Fact Sheet 1: Do You Need Geospatial Analysis?

This fact sheet is the first of four fact sheets developed by ITRC to accompany its guidance titled *Geospatial Analysis for Optimization at Environmental Sites* (GRO-1) (available at www.itrcweb.org/gro-1). This fact sheet introduces the value and use of geospatial analysis to project managers, program or financial managers, and stakeholders. The GRO-1 guidance defines geospatial analysis as the process of compiling and analyzing data that are related in time or space.

How Do Geospatial Methods Support Optimization Activities During Stages of the Environmental Project Life Cycle?

The GRO-1 guidance defines optimization and identifies the questions to be answered, and also offers guidance on how to determine if site conditions are suitable for geospatial analysis (see Fact Sheet 2). Depending on site-specific conditions and the regulatory framework, geospatial analysis can support optimization activities in any stage of the project life cycle. The minimum data for a viable geospatial analysis are different, and usually more stringent, than those for other types of data analysis. If the site data meet minimum data criteria (see the Data Requirements for Geospatial Analysis section), then appropriate geospatial methods can be selected. Numerous software packages are available to aid in applying these methods.

What is Optimization?

USEPA has published the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion (USEPA 2012a), which describes how regulators can develop and track remedial optimization programs. In this document, USEPA defines optimization as

> efforts *at any phase of the removal or remedial response* to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply *techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness*. (USEPA 2012a, emphasis added)

This optimization strategy has expanded from its original focus on remedial action and long-term monitoring to application throughout the stages of the project life cycle (including release detection, site characterization, remediation, monitoring, and closure). Optimization has been shown to improve performance, increase monitoring efficiency, improve cost effectiveness, and support technical decisions at contaminated sites (USEPA 2002b; ITRC 2004). Additional information and resources on optimization are included in the History of Remedial Process Optimization and Additional Resources sections. For examples of site-specific optimization activities, see the Case Studies section.

What are Geospatial Methods and Why Should They be Used?

Geospatial methods are spatial or temporal analytical methods used to estimate values (such as concentrations) at unsampled locations or times. These methods require data with information about sampling locations and times. Some methods can also generate measures of uncertainty associated with the estimates. Some common examples include contouring potentiometric surface or assessing chemical concentration data. In some cases, these methods can include statistical analyses involving spatial or spatial and temporal interpretations of environmental data as well as uncertainty evaluations of those data.

Geospatial analysis is the process of compiling and analyzing data related in time or space. Geospatial analysis can be used for optimization at any stage of the project life cycle to provide additional confidence in the data set. The analysis is especially useful for complex soil or groundwater cleanup projects, where optimizing the remediation or performance monitoring system is challenging. Unlike traditional statistical methods, geospatial methods implicitly or explicitly incorporate the spatiotemporal dependence between nearby data points, which is an important feature of almost all data collected as part of an environmental investigation (Goovaerts 1997). The results of geospatial analysis add additional lines of evidence to augment direct sampling, rather than relying on professional judgment alone. These results can be used for characterizing and optimizing sites.

The geospatial methods addressed in this guidance may be used to answer questions that are detailed in the Geospatial Methods for Optimization Questions in the Project Life Cycle Stages section. The geospatial methods are discussed in order of their complexity, ranging from simple to more complex to advanced. The simple methods typically do not require making any statistical assumptions. The more complex methods make inferences about the statistical distribution of a sampled population. Advanced geospatial methods, also known as geostatistical methods, are generally more robust. The assumptions for these methods require that data exhibit spatial or temporal relationships. More specific information about the types of methods and specific information about each are detailed in the Methods section. The section titled Work Flow for Conducting Geospatial Analysis presents information about the steps to select and implement geospatial methods.

Geospatial methods are typically performed using specialized software. Software selection depends on site-specific factors, cost, intended use, input, output, and the geospatial methods used. A number of widely-used software packages available for geospatial methods are summarized in the Software section.

How can Geospatial Analysis Help During Each Stage of the Project Life Cycle?

During Release Detection in Ongoing Monitoring Systems

- Geospatial analysis can show the location and intensity of a contaminant release by showing how contaminant concentration changes with the distance from the release and identifying localized areas of elevated concentration (hot spots).

During Site Characterization

- Geospatial analysis helps to demonstrate that sample spacing is appropriate, without any data gaps or redundancy in planned data points, and assesses the uncertainty of the estimated data.
- Geospatial analysis can show that a less expensive parameter can be used to interpolate the position of the contaminants of interest.
- Geospatial analysis can assist in making a representative map portraying the spatial relationships of measurements and showing the average concentration (both background and throughout the release).
- Geospatial analysis helps to identify localized areas of elevated concentration (hot spots), random releases, or storage areas.

During Remediation

- Geospatial analysis can assist in making a representative map portraying the changes throughout the plume and in identifying specific areas for remediation.
- Geospatial analysis can assist in calculating the average contaminant concentration in the background and throughout the release, computing future results from an existing remedial action.

During Monitoring

- Geospatial analysis can assist in making a representative map portraying the spatial relationships of measurements and how the contaminant concentrations change with the distance from the release.
- Geospatial analysis can demonstrate that the frequency and locations of monitoring points are optimal to avoid sampling location redundancy.

During Closure

- Geospatial analysis assists in determining the optimal spacing and frequency for closure sampling by adequately portraying the spatial relationships of measurements that show downward concentration trends across the site.
- Geospatial analysis assists in demonstrating that the data adequately represent the contaminant concentrations in order to show compliance levels in accordance with the regulatory requirements.

Benefits of Geospatial Analysis

Cost Optimization Throughout the Project Life Cycle

- improved project planning and development, including initial sampling plan or refinement of an existing design to determine the number and location of samples to support effective site decisions
- optimization of scope and costs for site characterization and monitoring programs
- demonstration of attainment of remediation goals or compliance with remediation endpoints

Enhanced Data Evaluation/Interpretation

- improved quality of site characterization and monitoring data
- identification of trends or patterns in site characterization and monitoring data
- improved estimates of future sampling results based on existing data
- more accurate estimates of average concentrations, perimeters, surface areas, volumes, and masses of contaminated materials, which can improve cost estimates for remediation alternatives

Enhanced Communication and Decision Making

- enhanced communication of site data to project stakeholders, including conceptualizing and simplifying complex site characteristics through the use of graphical presentations and geospatial visualizations
- better decision making regarding risk, liability, remedial options/effectiveness, sampling strategies, and site closure

Regulatory Barriers and Concerns

Many state and federal agencies have accepted the process for optimization during environmental project life cycle stages, in particular for long-term monitoring and remediation system optimization within some guidelines (see the History of Remedial Process Optimization section). The guidelines for optimizing actions vary by agency, so project managers should identify the regulatory authority and the applicable requirements for any specific project before proceeding with optimization activities. Modification and acceptance of site activities, such as changes to remediation processes or monitoring programs, may be difficult from a regulatory and technical perspective. Using geospatial analyses, however, may aid in the acceptance of the optimization of these activities.

Existing regulations may not reflect the “state of the science” or recognize the advantages and limitations of current geospatial practices. Specifically, ITRC has identified and provided guidance to address the following issues with optimization at environmental sites:

- understanding risk management, RRM-1 (ITRC 2011)
- using optimization with remediation activities, RPO-1 (ITRC 2004)
- using statistics with environmental data, GSMC-1 (ITRC 2013)

Barriers to using geospatial methods for optimization activities during the life cycle of an environmental project include regulators’ hesitance to use or accept new geospatial analysis and the need for training of regulators, consultants, and site owners to increase understanding of the methods and their potential for supporting optimization activities.

The nine case studies included in the GRO-1 guidance describe how geospatial methods have been successfully applied to optimization activities at seven sites across the United States, one site in Canada, and one site in Japan. In addition, other representative sites that have benefited from geospatial optimization are included in the summary table below. These sites have been documented on the Federal Remediation Technologies website.

Some of the software described in the guidance and in the table below has undergone independent evaluation or comparison. For example, the Summit Envirosolutions monitoring optimization software has been the subject of a demonstration project funded by the Department of Defense Environmental Security Technology Certification Program (ESTCP) (Harre et al. 2009). Additionally, USEPA funded a comparison of the MAROS software and the Parsons Three-Tiered Monitoring Optimization (3TMO) software, both of which integrate various geospatial techniques (USEPA 2004).

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Examples of geospatial analysis to support optimization documented on the Federal Remediation Technologies and Clu-in web sites

Site (Year)	State	Life Cycle Stage	Scope	Geospatial Methods	Software
Wash King Laundry Superfund Site (2006)	MI	Monitoring	Long-Term Monitoring Network Optimization (LTMO) Evaluation	Semivariogram, kriging	
Main Base/Sac Plume Area Former Mather Air Force Base (2003)	CA	Monitoring	Three-Tiered Groundwater Monitoring Network Optimization Evaluation	Semivariance, semivariograms	ArcGIS, Geostatistical Analyst
Camp Stanley Storage Activity – US Army (2005)	TX	Monitoring	Three-Tiered Groundwater Monitoring Network Optimization Evaluation	Semivariance, semivariograms	ArcGIS, Geostatistical Analyst
Operable Unit 2 Bunker Hill Mining Superfund Site (2006)	ID	Monitoring	LTMO	Semivariance, semivariograms	ArcGIS, Geostatistical Analyst
Newark, Muscoy, and Source Operable Units Newmark Superfund Sites (2007)	CA	Monitoring	LTMO		MAROS
Clare Water Supply Superfund Site Permeable Reactive Barrier and Soil Remedy Areas (2007)	MI	Remediation, Monitoring	LTMO		MAROS
Taylor Road Landfill Superfund Site Seffner, Hillsborough County, Florida (2007)	FL	Monitoring	LTMO		MAROS
Gilson Road Superfund Site Nashua, New Hampshire (2009)	NH	Monitoring	LTMO		MAROS
Selected Groundwater Plumes at the Massachusetts Military Reservation (2000)	MA	Remediation, Monitoring	Optimization Of Long Term Operations/LTMO	Kriging, global kriging weights, ordinary kriging, indicator kriging	
Hanford Site (2006)	WA	Remediation, Monitoring	LTMO		GTS
Ross Metal Sites (2005)	TN	Remediation, Monitoring			VSP
Marino Brothers Scrapyard (2005)	PA	Remediation (Pilot Study)	Using FIELDS and SADA to Develop Contour Maps of Contaminant Concentrations and Estimate Removal Volumes for Cleanup of Soil		FIELDS, SADA

Site (Year)	State	Life Cycle Stage	Scope	Geospatial Methods	Software
Delatte Metals Superfund Site (2009)	LA	Monitoring, Five Year Review Process	LTMO		
Peck Iron and Metal Superfund Site Portsmouth (2013)	VA	Characterization	Optimization of Sampling Analysis Plan to support the RI		
Fort Lewis, McClellan, Long Prairie Superfund Site – Pilot Study (2003)	WA, TX, MN	Monitoring	LTMO	Delaunay, Mann-Kendall, kriging	MAROS
NAS Brunswick (6 sites), Loring AFB (2006, 2004)	ME	Monitoring	LTMO	Temporal variograms	GTS
Frontier Hard Chrome Superfund Site, Vancouver (2007)	WA	Remediation, Monitoring	LTMO		MAROS
NAS Lemoore (NA)	CA	Characterization	Vapor Intrusion Sampling Plan Development		FIELDS, SADA
Site OT-24, Wurthsmith AFB (NA)	MI	Remediation, Monitoring	LTMO	Nonparametric Mann-Kendall	

Note: Blank cells indicate that information is not available or not applicable.

A correct and clear CSM results in quicker acceptance of optimization activities; however, inconsistent federal, state, and local regulations often complicate evaluating environmental data and using geospatial methods in developing the CSM. Regulators should be involved early in the process and understand the CSM and methods used in developing the CSM.

Project managers and regulators already use some simple geospatial methods to aid in developing the CSM, such as determining groundwater flow direction and developing contour maps that show equal concentrations. More complex and advanced geospatial methods, however, allow a more detailed understanding of the available data across all stages of the project life cycle. Specifically, project managers can inform regulators about the use of geospatial methods as follows:

1. Identify the regulatory authority and stakeholders who should understand the use of geospatial methods to assist in describing the site activities.
2. Clearly explain the CSM elements based on the known chemical data (matrix and contaminant distribution), geologic data (matrix distribution and preferential pathway), hydrologic data (direction, force, and saturation), and migration (advection, adsorption, and dispersion).
3. Identify the existing sample locations (horizontal and vertical).
4. Identify the project life cycle stages in which geospatial methods will be used to support site activities.
5. Explain how a geospatial evaluation of the existing data can help further develop the CSM.
6. Explain how the use of geospatial methods can aid in evaluating the needs for site activities, such as hot spot detection, monitoring location, monitoring frequency, and contaminant distribution.

See Fact Sheet 2 for information about site conditions that are suitable for using geospatial analyses.

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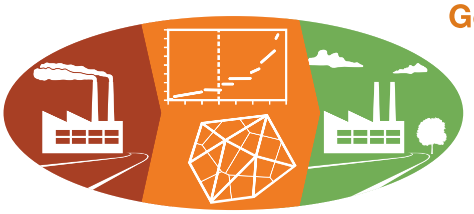

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