.

✓Problem Type #2: Occasionally, the problem arises because of specific requirements in a permit (clean closure of a regulated unit, removal of related equipment, etc.) or other legal requirements (e.g., tank removal, State requirement not based on installation-specific risk consideration) that have not yet been met. These problems are most often encountered when restoration is performed under RCRA or when state programs apply. These requirements are often clearly identified and can be accomplished without collecting data in an attempt to justify no-action or alternative actions. As such, they should be identified up front so that unnecessary studies are avoided.

✓Problem Type #3: Additionally, there may be conditions that either are not required (owner/operator internal policy) or that will be more difficult to assess than to resolve (e.g., small volume fuel releases on surface soils). When either of these situations are encountered, they should be flagged and to the extent possible, actions taken. (Note: The Army cannot expend monies without a clear requirement therefore when risk has not been shown to be unacceptable, clear documentation is required to quantify associated cost savings.)

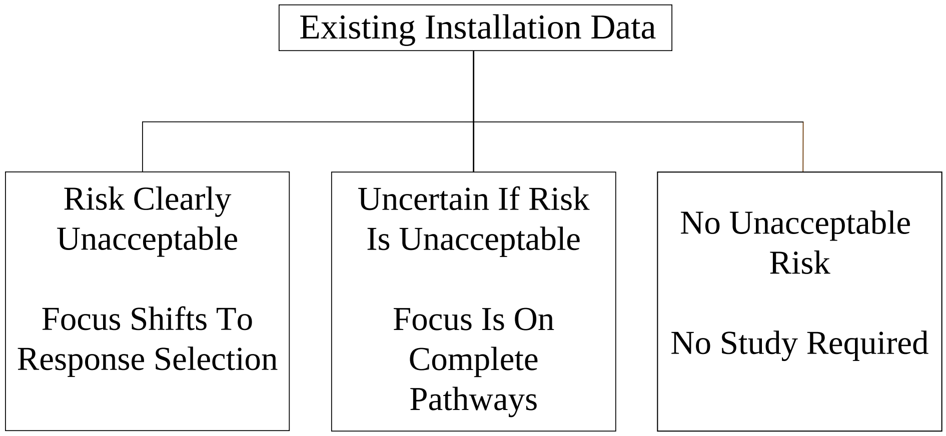
◆Non-Problems: In some cases, the data for areas of concern identified for evaluation may show that contamination is below screening levels. Therefore, the area of concern does not present a problem.

Logic Flow for Addressing Site Problems



◆The four types of sites can be addressed most efficiently by sequencing the relevant decisions. Once specific legal requirements beyond CERCLA are found to exist, all future work should be focused on meeting those requirements, not on assessing risk. Remaining actions should be risk driven unless it is less costly to remove a potential risk than to assess it. Risk driven actions will be the most common type of problem encountered and is the primary focus of this course.

Focus of Risk-Based Studies



◆Where remediation is driven by potential releases that may pose unacceptable risks, there are three categories of releases that should be identified for purposes of focusing data collection:

- ✓Category 1: Risk Clearly Unacceptable, Focus Shifts to Response Selection

  Releases that clearly exceed risk-based criteria to the extent that remedial action is required in the near term. These release sites are given a high priority for identifying likely responses, completing collection of data necessary to select and design a response, and implementing the response.

- ✓Category 2: Uncertain if Risk is Unacceptable, Focus is on Complete Pathways

  Installations where it is uncertain if releases have occurred at levels that pose significant risks. More data are needed to substantiate a problem

- ✓Category 3: No Unacceptable Risk, No Study Required

  Installations where it is unknown that no action is required. However, if significant resources are needed to demonstrate there is no problem, it may be advisable to leave the installation in the uncertain, low priority bin until resources are not needed elsewhere.

◆Priority is placed on conditions causing exposure to humans or impacts on the environment.

◆Priorities may change with time due to new data, completion of higher priority tasks, and/or changes which modify the nature and timing of potential exposures. For instance, priority for final remedy may be low for an installation with a high priority problem once stabilization is achieved. Hence, periodic reprioritization is necessary whenever new information is available.

Why Focus on Problem Definition?

- Problems are what you scope, decide to act on, and ultimately remediate
- The process of defining problems identifies information needs
- Problems are not necessarily operable units or areas of concern

◆Uncertainties in problem existence, regulatory issues, technology performance = data gaps = investigation. However, data gap ≠ data needs. Data <u>needs</u> include information to establish with sufficient certainty that a condition poses a problem, and information to focus on what response action to take. Data gaps not relevant to these fundamental decisions are generally not significant and need not be resolved.

◆A problem is seldom equal to a site, an operable unit, or an area of concern. Multiple problems may exist within these unit definitions, or problems may exist across unit boundaries.

◆For example, operable units may contain multiple types of waste disposal units, contaminants, media, receptors, and potential exposure pathways. Individual problems must be identified within the unit to be remediated.

◆Likewise, if soil contaminated with a particular contaminant is found throughout several areas of concern, a problem can be defined once, then can be applied to all occurrences of the contaminant in the soil (barring any additional receptors or other factors).

Poor Problem Definition Leads To:

- Poor project focus
  - ✓ Overly extensive or ineffective investigation (e.g., trying to remove insignificant uncertainties)
  - ✓ Extended process to decide on remedy
- Poor project execution
  - ✓ Not fixing the problem
  - ✓ Fixing the wrong problem
  - ✓ Fixing the problem at greater cost than needed
- Prolonging site closeout
- Inappropriate exit strategy

◆Often, problem definition is ***not***:

✓Focused sufficiently on the response aspect of the problem

✓Sufficiently based on existing data

✓Performed with rigor needed to focus environmental restoration planning

✓Done proactively, with project management team involvement and agreement

◆Often a problem is assumed if contamination is present, setting a default standard of background concentrations as the threshold above which a response is required. This may result in actions that do not significantly contribute to risk reduction.

How Do We Communicate Problems?

- A problem statement is a clear, concise description of a condition that needs a response
- A problem statement provides linkage to the key decisions that need to be made at any point in time by:
  - ✓ Specifying the condition requiring a response
  - ✓ Reflecting the current conceptual model of the site
  - ✓ Evolving with our knowledge of the site

◆Problem statements are an effective tool for communication because they focus decision-makers on the specific questions that need to be answered.

Documenting Problems Through Problem Statements

- Problem statements define the circumstances that require a response
- Key components of a problem statement include:
  - ✓ Media
  - ✓ Contaminants and concentrations
  - ✓ Volumes
  - ✓ Regulatory or other drivers

◆Problem definition becomes the "If" part of an "If/then" decision rule. A decision rule includes:

✓A statement of the unacceptable risk or condition (i.e., the problem)

✓The action that will be taken

✓When necessary, the data required (or sufficient) to support the decision

◆Decision rules are an accepted manner of linking together problem statements, likely response actions, and data required to support the decision because they clearly communicate how we intend to respond to a given set of circumstances and what thresholds or key factors will lead to our taking a specific action, i.e., they summarize our decision logic.

◆Decision rules are a concept used to document what constitutes sufficient information to make a decision. We are focusing on the decision whether to take action (i.e., when a problem exists). The data required to support this decision may vary widely -- from characterization information, to decisions about what concentrations pose a problem, to decisions by the project management team about stakeholder concerns

◆If sufficient information does not exist, it is collected only until a decision can be made

◆However, if sufficient information exists to define that a problem exists, the focus shifts away from data collection to the response needed to address the problem

Problem Statements Help Define Data Sufficiency

- Necessary data: Results could substantially change the content of the problem statement
- Sufficient data: All problem statements can be written for a release site
- When a problem statement can be written, the focus of decisions and therefore data collection shifts to what response is appropriate

◆For releases or situations where it is uncertain whether a problem exists, "necessary and sufficient data" are defined as the information needed to write the problem statement. At the site level, data are necessary and sufficient when a project manager or owner/operator can write all relevant problem statements.

◆Data are not necessary if regardless of their value, the decision will not change (i.e., data must have the potential to change a decision before they are necessary).

◆ Sufficiency can be defined as the set of all necessary data.

◆Problem statements may drive you to collect more data, or can help you to identify the response immediately.

◆Necessary and sufficient determinations are made by the PMT and involve an element of judgment. In general, the PMT must agree that further data collection is unlikely to have a substantive effect on formulating the problem statement(s) for a site.

Examples of Problem Statements

- Lead is found in excess of preliminary remediation goals, 400 ppm, in top 2 feet of soil over an area equal to or greater than one-quarter acre.

- Ground water quality data confirm contamination beneath the installation above MCLs for TCE while historic* use of bulk liquid solvents indicate a strong likelihood that at least a portion of the contaminant residues are present as DNAPLs. Off-site migration is indicated, but not confirmed, and the nature of residual source materials in the vadose zone is unknown.

*Records indicate storage of bulk liquid in tanks and maintenance of large inventories on site.

◆By preparing a good problem statement, there is a means of testing to see if proposed activities are necessary and sufficient to get us to a point where the best means of resolving the problem can be selected.

◆A problem statement helps focus our activities and serves as an effective vehicle for communicating with those involved who are affected by the decisions.

No Risk-Based Problem

- No history of release or information suggesting a probable release; or
- Data indicate concentrations below site screening levels at agreed level of confidence.
- Site conditions are such that there are no possible pathways to a receptor.

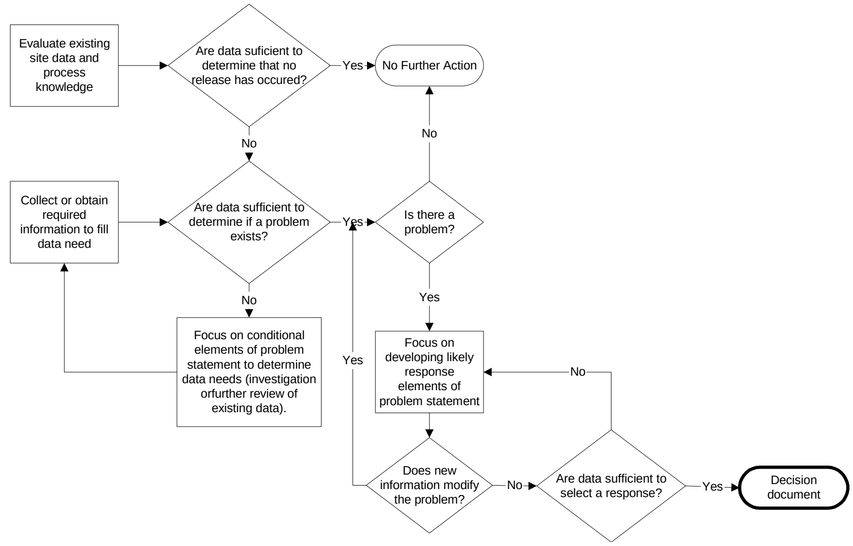
◆A continuing challenge at sites is the identification of the point at which the investigation is sufficient to declare there is no problem, i.e., when can we stop collecting data in search of a problem.

◆By definition, we do not investigate sites for which there is no history of release or any reason to believe a release may have occurred.

◆We may still be required to take a response because of legal obligations that are risk-driven or decisions made on the basis of factors other than risk. In these cases, information needs are limited to data required to select and design the appropriate response.

◆For these sites where a release may have occurred, we collect samples and analyze them to determine if chemical residues are present. Since there may be residues that do not pose a risk, we usually identify site screening levels (SSL) or preliminary remediation goals (PRG) as thresholds. If contaminant concentrations do not exceed the threshold, there is no problem. We need to be able to assert that at an accepted level of confidence. Because our initial samples are usually biased (i.e., taken from the likely point of greatest contamination) fewer samples may generate the desired level of confidence than required for random sampling plans.

Decision Logic



Documenting Problems through a Conceptual Site Model

- A conceptual site model is a depiction of key elements and interfaces which describe the fate and transport of contaminants from source to receptor at a given installation

◆Any model is a cartoon or abstraction of reality. It is intended to convey relationships and interfaces between component parts in a form that enhances our ability to understand those interrelationships and use them in a diagnostic and/or predictive mode. There are many formats for models depending on the intended use and the complexity of data available to put in them.

◆A conceptual site model (CSM) can be a simple drawing or diagram depicting the spatial relationship of key elements that determine the fate and transport of contaminants such as location of source materials, the direction of transport, presence and nature of media affecting transport, and extent of contamination.

◆Initially, a CSM is used to informally organize information on how contaminants have been released and transported. Ultimately, it helps to conduct evaluations of risk and focus on appropriate response actions.

◆For actual "risks" associated with a release to exist, there must be a complete pathway from the source to a receptor and the receptor must be there when the contamination arrives or is still present.

◆As a consequence, responses to risk-based concerns are needed only when complete pathways exist over which transport is sufficient to exceed acceptable risk levels in the time frame in which exposure, human or ecological, will occur.

◆Pathways are identified and transport quantified (to an appropriate degree) through use of the conceptual site model (CSM). The presence of receptors and the degree of exposure is most often determined by the likely land/resource use patterns present at the time of arrival (based on EPA directives on land use determinations).

Uses of the CSM

- Organize and communicate installation data
- Represent interrelationships that need to be understood to identify and prioritize problems/responses
- Identify uncertainties
- Provide basis for evaluating effectiveness of potential responses
- Communicate effectively with stakeholders

◆The CSM is used to organize and communicate information about installation characteristics. It should reflect the best interpretation of available information at any point in time. As a consequence, if new data are inconsistent, either the data are not valid or the model needs to be revised. Similarly, any positive hypothesis posed for the installation and any remedy must be consistent with the CSM. Evaluation of remedies that rely on mechanisms inconsistent with the CSM a wasted effort.

◆The model represents the location and the interrelationships of installation features that affect fate and transport of contaminants from source to receptor. As such, it can be used as a tool to determine if all current or potential future problems associated with a contaminant release have been identified. Moreover, since responses can remove sources, interdict pathways, or isolate receptors, the CSM can help to identify candidate responses and evaluate proposed ones.

◆The CSM helps identify uncertainties. To the extent that the CSM reflects our best understanding of the installation, uncertainties are clearly visible. Moreover, since pathways must be complete before a receptor is at risk from a source, the CSM can also indicate when uncertainties are not significant (e.g., relate to an incomplete pathway).

◆The CSM is a primary vehicle for communicating technical data. It provides a good summary of how and where contaminants are expected to move and what impacts such movement may have. Hence, it supplies additional information to explain why a problem is a problem, why it is inconsistent with desired results, and, therefore, why a response is anticipated.

What is a Good CSM?

- A good CSM does the following:
  - ✓ Identifies and locates contaminants, sources, release and transport mechanisms, pathways, exposure modes, and receptors
  - ✓ Delineates contaminant, concentrations in media, and flux rates by pathway in narrative and graphical forms
  - ✓ Quantifies background concentrations for each formation or unit
  - ✓ Explicitly recognizes and evaluates uncertainties (known and unknown conditions)
  - ✓ Evolves with data

◆Ultimately, the data needed are those that assist in making the important identified decisions in a consistent manner. One way to assure that we identify the right decisions and, therefore, the right data is to assure that we have a complete and accurate CSM.

◆To identify releases and distinguish those originating from installation activities as opposed to off-site sources, it may be important to establish background concentrations. Background may arise from naturally occurring substances (minerals, plant residues), deposition from regional or global transport (fallout), or plumes from upgradient sources. Because geochemistry can change with the nature of the host geology, background range should be determined for each soil unit, rock type, or aquifer.

What are the Common Forms and Elements of CSM?

- Narrative Summary
- Installation Maps
- Vertical Profile
- Tabular Data
- Flow Diagram

◆A CSM benefits from use of multiple formats to best portray available information.

◆A good narrative summary is the best means of describing the installation, its history, the nature of sources, quantitative aspects of migration pathways, and the identity of ecological and human receptors as well as the circumstances under which exposure is anticipated. Examples of such narratives are attached in the ASTM materials included in the "Supplemental Materials" section.

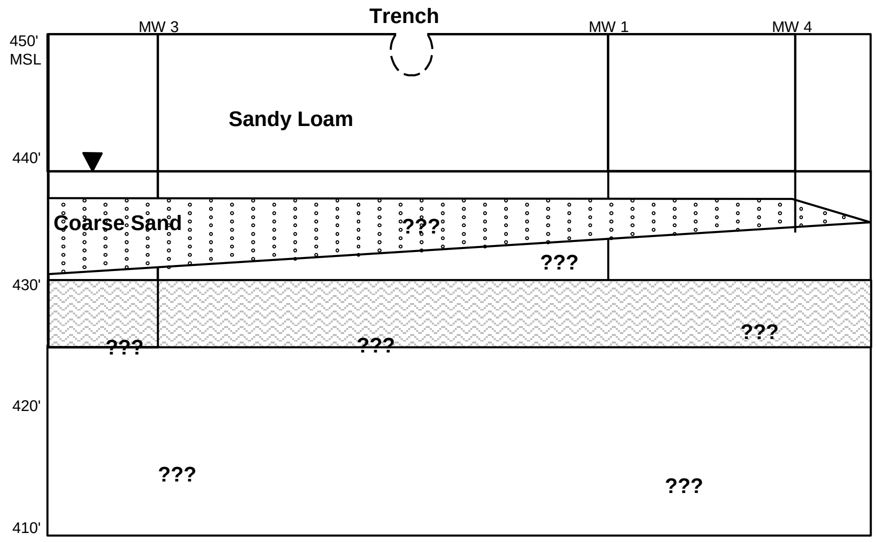
◆Maps should always be included in a CSM. At a minimum, maps should include relative position of sources, pathway determinants and near-field boundary constraints, surface water features, prevailing wind pattern, and plume contours. When multiple contaminants are present, it may be necessary to produce separate maps of each contaminant group to keep from obscuring data through multiple overlaps.

◆If subsurface contamination is present, a vertical profile of the installation should be included. Fence diagrams or representative boring logs may suffice, but simplified forms focused on the most important features are devised in order to facilitate communication with stakeholders.

◆Tabular data may be included, but tables should be keyed to map features and should contain representative data only, not an exhaustive display of all data.

◆A standard diagram has been developed to depict migration pathways and receptors for the purpose of conducting risk assessments. These diagrams can be useful to identify the pathways that have been considered and those that were found to be complete. One means of producing flow diagrams is the application of the Site Conceptual Exposure Model (SCEM) Builder. One advantage of using this software is that it can easily evaluate several alternative CSMs.

Example Initial Vertical Profile

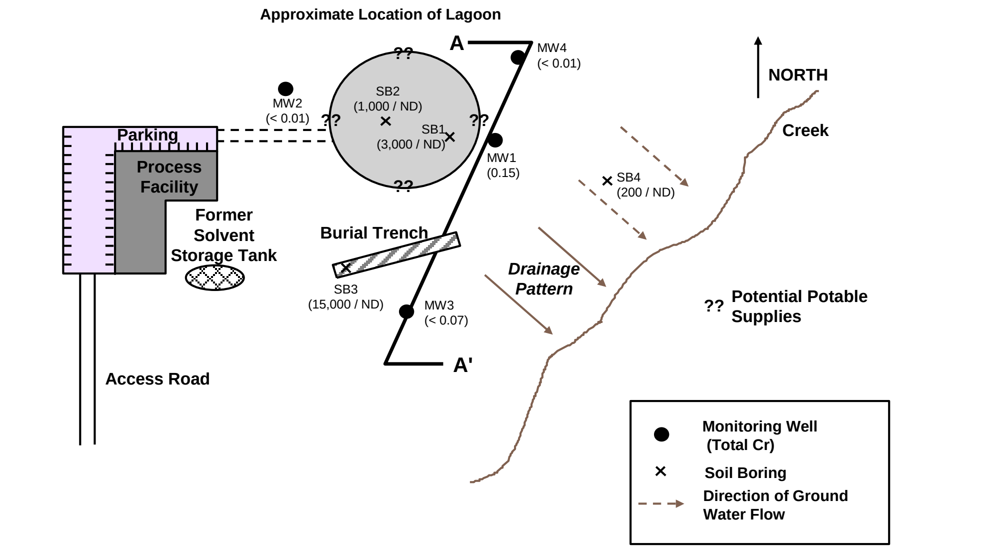


◆With collection of data, some of the uncertainties at an installation are likely to be reduced. That reduction should be reflected in the CSM through removal of question marks and replacement of uncertainty statements, with descriptions of sources, pathways, and receptors.

◆The CSM should contain only features and data that are important to the risk manager. As such, the focus is on the problem statement as currently written and the viable pathways for which responses will be necessary. Particular priority is placed on the ground water pathway and any other pathway believed to involve human exposure per the environmental indicators and program expectations.

◆An example of an expanded narrative CSM is attached in the "Supplemental Materials" section. As with the initial CSM, the narrative should be simple and concise. When data are presented, they should be synoptic, but representative of key findings relative to the problem statement and potential risks. The CSM will be a major part of any communications with stakeholders and, therefore, should be written without a lot of technical jargon or misleading information.

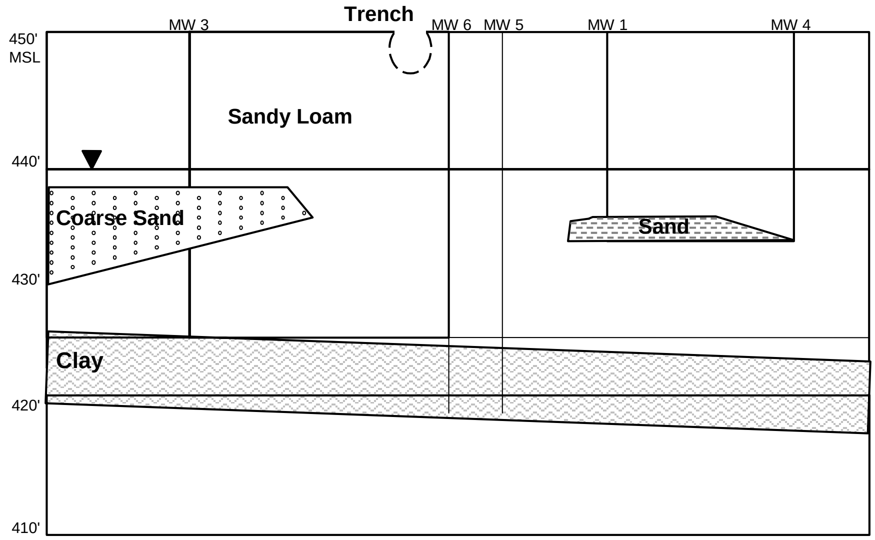
Example Initial Installation Map



◆As is apparent from guidelines for risk assessment, the nature of land and resource use dictates the identity of the exposure route and the circumstances under which the exposure will occur. Exposure scenarios differ significantly with the use. While current use is easily identified, future use is always an uncertainty which must be dealt with for persistent contaminants.

◆A simple approach to managing this uncertainty in the past has been to constrain future use through institutional controls. When institutional controls are employed, adequate provisions must be made to assure that those controls remain operable. In some instances phased responses may be appropriate. For instance, at sites with contaminates that are likely to be attenuated naturally over time, institutional controls will be required until such time as remedial action objectives are met.

Example Expanded Vertical Profile



◆Current and reasonably probable future land uses and corresponding exposure scenarios should be considered in the selection and timing of corrective actions. If land use changes can be predicted, they can serve as a basis for phased responses. As the uncertainty with respect to future use increases, there are more incentives for selection of robust remedies or well defined contingencies.

◆Reasonable land use assumptions should be assessed when developing goals for any given facility and used to focus all aspects of the remediation process. When major structural changes are anticipated (e.g., changes in industrial base, closure of large activities, resource depletion), the uncertainty can be bounded or the reasonable alternatives expanded.

◆In any event, change is inevitable and should be managed as an irreducible uncertainty.

Evidence of the Presence of DNAPLs

- Required
  - ✓ Physical-chemical properties
- Indicative
  - ✓ Pattern of use
  - ✓ Pattern of evidence
- Confirmatory
  - ✓ Direct observation

◆Required:

✓Fluid density> 1.01 mg/cm^3

✓Solubility<20,000 mg/L

◆Indicative:

✓Historic use patterns conducive to loss of pure liquid product

✓Dissolved plume concentrations>1% of solubility

✓Depth of penetration(D) > depth of vadose zone (Vd) where D-Vo/(A)(Rc) and A is the area over which the release occurred, RC is the retention capacity of the soil for the product

✓Soil vapor concentrations approach saturated vapor limits

✓OVA readings of 1,000 to 2,000 ppmv

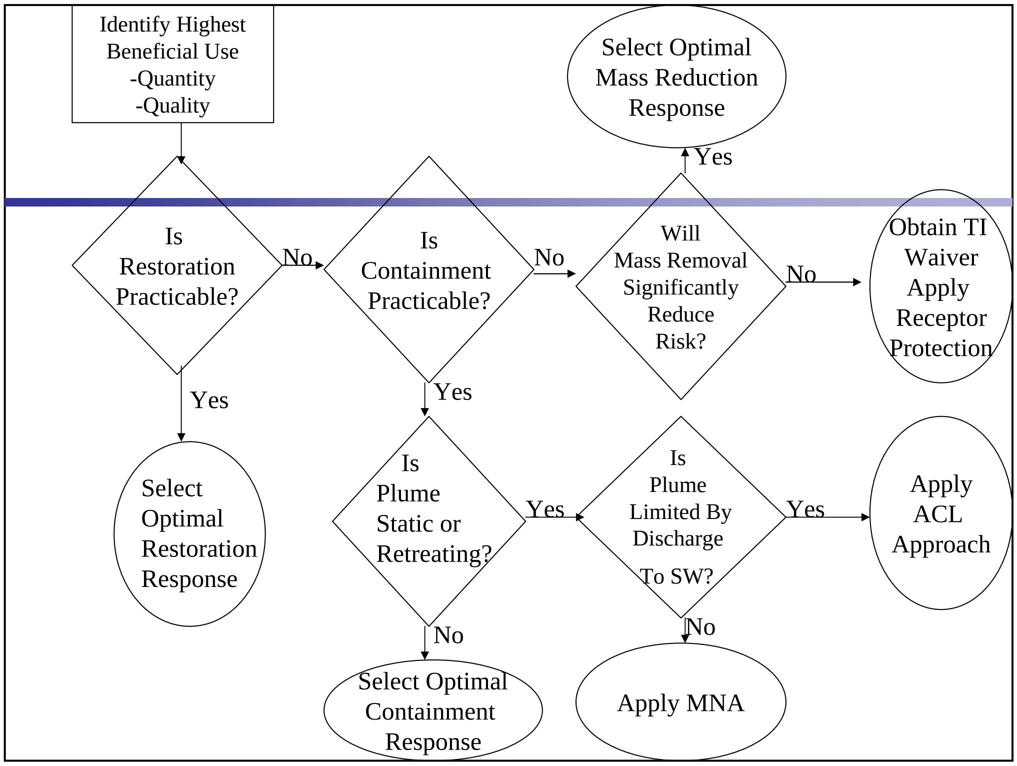
◆Confirmatory

✓Direct observation of DNAPL in borings or cores

✓Fluorescence of cores under ultraviolet light

Strategy for Investigation of Site Ground Water

- Restore Ground Water to Its Highest Beneficial Use
  - ✓ Maximum Yield
  - ✓ Quality
  - ✓ DNAPL
- Stop Plume Growth and Migration
  - ✓ Temporal Trends at Perimeter
  - ✓ Direction of Flow and Points of Dscharge
- Reduce Toxicity, Mobility, and/or Volume
  - ✓ Quantify Risk Reduction Associated with Proposed Remedy


Identify Highest Beneficial Use -Quantity -Quality
Select Optimal Mass Reduction Response
Yes
Is Restoration Practicable?
No
Is Containment Practicable?
No
Will Mass Removal Significantly Reduce Risk?
No
Obtain TI Waiver Apply Receptor Protection
Yes
Yes
Select Optimal Restoration Response
Is Plume Static or Retreating?
Yes
Is Plume Limited By Discharge To SW?
Yes
Apply ACL Approach
No
No
Select Optimal Containment Response
Apply MNA

Principle: Early identification of likely response actions is possible, prudent, and necessary

What are we going to do about a problem if response is required?

Early Identification of Likely Response Action(s) Allows:

- Early focus on appropriate remedial action objectives and an exit strategy
- Early consideration of potential response action implications
- Development of a hierarchy of probable technologies for a defined problem
- Early consideration of presumptive remedies, generic approaches, and a phased response to remediation
- Implementation of removal and/or interim actions

◆For many situations, there is a clear hierarchy of probable technologies.

◆Early identification and communication of response actions can streamline:

- ✓Workplan development
- ✓Sampling and analysis needs
- ✓Technology evaluation
- ✓Documentation
- ✓Design

◆Removal and interim actions eliminate unnecessary characterization efforts and can reduce the likelihood of extensive, low value requirements in the future while facilitating more rapid property transfer.

When to Identify Likely Response Actions

- As early as possible
- Absolute minimum information
  - ✓ Identity of contaminant(s)
  - ✓ Identity of media
- May occur before problem statement is complete

◆Once we have prioritized our concerns, we can proceed. Ideally, we identify likely responses for priority concerns as early in the process as possible. However, there is a balance that must be struck.

◆If identification is too early, it may well address the wrong problem and, thereby, lead to unnecessary activities.

◆In general, the identification process begins when a likely problem is identified. With only the identity of the contaminated and affected media, it is often possible to identify a very limited number of response actions. This can occur before the complete problem statement can be written in that there may be insufficient data to determine if resultant risks are unacceptable.

Determining Likely Response Actions

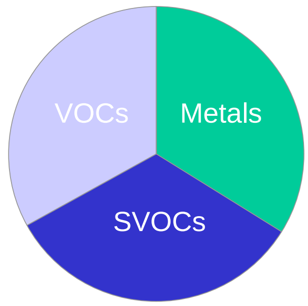
- Likely response actions are based on historical knowledge of what remedies work and do not work on different problems and installation conditions
- Hierarchy of preferred technologies is a short list of likely responses arising from cumulative experience/knowledge

◆The Army has over 20 years of experience in selecting, implementing, and evaluating long-term performance of remedies at contaminated installations. The knowledge of what has and has not worked that can be distilled from that experience often allows the identification of a very limited number of technologies which will likely be selected as a response.

◆The limited set is designated by the hierarchy of preferred technologies. It is a hierarchy, because technologies are listed in order of preference. The technologies are preferred because they have a history of being the most cost-effective, most often selected alternatives, and most successful. By focusing on this hierarchy, it is possible to anticipate data needs for the selection of one technology. Moreover, by narrowing the field, it is easier to commit resources to looking at innovative technologies with the potential to address weaknesses in more common candidates.

◆Hierarchies are particularly useful at Army installations where a number of release types are prevalent (e.g., burning grounds, fire-training areas, ammunition production lagoons, firing ranges, landfills, etc.).

Available Presumptive Technologies for Contaminated Soils



VOCs:
- Soil Vapor Extraction
- Thermal Desorption
- Incineration

Metals:
- Reclamation
- Immobilization
- Containment

SVOCs:
- Bioremediation
- Thermal Desorption
- Incineration

◆If presumptive remedies exist, they should be at the top of the list of likely response actions.

◆Presumptive remedy guidance introduces significant information on the data needs and methods to evaluate the efficiency of presumptive technologies.

◆Moreover, presumptive remedies for specific sources, such as SVOCs from wood treating, are applicable to SVOCs from other sources as well.

◆Presumptive remedy documents are available at: http://www.epa.gov/superfund/resources/presump/

Preferred Remedies for Groundwater Remediation

- Monitored Natural Attenuation
- High permeability:
  - ✓ Recirculating Wells
  - ✓ In Situ Air Sparging
  - ✓ Bioremediation/ Fenton's Reagent
  - ✓ Pump and Treat
- Low permeability (may justify technical impracticability waiver):
  - ✓ Treatment Barriers
  - ✓ Enhanced Permeability
  - ✓ Electrokinetics

◆Monitored natural attenuation is a viable alternative if the following criteria are met:

✓Active source has been removed

✓There is no current unacceptable risk to human health or the environment

✓Plume is static or retreating

✓Identified attenuative mechanisms indicate that goals can be achieved in a reasonable time frame

Data Requirements for Remedy Selection

- Necessary Data - Any information, the value of which could change the selection of a remedy to an alternative
- Sufficient Data - Characterization of an installation relative to the selected technology's fatal flaws and key design parameters

Fatal Flaws and Selection Parameters

- Once likely response actions have been identified, determining fatal flaws will help the PMT choose between remedies
- Fatal flaws are installation conditions or parameter values that would make a remedy impossible to implement effectively or less desirable relative to other remedies
- Selection parameters are conditions or characteristics for which values will affect whether one remedy is preferred over another and how the selected remedy would be designed
- Design basis questions are a tool provided to identify fatal flaws and selection parameters for most common remedies

◆The Supplemental Materials section contains a listing of the characteristics/conditions which affect the design and implementability of common remedial actions. Threshold values for some characteristics constitute fatal flaws.

Examples of Fatal Flaws and Selection Parameters

- Examples of fatal flaws for possible remedies:
  - ✓ Caps - waste buried below water table
  - ✓ Excavation - contaminant lies below buildings in active use
  - ✓ Permeable Treatment Wall - absence of an impermeable layer to key the wall into
- Examples of selection parameters:
  - ✓ Caps - Nature of release mediums at issue (e.g., volatilization vs. infiltration or direct contact)
  - ✓ Excavation - Depth of contamination
  - ✓ Permeable Treatment Wall - Aquifer permeability

Documenting Likely Response Actions

- Decision rules link problem statements with likely response actions
  - ✓ Example: If lead is found in the top 2 feet of soil at concentrations in excess of a preliminary remediation goal of 400 ppm across one quarter acre or more, then the soil will be removed and treated for reclamation and/or immobilization of the lead.

◆When a limited number of likely responses can be identified, the problem statement can be expanded into an "if...then" decision rule. If a single response is not indicated, the "then" portion of the statement can be tiered with an indication of the criteria that would be used to select among the hierarchy of preferred technologies.

◆Use of the decision rule form for the problem statement furthers its value as a tool for effective communication by clearly identifying the likely responses and the conditions under which each would be selected.

◆Advantages of writing a decision rule statement are that it:

✓provides a clear path forward;

✓reduces potential for unnecessary work; and

✓highlights identity of remaining issues.

◆To the extent possible, it is good to advise stakeholders of the criteria that will be used to select among alternatives or alert them to a single technology being considered so they can voice concerns early in the process.

◆An example of a Hierarchy of Preferred Technologies can be found in recent presumptive remedy guidance for metals in soils (i.e., reclaim/extract metals; immobilize metals; and contain metal contaminated soils). (This document is currently in concurrence.)

Principles of Environmental Restoration

Principle: Uncertainties are inherent and will always need to be managed

Why Focus on Uncertainty?

- Uncertainty management is essential for accelerated progress in site restoration because it helps make decisions when "perfect information" is not available
- Resolution of all uncertainties or unknown conditions is unlikely
- Yet, project managers must still:
  - ✓ Make decisions when uncertainties exist
  - ✓ Effectively communicate how uncertainties are addressed
  - ✓ Be able to distinguish between significant and insignificant uncertainties

◆Installation restoration project managers are "uncertainty managers" and need to develop strategies to manage major uncertainties.

◆Uncertainties of many types must be understood and managed to generate effective restoration strategies.

◆We will never have all the answers, but that should not keep us from getting the job done.

◆Understanding uncertainties and taking them into account in the decision-making process moves cleanup along, while minimizing costs and shortening schedules.

◆It is also important to note that, in some cases, no amount of resources can reduce an uncertainty and no management plan can guarantee that some degree of uncertainty does not remain.

◆Documents evaluating and addressing uncertainty tradeoffs help explain to audiences the rationale behind decisions about project uncertainties.

Uncertainties = Data Gaps

- Example Data Gaps:
  - ✓ The volume of sludge in a surface impoundment to be excavated is unknown
  - ✓ Existing data cannot determine whether contours of a TCE-contaminated plume are static or retreating and monitored natural attenuation is being evaluated for application
  - ✓ An innovative technology is recommended, but there is skepticism as to its ability to meet objectives

◆ Uncertainties, or data gaps, may arise from incomplete site characterization, inability to project into the future, use of new technology, or use of a technology in a new setting.

Examples of Uncertainties

- A developer of nearby residential properties has secured a right-of-first refusal from the existing owner/operator to purchase a 10-acre parcel previously remediated to industrial cleanup standards. The parcel has an institutional zoning control in place specifically designed to maintain a non-residential land use

- Treatment and disposal are proposed, but it is not clear if RCRA Phase IV Land Disposal Restriction Criteria will apply to residuals

◆Uncertainties do arise from the lack of definitive future use plans and the complexity of potentially applicable regulatory requirements.

Uncertainty Management: Key Concepts

- Understand the type of uncertainty and its impact on project decisions
  - ✓ Data gaps do not necessarily equal data needs
- Evaluate tradeoffs between costs of data collection and "decisional benefits" obtained
- Achieve project management team consensus to optimally balance:
  - ✓ Data collection
  - ✓ Contingency planning

◆ Key concepts focus on:

1. Impact of uncertainties on project, i.e., knowing whether you can "afford" to be wrong (and how wrong) or whether you must be right. If the value for an unknown parameter will not change the decision being made, the data gap is not a data need.

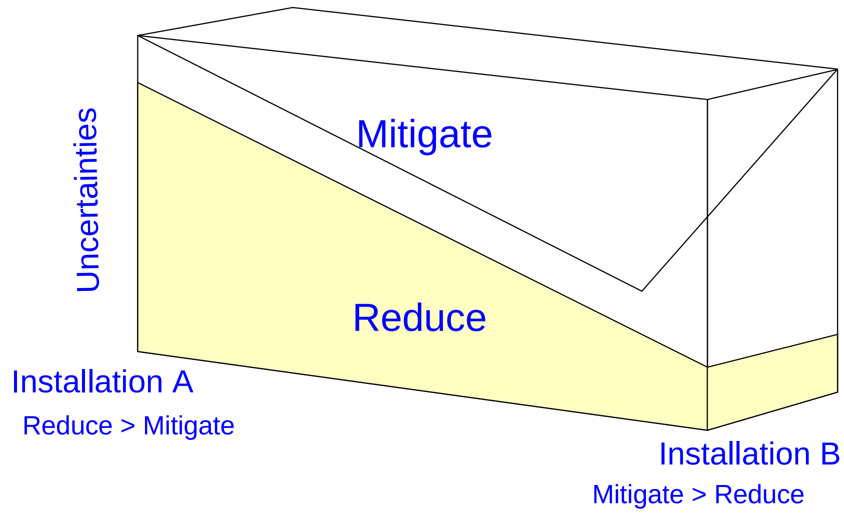
2. Tradeoffs between the benefits gained from additional information versus the cost (technical and schedule) to obtain it. The tradeoffs illustrate the central concept of determining when uncertainties can be managed in an effective and efficient manner.

3. An approach to managing uncertainty should be defined that will provide the balance between reducing and counteracting uncertainty at the least cost. In some cases, the uncertainty must be reduced to manageable levels through investigation (e.g., review existing data, site characterization, treatability studies). In other cases, the residual uncertainty is counteracted by contingency planning (If X happens, then do Y).

4. An approach to managing uncertainty must also be acceptable to the project management team. The history of a site may make it important to have a wider level of comfort (less uncertainty) than would be acceptable to just the project management team or technical project team staff. The process for establishing acceptable levels of uncertainty may include the general public (e.g., a restoration advisory board).

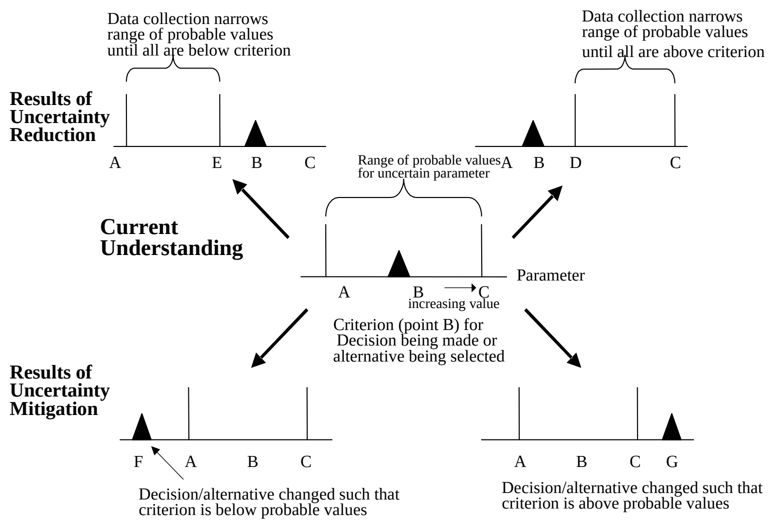
5. Consideration of uncertainty starts in scoping and continues through implementation.

The Optimal Amount of Uncertainty is Installation-Specific



- At some installations (e.g., an area with surface soil contaminated by dioxin), strenuous efforts to reduce uncertainty in advance may pay off in a much more efficient cleanup (Installation A).
- At other installations (e.g., a heterogeneous landfill), prior characterization may have little benefit, and the challenge is to manage uncertainty during remediation (Site B).
- At most installations, both approaches are used to some degree. Optimization means striking the right balance.
- For any given installation, there is a balance of uncertainty reduction and uncertainty mitigation that is optimum with respect to cost, time, or risk objectives.

Options for Uncertainty Management



◆Uncertainty management requires balancing reduction and mitigation. Reduction is aimed at narrowing the range of probable values for an unknown parameter or condition. If the range can be narrowed to the point where it lies completely above or below the threshold (decision criteria) then, the uncertainty is no longer significant for that decision. Mitigation is accomplished by changing the decision being made so that the decision criterion changes. If the criterion can be raised or lowered so that it no longer lies within the range of probable values for the unknown parameter or condition, that too renders the uncertainty insignificant.

Management Tradeoff

	Reduce	Mitigate
Release Type:	Landfill	Landfill
Remedy:	Cap	Exhume
Uncertainty:	Waste below water table	Volume to be excavated

- The significance of specific uncertainties can be affected by the remedy being contemplated. For example, at a landfill where exhumation is being considered, volume to be excavated can be important with respect to capacity of the proposed disposal site. Volume would not be important if capping were contemplated. However, the volume uncertainty is best mitigated by having a contingency for extra volume and proceeding with implementation since the exact volume can not be known until excavation is complete. Alternatively, if capping is contemplated, the presence of waste below the water table is a fatal flaw. Implementation will not lead to discovery of the flaw and will frustrate attempts to mitigate. Therefore, this is an uncertainty that must be reduced.

Sources of Uncertainty

- Installation characterization
- Technology selection
- Regulatory requirements
  - ✓ Administrative processes
- Future Land Use

◆Uncertainties need to be understood to be managed effectively. Organization, documentation, and planning of environmental restoration projects must address these uncertainties.

◆There are numerous ways in which we can be "wrong" or uncertain about an installation and its problems. Categorizing uncertainties by source helps to focus on the type of data needed to manage or reduce the uncertainties identified.

◆These sources of uncertainty are interrelated. For example, uncertainties in site characterization lead to uncertainties in whether a technology will work and what regulations apply. Uncertainties in technology performance can lead to uncertainties in regulatory compliance.

Impact of Uncertainties

- An uncertainty can be:
  - ✓ Insignificant to implementing the project and solving the problem (i.e., value of unknown parameters will not change the decision being made):
    - for example, presence of single drum in a landfill
  - ✓ Significant and needs to be:
    - reduced prior to response (i.e., data need); or
    - mitigated during the response through contingency planning

◆Insignificant uncertainties for a given problem (i.e., those that do not affect the overall direction of the project) are not necessarily trivial. For example, if a storage area has a capacity of 100,000 cubic yards and a response will only generate between 3,000 and 10,000 cubic yards, the volume of material to be generated is insignificant to the action. However, using up to 10 percent of available capacity for one response may create other sitewide issues.

◆There are two types of insignificant uncertainties:

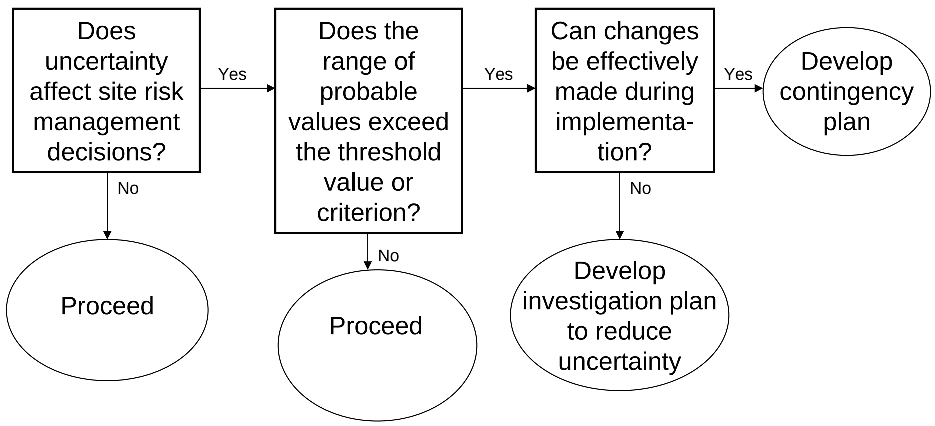
✓Those insignificant due to the nature of the uncertainty, and

✓Those insignificant because the range of possible or likely values falls below the threshold at which a response is necessary.

◆Uncertainties that must be reduced prior to an action results in a data need. The data may be obtained prior to implementation of a remedy (e.g., site characterization, pilot-scale treatability study), or it may be possible to collect the data in a post-decision design investigation.

◆Uncertainties that can be managed effectively are those that can be addressed through a contingency plan. These contingency plans are included in decision documents, or subsequent design documents.

Uncertainty Management Approach



◆The impact of an uncertainty will correspond to a specific management approach.

◆The approach to managing uncertainty will include both reducing and mitigating uncertainty. The challenge is to reach project management team consensus in establishing the balance between the two components.

Organizing Uncertainty Information

- Uncertainty can be characterized by the following information
  - ✓ Likely or expected condition
  - ✓ Reasonable deviation from the expected condition
  - ✓ Probability of occurrence
  - ✓ Time to respond
  - ✓ Potential impact on problem response/resolution
  - ✓ Monitoring plan
  - ✓ Contingency plan
- Uncertainty management changes emphasis from assessment to implementation

◆The likely condition is the expected or probable condition. Based on current data and assumptions, it is reflected in the conceptual site model, and is the basis for planning the response action.

◆Reasonable deviation from the expected or probable conditions can best be used to express uncertainty either quantitatively or qualitatively.

◆Monitoring/investigation are the kinds of observations or measurements that will be taken to determine if the uncertain condition (or reasonable deviations) if present. Using the threshold example, the monitoring would involve sampling to detect the presence of other contaminants.

◆All factors are assessed to determine how an uncertainty will be managed - either by reducing it or developing a contingency plan.

Categorizing Impact of Uncertainties

Consider a landfill which is to be exhumed to meet regulatory requirements for closure.

Probable Condition	Reasonable Deviation	Probability of Occurrence	Time to Respond	Potential Impact	Monitoring/ Investigation	Contingency Plan
Saturated soil conductivity expected to be 10E(-4) cm/s	Conductivity likely to range from 10E(-2) to 10E(-7) cm/s	High (based on existing hydrogeologic data)	Long	Low - May impact the drainage of rainwater if <10E(-4) cm/s	N/A	Insignificant - No impact on likely response action.
Soil is expected to be stable (i.e., greater than Class C)	Soil may be unstable (i.e., <50% or soil is less stable than Class C)	Low (based on results of previous slump tests)	Short (excavation face may sluff or cave in)	High - Threat to worker safety - Could increase cost or delay schedule	Conduct visual inspections an additional slump tests	Significant - Shore walls - Lay back excavation
Contents are expected to be solid waste only	Hazardous waste may be encoun-tered	Medium (based on process knowledge	Short (to prevent excavation from being delayed)	High - May delay excavation - May increase disposal costs and change handling requirements - May pose worker safety problems	Sample and analyze excavated materials; compare results to regulatory criteria	Significant - Develop contingency plans for excavation, storage, and disposal of hazardous waste; analyze cost impacts to ensure available funding

◆The matrix above focuses on uncertainties associated with the implementation of a likely response action, and illustrates the classification of identified uncertainties into the categories listed below:

✓Uncertainty insignificant to ultimate objective;

✓Uncertainty must be reduced with more data; and

✓Uncertainty, but can be managed by contingency plan.

◆Probable condition identifies nature of the uncertainty that exists.

◆Reasonable deviation from the expected condition is a quantitative or qualitative expression of uncertainty.

◆Probability that a deviation will occur, timeframe to respond to a deviation, and potential impacts of a deviation on the likely response are all considered in evaluating uncertainty.

◆Monitoring/Investigation are the kinds of observations or measures that will be taken to determine the existence of an expected condition or reasonable deviations.

◆The contingency plan documents how an uncertainty will be managed - either by reducing it or developing a contingency plan.

When Do You Evaluate and Manage Uncertainties?

- In work planning:
  - ✓ based on existing data,
  - ✓ based on understanding of programmatic expectations, and
  - ✓ as part of program development for a large site with multiple problems.
- During any necessary investigations:
  - ✓ as new data become available, and
  - ✓ as conceptual site model becomes sufficient to focus on likely response actions.

◆Uncertainty planning is done continuously and for both individual projects and for larger sitewide programs. In both cases, it starts with the initial assessment of existing data and the initial construction of the conceptual site model.

◆With an initial conceptual model, uncertainty management assists in defining the data needs and/or other strategies for addressing the uncertainty.

◆The consideration of uncertainties and their impact does not occur at any one discrete point in time. Rather uncertainties are continually evaluated throughout the investigation, design, and implementation phases. The iterative nature of the feedback is particularly evident during implementation. For instance, the nature of residual uncertainties may influence the type of contact vehicle being considered. Once a contract type is selected, contingencies must be scoped into the statement of work. If contingency costs are too high, an alternate design basis may be appropriate. Ultimately, the alternate design may best be implemented through a different contract vehicle.

When Do You Evaluate and Manage Uncertainties? (cont.)

- During remedy evaluation:
  - ✓ as key performance and technology characteristics are evaluated
- During remedy implementation:
  - ✓ based on results of monitoring and observations during implementation
- Throughout all phases:
  - ✓ as basis for more effective communication about why work is being conducted

◆During environmental restoration studies, its focus is on whether the technology can meet the desired cleanup objectives.

◆It is part of the documentation of the investigation results, technology evaluation, and all documentation associated with the selected remedy.

◆Finally, it is evaluated throughout remedy implementation to determine if any uncertain conditions are realized.

In Summary: What Does Categorizing Uncertainties Do?

- Forces explicit statements and consensus on uncertainties that may exist
- Establishes agreed to approaches to manage uncertainties
- Makes explicit the needs for data collection and/or contingency planning
- Helps document how the response will proceed
- Facilitates closeout by minimizing pursuit of unneeded data

◆Lack of explicit recognition of uncertainties, lack of consensus, and lack of planning on how to proceed will create substantial project management and project performance issues

◆Once problems are defined, data collection, studies, investigations, and analyses should be focused on identifying and planning on how to respond to uncertainties.

◆Uncertainty analysis needs to be explicitly communicated and agreed to among project management team members.

◆Again, interest may extend beyond the project management team.

◆The more explicit we are in what uncertainties exist, what their impact is, and how we will deal with them, the more likely it is that we can reach a consensus. Uncertainty issues are the source of most of the differences in opinion.

Principles of Environmental Restoration

Developing An Exit Strategy

What is an Exit Strategy?

- Exit strategy:
  - ✓ Defines the conditions or end state to be achieved;
  - ✓ The actions necessary to reach those conditions; and
  - ✓ The amount, type, and derivation of data necessary to demonstrate the condition has been reached
- Comprised of two key elements:
  - ✓ Closure Strategy
  - ✓ Contingency plans
- Should be developed as part of process of establishing remediation goals

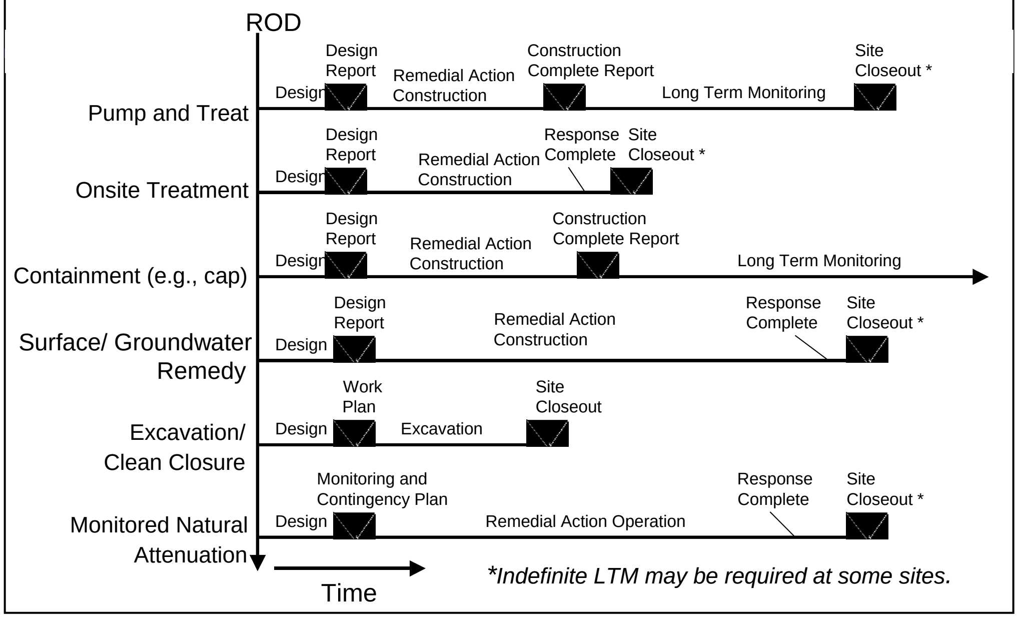
◆Exit strategies define the conditions or state to be achieved; the actions necessary to reach that condition or state; and the amount, type, and derivation of data necessary to demonstrate that the state or condition has been reached. Exit strategies are needed for any long-term obligations including monitoring, operation, maintenance, or other activities not required in perpetuity.

◆The closure strategy details the criteria against which system performance is measured, defines how compliance will be demonstrated, and provides the basis for system shutdown.

◆The contingency plans describe the steps to take if and when a system does not perform as anticipated, and address uncertain elements of system performance.

◆The exit strategy should be developed as part of the process of setting cleanup goals because it is necessary to evaluate whether or not it is technically feasible to meet the goals that are set.

Exit Strategies Largely Depend on Remedy Selected



◆The complexity and timing of the exit strategy will depend on the remedy scenario selected and what remains on site once the remedy is complete.

◆In general, <u>completion</u> is typically defined as the end of installations (i.e., construction complete) and start-up activities (system operational and functional). Construction completion may equate to response completion for some types of response (e.g., excavation, in-situ treatment). For other responses (e.g., pump and treat, monitored natural attenuation), there may be significant RAOs after construction completion to ensure the installation stays on the path to response complete.

◆<u>Remedial action operations</u> (RAOs) may include operation of pump and treat facilities, monitoring under an MNA response, or similar long-term activities conducted to cause or verify that the installation contaminant inventory is continuing to approach the desired long term monitoring state.

◆<u>Response complete</u> is defined as the point at which the desired long-term monitoring state has been reached. Response complete can occur with an inventory of contaminant in place if that inventory is within the desired long-term monitoring state (e.g., under a well-maintained cap).

◆The <u>long-term monitoring</u> state may be defined as target characteristics/conditions for which an installation response has been designed to attain. Describes physical condition of the installation/area once remediation activities are complete. Can include both clean closure and closure with containment of residuals.

◆<u>Site Closeout</u> means that the Army has completed active management and monitoring at an environmental restoration site, and no additional environmental restoration funds are expected to be expended at the site, unless the need for additional remedial action is demonstrated.

Closure Strategy

- Identifies necessary and sufficient data to demonstrate that the desired end state (e.g., long-term monitoring state) has been reached
  - ✓What?
  - ✓Where?
  - ✓How?
  - ✓How often?
  - ✓Under what conditions?
- Data interpretation and decision process

◆The closure strategy should define the data necessary and sufficient to demonstrate the desired state or condition has been reached. Where appropriate, a long-term monitoring plan can also include phased ramp downs associated with levels of greater confidence gained through the monitoring data.

◆Specifications are needed to identify:

✓The type of data required

✓Sample locations

✓Sample frequency

✓Target parameter thresholds characteristic of the desired long-term monitoring state

✓Duration required to demonstrate sustainability

✓Strategy should also describe how data will be interpreted and the key decision criteria or "triggers" indicating remedy success/failures.

✓

✓ Statistical algorithms to be applied to data (e.g., confidence limit, type of mean, etc.)

Monitoring Program

- Monitoring program consists of:
  - ✓ Performance monitoring
  - ✓ Detection monitoring
  - ✓ Ambient monitoring
- Implemented to manage uncertainty in performance of the remedy:
  - ✓ If monitoring data indicate system failure, contingency can be implemented to mitigate potential impact
  - ✓ If monitoring data verify predicted down trends (i.e., successful performance), exit strategy can be implemented to reduce long-term costs

◆No monitoring program should be implemented without some form of decision rule or contingency plan to indicate how unsatisfactory results will be defined and addressed and/or how success will be demonstrated and what that means with respect to future activities.

◆To the extent that performance data verify predicted trends for performance meeting expectations, they can be used to justify reducing monitoring activities in the future.

◆*Note*: In some situations, monitoring may trigger a re-evaluation of what needs to be done. As an example, if the remedy is a pump and treat system and data approach an assymptote above MCLs, technical impracticability or monitored natural attenuation may be more appropriate. Alternately, increases in concentration could indicate the presence of active sources that continue to feed the plume. Ideally, these potential outcomes will have been evaluated and decision criteria agreed upon in advance.

◆Performance monitoring is the first element of the closure strategy. Performance monitoring relates to measuring parameters to determine if performance is meeting expectations. This may include looking at contaminant inventory as well as other indicators, such as geochemical parameters, during MNA.

◆Typically, there exists a model that articulates remedy expectations to which the performance monitoring data are compared.

◆Detection monitoring is performed at sentinel wells to ensure that contaminants are not approaching exposure points at concentrations that pose unacceptable risks

◆Ambient monitoring involves the measurement of background conditions on a regular basis to provide a benchmark for evaluating detection and performance monitoring results.

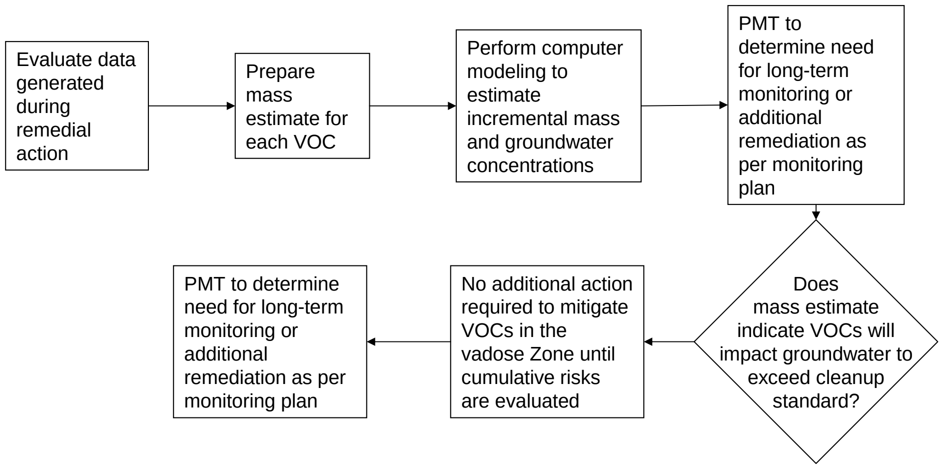
Developing "Ramp-Down" Strategy for Monitoring Program

- Prior to entering into monitoring program, need to establish decision rules describing when monitoring requirements can be reduced
  - ✓ At what point can certain analytes be eliminated from analysis?
  - ✓ When can the monitoring frequency be reduced?
  - ✓ What criteria will be used to reduce the number and/or location of monitoring wells?

◆Exit strategies will not be feasible for all remedies. For example, when waste is left in place (e.g., capped), monitoring will be required in perpetuity. However, this does not mean that the monitoring program cannot be reduced with time to reduce overall long-term stewardship costs. In addition, for long-term remedies (e.g., monitored natural attenuation), once performance monitoring has satisfied certain criteria, it may be possible to reduce frequency/ location/ or number of anlaytes required in the sampling and analysis plan.

◆The core team needs to establish the decision criteria for ramping down the monitoring program.

Example of an Exit Strategy*



◆Ideally, closure/exit strategies should be considered very early on in the decision-making process. Although it may not be appropriate to include such strategies in the Records of Decision or Statement of Basis, in some cases (e.g., in a very straight forward remedy), the Core Team may determine that documenting the exit strategy in the ROD is preferable.

◆For example, this simplified logic diagram provides a rudimentary exit strategy for an SVE remedy. Ideally, it would identify the data to be used as input to the model (which wells, etc.) and criteria for stopping the monitoring being conducted to look for evidence of rebound contamination.

◆*Taken from ROD from an NPL site.

Focus on Performance Metrics/Criteria

- Operational performance metrics/criteria assure that response remains protective
  - ✓ Involves periodically revisiting problem from its initial identification and definition through its final remediation
- May include
  - ✓ Monitoring contaminant migration and response effectiveness,
  - ✓ Inspecting disposal cells,
  - ✓ Enforcing access restrictions

◆Once it has been determined that the long-term monitoring state has been reached, the site will need to describe how to ensure that the response remains protective. Activities may be required to maintain an adequate level of protection to human health and the environment from the hazards posed by chemical materials, waste, and residual contamination remaining after cleanup is completed

◆Activities may include safeguarding CBM materials, monitoring the migration of contamination and the effectiveness of response, inspecting disposal cells, enforcing physical access restrictions, implementing permits and other legal or institutional controls, maintaining relevant information, and generally providing responsible long-term care of an installation

◆In many cases it is technically or economically infeasible to fully remediate an installation because of the degree of contamination and the type of contaminants present. At these installations, additional monitoring, maintenance and contingency plans will be required to ensure that human health and the environment remain protected after cleanup has been completed

◆For post-closure monitoring, contingencies may not be well-developed due to assumed low probability of need, but general response should be identified

Documentation

- Construction Complete Report
  - ✓ Documents as-builts
  - ✓ Defines any remedial action operation requirements
  - ✓ Defines when desired end state is reached to document achieving target
  - ✓ Defines any long-term care requirements
- Provides vital information for future stewards and long-term care organizations

◆Under RCRA: A written post-closure plan that will become part of the RCRA permit issued to the owner or operator must detail the activities to be carried out after response complete of each hazardous waste management unit. To amend this plan, the owner or operator must submit a written notification of, or request for, permit modification (40 CFR 264.118)

◆Under CERCLA: In the case of long-term remedial action sites (LTRA), an interim closeout report is developed. LTRAs are sites where achieving the remedial action objectives require continuous operation of the response over several years. When the cleanup levels are achieved, a final closeout report will be developed and submitted for EPA review and approval. Either of these documents (interim or final closeout report) may be referred to as remedial action reports. An interim report would be equivalent to the Construction Complete Report for LTRA sites while a final report would be the same as the Construction Complete Report for clean closure sites (e.g., excavation).

Elements and Source of Completion/Closure Reports

Completion/Closure Report Element	Source
Problem statement	Scoping and decision document decision rules
Description of selected response	Decision document
Details of implementation	"As-builts," notice of modifications
Contingencies executed	Memoranda filed to document need for and use of contingencies
Performance status	Results of performance measurements
Verification of completion/ closure	Evaluation of performance measurement results in the context of the definitions of construction complete
Design of O&M (completion) long-term care (closure)	"As-builts," decision document specifications, operations manual

◆Most of the required information is already available (i.e., generated as we have progressed); thus, all we are really doing is compiling the information into a low-cost document.

◆If adhered to principles throughout, document will mostly be written

◆Is an aggregation of largely existing byproducts from implementation

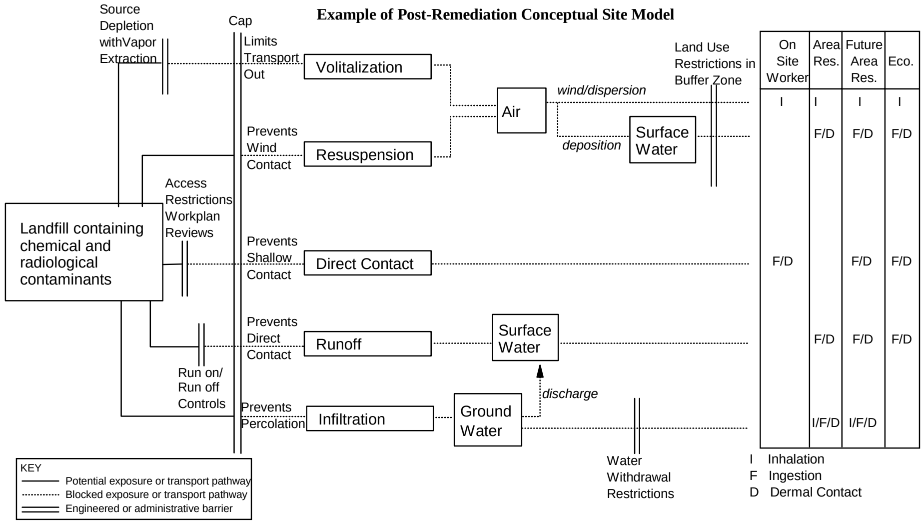
Role of Project Management Team

- Project Management Team is responsible for sharing appropriate response information and data with long-term care authorities
- Conducts five-year reviews
- Delegates authority for future actions as appropriate
- Assures knowledge management (archiving) for future stakeholders

◆Role of the project management team changes once response is complete

◆Need to determine lines of authority for future actions, including when to invoke contingencies and ramp down strategies

Example of Post-Remediation Conceptual Site Model

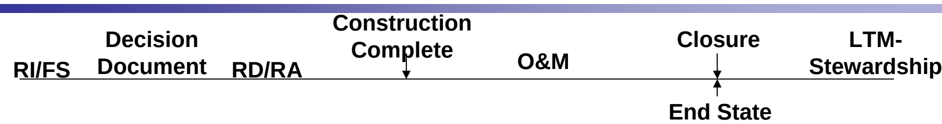


Components of End State	Description
Waste Characteristics	One landfill remains on site. Contaminants include: NO, CHCL, DCE, Toluene, H_3, C_{14}, and DCA. The estimated volume of material disposed in the landfill is 420,000 y_3 based on historical records and knowledge of past practices.
Unit Characteristics	Landfill is approximately 50 - 60 feet above the upper huydrostratigraphic unit (HSU) and approximately 80 ft. above the lower HSU of the groundwater aquifer. The contaminants detected in the upper HSU include: $CHCl_3$, DCA, Cr, NO_3, DCE, Toluene, H_3, and C_{14}. Contaminants detected in lower HSU include: Cr, NO, CHCl3, DCE, Toluene, H_3, C_{14}, and DCA.
Barriers in Place	One single-layer cap with a design life of 30 years covers the landfill. Vapor extraction system installed and operated until concentrations drop below threshold. Land use restriction covenants in place such that: (1) There can be no digging in the landfill area; and (2) There shall be no agriculture or residential use of groundwater; pumping groundwater from wells is prohibited.
Other Key Assumptions to Maintain Protectiveness	Land use will remain industrial. Monitored natural attenuation will demonstrate that contaminants in the groundwater are below MCLs in 20 years. Remaining contaminants in landfill are will not continue to leach to the groundwater. An alternate water supply is provided to local residents.

Application of the Principles in the Post-Construction Phase

Principle	Post-Construction
▪ Project management team	▪ Review data and communicate direction
▪ Problem statement	▪ Define long-term monitoring state
▪ Early response	▪ Post-construction activities and decision criteria for exit
▪ Uncertainty management	▪ Monitoring plan/ contingencies

Principles Apply Regardless of Regulatory Framework



RCRA	CERCLA	Common Requirements
RFA	PA/SI	Identify releases and need for further investigation
RFI	RI	Characterizes the nature and extent of contaminant releases (uncertainty reduction). Determine potential human and environmental risk.
CMS	FS	Identification, evaluation, and screening of remedial alternatives (uncertainty mitigation)
Statement of Basis	Proposed Plan	Identification and public notice of the preferred alternative
Permit Modification	ROD	REMEDY SELECTION
CMD	RD	Development of detailed plans for selected remedy
CMI	RA	Construction, testing, and implementation of selected remedy
Closure/Post-Closure	Completion	Construction completed and post-construction plans in place
Closure/Post-Closure	Closure	Specific cleanup levels reached and remedial activities complete.

◆Depending on the nature of the remedy selected, construction complete and closure may be concurrent (e.g., clean closure or containment) or may be separated by a period of operation and maintenance. If the end state leaves contaminants in place at concentrations above risk thresholds (e.g., capping) closure is followed by long-term maintenance and stewardship.

Principles of Environmental Restoration

PER Workshops

PER Workshop Deliveries

- Longhorn AAP
- Ft. Ritchie
- Seneca AD
- Marion LTA
- Ravenna AAP
- Operational Support Command
- Lompoc DB
- Deseret AD
- Picatinny Arsenal
- Aberdeen Proving Grounds

PER Workshop

- 2 Days
  - ✓ Optional technical assistance on Day 3
- 10-30 Trainees
- Army Staff and Regulators
- Key Issues for Exercises

- Standard Delivery
- Site-Specific Tailoring
- Handbook

For Additional Information

Contact Rob Snyder, AEC
(410)436-1522
Robert.Snyder@aec.apgea.army.mil

SUPPORTING MATERIALS

- Decision Logic Diagrams
- Design Basis
- Workshop Handbook
- Guidance Manual