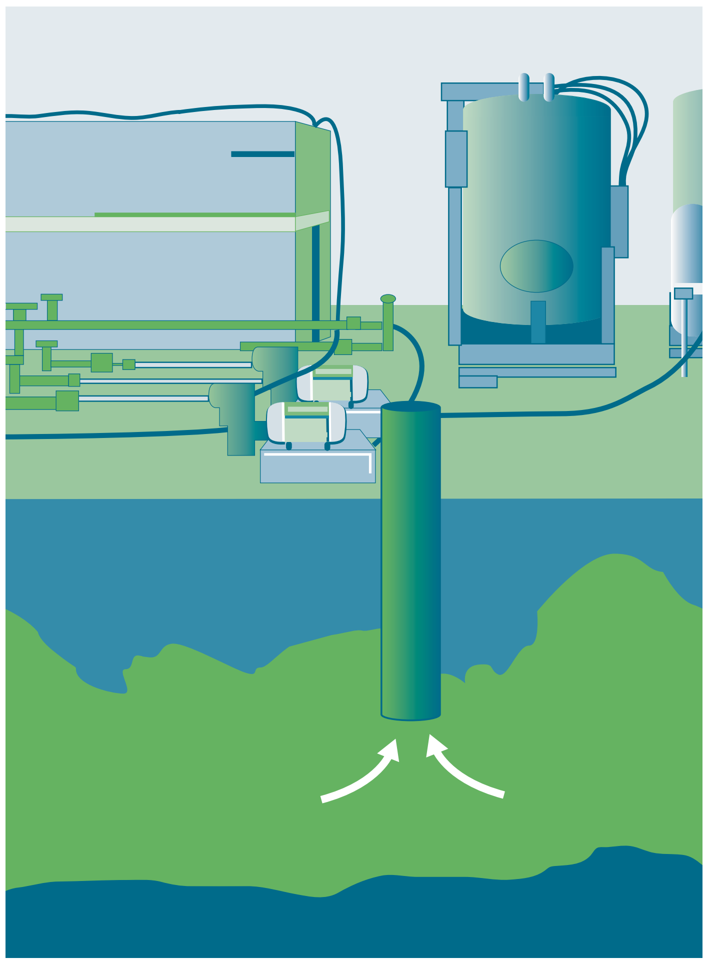
Technical/Regulatory Guideline

Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation



September 2004

Prepared by
The Interstate Technology & Regulatory Council
Remediation Process Optimization Team

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EXECUTIVE SUMMARY

For the foreseeable future, federal, state, and private-sector organizations will continue to spend billions of dollars on the characterization and assessment of contaminated environmental media and on the selection, construction, operation, maintenance, and monitoring of environmental remediation systems. As the various environmental cleanup statutes and their implementing regulations evolved, the initial assumption was that these programs could follow a basic "study, design, build" linear paradigm. However, years of experience has led to the realization that the significant uncertainty inherent in environmental cleanup requires more flexible, iterative approaches that manage uncertainty. Uncertainty, as demonstrated by frequently missed target dates, has forced the development of mechanisms that allow for both the systematic reevaluation of initial objectives and the continuous improvement and optimization of remediation technologies and techniques. These mechanisms and reevaluations are known collectively, or generally, as "remediation process optimization" (RPO). The Interstate Technology & Regulatory Council RPO Team developed this guide to respond to that realization. With schedules for projects in the operating and maintenance or long-term remedial action phase frequently being measured not merely in years, but in decades, RPO is not an just option, but a necessity.

In the initial stages of a remediation action, much of the effort is on characterization and source remediation; limited effort is spent on monitoring. As the project matures, most of the resources are spent for monitoring and operations and maintenance (O&M). Figure ES-1 depicts effort and cost vs. time for a typical conventional remediation action at a contaminated site. As shown by the dashed line, at most sites we cannot be sure how long it will take to reach closure.

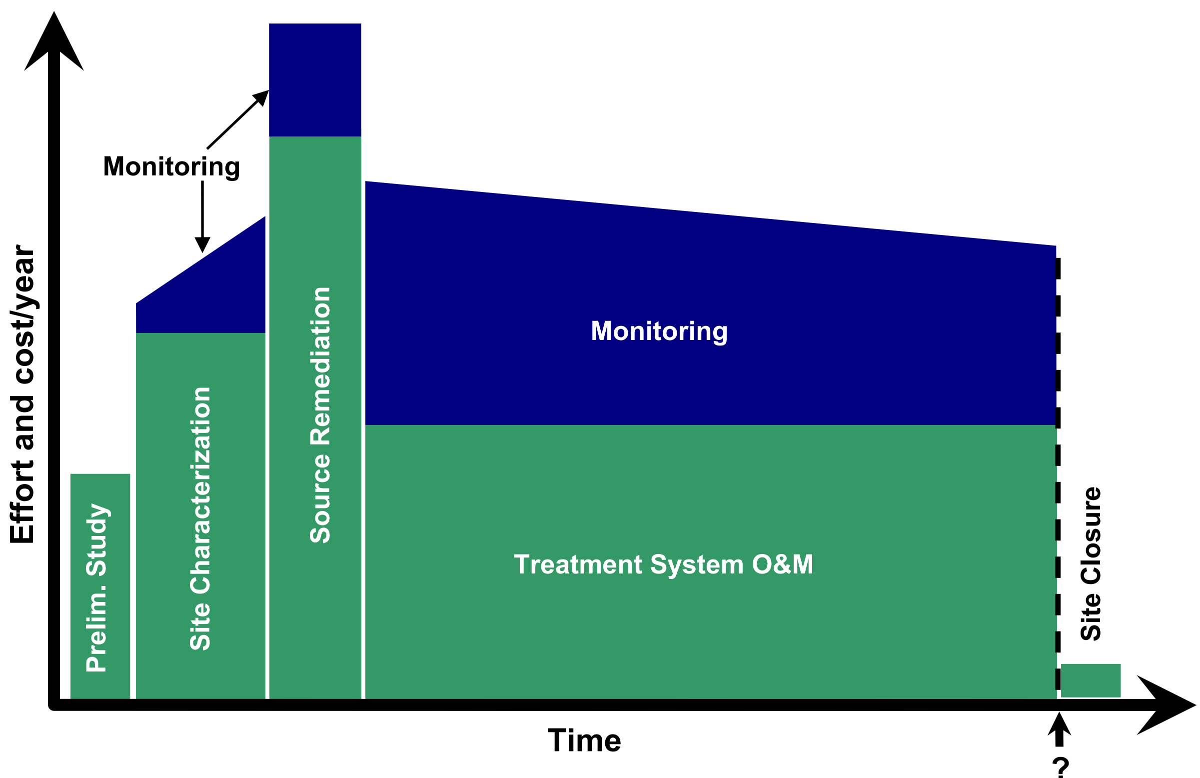

Figure ES-1. Effort vs. time in typical remediation actions.
(Modified from U.S. Navy 2003.)

An RPO review is a way to evaluate the status of remediation process and get an idea of when to expect closure. Instead of continuing with a long-term O&M, we can actually—through the process of optimization—reduce the cost as well as time to completion, as shown in Figure ES-2. Depending on site-specific conditions, such an RPO review could result in substantial savings.

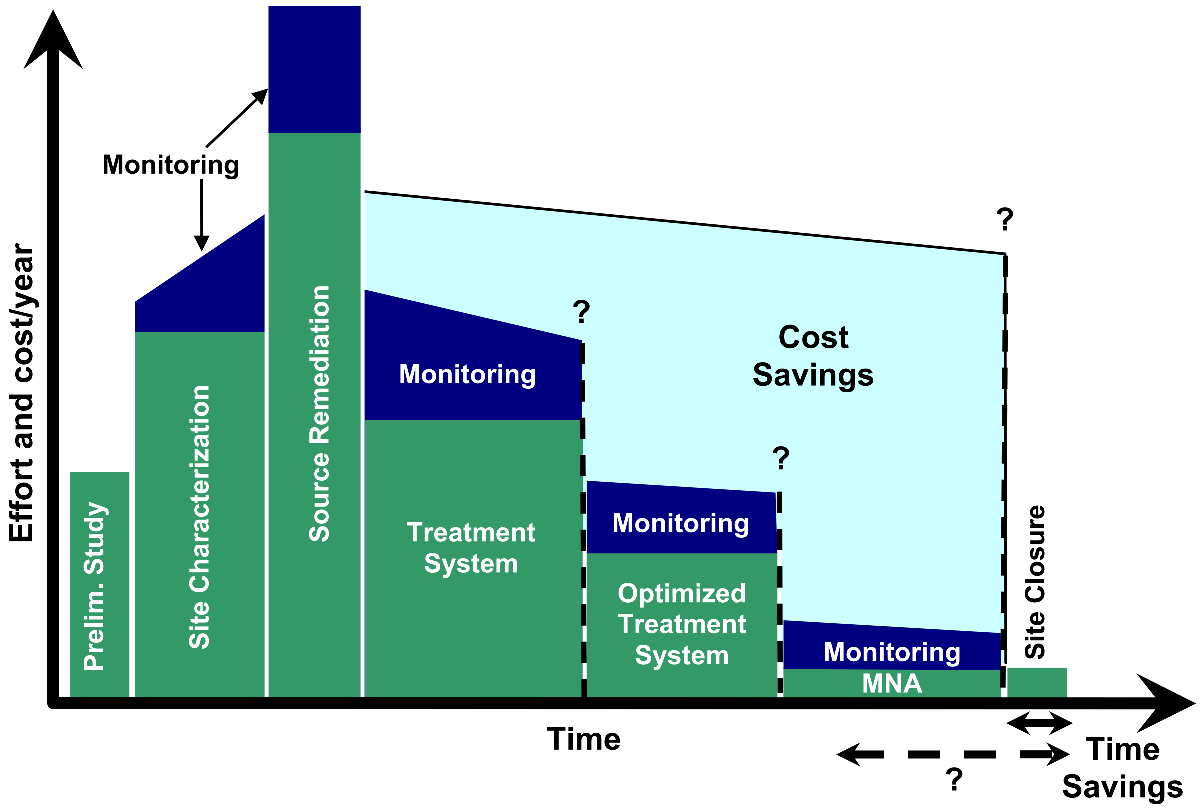

Figure ES-2. Effort vs. time in remediation actions with RPO.
(Modified from U.S. Navy 2003.)

This document provides interested parties—regardless of role (responsible parties, regulators, stakeholders)—with practical information and guidance on how to systematically evaluate and manage uncertainty associated with the remediation process by using RPO as a tool. Its primary goal is to provide information and tools to help ensure that the remediation process is progressing toward site cleanup objectives that are both acceptable and feasible and that selected remediation approaches attain those objectives and remain protective of human health and the environment. This document provides guidance on what could and should be included in an effective RPO proposal or program, including what RPO is, the regulatory framework that RPO must operate within, and references that provide examples of successful RPOs and resources for further examination of RPO.

The guidance describes the general regulatory and technical framework for evaluating remediation processes, regardless of the type or complexity of the remedy. Until recently, RPO has been associated with the "how" of remediation, such as the technologies in place. This document looks not just at the "how" of site cleanup, but also at the "why," which can be described as the conceptual site model (CSM). The CSM considers all factors involved with the site remediation, such as the environmental and (current and future) land-use plans, site-specific chemical and geologic conditions, and the regulatory environment.

The regulatory environment establishes the need to review and possibly revise cleanup goals to ensure their continuous applicability. As a result, scientific advances and regulatory changes—such as the movement towards risk-based goals and reevaluation of technologies deployed—are core features of a comprehensive RPO review. Therefore, consideration is given to the reevaluation of remediation goals and ways that potentially inapplicable or unattainable goals can be updated based on these and other new regulatory approaches.

The guidance identifies and describes the applicability, advantages, and disadvantages of various approaches, as well as where they are most appropriate for use. It also lays out key considerations when planning, designing, and implementing an optimization review.

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REMEDIATION PROCESS OPTIMIZATION: IDENTIFYING OPPORTUNITIES FOR ENHANCED AND MORE EFFICIENT SITE REMEDIATION

1. INTRODUCTION

Remediation Process Optimization (RPO) is the systematic evaluation and enhancement of site remediation processes to ensure that human health and the environment are being protected over the long term at minimum risk and cost. With this document, the Interstate Technology & Regulatory Council (ITRC) RPO Team intends to inform interested and affected parties about the value of optimization in efficiently and objectively setting and attaining remediation goals. Key elements of RPO include the following:

- appropriate use of up-to-date conceptual site model (CSM),
- flexible remedial action (RA) operations considering technology limitations and risk assessments,
- use of treatment trains for each target zone,
- developing performance objectives for each element of each treatment train,
- developing an exit strategy for each remedy component considering life-cycle factors,
- cost analysis as a decision-making tool with the requirement that protectiveness must be maintained or improved,
- consideration of life-cycle factors in remedial design, and
- continual evaluation of all the above through RA operations.

The ITRC RPO Team was formed in the fall of 2001 to develop this optimization guidance document and to provide RPO training. Several federal agencies and states have adopted unique optimization approaches. This document is intended to be a primer on the various optimization techniques. The RPO Team participated in several federal and state RPO efforts to understand the various approaches. The team included representatives from state environmental agencies (New Jersey, Maine, Florida, Georgia, South Carolina, Oregon, South Dakota, and California), federal agencies (Department of Energy [DOE], Department of Defense [DoD], and the Environmental Protection Agency [EPA]), environmental consultants, and academia. Descriptions and downloadable copies of other RPO documents that have been produced are available on the team page of the ITRC Web site (www.itrcweb.org).

1.1 Problem Statement

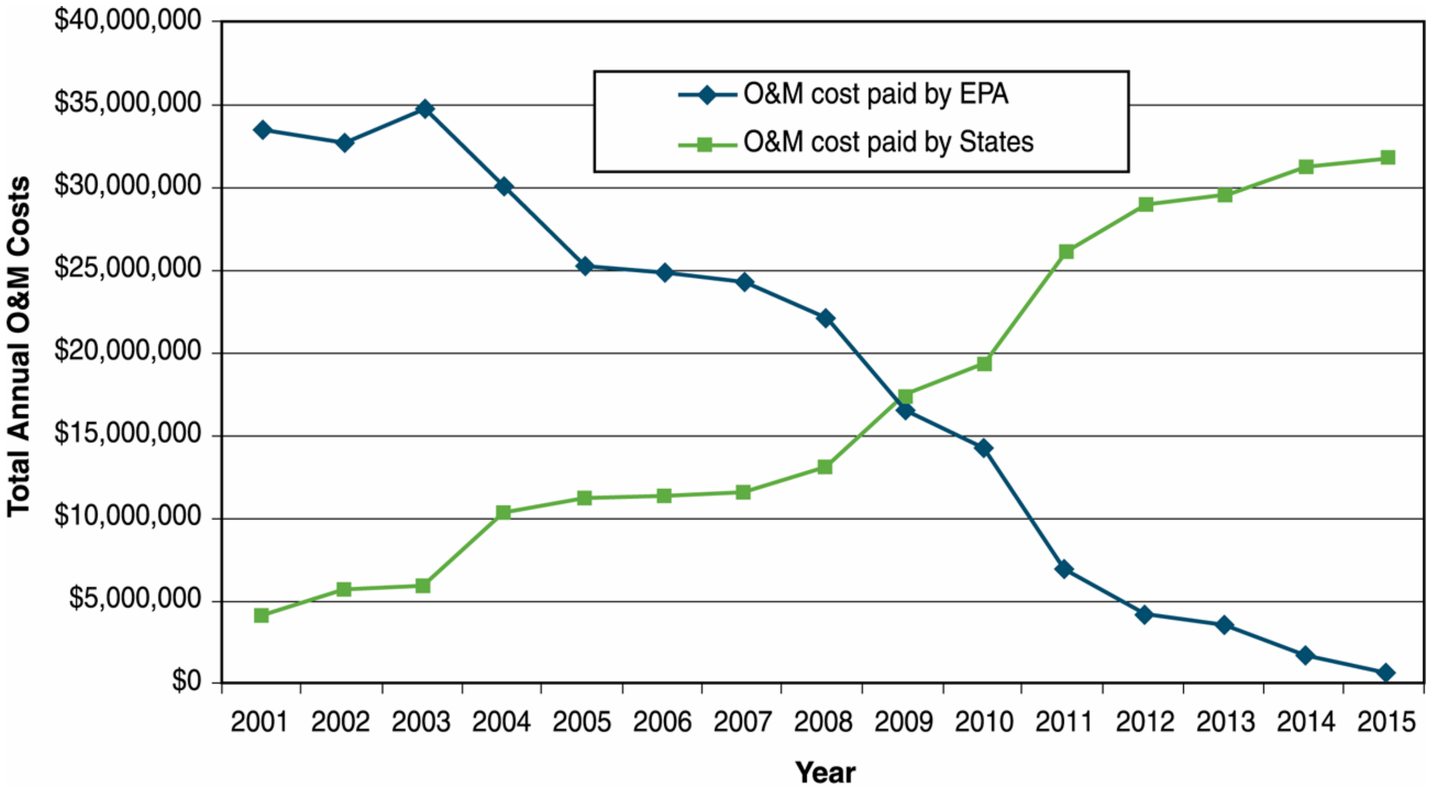
Federal, state, and private-sector organizations are spending billions of dollars to clean up the environment. These dollars are spent on characterizing and assessing contaminated environmental media and on selecting, constructing, operating, maintaining, and monitoring remediation systems. As the applicable environmental statutes and regulations continue to evolve and site-specific conditions become more apparent, coupled with new innovative technologies and diminishing resources, the need to apply flexible, iterative cleanup approaches is critical. An additional driver for states is their need to begin preparing for inheriting the responsibility for approximately 30% of EPA's Superfund sites. Table 1-1 presents EPA's projection on the number of systems and estimated costs that states will incur after long-term remedial action (LTRA). Figure 1-1 shows the trend in annual operating and maintenance (O&M) costs increasing for states in the future at current fund-led pump-and-treat sites as they are transferred from EPA to the states. Conducting RPOs at these sites before they are transferred to the states provides an assurance that the systems that they are inheriting are performing optimally.

Table 1-1. Future O&M costs of fund-led pump-and-treat systems expected to be incurred by each state after long-term remedial action

State	Number of systems	Total O&M cost expected to be incurred by state after LTRA	
		PV (discount rate of 5%)	No discounting
Arkansas	1	$2.6M	$5.4M
California	4	$15.5M	$32.0M
Florida	4	Unknown	Unknown
Idaho	1	Unknown	Unknown
Illinois	1	$0.2M	$0.2M
Indiana	1	$1.0M	$2.4M
Kansas	1	$0.6M	$1.0M
Louisiana	2	$4.5M	$7.2M
Maine	1	$0.0M	$0.0M
Massachusetts	4	$56.8M	$99.6M
Michigan	6	>$21.1M	>$48.8M
Minnesota	3	$4.4M	$8.4M
Missouri	1	Unknown	Unknown
Nebraska	1	$0.5M	$1.0M
New Hampshire	3	$0.5M	$0.5M
New Jersey	12	$69.4M	$154.7M
New Mexico	1	Unknown	Unknown
New York	10	$24.4M	$46.9M
North Carolina	4	>$0.2M	>$0.3M
Oregon	1	Unknown	Unknown
Pennsylvania	10	$24.2M	$56.5M
South Carolina	2	$1.0M	$1.8M
Texas	5	>$8.2M	>$18.4M
Virginia	2	$1.9M	$3.6M
Washington	3	>$9.3M	>$21.0M
Wisconsin	4	>$5.4M	>$10.3M
Total	88	>$251.7M	>$522.7M

Notes:

- Data reflect estimates provided by site Remedial Project Managers between February and May 2001. These estimates may vary from actual values. Data, including the number and status of systems, may change over time.
- Fund-lead pump-and-treat systems are those systems where groundwater extraction and treatment is specified in the Record of Decision and oversight is provided by EPA or by the state with financial support from Superfund.
- Annual O&M costs are estimates and include such components as labor, utilities, materials, analytical costs, etc.
- "Total O&M cost expected to be incurred by state after LTRA" refers to those costs incurred by the state after the long-term remedial action (LTRA). LTRA is the first 10 years of operation and function of a Superfund restoration action for surface or groundwater. Operation and maintenance costs of the remedy are 90% funded by Superfund and 10% funded by the state during this time period. Thereafter, 100% of the costs are assumed by the states.
- For some systems where the expected system duration is unknown, a value of 30 years may have been used as a default and may underestimate the expected duration of systems, especially those located at sites with continuing sources of groundwater contamination such as LNAPL and DNAPL.



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- Annual O&M costs are estimates and include such components as labor, utilities, materials, analytical costs, etc.
- This chart shows only the trends between 2001 and 2015. Existing systems and new systems are expected to operate beyond 2015.

Figure 1-1. Trend of estimated annual O&M costs of fund-lead pump-and-treat systems.

1.2 Purpose

The purpose of this document is to provide interested parties with practical information and guidance on how to systematically evaluate and refine remediation processes without sacrificing protectiveness. Its primary goal is to provide information and tools to help ensure two ends: (a) that the remediation process is progressing toward site cleanup objectives that are both acceptable and feasible and (b) that selected remediation approaches attain those objectives and remain protective of human health and the environment.

The guidance describes the general regulatory and technical framework for evaluating remediation processes regardless of the type or complexity of the remedy. RPO has been associated with the optimization of remedies and how—with a focus on technology—the remediation will be completed. Throughout the RPO process, it is equally important to review and possibly revise cleanup goals. A review of cleanup goals can ensure their continuous applicability in light of scientific advances and regulatory changes. For example, the movement towards risk-based goals and the acceptance of monitored natural attenuation, where appropriate, as a legitimate remedy could be possible RPO outcomes. Therefore, consideration is given to the reevaluation of remediation goals or the exit strategy and ways that potentially inapplicable or unattainable goals can be updated.

Please note that while this document uses primarily groundwater pump-and-treatment systems and monitoring as primary examples and case studies, RPO is applicable to many, if not all, site remediation activities. The primary work done in RPO to date has been in groundwater pump-and-treatment systems. Monitoring at these sites can have very high costs and presents numerous RPO opportunities. In practice however, in-depth RPO review teams, such as the Air Force uses, actually examine all aspects of site activity. Landfills and waste, utility, and energy management are examples of RPO opportunities. RPO is a dynamic and flexible process that has many applications. In addition, RPO can be applied at any stage of the site cleanup process. As highlighted by Figure 1-2, the ability to influence a project's costs is highest in the planning stages. Early application of RPO or feedback of RPO lessons learned into the remedy selection and design phases of work may be effective.

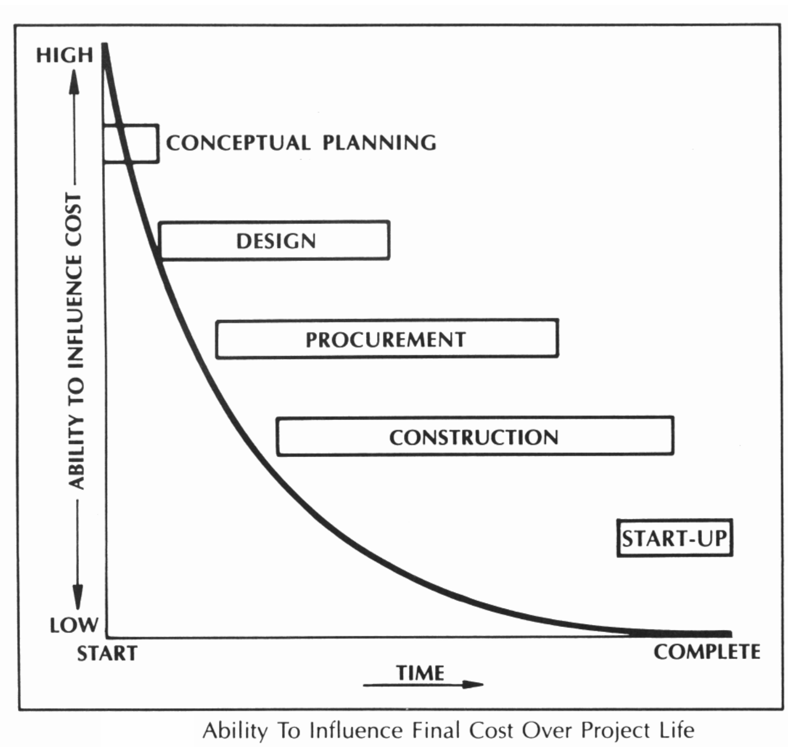

Figure 1-2. Future RPO study. (From Construction Industry Institute 1986.)

1.3 Contents

This guidance document consists of six sections, a list of references, a glossary, and five appendixes:

- Section 1 defines RPO, identifies the goals of this document, and provides a guide to its sections.
- Section 2 provides the regulatory framework for site remediation and identifies where in the regulatory process it is best to implement an RPO.
- Section 3 describes what is included in an RPO, including site selection, data collection and analysis, implementation strategy, estimating costs, evaluation of the exit strategy, and implementation tracking.
- Section 4 discusses the challenges and solutions associated with conducting an RPO.
- Section 5 addresses how stakeholder input should be factored into an RPO.
- Section 6 provides references used to write this document.
- The appendices include a list of acronyms, case studies, a toolbox of important RPO resources, federal program descriptions, and some ITRC information, including RPO Team contacts.

1.4 Relationship to Other ITRC Teams and Products

ITRC has been taking proactive measures to develop linkages among its various technical teams and work products. Identifying these linkages provides users of ITRC products with opportunities to explore other areas of technology and regulatory development that may aide them in their remediation activities. To that end, the following are a few of the linkages that have been identified between RPO and other ITRC technical teams and products:

- **Brownfields Team—**Many hazardous sites are only a step away from becoming candidates for the various state and federal brownfields programs. The ITRC RPO and Brownfields Teams have worked together to determine where RPO and brownfields have common points of interest. The issue of uncertainty in site remediation is key to both teams; without an acceptable level of certainty, redevelopment of sites will not occur and the exit strategy for the party conducting remediation will not function.

- **The Technology Teams**—Alternative Landfill Technology, Dense Nonaqueous-Phase Liquids (DNAPLs), Diffusion Sampler Protocol (DSP), In Situ Chemical Oxidation, Metals in Soils, Permeable Reactive Barrier, Thermal Desorption, Plasma Technology, and Phytotechnology all have application to the "how" of site remediation. Each of these technologies could be applied to one or more site cleanups undergoing an RPO evaluation. An example of the RPO involvement would be DSP; frequently, post-closure monitoring plans are not reexamined, and outdated sampling methodologies are employed. DSP or passive diffusion bag samplers frequently offer an alternative to more expensive, and often less accurate, purge-and-collect sampling methods.

- **The Process Teams**—Sampling, Characterization, and Monitoring (and the related Triad approach, see Appendix C), Radionuclides, and Brownfields (see example above) also offer guidelines or overviews of interest to RPO practitioners and regulators.

- **New Teams**—Some recently started ITRC teams have direct conceptual linkages to RPO. Future products, guidance documents, and training from these new teams will be worth reviewing for RPO-related content: Bioremediation of DNAPLs, Ecological Enhancements, and Enhanced Attenuation. The Perchlorate Team will be of special interest to DoD representatives.

2. REGULATORY OVERVIEW OF REMEDIATION PROCESS OPTIMIZATION

As previously discussed, RPO can be viewed from an engineering or process perspective. Regardless of how RPO is viewed, the regulator or practitioner must take into consideration the regulatory environment. An understanding of the regulatory environment for any candidate RPO site is critical, as regulatory requirements can strongly influence which elements of a remedy can be targeted most successfully for optimization. This section discusses RPO as it relates to major regulatory programs: Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Resource Conservation and Recovery Act (RCRA); and state-equivalent (EPA-delegated or other) programs.

Although there are multiple regulatory drivers affecting sites, there are commonalities in each that mandate performance monitoring and optimization of remedies and monitoring programs. CERCLA, RCRA, state hazardous waste and underground storage tank (UST), and other regulations all contain language that addresses periodic effectiveness reviews and optimization of remedial systems. Each regulatory environment has different requirements regarding how the implementation of optimization recommendations can be incorporated into the process. Currently, there are no regulations impeding this process; there are, in fact, regulations and federal policy supporting this process. All RPO review teams should consider the specific regulatory framework governing cleanup at the site when developing RPO recommendations.

2.1 CERCLA

2.1.1 The CERCLA Process

CERCLA requires that the responsible parties define and implement those response actions that are necessary and practicable to ensure reliable long-term protection of human health and the environment in a reasonable time frame. In addition to fund-led cleanup programs at nonfederal Superfund sites, the DoD Environmental Restoration Program (DERP) directs that all environmental cleanup and restoration programs at DoD installations be conducted in accord with CERCLA, as amended. The CERCLA process involves site and risk characterization during the preliminary assessment (PA), site inspection (SI), and remedial investigation (RI); analysis of applicable or relevant and appropriate requirements (ARARs), remedy screening, and detailed analysis of remedial alternatives during the feasibility study (FS); and documentation of the remedial action objectives (RAOs) and response actions required to achieve the RAOs in the record of decision (ROD), or determination that no further action (NFA) is warranted in an NFA decision document.

To effectively and efficiently address the environmental problem that requires a response, as defined during the site characterization effort(s), the responsible parties at sites with cleanup programs administered in accord with CERCLA must first define the response action objectives that must be met to ensure reliable protection and terminate response actions. The RAOs guide identification and evaluation of remedial actions, which represent the feasible and reasonable means to achieving the response objectives, and the performance metrics that will be used to document progress toward achieving the RAOs and demonstration of response complete (RC). Thus, the RAOs established in the ROD define the responsible party's response commitments and form the basis of all RA decisions and performance expectations. In the 1986 Superfund Amendments and Reauthorization Act (SARA), CERCLA was modified to require that response decisions consider the applicability and relevance or appropriateness of other legally enforceable state and federal environmental requirements. Substantive compliance with ARARs was intended to integrate different environmental regulations to improve the overall effectiveness and efficiency (i.e., protectiveness) of decisions during both the remedy construction (RA-C) and the remedy operations (RA-O) phases, and following RC. EPA and state regulatory agencies assist in identifying potential ARARs, and the lead decision authority at the site conducts an ARAR analysis to identify those requirements for which compliance is necessary, feasible, and reasonable.

In cases where promulgated requirements identified as ARARs for a given site do not meet the statutory tests of performance (i.e., necessity, feasibility, and reasonableness [CERCLA Part 121(d)(4)]), CERCLA provides flexibility by allowing for waiver of those regulatory requirements. Six types of ARAR waiver are identified, based on (1) an equivalent standard of protection to that afforded by the ARAR; (2) implementing an interim action to address a potential imminent danger; (3) avoidance of greater risk to human health or the environment that could result from compliance with an ARAR; (4) technical impracticability of meeting the requirement; (5) fund-balancing to avoid unreasonable cost through use of an alternative standard of control to that specified in an ARAR; and (6) inconsistent application of state laws among sites with similar environmental problems (responsible parties may not be held to different standards of compliance for similar problems). To petition for an ARAR waiver, the responsible party must meet specific requirements and provide supporting documentation to justify the waiver request. Note that a formal waiver is not required for to-be-considered criteria (i.e., a potential requirement that does not qualify as an ARAR but was considered during the response planning process).

Once RAOs have been determined, remedial alternatives, which are the means to achieve the RAOs, are comparatively evaluated during the FS using the nine screening criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), including protectiveness, effectiveness, implementability, and cost. Final RAOs, the selected remedial alternative, and performance metrics to be used to assess progress toward RC are documented in the ROD, which is a legally binding document that defines the response action commitments of the responsible party, and defines the performance expectations for the selected response.

The remedial design (RD) phase follows the ROD and develops the specific design of the remedial components. RA includes the RA-C and the RA-O. Optimization should be an inherent element of the remedy evaluation, selection, and design process, as the FS, ROD, and RD are intended to document the technical and regulatory basis for the response decision, which defines those RAOs and response actions that are necessary and practicable to ensure protectiveness in a reasonable time frame, and how performance will be measured. Because the ROD is essentially the strategic plan for achieving the RAOs (and RC), it also should incorporate decision logic and the basis for contingency planning as part of the overall completion strategy for the site.

CERCLA requires periodic effectiveness reviews to assess remedial progress and, if necessary (i.e., if remedy performance is below expectations), to apply lessons learned and evolving knowledge to refine the RAOs, the means, or both. CERCLA provides two methods for refining response decision: an explanation of significant difference (ESD) or a ROD amendment. An ESD is typically used to document relatively minor adjustments in the response design or implementation (e.g., a change in the number or placement of extraction wells, a change in the type of aboveground treatment required) and does not require public review. A ROD amendment is required when a significant change to the response decision is warranted (e.g., when a remedy has failed and a revised completion strategy is needed to ensure timely protectiveness). ROD amendments, like other decision documents (i.e., proposed plans and RODs) are subject to formal public comment periods.

2.1.2 RPO within the CERCLA Context

The RPO process is typically implemented during subsequent RA phases. Implementation of the selected remedy occurs during the RA-C phase of CERCLA, and, after prove-out, RA-C is followed by the RA-O and long-term management (LTM) phases. The RA-O phase of the remediation process involves operation, maintenance, and monitoring of remediation systems. For sites with contaminants remaining in place, an LTM phase is required to ensure that the remedy remains protective. This phase involves long-term monitoring and five-year reviews until such time as the property is considered suitable for unrestricted use. ROD changes may be required to implement some RPO recommendations. These changes are most often made for three reasons: changes in understanding of site conditions, changes to improve performance of the remedy (includes changes in remedial technology), and changes to reduce cost without effecting protectiveness.

Approximately 30% of Superfund sites are EPA-managed, fund-led sites. Under CERCLA, response decisions through the RA phase are implemented at fund-led sites using Superfund money. RA for fund-led sites is defined in the CERCLA statute to include operation of remedial systems for up to 10 years. Continued operation of the remedy to maintain effectiveness after that time is considered to be O&M; O&M costs at fund-led sites are to be borne by the states. RPO can be an effective method to control states' costs associated with long-term RA-O at these facilities.

The EPA employs a process of remedy optimization that is similar in goals and methodology to the RPO process described in this document. The process—called "remediation system evaluation" (RSE)—is designed to improve the effectiveness and efficiency of engineered remedies, thereby reducing RA-O costs. Periodic evaluation of remedial system performance relative to the performance metrics established in the ROD (as required under CERCLA), in conjunction with remedy optimization, can provide tangible benefits to those charged with remedy O&M. The RSE process is described in Appendix D. It should be noted that RSE focuses on engineered systems and does not explicitly assess optimizing the RAOs in the context of evolving site knowledge and technological lessons learned (see Section 3).

The findings of the EPA-sponsored RSE pilot study are instructive and have potential value for the states. The RSE pilot program revealed that the majority of pump-and-treat systems evaluated either were not obtaining plume capture or did not have sufficient data to evaluate capture. In addition, these evaluations were able to recommend reductions in monitoring costs for almost half of the remedial systems evaluated during the pilot study while meeting performance monitoring requirements. Furthermore, a number of the systems evaluated were either overdesigned for the current influent constituents or concentrations or were less than optimally designed. Specific recommendations were provided regarding the return on capital investment as a result of altering these systems; if implemented, the alterations could reduce O&M and monitoring costs over the life of the remedy. Other potential cost-saving measures evaluated included reducing oversight and personnel costs and changing groundwater discharge methods.

The annual cost reductions projected for the 20 remedial systems evaluated came to $4.8 million. This is a good example of an RSE process that goes beyond cost reduction; the pilot study recommended more aggressive source removal or alternative technologies at 13 of the 20 sites evaluated. Based on these findings, states clearly have a stake in ensuring that the remedial systems that they will soon inherit are necessary and feasible to complete within a reasonable time frame, as well as efficient and cost-effective.

A recent product of DOE's optimization effort (DOE 2002) is a guidance document issued to DOE project managers for optimizing groundwater response actions. The guidance does not address a specific DOE-wide RPO evaluation and optimization program, but it provides an overview of general considerations for designing and implementing groundwater remediation strategies. These considerations include groundwater restoration evaluations, source control measures, containment assessment, and monitoring. Several of these considerations are discussed in terms of technology selection rather than optimizing existing remediation systems.

DoD normally conducts RPO evaluations during the RA-O and LTM phases. The RA-O phase of the remediation process, which involves operation, maintenance, and monitoring (OM&M) of remediation systems, continues until the cleanup goals are achieved (unlike EPA's fiscal responsibilities at fund-led sites, there is no 10-year limit to RA-O at DoD sites on the NPL). For sites with contaminants remaining in place, an LTM phase is required to ensure that the remedy stays protective; this phase involves LTM and five-year reviews. Each DoD component has a specific program to perform optimization of sites in both RA-O and LTM phases at least every five years. The specific RPO program for each of these organizations—Air Force, Army, Navy, and Defense Logistics Agency (DLA)—is described in Appendix D.

2.2 RCRA

The value of the RPO process accrues both to the regulated community and to environmental regulators. State agencies have an obligation to ensure that their resources are used in the most productive way; in the same way, in this time of shrinking resources for site cleanup, it is increasingly clear that this obligation must be extended to helping the regulated community more effectively use their available cleanup dollars.

While some states may actively participate in or even initiate the RPO process, not all states have this ability. States may be barred from selectively providing services or other gratuities to entities such as the regulated community. This constraint does not mean, however, that the RPO process cannot go forward.

Many states use the CERCLA-based process proposed under Subpart S for approving plans for RCRA corrective action. The use of corrective measures studies (CMSs)—analogous to an FS under CERCLA—was envisioned as a way to optimize cleanup plans on the front end. These proposed provisions of Subpart S were later withdrawn by EPA but not before the process was built into the RCRA data management system and adopted, in practice, by many states. In some states, the CMS is not ordinarily used as a RCRA decision-making tool, based on the assumption that regulatory input on decision making at this stage would slow down initial decisions on cleanup efforts. RCRA-regulated facilities are free to screen technologies independently and propose any plan that, in their judgment, provides the correct balance of protectiveness and cost-effectiveness. While still subject to technical review, the corrective action plan is the only document that the permitted facility is required to submit.

The RCRA permitting framework contains provisions for periodic assessment of the effectiveness of corrective action. This routine effectiveness report provides an opportunity to view progress and fine-tune the remedy. However, this assessment is not the same as the RPO process, which is far more extensive. Although not all facilities make use of the opportunity, semiannual effectiveness reviews can be a tool for dialogue between the regulators and the regulated facility on the continued progress of the remedy or, conversely, of the need for adjustments. While there may be a perception that all proposed changes to the corrective action system will increase the cost of the remedy, this is not necessarily the case.

The primary focus of the process is to identify redundant or unnecessary monitoring requirements. Many RCRA facilities have a large number of monitoring and recovery wells that they are required to maintain under their permits. However, since changes in groundwater quality occur slowly, particularly under pump-and-treat remediation, the data from a large number of wells may not be required for decision-making purposes during the life of a groundwater remedy. Similarly, results from pump-and-treat systems may not be uniform throughout the plume, and certain recovery wells may become less useful over the life of the remedy. Careful review of semiannual effectiveness reports can reveal wells that can be decommissioned or sampled/pumped less frequently. Cost savings can often be realized by narrowing the slate of analyses being conducted. Permits that have been in force for many years sometimes contain institutionalized sampling and analysis requirements that can be eliminated on the basis of years of data collection and analysis. Other requirements, while still required, could be evaluated for possible reduction. Judicial use of expensive analytical methods—such as those cited in Appendix IX of RCRA, in particular—can result in substantial cost savings for facilities.

RCRA-regulated facilities often identify ways that cleanup costs can be reduced without sacrificing protectiveness. These are typically proposed to the regulatory agency in the form of a request for permit modification. While similar in intent to the RPO evaluations discussed elsewhere, these facility-led proposed modifications still proceed through the customary RCRA-style submittal/review/revision/approval process. While this process may not be accomplished as quickly as an RPO evaluation, in recent years, many states have been moving towards proactively building flexibility into permits to allow facilities—with state concurrence—to alter their sampling programs to "mothball" nonessential wells or to answer specific questions that arise as the remedy proceeds. Similarly, corrective action systems can be described in the permit in terms of results rather than by operational or design criteria. In this way, permitted facilities are free to obtain expert advice regarding the optimal operation of their corrective action systems and to work in partnership with state regulators to more effectively remediate their sites. When flexibility is incorporated into permits at the beginning of the corrective action process, the time-consuming and costly permit modification process is not needed. Resources on both sides are conserved, and cleanup can be optimized on a continuing basis. More specific approaches to corrective action can be reserved for permitted facilities that do not have the resources to retain high-quality environmental advice or for unmotivated or recalcitrant facilities that would not otherwise work diligently towards site cleanup.

2.3 State Regulatory Programs

Many states are delegated under either CERCLA or RCRA to conduct site cleanup operations or oversee the cleanup operations of others. States, in fact, have initiated cleanup programs under their own regulatory framework for both publicly funded site remediation and responsible party oversight. As a result, the states have many of the same regulatory interests in RPO as those mentioned in the sections on CERCLA and RCRA. This section discusses the areas of particular interest to states regarding the regulatory framework. Additional discussion of state regulatory involvement in the RPO process can also be found in Section 3.

There are no known direct references to RPO or RPO-like programs in state regulations. However, state rules—such as New Jersey's "Technical Requirements for Site Remediation," N.J. A.C. 7:26 E, a.k.a. the "Tech Rules"—recognize that "continuous effectiveness monitoring" and "periodic site condition reviews" may occur. This language may be broadly interpreted as an opportunity for an RPO review. See the definition of "remedial action costs" below:

> "Remedial action costs" means all costs associated with the development and implementation of a remedial action including all direct and indirect capital costs, engineering costs, and annual operation, maintenance and monitoring costs. Such costs, when applicable, shall include, without limitation, costs for construction of all facilities and process equipment, labor, materials, construction equipment and services, natural resource damages, land purchase, land preparation/development, relocation expenses, systems start up and testing, facility operation, maintenance and repair, *continuous effectiveness monitoring, periodic site condition reviews* [emphasis added] and legal, administrative and capital costs associated with the placement of institutional controls on a property. Remedial action costs shall be expressed as net present worth of all such costs over time by discounting all future costs to the current calendar year. The discount rate to be used for all present worth analyses shall be the current rate as specified by the EPA at the time of remedial action selection and shall be applied before taxes and after inflation. The period of performance for present worth costing analyses shall not exceed 30 years.

In addition to New Jersey's Tech Rules and their equivalents in other states, institutional controls such as classification exception areas (CEAs) for groundwater contamination and deed notices or declarations of environmental restriction (DERs) for soil contamination require periodic reviews. CEAs and DERs also have review requirements for modifications and termination. When broadly interpreted, these reviews could allow for RPO activity.

Lastly, state cleanup oversight or state-funded cleanup programs, based on either EPA delegation or state regulations, often require financial assurances. Financial assurances are only as sound as the cleanup efforts that they underwrite. States should look favorably upon a program—such as RPO—that seeks to increase the efficiency of the cleanup process so that the project does not exceed the financial assurances posted for the work, thus putting both the state and the responsible party at risk for additional cleanup cost. Using a publicly funded example, under CERCLA, states enter into a control document with the EPA called a "State Superfund Contract" (SSC). For LTRAs, the EPA will operate the site for up to 10 years. After 10 years, the LTRA becomes the responsibility of the state if contamination remains above standards. Therefore, it is in the best interest of the states to insist on an RPO review as early in the LTRA process as is practical. EPA recommends that an RPO be conducted in the second to forth year of an LTRA (EPA 2004a). Some states, including New Jersey, feel that the end of the second year is not too early to start the RPO process.

3. REMEDIATION PROCESS OPTIMIZATION

This section explains the elements of RPO, highlighting what should be included in an effective RPO program or proposal, from establishing site-selection criteria to evaluating the exit strategy and establishing an implementation tracking plan. This document does not reiterate details available from many other sources. See Appendix C, the RPO Toolbox, for links to established RPO programs.

There are several steps involved in performing an RPO evaluation. The scope of any RPO evaluation is dependent on the particular goals of the funding agency and the nature of the site and RA to be evaluated; however, several elements of RPO are common to all such evaluations. The following steps should be conducted for RPO:

- Identify candidate sites where the return on the investment in RPO is likely to be high.
- Develop an appropriate RPO review team.
- Assess the exit strategy (RA plan) for the site, including review of RAOs, CSM, remedy performance metrics, and contingency planning/decision logic.
- Assess the RA design and performance.
- Evaluate remedy cost-efficiency.
- Develop optimization recommendations.
- Develop an implementation and tracking strategy for the optimization recommendations.

This section reviews each of these RPO elements and provides information to help guide RPO evaluations. Figures 3-1 and 3-2 show flow charts for an RPO evaluation.

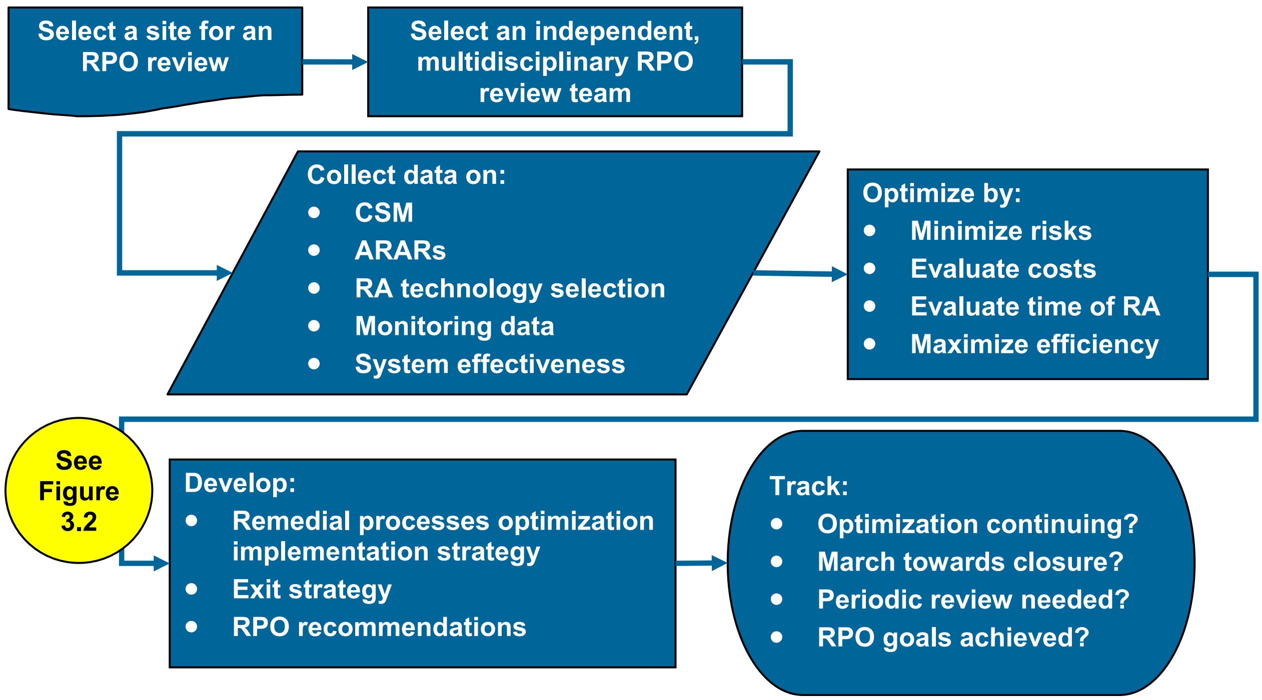

Figure 3-1. Overview of conducting an RPO evaluation.

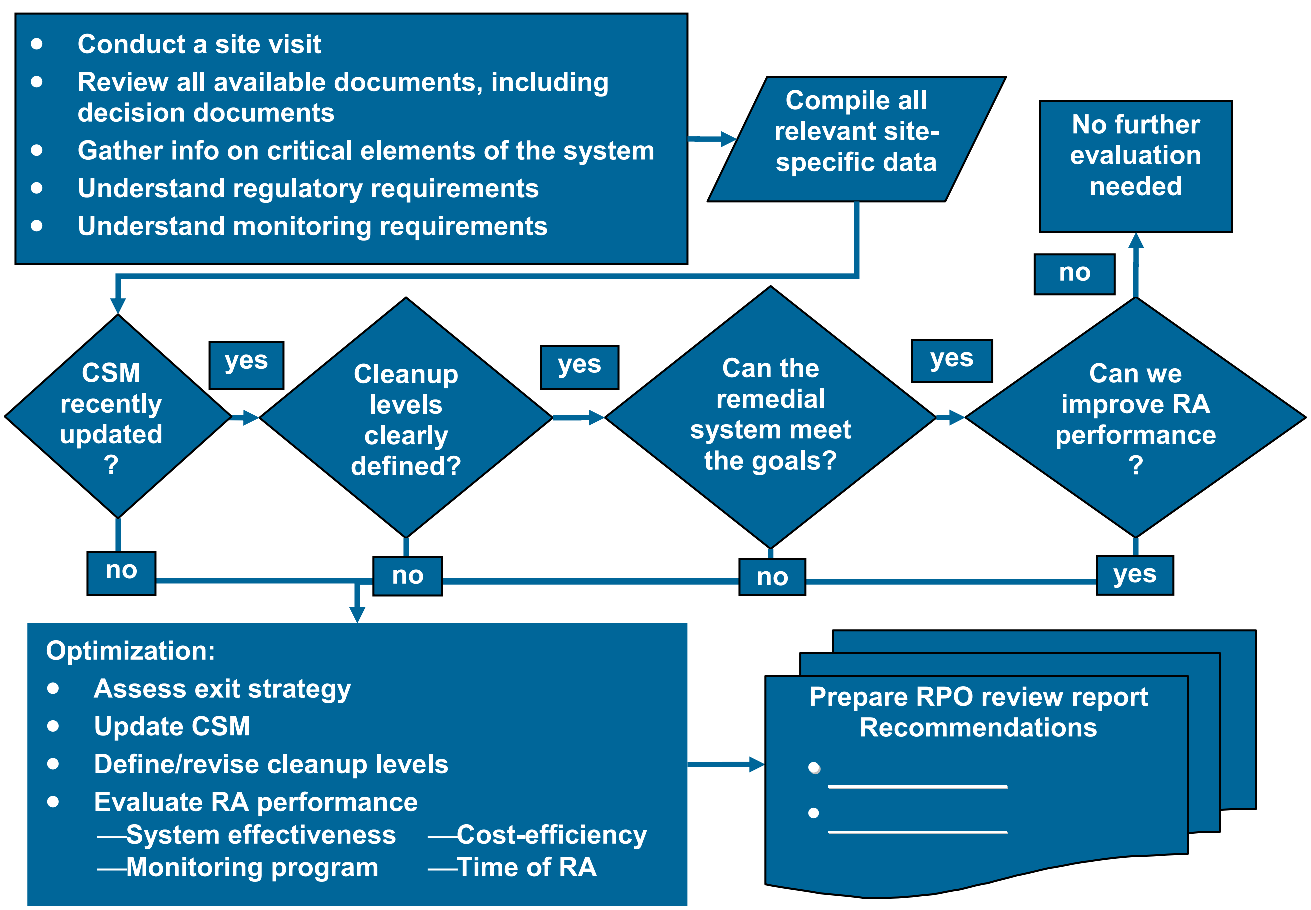

Figure 3-2. Process elements of an optimization.

3.1 Site-Selection Criteria

Based on observations from conducting RPO or RPO-like reviews for hundreds of remedial components at more than 50 facilities nationwide, virtually all long-term remedial-action sites can benefit from RPO. RPO not only redirects attention to potentially overlooked O&M issues, but also serves to reassure stakeholders that, based on the available information, the course of action being undertaken is sound. However, because there are up-front costs associated with performing an RPO evaluation and an interest in not overburdening site managers and regulators, prioritizing sites for RPO is appropriate. There are two primary criteria for prioritizing sites for RPO:

- concern that the current system is not achieving remedial goals effectively or efficiently (e.g., protectiveness of the remedy may be in question, or the rate of progress toward achieving site-cleanup criteria may be below expectations; see box) and
- high annual O&M costs associated with systems anticipated to operate for many years.

Other prioritization considerations include (1) sites with persistent contaminant sources, such as landfills or DNAPL releases, (2) sites with complex hydrogeology or geochemistry that is limiting the effectiveness of the response action, (3) sites for which decision documents have been in place for 10 years or longer, and (4) sites where cleanup is expected to take more than 10 years. Some of these criteria are subjective and case dependent in nature, but they provide useful guidelines for determining which sites are most likely to benefit from RPO. For example, the threshold for what may be considered "high annual operating cost" is relative to the fiscal constraints affecting the funding agency/organization. However, it usually is inappropriate to establish minimum criteria or rules of thumb for identifying RPO candidate sites based on operating costs or other O&M items alone. Some sites with low annual operating costs may still pose significant risk to human health and the environment, and sites anticipated to be shut down in the near future could benefit from an RPO review of the closure process or site completion criteria. However, sites with very low annual operating costs or sites anticipated to be shut down within one year should be closely screened to determine whether RPO is appropriate.

An example of a system that may not be achieving its remedial goal and where protectiveness may be in jeopardy:

A pump-and-treat system is installed at a trichloroethylene (TCE)-contaminated site with the primary goal of controlling off-site plume migration to prevent the plume from impacting a nearby water supply aquifer. A secondary goal is TCE mass removal to achieve the regulatory cleanup goal of 5 ppb TCE in groundwater. Although the system has been in operation for more than eight years, monitoring data are inconclusive regarding effective capture of the plume by the extraction well network. As a result, the down-gradient water supply aquifer may be in jeopardy. Further, mass removal has reached an asymptote, and the effectiveness of the remedy for achieving the 5-ppb goal in a reasonable time frame is in question.

This site should be considered a high-priority candidate for RPO given the concern of ineffective hydraulic control of the plume. The RPO team can evaluate the groundwater monitoring network, historical trends in TCE concentrations and groundwater elevations, and flow and transport models to determine whether capture is being achieved or if additional data collection and evaluation are necessary. The RPO team also would evaluate the effectiveness of mass removal and progress toward achieving the 5-ppb cleanup goal. If appropriate, the team can assess and recommend alternative remedial strategies or revised cleanup goals.

EPA is currently conducting a pilot program using the RSE process at several UST and other smaller site remediation projects to determine whether the RSE and "RSE Light" (limited-scope RSE) processes are of value to smaller, lower-cost projects. As there are over 23,000 UST sites undergoing site remediation in the United States, the potential of optimization is huge. Small savings in time and money on many small sites may have as much impact as a few saving on a few large sites. States, including New Jersey, are providing test cases for the evaluation. The first of the EPA reports are just being issued, and additional studies are under way. The ITRC RPO Team will report on the findings in future editions of this report.

For an agency or organization managing multiple LTRA sites, routine collection and periodical evaluation of cost and performance information for all response actions should be conducted to prioritize the sites as candidates for RPO. Often, the data are collected but may not be adequately compiled or assessed. An RPO review team undertakes to compile, present, and interpret the available historical cost and performance data as part of its evaluation. The Air Force and DLA encourage the review and collection of specific O&M data on an annual basis to track system performance, identify obvious opportunities for system improvement, and assess sites for detailed optimization reviews (RPO Phase II). Additional information on data compilation and recommendations for specific data to be collected are provided in the RPO Phase I Data Collection section of the *Remedial Process Optimization Handbook* (AFCEE and DLA 2001).

For agencies initiating an RPO program and looking for a simple method to prioritize sites, a data compilation/prioritization checklist developed by the EPA offers a process to quickly identify sites that may benefit from optimization. Table 3-1 provides a list of information useful for prioritizing sites or remedial systems for RPO evaluations that borrows from and expands on EPA's RPO prioritization assessment checklist. A review of the data outlined in the table likely will result in the identification of several sites as primary candidates for RPO. For a more quantitative assessment of this information, EPA created a weighting system to assist with selecting high-priority sites for RPO (EPA 2001c). Although this weighting system was created for evaluating pump-and-treat systems, it could be easily modified to accommodate other types of remedial actions.

Table 3-1. Suggested data to be collected for site prioritization

Data to be collected	Explanation
Remedial action (RA) objectives	Restoration of affected medium to maximum beneficial use, containment, mass removal, etc.
Primary contaminants of concern (COCs) and affected media	The primary COCs as identified in the decision document, and the media targeted by the RA
Description of all RA components and related monitoring programs	Descriptions of each capture, extraction, and treatment element of all engineered, intrinsic, and administrative elements of the RA (pump and treat, soil vapor extraction, monitored natural attenuation, passive reactive barrier, institutional controls), and background, performance, compliance, and sentry monitoring well networks
Current status of RA	Predesign, designed/not installed, under construction, installed, operational, completed

Data to be collected	Explanation
Date RA was implemented	Date of start-up for active systems, date installation was completed for passive systems
Documented RA performance metrics	Numeric cleanup objectives, designed operating parameters, schedule and cost to complete estimates, projected mass removal rates
Conclusions of other performance reviews	The site remedial program manager should indicate whether RA goals are being achieved and the source of supporting information (e.g., five-year review)
Approximate historical and current annual operations and maintenance cost	This category should include all O&M costs for the RA and related monitoring systems—labor, electricity, materials, discharge fees, system monitoring costs, and consulting and oversight costs
Long-term monitoring costs	Sampling, analysis, quality assurance, and reporting costs
Historical and current operating data	Groundwater/vapor extraction and discharge flow rates, COC concentrations at extraction and monitoring points, pump-cycling data, water levels, radii of influence for extraction/injection systems, notices of violation, etc.

3.2 Building an RPO Team

The persons conducting an RPO evaluation should be carefully chosen for their objectivity, technical qualifications, and experience. The team members should be free of potential conflicts of interest and should provide a "fresh view" of the project. An independent review is critical for identifying characterization and remediation design/performance issues that may have been overlooked by the previous or current project team. Those individuals who have had past involvement in decision making at the site may not have an unbiased perception of the current state of the system or the potential need for change. Qualified personnel from the sponsoring agency who have not been directly associated with the subject project would be acceptable; however, the use of staff from the design or O&M contractors typically is not appropriate due to possible conflicts of interest. Outside (third-party) contractors or representatives from other agencies or institutions could be suitable candidates for RPO review teams.

It is very important to include highly experienced technical and regulatory personnel on RPO review teams. The team members must have broad experience in regulatory requirements and policy interpretations; hydrogeology; geochemistry; risk and exposure assessment; remediation design, operation, and optimization; and related activities. The team should include regulatory specialists, engineers, hydrogeologists, chemists, and risk assessors, all of whom have a wide background in current best practices, innovative technologies, and optimization approaches and tools. Important support may be required from other disciplines, potentially including statistics, modeling (groundwater flow, contaminant transport and fate, exposure/uptake), cost engineering and estimating, risk communications, and contracting. The composition and size of each RPO review team should be based on the nature of the site and the administrative and technical challenges faced.

3.3 Exit Strategy Assessment

An exit strategy for a site is simply the detailed plan for achieving the RA objectives that have been selected as the end points of the RA. Stated another way, the RA objectives are the overall goals that must be met for the site to either achieve response complete or be approved for closeout or reuse. An exit strategy represents a formalized long-range process for taking the site from its current state to closure or to its best long-term use. The strategy represents a plan to actively manage the site and make decisions at various points that will best tailor the remediation and monitoring efforts to achieve the RA objectives in the most efficient and effective manner. The strategy is best developed with consideration of stakeholder and regulatory agency concerns, resource constraints, and technical realities; it also includes well-defined means to measure progress and a desired timeline. A well-developed exit strategy contains six elements:

- statement of and basis for the RA goals;
- summary of the CSM, including a description of the future site land use;
- decision tree, flow chart, or defined sequence of remedial activities and contingency triggers;
- clearly established process to evaluate performance measures relative to decision parameter;
- provisions for periodic reevaluation of the project goals and RA decisions (contingency planning); and
- means to verify cleanup following cessation of active remediation.

Because it is difficult to optimize any element of a remedial decision if the overall objectives (remediation end points) and site-specific technical constraints are not well understood, any optimization effort should begin with an evaluation of the exit strategy, which incorporates the RA objectives and the CSM as well as the RA components. Much of the information that composes the exit strategy may be developed for a site in multiple documents (e.g., site investigation, risk assessment, and feasibility study reports, decision documents, design documents, and monitoring plans). However, there often is little documentation on how to monitor progress toward site closeout or reuse in a reasonable time frame. Furthermore, little discussion is offered regarding what actions should be taken and when if progress toward site closeout or response complete does not meet expectations.

3.3.1 Evaluating the Remedial Action Objectives

The RAOs for a response action, established in the decision document for each remedy, are essentially the completion criteria that must be achieved to attain response complete (site closeout). Ideally, the basis for selecting the RA objectives also should be articulated clearly in the decision document so that appropriate performance metrics can be developed and monitored to track progress toward achieving the objectives. The decision document should specify the COCs, cleanup goals for each affected medium, and points of compliance. As part of the RPO process, these cleanup goals should be reviewed in the context of the refined CSM (see next section), accumulated remedy performance data, and improving technical and scientific information to determine whether they remain appropriate for the site. The evaluation should verify that the objectives are measurable, realistic (achievable in a reasonable time frame), and consistent with ultimate land use. Examples of measurable objectives include specific cleanup concentrations at compliance points, acceptable risk levels, or hydraulic conditions (for long-term containment). Realistic goals are those that are achievable with the current technology in a reasonable time frame (as defined by all parties). If the goals are not easily measured and clearly realistic, the exit strategy may generally still be valid, but it will be more difficult to assess the consistency between the RA objectives and the strategy, and some clarification or modification of the strategy or goals is needed.

Under the Superfund and RCRA Corrective Action programs, the results of qualitative and quantitative risk assessments are used to establish the need for remedial action and to develop remedial alternatives. For UST sites, many states have adopted risk-based corrective action (RBCA) programs. The review of exit strategies for these types of sites should consider state RBCA guidelines for modifying cleanup goals. Because the overarching objective of any environmental remediation project is protection of human health and the environment, cleanup objectives should be risk-based and appropriate to the receptors potentially exposed to site COCs. Therefore, every RPO evaluation of an exit strategy should carefully review the results of risk analyses and should assess the reasonableness and continued applicability of the exposure assumptions used to estimate risks.

Regulatory limits such as federal maximum contaminant levels (MCLs) and similar state drinking-water–based levels are commonly used as default cleanup goals for groundwater at contaminated sites. In addition, many state programs include nondegradation statutes that may be interpreted to require restoration of waters of the state to the greatest beneficial use, to the extent practicable. Because CERCLA, RCRA, and most state regulations mandate cleanup of sites to the extent necessary and practicable to protect human health and the environment in a reasonable time frame, the rationale behind selection of RA objectives (the risk assessment and an ARAR analysis) and the projected time to achieve those objectives should be carefully examined during any detailed RPO evaluation.

EPA considers 10 years to be a reasonable time frame for achieving protection, as reflected in the limitations on EPA obligations at fund-led sites. While cleanup objectives for many contaminants in unsaturated soils usually can be achieved in less than 10 years, cleanup of groundwater and certain types of persistent sources and groundwater contamination pose much greater challenges. For this reason, it is important to include regulatory and risk assessment specialists on RPO review teams that are evaluating sites with these types of complex cleanup challenges. Once operational systems and monitoring programs are optimized, responsible parties should continue to periodically assess the remedial progress and refine the exit strategy as appropriate. For sites where little measurable progress toward RA objectives is being made, the RPO review team can review and improve the ARAR analysis, assess compliance with the RA objectives established in the decision document, and develop alternative strategies for achieving protection in a reasonable time frame. This element of RPO is being increasingly recognized as critical as responsible parties begin to focus on exit strategies for their more complex sites. As examples, the pending Performance-Based Environmental Restoration Management Assessment (PERMA) guidance being developed by DLA and the 2003 DOE *Using Risk-Based End States* policy guidance outline strategies for evaluating the necessity, feasibility, and reasonableness of RA objectives and for optimizing these objectives, as well as the means to achieve them in a reasonable time frame. As remedial systems (the means to achieve response complete) are optimized through RPO and as states begin to inherit long-term O&M for fund-led sites, future optimization efforts will increasingly focus on the completion criteria themselves to reflect our evolving state of knowledge and understanding as to what is necessary, feasible, and reasonable to ensure protection of human health and the environment.

3.3.2 Evaluating the Conceptual Site Model

Once the RPO review team has reviewed the RA objectives, the CSM should be carefully reviewed and updated as necessary to reflect current site conditions and evolving site and technical information. The CSM is a comprehensive description of all available information about site conditions that could influence remedy design, selection, or performance. Thus, the CSM forms the basis for defining RA objectives and for developing and implementing a remediation strategy. A CSM is composed of several elements, including the following:

- nature and extent of contaminant (including source types and affected media);
- contaminant fate and movement in the environment;
- site geology;
- site hydrogeology;
- biological and geochemical conditions;
- monitoring points;
- risk assessment;
- receptors and potential receptors (under current and reasonably expected future exposure scenarios);
- past remedial actions and locations of remedial components and monitoring points;
- historical, current, and expected future land uses; and
- other factors relevant to the understanding of contamination at the site.

As O&M activities progress at a site and additional information related to contaminant distribution, fate and transport, and receptors becomes available, the CSM should be updated and incorporated into the decision-making process during optimization efforts.

3.3.3 Reviewing the Completion Strategy and Decision Logic

Another element of the RPO review team's exit strategy review should involve verifying that the approach to achieving closure or reuse is logical and realistic—both technically and from a regulatory perspective—and will result in (continuing) protection of current human and ecological receptors during and after remediation. Each site-specific strategy also should reflect the facility-wide closure strategy to ensure consistency of assumptions, objectives, and any administrative and engineered controls. Various remediation activities (e.g., extraction from specific wells, use of a particular aboveground treatment process, or in situ treatment of a source area) may be reduced or eliminated prior to site closure or attainment of long-term goals when continuation of these activities no longer contributes meaningfully to progress toward the RA objectives. The decisions as to when and how to implement these interim changes should be made in a technically sound manner based on reasonable metrics (e.g., "triggers").

The site completion strategy can often be effectively documented using a decision tree or flow chart that presents decision points in implementing the exit strategy in terms of "if/then/because" options. The RPO exit strategy review should verify that specific metrics are set for evaluating cleanup progress. Examples of these may be achieving specific concentrations in target monitoring wells by a certain date, percentage declines in extracted air or water COC concentrations, cumulative COC mass removed, a specified period of time during which COCs are static or below levels of concern at performance monitoring points, or similar parameters. Target values and time frames may be based on modeling. Failure to achieve predetermined metrics that measure the expected progress toward response complete or site closeout should trigger contingency actions to correct the course of the RA or to reassess the RA objectives.

The data collected by the monitoring program must provide adequate details to assess progress, as defined by the exit strategy metrics. The exit strategy should include a specific approach to tailoring necessary monitoring frequency, location, and analyses as site conditions change; this would include monitoring of aboveground treatment processes. As progress toward RA objectives is made, the scope of monitoring to make site decisions should drop. However, there are exceptions to this trend of decreasing RA activities under certain circumstances. Such has been the case at sites where emerging issues—based on improving knowledge about chemical toxicity, fate, migration, or technical advances that allow refined detection of COCs—expand the COC list or the exposure pathways of concern. There also may be a need for provisions for increased monitoring in the event that unexpected conditions are encountered. The exit strategy also should include provisions for monitoring of response of the subsurface to the cessation of any remediation activity for some period of time ("rebound" monitoring). There should be contingency provisions for restart of the remediation process if some undesirable response is observed.

3.4 Evaluating Remedy Performance

Remedial performance refers to progress toward meeting cleanup goals; system performance refers to the degree to which a particular remedial component is meeting its design expectations. Measures of both remedy and system performance should be objective and quantifiable, and appropriate performance monitoring and cost-tracking data should be readily available to the RPO review team. To evaluate remedial performance, O&M data are analyzed and compared with the cleanup criteria established in the RA objectives and with cost-to-complete and time data that should be documented in the feasibility or corrective measures study and the decision document. Common O&M data used for performance evaluations include the following:

- contaminant concentrations through time in in situ affected media and in treatment system influent and effluent streams;
- groundwater elevations;
- nonaqueous-phase liquid (NAPL) thickness (for fuel-contaminated sites);
- geochemical parameter concentrations/readings (e.g., dissolved oxygen and other gases, alkalinity, pH, oxidation/reduction potential) through time;
- system operating parameters (e.g., design and actual flow rates, throughput rates, pumping cycles, mass-removal rates, and secondary waste-stream generation; and
- operational history (performance problems, basis for and details of any system modifications, notices of violation).

These O&M data typically are analyzed to evaluate remedial performance using several analysis tools:

- graphs of remedial performance data for each extraction well through time to identify O&M and remedy feasibility issues (e.g., hydrogeological or geochemical/biofouling constraints);
- potentiometric surface maps under pumping and nonpumping conditions to analyze capture zones and assess containment;
- maps and cross sections illustrating contaminant and geochemical parameter concentrations and distributions through time and space to assess plume dynamics and containment, evaluate natural attenuation processes, identify preferential migration pathways, verify compliance with protective criteria at points of compliance, and document progress toward RA objectives;
- time-series plots of contaminant and geochemical data for each monitoring and extraction point to evaluate natural attenuation and mass removal;
- comparisons of treatment system influent and effluent concentrations through time to assess effectiveness (e.g., relative to design expectations), identify asymptotic conditions indicating potential technology limitation for contaminant removal, and assess compliance with discharge requirements;
- consumption of resources including electricity, fuel for on-site as well as estimates for transportation; and
- simple analytical models to predict future trends and progress based on trends observed to date.

For many of these assessments, readily available geographical information systems (GIS) software and simple trend-analysis statistical tools are very useful for data visualization and performance assessment; such tools can enhance data analysis capabilities.

To assess the effectiveness of a remedial decision, the RPO evaluation typically can be organized into two general assessment areas: performance of remedial components and effectiveness of the monitoring program. The following subsections provide further discussion of each of these assessment areas. Evaluation of remedy efficiency is reviewed in Section 3.5.

3.4.1 Remedial Component Performance Assessment

The performance of specific engineered remedial components that make up the RA for a site is a measure of how well a remediation system is meeting its mechanical design objectives. (Note that for assessment of monitored natural attenuation [MNA] as a component of the remedial strategy, the reader is referred to other available guidance.) To evaluate engineered system performance, O&M data are compared with the specifications from the original design and installation of the remedial system.

3.4.1.1 Evaluating Performance Data

Common O&M data used to evaluate remediation systems that use extraction and aboveground treatment processes include the following:

- extraction rates and COC concentrations at each extraction point;
- infiltration rates and capacities for percolation trenches or infiltration galleries;
- groundwater potentiometric surface elevations (to assess capture zones in three dimensions);
- treatment system parameters, such as influent flow rates, operating temperature, residence time, and chemical feed rates;
- influent/effluent contaminant concentrations for each component of the treatment system; and
- secondary waste stream generation rates (e.g., sludges, spent carbon; waste from descaling or biofouling maintenance).

For in situ treatment systems, the data for evaluation varies depending on the remediation technology. Injection rates and injection volumes are used to evaluate system performance for many in situ remediation technologies, including enhanced bioremediation (rate of nutrient/amendment injection) and targeted source remediation (e.g., volume of chemical injection for chemical oxidation or rate of steam/hot-water injection for thermal treatment).

Monitoring data that demonstrate the radius of influence around injection points and plume capture for passive barrier systems also are important measures of system performance. In all system optimization evaluations, observed operating conditions, parameters, and performance problems—such as low extraction yields, erratic pump cycling, excessive scale buildup, or biofouling—should be assessed against design specifications and tolerances to determine overall system effectiveness and efficiency. Trouble-shooting should include careful review of the problems in the context of the refined CSM and the current regulatory framework, with particular attention to geochemical, hydrogeological, and compliance constraints.

Run-time data and other data related to unusual system maintenance may reflect ineffective containment of subsurface contaminant plumes. Examples could include leakage through in situ barrier systems or frequent extraction system shutdown or underperformance relative to design specifications.

3.4.1.2 Assessing Remedial System Effectiveness

The results of the remedy performance assessment and the metrics identified in the exit strategy decision logic are used to assess overall progress toward achieving the RA objectives in the context of the refined CSM and the regulatory framework. The results of the remedial progress assessment are used to identify and recommend optimization opportunities that could improve RA performance under current site conditions and in light of improving technical knowledge and lessons learned at other sites with similar conditions. The following factors should be evaluated to determine whether the current remedy is suitable (necessary and feasible) for the site conditions and RA objectives:

- **Evidence of technical limitations on remedy performance.** Low-permeability aquifer materials, heterogeneous soils, complex geochemistry (e.g., abundance of reduction/oxidation-sensitive minerals that can contribute to fouling at the extraction points or in the treatment train), unaddressed preferential migration pathways, diffusion-limited concentrations of COCs in the aquifer, and presence of DNAPL in the saturated zone are examples of site conditions that can affect the effectiveness of remediation systems.

- **Adequacy of remedy design.** In light of the technical limitations identified and considering any emerging issues that have developed since the current remedy was selected/implemented, the remedial design should be revisited. For example, the injection or extraction well network must have adequate radius of influence to cover the targeted treatment zone or capture the extent of contamination required to achieve cleanup goals. Also, as emerging issues arise, treatment strategies may need to be reassessed for new COCs or different contaminant migration pathways (e.g., COC vapor intrusion into indoor air).

- **Life-cycle design limitations.** Remedial progress for systems designed for mass removal becomes increasingly limited at sites in the diffusion-limited phase of the life-cycle design. Such systems may reach asymptotic mass-recovery rates after relatively short periods of operation; the exit strategy should clearly define triggers for implementation of a contingency action or of rebound testing.

At sites where the systems fail the suitability analysis, alternative RAs should be explored (see Section 1.7). At sites with complex problems, such as completed exposure pathways, landfill sources with partially saturated waste deposits, or DNAPL releases below the water table, careful review of the RA objectives and the underlying assumptions—as described in Section 3.3.1—is important. In such cases, both the RA objectives and the RA itself may need to be revised in light of the growing body of empirical data that indicate that conventional engineered solutions to these kinds of environmental problems may not succeed in meeting the RA objectives in a reasonable time frame.

3.4.2 Evaluating Monitoring Programs

Regardless of the RA selected (active or passive, engineered or natural), the evaluation of monitoring programs should be an integral part of RPO at all remediation sites with groundwater contamination. Analysis of monitoring data is the key element in tracking and assessing progress of the RA toward achieving the stated RA objectives. The purpose of the monitoring network evaluation and optimization is to ensure that adequate data are collected to allow evaluations of remedial processes, system performance, and system suitability and that collection of superfluous data are eliminated. The evaluation of a monitoring program involves assessment of the following elements:

- number of monitoring points;
- spatial (horizontal and vertical) relationship of monitoring points to source areas, remedial components, compliance points, and edges of the contaminant plume;
- monitoring frequency;
- target analytical parameters; and
- sampling and analysis protocols.

3.4.2.1 Number and Locations of Monitoring Points and Monitoring Frequency

In general, a monitoring network should have sufficient wells to provide the following monitoring data:

- site background or upgradient conditions;
- horizontal and vertical extent of dissolved and NAPL contaminant plumes;
- groundwater elevations for each affected water-bearing unit sufficient to allow construction of potentiometric surface maps throughout the area of interest;
- feedback on performance of both active and passive remediation measures;
- confirmation of compliance with numeric cleanup goals at established compliance points;
- information on interactions between groundwater and nearby surface water bodies or underground utilities, such as storm sewer lines (where applicable);
- radius of influence of injected amendments; and
- capture and treatment zones of engineered in situ systems (e.g., passive reactive barriers, interceptor trenches, funnel-and-gate systems).

A monitoring network may include background (upgradient), compliance, sentry, and performance monitoring wells, and piezometers to meet site-specific requirements. Because contaminant, product, and injected-amendment plumes are dynamic, it is necessary to periodically reevaluate the role of each monitoring well in the network. This reevaluation may indicate a need for additional monitoring wells or may identify wells that are no longer needed to meet monitoring objectives. There are a number of approaches for performing redundancy and optimization analyses for monitoring networks (e.g., statistical trend analysis, geostatistics, and data visualization using GIS). More detailed information on specific approaches may be found in the RPO Toolbox, Appendix C.

The role of a monitoring location also should be considered when evaluating monitoring frequency. For example, less frequent monitoring for upgradient and immediate source area wells may not adversely impact the data required for the evaluation process. Plume-bounding wells, on the other hand, may require more frequent monitoring to assess plume migration and to trigger contingency actions if a plume expands to a sentry well or a point-of-compliance well. Generally, for system performance evaluations, quarterly COC and water-level monitoring data are necessary during the first six to eight quarters following startup of the remediation system. Following this initial phase, a reduced monitoring frequency (e.g., semiannual or annual) may provide adequate data for long-term monitoring objectives.

3.4.2.2 Monitoring Parameters and Sampling Procedures

For most remediation projects, the primary monitoring parameters are the COCs specified in the decision documents, plus any geochemical parameters that reflect plume behavior, remedy performance, or contaminant fate (indicators of biological or abiotic attenuation, other inorganic analytes such as redox-sensitive metals that could be mobilized in the presence of organic COCs, etc.). The COCs should have been identified based on a site's specific operational history and results of the risk assessment, and sampling and analytical protocols should be appropriate to measure COC concentrations equal to or less than the numeric cleanup levels established in the decision document. Other important analytes are those related to any substance injected into the subsurface as part of the RA (e.g., tracer compounds, biological substrates, oxidizing compounds). Nonspecific analytical methods that target carbon ranges (e.g., total petroleum hydrocarbons) or total metals (e.g., total chromium) fractions are generally not sufficient to monitor individual COCs (e.g., benzene or hexavalent chromium) and are generally inappropriate measures of performance. In some cases, target analytes may be deleted from the program if they are consistently not detected at concentrations of concern over time. In other cases, new analytes may need to be added as the understanding of the fate or toxicity of some chemicals evolves. It also may be possible that changes in analytical methods may be appropriate to refine the suite of analytes targeted, to take advantage of lower detection limits or other technical improvements, or to reduce costs. Note that changes in target analytes, analytical methods, or monitoring frequencies may require modification of the decision document and always require modifications to site-specific sampling and analysis or O&M plans, as well as appropriate negotiation with involved regulatory agencies.

The RPO monitoring evaluation process should also include review of the sampling procedures used at the site. With concurrence from the regulatory agencies, newer procedures, such as low-flow sampling or use of diffusion samplers, may be considered since these procedures can improve the data quality for performance and compliance monitoring and may reduce costs. Finally, the review process should assess the adequacy of the means to manage the analytical and physical data. The use of electronic tools—ranging from simple spreadsheets or databases to more complex as geographic information systems—can greatly assist in the efficient use of the data.

3.5 Remedy Cost-Efficiency Assessment

Another element of the remedy optimization evaluation process focuses on a review of the cost-efficiency of the remediation systems and monitoring program. This evaluation compares the actual O&M cost of a remediation system against projected cost—which was one of the criteria used to select the remedy from among other alternatives—and its progress toward achieving the RA objectives (e.g., containment or contaminant mass removal). This subsection discusses the required cost and performance data and cost-efficiency plots that should be prepared for every operating remediation system.

3.5.1 Evaluating Cost and Performance Data

Cost and performance data typically used for this evaluation include the following:

- projected (per the feasibility study or corrective measures study) and actual O&M costs,
- capital costs for system modifications and upgrades,
- degree of hydraulic containment/capture attained,
- mass of contaminant removed, and
- average monthly run time and downtime.

The O&M costs should be routinely tracked and reported on a weekly or monthly basis. Any capital costs associated with system upgrades and modifications or unplanned repairs should be included in this evaluation, but these costs should not be amortized. Some examples of O&M costs that are significant for remediation projects are listed below:

- labor,
- materials,
- utilities and fuel,
- monitoring including sampling and analysis,
- equipment lease/rental,
- off-site disposal fees (e.g., for sludges), and
- administrative costs (e.g., permitting fees, reporting, fines for violations).

For remediation systems involving aboveground treatment of extracted groundwater or soil gas, total contaminant mass removed is obtained from influent flow rates and influent/effluent contaminant concentration data. The evaluation should also determine contribution of COC mass from each extraction point, and extraction systems should provide for monitoring of flow rates and chemical data from individual extraction wells. For in situ remediation systems, contaminant mass removed may be calculated from analytical data obtained from the performance monitoring well network. An example calculation for COC mass removal from extracted groundwater is provided below:

$$\text{mass removed (kg)} = Q \text{ (gal/min)} \times C \text{ (}\mu\text{g/L)} \times T \text{ (days)} \times 3.8 \text{ L/gal} \times 1{,}440 \text{ min/day} \times 1 \text{ kg}/10^9 \text{ }\mu\text{g} \ ,$$

where

Q = average influent groundwater flow rate,
C = concentration of COC in influent,
T = time over which mass removed is calculated.

3.5.2 Cost-Efficiency Plots

Plots of cost and performance data should be used to track remediation system O&M costs, mass of contaminant removed or destroyed, and cost per pound of contaminants removed or destroyed through time since system startup. Some general conclusions can be drawn from these plots:

- efficient system operation demonstrated by low O&M cost and high mass-removal rate,
- decreasing system efficiency indicated by increasing O&M costs or decreasing mass-removal rates or frequent system shutdowns, and
- poor system efficiency demonstrated by asymptotic conditions.

A common type of cost-efficiency plot used for the evaluation shows cumulative cost incurred versus cumulative COC mass removed. The slope of this plot illustrates the degree of cost-efficiency. Near vertical segments on these plots represent periods of poor system efficiency as a result of high cost or low mass removal. Another type of cost-efficiency plot shows cost per unit mass removed versus time.

3.5.3 Estimating Life-Cycle Costs

According to EPA and Army Corps of Engineers (2002) *Guide to Developing and Documenting Cost Estimates during the Feasibility Study*, the term "life-cycle cost" refers to the total project cost across the lifespan of a project, including design, construction, O&M, and closeout activities. The cost estimate developed during the RPO is a projection of the life-cycle cost of an RA from design through response complete (excluding RI/FS and earlier phases). Engineered RAs typically involve construction costs that are expended at the beginning of a project (such as capital costs) and costs in subsequent years that are required to implement, maintain, and monitor the remedy after the initial construction period (e.g., annual O&M costs, periodic costs). A life-cycle cost analysis is a more realistic method of comparing costs for alternatives than simply comparing initial costs. Life-cycle cost analyses evaluate the total cost of ownership over the life of the project, including cost of money, length of service life of the units or components, maintenance, and operating costs. As used herein, a life-cycle cost analysis compares the present worth of the total annual costs of ownership for different RAs by estimating costs in today's dollars and amortizing those costs over the life of the project.

Present-value analysis is a method to evaluate expenditures—either capital or O&M—that occur over different time periods. This standard methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This single number, referred to as the present value (PV), is the amount of funding that must be set aside at the initial point in time (base year) to ensure that funds will be available in the future as they are needed, assuming certain economic conditions.

A present-value analysis of a remedial alternative involves four basic steps:

- Define the period of analysis (the expected project life cycle).
- Calculate the cash outflows (payments) for each year of the project.
- Select a discount rate to use in the PV calculation.
- Calculate the PV.

Cost-estimating summaries should address the following:

- the key cost components/elements for both RA and O&M activities,
- the major sources of uncertainty in the cost estimate,
- either discount rates or scale-up factors,
- the time expected to achieve RA objectives,
- periodic capital or O&M costs anticipated in future years of the project (e.g., remedy replacement or rebuilt),
- the methods and resources used for preparing the cost estimate (e.g., estimating guides, vendor quotes, computer cost models), and
- treatability study costs, when applicable.

The assumptions used to develop the cost estimate should be consistent with stated RA objectives; for instance, the duration of the life cycle for which costs are estimated should match the estimated time to achieve cleanup objectives.

3.6 Other RPO Review Elements

In some cases, it may be appropriate for the optimization team to verify that procedures are in place to ensure that roles and responsibilities of all involved parties are clearly defined, that adequate resources—both personnel and financial—will be available to implement the exit strategy, and that all pertinent project staff members are aware of the exit strategy decision logic and the RA objectives. Formal agreements among the responsible party and involved regulatory agencies (e.g., consent orders, memoranda of agreement, federal facilities agreements, and interagency agreements) should be reviewed to ensure that all parties are aware of decision authorities, concurrence or approval roles, review timelines, and dispute resolution procedures. It is also important to identify deficiencies in documenting these roles and responsibilities. Provisions for thorough documentation of all decisions and training of new personnel should be made to preserve continuity of the cleanup program for the site as staff turnover occurs.

The project lead who reviews the monitoring data and makes recommendations or decisions about the continued operation of equipment and processes or about the monitoring program must be clearly identified to the optimization team. The frequency of such a review should be evaluated to ensure that it occurs with adequate frequency relative to the cost and protectiveness implications of not making adjustments. The process for proposing such changes to the regulatory agencies should also be identified, and the extent to which actions can be taken without agency approval must be identified as well. The time frame and means of communication for regulatory agency approval should also be verified and should be reasonable, again considering the cost and protectiveness impacts of delayed or misdirected approval.

Following optimization reviews of all remedial components for a given RA, future costs and schedules projected for the cleanup should be reviewed for reasonableness given the likely time frame and level of effort required. Federal installations must prepare annual cost-to-complete and schedule-to-complete estimates to justify funding requests submitted to Congress and to facilitate the budget planning process. These estimates may require revision once RPO recommendations are implemented.

In some cases, one RPO review may not be sufficient. Another RPO evaluation may be necessitated by changes in site-specific conditions or regulations, advances in technologies, etc. RPO recommendations based on site-specific conditions should address this aspect of the process also.

3.7 Remedy Optimization

Once the exit strategy is reviewed and validated in the context of the refined CSM and regulatory framework (see Section 3.3) and after cost and performance data for the current remedy are evaluated and a need for system optimization is identified, modifications to the current remedial approach can be considered. Modifications might be made to improve the overall exit strategy or the effectiveness (protectiveness) of the remedy or to reduce the cost while maintaining or improving its protectiveness. Some of these changes may require amendments to formal decision documents. Early involvement of regulators and stakeholders in the optimization process can facilitate acceptance and implementation of the modifications.

3.7.1 Optimizing the Exit Strategy

An exit strategy is the plan for meeting the RA objectives; therefore, all optimization recommendations must be made in the context of this overall "remedy completion plan." The optimization team should recommend refinement of the exit strategy based on its overall remedy review. The RPO report should address the overall protectiveness of the remedy and the likelihood of attaining the cleanup goals as currently identified; it should also provide recommendations to enhance protectiveness, to improve the likelihood of achieving the RA objectives, and to reduce the time required to complete the RA. The following actions may be appropriate:

- Modify the RA objectives themselves based on updated site conditions and ARAR analyses (e.g., replace default cleanup goals with site-specific risk-based targets, change the point of compliance, or develop alternative concentration limits (ACLs) and request an ARAR waiver).
- Identify data needs for more complete evaluation of remedial progress or system effectiveness (further refine the CSM).
- Take advantage of improving site knowledge and technological advances to suggest new technologies that would expedite attainment of goals (see Section 3.7.2).
- Optimize the monitoring program to verify the basis for proposed remedy optimizations (see Section 3.7.3)

The RPO report also should present the results of a cost/benefit analysis to justify the optimization recommendations (see Section 3.8) and should identify the appropriate sequence of implementation of optimization recommendations so that changes that can easily be made now can be initiated while other more difficult or sensitive changes are evaluated or coordinated further (see Section 3.10). If no clear exit strategy or project decision tree exists, the team must recommend creation of such a tool and provide suggestions as to its structure and content. This exercise could involve defining "triggers" for future refinements of the remedy in the form of performance metrics and outlining possible contingency actions that may be considered.

In some cases, the optimization team may need to assist with the creation or modification of the exit strategy following the completion of the initial optimization study. The level of follow-on support to be provided by the RPO review team will depend on the complexity of the technical and regulatory issues and on the resources available (see Section 3.10.2).

3.7.2 Optimizing the Remedial System

System optimization is a process that looks at individual remedy components without losing sight of overall remediation objectives. Such strategies may include modifications to the extraction system, the treatment system, or the monitoring program, as well as considering alternative remedial approaches. Modifications can be made to any type of remediation systems, such as pump-and-treat systems, air sparging (AS)/soil vapor extraction (SVE) systems, and in situ and enhanced bioremediation systems. These modifications fall into one of the following two classifications:

- minor modifications to existing system operations (e.g., adjusting granular activated carbon (GAC) change-out frequency, flow rates, injection volumes, volume or type of chemical additions, and revising well maintenance requirements, etc.) or
- adding/removing or replacing components of the current system (e.g., downsize or remove unnecessary pumps, changing or removing off-gas treatment, add or remove extraction or injection wells, etc.).

If evaluation of the existing remedial system reveals that it cannot be reasonably modified to achieve the RA objectives in a reasonable time frame, then the remedial strategy needs to be revised. The optimization team should use available site characterization and remedy performance data—along with improved technical information about the available technologies—to conduct updated ARAR and feasibility analyses to optimize the overall remedial decision. Outcomes of such optimization efforts may include the following recommendations:

- Perform additional source reduction or hot-spot remediation (e.g., application of chemical oxidation, NAPL removal).
- Replace or supplement the current technology with a new technology or strategy (e.g., a passive reaction zone or MNA).
- Expand the use of institutional controls to achieve protection (e.g., exposure controls).

3.7.3 Optimizing the Monitoring Program

Monitoring programs typically outline the requirements for monitoring system—or process—performance of aboveground remedy components (e.g., within a treatment plant) or monitoring the performance and effectiveness of the remedy by assessing physical and chemical changes in targeted media (e.g., soils, groundwater, soil vapor, and surface water). Every sampling point should fill a specific data need, and modifications to the monitoring program must not compromise overall protectiveness of remedy in an attempt to reduce costs. Therefore, it should be clearly recognized that monitoring program optimization may actually require *increases* in numbers of sampling locations, target analytes, or sampling frequencies to provide the information required to track remedial progress, ensure compliance with RA objectives, and confirm remedy effectiveness. Examples of such modifications are outlined below:

- Process monitoring should be considered, including influent and effluent sampling as applicable in case of a pump-and-treat or SVE system or among individual components of such systems. The objectives of process monitoring are twofold: provide the data necessary to allow the system operator to efficiently run the remedial components and ensure compliance with discharge/emission permitting requirements.

- Optimization of subsurface monitoring should consider data quality objectives (DQOs), sampling locations, target analytes and parameters, analytical methods, frequency of sampling, sampling procedures, and data analysis, presentation, and reporting. Simple modifications to monitoring programs can be achieved by reviewing potentiometric surface or plume maps in the context of the monitoring well network array. Software packages that use geostatistics and temporal-trend analysis techniques also are available to evaluate and optimize monitoring programs (see the RPO Toolbox, Appendix C).

3.8 Cost/Benefit Analysis

The RPO review team should assess the costs—in terms of time, resource consumption, public perception, and dollars—associated with implementing each RPO recommendation against the benefits (e.g., enhanced protectiveness, reduced time or cost to achieve RA objectives) that would be realized. For example, the O&M costs of the existing remedy can be directly compared to the estimated capital and O&M costs associated with implementing a modified strategy or technology. In such an example case, a cost/benefit analysis can be performed using life-cycle costs and the estimated period of RA operation required to achieve RA objectives to calculate an PV for each recommended modification/alternative. The calculation of the present value of the proposed modification must carefully consider the appropriate discount value. Government agencies may be required to consider a lower discount rate than private parties (see ASTM 2003a). These PV values can then be used to directly compare remedial scenarios with differing capital costs, O&M costs, and operating periods. Ideally, for cost-reduction recommendations, a payback time of less than five years is preferred. Modifications that require a longer payback time are often disregarded because site conditions may change or innovative technologies may become more appropriate over a five-year time period. As noted, it is also important to consider intangibles such as public acceptance and impacts of optimization efforts at one site on remedial progress at other sites. These elements can outweigh short-term cost savings in some circumstances (for instance, where the remediation process is politically charged).

There are several references available that explain life-cycle cost–estimating, including EPA (2000) guidance, several standard industry practices developed by the American Society for Testing and Materials (ASTM 2003a, 2003b, and 2003c), and a recent DOE-funded publication entitled *Guide to Computing and Reporting the Life-Cycle Cost of Environmental Management Projects* (Shultz and Weber 2003). The reader is referred to such references (see Section 6) for more complete details on estimating life-cycle costs as part of a cost/benefit analysis.

3.9 RPO Review Recommendations

An RPO review may face opposition from the project team. After all, it can be perceived as a direct challenge to the decisions made by the project team that worked for years to reach the point of implementing a remedial action. However, it needs to be clearly explained to the project team that the RPO review is not an audit of the remediation system. It should be clearly stated that the RPO is an opportunity to evaluate the process as a whole and try to optimize the remediation action from a process point of view. It should also be highlighted that implementing changes that take advantage of technological advances and regulatory environment different from when the original decisions were made will achieve goals faster and by better methods using resources optimally. An RPO review report is the best place to clarify some of these intricacies and convey the positive message to the project team. The report should highlight some of the good things that are already happening at the site. Recommendations should be specific and should be divided into smaller and achievable intermediate steps as appropriate for the site-specific conditions. Specific recommendations whose implementation is critical for that of other stages of the remediation train should be clearly identified. Any potential issues that may need special attention should also be identified. Estimates of financial and human resources should be reasonable and realistic.

3.10 Implementing the Optimization Strategy

Once an optimization strategy is developed for a particular site, an implementation strategy should be developed by the RPO review team to facilitate implementation of the optimization recommendations. The implementation strategy is particularly important since implementing some recommendations may be contingent on the results from implementation of other recommendations.

3.10.1 Implementation Strategy

Implementation of optimization recommendations should consider the overall RA objectives and remedy performance expectations to develop a sequencing strategy that will maximize the desired improvements. For example, it would be imprudent to optimize a remedial system if a change in RA objectives could eliminate the need for continued system operation. Implementing some recommended modifications may be contingent on the results of implementing other modifications, and implementation of some recommendations may obviate the need for implementing other recommendations. It may be appropriate to eliminate a particular treatment step for extracted groundwater if the constituents targeted by that treatment process have been reduced below discharge limits or have reached asymptotic levels. However, if additional extraction wells are also recommended and mass removal is expected to increase, then the treatment component may need to remain in place until mass removal decreases in the future.

Development of an optimization strategy, while based largely on the projected potential for implementation of each recommendation to improve remedy performance and reduce cost, may also consider challenges that are technical, institutional, financial, and ethical in nature. See Section 4 for further discussion of these challenges and potential solutions.

3.10.2 Implementation Strategy Presentation/Recommendations

The management of the agency or organization sponsoring the RPO efforts should receive copies of reports prepared as a result of the RPO evaluation efforts. The recommended actions identified in the reports should be compiled for each site, as should the probable future action (and schedule for such actions) to be taken by the project team on these recommendations. The sponsoring organization may request justification for any decision by the project team not to execute the recommendations. To encourage the implementation of feasible recommendations, the sponsoring agency should identify a means to follow up on the status of the implementation of the RPO recommendations and to track reasons for any departure from the implementation schedule and strategy. Such tracking may be tied to performance assessment for project team members. Appropriate incentives may also be awarded to the project team as they achieve goals. One of the best ways to reward is not cutting resources from those who save resources implementing RPO recommendations. These issues represent challenges for the RPO process and are discussed more fully in Section 4.

3.11 Implementation Tracking/Tracking of Action Items

The findings and recommendations of an optimization effort should be monitored or tracked to verify the status of implementation, in much the same way as other project action items. The what, who, how, when, and expected outcome are the common items that need tracking. In RPO terms, this task generally translates into tracking the recommended action, the individual(s) responsible for approving and actually implementing the action, the recommendation be accomplished, the estimated or actual implementation date or time frame, and the expected or known outcome (cost savings, time savings, better protectiveness). This type of implementation tracking can be monitored and updated as frequently as needed with semiannual updating generally considered the minimum frequency. Table 3-2 offers an example of a set of tracking matrices used to track the implementation of some Air Force Real Property Agency (AFRPA) Performance and Protectiveness Review recommendations. As shown, a total of 19 recommendations were made at these facilities, 15 of which were met with favorable site responses. Only two of these recommendations were only cost saving, and five were both time and cost saving recommendations. A majority (11) of the recommendations were to increase protectiveness and improve quality.

Table 3-2. Summary of recommendations and resolutions

Performance and Protectiveness Review recommendations		Base assessment			Regulatory concurrence required
Type	Number	C[a]	U[b]	N[c]	
Save time	0	–	–	–	0
Save cost	2	2	–	–	2
Save time and cost	5	4	0	1	1
Increase protectiveness	7	5	0	2	5
Improve quality	4	3	0	1	2
Other[d]	1	1	0	0	0
Total	19	15	0	4	10

[a] C = A favorable response was provided by the base's program manager. The recommendation will be implemented or an evaluation will be conducted to assess the potential value of the recommendation prior to deciding on whether it should be implemented. In some cases, implementation may be one or more years in the future.

[b] U = A response was not provided for this recommendation. The base's position is unknown. The base and headquarters should review these recommendations.

[c] N = The response provided indicated that the recommendation would not be implemented.

[d] Other includes organizational items, data presentation methods, management initiatives, and other factors that do not fall into the more specific categories.

4. CHALLENGES AND SOLUTIONS IN THE RPO PROCESS

Challenges inherent in remediation process optimization include technical, institutional, contractual, and regulatory issues. Technical challenges are introduced by uncertainties in the performance of a remediation strategy. Institutional challenges result from competing objectives and different goals. Contractual challenges reflect the reality of limited resources such as finances. Regulatory challenges reflect the differing values of process participants, often raising ethical issues. Communication and education play very important roles in overcoming intrinsic resistance to the RPO process. Recognizing and addressing challenges facilitates successful outcomes. Therefore, RPO review teams should include independent, multidisciplinary participants who understand the challenges and can articulate objective recommendations and perhaps facilitate compromises.

Because RPO requires the definition and evaluation of goals and objectives, RPO helps organizations meet specific programmatic requirements. For example, as a number of federal agencies require risk-based cleanup at their facilities, RPO helps ensure that those sites comply with those requirements. Further, as RPO redirects resources, it frees up funds and people that were previously dedicated to a project to address other pressing remediation opportunities. By properly redeploying these resources, everyone can gain from their optimal use.

4.1 Technical Challenges and Solutions

Most technical challenges to RPO can be attributed to the uncertainties and variables in the performance of an engineered system within a dynamic, heterogeneous natural environment. Technical solutions to remediation problems should be based on the scientific method and ideally should include systems engineering design principles and quantitative optimization or decision analysis methods. Existing systems require objective evaluation not only of their ability to perform as originally intended, but also of their ability to meet revised goals and objectives. Should the RPO review team conclude that the existing system will not meet the revised remediation requirements, the team should consider evaluating possible alterations to the existing system, as well as the adoption of alternative technologies. Systems engineering approaches such as failure (or reliability) analyses can be applicable and useful in such cases. Stochastic analyses are especially useful because they account for inevitable uncertainty regarding the performance of the engineered system within the environment, and ensure that the design basis of the engineered system also accommodates those uncertainties.

See Appendix C for a more complete discussion of quantitative analytical tools and remediation technologies.

4.2 Institutional Challenges and Solutions

Institutional barriers may hinder the embracing of process optimization. Inertia of the existing remedial project structure, a lack of formal institutional policies regarding implementing and tracking optimization, sparse administrative support, poor relations with stakeholders, and frequent turnover of personnel may prohibit the acceptance of new approaches. Again, communication and education are key elements in successfully overcoming the reluctance of concerned parties to conduct an RPO review.

Many projects have an inherent inertia toward change. In many cases, there are few—or no—incentives for the project team to revisit the current remedy. Often, there is no aspect of the overall personnel performance evaluation process that gives credit for RPO-like activities. The performance metrics are more focused on meeting existing budget and schedule and avoiding problems rather than on improving performance and efficiency. The project staff may feel that any evaluation of the remedy that results in recommendations for change is an indictment of their past efforts, and they may resist RPO. Existing systems and entire programs may be entrenched in administrative processes and focused on "bean counting" or graduating sites out of the program. Unfortunately, there is often no mechanism for program-wide initiation, funding, and tracking of RPO at sites covered by such a program.

Earlier unsuccessful investments in other technologies may have created reluctance on the part of some stakeholders to invest additional funds to revise existing processes to make better use of limited resources. In other instances, certain stakeholders may be skeptical of attempts to reduce costs because of a perception that RPO is only about saving money, when in fact it is a process to better utilize resources to ensure protectiveness (see example in Table 3.2). Property owners, Potentially Responsible Parties (PRPs), and regulators alike may abhor revisiting the ROD due to the time (and expense) involved in the process. Uncertain and declining budgets and staff tend to exacerbate the situation even though the proposed changes may reduce the financial and personnel requirements in the long term. Finally, frequent changes in staff responsible for systems means there are few people with a long-term stake in the improvement of the system; there is also a loss of institutional memory regarding what has been tried or changed and the reasons behind those attempts.

Education and demonstration of successful RPO implementation at other sites are key factors to institutional acceptance. The more stakeholders and project staff know about RPO, its potential benefits, and application of such processes at other sites, the more they are likely to accept it. This process knowledge includes recognizing the need to periodically revisit the remedy at any site. Since this is the rule rather than the exception, the project staff should view RPO not as a criticism of their efforts but as a routine effort to apply new information relevant to the task at hand.

Management endorsement of RPO and formalization of the process for conducting, funding, and tracking the results of RPO at the overall program level greatly enhances the acceptance of RPO at the project level. This process also requires the development of specific RPO performance metrics for staff responsible for each system. Some positive recognition of successful RPO efforts (through such incentives as awards and cash) will further encourage acceptance and improve project staff performance. Resources (money and personnel) saved should be reinvested within the program area. If a team saves resources through RPO process but loses all those resources in the following years' budgets, it will not have an incentive to embrace challenging opportunities such as RPO. Focusing on the efficient use of limited resources across many sites while improving protectiveness will help garner support for RPO. Keeping this long-term focus will help overcome the skepticism some stakeholders have and a reluctance to make necessary changes to RODs or permits. The use (or continued use) of teaming approaches may offset loss of institutional knowledge as personnel changes.

It is worth noting that not all facilities are interested in optimizing their corrective action systems. After initial remedy construction is complete, some facilities view corrective action costs as an annual line item expenditure and are interested only in achieving a minimal degree of compliance with cleanup requirements with the lowest possible, predictable annual cost. These facilities will be resistant to the RPO process if it appears likely that additional capital outlay will be required.

4.3 Contractual Challenges and Solutions

Contractors may perceive that process optimization will result in a loss of revenue, particularly if their system is modified to reduce operating costs or is replaced with a more effective remediation alternative. However, contracting options are available that can align the contractor's financial incentives with the goals of the remediation program. Contracting strategies include using performance-based contracts when feasible and establishing a set of performance measures directly tied to the site closure strategy. In addition, contractors should recognize that their ability to provide an optimized approach to site closure will result in a favorable reputation, giving them an advantage in the competition for new contracts based on superior past performance.

Fixed-price and cost-reimbursable contracts are the types of contracts most widely used for environmental remediation. Contractors assume the greatest amount of risk under fixed-price contracts because they are responsible for the costs of performance; whereas under cost-reimbursable contracts, the government assumes the majority of risk. A fixed-price performance-based contract provides an incentive to the contractor to conduct operations effectively and efficiently and to manage costs. Cost-reimbursable contracts are appropriate during the first few months of operation (startup, shakedown, and optimization of new remedial systems). After the initial startup, fixed-price contracts are preferable during the remedial actions if the project scope is well defined, there are few unknowns, and it is unlikely that the scope will change. However, for nonroutine maintenance and expendable items (such as carbon and polymer) a cost-reimbursable contract can be used.

Contractor performance should be evaluated based on demonstrated cost-effective progress towards site closure. Performance measures should be established at the start of the contract and tied directly to the contractor's payments (in the case of a fixed-price contract) or award/incentive fees (in the case of a cost-reimbursable contract). Example performance measures are identified below:

- achievement of cleanup or closure criteria by a specified time (appropriate only if the heterogeneity is well defined and the subsurface processes are well understood),
- mass of contaminants removed,
- percent reduction of contaminant mass or concentration,
- reduction in total operating or monitoring costs,
- zero permit violations,
- maintaining a predetermined removal efficiency,
- maintaining plume capture, and
- maintaining plant up-time (particularly if there is a high degree of confidence that the remediation system is maintaining plume capture or removing contaminant mass at desired rates).

For these metrics to influence the optimization process, the contractor's scope must include the authority to implement changes to achieve site goals. Careful contract administration may be required with cost-reimbursable projects to ensure that excessive reimbursable costs are not incurred to achieve contract incentives and that adequate maintenance is conducted to avoid future added repairs.

Another contracting strategy used in RPO is to issue work in bulk packages. This approach can reduce contract burdens by minimizing the number of contracts requiring administration. Analytical costs can be reduced with bulk analysis discounts. Coordinating sampling events and instructing laboratories to analyze all routine and quality control analyses in the same analysis batch also improve data quality.

4.4 Regulatory Challenges and Solutions

The existence of one or more regulatory frameworks, the involvement of various agencies, and potentially changing regulations have an influence on the RPO process and require an integrated approach to optimization. Different regulatory programs may cover a single facility or site, and often state, local, and federal agencies are each involved. Disagreement among and within agencies may inhibit the ratification or implementation of a proposed RPO plan, particularly when the parties consider overturning agreed-upon decisions. Regulations may change over time, such as new contaminants being added to the regulated list or MCLs being revised upward or downward. In addition, while regulatory standards are commonly used to establish cleanup goals, more recently, risk-based goals have gained greater acceptance from the regulatory community. Room for flexibility by regulatory stakeholders while keeping within the governing environmental regulations will facilitate the optimization process.

Educating various parties on the benefits of RPO is necessary. Incorporating RPO into established regulatory and other review programs would be a logical interface. Opportunities include annual program reviews, CERCLA five-year reviews, and RCRA permit modifications. These reviews meet regulatory requirements to present cost and performance data, provide an opportunity to discuss remedial progress, and identify opportunities to optimize the remedial systems. The routine involvement of each agency in site evaluation will result in consensus conclusions and recommendations for changes and improvements.

5. STAKEHOLDER CONSIDERATIONS

Stakeholders should be involved at every stage of the evaluation, selection, and permitting (if necessary) of treatment systems. Experience has shown that stakeholder input will benefit the project during this process. While these outreach efforts may go beyond regulatory requirements, they can create a more cooperative partnering between the facility, regulators, and the community. Stakeholder involvement could benefit from the development and implementation of a public involvement plan, public meetings, open houses, and technology working sessions.

Stakeholders could include local, state, and federal government officials, representatives of affected tribes, facility owners and operators, nearby residents, and environmental groups. This outreach should, at a minimum, address the local state and federal statutes, regulation, guidance, and policy provisions for community input. In addition, efforts beyond those specifically mandated may be warranted at individual sites on a case-by-

> case basis. Such involvement will lead to better, more defensible solutions and will expedite the cleanup of contaminated sites. One of the objectives of the responsible parties should be to integrate tribes and stakeholders into all of their processes. Stakeholder discussions should clearly define the specific cleanup goals and criteria as explained in detail in this document.
>
> —*Technical and Regulatory Guidance for Surfactant/Cosolvent Flushing of DNAPL Source Zones* (ITRC 2003)

The ITRC RPO Team is in agreement with stakeholder statement as presented above. RPO is a proven process to evaluate and improve the effectiveness of remediation systems while maintaining protectiveness. The RPO process is designed to meet the remediation goals in the shortest time with proven practical solutions. The RPO process is a dynamic tool that should be regularly implemented to ensure that the site's remediation goals are met expeditiously and cost-effectively. Continuous improvement in the remediation process requires stakeholder support and concurrence. Following are guidelines that an RPM should follow to ensure that stakeholder concerns are addressed:

1. It is imperative that the remedial program managers (RPM) provide the RPO review team with clearly delineated end goals of the remediation project. The RPM should define in detail the intended use of the property once the remediation project is complete. A particular emphasis should be placed on the planned "protectiveness" condition of the site for people, groundwater, and the ecosystem; both during the active remediation phase and after the remediation process is complete.

2. The RPM should advise the RPO review team of the remediation project's stakeholder organizations, their respective designated contacts/representatives, and contact information. The RPM should also have knowledge of the type of stakeholders and the stakeholders' concerns with the remediation project and should provide the RPO review team with this information. The RPO team uses information provided to the RPO by the RPM to be sensitive to the stakeholders' concerns during the RPO investigation and in the preparation of recommendations.

3. It is responsibility of the RPM to decide the appropriate involvement of the stakeholders in the RPO process. Regardless of the RPM's decision to involve the stakeholders in the RPO process, the RPM should be prepared to explain to the stakeholders the RPO process, the RPO process schedule, the RPO review team members, each member's qualifications, the results of the RPO investigation, and why the RPO's team recommendations are being accepted or rejected.

4. Prior to any implementation of a RPO recommendation, the RPM must advise the stakeholders as required by the remediation project's regulatory requirements.

5. After a RPO recommendation implementation, the RPM should be prepared to advise stakeholders of the results of the RPO process. The RPO process should produce measurable results. The minimum measurable results that should be recorded are changes in

protectiveness, changes in the remediation project's time line, and changes in the remediation project's projected costs.

6. Each RPO review team should supply the RPM with a contact name and contact information should the RPM require the site RPO's team assistance when needed.

The technologies, processes, and regulatory environment for remediation are evolving. The RPO process is a valuable tool that should be used frequently to assess remediation projects to ensure the remediation objectives are met in a timely and cost-effective manner. Therefore, appropriate stakeholder involvement will enhance the implementation of the RPO process and increase public acceptance of proven approaches to meeting the final remediation goals. Tools available to the RPM to educate stakeholders and support the RPO process with the stakeholders are included in the RPO Toolbox (Appendix C). Those tools include, but are not limited to, case studies, proven practical RPO methods, fact sheets, the site's RPO review team members, and the ITRC Remediation Process Optimization Team.

6. SUMMARY AND CONCLUSIONS

This ITRC RPO guidance document addresses the methodology to successfully conduct an RPO at any given site. Decades of learning by EPA, federal and state agencies, and academic and industrial research has resulted in improved characterization and remediation techniques. Combined experiences have led to a flexible approach in managing uncertainties in the initial remedial objectives, the procedures used to arriving at these remedial objectives, assumptions for the projections of system performances, modeling parameters and in monitoring measurements, etc. The guidance document summarizes the systematic approach to reevaluation and continuous improvement of efficiencies in various remediation technologies.

Protectiveness of the human health and the environment is the primary consideration for any RPO. Uncertainty analysis with a clear exit strategy and the reduction of associated cost and time are other important considerations. Depending on site-specific conditions, one or more RPO reviews may be needed. The guidance discusses the general regulatory framework for evaluating remediation processes.

Review of remedial goals is always the best place to start with an RPO review. Sometimes, due to advances in technologies or application of modern techniques such as risk-based goals, there is a clear need to revise remedial goals, and RPO addresses this important aspect of RA process. Previously unconsidered aspects, such as application of natural attenuation at a given remedial site or the inability to attain the original goals after several years of RA operation, can also necessitate an RPO review of the remedial goals. The use of RPO is closely related to other ITRC areas of interest and can become an inseparable process compared to other ITRC areas.

RPO has a good foundation both under RCRA and CERCLA provisions. Many state programs also encourage a thorough review of RPOs at sites where RA is in operation, especially for long periods of time. An RPO review can be done early as an RA operation begins but is typically done from two to five years after the initiation of the RA.

Selection of a site for RPO is somewhat obvious. RA operations at sites which are failing to protect human health or the environment are given priority. RA systems that were expensive to start with and are continuing to drain important resources, especially for the O&M costs on an annual basis, are also candidates for an RPO review. Sites where return of investment in RPO is likely to be high are also always given priority.

Assembling a competent RPO team is equally important. The team should be independent of the facility being reviewed and must have the highest level of management support possible. Typical RPO teams consist of experts in environmental engineering, toxicology, risk-assessment methods, modeling, and other areas of science as appropriate for the specific remedial evaluation.

An exit strategy outlines a simple plan for achieving the RA objectives. Evaluating the RAOs, revising the CSM, and reviewing the completion strategy and decision logic are all part of this important step in the RPO process. *Remedy* performance evaluation measures progress towards meeting cleanup goals, whereas *system* performance evaluation measures the degree to which a particular remedial component is meeting its design expectations. O&M data are evaluated and analyzed in comparison to the criteria established in RA objectives. Using a variety of analysis tools—from simple trend analysis tools and statistical packages to advanced GIS software—one can readily visualize these data and assess the system performance. Each component of the remedial system is analyzed for performance evaluation, and appropriate recommendations are made in the RPO process. As monitoring is the key element in tracking the progress towards meeting RA objectives, evaluation of the monitoring programs is also an integral part of RPO reviews. The number of sampling locations and their actual placement, monitoring parameters, and sampling frequency and procedures are all part of review process for the monitoring programs. Time of remediation action is also an important aspect to evaluate. Cost analysis becomes a natural outcome of the optimization following such a thorough review of elements of the remediation action process. Life-cycle cost estimation is also critical in RPO reviews.

Following analysis, the actual optimization process is clearly planned and recommended. This is followed by a period of actual implementation of recommended changes in the RA operation. As some elements of optimization are dependent on other elements, tracking of RPO actions is also important in the process. Depending on the site-specific conditions, it may be appropriate to conduct periodic RPO reviews at a given site.

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APPENDIX A

Acronyms

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ACRONYMS

ACL	alternative concentration limit
AFCEE	Air Force Center for Environmental Excellence
AFRPA	Air Force Real Property Agency
ALT	alternative landfill technology
ARAR	applicable or relevant and appropriate requirement
AS	air sparging
ASC	accelerated site characterization
BTEX	benzene, toluene, ethylbenzene, xylene
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	corrective measures study
COC	contaminant of concern
CSM	conceptual site model
DER	Declaration of Environmental Restriction
DERP	DoD Environmental Restoration Program
DLA	Defense Logistics Agency
DNAPL	dense, nonaqueous-phase liquid
DoD	Department of Defense
DOE	Department of Energy
DQO	data quality objective
DSP	diffusion sampler protocol
EM	(DOE Office of) Environmental Management
EPA	Environmental Protection Agency
ESD	explanation of significant difference
FS	feasibility study
GAC	granular activated carbon
GIS	geographical information system
GW	groundwater
ISCO	in situ chemical oxidation
ITRC	Interstate Technology & Regulatory Council
LNAPL	light, nonaqueous-phase liquid
LTM	long-term management
LTRA	long-term remedial action
LTS	long-term stewardship
MCL	maximum contaminant level
MIS	metals in soils
MNA	monitored natural attenuation
NAPL	nonaqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	no further action
O&M	operations and maintenance
OM&M	operations, maintenance, and monitoring
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon

PCE	perchloroethene (*or* tetrachlorethene)
PERMA	Performance-based Environmental Restoration Management Assessment
PHYTO	phytotechnology
PM	preventive maintenance
POTW	publicly owned treatment works
P&PR	Performance and Protectiveness Review
PRB	permeable reactive barrier
PRP	Potentially Responsible Party
P&T	pump and treat
PT	plasma technology
PV	present value
OPS	operating properly and successfully
QA	quality assurance
QC	quality control
RA	remedial action
RA-C	remedial action construction phase
RAD	radionuclides
RAO	remedial action objective
RA-O	remedial action operation phase
RBCA	risk-based corrective action
RC	response complete
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFI	RCRA Facility Investigation
RI	remedial investigation
ROD	record of decision
RPM	remedial project manager
RPO	remediation process optimization
RSE	remediation system evaluation
SARA	Superfund Amendments and Reauthorization Act
SI	site inspection
SSC	Superfund Contract
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TCE	trichloroethene
TD	thermal desorption
TSD	treatment, storage, and disposal
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound

APPENDIX B

Case Studies

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CASE STUDIES

This appendix includes case studies of seven different locations that have conducted remediation optimizations. They include EPA and state Superfund sites, RCRA Treatment, Storage and Disposal (TSD) facilities and two former Air Force bases. The sites are good examples of typical results that can occur at these types of facilities through the implementation of RPO. Table B-1 indicates the total cost of each remediation at the site, the costs incurred for conducting the RPO, and the potential savings that may be realized through an RPO team's recommendations. Including 27 other remediation system evaluations conducted for EPA Superfund Sites, a total of 251 recommendations could be categorized in the following categories:

- 76 addressed effectiveness issues
- 75 identified potential cost reductions
- 69 suggested technical improvements in the operations, and
- 31 addressed means to facilitate site cleanup/close-out.

Table B-1. Comparison of cost data among case studies

Case study	Cost of remediation	Cost units	Cost of optimization[a]	Potential savings	Cost units	Maximum savings[b]
1	$3,150,000	Per year	$25,000	$2,100,000	Per year	
2	Unknown		$50,000	$430,000	Per year	$2,150,000[c]
3	Unknown		$50,000	$100,000	Per year	$1,500,000
4	$535,000	Per year	$25,000	$225,000	Per year	
5	$2,400,000	Per year	$25,000	$1,008,000	Per year	
6	$100,000	Per year	$260,000			$1,150,000
7	$91,000	Per year	$320,000			$1,000,000
8	$1,800,000	Per year	$18,000	$200,000		$200,000
9	$1,500,000	Per year	$40,000	$340,000	Per year	

[a] Case studies 6 and 7 include implementation costs.
[b] Would occur if all recommendations are accepted and implemented.
[c] A five-year savings was presented in the case study.

OPTIMIZATION CASE STUDY #1

Site Name: Baird and McGuire Superfund Site

Site Location (City, State, Zip Code): Holbrook, MA 02343

Funding Agency or Party for Site Remediation: USEPA Region I

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

Elaine Stanley, Remedial Project Manager
USEPA Region I
1 Congress Street
Boston, MA 02114-2023
(617) 918-1332
stanley.elainet@epamail.epa.gov

Funding Agency or Party for Optimization Effort: USEPA Technology Innovation Office

Agency, Party, or Contractor Performing Optimization: GeoTrans, Inc., with U.S. Army Corps of Engineers

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-mail):

Peter Rich, P.E.
GeoTrans, Inc.
Principal Engineer
844 West Street, Suite 100
Annapolis, MD 21401
(410) 990-4607
prich@geotransinc.com

Douglas Sutton, Ph.D.
GeoTrans, Inc.
Senior Engineer
2 Paragon Way
Freehold, NJ 07728
(732) 229-8728
dsutton@geotransinc.com

Start/Finish Dates of Optimization Effort:

Site Visit: April 18–19, 2001
Final Report: January 18, 2002
Follow-up calls to track implementation: May 9, 2002 and July 22, 2003

Optimization Process Used (if Specific Process Used):

Remedial System Evaluation (RSE) process developed by USACE and modified by GeoTrans

Cost of Optimization Effort:

- $25,000 for the RSE
- $2,500 per year for a period of two years for following up and tracking implementation of recommendations

Total Potential Cost Savings, if Any: $2,100,000 per year

Site Information:

Primary Contaminants of Concern:

- Benzene, toluene, ethylbenzene, xylene (BTEX)
- Tetrachlorethylene *or* perchloroethene (PCE)
- Polynuclear aromatic hydrocarbons (PAHs)
- Various volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs)
- Arsenic
- Light, nonaqueous-phase liquid (LNAPL)

Remediation Systems

- Pump-and-treat system for hydraulic containment and aquifer restoration
- LNAPL recovery system

Total Flow Rate

- Pump and treat—approximately 127 gpm of groundwater from seven wells
- LNAPL recovery—5–10 gpd of LNAPL from one well

Treatment Processes:

Pump and treat

- Equalization tank
- Chemical addition and rapid mix
- Clarifier
- Diffused air strippers (converted from activated sludge basins)
- Pressure filters
- GAC for liquid treatment
- GAC for vapor treatment
- Discharge to on-site infiltration basins

LNAPL recovery

- Passive separation
- Solidified with corncobs prior to transport for off-site disposal by incineration

Total Number of Monitoring Wells Sampled:

- 60 monitoring wells sampled annually
- 8 extraction wells sampled quarterly

Total Annual Cost for Remediation: $3,150,000 in 2001

Year Remediation System(s) Began Operation: Treatment system began operation in 1993 to support soil excavation and incineration but began operation for long-term groundwater remediation in 1997.

Site Point of Contact: Elaine Stanley

Optimization Effort:

Treatment Optimization:

Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings.

- Automate the system to allow operation without continuous operator attention and reduce operating staff from 10 full time to 2 or 3 full time ($100,000 to implement and $1,260,000 per year potential savings).
- Replace the current air strippers with a more efficient unit ($400,000 to implement and $30,000 per year potential savings).
- Dispose of LNAPL without solidification ($30,000 per year potential savings).
- Eliminate full-time site security ($144,000 per year potential savings).
- Improve the pressure filter performance to minimize GAC change-outs ($30,000 to implement and $50,000 per year potential savings).

Status of implementation of recommendations:

- EPA's contractors quoted extremely high costs to automate the system to the point that operating labor costs could be reduced. Thus, the operating staff has not been reduced.
- No changes to the treatment system have been made. The EPA O&M contractor is considering eliminating air stripping and upgrading the filtration prior to the GAC.
- Security has not been a concern since O&M began in 1997, but full-time security remains at the site due to community pressure.

Subsurface Performance Optimization:

Briefly describe recommendations for changes in subsurface extraction or in-situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings:

- Consider in situ chemical oxidation or other aggressive technology for LNAPL area (cost estimates were not provided).

Status of implementation of recommendations: Not implemented

Monitoring Program Optimization:

Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings:

- Reduce unnecessary process monitoring by 90% and eliminate on-site laboratory staff ($600,000 per year potential savings)

  Status of implementation of recommendations: EPA accepted a Value Engineering proposal from their contractor to reduce the scope process sampling by ~80% and reduce the on-site lab staff from five to one. This will result in a potential cost savings of ~$530,000 per year, but it is unclear if some of these savings will be used to provide a Value Engineering award to the contractor money for eliminating unnecessary work.

Summary:

The site addresses a variety of contaminants, including arsenic, VOCs, SVOCs, and LNAPL. Annual O&M costs for 2003 are about $3,000,000, which is significantly higher than other similar systems operated EPA. A reduction of $150,000 has occurred since the RSE. The optimization evaluation found that the subsurface performance adequate and therefore did not provide recommendations in this category. Recommendations were made to reduce annual O&M costs by over $2 million per year. However, few of these recommendations have been implemented, primarily due to contracting inefficiencies internal to EPA and apparent lack of support for reducing costs from the existing contractors.

OPTIMIZATION CASE STUDY #2

Site Name: Castle Airport (formerly Castle Air Force Base)

Site Location (City, State, Zip Code): Atwater, California

Funding Agency or Party for Site Remediation: Air Force Real Property Agency

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

Gerald Johnson
Air Force Real Property Agency (AFRPA)
Chief Environmental Division
1700 N. Moore Street
Arlington, VA 22209
(703) 696-5500
Gerald.johnson@afrpa.pentagon.af.mil

Funding Agency or Party for Optimization Effort: Air Force Real Property Agency

Agency, Party, or Contractor Performing Optimization: Air Force Real Property Agency

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-Mail):

Rod Whitten
Air Force Real Property Agency
EV Coordinator
San Francisco CA
(415) 977-8885
rod.whitten@brooks.pentagon.af.mil

Start/Finish Dates of Optimization Effort: September 2002

Optimization Process Used (if Specific Process Used): Remedial process optimization by AFRPA

Cost of Optimization Effort: ~$50,000

Total Potential Cost Savings, if Any: Cost avoidance has ranged from $330,000 annually for groundwater (GW) treatment and as much as $150,000–$300,000 annually as optimization efforts in GW and soil vapor monitoring are realized.

Site Information:

***Primary Contaminants of Concern*:** Halogenated VOCs in soil and groundwater

Remediation Systems: Groundwater and soil vapor extraction and treatment

Total Flow Rate (for Each Media Treated): Approximately 3500 gpm at four GW treatment plants

Treatment Processes: Combination of air stripping and GAC for groundwater with GW reinjection, and mostly GAC for soil vapor extraction

***Total Number of Monitoring Wells Sampled*:** Unknown

Total Annual Cost for Remediation: Unknown

Year Remediation System(s) Began Operation: 1994 for groundwater

Site Point of Contact: Greg Gangnuss, AFRPA/DD BRAC Environmental Coordinator

Optimization Effort:
There were about 40 specific optimization recommendations made and documented. This is a brief summary of main findings:

Groundwater Treatment Optimization: Shutdown the OU1 groundwater treatment plant and replumb the last extraction well operating to the Phase 3 treatment plant. This should save about $330,000 per year, or about $1,650,000 for every five years of RA-O.

Status of implementation of recommendations: OU1 has been shut down and the extraction well replumbed. The resulting RA-O budget went form $2,750,000 per year in FY03 to 2,420,000 per year in FY04.

Monitoring Program Optimization: Delete up to 55 groundwater monitor wells from the periodic monitoring program that are only supplying duplicate information. Potential cost savings of at least $100,000 annually.

Status of implementation of recommendations: The regulatory agencies approved monitoring curtailment of 54 of the 55 wells recommended. The resulting cost avoidance is at least $100,000 annually, or $500,000 over five years in the LTM budget.

OPTIMIZATION CASE STUDY #3

Site Name: Former Mather Air Force Base

Site Location (City, State, Zip Code): Rancho Cordova, California

Funding Agency or Party for Site Remediation: Air Force Real Property Agency

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):
Gerald Johnson
Air Force Real Property Agency (AFRPA)
Chief Environmental Division
1700 N. Moore Street
Arlington, VA 22209
(703) 696-5500
Gerald.johnson@afrpa.pentagon.af.mil

Funding Agency or Party for Optimization Effort: Air Force Real Property Agency

Agency, Party, or Contractor Performing Optimization: Air Force Real Property Agency

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-Mail):
Rod Whitten
Air Force Real Property Agency
EV Coordinator
San Francisco, CA
(415) 977-8885
rod.whitten@brooks.pentagon.af.mil

Start/Finish Dates of Optimization Effort: May 2002

Optimization Process Used (if Specific Process Used): Remedial process optimization by AFRPA

Cost of Optimization Effort: ~$50,000

Total Potential Cost Savings, if Any: Short-term cost avoidance about $100,000 annually from revisions to groundwater monitoring frequency. Long-term cost avoidance could be as much as $1,500,000 annually after model and optimization efforts are completed on the main base plume groundwater treatment plant and extraction network.

Site Information:
Primary Contaminants of Concern: Halogenated VOCs and BTEX in soil and groundwater

***Remediation Systems*:** Groundwater and soil vapor extraction and treatment

***Total Flow Rate (for Each Media Treated)*:** unk

***Treatment Processes*:** Air stripping for groundwater, thermal or GAC for SVE.

Total Number of Monitoring Wells Sampled: unk

Total Annual Cost for Remediation: unk

***Year Remediation System(s) Began Operation*:** 1995 for groundwater

Site Point of Contact: Tony Wong, AFRPA/DD BRAC Environmental Coordinator

Optimization Effort:
There were about 20 specific optimization recommendations made and documented. This is a brief summary two of the main findings:

Groundwater Treatment Optimization: For the main base plume, update the groundwater flow model and use results to shut down some extraction wells and add additional extraction wells needed to optimize extraction efficiency in aquifer units A and B. The resulting cost avoidance could be as much as $1,500,000 annually for every year the system can be shut down ahead of the 2069 estimated schedule to complete.

Status of implementation of recommendations: The modeling update and groundwater optimization of the main base plume and treatment network are being performed under a Phase II RPO. The work plan for this optimization effort is gaining concurrence from the regulatory agencies. Implementation is expected in FY05.

Monitoring Program Optimization: The recommendation is to switch from quarterly monitor well sampling to three times per year. Potential cost avoidance of about $100,000 annually once approved.

OPTIMIZATION CASE STUDY #4

Site Name: MacGillis & Gibbs Superfund Site

Site Location (City, State, Zip Code): New Brighton, MN 55112

Funding Agency or Party for Site Remediation: USEPA Region V

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

Darryl Owens, Remedial Project Manager
USEPA Region V
77 West Jackson Boulevard
Chicago, IL 60604-3507
(312) 886-7089
owens.darryl@epa.gov

Funding Agency or Party for Optimization Effort: USEPA Technology Innovation Office

Agency, Party, or Contractor Performing Optimization: GeoTrans, Inc., and U.S. Army Corps of Engineers

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-mail):

Peter Rich, P.E.
GeoTrans, Inc.
Principal Engineer
844 West Street, Suite 100
Annapolis, MD 21401
(410) 990-4607
prich@geotransinc.com

Douglas Sutton, Ph.D.
GeoTrans, Inc.
Senior Engineer
2 Paragon Way
Freehold, NJ 07728
(732) 229-8728
dsutton@geotransinc.com

Start/Finish Dates of Optimization Effort:

Site Visit: June 2000
Final Report: February 2001
Follow-up calls to track implementation: January 2002 and September 2003

Optimization Process Used (if Specific Process Used): Remedial system evaluation process developed by USACE and modified by GeoTrans

Cost of Optimization Effort:
- $25,000 for the RSE
- $2,500 per year for a period of two years for following up and tracking implementation of recommendations

Total Potential Cost Savings, if Any: $225,000 per year

Site Information:

Primary Contaminants of Concern:
- Pentachlorophenol
- PAHs
- Dioxin
- Chromium
- Arsenic

Remediation Systems:
- OU2 pump-and-treat system
- OU3 pump-and-treat system

Total Flow Rate: Approximately 50 gpm total
- OU2 less than 1 gpm from one well
- OU3 under 50 gpm from 12 wells

Treatment Processes: OU2 and OU3 both include an oil/water separator, fixed-film bioreactor system (by BioTrol), clarifier, bag filters, and GAC with discharge to the publicly owned treatment works (POTW).

Total Number of Monitoring Wells Sampled:
- None at the time of the RSE
- Eight extraction wells sampled quarterly

Total Annual Cost for Remediation:
- Estimated by site team as $535,000 during RSE (excludes monitoring and other costs)
- Actual costs during 2002 were ~$770,000 and reflect remedy costs prior to implementation of RSE recommendations.

Year Remediation System(s) Began Operation:

OU2: March 1998
OU3: March 1999

Site Point of Contact: Darryl Owens, EPA Region V

Optimization Effort:

Treatment Optimization:

Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings.

- Discontinue operation of the OU2 system and combine the flows to the OU3 system ($50,000 to implement and $140,000 per year potential savings).
- Modify the treatment system by eliminating the bioreactor and using the GAC as the main treatment ($25,000 to implement and $55,500 per year potential savings).
- Combine POTW discharge points to reduce analytical costs ($30,000 to implement and $30,000 per year potential savings.

Status of implementation of recommendations:

- The OU2 treatment system was shut down and was being dismantled in 2003.
- The OU3 bioreactor operating costs have been reduced since preheating the influent, adding polymer, and adjusting pH were determined to not be necessary. Therefore, the bioreactor has been kept, and the GAC bypassed.
- The effluent sampling frequency has been reduced resulting in cost savings of approximately $100,000 per year. The POTW discharge points have not been consolidated.
- Operating costs have been decreased by $115,000 despite an increase in utility rates, and in the extraction rate to improve capture, and regular capture zone evaluations (see below).

Subsurface Performance Optimization:

Briefly describe recommendations for changes in subsurface extraction or in situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings:

- The RSE report recommended that the site develop a target capture zone and analyze data to determine whether the capture is achieved ($30,000 to implement and $5,000 per year in continuing evaluation costs).

Status of implementation of recommendations: The site team performed capture zone analysis and added two additional extraction wells to provide capture of the target zone.

Monitoring Program Optimization:

Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings:

- The RSE recommended that a monitoring program be developed ($40,000 to implement plus no additional annual costs since a plan would have been developed in any event).

Status of implementation of recommendations: The site team has developed a program that includes annual sampling and analysis of 55 monitoring wells. Annual costs are approximately $90,000 per year.

Summary:
The pump-and-treat system aims to contain the groundwater plume, remove NAPL, and restore the aquifer. Actual annual O&M costs prior to implementing RSE recommendations were approximately $770,000 per year. RSE recommendations have been implemented to evaluate capture, improvement containment, simplify the treatment system, and reduce effluent monitoring. Despite increased pumping, enhanced data evaluation (i.e., periodic capture zone analyses), and increased utility rates, the annual costs for O&M have decreased to approximately $655,000 per year.

OPTIMIZATION CASE STUDY #5

Site Name: Ott/Story/Cordova Superfund Site

Site Location (City, State, Zip Code): Dalton Township, Muskegon County, MI 49445

Funding Agency or Party for Site Remediation: USEPA Region V

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

John Fagiolo, Remedial Project Manager
USEPA Region V
77 West Jackson Boulevard
Chicago, IL 60604-3507
(312) 886-0800
fagiolo.john@epa.gov

Funding Agency or Party for Optimization Effort: USEPA Technology Innovation Office and Office of Emergency and Remedial Response

Agency, Party, or Contractor Performing Optimization: GeoTrans, Inc., and U.S. Army Corps of Engineers (USACE)

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-mail):

Peter Rich, P.E.
GeoTrans, Inc.
Principal Engineer
844 West Street, Suite 100
Annapolis, MD 21401
(410) 990-4607
prich@geotransinc.com

Douglas Sutton, Ph.D.
GeoTrans, Inc.
Senior Engineer
2 Paragon Way
Freehold, NJ 07728
(732) 229-8728
dsutton@geotransinc.com

Start/Finish Dates of Optimization Effort:

Site Visit: September 27–28, 2001
Final Report: March 12, 2002
Follow-up calls to track implementation: May 8, 2002 and September 12, 2003

Optimization Process Used (if Specific Process Used): Remedial System Evaluation (RSE) process developed by USACE and modified by GeoTrans

Cost of Optimization Effort:

- $25,000 for the RSE
- $2,500 per year for a period of two years for following up and tracking implementation of recommendations

Total Potential Cost Savings, if Any: $1,008,000 per year

Site Information:

Primary Contaminants of Concern:

- Vinyl chloride
- 1,2-dichloroethane (DCA)
- Toluene
- 1,1-DCA
- Xylenes
- SVOCs
- PAHs

Remediation Systems: The remedy includes a pump-and-treat system with extraction wells in the source area (OU2) and down-gradient to prevent migration to Little Bear Creek (OU1). Source area soil removal actions have been conducted.

Total Flow Rate: Approximately 800 gpm total from 10 extraction wells

Treatment Processes:

Parallel treatment trains consisting of the following:

- Diffused air-stripping tanks
- Two-stage biological aeration and clarification system with the addition of phosphoric acid (nutrient), powdered activated carbon, and ferric chloride
- Sand filtration
- GAC for groundwater polishing
- Thermal oxidation for vapor destruction
- Filter presses for dewatering sludge

Total Number of Monitoring Wells Sampled

- Approximately 60–75 of the 95 wells are sampled quarterly.
- Water levels are collected from ~80 wells each month.

Total Annual Cost for Remediation: Approximately $2,400,000 per year

Year Remediation System(s) Began Operation: 1996

Site Point of Contact: John Fagiolo, EPA Region V

Optimization Effort:

Treatment Optimization:

Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings.

- Replace diffused air-stripping tanks with tray aerators: $750,000 to implement and potential cost savings of $192,000 per year.
- Bypass PACT unit (contaminant levels are ~2% of design values): $400,000 to implement and potential cost savings of $696,000 per year.
- Reduce oversight (two parties are providing oversight): Potential cost savings not quantified.
- Have on-site staff rather than a contractor from Kansas City conduct surface water and sediment sampling: Potential savings of $15,000 per year.

Status of implementation of recommendations:

- Two operators have left and not been replaced since the system operation is less difficult with the low influent concentrations.
- The allocation for oversight has remained the same, but actual spending has decreased.
- The surface water and sediment sampling is now being conducted by the state.
- The site team will consider the major process changes in 2004.

Subsurface Performance Optimization:

Briefly describe recommendations for changes in subsurface extraction or in-situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings:

- The subsurface performance was adequate. Therefore, no recommendations were provided.

Status of implementation of recommendations: Not applicable.

Monitoring Program Optimization:

Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings:

- Reduce sampling frequency of wells a number of wells, including those that are consistently nondetect after >20 quarters of sampling. This cut would result in a decrease of 125 samples per year and a potential savings of $55,000 per year.
- Reduce process sampling and on-site laboratory analysis; eliminate a laboratory technician position: Potential saving of $50,000 per year.
- Establish a consistent sampling methodology.

Status of implementation of recommendations: Groundwater sampling frequency has been reduced significantly and cost savings are greater than projected (approximately $250,000 per year). The site plans to reduce process sampling in 2004.

Summary:
The pump-and-treat system aims to contain the groundwater plume and restore the aquifer. Actual annual O&M costs prior to implementing RSE recommendations were approximately $2,400,000 per year. The subsurface performance has been adequate, and no recommendations were provided in this category. Optimization recommendations were made to substantially simplify the system, reduce/eliminate redundant oversight, and reduce the scope for both groundwater and process water monitoring. The groundwater monitoring has been modified and oversight spending has decreased, but implementation of the other recommendations will likely be pursued in 2004 and should result in savings of between $500,000 and $1,000,000 per year.

Status of Implementation of Recommendations: The regulatory agencies are reviewing this proposed change in a work plan and implementation is expected in FY05.

OPTIMIZATION CASE STUDY #6
(RCRA Site Optimization)

Site Name: Safety-Kleen Systems, Inc., Altamonte Springs RCRA Hazardous Waste TSD facility.

Site Location (City, State, Zip Code): Altamonte Springs, FL 32701

Funding Agency or Party for Site Remediation: Safety-Kleen Systems, Inc.

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

Gerhard L. Risse, P.E.
Senior Remediation Manager
Safety-Kleen Systems, Inc.
4810 South Old Peachtree Road
Norcross, Georgia 30071
(770) 418-1860
GRisse@safety-kleen.com

Funding Agency or Party for Optimization Effort: Safety-Kleen Systems, Inc.

Agency, Party, or Contractor Performing Optimization: Environmental Consulting & Technology, Inc.

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-Mail):

Richard J. Stebnisky, P.G.
Principal Hydrogeologist
Environmental Consulting & Technology, Inc.
1408 North Westshore Boulevard, Suite 115
Tampa, Florida 33607
(813) 289-9338
rstebnisky@ectinc.com

Start/Finish Dates of Optimization Effort: 4/1998 through 10/2001

Optimization Process Used (if Specific Process Used): Remediation systems evaluation and RCRA permit modification to adopt and implement alternate remediation systems, additional source removal actions, risk-based alternative cleanup levels, reduced remediation monitoring, and a post-remediation groundwater monitoring program to terminate RCRA post-closure.

Cost of Optimization Effort: $260,000

Total Potential Cost Savings, if Any: $1,150,000

Site Information:

Primary Contaminants of Concern:

- Tetrachloroethene
- Trichloroethene
- 1,2-Dichloroethene
- BTEX
- Naphthalene
- Chlorobenzenes

Remediation Systems: Original groundwater pump-and-treat remediation system (two deep, fully penetrating, recovery wells and an air stripper, at 10 gpm) was discontinued in favor of optimization via facilitywide in situ air sparging system; a localized soil vapor extraction system (after additional soil source removal actions); and a very-low-flow (1-gpm), shallow pump-and-treat system (carbon treatment) for the primary source area.

Total Flow Rate: Groundwater pump-and-treat system originally at 10 gpm, optimized system at 1 gpm; air sparging (injection) at 100 cfm, and vapor extraction (recovery) at 155 cfm.

Treatment Processes: Original air-stripping tower treatment process with effluent discharge to a POTW was replaced by soil source removal (excavation/disposal); in situ air sparging treatment; soil vapor extraction with temporary activated carbon treatment; and activated carbon adsorption treatment of pumped groundwater (1 gpm) with effluent discharge to an existing on-site infiltration gallery.

Total Number of Monitoring Wells Sampled: Fourteen monitor wells were originally being sampled; later reduced to three monitor wells.

Total Annual Cost for Remediation: \$100,000 per year prior to optimization actions; \$50,000 per year while operating the optimized systems from July 1998 until June 2000 when all remedial actions were terminated; \$30,000 per year during the post-remediation monitoring program phase, and \$0 per year after October 2001 when the post-remediation monitoring was completed and confirmed that remediation was successful throughout the entire facility (no further action required).

Year Remediation System(s) Began Operation: 1995

Site Point of Contact:

Richard J. Stebnisky and Gerhard L. Risse (see above), and
Bheem R. Kothur, P.E. DEE and Camille P. Stein, Environmental Specialist III
Florida Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400
(850) 245-8781 / bheem.kothur@dep.state.fl.us
(850) 245-8791 / camille.stein@dep.state.fl.us

Optimization Effort: In 1997, the new consultant for the facility reviewed the RCRA permit and existing data, evaluated the existing pump-and-treat system's effectiveness and progress toward the goal of facility-wide cleanup, and concluded (1) incomplete source removal hindered remediation progress, (2) the existing remediation system would require at least 12 years of additional operation to complete remediation, and (3) significant cost savings could be realized by proactively optimizing the efficiency and effectiveness of the remediation systems and associated remediation strategies. The optimization efforts recommended (all were implemented) are briefly described below.

Treatment Optimization:
Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings: Instead of continuing POTW disposal of treated effluent at 10 gpm for the additional 12 years expected to complete remediation ($100,000), (1) eliminate all POTW disposal, (2) bypass the air-stripping tower, and (3) install a 1-gpm activated-carbon treatment system that discharges to an existing on-site infiltration gallery ($10,000). Cost savings: $90,000.

Status of implementation of recommendations: Fully implemented and all media treatment has been completed.

Subsurface Performance Optimization:
Briefly describe recommendations for changes in subsurface extraction or in situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings: Instead of continuing O&M for groundwater pumping of 10 gpm from two deep, fully penetrating recovery wells for the additional 12 years expected to complete remediation ($360,000), (1) delineate, excavate, and dispose of remaining source soils and (2) install the following remediation systems and perform O&M for two years to complete remediation—a facilitywide 21-well air sparging system, a localized 15-well vapor extraction system, and a 1-gpm groundwater pumping system from a shallow monitor well in the primary source area ($170,000). Cost savings: $190,000.

Status of implementation of recommendations: Fully implemented and all remediation was completed in two years.

Monitoring Program Optimization:
Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings: Instead of continuing monitoring & reporting for 14 wells (and QA/QC samples) quarterly for VOCs, SVOCs, and various metals analyses for a 12-year remediation period to complete site cleanup and a three-year post-remediation period ($950,000), (1) monitor and report for 14 wells (and QA/QC samples) semiannually for only VOCs analyses during a two-year remediation period that completes site cleanup and (2) monitor three wells monthly for only VOCs analyses during a 16-month post-remediation period ($80,000). Cost savings: $870,000.

Status of implementation of recommendations: Fully implemented, all post-remediation monitoring has been completed, and RCRA post-closure has been terminated.

OPTIMIZATION CASE STUDY #7
(RCRA Site Optimization)

Site Name: Safety-Kleen Systems, Inc., Port Charlotte RCRA Hazardous Waste TSD facility

Site Location (City, State, Zip Code): Port Charlotte, FL 33948-2166

Funding Agency or Party for Site Remediation: Safety-Kleen Systems, Inc.

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):

Gerhard L. Risse, P.E.
Senior Remediation Manager
Safety-Kleen Systems, Inc.
4810 South Old Peachtree Road
Norcross, Georgia 30071
(770) 418-1860
GRisse@safety-kleen.com

Funding Agency or Party for Optimization Effort: Safety-Kleen Systems, Inc.

Agency, Party, or Contractor Performing Optimization: Environmental Consulting & Technology, Inc.

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-Mail):

Richard J. Stebnisky, P.G.
Principal Hydrogeologist
Environmental Consulting & Technology, Inc.
1408 North Westshore Boulevard, Suite 115
Tampa, Florida 33607
(813) 289-9338
rstebnisky@ectinc.com

Start/Finish Dates of Optimization Effort: 5/2001 to 4/2004

Optimization Process Used (if Specific Process Used): Applied RCRA Corrective Action program "flexibilities" to quickly and cost-effectively complete all assessment and remediation by focusing efforts on actual site work and results, rather than the program's administrative "process" (further described below).

Cost of Optimization Effort: $320,000 for the entire project (i.e., for all planning, negotiation, assessment, remediation, monitoring and reporting).

Total Potential Cost Savings, if Any: ~$1,000,000 (compared to average of various other RCRA facilities that had comparable impacts and followed the "standard" RCRA Corrective Action program "process").

Site Information:

Primary Contaminants of Concern:

- Chlorobenzenes
- Naphthalene

Remediation Systems: In situ bioremediation with bio-air-sparging and bioventing systems.

Total Flow Rate: Various low air flow rates for the various bio-air-sparging and bioventing systems. No groundwater pumping.

Treatment Processes: Biodegradation and volatilization/venting for groundwater and soil, and excavation/disposal for source soils.

Total Number of Monitoring Wells Sampled: Eighteen wells were initially monitored; later reduced to four and then two wells.

Total Annual Cost for Remediation: $91,000 per year (calculated as average for the total 3.5 years required to successfully plan, negotiate, assess, and complete all remediation and post-remediation monitoring—$320,000 over 3.5 years).

Year Remediation System(s) Began Operation: 2002 in primary source area, 2003 in secondary source area.

Site Point of Contact:

Richard J. Stebnisky and Gerhard L. Risse (see above), and
Bheem R. Kothur, P.E. DEE and Camille P. Stein, Environmental Specialist III
Florida Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400
(850) 245-8781 / bheem.kothur@dep.state.fl.us
(850) 245-8791 / camille.stein@dep.state.fl.us

Optimization Effort: Releases of mineral spirits (a petroleum hydrocarbon-based solvent) were confirmed by limited soil sampling in 1994. A RCRA Facility Investigation (RFI) work plan was submitted to EPA in 1994 and was still not approved when review comments were received in 9/2000; the project was stuck in the program "process" with no progress toward actual cleanup. In 1/2001, the new consultant for the facility reviewed the RCRA permit and the project file and recommended (and EPA and Florida Department of Environmental Protection approved) the following regulatory strategy and assessment/remediation strategy to quickly and cost-effectively complete all site assessment and remediation: (1) preclude the "standard" RCRA Corrective Action program administrative "process" (i.e., ignore the existing RFI work plan, preclude the

RFI Report, the CMS work plan, the CMS Report, and associated permit modifications, and preclude the significant amount of time required for preparation/review/approval of all those documents, etc.); (2) instead, apply the interim measures (IM) portion of the RCRA Corrective Action program via a simple, flexible, and approved IM work plan; (3) consistent with the various "flexibilities" inherent to the program, design the IM work plan to (a) investigate and document only the basic RFI-type and CMS-type site conditions that are essential to a final remedy to affect actual cleanup and (b) to facilitate rapid, flexible, effective, and concurrent assessment and remediation of ground water and soil impacts.

Treatment Optimization:
Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings: (1) Concurrently assess and excavate/dispose impacted source soils (1,080 tons) in real time (cost: $70,000); (2) treat all remaining impacts in situ (see next section).

Status of implementation of recommendations: Fully implemented, and all media treatment has been completed.

Subsurface Performance Optimization:
Briefly describe recommendations for changes in subsurface extraction or in situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings: (1) Plan and negotiate all actions; (2) assess site hydrogeology and all impacts via installation and monitoring of five monitor wells and 13 multipurpose wells; (3) in the primary source area and immediately after source soil excavation, (a) emplace bioremediation products directly into the open pit excavation (dug 3 feet below the water table) and (b) also emplace three 20-foot-long, horizontal, bio-air-sparging laterals below the water table at the base of the excavation, backfill with gravel, cover with geotextile fabric, and top with clean sand fill; (4) in the secondary source area (where the building structure precluded removal of some impacted soil), inject bioremediation products into the aquifer at 24 locations, install 10 bio-air-sparging wells, and install three biovent wells; (5) install all associated piping, blowers, and air compressors for the remediation systems; and (6) operate the systems to successfully complete all remediation (cost: $130,000).

Status of implementation of recommendations: Fully implemented, and all on-site assessment and remediation actions were completed in two years. Remediation in each source area was completed about two months after beginning operation of the remediation system in each respective area.

Monitoring Program Optimization:
Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings: Develop and implement assessment, remediation, and post-remediation groundwater monitoring and reporting programs as follows—(1) assessment monitoring initially included five wells sampled for VOCs, SVOCs, and various metals analyses; later a total of 18 wells were briefly monitored for VOCs only (no specific assessment monitoring frequency); (2) remediation monitoring included four wells sampled quarterly for only VOCs, and other wells were proactively

monitored occasionally; (3) post-remediation monitoring included two wells sampled quarterly for one year for VOCs and bioremediation breakdown products, and two other wells sampled monthly for one year for VOCs; and (4) quarterly reporting through the entire project (cost: $120,000).

Status of implementation of recommendations: Fully implemented, all post-remediation monitoring completed as of 4/2004, and all RCRA Corrective Actions successfully completed.

OPTIMIZATION CASE STUDY #8

Site Name: Tooele Army Depot Main Plume

Site Location (City, State, Zip Code): Tooele, Utah

Funding Agency or Party for Site Remediation: Army

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail):
Larry McFarland
Environmental Coordinator
Tooele Army Depot
Tooele, Utah

Funding Agency or Party for Optimization Effort: Army

Agency, Party, or Contractor Performing Optimization: U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise, with assistance from representatives from NFESC, AFCEE, and EPA TIO.

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-mail):
Dave Becker
Geologist
USACE HTRW CX
12565 W. Center Rd.
Omaha, NE 68144-3869
(402) 697-2655
mailto:mdave.j.becker@usace.army.mil

Start/Finish Dates of Optimization Effort: July–September 1998

Optimization Process Used (if Specific Process Used): Remediation System Evaluation

Cost of Optimization Effort: $18,000

Total Potential Cost Savings, if Any: ~$200,000

Site Information:

Primary Contaminants of Concern: TCE

Remediation Systems: Groundwater pump and treat

Total Flow Rate: 7000 gpm

Treatment Processes: Air stripping, sequestrant addition

Total Number of Monitoring Wells Sampled: >50

Total Annual Cost for Remediation: $1.8M

Year Remediation System(s) Began Operation: 1993

Site Point of Contact: See above

Optimization Effort:

Treatment Optimization:

Briefly describe recommendations for changes in treatment processes (including discharge options), costs for implementation, and potential cost savings: Recommend replacing sequestrant with carbon dioxide addition ($22,000 cost; $100,000/year savings). Reduce amount of packing in air stripper and reduce blower flow rate to realize energy savings since stripper efficiency is higher than needed to achieve discharge goal ($1000 cost; $3600/year savings).

Status of implementation of recommendations: Changed purchasing arrangement for sequestrant, saving $50,000/year.

Subsurface Performance Optimization:

Briefly describe recommendations for changes in subsurface extraction or in-situ treatment systems to enhance performance or protectiveness, costs for implementation, and potential cost savings: System achieving main plume capture. May be able to remove two wells from service without compromising performance (cost minimal; savings >$40K/year). Recommend addressing sources of contamination (no cost, savings computed).

Status of implementation of recommendations: No changes made to extraction system, but installation moving forward on source characterization and removal.

Monitoring Program Optimization:

Briefly describe recommendations for changes in monitoring program and process monitoring, costs for implementation, and potential cost savings: Implement diffusion bag samplers (cost $10K; savings $30K/year), tailor analytical suite, transfer data electronically to avoid data entry cost/errors (savings $4500/year).

Status of implementation of recommendations: Diffusion sampling conducted.

OPTIMIZATION CASE STUDY # 9

Site Name: Ellsworth AFB, SD

Site Location (City, State, Zip Code): Box Elder, SD 57706

Funding Agency or Party for Site Remediation: Air Force Air Combat Command

Funding Agency or Party Point of Contact
(Name, Organization, Title, Address, Phone, E-Mail)
Dell Peterson
Ellsworth AFB

Funding Agency or Party for Optimization Effort: Air Force Air Combat Command

Agency, Party, or Contractor Performing Optimization: U.S. Army Corps of Engineers Hazardous, Toxic, and Radioactive Waste Center of Expertise (HTRW CX)

Point of Contact for Optimization Effort
(Name, Organization, Title, Address, Phone, E-mail):
Dave Becker
Geologist
USACE HTRW CX
12565 W. Center Rd.
Omaha, NE 68144-3869
(402) 697-2655
mailto:mdave.j.becker@usace.army.mil

Start/Finish Dates of Optimization Effort: July–October 2000

Optimization Process Used (if Specific Process Used): Remediation System Evaluation

Cost of Optimization Effort: ~$40,000

Total Potential Cost Savings, if Any: ~$340,000 annually

Site Information:
Evaluation included 12 groundwater and soil vapor extraction systems.

Primary Contaminants of Concern: Benzene, TCE, and breakdown products

Remediation Systems: 12 different groundwater extraction and treatment systems, five of which include soil vapor extraction and treatment as well

Total Flow Rate: Treatment plant influent flows—45 gpm/88 gpm/29 gpm/18 gpm/ 43 gpm groundwater, up to 300 scfm at SVE systems

Treatment Processes: For the five treatment plants, air stripping plus carbon adsorption, air stripping, and three systems with carbon adsorption (with filtration). Generally there is no off-gas treatment..

Total Number of Monitoring Wells Sampled: >85

Total Annual Cost for Remediation: ~$1,500,000 at time of the evaluation

Year Remediation System(s) Began Operation: Varies 1996–1999

Site Point of Contact: Not available

Optimization Effort: Recommended alternative treated water discharge method, recharge trench, that avoided difficulties in meeting surface water standards for naturally occurring selenium. This would allow treatment at several sites to be discontinued and pumping reduced at other sites. One site converted to bioventing only. Some SVE systems recommended to be discontinued. Recommended source removal at one location to assist in future site closeout. Identified needed change in hydraulic containment to assure capture at one site. Recommended significant reduction in monitoring program frequency with large cost savings, though in some areas additional monitoring was recommended to verify capture and remediation progress. Recommended changes in well rehabilitation techniques as approximately 25% of the operators' time was occupied with this activity.

Status of implementation of recommendations: Many aspects implemented.

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APPENDIX C

Remediation Optimization Process Toolbox

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REMEDIATION PROCESS OPTIMIZATION TOOLBOX

The RPO Toolbox is a resource for deeper research into the subject of remediation process optimization. The first section includes links to various Web sites that have RPO information. The Technical Resources section provides examples of processes, technologies, and procedures that may be useful in the RPO process.

REMEDIATION PROCESS OPTIMIZATION WEB SITES

Multiagency

http://www.frtr.gov/optimization.htm

Sponsor: Federal Remediation Technologies Roundtable

Description: Provides a wide variety of information and links on the topic of optimization. The Federal Remediation Roundtable has prepared a comprehensive directory of long-term management and optimization case studies.

Air Force

http://www.afcee.brooks.af.mil/er/rpo.htm

Sponsor: Air Force Center for Environmental Excellence

Description: Contains the latest Air Force remedial process optimization (RPO) guidance. Includes the Air Force Center for Environmental Excellence (AFCEE) RPO Handbook.

Army Corps of Engineers

http://www.environmental.usace.army.mil/library/guide/rsechk/rsechk.html

Sponsor: United States Army Corps of Engineers

Description: Remediation System Evaluation checklists

Department of Energy

http://www.doe.gov/engine/content.do?BT_CODE=ENVIRONMENT

Site Owner: Department of Energy

Description: DOE's home page for environmental information. Search on "optimization" for various related topics.

United States Environmental Protection Agency

http://www.clu-in.org/optimization/

Sponsor: U.S. Environmental Protection Agency

Description: Part of the Technology Innovation Program's initiative to promote optimization of site remediation activity, the Clu-In optimization page provides a wealth of information on the topic of optimization.

http://www.epa.gov/superfund/action/postconstruction/optimize.htm

Sponsor: U.S. Environmental Protection Agency

Description: Located within the Superfund area of the EPA Web site, this page contains many of the EPA source documents on optimization, as well as links to other optimization Web pages.

http://www.epa.gov/oswer/iwg/about.htm

Sponsor: U.S. Environmental Protection Agency

Description: Provides information about and contact information for the Innovations Work Group. RPO frequently relies on innovative answers to remediation problems. The Innovation Workgroup provides a wide range of expertise in the area of innovative remediation technology.

http://envinfo.com/dec2000/implementation.pdf

Sponsor: U.S. Environmental Protection Agency

Description: Superfund Reform Strategy, Implementation Memorandum: Optimization of Fund-lead Ground Water Pump and Treat (P&T) Systems, December 2000.

http://www.epa.gov/superfund/resources/5year/index.htm

Sponsor: US Environmental Protection Agency

Description: A Superfund resources site for five-year review guidance.

Navy

http://enviro.nfesc.navy.mil/erb/

Sponsor: Navy, Naval Facilities Engineering Service Center

Description: Home page for NFESC's environmental information. Look for RPO links here.

http://enviro.nfesc.navy.mil/erb/support/work_grp/raoltm/main.htm#top

Sponsor: Navy and Marine Corps Working Group

Description: Optimizing remedial action operations and long-term monitoring.

http://enviro.nfesc.navy.mil/erb/erb_a/support/wrk_grp/raoltm/case_studies/tds_2066.pdf

Sponsor: Navy, Naval Facilities Engineering Service Center

Description: NAVFAC Tech Data Sheet SMART SITE—Cost-Efficiencies in Remedial Action Operations and Long-Term Monitoring.

State Agencies

http://www.nj.gov/dep/srp/training/sessions/rpo200304/

Sponsor: New Jersey Department of Environmental Protection

Description: Link to NJDEP's presentation on RPO.

Educational and Stakeholder

http://www.earthdrx.org/

Sponsor: Private

Description: Provides environmental information in a format directed at the general public. Unique approaches to groundwater remediation and subsurface gas migration are presented.

TECHNICAL RESOURCES

RPO Process Techniques

Data Quality Objectives

(This is additional information from DOE that presents an approach to establishing an effective and efficient monitoring system.)

The DQO process is one formalized process of systematic planning. The DQO process is a strategic planning approach based on the scientific method to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision error for the study, and how many samples to collect, balancing risk and cost in an acceptable manner.

Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application, resulting in environmental decisions that are technically and scientifically sound and legally defensible. In addition, using the DQO process guards against committing resources to data collection efforts that do not support a defensible decision.

To balance DOE environmental sampling and analysis costs with the need for sound environmental data that address regulatory requirements and stakeholder concerns, it is the policy of the Office of Environmental Management (EM) to apply up-front planning, where practical, to ensure safer, better, faster, and cheaper environmental sampling and analysis programs for all EM projects and operations. Specifically, it is EM policy that the DQO process be used in all environmental projects where there may be a need to collect significant environmental data. For EM's environmental restoration programs, the policy requires that the DQO process be used for

- focusing regulatory and public concerns relating to remediation,
- effectively identifying target analytes of concern for remedial activities, and
- determining when remediation has met cleanup levels.

The DQO planning process consists of seven key steps:

1. **State the Problem:** Stakeholders work together to define their concerns and issues based on descriptions of the site, waste stream, issue, etc., and agree on the question or problem to be studied.
2. **Identify the Decision:** Stakeholders design the answer or result that will answer the question or solve the problem, including the threshold level for action.
3. **Identify Inputs to the Decision:** Stakeholders define the measurements needed to answer the question.
4. **Define the Boundaries:** Stakeholders define the time and space circumstances covered by the decision.
5. **Develop a Decision Rule:** Technical staff and stakeholders develop the formulation to obtain the needed data (quality and quantity) and to identify acceptability or confidence in the ultimate decision.
6. **Specify Acceptable Limits on Decision Errors:** In concert with Step 5, stakeholders define the tolerance for making incorrect decisions.
7. **Optimize Data Design:** Technical staff identifies the most resource effective data collection design.

The DQO planning process has several notable strengths. It brings together the right players (stakeholders and technical staff) at the right time to gain consensus and commitment about the scope of the project. This interaction results in a clear understanding of the problem, the actions needed to address that problem, and the level of uncertainty that is acceptable for making decisions. Through this process, data collection and analysis are optimized so only those data needed to address the appropriate questions are collected.

Triad

The EPA-OSWER Technology Innovation Office is currently advocating a “Triad” paradigm for optimizing hazardous waste site cleanup. As described in a descriptive document available at http://www.epa.gov/swertio1/download/char/dynwkpln.pdf, the Triad paradigm supports the following elements of an idealized model that produces defensible site decisions at an affordable cost:

- It would be driven by achieving performance, rather than by complying with arbitrary policies or procedural checklists that do not add value.
- It would use transparent, logical reasoning to articulate project goals, state assumptions, plan site activities, derive conclusions, and make defensible decisions.
- It would value technical and scientific proficiency, understanding the need for technical experts in the scientific, mathematical, and engineering disciplines required to competently manage the complex issues of hazardous waste sites.
- It would require regular continuing education of its practitioners, especially in rapidly evolving areas of practice.
- Its practitioners would be able to logically evaluate the appropriateness of an innovative technology with respect to project-specific conditions and prior technology performance, with residual areas of uncertainty being identified and addressed.
- It would reward responsible risk-taking by practitioners who would not fear to ask, “Why don’t we look into...?” or “What if we tried...?”

Additional Triad resources are available at the following Internet sites: http://www.nj.gov/dep/srp/training/sessions/triad200309a.htm
http://www.itrcweb.org/SCM-1.pdf

Software Solutions

MAROS

MAROS ("Monitoring and Remediation Optimization System") and is public domain software. Per the AFCEE Web site:

> The software is intended to provide site managers with a strategy for formulating appropriate long-term groundwater monitoring programs that can be implemented at lower costs. The MAROS software optimizes a site-specific monitoring program that is currently tracking the occurrence of contaminant migration in groundwater. MAROS is a decision support tool based on statistical methods applied to site-specific data that account for relevant current and historical site data as well as hydrogeological factors (e.g. seepage velocity) and the location of potential receptors (e.g., wells, discharge points, or property boundaries). Based on this site-specific information the software suggests an optimization plan for the current monitoring system in order to efficiently achieve the termination of the monitoring program.

http://www.gsi-net.com/software/Maros.htm
http://www.afcee.brooks.af.mil/er/rpo.htm

Innovative Remediation Technology

Mass Removal

Many stakeholders have come to understand that a number of remedies used in succession, as in a "treatment train," or in conjunction with each other, that is "complementary technologies," may provide the best approach to truly solving difficult problems.

Fortunately, huge strides have been made in the ability to reduce the mass of contaminant in the subsurface. In the saturated zone, immiscible organic liquids (hydrocarbons) are primarily distributed as dissolved in the groundwater (aqueous phase) or as a discrete (free) liquid (nonaqueous-phase liquid). The aqueous solubility of the hydrocarbon largely affects the aqueous concentration, while a number of forces affect the distribution of the NAPL, including capillary pressure, viscosity, and gravitational forces. In many instances, large amounts of NAPL remain that slowly dissolve into the aqueous phase. Thus, many practitioners recognize that NAPL removal is the best way to reduce the dissolved-phase concentration and life of the plume.

Capillary pressure is directly proportional to the interfacial tension between the two liquids (NAPL and water) and inversely proportional to the radius of the water-filled pore. Please note that if the hydrocarbon is to flow, it must move into this pore volume. Thus, applying technologies that decrease interfacial tension and increase pore throat diameters can dramatically decrease capillary pressure and induce hydrocarbon flow and recovery.

The use of surfactants and cosolvents can be highly effective in situ technologies for recovering NAPLs. Surfactants and cosolvents work by both mobilization and solubilization of NAPL. That is, they grossly reduce the interfacial tension between the hydrocarbon and water and can raise NAPL solubility by up to four orders of magnitude.

Technologies that affect pore throat diameters are quite beneficial. For decades petroleum reservoir engineers have placed sheets of permeable solids into the geomatrix to induce greater fluid flow into extraction systems. These engineers have used and continue to use hydraulic fracturing technologies to place the solids. The environmental community has recently started to embrace fracturing technologies with much success.

Another oil field technology just starting to be used in the environmental arena is pressure pulse technology. Pressure pulsing induces a wave in the saturated zone that momentarily causes an increase in pore throat diameter, enabling liquids to move more rapidly and with greater sweep efficiency. Pressure pulsing can also be used to better place remedial amendments, such as surfactants, oxidants, etc., so that they contact the contaminant more efficiently.

As stated earlier, technologies that reduce viscosity can also be highly effective. Viscosity is inversely proportional to temperature. Thus, applying technologies that increase the temperature of the contaminant and/or the aquifer can dramatically decrease the viscosity of the contaminant and increase its ability to flow. Moreover, high temperatures may thermally destroy the contaminant in situ and may increase abiotic and biotic reaction rates. Available technologies include steam injection and electrical resistive heating.

Thus, by using appropriate mass removal technologies and by recovering 95% or more of the NAPL from a source zone, one can proceed to remediation of the sorbed and dissolved contaminant phases.

Oxidation and Reduction

The oxidation-reduction reaction can transform aqueous-phase contaminants into harmless by-products by biotic or abiotic pathways. Many effective remedial compounds have been recently introduced to the environmental marketplace. Certainly, more are on the way. In virtually all cases, it is absolutely imperative that the remedial amendment contacts the contaminant. Fluid flow enhancement technologies, such as pneumatic and hydraulic fracturing and pressure pulse technology, can improve the contact of the contaminant with the amendment.

Furthermore, well design techniques that can disperse fluids over very large areas, such as the case with horizontal wells, can also be quite beneficial. Horizontal wells can also create biologically active barriers far more efficiently than conventional vertical wells. Problems associated with "short-circuiting" of injected fluids through large screened intervals in horizontal wells have been overcome with the aid of computational analysis techniques.

APPENDIX D

Overview of Federal RPO Programs

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OVERVIEW OF FEDERAL RPO PROGRAMS

D.1 DEPARTMENT OF DEFENSE

D.1.1 United States Air Force

As required in the 2001 edition of DoD's *Management Guidance for the Defense Environmental Restoration Program* (DERP), the Department of the Air Force developed programs to optimize the performance of its environmental program from the initial investigative stage through long-term monitoring. The Air Force uses Remediation Process Optimization (RPO) as the systematic approach for evaluating and improving the effectiveness and efficiency of all environmental remediation activities. RPO addresses *how* the remedial system operates as well as *why* certain cleanup goals were established and updates those goals based on new regulatory decisions. The goal of RPO is to improve program efficiency and effectiveness while protecting human health and the environment without increased risk.

The Air Force Center for Environmental Excellence (AFCEE) has prepared the *Remedial Process Optimization Handbook* (2001) to assist site managers in carrying out their RPO responsibilities. For the past five years, the Air Force has been developing and applying its RPO process to provide remedial managers with the most current and effective tools available. The overall result has been to enhance remediation timelines, reduce the O&M burden, and more quickly return the property to beneficial reuse.

USAF has developed two consistent but separate RPO programs to differentiate cleanup at active bases versus installations managed under the BRAC or closing bases. The Air Force Environmental Restoration Program (ERP) Management Guidance directs that all *active* Air Force installations "shall conduct and document an optimization review at least annually." In support of this directive, the Environmental Restoration Branch of the Office of The Civil Engineer (HQ AF/ILEVR) set the following specific goals for the RPO program:

- Develop Air Force-wide policy to implement the ERP guidance.
- Optimize the investigative process.
- Inventory existing remedy-in-place systems.
- Report optimization efforts.
- Pursue a wide range of optimization strategies including new technology.
- Provide remedial program managers (RPMs) with the right tools.

Over the last four years, AFCEE has performed technical visits at numerous active bases and across several major commands (MAJCOMs) to demonstrate the successful implementation of RPO. To better support the remediation program managers at all levels, HQ AF/ILEVR established the RPO Outreach Office at AFCEE in 2002. This office provides key services that facilitate the RPO process, a repository of RPO information, and tools to assist in performing RPO evaluations. The RPO Outreach Office recently developed the RPO Inventory and Prioritization Software (RIPS) information system for use as a data management and prioritization tool. This system provides a management system to inventory and prioritize remediation systems for optimization potential, provide an annual update on system performance, and act as a command and control tool for environmental managers.

In a recent Air Force–wide policy working group, representatives from HQ AF/ILEVR, the MAJCOMs, and AFCEE, shared best practices across the Air Force and discussed development of a standardized Air Force RPO policy. There are four near-term goals for the work group:

- Discuss how the RPO process should be standardized across the Air Force.
- Structure appropriate Air Force RPO policy.
- Determine how the RPO process should be tied into the investigative process, as well as the five-year review process.
- Decide what RPO training will be needed.

The Air Force Real Property Agency (AFRPA) has implemented for the past three years its RPO program for BRAC bases through its headquarters environmental office (EV). This RPO program, implemented in partnership with the EPA, AFCEE, U.S. Army Corps of Engineers, and other federal and state agencies has been very successful in the identification of opportunities to improve remedial systems in the RA-O phase.

AFRPA's existing RPO program is also implemented largely in accordance with AFCEE's *Remedial Process Optimization Handbook* (2001). The program implements two separate functions in that it looks at optimization of individual systems (systems-level optimization) and examines the overall remedial process (process-level RPO). The program includes Phase I and Phase II site visits. The purpose of a Phase I site visit is to examine key performance data and evaluate progress toward site cleanup goals, while ensuring remedy protectiveness. The purpose of a Phase II site visit is to use the data collected and evaluated in the Phase I visit to review the ultimate remedial goals, overall system design, cost and performance metrics, overall effectiveness and efficiency, and examine the costs/benefits of changes to the system. The main responsibility for implementation of the RPO recommendations is left to the discretion of the operating location based on the belief that it is are best equipped to request funds and implement the recommended changes. However, AFRPA/EV tracks the implementation of all RPO recommendations. The RPO process is implemented on a rotational schedule such that each installation is visited at least once in every five years, with approximately six installations being visited each year.

AFRPA is currently looking at how to institutionalize its RPO efforts into the agency's standard business practices. Some of the elements of this institutionalization may include annual optimization analysis of systems by the RA-O contractors, service center oversight of the quality of the RA-O contractors' efforts, permanent RPO teams consisting of government experts drawn from other agencies, and management tracking of and cost and schedule impact of implementing RPO. Initial plans are for the AFRPA headquarters–sponsored RPO to be conducted every five years to be completed one year in advance of the CERCLA-required five-year review. The data from the RPO will then set the stage for the five-year review report.

In conclusion, the Air Force will continue to research and employ the most effective optimization technologies and strategies to meet its ultimate goal of improved program efficiency and effectiveness while protecting human health and the environment without increased risk in all of its remediation efforts.

D.1.2 United States Army

D.1.2.1 Intent and Benefits of a Remediation System Evaluation Process

The RSE process was developed by the U.S. Army Corps of Engineers (USACE) Hazardous, Toxic, and Radioactive Waste Center of Expertise (HTRW CX) during the late 1990s to assess the protectiveness and cost-effectiveness of operational systems. Specifically, RSEs have four primary purposes:

- Identify performance and remedy effectiveness problems.
- Reduce operating costs.
- Confirm the project team has a clear and appropriate exit strategy for the site.
- Verify proper maintenance of government-owned equipment.

The RSE provides an independent technical review of system operations and costs by a small team of senior technical staff. Site conditions and monitoring data gathered from the investigation phase through installation and operation of the remediation system are reviewed. The RSE includes a site visit that gives the team a sense of the on-site operations, abilities of the personnel, and changes that may have occurred at the site since it was commissioned.

D.1.2.2 Process

The RSE consists of three primary activities and report preparation.

Previsit Activities. Each RSE site visit is typically scheduled approximately two to four weeks in advance to allow adequate time to coordinate schedules of all parties. In addition, relevant documents describing selected remedies, site conditions, design basis, operating status, and cost are identified and forwarded to the team prior to the RSE site visit. The characterization, design, and performance data are used by the RSE team to develop a conceptual site model, an initial understanding of the installed components, an awareness of the past problems with the system, and what areas of O&M account for the bulk of the site costs (these are the most fruitful areas to focus on for optimization).

Site Visit. The one- to two-day site visit usually includes the RSE evaluation team plus the O&M contractor(s), the RPM, the state regulator, and other stakeholders as appropriate. The visit begins with introductions; an explanation about the RSE process; and a tour of aboveground equipment and the site features, such as extraction, injection, and monitoring well locations. Operational problems and maintenance issues are discussed. Surrounding land use and potential exposure points are also identified. Longer site visits may be needed for complex, multisystem, or large sites.

Data Analyses. Following the site visit, the RSE team performs various technical analyses to evaluate performance and alternatives to the current site operations, equipment, or remediation technology. Subsurface performance, such as adequacy of plume capture, is evaluated through quick hydrogeological calculations or simple models. The senior engineer assesses performance problems for treatment equipment with engineering calculations. Alternatives to existing approaches may be conceptually designed. Cost savings are estimated with an accuracy comparable to those estimates done for feasibility studies. The capital costs associated with implementing each recommendation are also estimated. Some recommendations actually increase annual costs but reduce the estimated time frame for remediation, while others decrease annual costs. The exact analyses to be done depend on the specific site conditions.

Report Preparation. The findings and recommendations of the RSE are documented in a report. If the RSE is being done to meet the requirement for a periodic review, the report should conform to the appropriate format. For example, the detailed RSE report for each site contains the sections identified in the box at right. Recommendations may include bench- or pilot-scale testing of alternative technologies, engineering design of alterations or new components, detailed groundwater modeling, detailed optimization of a specific treatment process or the monitoring program. These are not normally part of the RSE effort.

Exhibit A. RSE Report Contents

- Introduction—Details the purpose of the visit, the RSE team, the documents reviewed, persons contacted, site location, history, hydrogeology, etc.
- Description of the Remediation System—Includes the extraction and treatment systems
- System Objectives, Performance and Closure Criteria—Includes a summary of ARARs and remedial action objectives for site media
- Findings and Observations—Includes system and component performance, recurring problems, capture zone evaluation, and contaminant delineation
- Evaluation of the System Effectiveness—Evaluate treatment of groundwater, surface water, air, and soils
- Recommendations—Intended to enhance effectiveness, reduce life-cycle costs, improve technical operations, gain site close-out (includes a table summarizing the recommendations, including estimated cost increases and estimated cost reductions associated with each recommendation)

D.1.2.3 Timing

Though an independent technical review of projects in the design phase is beneficial, the RSE process is best applied to sites with some operational history. RSEs are beneficially conducted after approximately one or two years of operations and then conducted periodically, perhaps corresponding to five-year reviews. Changes, when identified and implemented early in the remediation, allow the system to operate at its maximum possible effectiveness during the period of time when these systems typically remove the maximum mass from the subsurface. Sites where the remediation technology, site conditions, or regulatory climate are complex should have RSEs done more frequently. In particular, sites where problems are noted or where conditions change over a short time should be evaluated frequently, perhaps every one to two years.

D.1.2.4 Tools

USACE has prepared a number of tools to guide and support effective RSEs. The primary tools for the personnel performing the RSE are the various RSE checklists, which are available on the Internet at http://www.environmental.usace.army.mil/ library/guide/rsechk/rsechk.html. The RSE checklists are meant to be a tool, not a rigid system that must be followed. The users have the freedom to use them as they see fit. The checklists remind the user of the data to collect, questions to ask, problems to look for, analyses to perform, useful references, and alternative technologies or equipment to consider. They can also be used as a record of observations. The checklists address optimization at various levels of detail, from the general to very component specific.

D.1.2.5 Past Federal Experience

The RSE process had been applied to more than 30 federal remediation systems as of October 2002. The RSEs identified potential remedy effectiveness issues, applicable or relevant and appropriate requirements (ARARs) conflicts, need for added studies, as well as potential cost savings of $35,000 to more than $500,000 *per year* in operations and maintenance at each site.

D.1.2.6 Personnel Requirements

Senior, experienced technical staff are needed to conduct the evaluation. Broad experience with a variety of systems and an understanding of subsurface processes and treatment techniques is critical to the success of the RSE. Generally, it is recommended that site visits be accomplished by a minimum of two senior individuals; a hydrogeologist, and a remediation engineer. Input from many other experienced professionals in other disciplines is likely to be required to ensure a comprehensive evaluation and presentation of recommendations. These areas of expertise include the following:

- policy and regulations,
- hydrogeology,
- engineering,
- risk assessment,
- contracting,
- chemistry,
- health and safety, and
- cost estimating.

D.1.2.7 Costs

An RSE typically costs less than $25,000 and can be completed in two to three months. Additional meetings to present report findings, engineering designs, modeling, or other studies are not included in the cost. Factors that can impact the cost of the RSE include the following:

- sites with extremely complex hydrogeology or treatment processes,
- sites that include multiple operable units,
- varying the number of individuals participating in the site visit,
- combining visits in the same vicinity, and
- extremely large or politically sensitive sites.

D.1.3 United States Navy

The Department of the Navy is committed to optimizing the environmental restoration (ER) program through careful evaluation of project goals, remediation system effectiveness, life-cycle design and cost analyses, and data management and reporting. The ER program comprises the installation restoration (IR) and munitions response (MR) programs. The Naval Facilities Engineering Command (NAVFAC) set specific goals in response to the DERP Management Guidance that requires optimization of all environmental restoration response actions at DoD facilities. NAVFAC goals include the following:

- developing policy and guidance to require optimization of all response actions,
- tracking/reporting the effectiveness of the optimization efforts for all sites,
- minimizing/eliminating use of pump-and-treat systems,
- developing site closeout guidance with appropriate exit strategies, and
- providing remedial project manager (RPM) training on these requirements.

NAVFAC has established seven workgroups to address specific issues regarding the ER program. Efforts related to optimization and site closeout have been delegated to the Remedial Action Operation/Long-Term Management (RAO/LTMgt) Optimization work group. This work group is composed of representatives from NAVFAC Headquarters, Engineering Field Divisions and Activities, Naval Facilities Engineering Service Center, Chief of Naval Operations, and Marine Corps Headquarters and acts as an advisory group to the Navy IR Managers.

Initial efforts of this work group included follow-on investigations from the DoD and EPA reviews of pump-and-treat systems coupled with development of guidance documents to optimize RAO and LTMgt actions. This first step included detailed collection and evaluation of specific performance data used to produce the RAO and monitoring guidance documents. Following is a description of these initial products.

The *Guidance for Optimizing Remedial Action Operation (RAO)* presents a stepwise process for optimizing RAO projects as developed by the Navy RAO/LTMgt Optimization Working Group. The objective of this guidance document is to provide information to Navy RPMs and their contractors on a process to maximize cost-effectiveness without compromising program and data quality. These steps are as follows:

1. Review and evaluate remedial action objectives.
2. Evaluate remediation effectiveness.
3. Evaluate the cost-effectiveness.
4. Consider remediation alternatives.
5. Develop and prioritize optimization strategies.
6. Prepare an optimization report and implement the optimization strategy with input from the regulatory agencies.

The *Guide to Optimal Groundwater Monitoring,* also produced by the Navy RAO/LTMgt Optimization Working Group, can be used by RPMs to ensure that their monitoring programs are designed and periodically optimized to cost-effectively support their monitoring goals without compromising program and data quality. The five general strategies that ensure a cost-effective monitoring program include the following:

- reducing the number of monitoring points,
- reducing monitoring duration and/or frequency,
- simplifying analytical protocols,
- ensuring efficient field procedures, and
- streamlining data management and reporting.

The RAO/LTMgt Optimization work group tracked the implementation of optimizations efforts and used this knowledge to target the root of the optimization requirements, up-front planning. These efforts include optimization of the technology screening, evaluation, selection, and design phases, which occur during the feasibility study, record of decision, and remedial design. The work group is also working on a process to streamline site closeouts.

To accomplish these objectives, the work group is developing two additional guidance documents that will be available in 2004. The *Guide for Optimizing Remedy Selection and Remedial Design* will provide guidance for optimizing the remedy evaluation, selection, and design phases by incorporating technology life-cycle concepts and serves as a companion to previous NAVFAC optimization guidance. It is recommended that the Navy RPM use a third party (i.e., other than the current operation and maintenance contractor) to conduct optimization studies. The RPMs are utilizing services from the Naval Facilities Engineering Service Center (NFESC), in-house technical support, or independent contractors to complete these optimization evaluations. For each site at which an optimization study is conducted, the RPM tracks and reports the baseline conditions, recommendations of the study, implemented strategies, and progress in the Navy's IR data management system.

The *Guide for Documenting Site Closeout* will outline a consistent approach for Navy RPMs to follow in recognizing and documenting specific milestones for achieving site closeout.

Additionally, the Navy is developing optimization policy for all response action sites. In early 2003, NAVFAC issued guidance to the field to conduct independent evaluations and obtain recommendations for optimizing the top 20% of the most costly environmental remediation projects within the remedial action operations stage. In late 2003, NAVFAC conducted a top-down review of the top 15% (by cost to complete) of all sites within the IR program using a team comprising members of several of the key work groups. Similar evaluations for the remaining sites will be addressed in future budget years. These efforts have been extremely effective to date in identifying means for improved system efficiencies, site protectiveness, and cost reductions. So far, cost avoidance in excess of $270 million has been realized in the ER program.

The Navy continues to emphasize the importance of optimization by providing training throughout the year to Navy environmental professionals, other DoD personnel, the Navy's environmental cleanup contractors, and environmental regulators working on ER sites. Courses are offered through the Civil Engineer Corps Officer School (CECOS), and include a two-day offering on optimizing remedy selection and site closeout. The Spring 2004 Remediation Innovative Technology Seminar (RITS) is being offered at seven locations throughout the country and will focus entirely on optimization of Remedial Actions. The seminar will emphasize documenting the site closeout process, developing conceptual site models, selecting technologies that optimize remedial operations, and choosing performance monitoring and optimization tools. Presentation material from this course, as well as guidance documents and other tools to assist with optimization and site closeout are available at the NAVFAC Environmental Restoration and BRAC Web site at http://enviro.nfesc.navy.mil/.

D.1.4 Defense Logistics Agency

The Defense Logistics Agency (DLA) approach to RPO is similar to that described for the Air Force because AFCEE and headquarters DLA coauthored the 2001 *Remedial Process Optimization Handbook*. The handbook was developed to comply with requirements for optimization of environmental programs as outlined in DoD's *Management Guidance for the Defense Environmental Restoration Program* (2001). The overall goal of DLA's RPO program is to review the entire environmental restoration program at each installation to continuously validate and improve past or pending remedial decisions. DLA accomplishes this goal by examining both the program objectives and the means to achieve those objectives to identify optimization opportunities to improve the effectiveness of the decisions and efficiency of the selected response actions.

Since 1998, DLA has implemented RPO at all of its distribution depots and supply centers, with initial emphasis on identifying, and conducting root-cause analyses of, underperforming remedial systems already in place, and critical reviews of assumptions underlying those response actions planned but not yet implemented. DLA's RPO efforts have been accomplished using a phased strategy. Issues requiring detailed evaluation typically are identified through a third-party RPO scoping visit (RSV) conducted by a team of scientist, engineers, and regulatory specialists. The RSV is a focused site visit that allows the RPO review team to review the Administrative Record, visit the subject sites and remedial systems, and interact with installation staff and contractors. If candidate issues for optimization are identified, the RSV is followed by an RPO Phase II evaluation, which focuses on determining the root-cause of identified deficiencies in program progress or system performance, and recommending solutions.

While systems and monitoring program efficiencies—and resultant cost savings—identified through the RPO program have been realized fairly quickly at most of its installations, DLA is committed to focusing its RPO program on long-term program success. DLA recognizes that meeting the DERP requirement to ensure protection of human health and the environment by achieving response complete in a reasonable time frame is its primary environmental obligation. While recognizing the importance of interim milestones in the DERP (e.g., ROD signing, certification that remedial systems are operating successfully and properly, and documenting last remedy in place [LRIP]), DLA encourages its site managers to develop and clearly articulate appropriate exit strategies for their sites as a way of maintaining focus on the long-term, DERP-mandated objective of response complete. DLA also is committed to ensuring that limited DoD resources are expended wisely and that the ever-expanding wealth of scientific knowledge is brought to bear to expedite environmental cleanup at its installations.

To assist its site managers in building defensible exit strategies and validating their response decisions and to supplement the RPO Handbook co-authored with AFCEE, DLA currently is developing a Performance-Based Environmental Restoration Management Assessment (PERMA) guide. This guide focuses on reassessment of the basis for response action decisions as site information and technical knowledge improve and on using specific tests of performance and metrics to assess progress toward achieving response complete. Together, the RPO Handbook and the PERMA guide will provide a comprehensive framework for routinely assessing and optimizing all aspects of the environmental restoration programs at DLA installations. A policy to require exit strategies at DLA installations is also under consideration as another means to institutionalize “smarter/faster” cleanups through optimizing decisions, remedial action objectives, and response actions.

The success of DLA’s RPO efforts to date can be traced in large part to a strong commitment to RPO principles, which starts at the headquarters program level and is embraced and implemented at the facility level. Because its facilities are limited in number, DLA has been uniquely positioned to incorporate innovative systems-evaluation techniques and regulatory strategies into implementation of its environmental restoration program. DLA has demonstrated its commitment to the program by routinely maintaining a program-level presence during RPO efforts at its installations, and by creating and supporting long-term programmatic involvement of its RPO review teams at the facility level. For example, at one of its NPL-listed Supply Centers, the RPO review team, with the DLA headquarters support, has joined forces with the installation staff and contractors to develop realistic cleanup goals and technically sound response actions that should significantly reduce the time to achieve response complete and therefore to ensure protection. In this case, the time (and therefore cost) to reach response complete likely will be decreased from around 80 years to about 10 years by changing cleanup goals from drinking-water-based objectives to more realistic—and equally protective—alternative concentration limits and altering the proposed response action from pump-and-treat to innovative source treatment and point-of-exposure controls. At other DLA installations, the facilities and their contractors have successfully negotiated RPO review team recommendations with involved regulatory agencies and realized significant cost savings through prompt implementation of optimization recommendations.

In conclusion, DLA will continue to research and employ the most effective optimization technologies and strategies to meet its ultimate goal of improved program efficiency and effectiveness while protecting human health and the environment without increased risk in all of its remediation efforts. DLA’s long-term commitment to optimization and responsible use of DoD resources under its environmental restoration program is manifested by its ongoing support of RPO at the program and facility levels and by its pending PERMA guide and commitment to developing exit strategies to ensure long-term program success through achieving response complete in a reasonable time frame.

D.2 DEPARTMENT OF ENERGY—Modifying Processes to Make Them Result Oriented

DOE’s environmental management mission is to clean up the radioactive, hazardous, and mixed waste left after 50 years of U.S. nuclear weapons production. To manage this mission, DOE in

1989 created the Office of Environmental Restoration and Waste Management (currently known as the Office of Environmental Management [EM]) to clean individual sites throughout the DOE complex. Current EM cleanup activities are spread more than 150 sites in more than 30 states and Puerto Rico.

Individual sitewide cleanup programs at many of the larger facilities have experienced difficulty in establishing well-defined technical scopes, costs, and schedules for completing the required restoration. Lack of detailed information regarding past activities at different sites, as well as the inherent uncertainties in remedial work, have contributed to this problem. To overcome these challenges, EM has been continuously engaged in developing and refining methodologies that would enhance its ability to better define remediation requirements and greatly facilitate faster cleanup at reduced costs. Remediation process optimization is an important tool to help DOE achieve that objective.

An area of great concern to DOE has been the restoration of groundwater contaminated from historical DOE activities. Challenges arise as a result of difficult hydrogeological settings (e.g., karst, fractured rock, extreme depth), recalcitrant contaminants (e.g., tritium, DNAPL, technetium-99), and sheer volume of contaminated water. Currently a significant portion of the DOE's groundwater cleanup costs are associated with the operation of pump-and-treat systems, and in absence of new and optimal technical and managerial approaches, these costs will continue to be a major expense.

To address these long-term cost concerns, EM's Office of Integration and Disposition developed a *Technical Guidance for Optimizing Ground Water Response Actions at Department of Energy Sites* (April 2002) to provide DOE's environmental restoration project managers and decision makers with an overview of key considerations in designing and implementing optimal groundwater response strategies. The guidance outlines the typical phases of a groundwater response and discusses important information needs to optimize technology applications for each phase of activities. In situations where restoration is determined not to be practicable, the guide outlines how EPA's programmatic expectations can be used to establish measures that are necessary and appropriate to minimize risk to human health and the environment.

EM has also developed and is widely implementing a set of "Environmental Restoration Principles" that dramatically improves the remedial investigation and remedy selection/implementation process. These principles, which are based on extensive field experience and successful project implementation, represent the underpinning of current CERCLA and RCRA streamlining initiative. There are four key "principles" considered to be essential to the successful implementation of environmental restoration projects:

- Creation of an effective "core team" is essential (where DOE, EPA, and state officials work together as "comanagers" of the project).
- Clear, concise, and accurate problem identification and definition are critical (to ensure the agencies agree on the specific need and basis for all proposed response actions).
- Early identification of likely response actions is possible, prudent, and necessary (to focus attention on actual cleanup rather than document generation).

- Uncertainties are inherent and will always need to be managed (to promote greater emphasis on our ability to plan for the unexpected, as opposed to perennial sampling in the futile attempt to know all before moving forward).

The application of these principles has helped reduce years off cleanup schedules and millions of dollars in restoration costs. This approach is being successfully applied at the DOE's Savannah River Site since 1999 and involves representatives of DOE, EPA, and South Carolina Department of Health and Environmental Control. This approach has resulted in redefining a variety of problems and re-scoping potential solutions. Detailed information about this process improving methodology can be found in *New Approach to RI/FS Decision Making Dramatically Improves Environmental Restoration Projects at Savannah River Site* (DOE/EH (CERCLA)-413-0102, June 2001).

This approach is also being applied at other DOE sites. It was effectively used by the core team of decision makers from DOE, the Kentucky Division of Waste Management, Kentucky Radiation Control Branch, and EPA Region IV for the cleanup of the Paducah Gaseous Diffusion Plant in Kentucky. The core team has made significant progress towards establishing effective communications between the agencies and is making progress towards site cleanup. The core team expeditiously arrived at consensus on the current and future land use and remedial action objectives, facilitating cleanup strategies that are consistent with the site's end state. This approach appears to facilitate the site cleanup by the planned date of 2010. This approach was also employed at the DOE's Mound plant in Ohio. The core team consisting of representatives from DOE, U.S. EPA, and Ohio EPA helped develop a new strategy for implementation of environmental restoration projects. Under this strategy, the site and the regulators worked to reach consensus on all necessary decisions. The implementation of this strategy has successfully reduced the original life-cycle baseline by 17 years and could potentially save over $1 billion.

Detailed information about this process improving methodology can be found in *From Paper to Progress: Environmental Restoration Success Stories from DOE Sites* (DOE/EH (CERCLA)-413-0103, June 2001).

D.3 ENVIRONMENTAL PROTECTION AGENCY

EPA's remediation process optimization efforts began in 1999 with the use of optimization software in conjunction with groundwater modeling to determine optimal pumping strategies for pump-and-treat systems. This initial effort, however, has expanded into a much larger and more comprehensive optimization program with the following two goals:

- improving remediation protectiveness and cost-effectiveness at EPA-owned and -operated sites (i.e., Superfund-financed sites) and
- sharing optimization approaches, tools, and lessons learned with other federal, state, and private organizations.

EPA's optimization program consists of the following areas:

- establishing programs/initiatives to encourage optimization,
- assisting in the development and application of optimization tools, and
- sharing those tools, providing the necessary training to use them, and conveying lessons learned (i.e., technology transfer).

Progress to date for each of these areas is discussed below.

D.3.1 Programs/Initiatives to Encourage Optimization

EPA's work with management practices began with issuing the Superfund Reform Initiative on July 7, 2000. This initiative committed EPA to conducting optimization evaluations at Superfund-financed remedies in each of its 10 regions. EPA staff members from each region with defined roles and responsibilities served as optimization liaisons. A nationwide pilot project was soon initiated that incorporated three phases:

- Phase 1—Gathering information via a Web-based survey to screen EPA sites that would benefit most from optimization (described in *Groundwater Pump and Treat Systems: Summary of Selected Cost and Performance Information at Superfund-financed Sites*, EPA 542-R-01-021a).
- Phase 2—Conducting 20 optimization evaluations throughout the EPA regions using the Remediation System Evaluation (RSE) approach developed by the U.S. Army Corps of Engineers (described in *Pilot Project to Optimize Superfund-financed Pump and Treat Systems: Summary Report and Lessons Learned*, EPA 542-R-02-008a through EPA 542-R-02-008u).
- Phase 3—Following up on the optimization evaluations to ensure recommendations were thoroughly considered and to document lessons learned.

EPA is currently developing a new directive that formalizes optimization as an integral part of its long-term remedial actions. Roles and responsibilities, information gathering, performance monitoring, and other aspects of a management system are being considered.

D.3.2 Development and/or Application of Optimization Tools

Optimization tools that EPA has been involved in developing and/or applying include RSEs, optimization software, and sensors.

EPA has conducted RSEs at over 30 Superfund-financed sites and has also sponsored RSEs at RCRA facilities and UST facilities. Conducting RSEs at fund-lead sites helps EPA optimize its own remedies, and conducting RSEs at other facilities helps to further develop the optimization process while introducing other organizations to the benefits of optimization.

EPA sponsored two projects (one in conjunction with DoD) to demonstrate simulation-optimization techniques to develop optimal pumping strategies for pump-and-treat systems. One project demonstrated "hydraulic optimization" software that links with a groundwater flow model like MODFLOW to optimize an extraction system to capture a contaminant plume. The other project demonstrated "transport optimization" software that links to a contaminant transport model like MT3D to optimize mass removal, cleanup time, or other aquifer restoration objectives. Another example of optimization software that EPA has helped pilot is geostatistical software used to optimize long-term groundwater monitoring programs. This software can help project managers and consultants eliminate redundant groundwater sampling, providing for a more cost-effective remedy.

EPA's involvement with sensors is also related to optimizing groundwater sampling. Multiple projects are geared toward using existing test kits to provide a relatively inexpensive on-site form of analysis. EPA has also conducted a review of the emerging sensor technologies that can be used for analyzing VOCs, including chemiresistors, quartz crystal microbalances, and fiber-optic sensors (documented in *A Review of Emerging Sensor Technologies for Facilitating Long-Term Ground Water Monitoring of Volatile Organic Compounds*, EPA 542-R-03-007).

D.3.3 Technology Transfer

EPA's commitments to optimization and technology transfer include the use of Internet seminars, development of fact sheets, development of internal EPA training courses, and cosponsorship of an optimization conference. EPA has presented the Internet seminar "Effective Management of Pump and Treat Systems: Lessons Learned from Evaluations of Systems Nationwide" to multiple audiences with hundreds of attendees. With regard to conferences, EPA (with the Federal Remediation Technologies Roundtable) has cosponsored the June 1999 conference "Subsurface Remediation: Improving Long-Term Monitoring and Remedial System Performance" held in St. Louis, Missouri and will cosponsor the June 2004 conference on "Accelerating Site Closeout, Improving Performance, and Reducing Costs Through Optimization" in Dallas, Texas. Recent or in-progress fact sheets developed from EPA's optimization work include the following:

- "Elements for Effective Management of Operating Pump and Treat Systems" (EPA 542-R-02-009, December 2002)
- "Cost-Effective Design of Pump and Treat Systems" (EPA 542-R-04-007, in review)
- "Effective Contracting Approaches for Operating Pump and Treat Systems" (EPA 542-R-04-005, in review)
- "O&M Report Template for Ground Water Remedies (With Emphasis on Pump-and-Treat Systems)" (EPA 542-R-04-003, in review)
- "A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Sites" (in progress)

In the upcoming years, EPA will continue to expand all three aspects of its optimization program by continuing to work both internally within EPA and externally with other federal, state, and private organizations.

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APPENDIX E

Sample RPO Work Plan

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SAMPLE RPO WORK PLAN

This appendix presents a sample scope of work for conducting RPO activities. This particular example includes an RPO evaluation in conjunction with the evaluation of alternate sampling methods; notably, passive diffusion bag sampling (PDBS). Combining an RPO evaluation with the evaluation of alternate sampling or investigative techniques is a complimentary method of contracting. RPO may make use of such techniques as PDBS, and PDBS may be useful in justifying the implementation of RPO.

REMEDIAL PROCESS OPTIMIZATION SUPPORT AND DEMONSTRATION OF PASSIVE DIFFUSION BAG SAMPLING TECHNOLOGY AT SEVERAL FEDERAL FACILITIES

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this statement of work (SOW) is to provide services, technical man-hours, and materials, under a time and materials type delivery order, to support Remedial Process Optimization (RPO) evaluations, demonstrate the effectiveness of Passive Diffusion Bag Samplers (PDBS), and perform natural attenuation related studies at selected Department of Defense locations worldwide. Services shall include developing a Work Plan with supporting documents, and a project schedule; preparing project management reports; installing and operating the PDBS(s), collecting and analyzing environmental samples; demobilizing at the end of the demonstration; preparing technical reports; and attending meetings, as requested. An RPO Phase II Evaluation is an intensive evaluation to explore system optimization, new technology, regulatory opportunities, or monitoring optimization at a particular restoration site/system. Benefits of RPO include better tracking of remediation progress, reevaluation of cleanup goals, reduced O&M costs, ensuring protectiveness, and accelerated site closure. Benefits of PDBS include significant reduction of investigation generated waste, reduction in sampling man-hour requirement, and capability to vertically profile the well being sampled.

1.1 Scope

1.1.1 Title I Services

1.1.1.1 In carrying out any work assignment issued, the Contractor shall furnish the necessary personnel, services, equipment, materials, and facilities and otherwise do everything necessary for or incidental to the performance of work set forth herein.

1.1.1.2 Primary services include three major groups:

- RPO Phase I and Phase II assessments as discussed in 1.1.1.3–1.1.1.6
- PDBS implementation as described in 1.1.1.7

1.1.1.3 Primary services under this task order include the performance of an RPO Phase I Evaluation at various FEDERAL FACILITY installations (see Annex A). The anticipated RPO Scoping Visit (RSV) Phase I Evaluation locations under this task order listed in Annex A.

1.1.1.4 For each RSV Phase I, the Contractor shall provide one team member and accomplish the following tasks:

- Review the previsit information package/become familiar with the site's location, conceptual site model, risk issues, and status.
- Attend the RSV Scoping Visit.
- Interview project managers on the approach and system operation of each site.
- Make specific RPO recommendations based on the eight RPO strategy components.
- Identify sites/areas which could benefit from detailed RPO Phase II Evaluations.
- Contribute to the draft RPO Scoping Visit Report.
- Contribute to the RPO Scoping Visit Out-Brief.
- Make additional comments on the draft RPO Scoping Visit Report after the RSV.

1.1.1.5 The anticipated RPO Phase II Evaluation locations under this task order are listed in Annex A.

1.1.1.6 RPO Phase II Evaluation activities include inspection of extraction and treatment systems, collection of environmental samples, and completion of field tests to identify and evaluate optimization opportunities. The Contractor shall accomplish the following general tasks for each Phase II Evaluation:

- Review key regulatory decision documents and historical monitoring and system performance data and complete a site visit to become familiar with site complexities and remediation system operations. Prepare a Phase II work plan outlining site-specific evaluation activities.
- Review the ultimate remediation goals for the site to ensure they are appropriate and reflect current regulatory options.

- Complete a design review and update of the conceptual site model. Review current performance criteria. If no performance criteria exist, develop performance criteria that are clearly defined and measurable.
- Evaluate remedial system effectiveness to determine whether ultimate cleanup goals can be achieved with the existing remedy (or are new technologies required).
- Evaluate site and system monitoring and analytical protocols to determine whether they are appropriate for the in-place remedy and remediation time frame.
- Evaluate system efficiencies and identify both short-term and long-term optimization opportunities.
- If needed, identify new regulatory approaches and/or new technical approaches to achieve the ultimate remediation goals for the site and perform a cost-benefit analysis for recommended changes.
- Prepare a Phase II final report which summarizes system protectiveness and effectiveness evaluations and recommends new regulatory and technical approaches, including short- and long-term optimization opportunities.

1.1.1.7 Primary services shall also include those items necessary to demonstrate and evaluate PDBS technology, "beta test" the Draft Final Interagency *Guidance Document For Use Of Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells (PDBS Guidance)*, and provide feedback to the PDBS workgroup to update the Interagency PDBS Guidance Document for Installation Restoration Program (IRP) managers. It is expected that this document will be used when designing new monitoring programs and revising existing Remedial Action Operation (RA-O) monitoring and long-term monitoring (LTM) programs. The work shall include the following:

- The contractor shall initially prepare a work plan (WP) applicable at any Federal Facility facility.
- The work plan will consider implementation of PDBS technology demonstration at the sites listed in Annex A. Implementation shall be conducted for thirty (30) VOC wells at each site.
- PDBS analytical results will be compared to current practice in a scientifically defensible manner using statistical analysis, and presenting the comparison in easy to read tables as specified in the PDBS Users Guide (2001).
- The Contractor shall obtain and review existing monitoring data from the installations listed in Annex A.
- The Contractor shall identify any data gaps in the existing site information and brief the COR on the need for, and an estimated cost to obtain, the missing data.
- At every PDBS site except________, the Contractor shall apply an appropriate algorithm (such as MAROS) to determine the site wells that provide relevant and sufficient information. Wells that are redundant will be recommended for decommissioning.
- The Contractor shall prepare one comprehensive report.
- The PDBS report shall include an analysis of the effectiveness of the technology, a list of operational parameters that promote the usability of PDBS, and a list of operational parameters that indicate when poor performance is likely to occur. The report shall recommend the cost effective, routine metrics required to monitor the performance of PDBS and the existing monitoring systems. The report shall also present any recommendations for modifications to the existing monitoring program(s) that may enhance operational control, or terminate long-term monitoring. Issues common to BRAC & ERA will be identified.
- The Contractor shall include a cost and performance analysis in the technical reports. These report shall include implementation costs, cost comparison to traditional sampling, sampling cost avoidance generated by PDBS, and return on investment assessment.

1.1.2 Title II Services

Not Applicable

1.1.3 Other Environmental A-E Services

1.1.3.1 Secondary services incidental to the primary services include collecting and analyzing groundwater samples for volatile organic contaminants of concern and potential intermediate degradation products. Any interfering component will be identified.

1.1.3.2 Whenever possible, the Contractor shall use the analytical laboratory sub-contracted by the installations' prime contractor to maintain data comparability. Quality assurance samples such as blind samples will be used to determine the laboratory's precision. This information is essential to assess the contribution of analytical variance to the analytical result due to sampling method (PDBS vs. traditional).

2. DOCUMENTS

The Contractor shall comply with the most current version of the associated installations' regulator-approved planning-documents and guidance and will be followed to assure data comparability. In all cases, existing installation documents will be used to their fullest extent to minimize duplication of effort in developing plans called for in this SOW.

2.1 Compliance Documents

The Contractor shall comply with all federal, state, and local regulatory agency requirements and applicable statutes, policies, and regulations.

2.2 Guidance Documents

All work for this SOW shall conform to the maximum extent practicable to the applicable requirements of the following guidance documents:

- Guidance for Conducting RI/FSs Under CERCLA (Office of Solid Waste and Emergency Response [OSWER] Directive 9335.3-01)
- Test Methods for Evaluating Solid Waste (SW-846), Third Edition (1986) and Updates (U.S. Environmental Protection Agency [EPA], OSWER)
- Guidance on Remedial Action for Contaminated Groundwater at Superfund Sites (OSWER Directive 9283.1-2), 1988
- A Compendium of Superfund Field Operation Methods (EPA/540/P-87/001, OSWER Directive 9335.0-14), December 1987
- Draft Final, Guidance Document For Use Of Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells, October 2000
- Air Force/Defense Logistics Agency Remedial Process Optimization Handbook, July 2001(RPO Handbook)
- HQ Air Combat Command (HQ ACC) Site Closure Guidance Manual (SCGM)
- AFCEE Remedial Action Operation/Long-Term Monitoring (RAO/LTM) Guidance Manual
- Other AFCEE, USACE and Federal Facility guidance relevant to the installation
- User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells (USGS Water-Resources Investigation Report 01-4060; 2001)

2.3 Facility-Specific Documents

The Contractor shall be responsible for obtaining through the facility Environmental Management Office any documents that may assist the Contractor in accomplishing the scope of work. In particular, the Contractor shall be responsible for obtaining prior IRP investigation reports to use in determining the history of the site, design/layout of the monitoring program(s), and development of a site-specific Work Plan.

3. ADMINISTRATIVE AND MANAGERIAL REQUIREMENTS

Perform management and planning functions, as well as performance measurement and cost status reporting, during the course of this effort as specified in 4.1.

3.1 Meetings and Conferences

3.1.1 Post Award Meeting/Teleconference

After the issuance of the work order, the Contractor shall attend a post award meeting to obtain consensus on the goals, objectives, expectations, and schedule for the project. The meeting will also review candidate facilities for PDBS and confirm selection of candidate facilities. The final version of the post award meeting minutes shall be prepared and distributed prior to commencement of any site visits for gathering of project data. Once candidate facility have been confirmed each selected facility shall be visited and three regional kickoff meeting will be held. The following personnel may participate in the on-site meetings:________.

3.1.2 Progress Meetings

The contractor shall attend up to two (2) quarterly progress meetings held at FEDERAL FACILITY headquarters. The Contractor shall prepare all materials and handouts for each briefing they present. Attend progress meetings with the installations and/or COR as listed in the site specific work plans.

3.1.3 Integration and Planning Meetings

The contractor shall hold meetings (not to exceed 3) with the COR as the RPO projects move from phase I to Phase II. Responsible federal facility personnel will also attend these meetings. The purpose of these meetings shall be to review work plans and schedule implementation of PDBS and RPO recommendations. It is through these meetings that any recommended variations from the project plan(s) and specifications shall be identified.

3.1.4 Attend Public Meetings and Hearings

As requested, the Contractor shall present the RPO/PDBS results to the Restoration Advisory Board (RAB) at the selected facilities. The Contractor shall present technical information and provide logistical support (e.g., preparation of handouts, report(s), recordings, verbatim transcripts, slides, or synopsis of the meetings/hearings) for events and/or meetings in support of the Government's position.

3.1.5 Final Meeting

The Contractor shall attend a final meeting to present the results of the demonstration to the Air Force. The Contractor shall be responsible for preparing all presentation materials.

3.2 Regulatory/Professional Interface

The contractor shall prepare for and attend two regulatory agency meetings at each selected BRAC facility to brief concerned parties. These meetings do not apply to the PDBS tasks. The primary purpose of the first meeting is to gain consensus and acceptance of the optimization recommendations for the RA-O and LTM programs, and to gain concurrence on the relative priorities for RPO/ Phase II implementation and follow up. The Contractor shall attend a second regulatory agency meeting (for FEDERAL FACILITY sites only) at each selected facility to present a six-month update of the implementation. Feedback and comments from these meetings shall be addressed in the final document submittals.

3.2.1 Interactions

Assist in interactions with: military and federal activities/agencies; state/local/host nation agencies; the public; and other interested parties during administrative or judicial proceedings related to the assigned project. Assistance shall include providing presentation materials, agendas, minutes, publications, news releases, public notices, and maintain/update mailing list.

3.2.2 Comments

Assist in project technical review, analysis, and discussions to integrate comments from federal, state, host nation, and local Governments on programs and related data and studies. Develop options for responses and prepare report(s) to communicate Government environmental priorities to regulatory agencies, consultants, interested parties, and other private/public/Government interest, as directed.

3.2.3 Interpretation

Assist with the review and interpretation of new statutory and regulatory requirements and make recommendations for Government facility planning and environmental policy integration as it applies to the assigned project.

3.3 Special Notification

3.3.1 Health Risks

Immediately report to the Contracting Officer and the Contracting Officer's Representative (COR), via telephone or e-mail any issues or incidents which may indicate potential imminent risk to contracted, federal, or host nation personnel, or the public at large or the environment. Following the telephone or e-mail notification, a written notice with supporting documentation shall be prepared and delivered within three (3) working days to the Contracting Officer. Upon request of the Contracting Officer , or their COR, provide pertinent raw laboratory data within three (3) weeks of the telephone or e-mail notification, documenting the concern and risk.

3.3.2 Identification and Change of Critical Contractor Personnel

Submit an organizational chart displaying key personnel involved in the effort and their respective labor categories. Notify the COR of all professional personnel to work on specific tasks under the task order. Obtain COR approval of any proposed changes in project personnel along with the steps taken/proposed to ensure there are no impacts to the schedule or costs associated with individual tasks. Identify to the COR all subcontractors to be used under task orders issued pursuant to this SOW, prior to contract and work being initiated. Provide to the COR subcontractor qualifications prior to contract utilization.

3.3.3 Unexploded Ordinance (UXO)

If UXO or any other munitions and explosives of concern are discovered during field activities, do not attempt to disturb, remove or destroy it, but immediately report the discovery to the facility point of contact (POC) and COR or to local law enforcement via telephone. Commencement of field activities cannot continue until an appropriate response (i.e., an explosives or munitions emergency response or a munitions response) is completed, and authorized by the CO.

3.4 Laboratories

The default laboratory in all cases will be the laboratory being used to analyze the Federal Facility installation environmental samples. Vertical profiling PDBS samples will be screened in the field whenever possible. The highest concentration PDBS and the one located at the traditional sampling depth will be submitted to the fixed-base laboratory.

3.4.1 General

Laboratories shall be USACE approved and may be subject review of their Quality Assurance/Quality Control (QA/QC) protocols and procedures. All laboratories shall meet Data Quality Objectives (DQOs) specified in task order project-specific Sampling and Analysis Plan(s) (SAP). The labs shall perform QA/QC requirements as specified in the project/site specific SAPs. The analytical capabilities of the laboratory shall be sufficient for the methods specified in the SAP, and the laboratory shall have sufficient through-put capacity to handle the necessary analytical load during all field activities.

3.4.2 On-Site Laboratories

An on-site laboratory may be utilized for the analytical methods required by the approved project/site specific SAP. The laboratory shall meet all applicable certification requirements for the necessary analysis methods prior to its implementation. On-site laboratories shall meet the DQO and QA/QC requirements specified in the site specific SAP. All proposed deviations from the above requirements shall be submitted in writing to the COR for concurrence prior to proceeding with the affected work.

3.5 Work Site Requirements

3.5.1 Safety Requirements

Responsible for protecting the lives and health of employees and other persons; preventing damage to property, materials, supplies, and equipment, avoiding work interruptions and complying with OSHA safety and health regulations and Facility safety office requirements. All on-site workers (contractor and subcontractor) performing hazardous operations, including working with hazardous materials, must have completed the OSHA 1910.120 HAZWOPER training and/or other applicable training, plus annual refresher courses. Maintain documentation supporting training records and have written Health and Safety Plan on site available for workers and/or regulatory review. Provide the CO copies of any OSHA report(s) submitted during the duration of the TO.

3.5.2 Work-Site Maintenance

Maintain the work site to: prevent the spread of contamination, provide for the integrity of the samples obtained, provide for the safety of all individuals in the vicinity of the work site areas, and prevent the release of any contamination to the environment. The work site shall be well marked to prevent inadvertent entry into all work areas. Access to work areas shall be monitored and thoroughly controlled. Standard work zones and access points for controlled operations shall be established and maintained as the site conditions warrant. Ensure compliance with any federal, state, host nation, and local regulations and QA/QC protocols and procedures for decontaminating tools, equipment, or other materials, as required. At all times, keep the work area free from accumulation of waste and hazardous materials. Remove nonessential equipment from the work site when not in use. The work-site shall be maintained to present an orderly appearance and to maximize work efficiency. Before completing the work at each sampling site, remove, from the work premises, any rubbish, tools, equipment, and materials that are not property of the Government. Properly dispose of all investigation derived waste. Upon completing the work, leave the area clean, neat, orderly, and return work site(s) to the original condition.

3.5.3 Minimize Impacts to Existing Operations

The contractor shall only install PDBS equipment at existing wells that previously have been surveyed (i.e., have northing and easting data) and that do not contain dedicated sampling equipment that would require removal. The installation POC and the COR shall be consulted to properly position sampling locations (wells, borings, soil gas probes, etc.) with respect to site locations, to minimize the disruption of installation activities, to minimize disruption of natural and cultural resources, and to avoid penetrating underground utilities. If drilling is required for Phase II RPO activities, the contractor shall coordinate all field activities with installation personnel. Provide for the detection of underground utilities utilizing geophysical or other techniques. All necessary permits and coordination shall be completed prior to commencement of individual sampling operations. Frequent communication and coordination with installation personnel shall be necessary to accomplish these goals.

3.5.4 Storage

Responsible for security and weatherproofing of stored material and equipment. Equipment or materials used in the work, requiring storage on the installation, shall be placed at site(s) designated by the installation POC. At the completion of the work, all temporary fences and structures (used to protect materials and equipment) shall be removed from the installation unless directed otherwise by the COR. Clean the storage area of all debris and material, performing all repairs as required to return the site to its original condition. Maintain an inventory of Government property, a copy of Government property control procedures at the site, and dispose of Government property as directed by the CO.

3.5.5 Site Access Badges

Responsible for obtaining and monitoring assigned (used by his/her own staff) security badges used during the duration of this contract. All security badges or passes shall be returned to the facility POC upon expiration of the badge, upon completion of the project, or when possession of the badge is no longer necessary (e.g., upon removal of contracted personnel from specific projects).

3.5.6 Permits and Site Access Agreements

Provide technical support in the identification and procurement of permits and/or access (including off-facility easements and leases) agreements as required to implement a site-specific project.

3.6 Work Breakdown Structure

Proposals, project schedules, and financial report(s) shall be organized according to the work breakdown structure (WBS) proposed by the contractor and approved by the COR.

3.7 Management, Planning, and Reporting Requirements

Plan project activities, including the development, implementation, and maintenance of project schedules, events, status of resources, report(s) on the activities and progress toward accomplishing project objectives, and document for Government review and approval the results of the project efforts for this TO.

3.7.1 WBS Requirements

Prepare and submit for approval a work breakdown structure (WBS). This WBS shall be used to report the cost and schedule status for each project.

3.7.2 Integrated Master Schedule

Not Applicable

3.7.3 Project Planning Chart

Prepare and submit a project planning chart (PPC) for approval. The PPCs will be created using Microsoft Project 98. The Contractor shall submit monthly Project Planning Charts to the COR, FEDERAL FACILITY POC, via e-mail. Hard copies of the PPC will be distributed to the COR and POCs every other month. The PPC shall detail the project schedule, project tasks, current status of all tasks, and current status of all resources through the use of Gantt charts. The percent complete for each task shall also be depicted. The COR, FEDERAL FACILITY POC shall approve the format of the PPCs. The PPC shall detail the project schedule and status through the use of Gantt charts, which shall depict percent complete for each task. Schedule activities shall be reported by the approved WBS.

3.7.4 Contractor's Progress, Status, and Management Report

Prepare and submit a Contractor's Progress, Status, and Management Report (CPSMR). The CPSMR shall be used to review and evaluate the overall progress of the project, along with any existing or potential problem areas. The CPSMR shall be submitted with the monthly invoice for payment and include a summary of the events that occurred during the reporting period, discussion of performance, identification of problems, proposed solutions, corrective actions taken, and outstanding issues. A preliminary payment and monitoring plan follows and shall be adjusted accordingly based on accepted efforts as proposed:

Task	% of Work/Payment
1. System RPO	45
2. Sampling, PDBS	35
3. Guidance Evaluation/Reports	20

3.7.5 Performance and Cost Report (P&CR)

Implement and maintain a cost accounting system and prepare a P&CR to correlate the status of expensed funds and man-hours against the progress of the work completed. The P&CR and associated graphics shall detail the current project status and identify funds and man-hours required to complete the assigned tasks.

4. WORK TASKS

The contractor shall evaluate through laboratory tests the comparability of analytical results using PDBS versus traditional sampling methods. The Contractor shall demonstrate this technology at the sites listed above to determine whether PDBS can successfully detect (identify and quantify) volatile organic contaminants in groundwater. The Contractor shall be responsible for accomplishing the following tasks to optimize the monitoring program(s):

- The Contractor shall provide the following design documentation in the Work Plan and final report:
  - A scaled map identifying the wells to be sampled, and an accompanying table identifying depths for each PDBS in each well.
  - Identify all redundant wells (sampling locations), and recommend decommissioning (this task incorporates only wells sampled using PDBS).
  - Identify appropriate sampling frequency for each well (sampling location) (this task incorporates only wells sampled using PDBS).
- The Contractor shall obtain any permits required to demonstrate/validate the PDBSs. The Contractor shall install the PDBS as described in the Work Plan. Sampling should be coordinated with the installations' Prime Contractor (RA-O/LTM contractor) and facility personnel. The Contractor shall instruct the installations' RA-O/LTM contractor on the appropriate protocol to install PDBSs. Equipment will be installed in the selected site VOC wells. One PDBS sampling round will be performed to statistically determine the performance of the PDBSs as compared to samples taken using "standard" groundwater sampling techniques.
- The Contractor shall return the selected site to its original condition.
- **Sampling and Analysis.** The Contractor shall collect groundwater samples in accordance with the procedures specified in the SAP. Samples shall be collected in a manner that is unbiased to any particular sampling technique.
- During the PDBS sampling round, the Contractor shall collect groundwater samples from each of the identified monitoring wells at the demonstration facility. Duplicate, trip, and other QA/QC samples will be taken according to the installations' SAP guidance. Samples will be analyzed according to the methods outlined in the approved FSP. Screening analytical methods may be used by the contractor to identify the optimum location of the PDBSs in the wells.
- **Performance Assessment.** Upon completion of each demonstration, the Contractor shall prepare a report to document the observations pertinent to the technology performance. These reports will form the appendices of the Final reports to be submitted. The Final BRAC report shall list all the demonstrations performed at BRAC sites. The Final ERA report shall list all the demonstrations performed at ERA sites. The Contractor shall evaluate the performance of the technology in terms of contaminant identification and quantification relative to the fixed laboratory samples. At the end of this beta test of the PDBS, the contractor shall ship items purchased as identified and directed by the COR.

4.1 Professional Planning and Programming

The Contractor shall coordinate as necessary to conduct RPO studies. On selected installations, the contractor shall assist in the selection of the monitoring wells for the demonstration of the PDBS. The selected wells shall satisfy the installation RA-O/LTM program(s).

4.1.1 Planning Actions

Review all available documentation and develop criteria to prioritize requirements, analyze projected environmental projects, provide execution options (funding release dates, obligation schedules and Notice to Proceed milestones), and accomplish other similar recommendations. The Contractor shall prepare a site-specific Work Plan and a project-specific Quality Program Plan (QPP) that includes a Health and Safety Plan (HSP) and SAP. The installations' HSP should be adopted if available. The SAP shall consist of a QAPP and FSP. The installations' SAP should be adopted if available. The Contractor shall prepare schedules and discretely prioritized cost estimates, as specified in this SOW. When developing these plans, the Contractor shall make practical use of previously approved plans. The Contractor shall comply with the specifications, procedures, and methodologies of the approved, contractor-prepared QPP. The CO, COR, and facility POC shall be notified in writing of any proposed modification to or deviation from any activity described in these documents.

4.1.2. Programming Actions

Prepare and submit all documentation necessary to acquire the authority and resources to accomplish the work recommended by the RPO Phase II Studies. Maintain a Record File of all actions taken and/or discussed in a secured location by project, by installation and by category of funding authorization (FEDERAL FACILITY). Proactive status reporting shall be maintained showing the progress of every project assigned from its inception through final closure and project release. Specific project identifiers will be established (using established project numbering system for that installation) for each requirement. Prepare and submit report(s) summarizing the programming actions assigned, their status and highlight those items requiring resolution. All documentation shall be retained in an electronic database. All costing information regardless of its stage in development shall be secured as directed by the CO.

4.1.3. Program Management Integration

Together with the COR develop a master schedule to execute support programs.

4.1.4 Tracking of Performance Metrics and Quality Performance Indicators

Assist in the development of performance metrics, including the tracking of data, development of report(s), and recommendation of improvements.

4.1.5 Statement of Work (SOW)

Not Applicable

4.2 Task Order Scoping and Plan Development Services

Perform task order scoping and plan development services to include:

4.2.1 Site Survey

Not Applicable

4.2.2 Easement Survey

Not Applicable

4.2.3 Project Plans

The Contractor shall submit monthly PPCs to the COR and FEDERAL FACILITY POC in both hard copy and electronic formats (via Microsoft Project). The PPC shall detail the project schedule, project tasks, current status of all tasks, and current status of all resources through the use of Gantt charts. The percent complete for each task shall also be depicted. The COR and FEDERAL FACILITY POC shall approve the format of the Project Planning Charts.

4.2.3.1 Quality Program Plans (QPPs)

Develop a QPP which will consist of any or all of the following:

- Work Plans—Installation-approved QA programming documents will be used to complete work specified in this TO. Whenever such documents do not exist, USACE guidance documents and direction shall be used for all phases of work specified in this TO. RPO and PDBS work plans require adherence to data quality objectives (DQO).

- Health and Safety Plan—Utilize to the fullest extent possible existing Health and Safety Plans (HSP), tailoring them to the current effort. If no HSP is available at the installation, the Contractor shall prepare a HSP to comply with USAF, Occupational Safety and Health Administration (OSHA), US EPA, state, host nation, and local health and safety regulations regarding the proposed work effort. Use US EPA guidelines for designating the appropriate levels of protection needed at the study site(s). The Contractor shall certify that the approved Health and Safety Plan has been reviewed with each employee and subcontractor's employees prior to the time each employee engages in field activities.
- Sampling and Analysis Plan (SAP)—Utilize to the fullest extent possible existing SAPs. The SAP shall consist of both a Field Sampling Plan (FSP) and a QAPP. If a SAP already has been prepared for a specific facility, each TO may require the preparation of project/site specific addenda to the plan(s). SAPs shall be prepared using the installations' appropriate guidance as agreed by the restoration project managers and/or BCTs.

4.2.3.2 Design Work Plan

Not Applicable

4.3 Studies and Services

Provide all labor, materials, and services necessary to deliver, for government review and approval, those studies and services that support environmental programs and projects at locations of interest to the Government. These activities include:

4.3.1 Community Involvement

Support the installation community involvement program for RPO sites only. Work includes internal as well as public meeting support and facilitation, risk communication, support of Government to Government Relations activities, Community Advisory Board (CAB) support, and Restoration Advisory Board (RAB).

4.3.2–4..3.4

Not Applicable

4.3.5 Repository

Provide a repository of technical and regulatory documents applicable to the accomplishment of this task order and maintain a database of due-in deliverables, and an on-line inventory of data management processes to ensure compliance with applicable regulations and requirements. The contractor shall maintain the project deliverable schedule, Gantt charts, and copies of the draft and final documents in a project-specific Web site similar to the existing one for the current RPO studies i.e. http://project1.Contractor.com/rpo. All draft deliverables shall be posted to the appropriate Web site.

4.3.6–4.3.9

Not Applicable

4.3.10 Quality Assurance and Quality Control (QA/QC)

Review, plan and/or develop QA/QC procedures and activities to ensure that data collected by or for the Contractor for this Task Order are accurate and defensible, and support project/program activities. When QA/QC elements for emerging technologies are not available, the contractor shall develop them to meet program DQO needs.

4.3.11–4.3.45

Not Applicable

4.3.46 Remedial Process Optimization

Perform all studies to monitor and evaluate the remedial process to plan, design and implement RPO. The purpose of remedial process optimization is to ensure the effectiveness and efficiency of the remedial process through feedback of information into the decision process.

4.3.46.1 Remedial Process Evaluation

Not Applicable

4.3.46.2 RPO Scoping Visit

The Contractor shall conduct facility-wide assessments to identify opportunities to implement the six RPO strategy components.

4.3.46.3 Evaluation of Remedial Systems and Environmental Equipment

Not Applicable

4.3.46.4 Monitoring Optimization

The contractor shall evaluate environmental monitoring programs and plan and design optimization of environmental monitoring programs in accordance with the USACE guidance, MAROS or other appropriate geostatistical package, and project-specific DQOs. Recommendations regarding well redundancy and sampling frequency will be made only for those wells sampled using PDBS.

4.3.47 Remedial Action Operations

Not Applicable

4.3.48 Warranty of Installed Equipment and Systems

Not Applicable

4.4 Technology (Demonstration) Evaluations

Evaluate cost, performance, and applicability of PDBS. Recommendations shall consider cost, schedule, protection of human health and the environment, public acceptance and technical risk.

4.4.1 Initial Methodologies

Not Applicable

4.4.2 Commercial and Emerging Technologies

Not Applicable

4.5 Miscellaneous Deliverables

4.5.1 Photo Documentation

Prepare photo documentation for training purposed of PDBS implementation. Photography of any kind must be coordinated through the installation POC.

4.5.2 Data Management

If applicable identify the environmental data management system to be utilized.

4.6 Title I Services

Perform all surveys, plans, studies, evaluations, and investigations identified in Section 1.1.1.6 and 1.1.1.8 of this SOW as necessary to support design efforts.

4.7 Evaluation Support

4.7.1 Title II Services

Provide services related to specific or proposed construction project(s).

4.7.1.1–4.7.1.6

Not Applicable

4.7.1.7 Evaluation of Ongoing Actions

As recommended by the RPO phase II, the Contractor shall performs on-site technical surveillance of field operations being performed by others. Provide integrated management oversight and technical assessment of ongoing field work. Assure conformance with the RPO selected remedies and regulatory requirements. Provide an evaluation to ensure that remedies are performing as designed.

4.7.2 Review of Deliverables

Not Applicable

4.7.3 Technical Evaluation of Response to Solicitations

Not Applicable

5. DATA MANAGEMENT

The Contractor shall collect, prepare, publish, and distribute the data in the quantities and types as designated. Designate a focal point who shall integrate the total data management effort and manage changes, additions or deletions of data items. Identify items to be added, recommend revisions or deletion of items as appropriate, and maintain the status of all data deliverables.

6. DELIVERABLE SCHEDULE

Deliverables shall be prepared and scheduled for as follows and shall be included as part of the contractor-prepared planning chart and progress report:

- The **planning chart** shall be due 10 days following an initial planning meeting to be held with USAF, USACE, and contractor personnel and conducted approximately mid-January 2002 timeframe.
- **Meeting Minutes** shall be prepared and submitted within 4 days following meetings.
- **RPO and Sampling Submissions Phase I** field study efforts shall commence in Jan 02 and preceding field studies shall follow and be conducted on a monthly schedule (approximately one per month for RPOs and two per month for PDBS). Order of study shall be initially based on order listed in Annex A. This list will be reviewed and updated at the initial planning meeting.
- **Guidance Evaluation Reports.** Draft and Final reports shall be provided for each technical area for review/update. Efforts for all areas shall commence upon date of award and be conducted concurrently. Drafts shall be due three months after date of award. Finals shall be due 6 months after date of award.

7. GOVERNMENT POINTS OF CONTACT

Project Manager Representative

Other Technical Points of Contact

Federal Facility

8. ABBREVIATIONS, ACRONYMS, AND TERMS

ACM	asbestos-containing materials
ACOE	Army Corps of Engineers
ADP/BDP	Area and Base Development Plan(s)
A-E	Architect-Engineering
AF	Air Force
AFCEE	Air Force Center for Environmental Excellence
AFH	Air Force Handbook
AFHCP	Air Force Hazard Communication Program
AFI	Air Force Instruction
AHERA	Asbestos Hazard Emergency Response Act
AICUZ	Air Installation Compatible Use Zone
ARAR	Applicable or Relevant and Appropriate Requirements
ASCII	American Standard Code Information Interchange
ASTM	American Society for Testing and Materials
BRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
CAA	Clean Air Act
CADD	computer-aided design drawing
CAPP	Compliance Assurance and Pollution Prevention
CDRL	Contract Data Requirements List
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	Contracting Officer
COR	Contracting Officer Representative
CPSMR	Contractor's Progress, Status, and Management Report
CQP	Construction Quality Plan
CRP	Community Relations Plan
CSM	conceptual site model
CSPER	Cleanup System Performance Effectiveness Review
CSSRA	Chemical and Site Specific Risk Analysis
CTP2	Compliance Through Pollution Prevention
CWA	Clean Water Act
DAA	Detailed Analyses of Alternatives
DD	Decision Document
DENIX	Defense Environmental Network &Information Exchange
DIDs	Data Item Description(s)
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DOPAA	Description of the Proposed Action and Alternatives
DOT	Department of Transportation
DQA	Data Quality Assessment
DQOs	Data Quality Objectives
EA	Environmental Assessment
EBS	Environmental Baseline Survey
ECAMP	Environmental Compliance Assessment and Management Program

EE/CA	Engineering Evaluation/Cost Analysis
EDMS	Environmental Data Management System
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right To Know Act
ERP	Environmental Restoration Program
ERPIMS	Environmental Restoration Program Information Management System
ERPTOOLS/PC	ERPIMS Quality Control Tool (software)
ESDD	Environmental Suitability Decision Documents
FEMA	Federal Emergency Management Agency
FFA	Federal Facilities Agreement
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FMER	Funds and Man-Hours Expenditure Report
FONPA	Findings of No Practicable Alternative
FONSI	Finding of No Significant Impact
FRA	Full Risk Assessment
FS	Feasibility Study
FSP	Field Sampling Plan
GCD	Guidance for Contract Deliverables
GIS	Geographic Information System
GPS	Global Positioning System
HABS/HAER	Historic American Building Survey/Historic American Engineering Record
HAZWOPER	Hazardous Waste Operations and Emergency Response
HMA	Hazardous Materials Act
HSP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Act
HTRW	Hazardous, Toxic, and Radioactive Waste
IMS	Integrated Master Schedule
INRMP	Integrated Management Plans
ISA	Initial Screening of Alternatives
ITIR	Informal Technical Information Reports
LBP	lead-based paint
LTM	long-term monitoring
MAJCOM	Major Command
MAP	Management Action Plan
MWRS	Morale, Welfare, Recreation and Services
NATO	North Atlantic Treaty Organizations
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NFA	No Further Action
NFAR	No Further Action is Required
NFRAP	No Further Response Action Plan
NHPA	National Historic Preservation Act
NHRP	National Register of Historic Places
NMFS	National Marine Fisheries Service
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRCS	National Resources Conservation Service
NRDA	Natural Resource Damage Assessment
NRUA	Natural Resource Use Analysis
O&M	Operations and Maintenance
OEBGD	Overseas Environmental Baseline Guidance Document

OPA	Oil Pollution Act
ORM	Operational Risk Management
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
P2	Pollution Prevention
P2OA	Pollution Prevention Opportunity Assessment
PA	Preliminary Assessment
PA/SI	Preliminary Assessment/Site Inspection
PC	personal computer
PCBs	polychlorinated biphenyls
PCOCs	potential chemicals of concern
PCR	Performance and Cost Report
POC	Point of Contact
POL	petroleum, oil, lubricants
PP	Proposed Plan
PPC	Project Planning Chart
QA/QC	Quality assurance and Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
QPP	Quality Program Plan
RACER	Remedial Action Cost Engineering and Requirements System
RAGS	Risk Assessment Guidance for Superfund
RAMP	Radon Assessment and Mitigation Program
RCRA	Resource Conservation and Recovery Act
RDBMS	Relational Database Management System
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RFP	Request for Proposal
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMP	Resource Management Plan
ROD	Record of Decision
RPO	Remedial Process Optimization
RSA	Risk Screening Analysis
RSV	Remedial Process Optimization Scoping Visit
SAM	Sampling , Analysis and Monitoring
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCS	Site Characterization Summary
SCS-ITIRs	Site Characterization Summary ITIRs
SDWA	Safe Drinking Water Act
SI	Site Inspection
SIAS	Socioeconomic Impact Analysis Study
SOW	Statement of Work
SWP3	Stormwater Pollution Prevention Plan
TEAM	The Environmental Assessment Manual
TO	Task Order
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSD	treatment, storage and disposal
TSMP	Toxic Substance Management Plan
US	United States
USAF	United States Air Force
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey

UXO	Unexploded Ordnance
WBS	Work Breakdown Structure
WofUS	Waters of the United States

APPENDIX F

Response to Technical Comments

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RESPONSE TO TECHNICAL COMMENTS

STATE OF MAINE

1. I've reviewed the draft and find I have very little to say about it. I can't tell whether the process the team advocates is a new approach or an amalgam of optimization processes already used by various federal agencies. The recommended steps are mostly common sense to anyone with experience in environmental remediation. They are general and all-inclusive enough so that it's impossible to disagree or offer specific, constructive comments.

   This document is intended to introduce a reader to RPO. The guidance describes the general regulatory and technical framework for evaluating remediation processes, regardless of the type or complexity of the remedy. The guidance identifies and describes the applicability, advantages, and disadvantages of various approaches, as well as where they are most appropriate for use. It also lays out key considerations when planning, designing, and implementing an optimization review.

2. The brand of RPO described in the case studies and in Appendix D is likely to be productive only at large-scale remediation projects. I don't disagree with the statement (Section 3.1) that virtually all long-term sites can benefit from RPO. However, the ITRC template would not be appropriate for 95%+ of our petroleum remediation sites and most Maine RCRA and CERCLA projects, where the potential return would seldom justify the investment. It may be useful to acknowledge this in Section 3 and point out that a focused study limited to a single area of inefficient/ineffective operation can produce dividends at sites where a comprehensive RPO isn't justified.

   Paragraph two in Section 3.1 partially addresses the comment. Additionally, EPA is currently conducting a pilot program using the Remediation System Evaluation (RSE) process. Developed by the U.S. Army Corps of Engineers, the RSE is being used at UST and other smaller site remediation projects to determine if the RSE or "RSE Light" (limited-scope RSE) processes are of value. Section 3.1 has been modified to reflect both the comment and to note the EPA pilot project.

STATE OF NEW JERSEY

3. The terms, "conceptual site model" and "uncertainty management" are key ones for RPO. I wanted to let you know that these terms are also major cornerstones of the Triad approach. You appropriately reference the ITRC Sampling, Characterization and Monitoring Team (note that it is called ASC team, which needs to be corrected) and related Triad guidance on page 1-4. I suggest you review the use of these terms in the SCM-1 Triad document recently published, and hopefully there can be consistent application of these concepts.

   The team name has been corrected. The terms "conceptual site model" and "uncertainty management" have been compared in each document: "conceptual site

model" (CSM) is consistent, usage and definition, between the documents; for example, CSM is a "central concept" in both documents. Further, the use of the Triad approach results in a good CSM, and a good RPO program needs to review the CSM to make sure the CSM remains accurate. Triad approaches can be used to confirm the CSM during RPO.

U.S. DEPARTMENT OF ENERGY OFFICE OF ENVIRONMENTAL MANAGEMENT

4. Considering that this is a coordinated effort among numerous agencies and organizations (DOE, EPA, DoD, States, industry, academia), some of the acronyms are confusing and hard to follow.

   The RPO Team acknowledges the comment and has struggled to minimize the number and use of acronyms. Unfortunately, for publishing purposes and as the comment notes, RPO is a multiagency/program process, so a number of acronyms need to be included. To assist the reader acronym lists can be found in Appendix A and embedded in Appendix E, Sample Scope of Work.

5. Groundwater remediation and monitoring are basically the only processes considered. There is limited discussion of other remedial actions, such as soil remediation, landfill maintenance, and facility D&D. There is no mention of waste management issues. Often packaging and transportation of waste are a huge impediment in making progress. Discussion could be added to explain that this document focuses on groundwater remediation and that waste management issues, although important, are not included.

   Comment acknowledged; the RPO Team concurs. RPO is applicable to a wide range of remediation activities. Section 1.0 has been modified to explain why groundwater remediation and monitoring are the focus of this report and to alert the reader to the possibility of applying RPO to remediation activities other than groundwater pump-and-treat systems and monitoring.

U.S. ARMY

6. The issues discussed in the draft ITRC Remediation Process Optimization Technical Regulatory document will not adversely impact Army environmental or operational activities. The document should make the regulatory community more comfortable with accepting the results of optimization efforts conducted by the Army and its contractors and therefore should benefit Army projects. I believe the document is quite consistent with Army (and DoD) positions regarding periodic remedy evaluation and exit strategy development.

   Comment acknowledged.

7. I recommend that (APPENDIX F Sample Work Plan) Section 3.3.3 (Unexploded Ordnance) be changed as follows:

If UXO or any other munitions and explosives of concern are discovered during field activities, do not attempt to disturb, remove, or destroy it, but immediately report the discovery to the facility point of contact (POC) and COR or to local law enforcement via telephone. Commencement of field activities cannot continue until an appropriate response (i.e., an explosives or munitions emergency response or a munitions response) is completed, and authorized by the CO.

Comment accepted. Appendix E, Section 3.3.3 has been modified.

U.S. NAVY

8. We gave this a thorough review from HQ to the field and have no comments. Our optimization experts have been engaged with the team from the beginning, and this document borrows heavily from DoD processes and guidance. I think it is a good example of the kind of work ITRC should be conducting. The document is well-written and presents the RPO concept in a way that is not prescriptive, yet provides enough framework and detail to be a valuable guide.

   Agreed.

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APPENDIX G

ITRC Contacts, Fact Sheet, and Product List

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ITRC REMEDIATION PROCESS OPTIMIZATION TEAM CONTACTS

Tom O'Neill, Team Co-leader
NJ Dept. of Environmental Protection
609-292-2150
tom.o'neill@dep.state.nj.us

Sriram Madabhushi, Team Co-leader
SCDHEC - BLWM
803-896-4085
madabhs@dhec.sc.gov

Patty Reyes, Team Program Advisor
Mitretek
703-610-2147
patricia.reyes@mitretek.org

David J. Becker
US Army Corps of Engineers
402-697-2655
Dave.J.Becker@nwd02.usace.army.mil

Ning-Wu Chang
Cal EPA Dept. of Toxic Substances Control
714-484-5485
nchang@dtsc.ca.gov

Tanwir Chaudhry
Intergraph/NFESC
805-982-1609
chaudhryt@navy.mil

Donald Gronstal
Air Force Real Property Agency
916-643-3672 x211
donald.gronstal@afrpa.pentagon.af.mil

Karla Harre
Naval Facilities Engineering Service Center
805-982-2636
Karla.Harre@navy.mil

Jon Horin
Mitretek
703-610-2059
horin@mitretek.org

Christopher Hurst
GA EPD, Hazardous Waste Branch
404-463-7508
chris_hurst@mail.dnr.state.ga.us

Bud Johnson
Remedial Operations Group, Inc.
281-462-8444
Bud.Johnson@rogcorp.com

Jill Kiernan
OR DEQ, Site Response
503-229-6900
kiernan.jill.a@deq.state.or.us

Mark Kluger
Dajak, LLC
302-655-6651
mkluger@dajak.com

Bheem R. Kothur
Florida DEP / DWM
850-245-8781
bheem.kothur@dep.state.fl.us

Judith Leithner
US Army Corps of Engineers
Buffalo District
716-879-4234
judith.s.leithner@usace.army.mil

Beth Moore
U.S. DOE - EM 23
202-586-6334
beth.moore@em.doe.gov

Peter Rich
GeoTrans, Inc.
410-990-4607
prich@geotransinc.com

Tess E. Rottero
AMEC Earth & Environmental, Inc.
865.687.7737
te.rottero@amec.com

Javier Santillan
Air Force Center for Environmental Excellence
210-536-5207
Javier.santillan@brooks.af.mil

Russell Sirabian
Battelle
914-576-7713
sirabianr@battelle.org

Robert Sypitkowski
Maine Dept. of Environmental Protection
207-941-4570
robert.a.sypitkowski@maine.gov

Chuck Whisman
Groundwater & Environmental Services, Inc.
610-458-1077 x156
CWhisman@gesonline.com

Rod Whitten
Air Force Real Property Agency (AFRPA/EV)
415-977-8885
rod.whitten@brooks.af.mil

Kathy Yager
U.S. EPA - ORSTI
617-918-8362
yager.kathleen@epa.gov

Xiaomin Yang
BP Remediation Management Function
630-836-7176
yangx22@bp.com

Laura Yeh
Naval Facilities Engineering Service Center
805-982-1660
yehsl@navy.mil

Shaping the Future of Regulatory Acceptance

INTERSTATE TECHNOLOGY REGULATORY COUNCIL — ITRC

www.itrcweb.org

We are ITRC

The Interstate Technology & Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, academia, citizen stakeholders, and federal partners working together to increase regulatory acceptance of state-of-the-art environmental technologies and approaches. With its diverse mix of environmental experts and stakeholders from both the public and private sectors and official participation of more than 40 states, ITRC builds consensus to eliminate barriers to the use of new technologies so that states can reduce compliance costs and maximize resources. Our network of more than 11,000 people from all aspects of the environmental community is a unique catalyst for dialogue between regulators and the regulated community to build and share technical knowledge about the selection, approval, and application of emerging technologies. Together, we're building the states' ability to expedite quality environmental decision making while protecting human health and the environment.

> "Regulation is necessarily conservative regarding deployment of new technologies, yet new technologies often are key to achieving better results sooner and at less cost. ITRC takes aim squarely at this dilemma and, drawing from the combined technical skills and experience of participating state and other agencies, makes the introduction and regulatory approval of new technologies both quick and safe."
>
> —Washington State Regulator

We create...

Guidance documents

ITRC's guidance documents include technology overviews, case studies, and technical/regulatory guidelines. These guidelines—often incorporating decision trees—suggest uniform data requirements for technology demonstrations or approvals. State concurrence with ITRC guidance makes the permitting process more uniform and efficient across states, helping technology consultants and vendors avoid the time and expense of meeting different requirements in each state where an innovative technology is proposed for use.

Training courses

ITRC develops and delivers free, live, interactive, Internet-based training on emerging environmental technologies and approaches. We also partner with industry and other organizations to develop inexpensive classroom courses offered across the country. Our cost-effective training has successfully reached more than 15,000 state, federal, industry, and other stakeholders. When asked about the impact of ITRC documents and training, 90% of respondents indicate that the knowledge they've gained will help them save time or money—usually both—and sometimes the savings amount to millions.

Consensus in the environmental community

Working in teams to create documents and training, ITRC participants leverage each other's expertise. The contentiousness that often characterizes relations between regulators and the regulated community dissipates as teams build understanding of the conditions under which new technologies should be applied, consensus about how they should be regulated, and confidence in their merits. Sharing problems, information, and lessons learned spreads news of successful solutions and increases deployments of the most appropriate technologies and approaches.

We're making a difference

ITRC has documented hundreds of helpful applications of ITRC documents and training beyond the examples presented here to illustrate the range of benefits and beneficiaries. Credit is shared, of course, with the developers of innovative technologies and approaches and the project managers who blaze trails by deploying them. More examples and details are available at www.itrcweb.org.

ITRC is bringing about a culture change in environmental decision making, replacing long-standing adversarial relationships with collaboration, consensus, and concurrence. State regulators are using ITRC guidance documents, training, and peer exchange to find creative ways to reduce regulatory barriers to new environmental technologies, cut approval time, and enhance their ability to make quality decisions. As a result, regulated industries and contractors are benefiting from reduced remediation costs and accelerated cleanup schedules. ITRC's ultimate beneficiary is the public—through a safer, healthier environment; redeveloped brownfields; and a better return on tax dollars.

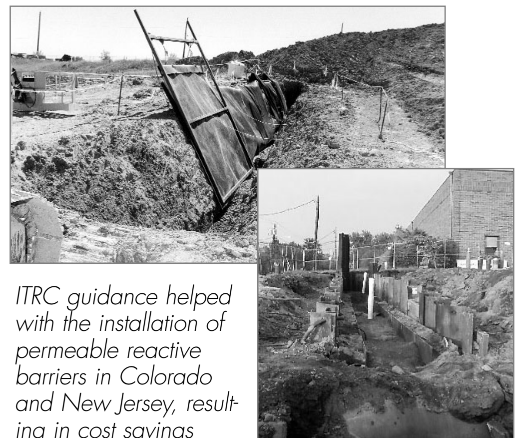
Finding better solutions

Lackland Air Force Base used the expertise, documents, and training of ITRC's Small Arms Firing Range Team to keep 3,500 truckloads of untreated soil off the highways and avoid the associated transportation and disposal costs. At base invitation, team member Gary Beyer, RCRA Corrective Action specialist for the Texas Commission on Environmental Quality, shared alternatives for disposal of lead-contaminated soils examined during the development of ITRC guidance. The soil was chemically stabilized and used to shore up a failing adjacent landfill, an alternative that saved well over $10 million. Beyer suggests that everyone involved with the cleanup of hazardous waste sites "consider participating in the programs, attend Internet training courses, and use guidance documents developed by ITRC to examine using cutting-edge technologies and regulatory solutions developed and promoted by ITRC to save time and money and promote the decreased risk from environmental hazards."

Slashing remediation costs

ITRC guidance on enhanced in situ biodenitrification was used extensively in developing the conceptual remedy for a New Jersey industrial site and in preparing the pilot and treatability study plans submitted to state regulators. "Use of the ITRC guidance saved our client perhaps six months of time and about $10,000 in consulting fees…on top of the remediation savings of between $250,000 and $1.5 million associated with the innovative alternative," according to the site's environmental consultant.

ITRC guidance documents were also key to implementing a bioremediation remedy instead of a large pump-and-treat system at a California chemical manufacturing facility. The facility estimates using ITRC guidance "saved at least a year of consulting time, modeling costs, and other documentation that would have been needed to develop an experimental design, convince the agency, and implement a plan that would have gotten us to the same point. ITRC protocols and principles saved our company at least half a million dollars." Further savings of at least $14 million in capital costs and $3 million in annual costs resulted because the facility was able to demonstrate, with the help of ITRC documents, that in situ bioremediation could work as the primary remedy.



ITRC guidance helped with the installation of permeable reactive barriers in Colorado and New Jersey, resulting in cost savings measured in millions.

Cutting approval time

ITRC's guidance and training for monitored natural attenuation (MNA) of chlorinated solvents helped lead the Louisiana Department of Environmental Quality to approve MNA at a Monsanto plant. Several potential remedies were examined for addressing residual contamination near the soil-groundwater interface. ITRC information and training on implementing monitoring for natural attenuation led to buy-in from LDEQ. Although MNA does require continued monitoring, overall savings of thousands of dollars will occur over time as a result of the adoption of this remedy. "It takes…energy to investigate new remedies and to break down barriers to implement alternative technologies to cleanup. ITRC information and expertise gives confidence that solutions are good." *—Doug Bradford, LDEQ Environmental Technology Division*

Results from passive diffusion bag (PDB) sampling are being used to determine additional removal or remediation steps to be taken at Nebraska's Ogallala groundwater contamination site. "It took some time to determine if the PDBs were applicable, but the information provided by ITRC allowed the decision to use PDBs to move forward," says EPA's Diane Easley. The use of PDBs is anticipated to save $20,000–$50,000 for this project alone. The experience gained at Ogallala also encouraged EPA to allow the use of PDBs at other Nebraska Superfund sites contaminated with volatile organic compounds.

> "I find the workshops extremely informative and very valuable in gaining perspectives in the application of new technologies. This includes both remedial technologies and innovative characterization technologies such as the diffusion sampling method. The fact that the regulatory community is involved helps to facilitate better acceptance of certain technologies and allows the consultant to understand what questions are important to the regulators when proposing a new method."
>
> —Environmental Consultant

Sharing expertise

ITRC documents and training helped consultant Mark Waltham review a site remediation plan incorporating in situ chemical oxidation. "I was able to use knowledge gained from ISCO training to confidently review the...plan. The ITRC training got me up the learning curve very quickly and the interactive nature of the seminar allowed me to get quick answers to my concerns about the technology from experts." The proposed strategy will save several hundred thousand dollars as well as reduce the remediation time from 5–10 years down to 1–2 years.

> "ITRC documents and training have helped South Carolina regulators provide more effective and efficient oversight at a multitude of sites. And in sharing this common foundation of knowledge with cleanup contractors and site owners, South Carolina has streamlined the deployment of innovative technologies and quickened the pace of cleanup at contaminated sites."
>
> —R. Lewis Shaw, Former Deputy Commissioner, South Carolina Department of Health and Environmental Control

Colorado wildland firefighters recently faced not only intense fires but also potential encounters with unexploded ordnance (UXO) on a former defense site. ITRC UXO Team members from the state's Department of Public Health and Environment helped staff from the U.S. Army Corps of Engineers add local and fire management protocol information to the team's UXO Basic Training. Forty firefighters attended the first course just one week after the need for the training was recognized. Subsequent iterations in other states have delivered critical training that would have otherwise been cost-prohibitive.

Building stakeholder confidence

When community leaders learned that uranium had been on a brownfield site in the San Francisco Bay area, they called on members of the ITRC Radionuclides Team to help determine the best protocol to ensure against subsurface contamination. ITRC expertise and synergy yielded a monitoring solution that increased public confidence and led to a quicker resolution of issues confronting site developers.

Praise for ITRC products

"I have worked on a number of very challenging DNAPL sites around the world with some of the top researchers in the country, many listed in your [DNAPL overview] document. One of my largest problems on these sites is finding a reference for the public and my clients which is not too technical yet still thorough enough to explain the many complications encountered on a DNAPL site. I have finally found the right document! Thanks very much for this effort!"—*Michael Moore, The Johnson Company, Montpelier, Vermont*

The Diffusion Sampler Team's Resource CD contains nearly 70 articles and presentations on various diffusion samplers, as well as an ITRC training video. One consultant says, "to effectively coordinate the PDB work performed by others at various remedial locations, I needed a concise source of current information on diffusion sampling procedures and results. The ITRC CD provided that information." Another reports the CD "detailed enough to fully educate the user on the key aspects associated with PDB sampling yet simple and interesting enough to keep a captive audience. We plan to [use] the CD to educate our field staff."

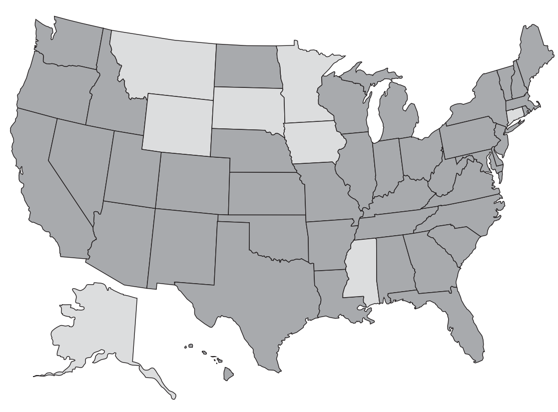
"Substantial dollar savings were realized by using the phytotechnologies decision tree to determine the feasibility of using phytoextraction. Classroom training and guidance documents were critical to the design and implementation of a remediation plan."—*Regulator with the Central California Coast Regional Water Quality Control Board*

"The ISCO training was very useful, timely, and presented in a professional manner. I am recommending that engineers in our organization take the ITRC Internet training."—*Ron Santini, Duke Energy*

"ITRC instructors are the crème de la crème, the most knowledgeable people covering the topics...well known, lending credibility and interest. The classes are good, solid material with a deep content. We get to hear regulators and subject matter experts discuss current, ongoing issues outside our own backyard."—*Teresa Feagin, Westinghouse Savannah River electronic training coordinator*

The training was extremely cost-effective and provided a tremendous amount of useful information. No fluff!"—*Industry participant*

"The networking opportunity provided by ITRC classroom training is great. We're able to successfully bring new technologies into the field more quickly as a result of the training and interaction with other folks versed in chemical oxidation technology. ITRC-sponsored training...has enhanced our ability to bring innovative, cost-effective solutions to our clients."—*Chuck Elmendorf, Panther Technologies, Inc.*



States recognize the value of ITRC, as shown by their growing support and participation. In 2003, states provided more than $2 million of in-kind support for ITRC. People from all 50 states and overseas participate in ITRC activities. The darker shaded states have designated official points of contact for ITRC.

We're organized for success

Teams focus on consensus priorities

The annual revision of ITRC's Five-Year Program Plan is an open process for soliciting and reviewing proposed areas on which to focus resources. With representatives from state agencies, industry, and citizen stakeholders and input from sponsoring federal agencies, ITRC's seven-member Board of Advisors makes final decisions on the technical areas and issues that ITRC's teams pursue. The 21 technical teams funded through this process in 2004 are addressing a diverse set of regulatory and technical issues related to many of the nation's most pressing environmental problems (see table).

> "ITRC resources and the industrywide dialogue within ITRC are critical to ensure that innovative technology is used and promoted appropriately."
>
> —DoD Project Manager

One or more state regulators lead each team, and membership typically includes 15–25 representatives from state agencies, federal agencies, industry, and other stakeholders. Active members and the organizations that they represent agree that they will spend 10% of their professional time supporting team activities. Most teams meet regularly by conference call and three times a year in person.

Teams are generally active for at least three years. The first year is devoted to developing a case study or technical overview document that establishes the state of the practice for an emerging technology or addresses a specific problem area and identifies related regulatory issues. In their second year, teams develop a technical and regulatory guidance document, often with a flow chart to guide decisions on technology selection, approval, and application. Finally, teams develop Internet-based and sometimes classroom training to share and increase use of their guidance documents and to build consensus for their use. In some cases additional documents and training topics are pursued.

State membership

More than 40 states and the District of Columbia are currently active in ITRC. Every member state assigns a point of contact (POC) on the State Engagement Team to help the state benefit from ITRC products and activities and to raise its environmental technology priorities to a national level. Reaching out through its network of POCs, the State Engagement Team works to transform the regulatory process by encouraging state concurrence on ITRC guidance documents, helping technical teams refine their training courses, and tracking where and how ITRC's products and services are making a difference.

ITRC is hosted by the Environmental Council of the States. Experienced regulators' time contributed by member states is the backbone of our program.

Three federal agencies cosponsor and fund ITRC activities: the U.S. Department of Energy, the U.S. Department of Defense, and the U.S. Environmental Protection Agency.

2004 Technical Teams*

Team Name	State Lead(s)
Alternative Landfill Technologies	Colorado
Arsenic in Groundwater	New Jersey
Bioremediation of DNAPLs	Maine
Brownfields	New York
Contaminated Sediments	New Jersey, Washington
Dense Nonaqueous Phase Liquids	New York
Diffusion Samplers	New Jersey
Ecological Enhancements	Colorado
In Situ Chemical Oxidation	Missouri, Louisiana
Mitigation Wetlands	Washington, Minnesota
MTBE and Other Fuel Oxygenates	New Hampshire
Natural Attenuation and Passive Bioremediation	Florida, South Carolina
Perchlorate	Nevada, California
Permeable Reactive Barriers	New Jersey
Radionuclides	Ohio, Colorado
Remediation Process Optimization	New Jersey
Risk Assessment Resources	California
Sampling, Characterization, and Monitoring	New Jersey
Small Arms Firing Range	New Jersey, Washington
Unexploded Ordnance	Alaska, Colorado
Vapor Intrusion (Indoor Air)	Kansas, New Jersey

*All guidance documents can be downloaded from the Web site, including guidance from former ITRC teams: Accelerated Site Characterization, Constructed Wetlands, Environmental Technology and Reciprocity Partnership, In Situ Bioremediation, Low-Temperature Thermal Desorption, Metals in Soils, Phytotechnologies, Plasma Technologies, Policy, Six-State Memorandum of Understanding, and Verification.

Join us!

ITRC is the only organization of its kind led by state regulators and actively involving federal agencies, industry experts, and citizen stakeholders. Our network of environmental professionals exceeds 11,000 and is still growing. We welcome your involvement in our unique approach to tackling the issues facing the environmental characterization, monitoring, and remediation fields. There are many ways you can participate with ITRC:

- Use ITRC guidance documents, and attend our training.
- If your state is not already a member, make participation in ITRC official by appointing a POC to the State Engagement Team.
- Join a team—With just 10% of your time, you can have a positive impact on the regulatory process.
- Be part of our annual conference, where you can learn the most up-to-date information about regulatory issues surrounding innovative technologies.
- Submit proposals for new technical teams and projects.
- Fund ITRC's technical teams and other activities.

Go to www.itrcweb.org to find out more

INTERSTATE TECHNOLOGY & REGULATORY COUNCIL

Product List

September 2004

ITRC documents and other products listed below are available on the ITRC Web site at **http://www.itrcweb.org**.

Document types are shown using the following codes:

G Technical/Regulatory Guidelines
O Technical or Regulatory Overviews
C Case Studies
X Other

Doc. #	Title	Description	Type	Partners
Accelerated Site Characterization (ASC)				
ASC-1	*ITRC/ASTM Partnership for Accelerated Site Characterization–FY-97 Summary Report* (December 1997)	ITRC review and input on *ASTM Guide for Expedited Site Characterization of Hazardous Waste* and report on the options for future collaboration between ITRC and ASTM.	O	American Society for Testing and Materials (ASTM)
ASC-2	*ITRC/USEPA Consortium for Site Characterization Technology Partnership–FY-97 Summary Report* (January 1998)	State participation in the USEPA verification of PCB field analytical and well-head monitoring and soil and soil-gas sampling technologies.	O	USEPA
ASC-3	*Multi-State Evaluation of an Expedited Site Characterization Technology: Site Characterization and Analysis Penetrometer System–Laser-Induced Fluorescence* (SCAPS–LIF) (May 1996)	California certification, USEPA verification, and multi-state acceptance of the SCAPS sensor for in situ subsurface field screening method for polynuclear aromatic hydrocarbons (PAHs).	G	U.S. Navy, Army, and Air Force
ASC-4	*Multi-State Evaluation of the Site Characterization and Analysis Penetrometer System–Volatile Organic Compounds (SCAPS–VOC) Sensing Technologies* (December 1997)	Evaluation and approval of SCAPS-deployed hydrosparge VOC sensor for real-time in situ detection of VOCs below the water table.	G	U.S. Army Corps of Engineers, Waterways Experimental Station
Alternative Landfill Technologies (ALT)				
ALT-1	*Technology Overview Using Case Studies of Alternative Landfill Technologies and Associated Regulatory Topics* (March 2003)	Presents examples of flexibility in regulatory approval of alternative landfill covers, research about the use of alternative covers, and examples of approved designs and constructed covers.	O	
ALT-2	*Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers* (December 2003)	Focuses on the decisions and facilitating the decision processes related to design, evaluation, construction, and post-closure care associated with alternative final landfill covers.	G	
Brownfields (BRNFLD)				
BRNFLD-1	*Vapor Intrusion Issues at Brownfield Sites* (December 2003)	An overview of vapor intrusion, contaminant types with vapor intrusion potential, brownfield sites' potential for indoor air exposure from vapor intrusion, and steps that can limit exposures.	O	
Dense Non-Aqueous Phase Liquids (DNAPLs)				
DNAPLs-1	*Dense Non-Aqueous Phase Liquids (DNAPLs): Review of Emerging Characterization and Remediation Technologies* (June 2000)	Reviews three types of emerging characterization technologies—geophysical, cone penetrometer, and in situ tracers—and two categories of emerging remediation technologies—thermal enhanced extraction and in situ chemical oxidation.	O	
DNAPLs-2	*DNAPL Source Reduction: Facing the Challenge* (April 2002)	Summarizes current regulatory attitudes regarding DNAPL source zone remediation and outlines the pros and cons of partial source removal.	O	
DNAPLs-3	*Technical and Regulatory Guidance for Surfactant/Cosolvent Flushing of DNAPL Source Zones* (April 2003)	Summarizes information needed by regulators and others in selecting and evaluating design and implementation work plans for surfactant and cosolvent flushing of DNAPLs.	G	
DNAPLs-4	*An Introduction to Characterizing Sites Contaminated with DNAPLs* (September 2003)	Discusses scientific approaches and strategies used to characterize sites that are known, or suspected, to be contaminated with DNAPLs.	O	

Doc. #	Title	Description	Type	Partners
Dense Non-Aqueous Phase Liquids (DNAPLs) *Continued*				
DNAPLs-5	*Strategies for Monitoring the Performance of DNAPL Source Zone Remedies* (August 2004)	Presents approaches to performance monitoring of various in situ technologies for treating DNAPL source zones	G	
Diffusion Sampler Protocol (DSP)				
DSP-1	*User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells* (March 2001)	A jointly developed protocol for determining when, where, and how to use diffusion samplers for groundwater sampling.	G	U.S. Geological Survey, Navy, Air Force, USEPA
DSP-2	*ITRC Diffusion Sampler Resource CD, Ver. 3* (July 2004)	Contains DSP-3, nearly 80 articles and presentations on various diffusion samplers, a two-hour training video, and an AFCEE/Parsons field sampling video.	X	
DSP-3	*Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater* (February 2004)	Guidance for regulators, technology users, and stakeholders to facilitate the use of polyethylene diffusion bag sampling, particularly for long-term monitoring, including applicability and regulatory issues, a cost model, and case histories.	G	
Ecological Enhancements (ECO)				
ECO-1	*Making the Case for Ecological Enhancements* (January 2004)	Presents white paper and case studies on natural alternatives to traditional remediation processes.	C	Wildlife Habitat Council
Enhanced In Situ Biodenitrification (EISBD)				
EISBD-1	*Emerging Technologies for Enhanced In Situ Biodenitrification (EISBD) of Nitrate-Contaminated Ground Water* (June 2000)	Description of nitrate in the environment, sources of nitrate, environmental and health effects of nitrate, current nitrate remediation practices, and the emerging technology of EISBD.	O	
In Situ Bioremediation (ISB)				
ISB-1	*Case Studies of Regulatory Acceptance of ISB Technologies* (February 1996)	Case studies of the regulatory barriers and implementation of in situ bioremediation in six states.	C	Colorado Center for Environmental Management
ISB-2	*ISB Protocol Binder & Resource Document for Hydrocarbons* (June 1996) (re-released September 1998)	General protocol and outline for ISB and literature review for natural attenuation and bioventing of petroleum hydrocarbons.	G	
ISB-3	*Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practices* (reprinted September 1999)	Description of practices to be used to recognize and evaluate the presence of natural attenuation of chlorinated solvent contamination.	G	Industrial members of the Remediation Technology Development Forum (RTDF): Ciba Specialty, Dow, DuPont, GE, GeoSyntec Consultants, ICI, Novartis, Zeneca
ISB-4	*ITRC/ISB Closure Criteria Focus Group Report* (March 1998)	Evaluation of state practices for establishing and implementing closure criteria for bioventing, vapor extraction, and natural attenuation of petroleum hydrocarbons and chlorinated solvents.	O	RTDF industrial members
ISB-5	*Cost & Performance Reporting for In Situ Bioremediation Technologies* (December 1997)	Template for obtaining and reporting cost and performance information about the use of in situ bioremediation.	G	RTDF industrial members
ISB-6	*Technical and Regulatory Requirements for Enhanced In Situ Bioremediation of Chlorinated Solvents in Groundwater* (December 1998)	Presents and discusses regulatory processes appropriate to a variety of active bioremediation techniques for chlorinated solvents in groundwater.	G	RTDF industrial members, DOD
ISB-7	*Five-Course Evaluation Summary for the ITRC/RTDF Training Course: Natural Attenuation of Chlorinated Solvents in Groundwater* (September 1999)	Presents a summary of results of surveys returned by people who took the natural attenuation course.	X	RTDF industrial members
ISB-8	*A Systematic Approach to In Situ Bioremediation in Groundwater* (August 2002)	Presents flow paths for defining parameters and criteria leading to decision points for deployment of ISB. Includes decision trees for evaluating in situ bioremediation for treating nitrates, carbon tetrachloride, and perchlorate in groundwater.	G	

Doc. #	Title	Description	Type	Partners
In Situ Chemical Oxidation (ISCO)				
ISCO-1	*Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater* (June 2001)	Discusses the capabilities, limitations, costs, regulatory concerns, and data requirements for using ISCO to remove or destroy BTEX, chlorinated volatile organics, polycyclic aromatic hydrocarbon compounds, and chlorinated semi-volatile organic compounds.	G	
Metals in Soils (MIS)				
MIS-1	*Technical and Regulatory Guidelines for Soil Washing* (December 1997)	Technical requirements for using soil washing technologies.	G	DOE (Office of Environmental Restoration and the Mixed Waste Focus Area)
MIS-2	*Fixed Facilities for Soil Washing: A Regulatory Analysis* (December 1997)	A case study of fixed facilities for soil washing in the United States and in other countries for identifying successful models of deployment.	C	RTDF IINERT Technology Team
	Emerging Technologies for the Remediation of Metals in Soils:	Three separate status reports on technologies for the treatment of metals in soils and the potential regulatory issues associated with their use.	O	RTDF, USEPA
MIS-3	*In Situ Stabilization/Inplace Inactivation* (December 1997)			
MIS-4	*Electrokinetics* (December 1997)			
MIS-5	*Phytoremediation* (December 1997)			
MIS-6	*Metals in Soils 1998 Technology Status Report: Soil Washing and the Emerging Technologies of Phytoremediation, Electrokinetics, and In Situ Stabilization/In Place Inactivation* (December 1998)	Updates the five previous documents.	O	
Permeable Reactive Barriers (PRB, formerly PBW)				
PBW-1	*Regulatory Guidance for Permeable Reactive Barriers Designed to Remediate Chlorinated Solvents* (2nd Edition, December 1999)	Review of regulatory issues associated with permeable reactive barriers.	G	RTDF
PBW-2	*Design Guidance for Application of Permeable Reactive Barriers for Groundwater Remediation* (March 2000)	U.S. Air Force document revised with state input to provide technical information for PRB installation.	G	U.S. Air Force, Environics Directorate, Armstrong Lab, Battelle
PRB-3	*Regulatory Guidance for Permeable Reactive Barriers Designed to Remediate Inorganic and Radionuclide Contamination* (September 1999)	Provides regulatory guidelines for the installation of permeable reactive barriers for the remediation of inorganics and radionuclides.	G	RTDF
Phytotechnologies (PHYTO)				
PHYTO-1	*Phytoremediation Decision Tree* (December 1999)	A tool for determining the applicability of phytoremediation at a given site.	X	USEPA
PHYTO-2	*Phytotechnology Technical and Regulatory Guidance Document* (April 2001)	Identifies key regulatory and technical issues relevant to the implementation of phytoremediation.	G	
Plasma Technologies (PT)				
PT-1	*A Regulatory Overview of Plasma Technologies* (June 1996)	General description of plasma technology and regulatory pathways for permitting.	O	

Doc. #	Title	Description	Type	Partners
Policy (POL)				
POL-1	*An Analysis of Performance-Based Systems for Encouraging Innovative Environmental Technologies* (December 1997)	Case studies of performance-based environmental regulatory and contracting practices and an analysis of activities that could encourage development and deployment of innovative technologies.	C	U.S. Army Environ. Policy Institute, DOD (ES), Idaho National Engineering and Environmental Lab.
POL-2	*Case Studies of Selected States' Voluntary Cleanup/Brownfields Programs* (September 1997)	In-depth case studies of selected states' voluntary cleanup/brownfields programs and recommendations for possible enhancements.	C	Colorado Center for Environ. Mgmt,. Assoc. of State & Territorial Solid Waste Mgmt. Officials
Radionuclides (RAD)				
RAD-1	*Radiation Reference Guide: Relevant Organizations and Regulatory Terms* (December 1999)	Resource of organizations, activities, and technical terminology related to radioactive contamination.	X	
RAD-2	*Determining Cleanup Goals at Radioactively Contaminated Sites: Case Studies* (April 2002)	Summarizes the various regulatory standards and requirements dictating the cleanup of radioactively contaminated sites, processes for developing cleanup levels and, case studies from 12 sites.	C	
RAD-3	*Issues of Long-Term Stewardship: State Regulators' Perspectives* (July 2004)	Presents the results of the survey of state regulator perspectives on long-term stewardship.	O	
Remediation Process Optimization (RPO)				
RPO-1	*Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation* (September 2004)	Provides guidance on how to systematically evaluate and manage uncertainty associated with the remediation process by using RPO as a tool.	G	
Sampling, Characterization and Monitoring (SCM)				
SCM-1	*Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management* (December 2003)	Introduces the Triad approach to conducting environmental work, which increases effectiveness and quality and reduces project costs.	G	
Small Arms Firing Range (SMART)				
SMART-1	*Characterization and Remediation of Soils at Closed Small Arms Firing Ranges* (January 2003)	Provides decision diagram and guidance for planning, evaluating, and approving lead soil remediation systems.	G	
Technology Acceptance & Reciprocity Partnership (TARP)		**www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp**		
	Tier 1 Guidance (December 2000)	A protocol for defining the quality of information that TARP states will accept for a field demonstration of any technology	X	Massachusetts, Pennsylvania, New Jersey, New York, California, Illinois
MOU-1	*Strategy for Reciprocal State Acceptance of Environmental Technologies* (December 2000)	The six-state strategy for reducing duplicative demonstration and testing of technologies, expediting multistate technology acceptance and reducing costs for both vendors and state regulators	X	Massachusetts, Pennsylvania, New Jersey, New York, California, Illinois
	Protocol for Stormwater Best Management Practice Demonstrations (July 2003)	Provides a uniform method for demonstrating stormwater technologies and developing test quality assurance plans for certification or verification of performance claims.	X	Massachusetts, Pennsylvania, New Jersey, New York, California, Illinois, Virginia

Doc. #	Title	Description	Type	Partners
Thermal Desorption (TD)				
	Technical Requirements for On-Site Low Temperature Thermal Desorption of	These three reports serve as the protocol for minimum technical requirements and can be used together when treating a mix of contaminants.	G	DOE Mixed Waste Focus Area
TD-1	*Non-Hazardous Soils Contaminated with Petroleum/Coal Tar/Gas Plant Wastes* (December 1997)			
TD-2	*Solid Media Contaminated with Hazardous Chlorinated Organics* (September 1997)			
TD-3	*Solid Media and Low Level Mixed Waste Contaminated with Mercury and/or Hazardous Chlorinated Organics* (September 1998)			
Unexploded Ordnance (UXO)				
Doc. #	**Title**	**Description**	**Type**	**Partners**
UXO-1	B*reaking Barriers to the Use of Innovative Technologies: State Regulatory Role in Unexploded Ordnance Detection and Characterization Technology Selection* (December 2000)	Using case studies, this document recommends including states in the selection of technologies for detecting and characterizing unexploded ordnance.	C	
UXO-2	*Technical/Regulatory Guideline for Munitions Response Historical Records Review* (November 2003)	A guide for regulators, stakeholders, and others involved in oversight or review of munitions response historical records review projects on munitions response sites.	G	
Verification (VT)		**Nancy Uziemblo (WA) • (509) 736-3014**		
VT-1	*Multi-State Evaluation of Elements Important to the Verification of Remediation Technologies, 2nd Edition* (December 1999)	A matrix of data requirements for a technology verification process to enhance states' confidence in the technology verification and demonstration results. Use of this matrix will allow verification programs to modify their efforts and provide the data most needed by states in their approval process. This type of data collection will encourage states to consider reciprocal state acceptance of verification efforts. Highlights of the verification programs are also provided.	G	11 North American verification programs, DOE, USEPA
Wetlands (WTLND)				
WTLND-1	*Technical and Regulatory Guidance for Constructed Treatment Wetlands* (December 2003)	A guide to help regulators, consultants, and stakeholders make informed decisions about the use of constructed treatment wetland systems for remediating a variety of waste streams, including acid mine water, remedial wastewaters, and agriculture waste streams.	G	