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Project Life Cycle Stages

Geospatial methods can apply throughout the life cycle of environmental cleanup projects, including monitoring of active remediation systems. The terminology and regulatory framework for the stages of the project within its life cycle, however, often vary under different regulatory programs. For clarity, this guidance organizes site management around five main tasks: release detection, site characterization, remediation, monitoring, and closure. These life cycle stages are appropriate for most groundwater remediation projects and apply to other media as well.

These tasks correlate with the activities described in various regulatory programs (such as RCRA, CERCLA, State Voluntary Cleanup, and UST Site Cleanup). Although individual projects may vary in their progression through these stages, statistical tests can support decision making regardless of how the project stages are defined. Figure 126 summarizes the correlations between the terms used in this guidance document and the terms used in several regulatory programs.

Project Lifecycle Stage	Release Detection	Site Characterization	Remediation and Monitoring				Closure
			Remediation		Monitoring	Remediation	
CERCLA/ Superfund	Preliminary Assessment/Site Inspection	Remedial Investigation	Feasibility Study or EE/CA	ROD	Remedial Action	Response Complete	LTM/LTMgt/ LTMO
RCRA	Release Detection	RCRA Facility Investigation	Corrective Measures Study	RCRA Permit	Corrective Measures Implementation/ Compliance Monitoring	Certification of Remedy Completion or Construction Complete	Post Closure Care
UST/ LUST	Varies by Regulatory Authority						
State	Varies by State						

Figure 126. Correlation of regulatory terms.

Source: GSMC-1 (ITRC 2013), Adapted from ITRC RRM (ITRC 2011) IBT slide 2011.

Release Detection

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At cleanup sites or at waste management facilities, groundwater monitoring may be used to determine if a release has occurred. A release may be detected by comparison of compliance well data to a criterion or by detection of a trend in the compliance well data. Groundwater concentrations may be compared to a criterion to determine facility compliance. A release may also be detected when the concentration of a chemical in groundwater exceeds background. Accordingly, an important aspect of release detection monitoring is determining the background concentrations (either natural or anthropogenic) for chemicals. Natural background would be representative of pristine or pre-industrial conditions. Anthropogenic background refers to concentrations in the surrounding groundwater that may be impacted by human activity, but not by the site.

Site Characterization

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Site characterization is typically the first stage of a cleanup project. Site characterization describes the physical conditions of the site such as soils, geology, hydrology, the presence of existing contamination, the potential for contamination to be released, and the actual and potential pathways and mechanisms for contamination transport. This stage of the project life cycle considers the chemical characteristics of the contaminants and their potential to be mobile in the environment. All of these aspects of site characterization are needed to develop an appropriate groundwater-monitoring program, understand groundwater contaminant concentrations, and select and interpret groundwater statistical analyses.

Remediation

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Remediation of contaminated groundwater is a challenge. On average, attainment of regulatory closure at sites with contaminated groundwater takes significantly longer compared to sites that have contaminated soil but no groundwater impacts. At many sites, it is estimated that attainment of groundwater standards will take decades or more (see NAP 2012 (National Academies Press (NAP) 2012)for a discussion of the challenges of managing complex contaminated groundwater sites).

This section provides guidance on the use of statistics to support remedy selection and evaluation of remedy effectiveness. For remediation, statistical analyses are most useful for evaluating changes in concentration over time (trend analyses). An objective and accurate evaluation of changes in contaminant concentrations over time can help to resolve groundwater remediation issues.

Monitoring

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Groundwater monitoring is conducted to observe and assess characteristics of interest at cleanup, RCRA facility, or waste disposal sites. Often, monitoring is conducted on a long-term basis, sometimes for decades. Monitoring may be required even after closure of a site during postclosure monitoring. As such, monitoring may be conducted to describe characteristics at a specific location or point in time or to show how these characteristics change over time or space.

Changes in groundwater quality may have either natural or human causes. Proper evaluation of groundwater data helps you understand whether the criteria or goals of the monitoring program are met or if significant, adverse changes in groundwater concentrations have occurred. Proper design of the monitoring network depends upon the type of the site, the contaminants present, and the regulatory program. Prior to implementing a monitoring program, review well placement, parameter selection, sampling frequency, and whether or not a release has been identified. Typical activities in the monitoring stage include observing changes in concentration levels over time and space, and comparing concentrations to numerical criteria. After sufficient data are collected, it may also be possible to optimize sampling locations and sampling frequencies to improve and streamline the monitoring program.

Closure

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Closure is the final stage of the project life cycle and therefore is subject to extra scrutiny. At this stage in the process, data planning and collection should have been managed through a systematic planning process and the CSM is assumed to be complete for the purposes of making a final determination on whether monitoring may be permanently discontinued and the site closed. This decision point may be reached at any time during the life cycle process (for example, during site characterization, remediation, or monitoring). Significant variation occurs across regulatory programs, but in general, when contaminants are no longer detected in any wells for several sampling events or over a specified period of time, the remedial goals are deemed complete and the groundwater is no longer considered contaminated. However, in instances where contaminants decrease but remain measurably present, or are present in natural or anthropogenic background, statistics can support a closure decision.

Given the importance of this decision, managers must have a high degree of confidence that the data fully support closure. Closure should verify that site contaminants are no longer present in the groundwater, or are not present at concentrations that pose an unacceptable risk to human health or the environment. In cases where concentrations of contaminants are allowed to remain (such as under institutional or engineering control scenarios), trend analysis results may be used to show that contaminants will not migrate or increase concentrations outside of the defined boundaries of the controlled area.

Following remediation, formal statistical testing will usually involve an upper confidence limit around the mean or an upper percentile compared against a criterion. The overriding concern in corrective action is that remediation efforts must have sufficient statistical proof to be declared successful. Since groundwater is now presumed to be contaminated, a facility should not exit corrective action until there is sufficient evidence that contamination has been abated (see Chapter 7.2, Unified Guidance).

By the time a site reaches the closure life cycle stage, the evaluation assumes that contamination exists. Therefore, the statistical approach may involve comparing an upper confidence limit of the data to a criterion. The upper confidence limit (UCL) should lie below the criterion to accept the hypothesis that concentration levels support closure. If the entire confidence interval (considering both the lower and upper confidence limits) lies below the criterion, there is statistically significant evidence that the true value of the parameter (for instance, the mean) is less than the criterion. When the confidence interval straddles the criterion, the correct decision is uncertain within the stated confidence level. The true value of the parameter might be less than or greater than the criterion and no clear decision with high statistical confidence is possible (see Chapter 5, Unified Guidance).