Developing Exit Strategies for Environmental Restoration Projects

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This guide is primarily intended for personnel with line management responsibility for Department of Energy (DOE) environmental remediation projects conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). It highlights the importance of establishing clear, measurable performance metrics for remediation technologies, and discusses how these measures can be used to demonstrate that response objectives have been attained and project activities terminated.

Introduction

Many planned or on-going environmental restoration projects involve remedial strategies that will require some form of long-term monitoring or operation and maintenance. These long-term obligations will constitute a significant commitment of resources and, therefore, it is important that these requirements be fully understood, both in terms of the types of activities and the length of time the activities are likely to be required. In addition, project managers need to ensure that *exit strategies* are in place that will ultimately allow these long-term requirements to be terminated once remedial objectives have been reached.

[Note: For those actions that will require activities in perpetuity (e.g., monitoring disposal cells), the focus shifts to establishing an appropriate “ramp-down” strategy as confidence is gained that engineered systems are functioning as intended and human health and the environment are fully protected. A brief discussion of ramp down strategies is provided in Highlight 2 at the back of this fact sheet.]

Experience has shown that without an exit strategy, it is difficult to reach consensus on when to stop active remediation or associated monitoring. The difficulty arises from a failure to define how we will determine that a response objective has been met. The default position - continually extend operations until some undefined event makes it clear that termination is appropriate - is particularly problematic because without a clear definition as to what that undefined event would look like, the likelihood of generating consensus that it has been reached is diminished. Therefore, it is prudent to understand what is required to stop an activity before the activity is begun. This is particularly important at sites relying on long-term ground water remediation systems.

What is an Exit Strategy?

An exit strategy may be viewed simply as the set of information that will be used to demonstrate the desired performance has been achieved, the response objective has been met and that associated activities (e.g., pump and treat systems, monitoring) can be terminated. An exit strategy is particularly important for any activity that is performance based as opposed to design based, since it defines the data necessary and sufficient to demonstrate that the desired performance has taken place. Too often, however, the necessary level of detail to clarify how performance will be measured is lacking in project workplans. Such detail is embedded in the four essential elements of an exit strategy:

1) A description of the objective of the activity, i.e., the response action objective;
2) A performance “model” that describes the expected course of the remediation process, i.e., how conditions are expected to change over time from the current state until the response objective is attained;
3) A listing of the performance metrics, decision criteria, and endpoints that will be used to assess how the response is progressing and demonstrate when the objective has been reached; and
4) A contingency plan that will be implemented if data indicate that objectives will not be met.

Developing an Exit Strategy

Defining Response Objectives

Response objectives establish the desired condition of the site once response activities are complete. Response objectives may specify allowable level(s) of residual contamination in environmental media, a required level of contaminant mass reduction within media, or a required reduction in contaminant flux between media. Whatever the objective, it is critical that it be understood and agreed to before a response action is initiated. Without such agreement, it is difficult, if not impossible to develop the performance model and metrics that will be used to assess a technology's progress in achieving the stated objective.

Performance Model

In order to develop an appropriate monitoring strategy and performance metrics, a performance model should be developed in advance to define the expected system response to the remedial technology. The Performance Model may be anything from a simple diagram to a set of numerical constructs designed to predict what remedy performance will be and what the site will look like at various times in the future after remediation is initiated.[1] As performance assessment data are collected they are compared to the performance model to determine if the remedy is indeed performing as planned. In turn, the understanding gained from this activity is fed back into the conceptual site model (CSM), to ensure that the linkages are accurately portrayed based on any new findings.

Performance Metrics

Exit strategies must include quantitative criteria that will be used to assess system performance, and ultimately to determine when the remedial technology has achieved its intended goal. Without predefined metrics, any uncertainty resulting from collected data may lead to a seemingly endless process of additional sampling and analysis to support a decision ("Let's collect one more round of samples to see what that tells us."). Although ultimately a decision may be reached, the latter is not an efficient or effective approach.

The quantitative criteria established to assess performance need to specify not only where and how the criteria apply, but how they will be measured (See Highlight 1). As an example, a decision document may state that "*operation of groundwater pump and treat system will continue until MCLs are met in the aquifer*." Yet, such language is not sufficiently clear to differentiate among alternative measures to which the MCL is to be compared such as average concentration, the concentration from two consecutive quarterly sampling events, or some other measure. Similarly, the language fails to clarify whether the MCL must be met everywhere in the aquifer, at specified monitoring wells, or along an agreed to compliance boundary.

Highlight 1: Exit Strategy Metrics

- The type of data required
- Sample locations
- Sample frequency
- Target parameter thresholds
- Duration required to demonstrate sustainability
- Statistical algorithms to be applied to data (e.g., confidence limit, type of mean, etc.

Performance criteria may be defined according to interim milestones to evaluate progress (e.g., concentrations reduced by 50 percent within a specified time frame; specified mass removal rates at different times during the remediation). Alternately, monitoring criteria may be defined in terms of conditions at a specified location such as concentrations along the leading edge of a plume, or hydraulic gradients around a containment system.

The development of performance criteria should be viewed as a dynamic process that continues throughout the duration of the remedial action. In this way, performance monitoring can serve multiple purposes; to demonstrate the efficacy of remediation when the system is operating as anticipated (e.g., conditions are being met at specified points of compliance), or to allow for expedient action (e.g., technology enhancement) should performance deviate from predefined expectations. In addition, performance monitoring results are used to update and refine both the conceptual site model and the performance

[1] Because some uncertainty on technology performance will always exist, a certain degree of flexibility should be allowed to refine performance model expectations as data are collected and evaluated over time.

model, thus increasing confidence in our ability to predict performance over time.

Contingency Plans

A contingency plan establishes a predefined course of action should performance monitoring indicate remediation is not progressing as expected. Project managers should utilize contingency planning to address potential deviations that would significantly impact the expected system performance.[2] The contingency plan should not only define the criteria to signify a deviation has occurred, but also the course of action to be taken. For example, contingencies may include: 1) the collection of additional data to better assess performance, 2) re-evaluation of performance data to determine whether expectations need to be redefined, *or in limited situations*, 3) implementation of an alternative remediation strategy, or 4) re-analysis of response objectives to determine whether they are indeed attainable.

Essential activities in contingency planning include:

- Identifying potential deviations from the expected performance (the latter defined by the performance model);
- Evaluating the likelihood a deviation will occur;
- Assessing the potential impacts should a deviation occur, i.e., potential impacts on system performance, or project schedule, and the time needed to respond;
- Defining the required data, data quality criteria, and baseline comparison to be used to recognize a deviation has occurred (as opposed to expected variability in data); and
- Defining the appropriate course of action for specified deviations and developing implementation plans.

The level of detail described for each element can and should be in simple terms. The purpose is not to perform a feasibility study, but rather to define acceptable and unacceptable performance/conditions, identify required data for evaluation of performance, and come up with some initial considerations of suitable contingencies.

Some examples of performance measures or conditions that may be addressed through contingency plans follow:

- If new sources are identified or plume distribution is different than originally characterized, install additional source control measures or reconfigure the existing monitoring well system to capture plume data.
- If treatment plant influent concentrations are different than expected (higher, lower, different toxic constituents, or different inorganic compounds that affect the treatment process), modify the existing treatment configuration to enhance system's capabilities to meet the performance criteria.
- If a new policy or guidance from regulatory agencies becomes available (e.g., EPA's policy directive on monitored natural attenuation, OSWER Directive 9200.4-17), evaluate policy to determine potential application to existing site conditions. If the new policy provides remedial options or flexibility that were not available at the time the original remedy was selected and implemented, and the application of these provisions will significantly reduce long-term monitoring obligations or enhance the long-term protection of human health and the environment, proceed as appropriate to formally incorporate the policy.

Please refer any questions concerning this material to:

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[2]See related fact sheet, *Uncertainty Management: Expediting Cleanup through Contingency Planning, DOE/EPA's Principles of Environmental Restoration Workshop.*

Highlight 2: Ramp-Down Strategy

Ramp-down strategies help conserve resources spent on monitoring. They can be viewed as: 1) an intermediate step in an exit strategy in situations where eventually all monitoring will be terminated, or 2) the final phase of a monitoring strategy for those remedies where monitoring in perpetuity will be required. Ramp-down strategies should include criteria that can allow the following:

Eliminate unnecessary analytes, including:

- Analytes not found in initial samples and for which there is no evidence of a release (some analytes may be included to monitor geochemical conditions pursuant to demonstrating conditions will support natural attenuation mechanisms);
- Analytes not identified above detection limits in three successive samples; and
- Analytes detected at less than half the action level for at least three successive samples and displaying a static or downward trend.

Eliminate redundant locations (wells), including:

- Wells in the interior of plumes whose boundaries are defined by other wells (these wells may be needed to support performance monitoring for response such as monitored natural attenuation);
- Wells outside plumes and not deemed to be in the pathway of on-coming plumes and not required to establish background;
- Wells duplicated by proximate wells on the same isopleth; and
- Wells for which analytical data will have no clear use in future decision making such as consideration of when to implement a contingency.

Reduce sampling frequency:

- Initial quarterly sampling is needed to establish seasonal variations. Annual monitoring helps identify variations from changes in precipitation (wet versus dry years). Beyond those distinctions, sampling frequency should be selected on the basis of the slope of the observed trend lines, the degree to which empirical data match predictions, and the relative velocity of groundwater. The more predictable the data are, the less need there is for frequent confirmation.

- Monitoring is only required when there is uncertainty as to the fate and transport of contaminants and the effectiveness of remedies that are implemented. As the uncertainty is reduced, or as its consequences become less significant, the need for further monitoring is diminished. Similarly, slow moving groundwater requires less frequent monitoring because trends are slower to develop and there is more time to respond.