DOE/EH-0505

Environmental Guidance

Guide to Ground Water Remediation at CERCLA Response Action and RCRA Corrective Action Sites

October 1995

U.S. Department of Energy
Office of Environmental Policy and Assistance
RCRA/CERCLA Division (EH-413)
Washington, D.C.

Guide to Ground Water Remediation at CERCLA Response Action and RCRA Corrective Action Sites

October 1995

Prepared by:
Office of Environmental Policy and Assistance
U.S. Department of Energy
Washington, D.C.

Technical support by:
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
managed by
Martin Marietta Energy Systems, Inc.
for the
U.S. Department of Energy
under Contract No. DE-AC05-84OR21400
and
JAYCOR Environmental, Inc.

Preface

The Office of Environmental Policy and Assistance, Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) Division (EH-413), is grateful for the support of the external organizations and internal U.S. Department of Energy (DOE) elements that provided valuable comments and assistance during preparation of this document. The external organizations include:

- U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Hazardous Site Control Division;
- U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Solid Waste, Permits and State Programs Division; and
- U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Waste Programs Enforcement, RCRA Enforcement Division.

The DOE elements are:

- Office of Environmental Policy and Assistance, Air/Water/Radiation Division;
- Office of Environmental Management, Office of Engineering and Cost Evaluation;
- Chicago Operations Office, Program Management Division; and
- Savannah River Operations Office.

This document was prepared by the Office of Environmental Policy and Assistance, RCRA/CERCLA Division (EH-413), with the support of the Environmental Assessment and Compliance Group, Environmental Sciences Division, Oak Ridge National Laboratory, and JAYCOR Environmental.

Table of Contents

Acronyms and Abbreviations viii

1. Introduction 1-1
1.1 Guide Format 1-4
1.2 Getting Started 1-5
1.3 Chapter References 1-5

2. Scoping the RI/FS–RFI/CMS 2-1
2.1 CERCLA Program Expectations/RCRA Corrective Measure Considerations 2-1
2.2 Key Parameters To Be Characterized 2-3
2.3 Developing Site Conceptual Models 2-5
2.4 Exposure Pathways To Be Considered 2-6
2.5 Special Considerations for NAPLs 2-7
2.6 Community Relations/Public Involvement ("Public Participation") 2-8
2.7 Identifying Data Needs and DQOs 2-9
2.8 Development/Function of PRGs/TCLs 2-11
2.9 Remedial Action Objectives 2-12
2.10 Ground Water Response Objectives 2-14
2.11 Remedial Alternatives/Corrective Measures Development 2-15
2.12 Ground Water Aquifer Classification 2-15
2.13 Establishing Points of Compliance for Ground Water 2-16
2.14 Appropriateness of Attaining Remediation Goals/Media Cleanup Standards 2-17
2.15 Use of Alternate Concentrations Limits 2-19
2.16 Determining the Appropriateness of Early Actions 2-19
2.17 Removal Versus Remedial Authority and the Use of "Early Actions" 2-21
2.18 RCRA Streamlining (i.e., Stabilization) 2-24
2.19 Administrative Requirements for Early Actions/Stabilization 2-26
2.20 Streamlined Approach for Environmental Restoration 2-30
2.21 Treatability Studies/Innovative Technologies 2-31
2.22 Preliminary Evaluation of Corrective Measures Technologies 2-32
2.23 Preliminary Identification of ARARs 2-33
2.24 RCRA Compliance with Applicable Laws/Regulations 2-34
2.25 Project Planning Documents 2-35
2.26 Chapter Summary 2-36
2.27 Chapter References 2-37

3. Site Characterization 3-1
3.1 Field Support Activities 3-1
3.2 Ground Water as "Solid Waste" 3-3
3.3 Identification of Ground Water as "Hazardous Waste" 3-3
3.4 Hazardous Waste Determinations/Waste Analysis Plans for Investigation-Derived Wastes 3-4
3.5 Mixed Waste and Waste Analysis Plan Issues 3-6
3.6 Exemptions for Sample Analysis and Treatability Testing 3-7
3.7 Identifying the Presence of DNAPLs 3-8
3.8 Risk Minimization Precautions During NAPL Plume Characterization 3-9
3.9 Integrating the RI/FS and NRDA Processes 3-10
3.10 Components of the Baseline Risk Assessment 3-11
3.11 Reasonable Maximum Exposure Assumptions 3-13

Table of Contents (continued)

3.12 Communication of Baseline Risk Assessment Results 3-15
3.13 Treatability Study Performance Goals 3-16
3.14 Three Tiers of Treatability Studies 3-17
3.15 Recommended Approach to Treatability Studies 3-17
3.16 RI/RFI Reporting and Documentation 3-18
3.17 Chapter Summary 3-20
3.18 Chapter References 3-21

4. Identifying Governing Standards 4-1
4.1 Applicability of ARARs During On-site Study/ Characterization 4-1
4.2 Requirements for Off-site Transfer of "CERCLA Wastes" 4-3
4.3 Hazardous Waste Characterization for Extracted Ground Water 4-4
4.4 Applicability or Relevance and Appropriateness of RCRA Subtitle C 4-5
4.5 AOC/CAMU Relationship to LDRs/Minimum Technology Requirements 4-6
4.6 Additional Options to LDR Management 4-8
4.7 Management of Hazardous Waste "Leachate" 4-8
4.8 Reinjection of Contaminated Ground Water 4-9
4.9 Delisting Ground Water Containing Low Hazardous Waste/ Hazardous Constituent Concentrations 4-10
4.10 RCRA Closure/Post-closure Requirements 4-11
4.11 Evaluating PCB Cleanup Levels and Management Options 4-12
4.12 Safe Drinking Water Act Regulatory Levels and Their Applicability 4-14
4.13 Applicability of FWQC and WQSs to Discharges 4-15
4.14 Discharge Activities Subject to NPDES and Other Regulations 4-16
4.15 Pretreatment Standards for Indirect Discharges 4-17
4.16 Evaluating the Indirect Discharge Option 4-18
4.17 Applicability of CAA/RCRA TSDF Air Emission Standards 4-19
4.18 ARAR Waivers 4-22
4.19 Chapter Summary 4-23
4.20 Chapter References 4-23

5. Screening and Detailed Analysis 5-1
5.1 Development and Role of Remedial Action/Corrective Measure Objectives 5-1
5.2 Initial Screening of Remedial Alternatives/Corrective Measures 5-3
5.3 Screening Criteria and Conditions To Address Ground Water 5-5
5.4 Engineering Controls for Ground Water 5-7
5.5 Enhancement Technologies for Engineering Controls 5-7
5.6 Institutional Controls 5-9
5.7 Nine Evaluation Criteria/Remedy Selection Factors (i.e., Detailed Analysis) 5-9
5.8 FS/CMS Administrative Requirements 5-12
5.9 Chapter Summary 5-14
5.10 Chapter References 5-15

6. Documenting Decisions 6-1
6.1 Objective and Presentation of the Proposed Plan 6-1
6.2 "No Action" Proposed Plan and ROD/RCRA Determination of No Further Action 6-3
6.3 Postproposed Plan Activities (i.e., Public Participation) 6-4
6.4 Documentation of the Final Remedy 6-4

Table of Contents (continued)

6.5 ROD Structures/Language for Ground Water 6-7
6.6 RD/Work Plan Development 6-8
6.7 Public Participation (Community Relations/Public Involvement) During RD/CMI Activities 6-11
6.8 Modifications During RD/RA and CMI 6-11
6.9 Activities, Records, and Reports Related to RA/CMI 6-13
6.10 Chapter Summary 6-16
6.11 Chapter References 6-16

7. Remedial Action Performance 7-1
7.1 Timelines for Evaluation of CERCLA Remedy Performance 7-1
7.2 Considerations During Performance Evaluations 7-3
7.3 Statistical Analysis for Determining Attainment of Cleanup Standards 7-4
7.4 Technical Impracticability Determinations 7-5
7.5 Classification of Action as Construction Complete 7-6
7.6 Requirements To Demonstrate Site Completion 7-8
7.7 Completion of Corrective Measures 7-8
7.8 NPL Deletion Process 7-9
7.9 Chapter Summary 7-10
7.10 Chapter References 7-11

8. Additional Resources 8-1
8.1 DOE Guidance Documents 8-1
8.2 Applicable or Relevant and Appropriate Requirements 8-4
8.3 EPA Policy Interpretations 8-5
8.4 Ground Water Information 8-7
8.5 QA/QC 8-8
8.6 RODs 8-8
8.7 RI/FS—RFI/CMS 8-9
8.8 Remediation Technologies 8-10
8.9 Risk Assessments 8-11

List of Tables

1 Project planning documents 2-35

List of Figures

1 Ground water remediation information flow 1-2
2 Scoping the RI/FS—RFI/CMS 2-2
3 Site characterization flowchart 3-2
4 Identifying governing standards 4-2
5 Screening and detailed analysis of remedial alternatives/corrective measure technologies 5-2
6 Documenting Remedial Alternatives/Corrective Measures decisions 6-2
7 Remedial Alternatives/Corrective Measures performance 7-2

Acronyms and Abbreviations

ACL	alternate concentration limit
AEA	Atomic Energy Act
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available technology
BDAT	best demonstrated available technology
BRA	baseline risk assessment under CERCLA
CAA	Clean Air Act
CAMU	corrective action management unit
CCL	Construction Completion List
CCP	commercial chemical product
CCR	construction completion report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CMC	Corrective Measure Completion
CMI	corrective measures implementation
CMO	corrective measure objectives
CMS	Corrective Measures Study
COR	close out report
CRP	community relations plan
CWA	Clean Water Act
DAF	dilution/attenuation factor
DCG	derived concentration guide
DNAPL	dense nonaqueous-phase liquid
DOC	U.S. Department of Commerce
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	Department of Transportation
DQA	Data Quality Assessment
DQO	data quality objective
DWEL	drinking water equivalency level
EE/CA	Engineering Evaluation/Cost Analysis
EM	Office of Environmental Restoration and Waste Management
EO	Executive Order

Acronyms and Abbreviations (continued)

EPA	U.S. Environmental Protection Agency
EPACML	Environmental Protection Agency Composite Landfill Model
ERA	Ecological Risk Assessment
ERPM	Environmental Restoration Program Manager
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FFCAct	Federal Facility Compliance Act
FFCA	Federal Facility Compliance Agreement
FR	*Federal Register*
FS	Feasibility Study
FSP	Field Sampling Plan
ft.	feet
FWQC	federal water quality criteria
GACT	generally available control technology
gal.	gallon
HA	health advisory
HAP	hazardous air pollutant
HEA	Health and Environmental Assessment
HEAST	health effects assessment summary table
HFO	Head of Field Organization
HRS	Hazard Ranking System
HSP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendments
IAG	Interagency Agreement
IDW	investigation-derived waste
IGCE	Independent Government Cost Estimates
IRIS	Integrated Risk Information System
ISM	interim/stabilization measures
LAER	lowest achievable emission rate
LDR	Land Disposal Restrictions
LNAPL	light nonaqueous-phase liquid
LTRA	long-term remedial action
M&O	management and operations
MACT	maximum achievable control technology
MCL	maximum contaminant level

Acronyms and Abbreviations (continued)

MCLG	maximum contaminant level goal
MCS	media cleanup standard
min.	minute
NAAQS	National Ambient Air Quality Standards
NAPL	nonaqueous-phase liquid
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutant
NFA	no further action
NORM/ NARM	naturally occurring or accelerator-produced radioactive materials
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRDA	Natural Resource Damage Assessment
NSPS	New Source Performance Standards
NTCR	non-time-critical removal
NTIS	National Technical Information Service
OA	Observational Approach
O&M	operation and maintenance
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Act
OU	operable unit
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
PECMT	preliminary evaluation of corrective measures technology
PIP	Public Involvement Plan
PM	particulate matter
PMP	Project Management Plan
POTW	publicly owned treatment works
ppb	part per billion
ppm	part per million
ppmw	part per million by weight
PRG	preliminary remediation goal
PSCS	Preliminary Site Characterization Summary
QAPP	Quality Assurance Project Plan

Acronyms and Abbreviations (continued)

QA/QC	quality assurance/quality control
RA	remedial action
RAO	remedial action objective
RAR	remedial action report
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDT	Regional Decision Team
RFA	RCRA Facility Assessment
RfD	reference dose
RFI	RCRA Facility Investigation
RG	remediation goal
RI	Remedial Investigation
RME	reasonable maximum exposure
RMS	Remedial Management Strategy
RMW	radioactive mixed waste
ROC	regional off-site contact
ROD	Record of Decision
RSD	risk-specific dose
SACM	Superfund Accelerated Cleanup Model
SAFER	Streamlining Approach for Environmental Restoration
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SB	statement of basis
SDWA	Safe Drinking Water Act
SG	specific gravity
SI	Site Investigation
SMCL	secondary maximum contaminant level
SOW	Statement of Work
SWMU	solid waste management unit
TBC	to be considered
TCE	trichloroethylene
TCL	target cleanup levels
TI	technical impracticability
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility

Acronyms and Abbreviations (continued)

USPS	U.S. Postal Service
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WAP	Waste Analysis Plan
WQC	water quality criteria
WQS	water quality standard
yd.	yard

1. Introduction

This Guide contains the regulatory and policy requirements governing remediation of ground water contaminated with hazardous waste [including radioactive mixed waste (RMW)], hazardous substances, or pollutants/contaminants that present (or may present) an imminent and substantial danger. It was prepared by the Office of Environmental Policy and Assistance, RCRA/CERCLA Division (EH-413), to assist Environmental Program Managers (ERPMs) who often encounter contaminated ground water during the performance of either response actions under CERCLA or corrective actions under Subtitle C of RCRA.

The term ERPM subsumes and is functionally equivalent to the terms On-Scene Coordinator and Remedial Project Manager, both of which are defined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 of the *Code of Federal Regulations* (CFR) §300.5] as "the Federal official predesignated by …the lead agency to coordinate and direct removal or other response actions under subpart E of the NCP." The U.S. Department of Energy (DOE) may serve as the "lead agency" when a release or the sole source of a release is from any facility or vessel under the jurisdiction, custody, or control of DOE. The term ERPM should also be viewed as including DOE Area or Site Offices overseeing management and operations (M&O) contractor personnel responsible for conducting RCRA corrective actions.

On January 23, 1987, the President signed Executive Order (EO) 12580 entitled, *Superfund Implementation* delegating to the Secretary of Energy certain responsibilities and functions related to hazardous substance response activities (e.g., remedial and removal investigations and actions) as identified in the NCP. [(1)]

On October 6, 1992, the Federal Facility Compliance Act (FFCAct) was enacted. The act's legislative history indicates that its primary purpose is to ensure that federal facilities are treated the same as private parties regarding compliance with the provisions of RCRA, including RCRA corrective action provisions.

The U.S. Environmental Protection Agency (EPA) typically employs administrative tools that dictate CERCLA response and RCRA corrective action requirements. DOE, EPA, and/or authorized states may enter into an agreement to conduct a Remedial Investigation/Feasibility Study (RI/FS) via a CERCLA §120 Interagency Agreement (IAG)/Federal Facility Agreement (FFA). EPA or the authorized state and DOE typically enter into a Federal Facility Compliance Agreement (FFCA) to conduct RCRA corrective action; however, permitting authority or enforcement orders may also be used. EPA intends to coordinate the application of CERCLA and RCRA authorities through the use of CERCLA §120 IAG/FFAs. The IAG/FFAs provide a vehicle for defining the procedural and technical requirements that will satisfy the statutory and regulatory provisions of both CERCLA and RCRA.

[Update 9/99: It should be noted that if there is evidence of conditions posing an imminent and substantial endangerment to health or the environment, EPA may choose to issue an order to abate conditions as quickly as possible under the imminent hazard provisions of Sect. 7003 of RCRA instead of under other provisions of RCRA or CERCLA.]

The Guide provides a DOE perspective on the EPA-recommended approach to integrating requirements of CERCLA and RCRA. The Guide further lays out the applicable "regulatory road map" and provides ERPMs with explanations of how they may address specific requirements or program management responsibilities. It assists ERPMs in conducting efficient and effective ground water restoration activities while meeting CERCLA and RCRA regulatory requirements and pertinent EPA guidance and policy directives.

The Guide identifies key decision points and actions that must be addressed to ensure compliance with internal management protocols established through DOE orders and guidance memoranda. It highlights opportunities and suggestions (e.g., identification of reporting requirements, milestones, deliverables) at key decision points throughout the CERCLA response action or RCRA corrective action process.

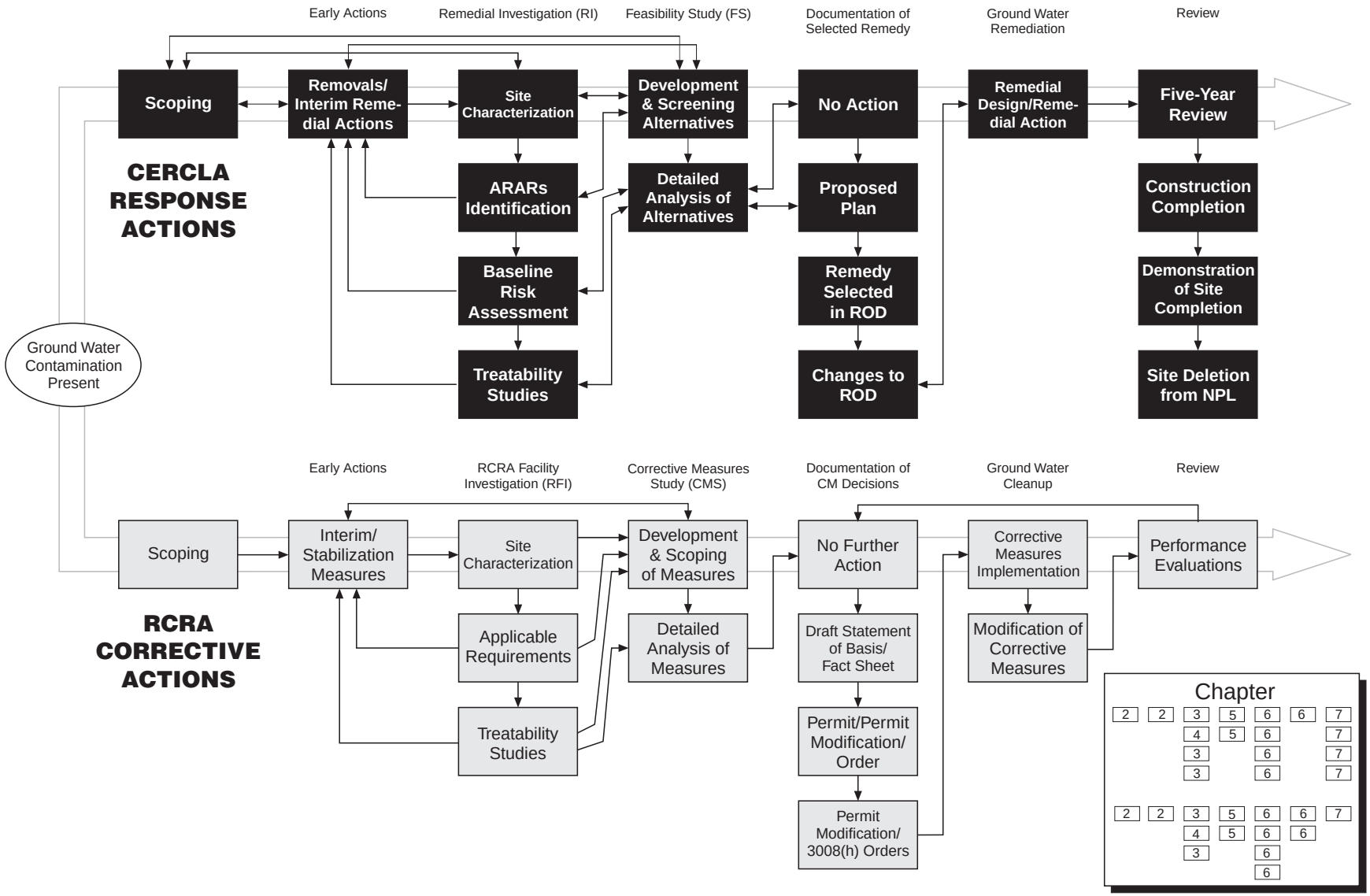

Figure 1. Ground water remediation information flow.

A potential problem is the remediation of ground water contaminated with nonaqueous phase liquids (NAPLs). NAPLs are organic compounds (or mixtures of compounds) that are immiscible (resistant to mixing) with water. Recently, EPA surveyed 310 CERCLA sites to determine the likelihood of dense nonaqueous phase liquid (DNAPL) presence. The results indicate that approximately 60% of all National Priorities List (NPL) sites have a moderate to high likelihood of DNAPL occurrence.

Many of DOE's most difficult ground water remediation issues involve NAPLs identified as hazardous waste and as a component in RMW. The latter is waste containing hazardous waste subject to RCRA and radioactive waste subject to the Atomic Energy Act (AEA). Accordingly, this Guide specifically focuses on issues related to the remediation of ground water contaminated with NAPLs, hazardous waste, and/or RMW under the CERCLA and RCRA programs and relevant DOE guidance.

The Guide incorporates the concept of CERCLA/RCRA integration (i.e., remedial actions under CERCLA essentially parallel corrective actions under RCRA) which is based on EPA's objective of achieving substantive consistency between the policies of CERCLA and RCRA. The Guide highlights the parallels or similarities between CERCLA's RI/FS/Record of Decision (ROD)/remedial action (RA)/remedial design (RD) process and RCRA's RCRA Facility Investigation (RFI)/Corrective Measures Study (CMS)/permit modification/corrective measures implementation process. ERPMs should remain cognizant of this relationship to avoid potentially duplicative efforts. As stated by EPA, "[EPA] anticipates that there may be a number of facilities at which substantial CERCLA remedial studies and/or actual remediation will have been already conducted at the time a RCRA permit is issued. . . . In such cases, if the remedial work has been conducted according to the CERCLA NCP, EPA would consider that work consistent with the requirements of [RCRA] Subpart S, and therefore additional studies or cleanup requirements would be unnecessary" [55 *Federal Register* (*FR)* 30852]. However, although CERCLA response actions and RCRA corrective actions are substantively consistent, programmatic differences do exist. These differences must be addressed separately when appropriate.

DOE orders and guidance memoranda on CERCLA and RCRA programs are summarized and integrated into the Guide. DOE guidance memoranda are either developed in-house by EH-41 or are transmittals of EPA-produced guidance with supplemental information provided by EH-41. DOE develops orders and memoranda when the department believes a need exists to supplement and clarify internal environmental management responsibilities and externally established environmental protection requirements that are applicable to DOE operations. DOE orders are issued in accordance with the authorities of AEA, and other statutes and have the same applicability at DOE facilities or "within DOE" as do actual regulations. The requirements of orders are legally enforceable by DOE against contractors operating DOE installations.

Some references are made to DOE orders that focus on radioactive waste management (e.g., DOE 5400.5, 5480.11, 5820.2A). However, they are not discussed in detail because their specific applicability to ground water remediation efforts is beyond the scope of this Guide. Further, no guidance is directed to the special radiological concerns that may arise with off-site management of RMW. DOE guidelines require that all DOE radioactive wastes and RMW be disposed of at a DOE facility.[2] This prohibition does not apply to (1) when small volumes of RMW qualify on a case-by-case basis, as determined by the appropriate Head of Field Organization (HFO), for off-site disposal pursuant to a conditional exemption granted by the DOE Assistant Secretary for Environmental Restoration and Management or (2) when off-site

disposal has been designated as the preferred alternative for RMW management in a site-specific treatment plan after consultation with EH-1.[3]

The Guide begins with coverage of the regulatory and technical issues that are encountered by ERPM's after a CERCLA Preliminary Assessment/Site Investigation (PA/SI) or the RCRA Facility Assessment (RFA) have been completed and releases into the environment have been confirmed. It is based on the assumption that ground water contamination is present at the site, operable unit, solid waste management unit, or facility. The Guide's scope concludes with completion of the final RAs/corrective measures and a determination by the appropriate regulatory agencies that no further response action is necessary.

1.1 Guide Format

The text in this Guide is formatted in a question-and-answer structure. Often questions/answers address both CERCLA response action and RCRA corrective action requirements. The Guide's text identifies the CERCLA term (or action) first. The corresponding RCRA corrective action term (or action) follows, and the two program-specific terms are separated using a slash mark (CERCLA term/RCRA term). The following examples illustrate this editorial convention:

- FS/CMS,
- final remediation goals/media cleanup standards, and
- area of contamination (AOC)/corrective action management unit (CAMU).

Limited exceptions occur (e.g., interim/stabilization measures, remedial design/remedial action) where the slashes indicate activities under the same program.

Within the text of each answer (and sometimes the question itself), key informational resources are referenced. These references are listed at the end of each chapter under the subheading "Chapter References." Because of length constraints and the Guide's focus on program management–related issues, various resources that contain detailed information on technical issues (e.g., containment technologies for contaminated ground water, contaminant transport in fractured media) were evaluated during the development of the Guide but are not discussed in detail. These references represent potential sources of technical information and are listed in Chapter 8, "Additional Resources." "Chapter References" and "Additional Resources" identify each specific document by publisher, date, title, etc.

Documents published by DOE are available to DOE and DOE contractor personnel by contacting:

DOE Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 36831
Telephone: (615) 576-8401 or (615) 576-1301
FAX: (615) 576-2865

The majority of EPA guidance and directives are available from the National Technical Information Service (NTIS). Persons interested in an EPA document should contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Telephone: Regular Service: (703) 487-4650
Rush Service: (800) 553-NTIS

The Guide begins with a remediation process diagram (Fig. 1) that identifies the broad phases associated with CERCLA response/RCRA corrective action. Activities that take place within each broad phase of operation are further illustrated within the Guide by separate, modular flowchart figures. These modular flowcharts enhance the use of the Guide by summarizing and highlighting within a single figure the information covered within the respective chapter. Individual flowchart items (e.g., boxes), which identify a specific CERCLA response/RCRA corrective action activity, are shaded to illustrate whether the activity is (1) strictly a CERCLA requirement (black), (2) strictly a RCRA requirement (shaded), or (3) pertains to both programs (white).

1.2 Getting Started

To use the Guide effectively, ERPMs should evaluate the status of their site, operable unit, solid waste management unit, or facility relative to the CERCLA and/or RCRA programs (e.g., scoping stage of the RI, initiation of a RCRA CMS), etc.

Based on the results of their detailed evaluation, ERPMs should then determine which CERCLA response/RCRA corrective action phase applies to their given set of site-specific conditions. ERPMs should then proceed to the chapter referenced in the remediation information flow diagram (Fig. 1). If so desired, ERPMs can proceed directly to the appropriate chapter. However, it is suggested ERPMs first review the remediation information flow diagram to determine which chapter is appropriate, and subsequently, where to initiate a review of applicable questions and answers.

This Guide provides as much procedural specificity as possible to clearly define ERPM responsibilities during CERCLA response or RCRA corrective actions. The Office of Environmental Management, Office of Engineering and Cost Evaluation, and appropriate offices within EPA have reviewed this document to ensure its completeness. However, the Guide cannot serve as a substitute for a detailed analysis of applicable regulations or project site-specific conditions. Accordingly, although the Guide is intended to serve as a useful reference document, ERPMs should not make final regulatory decisions or interpretations without the involvement of regulators or other key stakeholders. DOE personnel and DOE contractors are responsible for evaluating state, local, and site-specific regulations and requirements to ensure that all applicable protocols and regulations are addressed. Further, ERPMs must remain cognizant of and consider any site-specific FFA and FFCA provisions that may govern their response activities.

1.3 Chapter References

1. DOE, May 1993. *Executive Order 12580: Superfund Implementation*, Information Brief, EH-231-015/0593, Office of Environmental Guidance, Washington, D.C.
2. DOE, Sept. 26, 1988. *Radioactive Waste Management*, DOE Order 5820.2A, U.S. Office of Defense Waste and Transportation Management, Washington, D.C.
3. DOE, Oct. 12, 1993. Thomas P. Grumbly, DOE Assistant Secretary for Environmental Restoration and Management, *Exemption from Department of Energy Order 5820.2A for Mixed Waste from Environmental Restoration and Waste Management Activities.*

2. Scoping the RI/FS–RFI/CMS

Figure 2 provides a graphic representation of the process of scoping the RI/FS–RFI/CMS and the organization of this chapter.

2.1 CERCLA Program Expectations/RCRA Corrective Measure Considerations

The CERCLA RI/FS process is a dynamic, flexible process—tailored to address the specific circumstances of individual sites. The RI/FS and analogous counterparts under RCRA corrective action—the RFI and CMS—establish general performance standards to allow considerable flexibility when tailoring the specific scope, level of detail, and data requirements for each action. The objective of the RI/FS and RFI/CMS process is to gather sufficient information to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site. ERPMs should consider either (1) the program goals, program management principles, and expectations contained in the NCP or (2) the scope of work identified in the permit, order, or FFCA, as well as confer with regulators to develop an RA/corrective measures strategy. [See 40 CFR § 300.430(b) and proposed 40 CFR § 264.522(a), respectively.]

Q. *What clarification has EPA provided to initially guide ERPMs toward remedy selection?*

A. In the March 8, 1990, final rule entitled *National Oil and Hazardous Substances Pollution Contingency Plan*, EPA identifies its program expectations of the identification and implementation of appropriate remedial actions. Program expectations ultimately influence the establishment of remedial action objectives and the corresponding identification of potential remedial alternatives. The following expectations should be considered by ERPMs when identifying remedial alternatives under CERCLA:

- Treatment is expected to address the principal threats posed by a site wherever practicable. "Principal threats" include liquids, areas with high concentrations of toxic compounds, and highly mobile materials.
- Engineering controls are expected for wastes that pose a relatively low long-term threat or where treatment is impracticable.
- Institutional controls (e.g., deed restrictions) should be used to supplement engineering controls and may be used during the RI/FS, RA implementation, or as a component of the final remedy. Institutional controls cannot be substituted for active response measures unless active measures are not practicable.
- Innovative technologies should be used when comparable or superior treatment performance or implementability, less adverse impacts, or lower costs for similar levels of performance are achievable.
- Usable ground waters are expected to be returned to beneficial uses, whenever practicable, within a time frame that is reasonable given the particular circumstances of the site. When such restoration is not practicable, the prevention of further migration of the plume and exposure to the contaminated ground water is expected. An evaluation of further risk reduction is also expected. [40 CFR § 300.430(a)(1)(iii)].

As previously noted, treatment is expected to address the principal threats posed by a site. Contaminated ground water is generally not categorized as a principal threat. However, EPA points out that the presence of NAPLs in ground water [i.e., pools of DNAPLs submerged

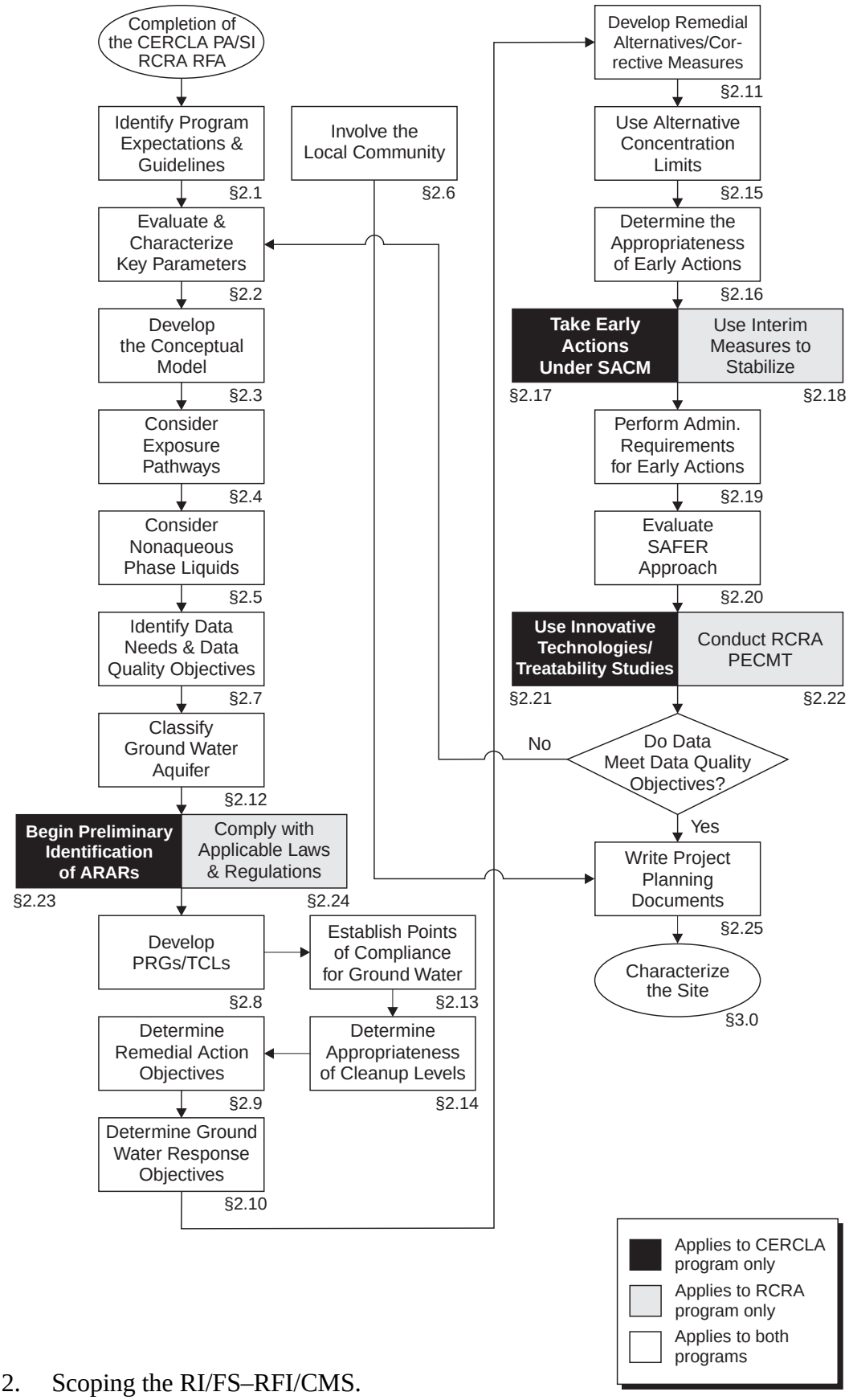

Figure 2. Scoping the RI/FS–RFI/CMS.

beneath ground water or light nonaqueous-phase liquids (LNAPLs) floating on ground water] generally may constitute a principal threat.[1]

While EPA's expectations guide the development of appropriate alternatives, the fact that a remedy is consistent with the expectations does not constitute sufficient grounds for the selection of that remedial alternative. Furthermore, ERPMs should be prepared to use a combination of methods to achieve protection of human health and the environment (55 *FR* 8702).

EPA has promulgated two primary RCRA corrective action program regulations applicable to permitted facilities (or facilities pursuing a permit or post-closure permit). These regulations can be found in Subpart F to 40 CFR Part 264 (for releases to ground water from "regulated units") and proposed Subpart S to 40 CFR Part 264 [for releases from "solid waste management units" (SWMUs)]. Most corrective actions are guided by the applicable permit, order, or FFCA. EPA anticipates that the scope of the corrective measure alternatives evaluation during the CMS will also be dependent upon and tailored to each facility. As explained, ". . . it is [EPA's] general intention to focus these studies on plausible remedies, tailoring the scope and substance of the study to fit the complexity of the situation" (55 *FR* 30821).

In a CMS, ERPMs are required to list and briefly describe potentially applicable technologies that may be employed to achieve corrective action objectives. ERPMs should evaluate these alternatives with the following considerations in mind:

- performance, reliability, ease of implementation, and potential impacts of the remedy (e.g., safety impacts, cross-media impacts);
- effectiveness of potential remedies in achieving source control/cleanup;
- time required from remedy initiation through completion;
- estimation of costs of remedy implementation; and
- institutional requirements (e.g., state or local permit requirements that may substantially affect implementation of the remedy [40 CFR § 264.522(a)(1)–(5)].

ERPMs who determine that only one corrective measure alternative is appropriate for a given situation must identify this measure early in the RFI. Then they may streamline their data collection efforts to include only data needed for the evaluation of that specific corrective measure. Although these considerations are established under the proposed Subpart S rule, EPA contends that the regulations under Subpart F of 40 CFR Part 264 will be revised to make them consistent with the key features of Subpart S.[2]

2.2 Key Parameters To Be Characterized

Scoping is the initial planning phase of ground water remediation activities under the CERCLA RI/FS. RFI activities during a RCRA corrective action closely mirror CERCLA scoping activities. However, several programmatic differences exist. One difference is the use of differing terminology (e.g., "preliminary remediation goals" under CERCLA versus "preliminary target cleanup levels" under RCRA). Another difference is identifying preliminary applicable or relevant and appropriate requirements (ARARs) during scoping under CERCLA but complying only with applicable requirements under RCRA corrective actions. Another major difference is waiving permit requirements for "on-site" CERCLA response activities and complying with permit-related requirements for on-site RCRA corrective action activities.

During scoping/RFI activities, the ERPM strategy must ensure that the data generated and collected to address site goals are adequate to support a clear definition of the remediation

objectives, ERPM decisions, and the analytical method by which ERPM decisions will be made. Before project planning activities can be conducted, an evaluation of existing site characterization data must be performed.

Q. *What are some of the key parameters that must be evaluated and characterized?*

A. A scoping/RFI strategy that incorporates investigative and analytical studies should be tailored to site circumstances so that the scope and detail of the analysis are commensurate with the complexity of the site. The initial phase of the strategy includes assembling and evaluating existing data on the site. Depending on the ERPM requirements, the scoping/RFI strategy should address the investigation goals listed below:

- regional environmental setting (e.g., regional geology, background water quality for ground and surface waters);
- site hydrogeology (e.g., depth and description of aquifers present, flow gradients);
- contaminants of concern (e.g., chemical types and properties);
- contamination characterization (horizontal/vertical extent of contaminant plume, velocity of contaminant plume);
- source identification/characterization (e.g., disposal unit/area characteristics);
- likelihood that subsurface NAPLs may be present;
- routes of migration (including extrapolation of future contaminant movement), which when combined with potential receptors may indicate the need for early actions/interim measures;
- potential receptors (local uses/possible future uses of ground water, proximity to local populations and ground water supplies, target organisms);
- assessment of design parameters for potential treatment technologies (including laboratory, bench-scale, and/or pilot-scale tests or studies); and
- consideration of technical uncertainty and use of statistical analyses to aid in interpretation of data. [3, 4]

Based on available information (e.g., PA, SI, RFA), ERPMs and regulators should meet and begin to identify the following:

- types of actions that may be required to address site problems;
- the necessity of removal actions or interim remedial actions/stabilization measures to mitigate potential threats, prevent further environmental degradation, or rapidly reduce risks significantly; and
- the optimal set and sequence of actions to address site problems.[5]

Historically, a substantial amount of time and money has been expended in the remediation process to characterize key parameters at similar sites or sites with recurring contamination problems. EPA has undertaken an initiative to develop presumptive remedies to accelerate cleanups. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's evaluation of performance data. ERPMs should consider employing (with regulator concurrence) a presumptive remedy approach for contaminated ground water if key parameters indicate the site is one for which a presumptive remedy has been developed.[6]

The ability to adequately scope a specific site is closely tied to the amount and quality of available information. ERPMs should determine the need to update the existing information or augment certain data during the scoping/RFI phase of remediation.

2.3 Developing Site Conceptual Models

Based on an evaluation of the existing data compiled during scoping/RFI, ERPMs need to develop a conceptual understanding of the site. A conceptual model synthesizes data acquired from historical research and available site characterization data/remediation system operation data. Conceptual models are presented schematically, using components from computer models, analytical methods, graphic models, subsurface investigation logs, and other techniques.

Q. *While developing the conceptual model, what elements should ERPMs assess to determine the appropriateness of response/corrective measures at their sites?*

A. Conceptual models serve as the foundation for evaluating the restoration potential of a ground water contamination site. As such, the clarity of each conceptual model is critical to the decision-making process. A conceptual model should identify the contaminants present, the routes of migration, and the potential impacts on sensitive receptors. Additional elements that may be needed (depending on the scope and complexity of the site) include the following broad categories:

- Background Information:
  - location of water supply wells,
  - ground water classification,
  - nearby wellhead protection areas or sole-source aquifers, and
  - location of potential environmental receptors.
- Geologic and Hydrogeologic Information:
  - physical properties of subsurface materials (e.g., texture, porosity, density);
  - stratigraphy, including thickness, lateral extent, continuity of units, and presence of depositional features (e.g., channel deposits that may form preferred pathways for, or barriers to, contaminant transport);
  - geologic structures (e.g., fractured bedrock) that may form preferential pathways for NAPL migration or zones of accumulation;
  - ground water recharge and discharge information; and
  - ground water/surface water interactions.
- Contaminant Source and Release Information:
  - location, nature, and history of previous releases or sources;
  - locations and characterizations of continuing releases or sources; and
  - locations of subsurface sources (e.g., NAPLs).
- Contaminant Distribution, Transport, and Fate Parameters:
  - phase distribution of each contaminant in the saturated and unsaturated zones;
  - spatial distribution of subsurface contaminants in each phase;
  - sorption information, including contaminant retardation factors;
  - contaminant transformation processes and rate estimations;

- assessment of transport mechanisms (e.g., colloidal transport); and
- geochemical characteristics of subsurface media that affect contaminant transport and fate.[7]

The conceptual site model is the primary tool for presenting the known or suspected source-pathway-receptor connections. Site problems (i.e., specific waste sources or situations that present a distinct risk to human health or the environment such as migrating contaminant plumes) are most often developed in terms of source and pathways. Conceptual models, therefore, serve as a logical place to begin identifying and defining site problems that may be good candidates for taking early actions under CERCLA authority or interim stabilization measures under RCRA authority.

Unlike the conceptual model for a comprehensive RI/FS, an early action site conceptual model does not explain in complete detail "how the site works" and need not describe or explore all of the site's source-pathway-receptor relationships. It should summarize all available information about the site problem(s) being addressed.[8]

During conceptual model development, ERPMs should perform a preliminary analysis of the ecosystem, stressor characteristics, and ecological effects to define possible exposure scenarios. Ecological data should be adequate to define contaminant transport between media and biota and among the various trophic levels.[9]

Data evaluation should be undertaken at the initiation of any CERCLA response action/RCRA corrective action program and at each point within the program that additional data are obtained. The conceptual model must be designed so that key model hypotheses may be tested and revised to reflect new information throughout the duration of the project.

2.4 Exposure Pathways To Be Considered

Potential sources of contamination and all associated exposure pathways are identified as part of the conceptual site model. An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual. The model should include known/potential contaminant sources, routes of migration, and human or environmental receptors.

Q. *What contaminant sources and exposure pathways should ERPMs consider at sites with contaminated ground water?*

A. Once ERPMs discern that contaminant release and transport have occurred, the following potential ground water contaminant sources should be identified and evaluated:

- domestic drinking water wells,
- domestic wells for lawn sprinkling,
- public drinking water wells,
- surface water intakes for drinking water,
- agricultural irrigation wells,
- industrial production wells,
- springs,
- surface waters, and

- construction dewatering wells.[3]

Depending on site-specific and regional-specific water use, humans may be exposed to contaminants in ground water through the following exposure pathways: ingestion (i.e., drinking water, eating irrigated crops), dermal contact (i.e., bathing or swimming), and inhalation (i.e., showering, cooking, or washing clothes). Ingestion and inhalation are usually the most important exposure pathways to consider for ground water.

Locations where environmental receptors could become exposed to ground water contaminants may also need to be considered. For example, aquatic life could be exposed to contaminants where ground water flows to wetlands or other surface waters.

2.5 Special Considerations for NAPLs

Hydrogeologic factors (e.g., fractured or karst aquifers), continued leaching from source areas, and system design factors (e.g., pumping rate, location of wells) are all considered when conceptualizing the remedial/corrective action approach. In addition, contaminant factors such as the presence of NAPLs will have a significant influence on the time frame required and the likelihood of achieving appropriate cleanup levels over the entire area of contamination.[10] However, the collection of information on contaminant factors can be combined with other efforts so that site investigation costs and time frames are not adversely impacted.

Q. *What are some of the special considerations for NAPLs?*

A. Many of the organic chemicals of environmental concern enter the subsurface in the nonaqueous phase. How these organics move through the subsurface depends on the grain size and porosity of the aquifer, degree of water saturation in the pore space, and the density and viscosity of the organic relative to water.[11] Once in the subsurface, NAPLs serve as long-term sources of contaminants to ground water. NAPL contamination can be characterized as exhibiting three distinct phases in the subsurface:

- dissolved-phase NAPL (i.e., the portion dissolved in the ground water that migrates principally by advection),
- free-phase NAPL (i.e, the undissolved portion that is capable of migrating to lower depths in the aquifer or to deeper aquifers because of gravity), and
- residual-phase NAPL (i.e., the undissolved portion that is trapped in pore spaces by capillary forces or by chemical gradients and, although immobile, is still a source of dissolved contaminant).

Releases from the immiscible liquid phases (i.e., free-phase and residual-phase) result in a zone of contaminant vapors above the water table and a zone of dissolved contaminants below the water table.

ERPMs need to make an initial determination on whether the presence of NAPLs should be anticipated. This determination is based on the evaluation of existing site characterization data gathered during scoping (e.g., known or suspected types of chemicals released, types of industrial processes used, chemical storage, waste disposal practices). If site information indicates confirmed or high potential for NAPLs at the site, ERPMs should determine whether the NAPLs can be categorized as LNAPLs or DNAPLs. LNAPLs are less dense than water [specific gravity (SG) ≤ 1] and tend to float on the ground water table. DNAPLs are more dense than water and tend to sink downward by gravity, even if this entails movement across or in the opposite direction of ground water flow.[12]

Most common LNAPLs are petroleum fuel (SG: 0.74), fuel oil No. 2 (SG: 0.8654), and related chemicals such as toluene (SG: 0.866) and benzene (SG: 0.8787). Because LNAPLs tend to be found at the water table (shallower depths), they are often easier to locate, tend to migrate in a more predictable manner, and are generally easier to remediate.

DNAPLs include a wide range of compounds and chemical mixtures such as trichloroethylene (TCE) (SG: 1.4649), tetrachloroethylene (SG: 1.623), coal tar creosote (SG: 1.08), and ethylene dibromide (SG: 2.172). DNAPLs can be difficult to locate in the subsurface. The contamination problem at DNAPL sites has two different components that should be characterized: (1) the dissolved plume and (2) the DNAPL zone. The dissolved plume includes those portions of the site where only dissolved-phase contaminants are present in ground water. The DNAPL zone includes those portions of the site where immiscible liquids are present in the subsurface either as free-phase or residual DNAPL.

EPA has devised a guide of two decision charts and a classification matrix for estimating the potential for DNAPL occurrence. By using existing data (i.e., historic site use and site characterization data), ERPMs may apply EPA's guide for estimating the potential for DNAPL occurrence at a site.[13] Among the transport and fate conceptual approaches, ERPMs may need to consider and evaluate the following scenarios:

- DNAPL is released to the vadose zone only, providing a contaminant source of leachable soluble phase compounds and/or DNAPL vapors.
- DNAPL is released to the unsaturated and saturated zones, vertically migrating until the volume is eventually exhausted and is trapped as residual phase where it serves as a continuing source of contamination.
- DNAPL is released into both the unsaturated and saturated zones, vertically migrating down until it is intercepted by a low permeable formation where it begins to migrate laterally, and from which it may spill over and resume its vertical migration.
- DNAPL is released and migrates through the unsaturated and the first saturated zone where it encounters clay with fractures large enough to permit vertical migration downward to the deeper aquifers.
- DNAPL is released and migrates through the unsaturated and the first saturated zone where it encounters a fractured rock or fractured clay system, which allows relatively small amounts of DNAPL to penetrate deeply into the systems.[13, 14]

Depending on the volume of the release and subsurface geology, the DNAPL zone may extend to great depths over large lateral distances from the entry location.

2.6 Community Relations/Public Involvement ("Public Participation")

"Public participation" is DOE's equivalent to the terms "community relations" discussed in CERCLA and "public involvement" used in RCRA. As stated by DOE, "the new culture and operating philosophy of open communication and public participation is central to the management of the Office of Environmental Restoration and Waste Management (EM) . . . . It is Departmental policy to go beyond the specific requirements of laws and regulations to accommodate community and public requests for participation, to the degree practicable. . . ."[15]

A well-designed and implemented public participation program establishes the forum for anticipating and resolving community concerns. At minimum, a public participation program

may reduce the vulnerability of a DOE project to concerted public opposition and strengthen DOE's position in the event of a legal or regulatory challenge.

Q. *What public participation program requirements must ERPMs implement during ground water remediation?*

A. EPA elaborates on CERCLA community relations and RCRA public involvement requirements that must be met during the various phases of ground water remediation in the NCP final rule and in the Subpart S proposed rule (see 55 *FR* 8766-8774 and 55 *FR* 30858, respectively). ERPMs overseeing sites subject to both CERCLA and RCRA may choose to conduct technical and public participation activities simultaneously. As DOE has noted, "Integration offers the opportunity to avoid duplication of effort if CERCLA and RCRA activities are on concurrent schedules."[16] As part of the regulatory requirements [e.g., 40 CFR § 300.430(c), 40 CFR Part 124] or based on DOE and/or EPA guidance, ERPMs should perform the following public participation activities before initiating site characterization field work during the RI/RFI investigation:

- schedule and conduct community interviews with local officials, community residents, etc., to solicit their concerns and information;
- develop a formal community relations/public involvement plan based on these interviews;
- establish an administrative record and at least one information repository (during RCRA corrective actions, the administrative record is maintained by the regulators; it is recommended, however, that DOE facilities also maintain all decision-making documentation);
- notify the community of the information repositories in a local newspaper of general circulation and issue a "kickoff" fact sheet; and
- inform the community of the availability of technical assistance grants at CERCLA response action sites that have been placed on the NPL.[16]

An important difference exists between an information repository and an administrative record. Briefly, information repositories contain information that is not site-specific but that educates the community on the CERCLA process using fact sheets, press releases, newspaper articles, etc. The administrative record is a legal file of documents that form the basis for the lead agency's selection of a response action at that site (55 *FR* 8800).[17, 18]

2.7 Identifying Data Needs and DQOs

Once ERPMs obtain the general conceptual understanding of the site, the appropriate level of detail and data needs (i.e., data gaps with unacceptable or unmanageable uncertainties) must be identified. Data needs are identified by evaluating the existing data and determining what additional data are necessary to:

- characterize the site,
- develop a better conceptual understanding of the site,
- better define ARARs,
- narrow the range of remedial alternatives, and
- support remediation activities.[5]

Data quality objectives (DQOs) are qualitative and quantitative statements that define the type, quality, and quantity of data necessary to support defensible risk management decision making. DQOs are developed after the data needs are established but before data are collected.

Q. *What function do DQOs serve and how many steps are typically involved?*

A. The primary focus of the DQO process is establishing a sampling plan that requires ERPMs to obtain a minimum number of samples that still provide adequate data quality to support a defensible decision.

DQOs play a pivotal role in the planning phase of the data collection life cycle. During the implementation phase of the data collection life cycle, samples are collected and analyzed. During the assessment phase, Data Quality Assessment (DQA) is performed on the data to determine whether the DQOs have been satisfied. At the completion of the DQO process, ERPMs should have documented the project objectives and key performance requirements and identified a sampling design that is expected to achieve the DQOs.

DQOs describe the degree of uncertainty that a decision maker is willing to accept. They are derived from the outputs of each step of the DQO process and are statements that:

- clarify the objective of the data collection effort;
- specify how the data will be used to support the risk management decision being addressed;
- define the most appropriate type of data to collect;
- specify acceptable levels of decision errors (a decision error rate is the probability of making an incorrect decision based on data that inaccurately estimate the true conditions at the site); and
- specify the quantity and quality of data to be collected.[19]

The DQO process involves a series of steps that gradually narrows, focuses, and divides a potentially complex problem into manageable pieces. The process consists of seven steps, which are sequential and iterative. In most cases, each successive step derives information from the previous ones. Thus, each step should be completed in the following order:

- Step 1: State the problem—summarize the contamination problem that will require new environmental data and identify the available resources and the relevant deadlines.
- Step 2: Identify the decision—state the decision (or categorize multiple decisions) that requires new environmental data, as well as the actions and outcomes that may result from the decision.
- Step 3: Identify inputs to the decision—identify the information needed, the resulting measurements needed, and the sources for this information. Specify which inputs require new environmental measurements.
- Step 4: Define the study boundaries—specify the conditions (e.g., time periods, spatial areas, situations) to which the decisions will apply and within which the data will be collected.
- Step 5: Define a decision rule—develop a logical "If, then" statement that defines the conditions that would cause the decision maker to choose among alternative actions.

- Step 6: Specify acceptable limits on decision errors—specify, in statistical terms, the decision maker's acceptable error rates based on the consequence of making an incorrect decision. This establishes performance goals for limiting uncertainty in the data.
- Step 7: Optimize the design for obtaining data—identify the most resource-efficient design for data collection that satisfies all DQOs.

Detailed examples of how these steps are applied at CERCLA sites have been published.[20] This guidance details the use of DQOs relative to the conceptual site model and the Superfund Accelerated Cleanup Model (SACM). It also applies DQO development to three detailed CERCLA response scenarios including a preremedial (site inspection) ground water example.

In many situations it may not be possible to identify all data needs during the initial scoping activities. Therefore, these steps should be undertaken in an interactive and iterative manner where all elements of the DQO process are continually reviewed and applied during data collection activities. As such, DQOs are developed at the onset of remedial investigations and revised or expanded as needed based on the results of each data collection activity.

Under CERCLA, the documentation of DQOs is typically not submitted as a separate deliverable. Instead, DQOs are reflected primarily in the sampling and analysis plan, which includes the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP).[20] Under RCRA, DQOs may be summarized, in general terms, in the QAPP section of the RFI Work Plan.[4]

2.8 Development/Function of PRGs/TCLs

Remediation goals/media cleanup standards (MCSs) are quantitative concentrations of contaminants for each exposure route. These cleanup levels are initially established as preliminary remediation goals (PRGs)/target cleanup levels (TCLs).

Q. *How are PRGs/TCLs developed and what purposes do they serve?*

A. Establishing PRGs/TCLs early in the process serves to focus the development of alternatives/measures on technologies that can achieve these levels; this limits the number of technologies to be considered in the later phases of the FS/CMS. The initial development of chemical PRGs/TCLs is not intended to be a lengthy undertaking. PRGs/TCLs are based on, or derived from, readily available information [e.g., maximum contaminant levels (MCLs), water quality criteria (WQC), concentrations associated with reference doses or cancer potency factors].

During scoping, risk-based PRGs may be calculated for both carcinogenic and noncarcinogenic contaminants using site-specific information and "reduced" equations. In developing PRGs, ERPMs should observe the following steps:

- Identify the media of potential concern (includes currently contaminated media and media that may become contaminated because of contaminant transport).
- List the chemicals of potential concern (i.e., any chemical reasonably expected to be of concern at the site based on known data).
- Assume the most appropriate future land use (i.e., residential, commercial/industrial, agricultural, recreational).
- Evaluate and include in a tabular summary all potential chemical-specific ARARs (e.g., MCLs, federal WQC).

- Identify exposure pathways, parameters, and equations (ground water exposure is generally based on residential exposures once the ground water is determined to be suitable for drinking).
- Identify readily available toxicity values [i.e., by the Integrated Risk Information System (IRIS) or health effects assessment summary tables (HEASTs) values] for all of the chemicals of potential concern for a given exposure pathway.
- Identify target risk levels (for carcinogens the target risk level is initially set at 10^{-6} excess cancer risk as a point of departure).[21]

When ARARs are not available (or when the aggregate risk of contaminants based on existing ARARs exceeds 10^{-4}), PRGs for carcinogens are set at a 10^{-6} excess cancer risk as a point of departure. These PRGs may be revised based on consideration of the following:

- exposure factors (e.g., cumulative effect of multiple contaminants/multiple exposure pathways, cross-media impacts of alternatives);
- uncertainty factors (e.g., reliability of exposure data, reliability of alternatives, weight of scientific health effects evidence); and
- technical factors (detection/quantification limits for contaminants, ability to monitor/control contaminant movement).

The use of the 10^{-6} "point of departure" does not reflect a presumption that the final remedial action should attain such levels (55 *FR* 8716–8718).

For mixed waste, standardized default exposure equations and parameters used to calculate PRGs for the radioactive component are similar in structure and function to those for nonradioactive chemical carcinogens. However, several important areas exist in which risk-based PRG equations and assumptions for radioactive contaminants differ substantially from those used for chemical contaminants. For example, risk equations accept input quantities in units of activity [picocuries (pCi)] rather than in units of mass [milligrams (mg)] and consider only the carcinogenic effects of radionuclides.[21]

Early development of PRGs serve to focus (and in some situations direct) the development of remedial alternatives toward technologies that can achieve the projected goals/levels. This early development limits the number of alternatives that must be considered during the FS/CMS (55 *FR* 8713 and 55 *FR* 30822 respectively).

Under RCRA, preliminary TCLs are typically provided by the regulators and serve as preliminary estimates of the MCSs, which may be established in the remedy selection process. TCLs may be initially established at the applicable action levels and modified as appropriate. If regulators are unwilling to set target levels for the facility, ERPMs should consider developing their own for use in evaluating the corrective measure alternatives.[2] In any case, regulators reserve the right to establish MCSs that differ from TCLs. Typically, regulators will select the MCSs that must be achieved (as well as the corrective measures) after reviewing and approving the ERPM's CMS report.

2.9 Remedial Action Objectives

After the existing site information has been analyzed, a conceptual understanding of the site has been obtained, and DQOs have been identified, ERPMs should begin to identify potential remedial action/corrective measure objectives. Remedial action objectives (RAOs) are generally developed as the first step of the FS. They may include both short-term remediation objectives

(e.g., prevent exposure, containment) and long-term remediation objectives (e.g., remove free-phase, residual, and vapor-phase NAPLs).

Q. *What should ground water remedial action objectives aimed at protecting human health and the environment specify?*

A. RAOs are site-specific, quantitative goals that consist of medium-specific or operable unit-specific standards for protecting human and environmental receptors. Regulatory language under 40 CFR § 300.430(e)(2)(i) indicates that RAOs must specify:

- the contaminants and media of concern,
- the potential exposure pathways and receptors, and
- the remediation goals [i.e., an acceptable contaminant level or range of levels for each exposure medium or operable unit (e.g., contaminant-specific cleanup levels to be attained in an aquifer by a restoration action, concentration levels to be attained in treated water using a wellhead treatment action)].

The following are examples of site-specific RAOs:

- Prevent human ingestion of strontium-contaminated ground water above the maximum contaminant level of 8 pCi/L.
- Meet federal water quality criteria for mercury (0.012 mg/L) and cyanide (5.2 μg/L) at Green River recharge areas to protect resident trout.

In some cases, establishing RAOs involves "plugging in" the appropriate information:

- Prevent ingestion of ground water having (insert carcinogen) in excess of (insert MCL mg/L) and a total excess cancer risk (for all contaminants) of greater than 10^{-4} to 10^{-6}.
- Prevent ingestion of water having (insert noncarcinogen) in excess of (insert MCL mg/L) or [insert reference dose (RfD) mg/kg/day].

By specifying both a contaminant level and an exposure route, ERPMs recognize that protectiveness may be achieved by reducing exposure (e.g., limiting access, alternate water supplies) as well as by reducing contaminant levels.[3]

As with CERCLA response actions, protectiveness is a primary goal of the RCRA corrective action process. Although not required by regulatory language, corrective measure objectives should be proposed as a component of the CMS Work Plan and include proposed target MCSs (i.e., TCLs) and points of compliance.[4] EPA has identified four considerations that may be used when establishing MCSs that protect human health [40 CFR § 264.525(d)(1)(iii)]:

- multiple contaminants in the medium—the risks posed by other constituents in the medium (i.e., ground water) before establishing the MCSs for a single constituent;
- environmental receptors—actual or potential exposure threats to sensitive ecosystems (e.g., wetlands) or threatened or endangered species or habitats;
- other exposures—the presence of other exposures or potential exposures (e.g., high exposure to lead due to the presence of a lead smelter in close proximity to the site); and
- remedy-specific factors—the remedy's reliability, effectiveness, practicability, and other factors (55 *FR* 30826).

RAOs are the first component of the FS. However, ERPMs should not delay their development because the RI and FS are not sequential but rather concurrent processes. After determining RAOs appropriate to the site, a range of remedial alternatives for attaining these objectives will be developed, screened, and compared against the CERCLA "nine evaluation criteria." Each alternative includes a specific combination of remedial methods and technologies that is distinct from the other alternatives under consideration.

If early actions are anticipated, ERPMs should establish strategic-level objectives for each early action identified in the site's phased approach strategy. Strategic objectives are similar to RAOs and identify how an early action will contribute to the overall site remediation. In formulating objectives, note the value of establishing the site problems to be addressed and the actions to be taken, as well as the problems that will not be addressed by the early action(s).

As with RAOs, strategic objectives are dynamic and may be refined in the consensus memorandum or in the work plan for each early action. They should be more clearly defined than is generally possible for RAOs; if an early action is conducted, a decision has been made that some type of intervention or remediation is required, and the general nature of the action has been established.[8]

2.10 Ground Water Response Objectives

Response objectives are medium-specific, initial cleanup objectives. They are established on the basis of the nature and extent of the contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure.

Q. *Relative to contaminated ground water, what are some potential response objectives?*

A. The following list identifies potential or generic (i.e., nonsite-specific) objectives that may be appropriate for responding to ground water contamination:

- Prevent exposure to ground water contaminants.
  - Provide an alternate water supply.
  - Treat contaminated ground water at the point of use (wellhead treatment).
  - Restrict use with institutional or engineering controls.
  - Prevent contaminants from reaching wells or environmental receptors.
- Prevent further migration of contaminants to or within ground water.
  - Minimize migration of contaminant plume (plume containment).
  - Minimize migration of contaminants to ground water from source areas (e.g., contaminated soils or NAPLs) using containment methods (source containment).
  - Minimize migration of contaminants to ground water by removing or treating sources (source removal/treatment).
- Remove contaminant from ground water (ground water restoration).
  - Reduce contaminant concentration to levels safe for domestic use (i.e., drinking and/or inhalation exposure).
  - Reduce contaminant concentration to levels safe for biological receptors that may be affected at the release point.[3]

The number and type of alternatives that may be employed to attain appropriate response objectives should reflect the scope, characteristics, and complexity of the site problem that is

being addressed. Further, the extent of cleanup to achieve the response objectives will be defined by the site-specific, quantitative RAOs.

2.11 Remedial Alternatives/Corrective Measures Development

As discussed in the NCP final rule, RAOs are initially developed at the work plan stage before the commencement of RI/FS activities. (55 *FR* 8712)

Q. *In addition to identifying preliminary RAOs and general response objectives, what additional activities should ERPMs perform?*

A. Concurrent with developing site-specific RAOs, ERPMs should begin developing a preliminary list of remedial alternatives/corrective measures for attaining these objectives. These alternatives/measures will be screened and compared using either the nine evaluation criteria from CERCLA or the four general criteria and five decision factors from RCRA during the FS/CMS.

The identification of potential technologies at this stage will help ensure that the data necessary to evaluate them will be collected as early as possible. Furthermore, early identification of technologies will facilitate an earlier determination that treatability studies are necessary.[5] Several broad categories of ground water remedial alternatives/corrective measures can be selected. For both deep and shallow ground water, ground water remediation objectives and the associated remedial alternatives might include:

- action restoration—three extraction wells pumping at a rate of 10 gal./min. to a carbon adsorption unit and discharging to a publicly owned treatment works (POTW);
- plume containment—installation of a bentonite barrier wall and use of well construction permits to prevent new well installation within the area of contamination;
- natural attenuation—monitoring of ground water for 10 years when contaminant levels are expected to dilute and attenuate to health-based levels; or
- no action response—development of alternate concentration levels and issuance of well-construction restrictions.[3]

The preliminary list of alternatives/corrective measures should include a specific remedial method or combination of remedial methods and technologies that is distinct from the other alternatives under consideration. At a minimum, this list should include a treatment alternative that significantly reduces the toxicity, mobility, or volume of waste; a containment alternative with little or no treatment; and a no-action alternative.[5]

2.12 Ground Water Aquifer Classification

Ground water PRGs (i.e., cleanup levels) are established based on the nature and extent of the contamination, the resources that are currently or potentially threatened, and the potential for human and environmental exposure.[3] The first step in identifying ground water PRGs is to classify the ground water (e.g., current or potential sources of drinking water). In the March 8, 1990, NCP final rule (55 *FR* 8732) and the December 21, 1988, proposed rule (53 *FR* 51433), EPA explained its ground water classification systems and the use of a draft document entitled *Guidelines for Ground Water Classification.* This document employed a three-tiered system (i.e., Class I, II, and III) for classification of ground water. Since that time, however, EPA has prepared guidance to assist states in establishing their own ground water protection goals and

their own classification system (which many states have done), and is encouraging states to evaluate their ground water resources.

Q. *What guidelines should ERPMs use to evaluate the resources (i.e., ground water aquifers) that are currently or potentially threatened?*

A. Current EPA and DOE ground water policy is based on value, use, and vulnerability. The policy takes into account technical practicability and social and economic factors rather than the three-tiered classification system.[22] The three-tiered system is also too open-ended on Class III ground water. It implies that any ground water with a total dissolved solids content of 10,000 mg/L can be contaminated with no limit.

DOE does not favor the three-tiered approach contained in the 1986 guidance. It recognizes EPA's July 1991 policy, which bases the approach on two classes (i.e., either the ground water is a current or potential future source of ground water or it is not). The July 1991 EPA ground water policy states that remediation will generally attempt to achieve a total lifetime cancer risk level in the range of 10^{-4} to 10^{-6} and exposure to noncarcinogens below appropriate RfDs. This policy further clarifies that more stringent measures may be selected based on site-specific factors (e.g., cumulative effect of multiple contaminants, exposure from other pathways). Less stringent measures may be authorized based on factors such as technological practicability, adverse environmental impacts of remediation measures, cost, and low likelihood of use.[23] The DOE Ground Water Protection Policy is consistent with EPA's and places added emphasis on "economic" factors.

Finally, as noted above, many states have established their own classification systems based on several factors (e.g., hydrogeologic factors, suitability to accept specified releases, wellhead protection and recharge areas, geologic confinement, use and/or quality). ERPMs should recognize that many states use their classification systems as a guide to establishing cleanup standards in state remediation activities. The states generally evaluate remediation on a case-by-case basis.

The guidelines discussed above should serve as guidance for ERPMs negotiating cleanups that are subject to legally applicable procedures and for determining remedial action. ERPMs should be aware that once ground water is determined to be suitable for drinking, risk-based PRGs/preliminary TCLs generally should be based on residential exposures.[21]

2.13 Establishing Points of Compliance for Ground Water

Q. *Although points of compliance for attaining remediation goals/media cleanup standards are established on a site-specific basis, what general policies should ERPMs implement when establishing the points of compliance for ground water?*

A. EPA policy discussions indicate what is necessary to achieve "remediation" of ground water aquifers under CERCLA/RCRA Subpart S. Final remediation goals/media cleanup standards should be attained throughout the contamination plume or at and beyond the edge of the waste management area when the waste is left in place. (Under CERCLA, this area is also known as the area of attainment.) Where an alternative strategy results in source containment, portions of the plume outside the containment area should be restored. For further discussion on points of compliance see 55 *FR* 8753 (CERCLA) and 55 *FR* 30830 (RCRA).

Based on site-specific circumstances, alternative points of compliance that continue to protect human health and the environment may be necessary. When determining an alternative point of

compliance for ground water, ERPMs should consider the following factors (under both CERCLA and RCRA Subpart S):

- proximity of the sources of contamination,
- technical practicability of ground water remediation at that site,
- vulnerability of ground water,
- possible uses of ground water, and
- exposure or likelihood of exposure (55 *FR* 8753 and 55 *FR* 30830, respectively).

In contrast, under 40 CFR § 264.100 (Subpart F), regulators establish a different point of compliance. Specifically, under Subpart F, the point of compliance is at the vertical plane located at the hydraulically downgradient limit of the regulated unit, extending from the surface to the lowest point of the uppermost aquifer underlying the regulated units.[(2)] At this point the ground water protection standard (also established by the regulators) applies, and monitoring must be conducted. If the facility contains more than one regulated unit, the regulated unit is described by an imaginary line circumscribing those regulated units (40 CFR § 264.95).

For corrective actions under existing Subpart F of 40 CFR Part 264, regulators require ERPMs remediating ground water contamination to continue corrective action until the designated ground water protection standard has not been exceeded for a period of three years (40 CFR § 264.100). Under Subpart S, to demonstrate compliance with media cleanup standards, regulators will specify the length of time during which ERPMs must demonstrate that concentrations of hazardous constituents have not exceeded the established standards [40 CFR § 264.525(e)(3)].

2.14 Appropriateness of Attaining Remediation Goals/Media Cleanup Standards

Q. *In addition to situations where ground water is not an actual or potential source of drinking water, are there other situations when ERPMs may not be required to attain the established remediation goals/media cleanup standards within the aquifer (i.e., restore contaminated ground water)?*

A. In some situations, based on engineering feasibility and reliability, it may not be practicable or feasible to fully restore ground water. The following two conditions may limit the effectiveness of ground water restoration:

- hydrogeological constraints (e.g., aquifers with transmissivity less than 50 $ft.^2$/day, contaminant migration into fractured bedrock or karst aquifers), and
- contaminant-related factors [e.g., presence of DNAPLs, interactions between contaminants and the aquifer material (sorption) that limit removal rates].

When confronted with one of these situations, ERPMs conducting CERCLA response actions may need to consider identifying ground water restoration as technically impracticable from an engineering perspective. They should evaluate the appropriateness of pursuing a technical impracticability (TI) ARAR waiver. A third condition is not considered by EPA to have sufficient justification for a determination of technical impracticability.[(7)] In this situation, remediation design system inadequacies (e.g., insufficient number of extraction wells, excessive downtime) inhibit a system's ability to achieve the selected cleanup levels.

If multiple contaminants are present, ERPMs should evaluate the potential for, and advantages of, attaining cleanup levels for some of the contaminants. Based on the contaminants

present, ERPMs may choose to invoke a TI waiver for one or more contaminants, (e.g., TCE) while attaining cleanup levels for contaminants that are amenable to restoration (e.g., chromium).[7]

Under RCRA, in addition to technical impracticability, EPA proposes two circumstances (based on a site-specific demonstration by the ERPM) where the Regional Administrator may determine that remediation of a release of a constituent to a media cleanup standard is not necessary (55 *FR* 30828–30830). To warrant this determination, ERPMs must demonstrate the following [40 CFR § 264.525(d)(2)]:

- The affected medium is also contaminated by substances that are naturally occurring or have originated from another source.
- Remediation would provide no significant reduction in risks.
- The constituent is present in ground water that is not a current or potential source of drinking water and is not hydraulically connected with waters to which hazardous constituents are migrating or are likely to migrate in concentrations greater than action levels.

Under RCRA, upon successful demonstration, the Regional Administrator may require any alternative measures or standards deemed necessary [40 CFR § 264.525(d)(3)]. The regulators may not require any remediation. They may elect to limit the response to implementing source controls. They may require remediation to levels that are protective of environmental receptors and impose deed restrictions on well installation. Natural attenuation could be determined to be the most appropriate solution based on factors such as location, proximity to population, and likelihood for exposure. Although a TI decision may precede a decision to select natural attenuation, TI of restoration is not a precondition for the use of natural attenuation.[7]

Determinations regarding whether CERCLA cleanup levels or RCRA media cleanup standards are technically practicable may be made either as part of the FS/CMS ("front-end decisions") or after the selected remedy has been implemented and monitored for a period of time ("postimplementation decisions"). EPA believes that, in many cases, TI decisions should be made only after the interim or full-scale aquifer remediation systems are implemented.

When ground water restoration is determined to be impracticable, ERPMs conducting CERCLA response actions should begin considering alternative remedial strategies. Under CERCLA, potentially appropriate alternative remedial strategies must prevent further migration of, and prevent exposure to, the contaminated ground water plume while further risk reduction measures are evaluated. ERPMs should be aware that the choice among available alternative remedial strategy options may involve a consideration of the aggressiveness of the remedy (i.e., a concept that includes the selection of the remedial technology as well as the relative intensity of how that technology is applied at the site).

Under both programs, when an alternative strategy results in source containment, portions of the plume outside the containment area should be restored. However, when remediation goals/cleanup standards must be met, both the CERCLA and RCRA programs require that these levels be attained throughout the contaminated plume or at and beyond the edge of the waste management area when the waste remains in place. For further discussion on points of compliance see 55 *FR* 8753 (CERCLA) and 55 *FR* 30830 (RCRA).

2.15 Use of Alternate Concentrations Limits

Q. *Are there any other options that may be employed when active restoration of the ground water to MCLs or other protective levels is not practicable?*

A. Active restoration of the ground water to nonzero maximum contaminant level goals (MCLGs) or MCLs may not be practicable based on an analysis using CERCLA remedy selection "balancing" and "modifying" criteria. ERPMs should then consider establishing alternative concentration limits (ACLs) provided all of the following statutory conditions [CERCLA § 121(d)(2)(B)(ii)] are met:

- The ground water has known or projected points of entry into surface water, which is a reasonable distance from the facility boundary.
- There will be no statistically significant increase (at the 95% confidence level) of constituent concentrations occurring in surface water at the discharge zone or at any point where constituents are expected to accumulate (e.g., downstream sediments).
- Enforceable measures (e.g., institutional controls) will be implemented that will preclude human exposure to the ground water contaminants between the facility boundary and all known or projected points of entry into the surface water.[3]

If a situation fulfills the conditions discussed above, documentation of these conditions for the ACL is sufficient. Additional documentation of an ARAR waiver of the nonzero MCLG/MCL is not necessary (55 *FR* 8754).

During RCRA corrective actions, although no specific statutory or regulatory citation specifically authorizes the use of ACLs, the Regional Administrator has the authority to "require any alternative measures or standards [e.g., ACLs] . . . necessary" [40 CFR § 264.525(d)(3)].

Site-specific cleanup levels (e.g., ACLs established in response to a TI determination) should not be confused with ACLs established as part of the ground water monitoring program for RCRA-regulated units under 40 CFR § 264.94. ACLs established under 40 CFR § 264.94(a)(3) represent concentrations that regulators determine will not pose a threat to human health or the environment. If regulated unit (as defined under RCRA) ACLs are exceeded, then corrective action responsibilities for the owner/operator of the regulated unit are triggered.[7]

2.16 Determining the Appropriateness of Early Actions

At sites with complex ground water contamination problems, ERPMs may face uncertainty regarding the restoration potential of their site. At the same time, they must recognize the need to control risk of exposure to, or limit further migration of, the contamination.

Q. *What factors must ERPMs assess when determining the appropriateness of early actions to address this situation?*

A. One of EPA's recent program management initiatives focuses on maximizing near-term environmental benefits. This initiative identifies, evaluates, and addresses sites or releases that present the greatest risk to human health and the environment. Under CERCLA, the SACM initiative encourages expanded use of "early actions" to achieve this goal. Under RCRA, interim/stabilization measures (ISMs) are the recommended actions that are used to achieve this goal (known as "stabilization").

Early actions are appropriate where the need for action is obvious and the nature of the required action is relatively clear. That is to say, an early action begins with the premise that an action is necessary and, usually, a clear idea of what that action most likely should entail.

ERPMs overseeing site restoration activities should consider a phased approach to remediation that incorporates the use of early actions/ISMs when it is necessary to quickly control risk of exposure to, or limit further migration of, the contamination at their site. EPA has interpreted this to mean "If . . . receptors could be exposed to contaminants within 5 to 10 years or interim measures could reduce the present or near-term (i.e., less than 2 years) risks, then this criterion has been met."[7]

The SACM/stabilization initiatives do not create new regulatory or administrative processes. They are implemented through the existing provisions within each respective program. Early actions under CERCLA may be
initiated by ERPMs and rely on either removal or remedial action authority. Removal actions are classified as emergency, time-critical (response must be initiated within 6 months), or non-time-critical removal actions (NTCRs) (at least 6 months before activities must be initiated).

Additional factors identified by DOE for determining candidates for an early action include: amount of understanding that already exists about site problems, intended scope of action, and allowable provisions of any site-specific agreements (i.e., IAG/FFA) already in place. Additional DOE considerations— nature of threat/risk to be addressed, risk reduction/other objectives, and certainty of threat—are also appropriate for identifying candidates for an early action.[8]

Under remedial authority, early actions include the use of interim remedial actions and early final remedial actions. Early final remedial actions are used for the final cleanup of an operable unit or portion of a site early in the remediation process. Interim remedial actions address a threat in the short term while a long-term solution is developed.[24] These actions may be taken at DOE sites on the NPL provided the remedial response is consistent with, and does not preclude implementation of, the final remedial action.[10]

The categorization in SACM of early removal action and early remedial actions as "early actions" is meant to better communicate the timing and nature of actions designed to achieve rapid reduction of risk. These actions do not necessarily include cleanup of all contamination. A phased approach strategy must reflect a consensus of the extended project team (DOE, EPA, and state agencies). Meetings of the extended project team and exchanges of draft iterations of the site's phased approach strategy are appropriate methods for reaching consensus. Necessary points of consensus include:

- appropriateness of a phased approach for an operable unit,
- identification of some site problems that are candidates for early actions,
- identification of some site problems deferred to a comprehensive RI/FS/RD/RA, and
- identification of steps and schedule for implementing a phased approach.[8]

Under RCRA, ERPMs may achieve stabilization using interim measures. Interim measures are an optional phase to be conducted at the discretion of the regulators. Under RCRA, only a potential release or threat of a release is needed to afford ERPMs the opportunity to request the option of focusing limited DOE resources on near-term activities. These activities would control or abate threats and/or prevent or minimize the further spread of contamination (i.e., implement ISMs). As with CERCLA remedial actions, ISMs must not conflict with the final action.

The decision to initiate early actions/ISMs will be based generally on an evaluation of information gathered during the CERCLA PA/SI or the RFA. Early actions/ISMs are typically performed before or concurrent with the RI/FS or RFI/CMS. However, decisions to implement early actions/stabilization may come at various stages in the CERCLA response/RCRA corrective action process. The timing depends on when information is produced that suggests such actions are warranted.

ERPMs also may choose to employ a phased approach to site characterization and remediation when there is uncertainty regarding the ultimate restoration potential of a site and when a need to quickly control risk of exposure or limit migration exists. A phased approach to restoration affords ERPMs an important opportunity to achieve interim goals at the outset of the response action, while concurrently gathering additional site information. ERPMs should use the information gathered during implementation of early actions/ISMs to develop a better understanding of the restoration potential of the contaminated ground water. They should incorporate this information into their conceptual understanding of the site. By utilizing a phased approach, ERPMs may be able to reduce the uncertainty associated with site remediation while gathering the information necessary for the next phase of characterization.(7)

In addition to reducing the risks posed by a site, advantages for using a phased approach include: expediting response actions because ERPMs are afforded the opportunity to conduct parallel or concurrent response activities, demonstrating earlier progress to stakeholders through early cleanup of site problems, using the phased approach process to provide a forum for stakeholders to voice their concerns and then responding to their concerns, and reducing costs by focusing studies/data collection and reducing the overall time for preparing design documents and conducting response actions.(8)

ERPMs conducting RCRA corrective action should consider a request to the regulators allowing them to phase remediation by performing a release assessment (or Phase I RFI) as the first phase of an RFI. The release assessment takes place between the RFA and RFI. It is used to minimize corrective action activities (by focusing the RFI, not adding another step in the process). It should serve as an update to the RFA if some uncertainty exists regarding releases (e.g., because of activity subsequent to the RFA) or to determine whether there has been a release to ecological/living resources.(4)

2.17 Removal Versus Remedial Authority and the Use of "Early Actions"

Under CERCLA, EPA provides detailed guidance on the implementation of early actions within the context of the new SACM initiative. Early actions may be implemented under removal action or remedial action authority, depending on the timing and nature of the action.

Q. *What factors should ERPMs consider when deciding between using removal and remedial authorities?*

A. As the lead agency, DOE may conduct removal actions under its own authority. Early remedial actions generally require regulator approval. Specific FFAs should be consulted because some may restrict DOE's use of a specific CERCLA response authority or explicitly require regulatory agency consent before initiating an action.(8)

When determining which CERCLA authority is warranted, ERPMs should assess whether the site is on the NPL. In general, CERCLA remedial authority cannot be initiated unless a site has been listed on the NPL. Once a site is listed, the only requirement for an interim remedial action is that it be consistent with, and not preclude implementation of, the expected final remedy [40 CFR § 300.430(a)(1)(ii)(B)].

Regardless of a site's NPL status, emergency removal actions should be used to respond to acute situations that have no alternate to immediate action. These are often addressed a part of ongoing operations using facility response plans.

Time-critical removal actions (e.g., providing an alternate water supply) require less than 6 months planning and can be implemented in very short time frames. Although DOE generally has the authority to implement time-critical removals without prior notification of, or approval from, the regulators, DOE field offices should not attempt to operate independently of regulatory agency or public involvement. Furthermore, useful information may be contributed by regulators as part of the extended project team.

Time-critical removal actions are appropriate when:

- a release or threat of release requires near-term action,
- the required response is fairly obvious and straightforward, and
- temporary or final waste management capacity is available.

Additionally, time-critical removal actions are appropriate when the predefined criteria established under the contingent removal program are met.

Contingent time-critical removal actions, which are preplanned procedures for implementing time-critical removal actions, may be useful in reducing the possibility of delays. Contingent time-critical removal actions utilize predefined criteria (e.g., ground water in downgradient monitoring wells exceeds MCL), planning and decision procedures (i.e., environmental management personnel will sample for the contaminant(s) at the entry point to the public water supply distribution system), and appropriate technical approaches [i.e., extraction rates will be increased in recovery (extraction) wells 5, 6, and 7 and alternate drinking water will be supplied until samples taken form the distribution system no longer exceed the MCL]. These criteria, procedures, and approaches may be established by a DOE field office but typically require extended project team consensus.

Major uncertainties and data gaps generally cannot be tolerated for a time-critical removal action. Any unknowns that render implementation or probable success of the action highly uncertain will usually require a more involved study than is feasible within a 6-month time period. Further, data collection prior to action generally is not feasible for a time-critical removal action.[8]

In most cases, ERPMs should continue to use remedial action authority to respond to most contamination problems that are expected to require more than 5 years to complete ("long-term action") such as ground water restoration projects.[24] To address complex ground water contamination sites, ERPMs should consider performing remedial action in phases using operable units as early actions [40 CFR § 300.430(a)(1)(ii)(A)]. Operable units are discrete actions that comprise incremental steps toward the final remedy and can address a geographical portion of the site or the entire site. Examples of operable units related to ground water include:

- providing alternate water supplies,
- remediating a contamination plume,
- remediating contamination in a shallow aquifer,
- remediating contamination in a deep aquifer, and
- implementing source control actions.[3]

ERPMs should be aware that early actions may also be performed at sites that are not listed on the NPL but qualify as "NPL caliber sites." Under SACM, NPL caliber sites are a focus of early actions (and integrated assessments) and include sites that have a Hazard Ranking System (HRS) score above 28.50. Included as well are sites at which public drinking water supplies are contaminated with hazardous substances or private wells are contaminated above a health-based benchmark.[25]

For ERPM's overseeing response actions at sites that are NPL or NPL caliber sites, additional guidance for determining whether to use removal authority or remedial authority may be found in preamble language to the NCP final rule. In this final rule, EPA identifies the factors that ERPMs should consider when deciding whether an early action should be implemented as a removal action or a remedial action. Specifically, ERPMs should consider the following:

- the criteria and requirements for taking removal actions identified in 40 CFR § 300.415(b)(2) including:
  - actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants;
  - actual or potential contamination of drinking water supplies or sensitive ecosystems;
  - hazardous substances, pollutants, or contaminants in drums, barrels, tanks, or other bulk storage containers that may pose a threat of release;
  - high levels of hazardous substances, pollutants, or contaminants in soils at or near the surface that may migrate;
  - weather conditions that may cause hazardous substances, pollutants, or contaminants to migrate or be released;
  - threat of fire or explosion;
  - the availability of another appropriate federal or state response mechanism to respond to the release; and
  - other situations that may pose threats to public health or welfare or the environment;
- the statutory limitations on removal actions ($2 million/12 months) and the criteria for waiving those limitations (e.g., not Superfund-financed);
- the availability of resources; and
- the urgency of the site problem (55 *FR* 8704).

EPA guidance also indicates that the Office of Emergency and Remedial Response has established an action-level policy that differs from the action levels that trigger corrective action under RCRA and the proposed Subpart S rule. This action level determines whether a removal action should be implemented in response to ground water contamination. Action levels may be either:

- numeric values based on drinking water equivalent levels (DWELs), which also depend on whether the contaminants are volatile organic chemicals and/or potential human carcinogens or
- site-specific factors including the possibility of contamination of drinking water or sensitive environments or other situations or factors that may pose threats to public health, welfare, or the environment.[3]

EPA has published detailed guidance for calculating action levels, including detailed site-specific factors.[26] For quick reference, a list of drinking water contaminants and their

relevant information (e.g., DWELs, 10^{-4} cancer risk levels, MCLs/MCLGs) has been published and is routinely updated.[27] It is available by contacting the Safe Drinking Water Hotline, (800) 426-4791.

DOE has developed a matrix of factors that may be useful when assessing the scope of an early action (i.e., emergency/contingent removal, time-critical removal, non-time-critical removal, early remedial). These include:

- investigation possible/required,
- scope of action,
- implementability consideration (including waste management),
- cost limits,
- evaluation needed,
- consistency with final remedy,
- stakeholder involvement, and
- ability to tolerate limited success of action.

The key to a well-developed phased approach strategy is careful determination of the type of early action that is appropriate for addressing each specific site problem. Extended project team discussion of the appropriate use of early actions may be based on these and other factors.[8]

During the implementation of remedial actions, all ARARs identified in the ROD must be attained. If a component of the remedy was not identified when the ROD was signed, ARARs that are in effect when that component of the remedy is identified (e.g., during remedial design) must be attained (55 *FR* 8757–8758). Under 40 § CFR 300.415(i)(1) and (2), removal actions (regardless of whether the site is listed on the NPL) must attain ARARs to the extent practicable. These actions must consider the urgency of the situation (i.e., the need for prompt response) and the scope of the removal action (e.g., attaining a degree of cleanup that would be inappropriate or inconsistent with the limited scope and purpose of a removal action.).[28] When evaluating the appropriate response authority, "Strong consideration should be given to NTCRs (i.e., where an estimated 6-month planning period is required), that will achieve results comparable to a remedial action, but which may be completed in less time."[29]

Even in situations where attainment of ARARs is practicable, ERPMs may consider whether one of the statutory waivers from compliance with ARARs [codified under 40 CFR § 300.430(f)(1)(ii)(C)] is appropriate for a response action. (See 55 *FR* 8694–8696 for related discussions.)

2.18 RCRA Streamlining (i.e., Stabilization)

Q. *Are there any provisions under the RCRA corrective action program that are comparable to the SACM early actions initiative?*

A. In July 1990 the RCRA Implementation Study recommended more frequent use, where appropriate, of interim/stabilization measures during the early stages of corrective action. The goal was to achieve near-term environmental protection at facilities with the most serious problems.[30] EPA's RCRA program has adopted as a program management initiative—the "stabilization" of RCRA facilities. The overall goal of the stabilization process is "to control or abate threats to human health and/or the environment from releases and/or prevent or minimize

the further spread of contamination while long-term remedies are pursued."[4] ERPMs may suggest opportunities for conducting stabilization. However, decisions concerning how and when to streamline the corrective action process are made at the discretion of the regulators.[4]

The stabilization initiative incorporates the use of ISMs, which may be initiated either through enforcement actions, through RCRA permitting procedures, or voluntarily. If stabilization is imposed by the regulators, it is implemented using the following six-step process:

- Assign a priority level for corrective actions and stabilization.
- Evaluate the facility and its contaminant releases to determine the appropriateness of stabilization measures.
- Issue an order, issue a permit, or amend an existing permit to include clauses requiring stabilization.
- Collect data needed to select and design the stabilization measures.
- Select and design the stabilization measures.
- Implement the stabilization measures (this step includes implementation of a monitoring program after the stabilization measures are in place).[31]

ISMs are used to achieve near- to mid-term results at RCRA corrective action sites. ISMs are comparable to early actions under CERCLA and can be performed under either emergency or nonemergency conditions. In the first case, ISMs are deemed immediately necessary, and measures that are taken (often in accordance with the facility's RCRA contingency plan) are subsequently followed by notification of the regulators. Under nonemergency conditions, ISMs may occur over a period of several weeks up to 2 or more years. Nonemergency measures are prescribed by regulators and will generally follow a work plan. The plan is prepared by the ERPM and must be approved by the regulators before implementation.

Because of the broad spectrum of situations that exists at the beginning of an RFI investigation, stabilization often calls for a flexible, phased approach. "Remedial phases" (also referred to as "phased remedies") under RCRA consist of a logically connected set of actions performed sequentially over time or concurrently at different parts of a site and are similar to the designation of operable units under CERCLA. Initial remedial phases should be consistent with, and complementary to, the final remedy selection and in no way impede future cleanups (55 *FR* 30835). Frequent, informal communication between ERPMs and regulators can facilitate the integration of the ISM process with the long-term corrective action process.

In the case of Federal facilities, conditional remedies may be useful during phased approaches under RCRA, especially when technical limitations and/or financial constraints impede cleanup operations. Conditional remedies, which are site-specific, allow ERPMs to phase in corrective measures provided certain conditions are met (e.g., media cleanup standards are achieved for ground water migrating beyond the point of compliance). The primary benefit of using the conditional remedy provisions is that existing contamination may be allowed to remain within the facility boundary for the term of the permit. Appropriate site circumstances include:

- ERPMs implement source controls which prevent off-site migration;
- the risk of exposure, additional releases, or further migration is low; and
- remediation of off-site contamination is implemented to achieve media cleanup standards.

Authorizing conditional remedies is a discretionary function; therefore, EPA is under no obligation to allow use of this option. Through negotiations with the regulators, ERPMs should seek authorization to conduct conditional remedies whenever appropriate. [The objective of a conditional remedy (i.e., stabilizing risks and delaying the final remedy) can be achieved through the implementation of stabilization. Once stabilization under RCRA is fully implemented at Federal facilities, conditional remedies will not be necessary.][(2)]

Another consideration for the planning process is the use of CAMUs. EPA explicitly provides for situations where CAMUs may be appropriate for remediation waste management before final remedy implementation (58 *FR* 8672). CAMU provisions are designed to reduce or eliminate certain waste management requirements (e.g., land disposal restrictions, minimum technology requirements) that may impede remediation activities. Regulators will consider the applicability of the CAMU provisions on a case-by-case basis. ERPMs desiring to take advantage of the CAMU approach must contact EPA and propose their designated area as a CAMU. EPA's decision will depend on an assessment of the following:

- the extent and nature of the contamination,
- the location of existing SWMUs within the contaminated area, and
- the remedial objectives established for the entire facility.

In some cases, existing RFI work schedules and requirements may have to be revised to accommodate the selection of an interim measure, designation of an area as a CAMU, or data collection for stabilization activities. Accordingly, for RFI work plans that are being negotiated, if appropriate, ERPMs should propose incorporating ideas and strategies for stabilization. Existing RFI work plans and schedules of compliance may not be sufficiently flexible to accommodate stabilization activities. If so, the potential benefits of stabilization should be weighed against the time and effort needed to obtain modifications to the cleanup agreement.

2.19 Administrative Requirements for Early Actions/Stabilization

Q. *Are there any administrative requirements associated with performance of early actions/stabilization activities?*

A. ERPMs often work in concert with or as part of Regional Decision Teams (RDTs). They determine the appropriate CERCLA response action based on the type of situation, the urgency and threat of the release or potential release, and the subsequent time frame in which the action must be initiated and its duration. The type of action employed (e.g., emergency removal action, interim remedial action, early final remedial action) will impact the level of analysis, level of documentation, timing of administrative record development, and extent of public participation required under the NCP.[(24)]

To develop and document an integrated site response program, ERPMs should prepare a phased approach strategy to address individual operable units (OUs). The strategy is developed jointly by the extended project team (i.e., DOE, EPA, and the state) and identifies the following for each OU:

- problems amenable to early action,
- the specific removal and remedial authorities that will be used to support investigation and action for each site problem,
- the planned timing of the approach, and

- issues associated with integrating the phased approach and the final cleanup.

A strategy memorandum that summarizes the OU phased approach strategy is prepared. The memorandum should be as short as possible (i.e., target 10 pages) and include declarative statements regarding what has been agreed upon. A key element is a table or flowchart that presents all of the site problems and the action(s) envisioned (early or final) for each one. Site problems without an established course of action should be noted. The memorandum should acknowledge the undecided issues (e.g., land use) and provide working assumptions (e.g., land use assumed to be industrial until a final land use decision is made).

Site problems (which when aggregated constitute an OU) require additional planning. The exact site problem, strategic objective, scope of the anticipated action, measure of success, and issues associated with integrating the early action with the full RI/FS/RD/RA must be explicitly defined for each early action identified in the phased approach strategy. These decisions are incorporated into a consensus memorandum.

In the phased approach strategy, undecided issues were acknowledged and preliminary agreements or working assumptions were developed. In the consensus memorandum, outstanding issues are accommodated and resolutions are agreed upon by the extended project team. Therefore, the consensus memorandum serves as a link between the phased approach strategy and the Early Action Work Plan.[8]

An integrated removal and remedial site management strategy under SACM will most likely involve the increased use of NTCR authority to achieve prompt risk reduction at CERCLA sites.[32] NTCR actions are implemented when a removal action is necessary. These actions are based on the urgency, threat of the release or potential release, and the subsequent time frame in which the action must be initiated.

If a non-time-critical removal action or an early remedial action will be implemented, an Early Action Work Plan, which builds on decisions established in the consensus memorandum, should be used to delineate all aspects of the early action. The plan details activities and decision points for the early action process through the decision phase and preparation of the Action Memorandum or Interim Action/Final Action ROD. Work Plans should incorporate site plans [e.g., the QAPP, the Health and Safety Plan (HSP), the Monitoring Plan, the Waste Management Plan, and the investigation-derived waste (IDW) Waste Management Plan and Sampling and Analysis plan (SAP) (when limited field investigations are involved)] as appendices.[8]

First, a Removal Site Evaluation must be completed, and the need for an NTCR action (planning period of at least 6 months) must be determined. ERPMs [acting as the On-Scene Coordinator (OSC)] then prepare an Engineering Evaluation/Cost Analysis (EE/CA) Approval Memorandum (or its equivalent). This memorandum secures management approval and funding and documents that the situation meets the NCP criteria for initiating an NTCR action. It also provides detailed information illustrating that a threat or potential threat to public health, welfare, or the environment could exist and justifies the need for conducting an EE/CA.[32]

For NTCR action, the Removal Site Evaluation fulfills the purposes served by the RI report. An EE/CA serves a similar function to the Focused Feasibility Study report that is written for an interim remedial action or early final action.

An EE/CA or its equivalent must be completed for all NTCR actions [40 CFR § 300.415(b)(4)(i)]. ERPMs must conduct an EE/CA or its equivalent and identify the objectives of the removal action. Then they analyze the various alternatives that may be used to achieve these objectives for cost, effectiveness, and implementability. While the EE/CA is similar to the

RI/FS conducted for remedial actions, it is less comprehensive. To ensure an early action is consistent with any long-term action that may be required, ERPMs should fully evaluate the opportunities for treatment and permanence in the EE/CA. ERPMs should also prepare a streamlined risk evaluation that is intermediate in scope between the risk evaluation for emergency removal actions and the conventional baseline risk assessment. The "streamlined risk evaluation" should identify only contaminants of concern, contaminant concentrations, and the toxicity associated with the chemical in the affected media. ERPMs that use presumptive remedy guidance may in many cases provide an immediate focus to the discussion and selection of an alternative. This focus accelerates the EE/CA process by limiting the universe of effective alternatives for the NTCR action.[32]

Selection of the appropriate response is documented in the Action Memorandum. This memorandum summarizes the EE/CA, identifies the proposed action, and explains the rationale for the removal. The Action Memorandum serves as the primary decision document substantiating the need for a removal response and is a critical component of the administrative record. In this respect, the Action Memorandum for removals (both time-critical and NTCR) parallels the function of the ROD but is not as elaborate as the ROD.[33]

Consensus on the need for, and the scope and objectives of, a time-critical removal is developed by the extended project team using one of three avenues:

- through the development of a consensus memorandum under a phased approach,
- through the development of a contingent time-critical removal actions criteria, or
- if neither of these approaches has been pursued, through the issuance of an Action Memorandum addressing a single action on an ad hoc basis.

For time-critical removal action (less than 6 months planning), the Removal Site Evaluation fulfills the purposes served by the RI report and the FS for a remedial action. It is typically based on available information and describes site problems, the action objectives, and the alternatives considered. It also presents a recommendation to proceed with a removal action.

To streamline the planning phase, the Removal Site Evaluation may be conducted in conjunction with the Action Memorandum, and the Removal Site Evaluation can be integrated with the Action Memorandum to consolidate planning documentation. (Note: For a time-critical action, no draft Action Memorandum is prepared for public review and comment.)

If a consensus is reached that time-critical removal authority should be used to address an early action, a Removal Action Work Plan that complements the Action Memorandum should be developed. This work plan should incorporate site plans (e.g., the QAPP, the HSP, the Monitoring Plan, the Waste Management Plan) as appendices.[8]

When an early action is considered a removal action under 40 CFR § 300.415, ERPMs conducting the removal action also must submit, when appropriate, an On-Scene Coordinator Report to the Regional Response Team. The report's format chronologically summarizes all events, identifies the effectiveness of the removal action, lists any difficulties encountered, and makes recommendations regarding future actions [40 CFR § 300.415(l)].

As noted earlier, ERPMs may also perform early actions under remedial action authority. As part of the documentation that forms the basis for the selection of an early remedial action (i.e., interim remedial action or early final remedial action), ERPMs should prepare a Proposed Plan and a draft ROD that are tailored to the limited scope and purpose of the response action. These

draft documents should be submitted to the regulators for written approval, as well as maintained in the administrative record (40 CFR § 300.810).

In general, less documentation is required for an Interim Action ROD than for a Final Action ROD. Interim remedial action RODs do not require a completed baseline risk assessment but must still include sufficient information to demonstrate the potential for risk and the need to take action.[34] Streamlined plans/RODs should include the following level of detail:

- The site risk analysis discussion should be brief.
- The number of alternatives should be limited to three or fewer options.
- ERPM's selection from among nine-criteria evaluation should be commensurate with the scope and purpose of the early action (i.e., focus on those criteria most pertinent to short-term effectiveness and reduction of toxicity, mobility, or volume).
- Limited discussion of §121 statutory determinations should focus on how the interim action furthers those requirements.
- Specific preliminary remediation goals should be accompanied by clarification that the purpose is to work toward the goal of restoration and that the early action does not constitute final action.
- To the extent possible, a specific period of operation should be provided.[35, 36]

Documentation (e.g., the ROD) should reflect the amount of relative uncertainty associated with achieving remediation goals in ground water. An Interim Action ROD should emphasize that the purpose of the action is to work toward the goal of restoration, not to achieve final remediation goals for the ground water. MCLs/MCLGs or state cleanup standards are not ARARs for the early action because they are beyond the scope of the early action.[35] In situations where early actions might serve as the final remedial action, a Final Action ROD must be prepared, and public participation should be included as part of that action. ERPMs should publish a notice of availability and make the draft ROD publicly available.

During RCRA corrective actions, the specific work that ERPMs must perform and the compliance schedule will be dictated by the regulators as part of a hazardous waste management permit, a modified permit, an enforcement order (at nonpermitted facilities), or an FFCA. During the corrective action process, regulators may identify a need for early action (i.e., ISMs). Typically, ISMs that are performed under emergency conditions are taken in concert with a treatment, storage, or disposal facility (TSDF) contingency plan. Such measures must be followed by regulator notification [40 CFR § 264/265.56(i)] and a follow-up report [40 CFR § 264/265.56(j)].

ISMs that are performed under nonemergency conditions generally comply with a work plan that is developed in accordance with permit/order conditions. As part of an Interim Measures Work Plan, ERPMs should include:

- interim measure objectives,
- an HSP, and
- a Public Involvement Plan.[2]

In addition to an Interim Measures Work Plan, the regulators' "Scope of Work for Interim Measures Implementation" will generally require ERPMs to prepare an Operation and Maintenance Plan and an Interim Measures Plans and Specifications. If the ERPM can justify

that a plan or portions of it are not needed, the regulators may waive that requirement. ERPMs should ensure that regulators balance the requirement for plans and specifications against the need to quickly implement interim measures at their facility.[4] Site-specific RCRA permits, orders, or FFCAs generally specify reporting requirements, which typically consist of interim progress reports (e.g., monthly) as well as a final report.[2]

Depending on the scope of the action, ERPMs may be required to submit either a hazardous waste management permit application or an updated permit application to modify an existing permit. Permit modifications may be incorporated into a facility's existing permit following the provisions for regulator-initiated modification under 40 CFR § 270.41 (permit schedules of compliance may be modified in accordance with proposed 40 CFR § 270.34 when Subpart S is finalized). Modifications may also be incorporated after ERPMs (1) request a modification to the existing permit, (2) provide for regulator/public review and comment, and (3) receive regulator approval in accordance with 40 CFR § 270.42. In many cases, corrective action permits or schedules of compliance will require modification at the time EPA approves a remedy. However, this documentation (i.e., permit modification and statement of basis/fact sheet) will generally be prepared by the regulators.

When site conditions are appropriate, ERPMs should consider voluntarily undertaking RCRA corrective action to facilitate timely corrective action. For example, ERPMs may initiate voluntary corrective actions upon approval of a temporary authorization request [40 CFR § 270.42(e)]. Under this provision, ERPMs are afforded a period of not more than 180 days (and one additional term of 180 days) to facilitate timely implementation of corrective action activities. A request for temporary authorization may be granted by the regulators without prior public notice and comment (i.e., without going through the full permit/permit modification procedures of 40 CFR Part 124).

2.20 Streamlined Approach for Environmental Restoration

As with EPA's commitment to accelerating the cleanup process, DOE recognized the need to accelerate the environmental restoration process at DOE facilities. DOE's initial response to this need resulted in application of the Observational Approach (OA). This approach focuses on data sufficiency rather than data completeness and is taken from geotechnical engineering. The OA has matured into DOE's Streamlined Approach for Environmental Restoration (SAFER).

Q. *What is SAFER and how is it applied to environmental restoration efforts?*

A. SAFER is the result of a cross-organizational effort between the Office of Environmental Management [Office of Program Integration (EM-43) and Office of Transportation, Emergency Management and Analytical Services (EM-26)] and an office within the Office of Environment, Safety and Health [Office of Environmental Policy and Assistance (EH-41)]. The Office of Environmental Activities (in EM) recently also became involved.

The SAFER approach is an integration of the major tenets of two important initiatives—the DQO process and OA. SAFER recognizes that inherent uncertainty will always be a factor in three broad areas of environmental restoration activities: site conditions, remedial technology performance, and regulatory requirements. It further recognizes that uncertainty in data measurement systems during the development and implementation of solutions also exists. The SAFER approach is a methodology that allows an explicit (i.e., formal, documented) optimization between reducing uncertainty in environmental restoration decisions and managing uncertainty during remediation. The objective is to identify how much effort should be put into reducing uncertainty through data collection and into managing the remaining uncertainty. To

address inherent uncertainty, SAFER places emphasis on up-front planning and encourages the aggressive use of early actions under CERCLA removal action and remedial action authorities. It also incorporates active and early stakeholder participation as an important component of the approach.[37]

Three phases comprise the SAFER framework—planning (or scoping), assessment and selection, and implementation. SAFER has four essential elements within these phases that must be a formal component of the environmental restoration activity if it is to be applied. These elements include:

- defining and using a conceptual model [provides identification and representation of uncertainties in the areas of concern (e.g., waste sources, pathways, release mechanisms] that helps to identify data gaps;
- planning and conducting the assessment, remedy selection, and remedial action on a "learn-as-you-go" basis;
- recognizing the management of uncertainty as a key to conducting each phase of the remedial process; and
- recognizing the role and contributions of stakeholders (e.g., public participation in developing the overall site-specific strategy for managing uncertainty, input to and acceptance of the conceptual model).[38]

In 1992 DOE approached EPA with the idea of testing SAFER on a pilot project scale. In 1994 the DOE Deputy Assistant Secretary for Environmental Restoration and Waste Management selected four DOE facilities to host the SAFER pilot projects. DOE and EPA are jointly sponsoring the four pilot projects that consist of operable units from Oak Ridge National Laboratory, Hanford, Savannah River Site, and Mound Plant.[37]

2.21 Treatability Studies/Innovative Technologies

Under CERCLA, after identifying and evaluating existing site data, ERPMs must determine whether the available remediation technology data can adequately address all nine of EPA's remedy evaluation criteria under the NCP [40 CFR § 300.430(e)(9)(iii)(A)-(I)].

Q. *If an ERPM's evaluation identifies data deficiencies because of a lack of* ***treatment technology*** *information, are there additional scoping activities that may require early attention?*

A. Yes. ERPMs must first determine that the assembled treatment technology information does not adequately address the nine NCP criteria. ERPMs should then determine whether the missing data is obtainable from other readily available sources (e.g., EPA's Engineering Technical Support Center, Risk Reduction Engineering Laboratory, Office of Research and Development). If technology data gaps continue to exist, additional activities might be necessary. These activities include:

- identification of innovative technologies, and
- initiation and evaluation of treatability studies.

If an innovative technology offers potentially significant advantages over conventional treatment (e.g., more efficient destruction) or lower cost, the innovative technology should be evaluated. Innovative technologies should not, however, be eliminated from consideration solely because of uncertainties in their performance and cost. After considering potential benefits (e.g., increased protection, greater community acceptance) innovative technologies may be found to be

more cost-effective.[39] An innovative technology may not have achieved remedial objectives in practice at any other facility. This technology may still be selected with a proven treatment technology included in the Proposed Plan and ROD as a contingent remedy.[36] ERPMs should recognize that in some circumstances, program goals and commitments must be adjusted to achieve better cleanup solutions through innovative treatment technology development. EPA has indicated a willingness to accommodate these needs, when appropriate.[39]

Historically, treatability studies have been delayed until after the ROD has been signed. However, many treatability studies, especially pilot studies, may take several months or longer to complete and can delay completion of the FS. Therefore, as soon as it becomes evident that uncertainties exist regarding the performance, reliability, and/or cost of available treatment alternatives, treatability studies should be initiated. Sufficient information describing a promising technology must be available (and support the ERPM's decision).[5, 40] Technology prescreening and treatability study scoping includes determining data needs, identifying preliminary DQOs, searching technology literature and treatability databases, consulting with technology experts, identifying potential treatability study sources or contractors, and preparing a work assignment.[41]

2.22 Preliminary Evaluation of Corrective Measures Technologies

The purpose of the CMS portion of the RCRA corrective action process is to identify and evaluate potential remedial alternatives, including innovative technology alternatives, for addressing releases that have been identified at a facility. Treatability studies may be integral to properly assessing a corrective measure technology. A determination that corrective measures are necessary may occur at any point during the RFI or may not become evident until after the RFI is completed. EPA guidance and proposed Subpart S regulations, however, indicate that a CMS will usually follow completion of the RFI.

Q. *During the performance of RFI, what mechanism might regulators use to request that ERPMs conduct treatability studies?*

A. Recent EPA guidance indicates that ERPMs may conduct laboratory and/or bench-scale studies to determine the applicability of corrective measure technologies to facility conditions any time during the RFI.[4] These studies are an optional component of the RFI scope of work and dependent upon regulator discretion. This optional component is entitled "Preliminary Evaluation of Corrective Measure Technologies by Laboratory or Bench-Scale Studies" and includes the following principal activities:

- analyzing the technologies based on literature, vendor contracts, and past experience to determine the testing requirements;
- developing a testing plan identifying the types and goals of the study, the level of effort needed, and the procedures to be used for data management and interpretation;
- evaluating the testing results based on the general evaluation criteria (i.e., performance, reliability, effectiveness, time to implement, cost, institutional requirements); and
- preparing a report summarizing the testing program and its results (both positive and negative).[4]

Treatability testing conducted as part of the RFI should be limited in scope (e.g., laboratory screening). Analysis during the CMS process may demonstrate that the technology is clearly inappropriate for site conditions.[2] Some innovative technologies may not achieve remedial objectives in practice at any other facility, or uncertainties may arise regarding their use. These

technologies may still be selected with a proven treatment technology included in the Statement of Basis and draft permit as a contingent remedy.[42]

ERPMs should review the applicable permit, order, or FFCA to determine whether the requirements and responsibilities for conducting a preliminary evaluation of corrective measures technology (PECMT) are included or whether they need to initiate a request for such activity.

2.23 Preliminary Identification of ARARs

When CERCLA environmental restoration activities are conducted on-site, ERPMs must ensure that all ARARs and other appropriate criteria, advisories, or guidance to be considered (TBCs) are attained. On-site remedies must comply with the substantive ARARs but need not comply with administrative and procedural requirements associated with ARARs. The detailed definition of "on-site" has been published (55 *FR* 8688). In general, "on-site" refers to the areal extent of contamination (both surface areas and air above the site) as well as all suitable areas in close proximity to the contamination necessary for implementation of the response activities.

Q. *In general, what preliminary ARARs and TBCs should be evaluated for ground water?*

A. Initially, two kinds of standards should be considered as potential ARARs for remediation of ground water that is current or potential drinking water. These standards are nonzero MCLGs/MCLs and promulgated state drinking water standards. If nonzero MCLGs/MCLs or state drinking water standards have not been established for a particular contaminant, then ERPMs should evaluate other guidance to identify potential ARARs or TBCs.

As part of their ARAR evaluation, ERPMs should consider the following that may be relevant and appropriate for ground water remediation:

- federal water quality criteria (FWQC), which are nonenforceable guidance concentrations established by EPA for evaluating toxic effects on human health and aquatic organisms, or
- water quality standards (WQS), which are established by a state considering FWQC and consist of designated uses (i.e., fishing, swimming, drinking water) and criteria for pollutants set at levels that are protective of the water's designated uses.

When ARARs do not exist for a contaminant, then TBCs should be identified. The following may qualify as TBCs:

- proposed MCLs;
- risk specific doses (RSDs), which represent the dose of chemical in milligrams per kilogram of body weight per day associated with the specific risk level used;
- RfDs, which are an estimate of the daily exposure to the human population that is likely to be without appreciable risk of adverse effect during a lifetime; and
- drinking water health advisories (HAs) (also available through IRIS), a medium-specific (i.e., water) lifetime exposure level at which noncarcinogenic health effects would not be expected to occur.

IRIS is an authoritative source of risk information that includes oral and inhalation RfDs and cancer potency factors (i.e., oral slope factors, inhalation slope factors).[43] If no verified toxicity value is available through IRIS, then HEAST is the next preferred source.[19]

Preliminary identification of potential ARARs should be completed during the scoping phase. Early identification assists ERPMs tasked with identifying remedial treatment alternatives that achieve potential ARARs. It is also valuable for initiating communication with regulators. ERPMs should request potential ARARs from the support agency (e.g., the state) no later than the time that the site characterization data are available. Support agencies must communicate in writing those potential ARARs to DOE (i.e., the lead agency) within 30 working days of receipt of the lead agency's request for potential ARARs [40 CFR § 300.515(h)(2)]. These early efforts should (1) facilitate compliance with certain environmental resource statutes, state criteria, advisories and guidance, nonbinding guidelines, and local ordinances and (2) ensure before implementation that the selected ARARs address the regulator's concerns and receive concurrence as applicable or relevant and appropriate.

For documentation purposes, a dynamic list of potential ARARs should be developed and maintained by ERPMs and the regulators as potential ARARs are identified for a site.[5] At scoping it is often uncertain which potential ARAR is most likely to become the ARAR-based PRG. Therefore, all potential ARARs should be included at this stage, even when ERPMs doubt whether a value is a potential ARAR.[19]

2.24 RCRA Compliance with Applicable Laws/Regulations

ERPMs are not required to attain relevant and appropriate requirements while conducting RCRA corrective actions. However, in addition to complying with other RCRA requirements and other conditions (i.e., conditions specified in a permit, order, or FFCA), ERPMs must comply with codified requirements established under the authority of other laws. In many cases, compliance with the legally applicable requirements of other laws entails obtaining permits, controlling emissions or releases, and protecting workers.

Q. *During RCRA corrective actions, what are some of the more important requirements for compliance with other federal environmental laws?*

A. ERPMs conducting RCRA corrective action are typically subject to RCRA Subtitle C regulations as permitted or interim status facilities. Continued compliance with applicable RCRA requirements is mandatory. For example, an ERPM may transport extracted ground water that meets the definition of hazardous waste (e.g., the ground water "contains" listed hazardous wastes) off-site for treatment, storage, or disposal. Each shipment must be accompanied by a Uniform Hazardous Waste Manifest (Subpart B of 40 CFR Part 262) and a notification/certification under the Land Disposal Restrictions [40 CFR § 268.7(a)]. An ERPM's corrective measure may require an air-stripping system that emits or has the potential to emit hazardous air pollutants (HAPs) (e.g., TCE, methylene chloride) from extracted ground water above an established threshold (e.g., 10 tons/year). The corrective measure may require a Clean Air Act (CAA) operating permit, and ERPMs may be required to apply maximum achievable control technology (MACT) standards. The following list identifies some of the more important laws and regulations ERPMs should evaluate for applicability:

- Other provisions of RCRA;
- Clean Water Act (CWA);
- CAA;
- Occupational Safety and Health Act (OSHA);
- CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA);

- Toxic Substances Control Act (TSCA);
- Safe Drinking Water Act (SDWA); and
- state and local laws.

ERPMs conducting RCRA corrective action should consult individuals that are knowledgeable and experienced in compliance with other laws and regulations. Frequent consultations should ensure that actions will comply with applicable environmental resource statutes, state criteria, advisories and guidance, nonbinding guidelines, and local ordinances. Compliance with other laws is especially important during the CMS and corrective measures implementation phases of corrective action.[2]

2.25 Project Planning Documents

The project planning stage (scoping/RFI) culminates in the preparation of various project plans. At this stage, data collection of human health and ecological assessment information (e.g., common flora and fauna, location of threatened, endangered, or rare species, sensitive environmental areas or critical habitats) should be planned.[44]

Q. *What kind of project plan deliverables should be addressed during this stage of CERCLA remedial actions/RCRA corrective actions?*

A. In general, the project plans submitted under both the CERCLA response action and the RCRA corrective action program are functionally equivalent (i.e., the goals and objectives of the RI/FS and RFI Workplans and supporting documents are similar). Table 1 identifies project planning deliverables that must be prepared for submittal under CERCLA and the functionally equivalent RCRA documents that may be requested for submittal:

Table 1. Project planning documents

CERCLA	RCRA
RI/FS Work Plan (an early action work plan may be necessary) • Sampling and Analysis Plan - Field Sampling Plan - Quality Assurance Project Plan • Health and Safety Plan • Data Management Plan • investigation-derived Waste Management Plan • Community Relations Plan[37]	RFI Work Plan (an interim measures work plan may be necessary) • Quality Assurance Project Plan • Health and Safety Plan • Data Management Plan • Project Management Plan • schedule for facility investigation • Public Involvement Plan[4]

Under CERCLA, the RI/FS Work Plan should be developed in conjunction with the SAP and the site HSP, although each plan may be delivered under separate covers. Additionally, plans for managing IDW should be included as an appendix to the RI/FS Work Plan. This may entail the development of OU IDW plans, which reference an existing site-wide IDW plan and tailor the plan to any unique aspects of the OU. If a site-wide IDW plan does not exist, the plan will be more extensive and prescribe procedures for the following:

- initial handling of IDW from all activities,
- handling of IDW during sampling and analysis activities, and
- final management of IDW (i.e., immediate disposal, interim storage).[38]

Under RCRA, the site-specific permit, RCRA § 3008(h) order, or FFCA generally will dictate whether any or all of these elements must be submitted for approval as part of the RFI Work Plan. ERPMs may refer to Submodule 1.5 of DOE's RI/FS guidance[38] and Appendix B of the RI/FS guidance[5]/submodule 3-2-5 of DOE's Subpart S guidance,[2] and Chapter III, Section II of EPA's guidance[4] for comprehensive descriptions of the elements to be included within each program-specific project plan.

2.26 Chapter Summary

Scoping is the initial planning phase of site remediation. Site-specific information should be gathered and evaluated to determine whether data is sufficient and of appropriate quality for environmental decisions. The main objectives of scoping are to identify the types of decisions that need to be made and to determine the types (including quantity and quality) of data needed to make these decisions within an acceptable range of uncertainty. Public participation activities should be initiated early in the scoping process to help facilitate stakeholder consensus on, and acceptance of, future DOE-selected activities. To accomplish this, ERPMs should compile the gathered information into a dynamic, conceptual model, which may include the development of a site ecological model that is consistent with and refines the conceptual model.

Conceptual models synthesize existing data and identify all potential or suspected sources of contamination, potentially contaminated media, and potential exposure pathways, including receptors. The model facilitates the identification of data needs. Based on these needs, ERPMs may design efficient studies to collect the necessary data.

ERPMs should identify preliminary cleanup levels. Early development of preliminary cleanup levels serves to focus (and in some situations to direct) the concurrent development and screening of remedial alternatives (under the FS/CMS) toward technologies that can achieve the projected levels. This early development potentially limits the number of alternatives that must be considered during screening and detailed analysis of remedial alternatives/corrective measures.

At sites with complex ground water contamination problems, it may be difficult to determine what actions are necessary or whether the anticipated cleanup levels are achievable. When feasible, ERPMs should consider employing a "phased approach" to remediation. Site remediation activities may be conducted in phases to achieve interim goals at the outset, while developing a more accurate understanding of the contaminated aquifer and its restoration potential. ERPMs should consider using (or requesting the approval to use) early actions whenever those actions will not be inconsistent nor preclude application of the expected final remedial alternative.

Based on the information gathered and decisions made during scoping, ERPMs evaluate the types of removal and/or remedial measures and whether they are suitable to abate the threat. Regardless of the technologies employed, certain management standards and environmental regulatory requirements will be applicable and/or relevant and appropriate under other authorities. ERPMs should attempt to define these standards/requirements early, to ensure that all potential federal and state requirements are considered and, when necessary, attained during ongoing and future site activities. The activities that occur during the project planning stage (i.e., scoping) culminate in the preparation of various project plans. ERPMs should evaluate their facilities' existing plans (e.g., community relations plan, investigation-derived waste plans) and tailor those plans to any unique aspect of operable units.

2.27 Chapter References

1. EPA, 1991. *A Guide to Principal Threat and Low Level Threat Wastes*, OSWER Directive 9380.3-06FS, Office of Emergency and Remedial Response, Washington, D.C.
2. DOE, 1993. *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.
3. EPA, 1988. *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, OSWER Dir. 9283.1-2, Office of Emergency and Remedial Response, Washington, D.C.
4. EPA, 1994. *RCRA Corrective Action Plan*, OSWER Dir. 9902.3-2A, Office of Waste Programs Enforcement, Washington, D.C.
5. EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Dir. 9355.3-01, Office of Emergency and Remedial Response, Washington, D.C.
6. EPA, 1993. *Presumptive Remedies: Policy and Procedures*, OSWER Dir. 9355.0-47FS, Office of Emergency and Remedial Response, Washington, D.C.
7. EPA, 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration, Interim Final*, OSWER Dir. 9234.2-25, Office of Solid Waste and Emergency Response, Washington, D.C.
8. DOE, 1995. *Phased Approach/Early Actions Guidance* (in press), Office of Environmental Policy and Assistance, Washington, D.C.
9. DOE, 1994. *Incorporating Ecological Risk Assessment into Remedial Investigation/Feasibility Study Work Plans*, DOE/EH-0391, Office of Environmental Guidance, Washington, D.C.
10. EPA, 1992. *Considerations in Ground-Water Remediation at Superfund Sites and RCRA Facilities—Update*, OSWER Dir. 9283.1-06, Office of Solid Waste and Emergency Response, Washington, D.C.
11. EPA, 1991. *Seminar Publication: Site Characterization for Subsurface Remediation*, EPA/625/4-91/026, Office of Research and Development, Washington, D.C.
12. DOE, 1992. *Groundwater Remediation Considerations in Environmental Restoration Activities*, EH-231 Memorandum, Office of Environmental Guidance, Washington, D.C.
13. EPA, 1992. *Estimating the Potential for Occurrence of DNAPL at Superfund Sites*, OSWER Dir. 9355.4-07FS, Office of Solid Waste and Emergency Response, Washington, D.C.
14. EPA, 1991. *Ground Water Issue: Dense Nonaqueous Phase Liquids*, EPA/540/4-91-002, Office of Research and Development, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.
15. DOE, 1990. *Public Participation in the Department of Energy's Environmental Activities*, EM-1/EH-1 Guidance Memorandum, Washington, D.C.
16. DOE, 1991. *Public Participation in Environmental Restoration Activities*, DOE/EH-0221, Office of Environmental Guidance, Washington, D.C.
17. DOE, 1991. *The Information Repository*, DOE/EH-231-009/1291, EH-231 Information Brief, Office of Environmental Guidance, Washington, D.C.

18. DOE, 1991. *The Administrative Record*, DOE/EH-231-010/1291, EH-231 Information Brief, Office of Environmental Guidance, Washington, D.C.

19. DOE, 1994. *Using the Data Quality Objectives Process in Risk Assessment*, EH-231-023/0794, EH-231 Information Brief, Office of Environmental Guidance, Washington, D.C.; Appendix II.

20. EPA, 1993. *Data Quality Objectives Process for Superfund; Interim Final Guidance*, OSWER Dir. 9355.9-01, Office of Emergency and Remedial Response, Washington, D.C.

21. EPA, 1991. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, OSWER Dir. 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

22. DOE, 1993. "Draft Ground-Water Protection Policy," pp. 1219–22 in *Proceedings of ER '93—Meeting the Challenge, Environmental Restoration Conference*, Augusta, Georgia.

23. EPA, 1991. *Protecting the Nation's Ground Water: EPA's Strategy for the 1990s, The Final Report Of the EPA Ground-Water Task Force*, 21Z-1020, Office of the Administrator, Washington D.C.

24. DOE, 1992. *EPA Superfund Accelerated Cleanup Model*, EH-231 Memorandum, Office of Environmental Guidance, Washington, D.C.

25. EPA, 1993. *Additional Guidance on "Worst Sites" and "NPL Caliber Sites" to Assist in SACM Implementation*, OSWER Dir. 9320.2-07, Office of Emergency and Remedial Response, Washington, D.C.

26. EPA, 1988. *Guidance Document for Providing Alternate Water Supplies*, OSWER Dir. 9355.3-03, Office of Emergency and Remedial Response, Washington, D.C.

27. EPA, 1994. *Drinking Water Regulations and Health Advisories*, EPA/822-R-94-001, Office of Water, Washington, D.C.

28. EPA, 1991. *Superfund Removal Procedures; Guidance on the Consideration of ARARs During Removal Actions*, OSWER Dir. 9360.3-02, Office of Emergency and Remedial Response, Washington, D.C.

29. DOE, EPA, DOD, 1994. *Guidance on Accelerating CERCLA Environmental Restoration at Federal Facilities*, Memorandum from Steven A. Herman, Elliott P. Laws, Thomas P. Grumbly, and Sherri W. Goodman to Addressees, August 22, 1994, Washington, D.C.

30. EPA, 1990. *The Nation's Hazardous Waste Management Program at a Crossroads: The RCRA Implementation Study*, EPA/530-SW-90-069, OSWER, Washington, D.C.

31. EPA, 1992. *RCRA Corrective Action Stabilization Technologies; Proceedings*, EPA/625/R-92/014, Office of Research and Development, Washington, D.C.

32. EPA, 1993. *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*, OSWER Dir. 9360.0-32, Office of Emergency and Remedial Response, Washington, D.C.

33. EPA, 1990. *Superfund Removal Procedures; Action Memorandum Guidance*, OSWER Dir. 9360.3-01, Office of Emergency and Remedial Response, Washington, D.C.

34. EPA, 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Dir. 9355.0-30, Office of Emergency and Remedial Response, Washington, D.C.

35. EPA, 1990. *Suggested ROD Language for Various Ground Water Remediation Options*, OSWER Dir. 9283.1-03, Office of Emergency and Remedial Response, Washington, D.C.

36. EPA, 1989. *Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment*, OSWER Dir. 9355.3-02, Office of Emergency and Remedial Response, Washington, D.C.

37. DOE, 1994. *Streamlined Approach for Environmental Restoration (SAFER) Pilot Project Management Plan/Quarterly Status Report*, Office of Environmental Guidance, Washington, D.C.

38. DOE, 1993. *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements, and Techniques Guidance*, Office of Environmental Guidance, Washington, D.C.

39. EPA, 1991. *Furthering the Use of Innovative Treatment Technologies in OSWER Programs*, OSWER Dir. 9370.0-17, Office of Emergency and Remedial Response, Washington, D.C.

40. EPA, 1989. *Guide for Conducting Treatability Studies Under CERCLA; Interim Final*, OSWER Dir. 9370.3-02, Office of Emergency and Remedial Response, Washington, D.C.

41. EPA, 1992. *Guide for Conducting Treatability Studies Under CERCLA: An Overview*, OSWER Dir. 9370.3-10FS, Office of Emergency and Remedial Response, Washington, D.C.

42. EPA, 1991. *Guidance on RCRA Corrective Action Decision Documents: The Statement of Basis Final Decision and Response to Comments*, OSWER Dir. 9902.6, Office of Emergency and Remedial Response, Washington, D.C.

43. DOE, 1991. *Integrated Risk Information System*, DOE/EH-0194, Office of Environmental Guidance, Washington, D.C.

44. EPA, 1989. *Risk Assessment Guidance for Superfund: Volume II—Environmental Evaluation Manual*, OSWER Dir. 9285.7-01A, Office of Emergency and Remedial Response, Washington, D.C.

3. Site Characterization

Figure 3 provides a graphic representation of the site characterization process and the organization of this chapter.

3.1 Field Support Activities

Field investigations attempt to define a site's physical characteristics as well as the sources, natures, and extent of contamination. In addition, field investigations are conducted (1) to gather data to assess the risks to human health and the environment and (2) to refine design/operation parameters for technology alternatives being considered for remedial action/corrective measures.

Q. *Before conducting field investigations, what support activities might ERPMs take to ensure that field activities can be conducted in a consistent and timely manner?*

A. The overall objective of site characterization is to identify and describe areas of the site that may pose a threat to human health and the environment. To achieve this objective, ERPMs must ensure a timely performance of information gathering and sample collection and analysis activities. Site characterization activities typically generate an extensive amount of information, the quality of which must be consistent and well documented. DQOs that are established before field sampling may be used to justify alternate characterization tools [e.g., field screening for the presence of NAPLs using a hydrophobic dye (Sudan IV) shake test or ultraviolet (UV) florescence]. This step may reduce the time necessary to characterize a site.

Field sampling and analytical protocols are subject to data management procedures. These procedures should be identified and documented before field investigation activities. Data management tasks for sampling efforts include the following:

- quality assurance/quality control (QA/QC) plans,
- a data security system (e.g., outline of measures taken to safeguard chain-of-custody records and prevent free access to project records), and
- field logs that are signed and dated (i.e., general description of daily activities, any unusual occurrences or circumstances, deviations from the procedures outlined in the site plans).

Accurate record-keeping procedures are critical because field information will be used to support remedy selection decisions and address any legal actions. In addition to establishing data management procedures, ERPMs should ensure that the following activities are performed before initiating field activities:

- obtain access to areas of investigation (i.e., adjacent property);
- procure contractors, subcontractors (e.g., drillers, surveyors), equipment (e.g., air-monitoring devices, decontamination equipment), and supplies (e.g., tape, notebook, baggies, aluminum foil);
- select and coordinate with an analytical laboratory (e.g., sample bottle acquisition, sample schedule, chain-of-custody records);
- procure on-site facilities for field activities (e.g., on-site water, electric, telephone, and sanitary utilities); and
- provide for on-site management of contaminated materials (e.g., drilling muds, decontamination solution, contaminated well water purged before sampling).[1]

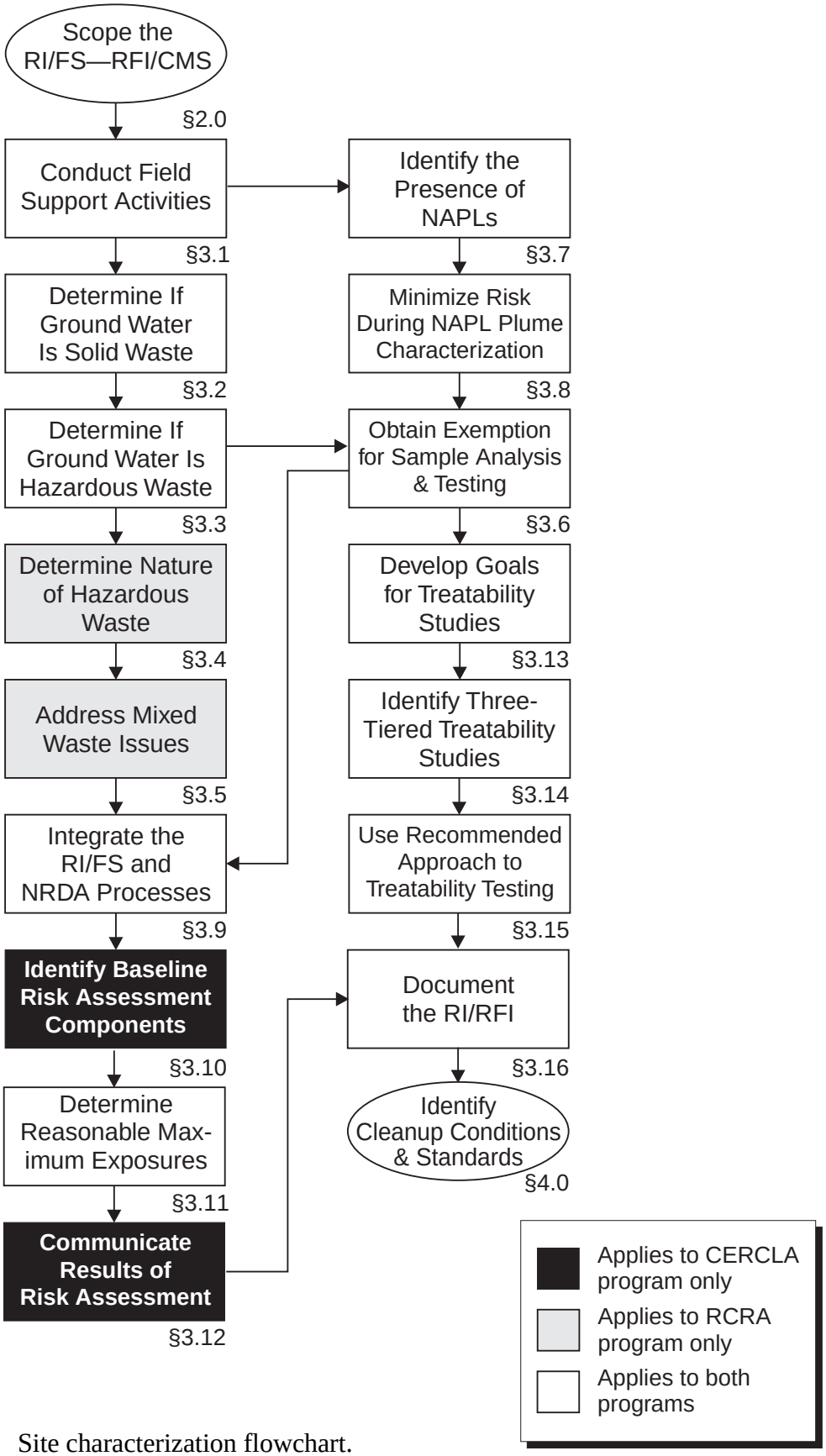

Figure 3. Site characterization flowchart.

Field support must be performed in accordance with the work plan (including the IDW plan) and SAP. Generally it should be initiated following approval of the work plan, SAP, and HSP. Guidance for selecting and implementing ground water field methods, sample procedures, and custody under the CERCLA program has been published.[2, 3] Guidance for the development and performance of an investigation during RCRA corrective action is also available.[4]

3.2 Ground Water as "Solid Waste"

Subtitle C of RCRA establishes the framework for the safe management of "hazardous waste." In accordance with the concept of ARARs, ERPMs must be cognizant of, and remain in compliance with, germane RCRA Subtitle C substantive requirements while performing CERCLA response actions. ERPMs managing RCRA corrective actions need not consider ARARs but must comply with legally applicable substantive and administrative requirements of Subtitle C.

Q. *What is the first step in identifying whether contaminated ground water is a hazardous waste, and therefore, subject to Subtitle C requirements?*

A. Before a material can qualify as hazardous waste under RCRA Subtitle C, ERPMs must first identify that material as a "solid waste." EPA's Office of Solid Waste has indicated that, as a matter of interpretation, ground water occurring in an aquifer is not a "solid waste" because it has not been "discarded" by being abandoned, recycled, or inherently waste-like [40 CFR § 261.2(a)(2), (3) and (5), respectively].

3.3 Identification of Ground Water as "Hazardous Waste"

Before a material can qualify as hazardous waste, it must first be defined as a solid waste. As stated above, environmental media (i.e., ground water) typically does not qualify as "solid waste."

Q. *How can contaminated ground water that is extracted during CERCLA responses or RCRA corrective actions be subject to Subtitle C regulation?*

A. RCRA uses two approaches to determine if a "solid waste" qualifies as hazardous waste. Under the first approach, solid waste will qualify as hazardous waste if it is any of the following:

- specifically listed by name in 40 CFR § 261.31 to 261.33,
- a mixture of a waste that is listed in 40 CFR § 261.31 to 261.33 and a solid waste, or
- derived from the treatment, storage, or disposal of a listed hazardous waste.

Contaminated ground water is not specifically listed by name, nor is it considered a hazardous waste via the "mixture" rule [40 CFR § 261.3(a)(2)(iv)] or the "derived-from" rule [40 CFR § 261.3(c)(2)(ii)]. It is not listed because it does not qualify as a solid waste. Nevertheless, ground water that "contains" either listed hazardous waste [e.g., unused methylene chloride (U045) from a leaking underground storage tank (UST)] or hazardous waste leachate (i.e., liquid that percolated through land disposed listed hazardous waste) will be subject to Subtitle C regulation.

In accordance with EPA's "contained-in" policy, however, extracted ground water (either as generated or after treatment) that does not contain significant levels of hazardous constituents listed in Appendix VIII of 40 CFR Part 261 is no longer subject to Subtitle C regulation. Significant levels are typically established at health-based thresholds. This determination is site-specific and should be established through consultation with regulators (e.g., EPA Regional

Administrator).[5] EPA has proposed a set of decision factors that may be considered by the Regional Administrator in making contained-in determinations (58 *FR* 48127).

The second approach uses characteristics of hazardous waste (i.e., ignitability, corrosivity, reactivity, or toxicity) to identify whether a solid waste is a hazardous waste. Ground water that is extracted and is subsequently intended for disposal (e.g., placed into a surface impoundment before release to navigable waters) becomes a solid waste. If it exhibits any of the hazardous characteristics, the ground water qualifies as hazardous waste.

Some guidance for identifying hazardous waste under CERCLA is provided in the preamble to the NCP final rule. EPA notes that it is necessary to know the origin of the waste to determine whether extracted ground water is a listed waste. If such documentation is lacking, ERPMs may assume it is not a listed waste (55 *FR* 8758). Furthermore, EPA also makes it clear that a decision that a waste is not characteristic, in the absence of testing, may not be arbitrary but must be based on site-specific information and data (55 *FR* 8762). Residues generated during the treatment, storage, or disposal of contaminated ground water that met a listing must themselves be managed as a listed hazardous waste (unless delisted under 40 CFR § 260.20 and 260.22).[5]

ERPMs may encounter ground water that is contaminated with an unused commercial chemical product (CCP), resulting from a leaking storage unit. Unused CCPs (including intermediates, off-specification variants, and spill residues) are not considered "solid waste" when they are recycled in a manner that is consistent with their normal use. This policy includes CCPs that are listed under 40 CFR § 261.33 as well as nonlisted CCPs (see 50 *FR* 14219).

Therefore, ground water may contain an unused CCP (e.g., No. 2 fuel oil, gasoline, methanol) that can be separated from the ground water and used for its intended purpose or legitimately recycled. The recovered portion does not meet the definition of solid waste under 40 CFR § 261.2(c)(3) and does not become subject to Subtitle C regulation. The burden of proving that the recovered material is not a solid waste, however, falls on the ERPM. Objective considerations that might be used to satisfy this burden include whether the ERPM has begun to recycle the recovered material, the value of the recovered material, whether it is technically feasible or technically practicable to recycle the recovered material, and whether there is any past history of ERPMs (or other entities) recycling this type of recovered material.

Separating a CCP from the ground water to recover a viable product also may yield ground water that no longer contains that CCP. Regions or authorized states will determine when, or at what levels, ground water contaminated with listed hazardous waste no longer "contains" that hazardous waste. The original waste contaminating the ground water may have been considered hazardous only because it exhibited a characteristic. ERPMs must evaluate the ground water to determine whether it continues to exhibit the original (or any other) characteristic of hazardous waste (i.e., the contained-in policy does not apply to characteristic wastes).

3.4 Hazardous Waste Determinations/Waste Analysis Plans for Investigation-Derived Wastes

During both CERCLA response actions and RCRA corrective actions, ERPMs must evaluate investigation-derived waste (e.g., stagnant ground water purged from a monitoring well, drilling mud and cuttings, spent carbon) to determine whether it must be managed as hazardous waste. Under RCRA Subtitle C, the regulatory status of extracted ground water hinges on whether the extracted media "contains" waste listed in Subpart D of 40 CFR Part 261 or exhibits a characteristic of hazardous waste identified in Subpart C of 40 CFR Part 261. DOE personnel

meet the definition of "generator" under 40 CFR § 260.10 when the act of purging a well "first causes a hazardous waste to become subject to regulation."

Q. *As generators, what regulations must ERPMs evaluate when performing their hazardous waste determinations on investigation-derived wastes?*

A. To determine whether IDW is hazardous waste under Subtitle C, ERPMs (acting as generators) may either test a representative sample of the waste or apply their knowledge of the waste (e.g., materials used or the process from which the waste was generated). Testing involves using standardized procedures to eliminate extraneous sources of error and promote the representative results. Regulations governing generator hazardous waste determinations are found in 40 CFR Part 262. Under these regulations, ERPMs must determine whether the extracted ground water is (1) excluded from Subtitle C regulation, (2) "contains" a listed hazardous waste found in Subpart D of 40 CFR Part 261, or (3) exhibits a characteristic identified in Subpart C of 40 CFR Part 261. Further EH-413 information regarding proper waste characterization under RCRA has been published.[6–12]

For RCRA interim status and permitted TSDFs that are conducting corrective action, facility sampling and testing procedures will rely on a QAPP. This plan is a component of the RFI Work Plan, an equivalent sampling analysis plan, or the facility's Waste Analysis Plan (WAP). Requirements that should be included within every WAP are:

- identification and discussion of waste streams, test parameters, and rationale for sampling and analytical methods selection;
- discussion of test methods for analyzing parameters;
- identification and discussion of procedures for collecting representative samples; and
- identification of the frequency of sample collection/analyses.[13]

Under RCRA, to address corrective action sampling, existing WAPs may require modifications to reflect the additional sampling and analysis operations that occur during corrective action. For permitted TSDFs, the WAP is submitted to the regulator as part of the original hazardous waste management facility permit application. Upon issuance by the regulator, it becomes an enforceable condition of the permit. Modifications of an approved WAP may occur following regulator-initiated procedures (40 CFR § 270.41) or in accordance with the permit modification procedures of 40 CFR § 270.42 (for ERPM- initiated modifications).

For interim status TSDFs, the WAP is retained at the facility. It should be revised by the ERPM when either treatment, storage, or disposal operations at that facility change or in accordance with an interim status corrective action order (40 CFR § 270.72).

Under CERCLA, RI/FS studies and investigations are considered removal actions. Accordingly, on-site handling, treatment, or disposal of IDW must satisfy substantive ARARs to the extent practicable, considering the urgency of the circumstances and the scope of the action. RCRA WAP requirements, which are administrative rather than substantive, are not considered ARARs. Rather, CERCLA sampling and analysis protocols will be identified in the SAP submitted as part of the scoping deliverables. Generally, it will not be necessary to obtain a waiver if an ARAR cannot be practicably attained during field investigations activities.[14]

3.5 Mixed Waste and Waste Analysis Plan Issues

Q. *Are there any WAP issues that are unique to DOE facilities and might require special procedures?*

A. Special management procedures exist for radioactive mixed waste. This waste contains both a radioactive component subject to the AEA and a hazardous waste subject to RCRA. Mixed waste management is governed by selected aspects of both the AEA and RCRA but primarily those sections that represent the most stringent requirements. ERPMs must evaluate extracted ground water to determine whether it qualifies as mixed waste [e.g., ground water that contains tritium, ^{129}I, or uranium (the radioactive component) and carbon tetrachloride or TCE (the hazardous waste component)]. Typically, the procedures used to determine whether a ground water qualifies as mixed waste include:

- identifying the radioactive component and
- identifying the hazardous waste component by:
  - determining whether the ground water contaminant is listed as hazardous waste in Subpart D of 40 CFR Part 261 or
  - determining whether the ground water exhibits a characteristic of hazardous waste identified in Subpart C of 40 CFR Part 261 (i.e., ignitability, corrosivity, reactivity, or toxicity).

Ground water that contains naturally occurring or accelerator-produced radioactive materials (NORM/NARM) is not regulated under AEA. EPA maintains that NORM/NARM do not fall under the definition of mixed waste.

In determining whether a radioactive waste is a RCRA hazardous waste, ERPMs may use surrogate samples (identical to the mixed waste except with significantly less or no radioactive component). The surrogate must represent the hazardous constituents of the potentially mixed waste. Before sampling for mixed waste, ERPMs should evaluate the mixed waste to determine the need to deviate from approved methods. The following checklist may be used to facilitate each ERPM's evaluation and, for RCRA corrective actions, should be addressed in the facility WAP:

- list of all mixed waste streams present;
- identification of the hazardous constituents, physical properties, and other waste components (e.g., radioactive component) that require specialized health and safety procedures that, in turn, could affect selection of subsequent sampling or analysis procedures;
- identification of the hazardous constituents, physical properties, and other waste components (e.g., radioactive component) that require modified or new sampling or analysis procedures (unrelated to health and safety procedures);
- results of hazardous constituent evaluation showing that if EPA-approved methods are unacceptable, specialized or new methods are required;
- identification of methods selected;
- justification that alternative methods selected are the only methods available or that these methods provide for an acceptable level of performance [particularly in representativeness (for sampling procedures) and accuracy and precision (for sampling and analysis procedures)]; and

- justification that process knowledge is appropriate in characterizing the waste and documentation of such process knowledge.[13]

Additional policies, guidelines, and minimum requirements related to DOE's management of mixed waste have been published.[15]

3.6 Exemptions for Sample Analysis and Treatability Testing

Regulations governing the management of hazardous waste (e.g., exhumed ground water that is contaminated with leachate from a listed hazardous waste) seem inappropriate for relatively small quantities of contaminated ground water that is exhumed for sample analysis or treatability testing.

Q. *Is there any relief from Subtitle C substantive and administrative burdens associated with sending hazardous waste off-site when the hazardous waste is being sent off-site for sample analysis or treatability testing?*

A. Two potential exemptions from RCRA Subtitle C exist for extracted ground water that is sent off-site for analysis and/or testing provided ERPMs comply with prescribed conditions. The first exemption is known as the sample exclusion [40 CFR § 261.4(d)]. Under this exemption, ground water samples of typically no more than one gallon are collected and shipped off-site for the sole purpose of testing to determine their characteristics or composition. ERPMs claiming the sample exclusion must meet the conditions prescribed in 40 CFR § 261.4(d) to qualify. Briefly, these include following certain management standards; complying with the U.S. Department of Transportation (DOT), U.S. Postal Service (USPS), etc.; and providing appropriate packaging.

The second exemption—the treatability study exemption [40 CFR § 261.4(e)-(f)]—was created to facilitate the expeditious management of larger-scale samples used in treatability studies at pilot plants or other experimental facilities. ERPMs may cite a broad range of purposes when claiming the treatability exemption including determining any of the following:

- whether the waste is amenable to a specific type of treatment;
- what pretreatment, if any, is necessary;
- the optimal process conditions needed to achieve the desired treatment;
- the efficiency of a treatment process;
- the volume or characteristics of residuals resulting from various treatment processes;
- liner compatibility; and/or
- toxicological and health effects studies.

To qualify and remain eligible for the treatability exemption, several conditions must be met. These conditions were revised in 1994 (59 *FR* 8362) and include, among others:

- a limitation on the shipment size [10,000 kg (approx. 2,640 gal.) of ground water that contains nonacute hazardous waste; 2,500 kg (approx. 660 gal.) of ground water that is contaminated with acute hazardous waste per shipment],
- packaging and handling standards,
- the quantity of waste used in all treatability studies initiated in any single day does not exceed a total of:
  - 10,000 kg of "as received" media contaminated with nonacute hazardous waste or

- 2,500 kg of media contaminated with acute hazardous waste,

- shipments of contaminated ground water must be to an exempt laboratory,
- maintenance of records for 3 years following completion of the treatability study, and
- reporting under the biennial report.

Regulators may grant ERPM requests to ship, store, and conduct treatability studies on additional quantities (e.g., up to an additional 5,000 kg of media contaminated with nonacute hazardous waste) in advance of commencing treatability studies, or after initiation or completion of initial treatability studies, provided ERPMs make the proper demonstrations [40 CFR § 261.4(e)(3)]. ERPMs should note that the new final rule is less stringent than the existing regulations. States that have already received authorization for the existing regulations are not required to adopt the new final rule.[16]

3.7 Identifying the Presence of DNAPLs

Recently, EPA surveyed 310 CERCLA sites to determine the likelihood of the presence of DNAPL. The results indicate that approximately 60% of all NPL sites have a moderate to high likelihood of DNAPL occurrence.[17] The potential for extensive contamination of ground water by NAPLs is high because of their widespread utilization within the DOE system. Historically, however, many site investigations were not designed or equipped to detect or delineate the presence of NAPLs. As a result, reliable, quantitative information concerning the extent of NAPL contamination is not currently available.

Q. *How might ERPMs identify the presence of DNAPLs?*

A. To help ERPMs determine if DNAPL-based characterization strategies should be employed at a particular site, EPA developed a guide for estimating the potential for DNAPL occurrence. EPA's approach requires application of two types of existing site information: (1) historical site use information and
(2) site characterization data.

By using available data, ERPMs enter a system of two flowcharts and a classification matrix for estimating the potential for DNAPL occurrence at their site. Based on the application of their site-specific conditions, ERPMs will categorize their site as one of the following:

- Category I—confirmed or high potential for DNAPL at site,
- Category II—moderate potential for DNAPL at site, or
- Category III—low potential for DNAPL at site.

If the potential for DNAPL occurrence is moderately high, ERPMs should consider employing a different conceptual approach during the site investigation to account for problems associated with DNAPL in the subsurface.[18]

While conducting site investigations at potential NAPL sites, one important consideration is the risk of expanding the zone of contamination by creating pathways for NAPL migration. The risks involved in the use of invasive techniques (e.g., drilling, well installation) suggest that ERPMs (1) evaluate site history and existing data and (2) use noninvasive techniques before invasive techniques. Noninvasive techniques that may be applicable to initial site characterization at NAPL sites might include:

- air photo interpretation,

- soil-gas analysis (where volatile constituents may be present), and
- geophysical methods (e.g., ground-penetrating radar, complex resistivity, electromagnetic induction methods).

The use of geophysics at most sites may not aid in the direct detection of NAPLs but may help in furthering characterizing where the NAPLs may be going based on the geologic context.[19] Furthermore, detection of organic compounds using geophysical techniques is an emerging technology and is not readily available. Therefore, invasive techniques continue to be indispensable for characterizing most NAPL sites.

Two basic site characterization approaches exist. These approaches have been referred to as the outside-in strategy and the inside-out approach.[19] Invasive characterization techniques that might be utilized when implementing either of these approaches include test pits and trenches, subsurface soil sampling, piezometer and monitoring well installation, and modified methods such as telescoped well casings and cone penetrometer.[20, 21] For those sites where characterization efforts have yet to begin, a previously published document on the planning of such efforts may be helpful.[22] This publication offers detailed text on DNAPL contamination at hazardous waste sites and presents extensive discussion of various investigation techniques and strategies.

3.8 Risk Minimization Precautions During NAPL Plume Characterization

Q. *When considering the risk of expanding the zone of contamination by creating pathways for NAPL migration, should ERPMs consider any risk minimization precautions?*

A. EPA's Office of Research and Development provides 13 risk minimization suggestions that ERPMs might consider. These suggestions include the following:

- Use noninvasive techniques.
- Use knowledge of stratigraphy and NAPL distribution to guide drilling.
- Characterize the NAPL zone by limiting drilling to shallow depth; deeper stratigraphy can be characterized by drilling outside of the DNAPL zone.
- Characterize the NAPL zone from the top down.
- Drilling should, whenever possible, follow an outside-in approach.
- Avoid unnecessary drilling in the NAPL zone.
- Minimize time during which borings are open.
- Minimize the length of the hole open to formation.
- Maintain the hydrostatic head in the bore hole—consider using dense drilling fluid.
- Use telescoped-casing drilling techniques to isolate contaminated zones.
- Use less invasive "direct-push" sampling methods (e.g., cone penetrometer) to examine stratigraphy, soil gas, and fluids with depth.
- Carefully examine samples as drilling progresses to avoid drilling through a barrier layer below DNAPL. Examine exhumed soil for the following:
  - visual evidence (e.g., sheens, stains, globules);
  - organic vapor analysis;

- hydrophobic dye shake test (e.g., Sudan IV powder) and/or UV examination (florescence);
- fractures, soil ped faces, macropores, and coarser lenses; and
- inner surfaces revealed upon dissection.

- Consider compatibility of well materials.[21]

ERPMs should select the appropriate characterization method to avoid exacerbating the contamination problem. Therefore, a phased site characterization, during which ERPMs iteratively refine their conceptual model of NAPL (and other constituent) contamination, is recommended.

3.9 Integrating the RI/FS and NRDA Processes

A Natural Resource Damage Assessment (NRDA) "is a process by which a Natural Resource Trustee may pursue compensation on behalf of the public for injury to natural resources resulting from releases of hazardous substances." The four phases of the NRDA process are (1) a preassessment screen, (2) an assessment plan preparation, (3) a Type B assessment, and (4) a postassessment phase. If discharges or releases occur, and injury to a natural resource (e.g., ground water) may have resulted at a DOE environmental restoration site, appropriate federal and state trustees overseeing the affected natural resources must be notified in a timely manner.

Q. *What role may ERPMs be called on to perform when DOE facilities potentially injure natural resources?*

A. Under EO 12850, the Secretary of Energy is designated as Natural Resource Trustee on DOE sites. Therefore, ERPMs may have a dual role. Because trusteeship is not a function of geographical location, nor is it strictly tied to land ownership, DOE is not likely to be the only trustee for natural resources associated with its sites. Trusteeship may be shared with other federal/state/ Indian tribe cotrustees. Where contaminants have moved outside the boundaries of the DOE property to affect natural resources off-site, DOE may have no trustee authority at all (e.g., the state may have sole trusteeship).[23]

As trustee representatives, ERPMs are responsible for coordinating the assessments, evaluations, investigations, and planning with state and federal cotrustees, when appropriate. ERPMs may develop unique approaches to risk management. IAGs (i.e., FFAs, FFCAs) and/or Consent Decrees governing management of the site should address:

- the trustee roles of DOE and the states,
- the framework for addressing natural resource injuries, and
- the conditions that enable state trustees to release DOE from liability.[5]

Although cotrustees may be responsible for certain natural resources affected or potentially affected by a release, ERPMs retain the responsibility for managing environmental restoration activities at the site. ERPMs should use the preassessment screen procedure, based on a review of readily available data, or a baseline risk assessment as a threshold to determine if a covered release has occurred.

DOE activities may result in a release of a hazardous substance, pollutant, or contaminant. If the release is on, or the sole source of the release is from such activities, then DOE generally serves as the lead response agency and as such may be subject to natural resource liabilities to other trustees. Early coordination with Natural Resource Damage Assessment cotrustees may

facilitate the acquisition of valuable technical assistance and may prove beneficial and cost-effective during development of the RI/RFI Sampling Plan. (Significant funds may be lost if opportunities to analyze and assess natural resources are inadvertently overlooked during scoping and site characterization.)

Site characterization in the RI includes a baseline risk assessment to identify existing and potential risks to human health and the environment posed by the site. The assessment of risks to the environment, including natural resources, requires the use of Ecological Risk Assessment (ERA). Although the RI/FS does not call for an ERA until the RI phase, DOE suggests that ERA-related activities be initiated during scoping so that data needs for ERA may be incorporated into the RI work plan.[23] Accordingly, during scoping, a preliminary ERA should incorporate existing data and an ecological reconnaissance to determine the nature of the environmental hazard posed, resulting in the development of a site ecological conceptual model. Early natural resource surveys, inclusion of resources as potential receptors in the site conceptual modeling, and performance of ERA may provide an improved understanding of some potential natural resource injuries.

The ERA may serve as a constructive link to the natural resource trustee process (i.e., the ERA data may be useful during NRDA injury determinations and quantification of resource service reductions).[24] To estimate natural resource damages most accurately, however, cotrustees may choose to conduct an NRDA after completion of remedial action. It is only at this point that residual injuries (i.e., those not addressed by the remedial action) may be accurately measured.[23]

3.10 Components of the Baseline Risk Assessment

Baseline risk assessments evaluate potentially adverse site impacts on human health and the environment in the absence of any remedial action [i.e., evaluation of the no-action alternative (55 *FR* 8710–11)]. When used in the context of exposure, "potential" means a reasonable chance of occurrence within the context of the reasonable maximum exposure (RME) scenario for that site (55 *FR* 8717). The overall objective of a CERCLA risk assessment is to provide risk-based information to ERPMs for remedial decision making. This assessment includes deciding whether remediation of a site is warranted, establishing acceptable exposure levels for use while developing remedial alternatives/ corrective measures, and in certain situations (e.g., situations involving cumulative risk of multiple contaminants or multiple exposure pathways), modifying preliminary remediation goals/target cleanup levels. ERPMs are responsible for ensuring adequate evaluation of risks and for determining the level of resources to be committed to the evaluations.

Q. *What are the key components of a baseline risk assessment and what common errors/problems are associated with these components?*

A. According to the concept established by the National Academy of Sciences in 1983, four key components of a risk assessment exist in the context of environmental protection: hazard identification, dose-response identification, exposure assessment, and risk characterization. Common errors/ problems associated with each component are listed below.

Common Risk Assessment Errors

- Hazard Identification:
  - failure to address background hazards or risks,
  - inadequate application of QA,

- failure to address degradation products or intermediates, and
- inclusion of hazardous substances found in "hot spot" areas for the entire site.

- Dose-Response Evaluation:
  - use of out-of-date toxicity values,
  - assumption that identical toxicity values can be applied for other exposure routes, and
  - failure to address bioavailability and the extent of absorption by the receptor.
- Exposure Assessment:
  - use of unrealistic exposure assumptions (the "reasonable maximum exposure" concept should be applied);
  - failure to incorporate site-specific exposure information;
  - use of incorrect averaging time to modify daily average intake;
  - failure to include physical/biological degradation;
  - prediction of exposure point concentrations without identifying uncertainty factors;
  - failure to address entire conceptual model exposure pathways;
  - failure to incorporate site-specific geological, hydrogeological, and atmospheric information in the exposure pathway analysis; and
  - failure to consider possible exposure routes through the food chain.
- Risk Characterization:
  - conversion errors,
  - use of inappropriate assumptions in biokinetics uptake models (e.g., impact of lead in ground water on blood lead levels),
  - failure to use subchronic toxicity values while assessing less than long-term exposure,
  - inadequate uncertainty analysis, and
  - failure to address risks from all pertinent site-related hazardous substances (i.e., chemicals *and* radionuclides).[25]

EPA modified these initial components of risk assessment to address site-specific risk assessments under CERCLA. The revised components during a CERCLA baseline risk assessment (BRA) include (1) data collection and evaluation, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization. Data collection and evaluation begins early in the process (scoping) and consists of gathering and analyzing relevant site data and identifying contaminants of concern.

Exposure assessment is the next step of a BRA. When assessing exposure to ground water contaminants (i.e., evaluating the intensity, frequency, duration of contact), ERPMs may be able to obtain useful guidance from published DOE guidelines.[26] Additional exposure assessment guidance is available in 57 *FR* 22888 as well as in several EPA documents.[27–30]

Toxicity assessment is the third step of a BRA. It incorporates both hazard identification and dose/response evaluation. During the toxicity assessment, risk assessors decide whether a substance can potentially produce an adverse effect ("hazard identification") and quantify the dose-response relationship ("dose-response evaluation"). Limited consolidated guidance concerning hazard identification has been issued to date. However, common errors related to

dose response (the relationship between chemical exposure and estimated human health effects) may be avoided by using information from EPA's IRIS. IRIS data is periodically updated and contains EPA-verified toxicological data and information.[31]

The final component of BRA—risk characterization—integrates information collected during exposure and toxicity assessments into quantitative and qualitative expressions of risk. DOE published guidelines that restate, clarify, and expand upon current risk assessment concepts.[32] Additional sources on human health characterization may be found in EPA publications.[33-37]

EPA has also established criteria (i.e., "Data Useability Criteria") that may assist ERPMs (and their risk assessors) when preparing the project plans (e.g., SAPs), and the BRA approach maximizes the useability of environmental data.

By comparing the data obtained with each of the data useability criterion, regulators and risk assessors may evaluate the data as acceptable, acceptable with qualifications, or unacceptable for use in the risk assessment.[38]

EPA classifies all radioactive substances as Class A carcinogens. Therefore, any radioactive substance (e.g., a radioactive component of mixed waste) detected or suspected of being present at, or released from, a site should be considered to be a potential contaminant of concern. ERPMs may want to consult a supplement to EPA's data useability Part A guidance when their sites are contaminated with radioactive constituents.[39]

In some cases, ERPMs may avoid the common errors/problems during BRA activities and perform the BRA in accordance with EPA guidelines. However, issues may arise because of the manner in which EPA guidance is interpreted and applied by the regulators. These issues may have a tremendous impact on the risk estimates obtained and, in turn, the remedial alternative selected to reduce those risks. DOE has developed a detailed discussion of BRA-related issues in an EH-41 guidance manual.[40] This publication provides insight into the current EPA position on science policy issues underlying the BRA process. The reference manual also outlines the pros, cons, weaknesses, uncertainties, and areas for negotiation for each science policy issue. It should be used (1) to guide risk assessors through the process of interpreting BRA policy and (2) to help risk assessors discuss EPA guidance with regulators as it relates to conditions at a particular DOE site.

Upon completion of the baseline risk assessment, ERPMs should review the site conceptual model, future land-use assumptions, exposure assumptions, and the media and contaminants of potential concern originally identified at scoping and determine whether preliminary remediation goals need to be modified. Substances that present cancer risks within ground water of less than 10^{-6} or present a Hazard Index of less than 1 should not be retained as contaminants of concern unless there are significant concerns about multiple contaminants and pathways.[41]

3.11 Reasonable Maximum Exposure Assumptions

At DOE facilities ERPMs may find that controlling public access and/or limiting the activities of on-site personnel can reduce the exposure to hazardous substances.

Q. *What exposure assumptions should be made when ERPMs characterize exposures to human population during the baseline risk assessment?*

A. Unrealistic exposure assumptions can exaggerate site risks, leading to overly stringent remediation goals/media cleanup standards. During CERCLA response actions, the responsibility for conducting baseline risk assessment falls on the lead agency (i.e., DOE). EPA's 1989 risk assessment guidance[35] states that assessors should use the RME expected to

occur under both *current* and *future* land-use conditions. RME is defined as ". . . the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual pathways. If a population is exposed via more than one pathway, the combination of exposures across pathways also must represent an RME."[35] EPA's 1989 guidance needs to be interpreted in light of more up-to-date memoranda on risk assessment and risk characterization.[29, 33, 34, 41, 43]

EPA has provided standard factors that are intended to be used for calculating RME estimates for each applicable scenario at a site. Exposure scenarios and their corresponding quantitative assumptions were developed within the context of the following current land-use (and future land-use) classifications:

- residential,
- commercial/industrial,
- agricultural, and
- recreational.

EPA regional personnel should be consulted before application of these classifications because the definition of these zones can differ substantially from region to region.[29] For comparative purposes, EPA guidance states that an average estimate of exposure also should be presented in risk assessments.[42]

The NCP final rule encourages protection of ground water to maximize its beneficial use. Thus, the regulators' risk-based preliminary remediation goals likely will be based on residential exposures after it has been determined that ground water is suitable for drinking and that it is reasonable to assume that people will be using it as such. Residential land-use default equations are based on ingestion of drinking water and inhalation of volatile chemicals originating from the household water supply (e.g., dish washing, showering). In addition, when radionuclides are present, additional exposure routes (e.g., external radiation exposure due to immersion) should be considered as possible exposure routes.[41]

Existing or proposed institutional controls (e.g., erecting fences, utilizing security guards) or other measures that limit exposure should not be considered when establishing the true RME baseline. Baseline risk assessments for DOE sites destined to remain under federal government control after the remedial actions are complete should include an analysis indicating that exposure estimates that assume no action (e.g., preventing access) represent RME but do *not* reflect realistic expectations for future uses of the site.[43]

Under RCRA corrective action authority, ERPMs will be required (by the regulators) to perform a facility investigation. As components of this investigation, ERPMs shall characterize any ground water plume contamination and collect data describing the human populations and environmental systems that currently or potentially are at risk of contaminant exposure. Under RCRA, the risk assessment can be used by the ERPM to justify whether:

- an interim/stabilization measure is necessary or
- a CAMU is appropriate and will not pose unacceptable risks.

EPA has acknowledged that the RCRA corrective action process and the CERCLA programs are substantially equivalent. Further, Section 8 of EPA's RFI guidance ("Health and Environmental Assessment") makes numerous references to CERCLA risk assessment

guidance. Therefore, EPA's risk assessment guidance may be followed to perform a risk assessment during RCRA corrective action.[44]

Currently, exposure assumptions during the Health and Environmental Assessment (HEA) reflect a reasonable *worst* case scenario. However, EPA is considering the use of different exposure assumptions where different exposure scenarios are likely based on current and future land use at/near the site (55 *FR* 30827).

3.12 Communication of Baseline Risk Assessment Results

In his memorandum entitled *Guidance on Risk Characterization for Risk Managers and Risk Assessors*,[34] EPA's Deputy Administrator observed that the results of risk assessments often are boiled down to a point estimate of risk; that this "short hand" form of risk communication does not adequately convey the full range of information necessary to support informed interpretation of those results.

Q. *How should baseline risk assessment results be effectively communicated to decision makers and the public?*

A. At the completion of the BRA, ERPMs typically prepare a BRA report that references and supports the RI/FS report. Depending on the site, a BRA report may range from a small, simple document that is added to the RI/FS report. as a chapter to a large, complex, stand-alone document with many appendices. EPA provides both a suggested outline and a reviewer checklist for a BRA report as Exhibits in RAGS I.[35]

EPA has determined that three principles must be addressed when presenting risk assessment information (e.g., the BRA report). These principles include:

- reports should be full and complete regarding the level of confidence of and uncertainties inherent in the assessment results;
- reports should adhere to terminology (i.e., standard descriptors of exposure and risk) provided in EPA Exposure Guidelines (57 *FR* 22888) to promote consistency and comparability; and
- professional scientific judgment should be used to ensure that the most significant data and uncertainties from the assessment (i.e., those that define and explain the main risk conclusions) are presented so that stakeholders and decision-makers are not overwhelmed by valid but secondary information.

In addition to the BRA report, ERPMs will prepare two additional reports—a RI report and a ROD—that communicate summaries of the BRA. For the RI report, typically, one of the chapters is devoted to a summary of the BRA. This summary should address both the human health and environmental evaluations. The human health summary often follows the same outline as the BRA report. Although the summary condenses most of the BRA report chapters, the risk characterization chapter may be included in the RI/FS report essentially unchanged.

Baseline risk assessment results also are documented in various sections of the ROD Decision Summary. The following examples illustrate where BRA results may also be discussed in the ROD.

- risks associated with current and future land use for each exposure medium, or combined risks of exposure via more than one medium ("Summary of Site Risks" section);

- the initial risk and how each remedial alternative will reduce these risks by achieving remediation goals through treatment or by eliminating exposure using engineering controls ("Description of Alternatives" section);
- each of the nine remedy selection criteria, which, for several evaluation criteria (e.g., overall protection, long- and short-term effectiveness), include consideration of risks as part of their discussion ("Comparative Analysis of Alternatives" section); and
- substance-specific remediation goals and corresponding substance-specific risk levels after the goals are attained, as well as the ERPM's basis (i.e., risk calculation, ARARs) justifying the selected goals ("Selected Remedy" section).

ERPMs may want to consider arranging the Remediation Levels and Corresponding Risks into tabular form when displaying the information discussed under the fourth bullet listed above. This arrangement may be completed for each media for which the ROD identifies final remediation goals.[48] Sample language and detailed outlines of the information to be included relative to each section listed above have been published.[45]

3.13 Treatability Study Performance Goals

Available technical literature or remedial technology databases may not contain the information necessary to identify and evaluate appropriate treatment alternatives. Treatability studies can be used to fill these data gaps. Scoping and initiating treatability studies as early as possible may assist ERPMs in keeping the RI/FS on schedule and within budget. Setting goals or objectives for the treatability study is critical to the ultimate usefulness of the study and should be completed before the treatability study is performed.

Q. *Has EPA identified goals that are useful when identifying ground water treatability study technology performance?*

A. Treatability studies serve two primary purposes: (1) to support in the *selection* of the remedy and (2) to aid in the implementation of the selected remedy. Treatability studies conducted during the RI/FS phase indicate whether a given technology can meet the expected cleanup goals for the site. Treatability studies conducted during the RD/RA phase establish the design and operating parameters for optimizing technology performance. Ideal goals for assessing ground water treatment technology performance are the final media-specific remediation goals/cleanup standards (e.g., nonzero MCLGs/MCLs). Often, however, final cleanup criteria are not *established* until remedy selection has occurred (i.e., after the ROD is signed, permit/permit modification is issued, FFCA is executed). In the absence of established cleanup levels, ERPMs should estimate treatability study performance goals based on the following criteria:

- levels that provide overall protection of human health and the environment;
- levels that comply with potential ARARs;
- levels that ensure a reduction of toxicity, mobility, or volume (e.g., LDR treatment standards under 40 CFR §§268.41–268.43);
- published levels acceptable for delisting of hazardous waste;[46] or
- levels established by the state or EPA region for another site containing contaminated ground water with similar characteristics/contaminants.

Remediation goals/cleanup standards directly relate to the ERPM's final management strategy for the contaminated media. Nonattainment of the established goals/standards (or the criteria

listed above) may indicate the need for additional treatment processes (i.e., application of treatment trains).[47]

3.14 Three Tiers of Treatability Studies

Treatability studies should be performed in a systematic fashion and should occur in three levels (i.e., tiers).

Q. *What are these three tiers and what type of data needs should ERPMs apply?*

A. The three levels—laboratory screening, bench-scale, and pilot-scale testing—can be used throughout the treatability study process. Typically, laboratory screening and bench-scale testing are employed during remedial alternative evaluation. Pilot-scale testing is generally (but not always) used during remedy implementation. In addition to the three tiers of testing, EPA establishes five analytical levels used during the RI/FS process. Analytical levels I and II apply to laboratory screening, and analytical levels III, IV, and V apply to bench- and pilot-scale treatability studies.

Laboratory screening is limited in size and scope to small-scale jar tests and beaker studies. It requires little or no replication and a low level of QA/QC. Bench-scale testing is also performed in a laboratory; relatively small volumes of contaminated ground water are used. However, bench-scale testing requires duplicate or triplicate replications, and a moderate to high level of QA/QC. Bench-scale testing may be appropriate when attempting to determine any of the following:

- effectiveness of the treatment alternative on the contaminated ground water,
- differences in performance between competing manufacturers,
- differences in performance between alternative chemicals,
- sizing requirements for pilot-scale studies,
- screening of technologies to be pilot tested,
- sizing of those treatment units that would sufficiently affect the cost of implementing the technology, or
- compatibility of materials with the contaminated ground water.

Bench-scale tests may also be conducted for well-developed and documented technologies that are being applied to a new waste (e.g., mixed waste).

Pilot-scale testing should be limited to situations in which bench-scale testing or field sampling of physical or chemical parameters provide insufficient information to evaluate an alternative. Pilot studies may also be appropriate when there is a need to evaluate secondary effects of the treatment process (e.g., release of air emissions) or secondary treatment processes (e.g., air emission control technologies).[1]

3.15 Recommended Approach to Treatability Studies

The need for treatability studies should be identified during project scoping to avoid delays in the RI/FS schedule. During scoping, a literature survey should be conducted to gather information on a technology's applicability, performance, implementability, relative costs, and operation and maintenance requirements. If practical candidate technologies have not been

sufficiently demonstrated or cannot be adequately evaluated based on the available information, treatability testing should be performed.

Q. *Does EPA recommend an approach or protocol that should be followed during treatability studies?*

A. Yes. EPA has developed a "stepwise approach or protocol" that ERPMs should follow for all phases of the investigation. This approach includes the following steps:

- establishing DQOs,
- selecting a contracting mechanism,
- issuing the task assignment,
- preparing site plans (e.g., the Work Plan, Sampling and Analysis Plan, Health and Safety Plan),
- conducting community interviews,
- complying with regulatory requirements,
- executing the study,
- analyzing and interpreting the study data, and
- reporting the results.

If a treatment technology is to be tested at multiple tiers, it may not be necessary to prepare a formal report for the results of each tier of testing. Interim reports prepared at the completion of each tier may suffice. As an aid to EPA's Office of Emergency and Remedial Response, ERPMs should submit a copy of all treatability study reports to EPA's Superfund Treatability Data Base repository, maintained within the Office of Research and Development.[47]

3.16 RI/RFI Reporting and Documentation

The ERPM's role in overseeing a CERCLA response action/RCRA corrective action involves, to a large extent, ensuring that the work progresses according to the priorities and objectives established during site management and project planning. The ERPM facilitates the interactions between DOE and stakeholders to ensure that all involved parties are aware of their roles and responsibilities. During site characterization, routine communication between DOE, their contractors, and the other support agencies and other stakeholders may be prescribed by EPA and DOE and documented on a site-specific basis (e.g., FFA, RI/FS Work Plan, RFI Work Plan).

Q. *While performing, or at the conclusion of the RI/RFI, do ERPMs encounter substantial reporting or documentation requirements?*

A. Immediately following completion of field sampling and analysis, ERPMs may be required to prepare a Preliminary Site Characterization Summary (PSCS). This summary briefly reviews the investigative activities that have taken place and describes and displays site data (e.g., analytical results). Although the format of the PSCS is optional, use of a technical memorandum, which illustrates the location and quantities of contaminant at the site, is strongly encouraged by EPA.[1]

In addition to the PSCS, ERPMs should be aware that an RI report must be prepared and submitted to the regulators. Draft RI reports should be prepared between completion of the

baseline risk assessment and completion of the draft FS reports. EPA's suggested format of a draft RI report includes the following headings:

- Executive Summary,
- Introduction,
- Study Area Investigation,
- Physical Characteristics of the Study Area,
- Nature and Extent of Contamination,
- Contaminant Fate and Transport,
- Baseline Risk Assessment, and
- Summary and Conclusions.

Additionally, appendices to the RI report should include:

- Technical Memoranda on Field Activities (if available),
- Analytical Data and QA/QC Evaluation Reports, and
- Risk Assessment Methods.

The draft RI report should be produced for review by the regulators, as well as submitted to the Agency for Toxic Substances and Disease Registry (ATSDR) for its use in preparing a health assessment.[(1)]

In limited situations, the baseline risk assessment provides the basis for concluding that conditions at a site (or portion of a site) pose no current or potential threat. ERPMs, therefore, may determine that remedial actions need not be invoked. Under such circumstances, the statutory cleanup standards (e.g., compliance with ARARs, cost effectiveness) are not triggered and need not be addressed when documenting a "no-action" decision.[(49)]

During RCRA corrective actions, ERPMs should conduct periodic reviews of the RFI and any interim CMS to assess the progress toward achieving the objectives set during the planning (i.e., scoping) process. A document summarizing the findings of each review should be prepared. These periodic progress review documents and action level reports should be submitted to the regulators.[(50)] In addition, an RFI report, which is similar to the RI report, must be submitted to the regulators. The RFI report incorporates or references all the information collected during the RFI (and Interim Corrective Measure Study if applicable). It forms the basis for the regulators' "Determination of No Further Action" or substantiates their decision to require ERPMs to perform the CMS. Preparation and contents of the draft RFI report is specified by the regulators. This typically entails 14 steps.[(50)]

Upon regulator approval of the RFI report, ERPMs must mail the final report's Executive Summary to all parties on the facility mailing list. This list is developed and maintained as part of the permitting process [40 CFR § 124.10(c)(1)(viii)]. Based on the information contained in the RFI report, if there is no evidence of a release or threatened release of a hazardous waste/constituent from a solid waste management unit, ERPMs may request a determination from the regulators that no further action (NFA) be required at their facility. "The most direct method of preparing a comprehensive document to support such a request is to include all pertinent data in the RFI report and to make the request when the RFI report is submitted." The

NFA request also requires concurrent submittal of a Class III modification request of the facility's permit (or FFCA).[50]

No public participation activities are required by law at the release of the RI/RFI report. However, in addition to DOE-suggested activities, DOE guidance specifies that ERPMs:

- prepare and issue a fact sheet that describes the findings of the RI/ RFI and highlights upcoming opportunities for public participation;
- hold a public meeting to explain the findings of the RI/RFI report and to provide a forum for questions from interested parties; and
- issue a press release announcing the following: (1) the availability of the RI report/RFI report, (2) the findings of the RI/RFI, and (3) the date, time, and location of the public meeting, when appropriate.[51]

The final RI (and FS) report typically is released to the public by being placed in the administrative record at an information repository near the site concurrent with release of the Proposed Plan. The final RFI report generally becomes publicly available as part of the administrative record for draft permits/permit modifications. It is part of the supporting documentation when the draft permit/permit modification and statement of basis (or fact sheet if a state has the lead) is released.

3.17 Chapter Summary

Although a tremendous amount of historical site information may be gathered during the scoping stage of the RI/RFI, additional data may be required to refine the conceptual site model and address data needs. During site characterization under CERCLA, the SAP (developed as a component of the RI Work Plan) is implemented in an attempt to determine or confirm to what extent a site poses a threat to human health or the environment. For RCRA corrective actions, ERPMs will be required to prepare, submit to regulators, and implement upon approval a QAPP that identifies how they will characterize the environmental setting, sources, and contamination. Investigations (i.e., site characterization) under CERCLA and RCRA must be performed in accordance with the approved SAP/QAPP and should result in data of adequate technical quality to support the development and evaluation of the remedial alternatives/corrective measures during the FS/CMS.

To investigate the impacts of past activities on ground water and define a site's ground water contamination, ERPMs must perform a hydrogeologic investigation. Each site's RI/FS or RFI work plan will describe the location, methods, and strategies that will be used while drilling and installing monitoring wells. The plan will prescribe the appropriate tests that will be used (e.g., slug tests, pumping tests) to determine aquifer characteristics. Finally, a media- sampling strategy will be developed and implemented to identify contaminant sources and characterize the extent of contamination, as well as to evaluate alternatives for remediation. For ground water, this strategy may include residential, commercial, and monitoring well sampling.

Under CERCLA, ERPMs should sample and analyze for the full complement of Target Compound List/Target Analyte List parameters to accurately characterize the occurrence and distribution of contamination in the ground water. Under RCRA, regulators may require that ERPMs analyze for Appendix IX of 40 CFR Part 264 ("Ground Water Monitoring List") when determining the presence and levels of hazardous constituents. In addition, ERPMs may need to analyze for engineering-related parameters (e.g., total suspended solids, pH, temperature, conductivity).

During site characterization, ERPMs may encounter contaminants that require specialized management procedures or characterization approaches. In some cases, investigation-derived waste (e.g., ground water purged from a monitoring well) may qualify as hazardous waste and/or RMW. Management activities associated with these wastes will be governed by Subtitle C (as well as AEA for RMW) requirements. Also, if the potential of NAPL occurrence is moderately high, ERPMs should consider specialized characterization techniques.

Because estimates of actual or potential exposure activities may be refined as new information is collected, site characterization information should be fully integrated with the development and assessment of natural resource damage and baseline risk. These assessments draw on site characterization data to evaluate potentially adverse site impacts on natural resources, human health, and the environment.

Rescoping may occur at several points in the site characterization process, especially when initial information on a site was limited or if the results of field screening or laboratory analyses indicate that site conditions significantly deviated from the expected conditions.

3.18 Chapter References

1. EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Dir. 9355.3-01, Office of Emergency and Remedial Response, Washington, D.C.
2. EPA, 1987. *A Compendium of Superfund Field Operations Methods*, OSWER Dir. 9355.0-14, Office of Emergency and Remedial Response, Washington, D.C.
3. EPA, 1991. *Compendium of ERT Ground Water Sampling Procedures*, OSWER Dir. 9360.4-06, Office of Emergency and Remedial Response, Washington, D.C.
4. EPA, 1989. *RCRA Facility Investigation (RFI) Guidance; Interim Final; Volumes I–IV*, OSWER Dir. 9502.00-6D, Office of Emergency and Remedial Response, Washington, D.C.
5. DOE, 1989. *Fact Sheets: Natural Resource Trusteeship Under CERCLA and Management of Ground Water as Hazardous Waste*, EH-231 Memorandum, Environmental Guidance Division, Washington, D.C.
6. DOE, 1992. *Definitions of Solid and Hazardous Waste*, DOE/EH-0273, Office of Environmental Guidance, Washington, D.C.
7. DOE, 1993. *The "Derived-from" Rule under the Resource Conservation and Recovery Act (RCRA)*, Information Brief, DOE/EH-231-035/0593, Office of Environmental Guidance, Washington, D.C.
8. DOE, 1993. *Exclusions and Exemptions from RCRA Hazardous Waste Regulation*, Information Brief, DOE/EH-231-034/0593, Office of Environmental Guidance, Washington, D.C.
9. DOE, 1991. *Identification of Certain RCRA Wastes—the F-Spent Solvent, P, and U Listings*, Information Brief, DOE/EH-231-008/1291, Office of Environmental Guidance, Washington, D.C.
10. DOE, 1991. *The Mixture Rule under the Resource Conservation and Recovery Act*, Information Brief, DOE/EH-231-005/1291, Office of Environmental Guidance, Washington, D.C.
11. DOE, 1991. *Overview of the Identification of Hazardous Waste under RCRA*, Information Brief, DOE/EH-231-007/1291, Office of Environmental Guidance, Washington, D.C.

12. DOE, 1991. *Questions and Answers on the RCRA Toxicity Characteristic*, Information Brief, DOE/EH-231-003/1291, Office of Environmental Guidance, Washington, D.C.

13. DOE, 1993. *Preparation of RCRA Waste Analysis Plans (Interim Guidance)*, DOE/EH-0306, Office of Environmental Guidance, Washington, D.C.

14. EPA, 1992. *Guide to Management of Investigation-Derived Wastes*, OSWER Dir. 9345.3-03FS, Office of Emergency and Remedial Response, Washington, D.C.

15. DOE, Sept. 26, 1988. *Radioactive Waste Management*, DOE Order 5820.2A, Office of Defense Waste and Transportation Management, Washington, D.C.

16. DOE, 1994. *Hazardous Waste Treatability Studies Sample Exclusion; Revised Rule Issued; Effective Date: February 18, 1994*, Regulatory Bulletin, Office of Environmental Guidance, Washington, D.C.

17. EPA, 1993. *Evaluation of the Likelihood of DNAPL Presence at NPL Sites*, OSWER Dir. 9370.7-02C, Office of Emergency and Remedial Response, Washington, D.C.

18. EPA, 1992. *Estimating the Potential for Occurrence of DNAPL at Superfund Sites*, OSWER Dir. 9355.4-07FS, Office of Solid Waste and Emergency Response, Washington, D.C.

19. EPA, 1992. *Dense Nonaqueous Phase Liquids—A Workshop Summary, Dallas, Texas, April 16–18, 1991*, EPA/600-R-92/030, Office of Research and Development, Washington, D.C.

20. EPA, 1991. *Ground Water Issue: Dense Nonaqueous Phase Liquids*, OSWER Dir. 9370.7-02C, Office of Emergency and Remedial Response, Washington, D.C.

21. EPA, 1993. *Seminar on Characterizing and Remediating Dense Nonaqueous Phase Liquids at Hazardous Sites: Presentation Outlines and Slide Copy*, EPA/600/K-93/003, Office of Research and Development, Washington, D.C.

22. Cohen, R.M. and Mercer, J.W., 1993. *DNAPL Site Evaluation*, Lewis Publishers, Chelsea, Michigan.

23. DOE, 1993. *Integrating Natural Resource Damage Assessment and Environmental Restoration Activities at DOE Facilities*, Office of Environmental Guidance, Washington, D.C.

24. DOE, 1993. *Natural Resource Damages Under CERCLA*, Information Brief, EH-231-017/0693, Office of Environmental Guidance, Washington, D.C.

25. DOE, 1992. *CERCLA Baseline Risk Assessment Human Health Evaluation*, Information Brief, EH-231-012/0692, Office of Environmental Guidance, Washington, D.C.

26. DOE, 1994. *Exposure Assessment Guidelines*, Information Brief, EH-232-009/08/94, Office of Environmental Guidance, Washington, D.C.

27. EPA, 1988. *Superfund Exposure Assessment Manual*, OSWER Dir. 9285.5-1, Office of Remedial Response, Washington, D.C.

28. EPA, 1989. *Exposure Factors Handbook*, EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C.

29. EPA, 1991. *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors,"* OSWER Dir. 9285.6-03, Office of Emergency and Remedial Response, Washington, D.C.

30. EPA, 1991. *Exposure Assessment Methods Handbook*, EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C.

31. DOE, 1991. *Integrated Risk Information System*, DOE/EH-0194, Office of Environmental Guidance, Washington, D.C.

32. DOE, 1994. *EPA Guidance on Risk Characterization for Risk Managers and Risk Assessors*, EH-232-008/08/94, Office of Environmental Guidance, Washington, D.C.

33. EPA, 1995. *EPA Risk Characterization Program*, Memorandum from Carol M. Browner to Assistant, Associate, and Regional Administrators (with attachments), General Council Inspector General, March 21, 1995, Washington, D.C.

34. EPA, 1992. *Implementing the Deputy Administrator's Risk Characterization Memorandum*, OSWER Dir. 9285.7-13, Office of Emergency and Remedial Response/Office of Waste Programs Enforcement, Washington, D.C.

35. EPA, 1989. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual; Part A, Interim Final*, OSWER Dir. 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

36. EPA, 1989. *Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual*, EPA/540/1-89/001, Office of Emergency and Remedial Response, Washington, D.C.

37. EPA, 1992. *Framework for Ecological Risk Assessment*, EPA/630/R-92/001, Risk Assessment Forum, Washington, D.C.

38. EPA, 1992. *Guidance for Data Useability in Risk Assessment (Part A)*, OSWER Dir. 9285.7-09A, Office of Emergency and Remedial Response, Washington, D.C.

39. EPA, 1992. *Guidance for Data Useability in Risk Assessment (Part B)*, OSWER Dir. 9285.7-09B, Office of Emergency and Remedial Response, Washington, D.C.

40. DOE, 1995. *CERCLA Baseline Risk Assessment Reference Manual*, DOE/0484, Office of Environmental Policy and Assistance, Washington, D.C.

41. EPA, 1991. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals) Interim*, OSWER Dir. 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

42. EPA, 1992. *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Dir. 9285.7-08I, Office of Solid Waste and Emergency Response, Washington, D.C.

43. DOE, 1992. *Use of Institutional Controls in a CERCLA Baseline Risk Assessment*, Information Brief, EH-231-014/1292, Office of Environmental Guidance, Washington, D.C.

44. DOE, 1994, *RCRA Corrective Action Human Health Assessment*, Information Brief, EH-231-045/0594, Office of Environmental Guidance, Washington, D.C.

45. EPA, 1989. "Key Elements of the Decision Summary," Sect. 6.3 in *Interim Final Guidance on Preparing Superfund Decision Documents*, OSWER Dir. 9355.3-02, Office of Emergency and Remedial Response, Washington, D.C.

46. Science Applications International Corporation, 1991. *Docket Report of Health-Based Levels and Solubilities Used in the Evaluation of Delisting Petitions, Submitted under 40 CFR § 260.20 and § 260.22*, Falls Church, Virginia.

47. EPA, 1989. *Guide for Conducting Treatability Studies Under CERCLA: Interim Final*, OSWER Dir. 9370.3-02, Office of Emergency and Remedial Response, Washington, D.C.

48. EPA, 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Dir. 9355.0-30, Office of Solid Waste and Emergency Response, Washington, D.C.

49. EPA, 1989. *Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment*, OSWER Dir. 9355.3-02, Office of Emergency and Remedial Response, Washington, D.C.

50. DOE, 1993. *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.

51. DOE, 1991. *Public Participation in Environmental Restoration Activities*, DOE/EH-0221, Office of Environmental Guidance, Washington, D.C.

4. Identifying Governing Standards

Figure 4 provides a graphic representation of the process of identifying governing standards and the organization of this chapter.

4.1 Applicability of ARARs During On-site Study/Characterization

Under CERCLA, on-site response actions must be protective of human health and the environment and must comply with ARARs. ARARs incorporate the use of program-specific terms and definitions. ARARs that define a level or standard of control (i.e., substantive requirements) must be met during on-site CERCLA response activities. Requirements such as issuance of permits, documentation, and reporting/record keeping are viewed as administrative burdens and do not apply to on-site CERCLA actions. Monitoring requirements are considered substantive requirements and are necessary to document attainment of remediation goals, compliance with emission limitations or release levels, etc. (55 *FR* 8757).

Q. *How do ARARs apply to wastes generated while performing on-site studies or characterization activities?*

A. Identification of ARARs (identified on a case-by-case basis) involves a two- part analysis. First, ERPMs must determine whether a given requirement is "applicable" [i.e., federal- or state-promulgated requirement that specifically addresses a hazardous substance (including hazardous waste), pollutant, contaminant, response action, location (e.g., wetland), or other circumstance]. Second, if not applicable, ERPMs must determine whether that requirement is "relevant and appropriate" (i.e., the requirement addresses similar situations or problems and is well-suited to the particular site). As a matter of law, ARARs apply to remedial actions. However, consistent with EPA's policy, ERPMs should attain ARARs to the extent practicable when conducting removal actions associated with ground water remediation.

CERCLA §101(23) defines removal to include "such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances . . . [including] action taken under §104(b) of [CERCLA]." Site studies and investigations (i.e., site characterization) that are performed during the RI/FS are considered removal actions.

During site characterization, ground water investigation activities may result in the generation of IDW. This waste often includes drilling muds, cuttings, and purge water from test pit and well installation; well development purge waste; and solutions used to decontaminate nondisposable drilling equipment. General options for managing IDW include collection and either (1) immediate disposal or (2) some type of interim management. ERPMs are encouraged to consider minimization of IDW generation and management of IDW consistent with the final (or projected final) remedy for the site.[(1)]

When managing IDW, ERPMs must select an option that is protective considering the contaminants, their concentrations, and total volume of IDW; the media potentially affected; the location of the nearest population; the potential exposures to site workers; and the potential for environmental impacts. Additionally, ERPMs must ensure the on-site management of IDW satisfies ARARs to the extent *practicable*. EPA offers a great deal of flexibility. EPA explains two factors in the final NCP—urgency of the situation (i.e., the need for prompt response) and scope (i.e., purpose) of the removal action—that should be used by ERPMs when determining whether compliance with an ARAR is "practicable." Even if attainment of an ARAR is practicable, based on the two factors listed previously, ERPMs should consider whether a waiver (i.e., interim measure, greater risk to human health and the environment, technical impracticability, equivalent standard of performance, or a state requirement applied

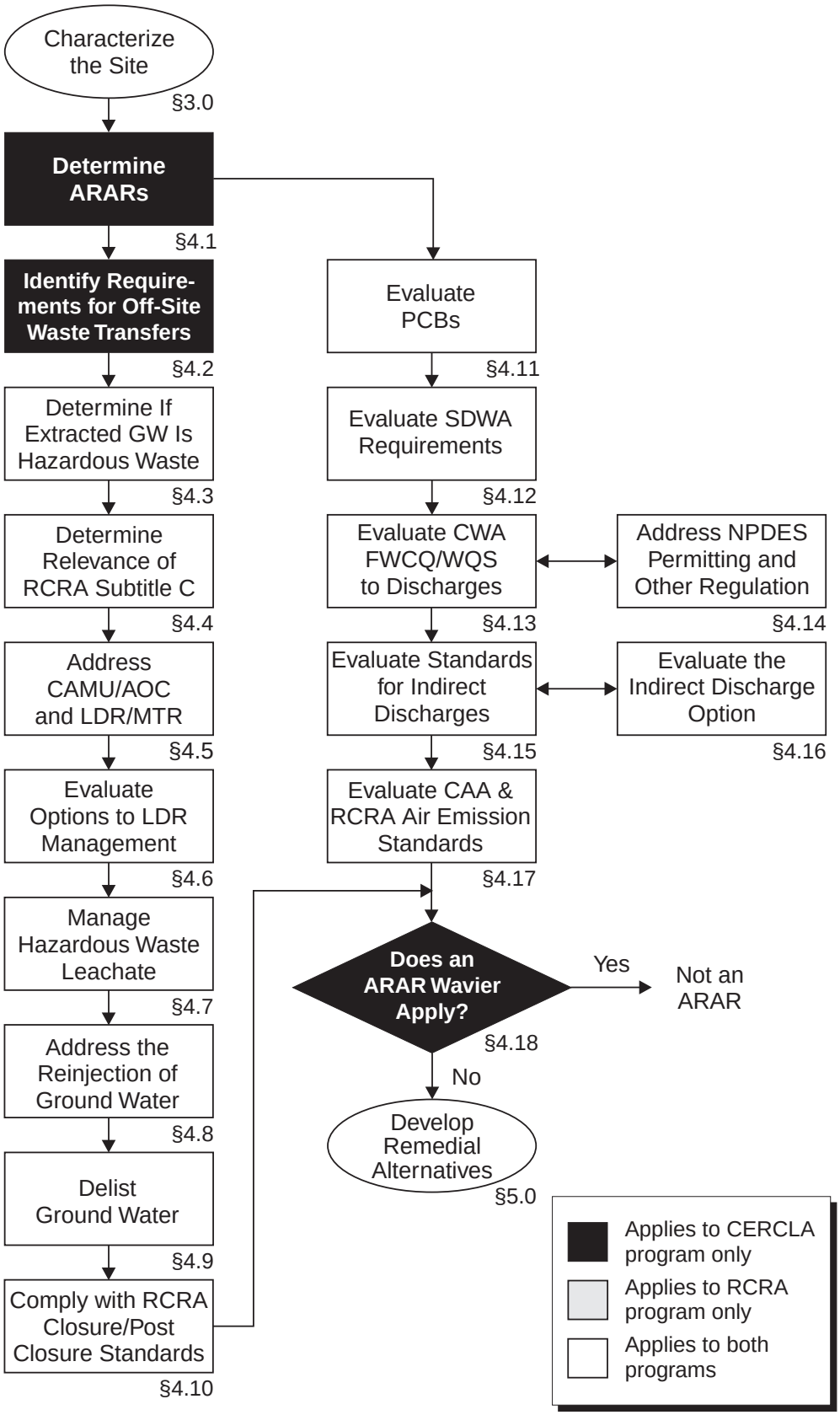

Figure 4. Identifying governing standards.

inconsistently) is appropriate.[2] It will generally not be necessary to obtain a waiver if an ARAR cannot be practicably attained during RI/FS and RD field investigations.[3] If ERPMs determine that compliance with an ARAR is not practicable, removal actions must still be conducted in a manner that prevents, minimizes, or mitigates damage to public health, welfare, and the environment.[2]

IDW that is sent off-site for storage, treatment, or disposal must comply with legally applicable requirements (both substantive *and administrative*), including the CERCLA Off-site Rule codified under 40 CFR § 300.440.

4.2 Requirements for Off-site Transfer of "CERCLA Wastes"

As discussed above, under CERCLA, on-site response actions must be protective of human health and the environment and must comply with ARARs. The definition of "on-site" is case-specific and means the aerial extent of contamination and all suitable areas in close proximity to the contamination necessary to implement response actions. In some cases, on-site may include noncontiguous facilities that are related on the basis of geography (e.g., both facilities contribute significant sources of ground water contamination) or related based on the threat posed (55 *FR* 8688 and 58 *FR* 49204). "EPA policy further defines 'on-site' to include the soil and the ground water plume that are to be remediated."[4] Areas not covered by the definition of on-site fall within the definition of "off-site."

Q. *In addition to certain regulation-based administrative requirements (e.g., manifests, LDR notification/certification), what requirements must be addressed by ERPMs before or during the off-site transfer of CERCLA hazardous substances, pollutants, or contaminants (i.e., CERCLA wastes)?*

A. On September 22, 1993, EPA issued a final rule that amends the NCP to include procedures that must be observed when a response action under CERCLA involves the off-site management of CERCLA wastes. In this final rule, EPA explains

> . . . if a Federal agency plans to transfer CERCLA wastes off-site from a Federal facility under a CERCLA authority . . . the Federal agency may transfer CERCLA wastes only to facilities found to be acceptable under this rule. Federal facilities may transfer wastes off the CERCLA site to treatment, storage, or disposal units on the same Federal property, but only if the other units (and the larger Federal facility or installation) meet the requirements of this rule [58 *FR* 49204].

This means that the off-site facility receiving CERCLA waste must be evaluated by the EPA Regional Office and determined to be acceptable before shipping waste to it regardless of whether it is a DOE facility or not.[5] ERPMs should contact their EPA Regional Off-site Contacts (ROCs) to obtain up-to-date, accurate information regarding the acceptability of facilities in their area. This information has been published[5, 6] and is also available from the RCRA/Superfund hotline (800) 424-9346.

An exemption from the Off-site Rule is provided for the off-site transfer of laboratory samples and treatability study wastes. Contaminated ground water sent off-site for (1) the sole purpose of testing to determine its character or composition or (2) the purpose of conducting treatability studies are not subject to the Off-site Rule provided certain management conditions are met [40 CFR § 300.440(a)(5)(i)-(iii)].

In some situations, ERPMs fulfilling the responsibilities of On-Scene Coordinators may determine that cleanup or stabilization activities must be initiated within hours or days (i.e., emergency removal actions, emergencies during remedial actions). In these situations, CERCLA

wastes may be transferred off-site without complying with the Off-site Rule [40 CFR § 300.440(a)(2)]. However, before off-site shipment, ERPMs should weigh, to the extent practicable, the following factors to determine whether a facility in noncompliance may be used for off-site disposal:

- the urgency of the situation,
- the availability of alternative receiving facilities,
- the reasons for the facility's primary unacceptability,
- the facility's status relative to public health threats, and
- the likelihood of the facility's return to compliance.

In some situations, it may be necessary to move material off-site before a facility's acceptability can be evaluated (58 *FR* 49204).

One notable administrative requirement associated with off-site shipments is the requirement that ERPMs provide notification for out-of-state shipments of CERCLA wastes. Before off-site shipment of CERCLA wastes to an out-of-state waste management facility, ERPMs must routinely provide written notice to the receiving state's environmental official. ERPM notification should specify:

- the name and location of the receiving facility,
- the type and quantity of waste involved,
- the expected schedule for the transfer of the CERCLA waste, and
- the method of transportation.

Although notification of CERCLA waste shipments should be provided for all remedial actions and NTCR actions, notification may be unnecessary for shipments of small amounts of waste (e.g., 10 yd.^{3}).[(7)] Further, emergency and time-critical removals are not covered by this policy (55 *FR* 8740).

4.3 Hazardous Waste Characterization for Extracted Ground Water

Subtitle C of RCRA establishes a "cradle-to-grave" framework for the safe management of "hazardous waste." The Hazardous and Solid Waste Amendments (HSWA) of 1984 amended RCRA and prohibit the land disposal of hazardous waste unless the waste meets prescribed treatment levels. Hazardous wastes that were land disposed before applicable LDR effective dates were not subject to LDR and are not required to be extracted or exhumed for treatment. Conversely, wastes or contaminated media (e.g., ground water) that are extracted or exhumed after the applicable LDR effective date may be subject to LDR requirements. Characterization (i.e., proper identification and listing of hazardous wastes) is essential in determining the applicability of the LDR requirements to a specific material or waste stream.

Q. *How should ERPMs perform their hazardous waste characterizations for extracted ground water?*

A. During the performance of CERCLA response actions or RCRA corrective actions, ERPMs may find it necessary to extract ground water (e.g., pump-and- treat, purge stagnant ground water from a monitoring well). Ground water itself is not a listed hazardous waste, and the "mixture" and "derived from" rules are not appropriate for contaminated media (i.e., ground

water is not a solid waste). Thus, EPA typically uses two methods for classifying ground water as hazardous waste.

First, ground water may be considered hazardous waste under EPA's "contained in" policy. EPA's policy states that ground water containing listed RCRA hazardous waste must be managed as if it is hazardous until (1) a determination by the EPA Regional Administrator concludes that the ground water no longer "contains" a hazardous waste (i.e., the concentration of all hazardous constituents falls below health-based thresholds) or (2) the hazardous waste is delisted.[8] The determination of whether the ground water contains hazardous waste is site-specific and should be decided through consultation with regulators (e.g., EPA Regional Administrator). EPA has proposed a set of decision factors that may be considered by the Regional Administrator in making contained-in determinations. These include:

- media characteristics,
- waste constituent characteristics (i.e., solubility, mobility, toxicity, interactive effects of constituents present that may affect these properties),
- exposure potential,
- an acceptable risk range (10^{-4} to 10^{-6}),
- surface and subsurface characteristics,
- climate conditions, and
- other site or waste-specific characteristics or conditions (58 *FR* 48127).

Second, extracted ground water can be identified as hazardous waste because, based on the ERPM's process knowledge or sampling and analysis, the ground water exhibits a characteristic of hazardous waste (e.g., exceeds the threshold concentration for cadmium, lead, mercury). In either case, the determinations of whether extracted ground water is a hazardous waste (and whether it is subject to LDR requirements) must be made *at the point of generation* (e.g., the point where the ground water exits the recovery unit).

ERPMs should have affirmative evidence (e.g., manifests, records, knowledge of the process) to demonstrate that ground water contains a listed hazardous waste. If such information is lacking, ERPMs may assume it does not (55 *FR* 8758). Hazardous waste listings are retroactive. Once a particular waste is listed, all wastes meeting that description are hazardous wastes no matter when disposed (53 *FR* 31145). To determine whether ground water is characteristically hazardous, ERPMs may either test a representative ground water sample or use their process knowledge. However, in the absence of testing, ERPM decisions must be based on site-specific information and data collected on the constituents and their concentrations during site investigations (55 *FR* 8762).

4.4 Applicability or Relevance and Appropriateness of RCRA Subtitle C

In accordance with the concept of ARARs, ERPMs must be cognizant of, and remain in compliance with, germane RCRA Subtitle C substantive requirements while performing on-site CERCLA response actions. By contrast, ERPMs overseeing RCRA corrective actions do not consider ARARs but must comply with legally applicable substantive *and* administrative requirements of Subtitle C.

Q. *What prerequisites should ERPMs consider when determining the applicability or relevance and appropriateness of RCRA Subtitle C requirements?*

A. Subtitle C requirements are applicable to on-site CERCLA response actions when contaminated ground water qualifies as RCRA hazardous waste and either:

- the contaminated ground water was initially treated, stored, or disposed of after the effective date of a particular RCRA requirement or
- the activity at the ERPM's site constitutes treatment, storage, or disposal of a hazardous waste.

If Subtitle C requirements are not applicable, they may still be "relevant and appropriate" based on consideration of several factors including:

- the nature of the waste and its hazardous properties,
- other site characteristics, and
- the nature of the Subtitle C requirement itself (55 *FR* 8763).

The codified factors for determining whether a requirement is relevant and appropriate can be found in 40 CFR § 300.400(g)(2) (see 55 *FR* 8763).

Unlike CERCLA response actions, RCRA corrective actions must integrate legally applicable substantive and administrative regulations under RCRA, as well as any other legally applicable federal and state environmental regulations [e.g., TSCA regulations for the management of ground water containing certain concentrations of polychlorinated biphenyls (PCBs)]. This integration is especially important during the CMS and CMI.[9]

4.5 AOC/CAMU Relationship to LDRs/Minimum Technology Requirements

Under Subtitle C, the LDRs prohibit, with certain exceptions, the "land disposal" (i.e., placement into or onto a land-based unit) of hazardous wastes unless the wastes are first treated to meet treatment standards established by EPA. LDR, when applied to certain contamination scenarios and associated remedies, may discourage the use of innovative technologies and potentially more protective remedies.

EPA's experience with the CERCLA program has shown that for some cleanups, treatment of the wastes using the best demonstrated available technology (BDAT) under LDR may provide only marginal environmental benefits over other treatment measures (e.g., excavation, stabilization, redeposition into the excavated area with liners and caps) and at a very high cost. EPA has developed concepts under both the CERCLA and RCRA programs that are designed to reduce or eliminate the need to address certain waste management requirements (e.g., LDR, minimum technology requirements) that can impede remediation activities.

Q. *What are the concepts designed to reduce or eliminate the need to address certain unnecessarily restrictive waste management requirements?*

A. Several substantive LDR requirements (i.e., storage prohibition, dilution prohibition) are triggered when ground water containing prohibited hazardous waste is initially generated (i.e., extracted from the ground and, thereby, first brought subject to regulation). However, the LDR provision requiring pretreatment to technology-based levels for hazardous wastes that will be "land disposed" can impact a remedial alternative dramatically. To address the often unnecessarily restrictive application of BDATs, EPA developed the concepts known as AOC under CERCLA and CAMU under RCRA.

Under CERCLA, EPA describes an AOC as an area consisting of continuous contamination of varying amounts and types. AOCs are identified on a case-by-case basis and are delineated by the extent of continuous contamination (e.g., a waste pit and the surrounding contaminated ground water is one AOC and may be viewed as a single unit). Therefore, an AOC is generally equated to a single RCRA land-based unit, or "landfill" (55 *FR* 8758–60). Extracted ground water, which contains listed hazardous waste or which exhibits a hazardous waste characteristic, is not required to meet LDR technology-based treatment standards before redeposition provided management of the restricted hazardous waste does not constitute placement into the unit. Under CERCLA, "placement" into an AOC does not occur if wastes are:

- moved within an AOC (e.g., drilling muds from ground water well installation, excess soil from "split-spoon" sampling, earth moving/grading operations),
- left in place (e.g., capping, in situ treatment such as permeable treatment beds), or
- consolidated within the AOC from which they were extracted (e.g., extracted ground water is placed into a surface impoundment within that same AOC.[10]

In most cases, AOCs are not subject to the design and operating requirements for Subtitle C landfills because they are *existing portions* of the landfill. However, any lateral expansion of the existing unit [i.e., AOC] could trigger the minimum technology requirements of 40 CFR § 264.301(c) as well as LDR treatment standards applicability.[11]

In contrast to AOCs, the designation of CAMUs under RCRA is more related to the function and purpose the unit will serve in facilitating management of remediation wastes during cleanup rather than the aerial extent and "contiguousness" of contamination at the facility before cleanup. Accordingly, ERPMs may request the Regional Administrator to include uncontaminated land areas within a CAMU. ERPMs must demonstrate that such inclusion will enhance the protectiveness of the remedial actions.

Integral to the CAMU concept's value is EPA's more lenient definition of actions that do not constitute "placement." EPA clarifies the applicability of LDR requirements to the management of remediation wastes in CAMUs (58 *FR* 8658). Specifically, EPA indicates that the following activities do *not* constitute placement and do not trigger LDRs:

- Remediation wastes are moved or consolidated within a designated land-based CAMU.
- Remediation wastes are gathered from an area or unit at the facility but outside a defined CAMU and are subsequently placed into the CAMU.
- Remediation wastes from one or more CAMUs at the facility are consolidated into a single land-based CAMU at the facility.
- Remediation wastes are excavated from a CAMU, and treated on-site in another unit; the waste (or residuals) are redeposited into the CAMU.
- Remediation wastes are excavated and staged in piles located within the CAMU boundary before being transported to a treatment unit.
- Remediation wastes are placed into a CAMU for land-based treatment (e.g., bioremediation) (58 *FR* 8666).

Ground water that qualifies as remediation waste is not required to meet LDR technology-based treatment standards before deposition in a land-based unit. The unit must be designated as a CAMU by the Regional Administrator, and the ground water is handled in a manner consistent with the previously discussed activities.

Relative to CERCLA response actions, the substantive requirements for CAMUs are expected to be ARARs for the remediation of RCRA hazardous wastes at federal facilities. ERPMs designating a CAMU under the ARAR provision should incorporate the substantive requirements into CERCLA decision documents rather than RCRA permits, orders, or FFCA (58 *FR* 8679). The Regional Administrator (or authorized state agency) will consider the applicability of the CAMU provisions on a case-by-case basis. Furthermore, implementation of CAMU regulations may vary from site to site depending on the authorization status of the state in which ERPMs are performing ground water remediation.

4.6 Additional Options to LDR Management

During CERCLA response actions, ERPMs may encounter situations where a Regional Administrator is not satisfied that the CAMU concept is applicable or relevant and appropriate. When confronting these situations, ERPMs should consider placing the waste into non-land-based units (i.e., tanks, containers, or containment buildings) that do not trigger LDR. In some situations, management of a RCRA-prohibited waste in nonland-based units is not viable. Wastes may require consolidation from different AOCs or consolidation and placement outside of an AOC (i.e., management constitutes "placement").

Q. *When wastes are being "placed" into an on-site, land-based unit in a temporary manner [e.g., ground water is being extracted and stored in an existing surface impoundment (that is not part of the AOC) before off-site release] to avoid subjecting the waste to LDR treatment standards, what options might ERPMs consider?*

A. Under CERCLA, LDR treatment standards are viewed as potential ARARs when "land disposal" of a restricted hazardous waste occurs (i.e., "any placement of such hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility. . . ." [RCRA 3004(k)]. ERPMs overseeing CERCLA response actions that entail placement of restricted wastes into an on-site, land-based unit may consider the use of an interim measure waiver (also referred to as the interim remedy waiver) to allow such placement without triggering LDR [40 CFR § 300.430(f)(1)(ii)(C)(1)]. The interim measure should not cause additional migration of contaminants, complicate the site response, or present an immediate threat to public health or the environment. Additionally, the interim measure (which does not attain all ARARs) is expected to be followed by final actions that will attain all ARARs.[12]

Dependent on the site-specific conditions, ERPMs may also evaluate the appropriateness of several additional options including the following:

- treatability variances (40 CFR § 268.44),
- equivalent treatment method petitions (40 CFR § 268.42),
- no-migration petitions (40 CFR § 268.6), and
- delistings (40 CFR § 260.20 and § 260.22).

These options constitute compliance with RCRA. They do not require an ARAR waiver under CERCLA.[10]

4.7 Management of Hazardous Waste "Leachate"

Extracted ground water that contains listed hazardous waste must be managed in compliance with Subtitle C regulations.

Q. *What LDR requirements apply to ground water that is contaminated with leachate derived from the disposal of listed waste?*

A. Extracted ground water may be contaminated with leachate (i.e., liquid that has percolated through land-disposed waste) that is derived from the disposal of listed waste. Under RCRA and CERCLA, this waste must be managed in compliance with hazardous waste management unit standards (e.g., in a container, tank, surface impoundment). Under the LDR, ground water that is contaminated with leachate derived from *one* listed waste must meet the waste-specific treatment standard (identified in Subpart D of 40 CFR Part 268) for the listed waste contaminating the ground water. However, ground water that contains leachate derived from the disposal of *more than one* listed waste must be managed as multi-source leachate, provided the listed wastes are also restricted from land disposal (55 *FR* 3765). Ground water/multi-source leachate must meet the treatment standards for each F039 constituent, as codified in Table CCW under 40 CFR § 268.43. To facilitate compliance with the LDR, ERPMs whose facility qualifies as a treatment, storage, or disposal facility should perform the following:

- obtain an initial analysis of all regulated constituents in F039,
- develop a list of F039 constituents to be analyzed on a regular frequency, and
- supplement this testing with less frequent, broader analyses (i.e., testing for all F039 constituents) to ensure that changes in the composition of the leachate are detected.

In situations where another prohibited waste is mixed with multi-source leachate, and the treatment standard for any constituent in the prohibited waste is more stringent than the standard for that constituent in multi-source leachate, then the entire mixture must meet the more stringent standard.

During CERCLA response actions and RCRA corrective actions, ground water that contains either leachate from a single listed waste or multi-source leachate must be managed in accordance with substantive Subtitle C regulations (e.g., storage in containers, tanks, surface impoundments that meet hazardous waste management unit design standards). In addition, during RCRA corrective actions, ERPMs who are managing sites contaminated with ground water containing hazardous waste leachate must also comply with Subtitle C administrative requirements. Administrative requirements [such as requesting a Class 1 permit modification under 40 CFR § 270.42(g) to treat, store, or dispose of the new waste code (F039)] may also require that new sampling and analysis procedures be incorporated into the Waste Analysis Plan (see 55 *FR* 22619–25).

Soils and/or residues from treating multi-source leachate (e.g., spent activated carbon filters, spent plastic packing rings from packed tower air strippers) must also be managed in accordance with Subtitle C requirements (residues remain hazardous waste under the "derived from" rule). Additionally, these residues must meet the treatment standards developed for the F039 nonwastewater treatability group before land disposal.

4.8 Reinjection of Contaminated Ground Water

Under Subtitle C of RCRA, LDR requirements prohibit "land disposal" of hazardous wastes unless the wastes are first treated to meet technology-based standards. By definition under RCRA 3004(k), injection of ground water constitutes "land disposal." Substantive RCRA requirements must be attained during CERCLA response actions if the requirements are determined to be ARARs. Furthermore, RCRA corrective actions must comply with any legally applicable substantive *and* administrative requirements.

Q. *How do LDR requirements apply during CERCLA response actions/RCRA corrective actions that entail extraction of contaminated ground water from an aquifer, treatment of the ground water, and reinjection of the treated ground water back into the aquifer during ground water "pump- and-treat" operations?*

A. Under certain circumstances, EPA has determined that LDR requirements do not apply to reinjection of ground water that is managed during pump-and- treat operations, even when the extracted ground water qualifies as hazardous waste. Briefly, RCRA §3020(a) prohibits the disposal of hazardous waste by underground injection:

- into a formation containing Class I or Class II ground water or
- above such a formation.

However, §3020(b) contains an exception that allows reinjection (of treated ground water) into the aquifer from which the contaminated ground water was extracted provided the three following conditions are met:

- the reinjection is part of a CERCLA §104 or 106 response action or is a RCRA corrective action,
- the contaminated ground water will be treated "to substantially reduce hazardous constituents before such injections," and
- the action will, *upon completion*, be sufficient to protect human health and the environment.

EPA has determined that RCRA §3020(b), which directly focuses on the injection of treated ground water, is more specific than the 3004(k) language that prohibits "land disposal" of hazardous wastes. Therefore, EPA has concluded that the LDR prohibitions do not apply to response/corrective actions that meet those three conditions.

Although the language of § 3020(b) is straightforward regarding its applicability during RCRA corrective actions, it is not explicit relative to CERCLA response actions conducted at federal facilities. During CERCLA response actions, DOE employs §104 authority (under the authority delegated by EO 12580). Accordingly, CERCLA response actions (which include ground water reinjection operations) conducted at DOE facilities can satisfy the first of the three previously listed conditions. Based on a case-by-case determination, ERPMs should consider contacting their Regional EPA Office to discuss invoking the § 3020(b) exception to the prohibition of underground injection of hazardous waste. ERPMs must be able to demonstrate that the two additional 3020(b) conditions are also met (i.e., the contaminated ground water is treated and actions will be protective).[13]

4.9 Delisting Ground Water Containing Low Hazardous Waste/Hazardous Constituent Concentrations

When managing ground water that contains listed hazardous waste or that exhibits a characteristic of hazardous waste, ERPMs must comply with substantive RCRA management standards during on-site CERCLA response actions or with substantive *and* administrative requirements during RCRA corrective actions. However, if the listed waste (or constituents thereof) contained in the contaminated ground water does not meet any of the criteria for which the waste was listed, ERPMs may petition EPA to have the ground water excluded from Subtitle C regulation (i.e., delisted).

Q. *What factors should ERPMs consider when planning CERCLA response actions/RCRA corrective actions that will address ground water contaminated with RCRA-listed waste in low concentrations (including treatment residuals that remain hazardous waste under the "derived from" rule)?*

A. During site characterization and the preliminary development of the baseline risk assessment, analysis may indicate that the RCRA-listed waste is present at or near the delisting levels. ERPMs may estimate whether the concentration of contaminants in extracted ground water is approaching delisting levels by:

- determining the waste's dilution/attenuation factor (DAF), which may range from 6 to 100 depending on the annual waste volume (1,000 to 300,000 y^3/year) and the type of waste unit (i.e., surface impoundment for storage/disposal of contaminated ground water);
- multiplying the DAF by the health-based level for each hazardous constituent present [health-based levels are often set at constituent's MCL (e.g., benzene, 0.005 mg/L; carbon tetrachloride, 0.005 mg/L; chromium, 0.1 mg/L; mercury, 0.002 mg/L)]; and
- comparing the calculated values [that corresponds to the maximum allowable concentration of the constituent in leachate to the constituent's leachate concentration as determined using an appropriate leaching test (e.g., the Toxicity Characteristic Leaching Procedure)] and determining whether the maximum allowable concentration is exceeded.

Ground water containing hazardous constituents at higher levels may also be delistable since the RCRA delisting process allows for consideration of fate-and transport modeling data.[10] EPA's current fate and transport model, Composite Model for Landfills (EPACML) is used to evaluate the impact of the petitioned wastes on human health and the environment (56 *FR* 32993). If ERPMs believe that the ground water poses no significant threat and that management in a Subtitle D facility would be fully protective, delisting should be evaluated as a potential option.

For CERCLA response actions, provided the ground water will be managed on-site, ERPMs need not comply with the administrative delisting requirements, which include undergoing a petition and rule-making process. Compliance with substantive requirements should be documented in various CERCLA reports including:

- the "Detailed Analysis of Alternatives" chapter of the FS Report;
- the "Description of Alternatives, Evaluation of Alternatives, and Community's Role in Selection Process" sections of the Proposed Plan; and
- the "Description of Alternatives" section of the ROD.[10]

For delisted wastes that will be managed off-site and/or RCRA corrective actions, ERPMs must comply with both substantive *and* administrative requirements, including the formal delisting procedure (40 CFR § 260.20 and § 260.22). Additional information on substantive and administrative delisting requirements has been published.[14] Unless testing or a treatability study performed during the RI/FS make delisting reasonably certain, the CERCLA ROD should also address, as a contingency, how the waste will be handled if it does not meet delisting levels.

4.10 RCRA Closure/Post-closure Requirements

Under RCRA, closure and post-closure requirements can be found in Subpart G of 40 CFR Part 264 (permitted facilities) and Part 265 (interim status facilities). These requirements

prescribe that TSDF owners/operators (e.g., ERPMs) prepare a written closure plan that contains a detailed schedule. The schedule describes how the facility will (1) remove and decontaminate all waste residues, contaminated system components, contaminated soils, and structures and equipment (i.e., "clean close") or (2) close the system with wastes left in place and perform post-closure care requirements that apply to landfills. The presence of contaminated ground water may indicate that all waste residues cannot be removed. If so, the facility should be closed as a landfill unless ERPMs can demonstrate that the contamination (i.e., hazardous waste/constituents or waste residues) did not originate from their hazardous waste management unit (53 *FR* 9944).

Q. *How do closure and post-closure care requirements apply to these TSDFs?*

A. The basic prerequisites for applicability of closure/post-closure requirements include the following:

- the waste must be hazardous waste and
- the unit (or AOC) must have received waste after the RCRA requirements became effective.

Under CERCLA, when RCRA closure requirements are applicable, ERPMs may be required to perform only (1) clean closure or (2) closure as a landfill. If closure requirements are not applicable, they may still be relevant and appropriate. In this case, ERPMs may implement the hybrid closure option, depending upon site circumstances. Briefly, hybrid closure allows ERPMs to remove enough contamination such that contamination is reduced to concentration levels that attain health-based levels.[10]

Interim status TSDFs maintain a written closure plan on-site and, depending on the type of closure (i.e., partial or final) and the type of unit, submit this plan a specified period of time before closure [40 CFR § 265.112(d)]. Permitted TSDFs (or TSDFs applying for a permit) must submit the plan as part of the Part B permit application and obtain regulator approval. During RCRA corrective actions, closure plans must be updated at least 60 days before any planned change or 60 days (30 days if closure is occurring) following any unexpected event that affects the closure plan [e.g., adverse weather conditions, fire, more extensive contamination (51 *FR* 16427)]. A permit modification is required when the ERPM amends the closure plan at a permitted facility.[9]

ERPMs responsible for managing TSDFs with approved closure plans must amend their closure plan by submitting a written request and a copy of the amended plan. The amended plan reflects any additional activities and timeline necessary to implement the additional ground water remediation activities. Closure plans (and amended closure plans) must "include sufficient detail to allow a third party to conduct closure or post-closure care in accordance with the plan if the [ERPM] fails to do so" (51 *FR* 16426).

4.11 Evaluating PCB Cleanup Levels and Management Options

EPA has 81 RODs that address PCB-contaminated media. These RODs were signed from FY 1982 to FY 1989. Components of 25 selected RODs include specific treatment technologies that address PCB-contaminated ground water. Specified technologies vary from treatment using a packaged ozone–UV system or activated carbon adsorption through treatment trains that include phase separation, filtration, and air stripping of ground water containing PCBs at a concentration above 1 ppb.

Q. *When evaluating PCB cleanup levels and the treatment technologies necessary to attain those levels for ground water contaminated with PCBs, what factors must ERPMs assess?*

A. Two primary aspects of the development of alternatives are considered and revised throughout the remedial action process:

- determination of the appropriate concentration of PCBs that can remain at the site (i.e., remediation goals/media cleanup standards) and
- identification of options for addressing contaminated ground water and the implications, in terms of long-term management controls, associated with these options.

For CERCLA response actions, determinations of whether treatment and/or containment is appropriate are guided by CERCLA program expectations. These expectations encourage ERPMs to return ground water to beneficial uses within a reasonable time frame (see question on p. 2-1 of this Guide). When ground water that is, or may be, used as a source of drinking water is contaminated with PCBs, CERCLA remediation goals/RCRA media cleanup standards should be established such that the ground water is returned to the MCL for PCBs (0.0005 mg/L or 0.5 ppb). Because PCBs are relatively immobile, their presence in ground water may have been facilitated by solvents or colloidal particles. Accordingly, if the effectiveness of removing PCB contamination is limited, an ARAR waiver under CERCLA (or nonattainment of the MCS under RCRA) may be supported based on the technical impracticability of reducing PCB concentrations to health-based levels.[15]

In addition to remediation alternatives (e.g., treatment, containment) and cleanup standards, management of PCB-contaminated ground water that is extracted during the performance of CERCLA response actions/RCRA corrective actions may be subject to regulation under other environmental laws. ERPMs must evaluate PCB-related requirements under RCRA, TSCA, and CWA to determine if these requirements are ARARs under CERCLA or legally applicable during RCRA corrective actions.

The current TSCA regulations require that any PCB or PCB item containing 50 ppm or greater PCB or materials contaminated with PCBs from an original source containing 50 ppm PCB or greater must be disposed of in a chemical waste landfill or incinerator as specified in 40 CFR § 761.60(a) or alternative method approved by EPA [40 CFR § 761.60(e)]. Additionally, after May 31, 1979, the "antidilution" provision [40 CFR § 761.1(b)] became effective. This provision states, "No provision specifying a PCB concentration may be avoided as a result of any dilution, unless otherwise specifically provided." This means that the PCB disposal requirements for materials containing 50 ppm PCBs and greater may not be avoided by either accidental or intentional dilution.

This provision does not prohibit dilution but clearly does require diluted material to be disposed as the PCB concentration of the original material. Thus, for actions involving extraction of contaminated ground water conducted under RCRA corrective action authority or state laws and regulations, contaminated ground water must be considered to have the same concentration as the original PCB material causing the contamination. This material must be managed as such, even though the actual concentration of PCBs in the ground water may be negligible. However, for NPL sites, the antidilution rule does not apply, and PCB-contaminated materials should be managed on the basis of the "as-found" concentration.[16]

Under federal RCRA Subtitle C regulations, PCBs themselves are *not* hazardous waste and are not subject to LDR requirements. However, if ground water contains listed hazardous waste (or exhibits a characteristic of hazardous waste) and also is contaminated with PCBs at

concentrations greater than or equal to 50 ppm but less than 500 ppm, the mixture must be either incinerated or burned in a high-efficiency boiler [40 CFR § 268.42(a)(1)]. Ground water qualifying as hazardous waste that is contaminated with PCBs at concentrations greater than or equal to 500 ppm must be incinerated at TSCA-approved incinerators.[16] Certain states regulate the PCBs themselves as hazardous waste under state authority and may have additional or more stringent state regulations to address PCB management.

4.12 Safe Drinking Water Act Regulatory Levels and Their Applicability

ERPMs should use enforceable cleanup levels (i.e., MCLs) that are established under the SDWA as potential remediation goals/media cleanup standards when remediating contaminated ground water that serves as current or potential source of drinking water.

Q. *What regulatory levels are established under SDWA and how might ERPMs apply them?*

A. Under the authority of SDWA, EPA establishes three separate regulatory levels (1) MCLGs, (2) MCLs; and (3) secondary maximum contaminant levels (SMCLs). In addition, EPA has promulgated treatment techniques for some drinking water contaminants.

- MCLGs are health-based goals set at concentration levels at which no known or anticipated adverse health effects would occur, allowing an adequate margin of safety. Establishment of a specific MCLG depends on the evidence of carcinogenicity from drinking water exposure or EPA's reference dose.[10]
- MCLs represent the enforceable standards under SDWA and represent that maximum permissible level of a contaminant which should be delivered to a consumer.[10]
- SMCLs are established to control contaminants in drinking water that primarily affect the aesthetic qualities (e.g., color, odor, taste) relating to the public acceptance of drinking water.[10]
- Treatment techniques are established to limit the amount of chemicals introduced by a public water system.[10]

Nonzero MCLGs rather than MCLs are generally applied because they are relevant and appropriate to the cleanup of ground water that is or may be used for drinking water. However, when MCLGs are determined not to be relevant and appropriate to the circumstances of the release (e.g., a contaminant is a carcinogen and its MCLG is zero), corresponding MCLs will be considered potential relevant and appropriate requirements. Factors for determining whether a requirement is "relevant and appropriate" are discussed in 55 *FR* 8750–52 and codified in 40 CFR 300.400(g)(2).) Further, MCLs may be "applicable" where water at a CERCLA site is delivered through a "public water supply system" (as defined under 40 CFR § 141.2).

SMCLs are *nonenforceable* limits intended as guidelines. However, they may represent potentially relevant and appropriate requirements in states that have adopted SMCLs as additional drinking water standards. Treatment techniques typically will not be considered during ARAR screening. However, if ERPMs are supplying drinking water as part of the response action (i.e., the facility qualifies as a "public water system" as defined in 40 CFR Part 141), ERPMs should consider whether the established dose and monomer levels for certain chemicals (e.g., acrylimide) are potential ARARs.

If cleanup levels based on ARARs and TBCs result in aggregate risk levels that fall outside the protective range (10^{-4} to 10^{-6}), ERPMs should adjust cleanup levels. Aggregate risks are calculated using a chemical's RSD for carcinogens or RfD for systemic toxicants.[17]

4.13 Applicability of FWQC and WQSs to Discharges

FWQC are nonenforceable, threshold level concentrations of contaminants determined by EPA to be protective of human health and/or aquatic organisms. Criteria for protection of human health are based on either exposure through drinking water and consumption of aquatic organisms or from consuming aquatic organisms, primarily fish. FWQC and the designated use of a given body of water (e.g., public water supply, recreation, industrial use) are considered by states when they establish WQS that are protective of that use. State-established WQS become legally enforceable maximum acceptable levels for water bodies.

Q. *Should ERPMs apply FWQC and/or WQS during remediation of a ground water aquifer or for discharges of treated ground water into navigable waters?*

A. Under CERCLA, FWQC are not "legally applicable"; however, FWQC may be used when found by ERPMs to be relevant and appropriate. For ground water, when a nonzero MCLG or an MCL exists, generally, these standards are the appropriate standards, even if a contaminant-specific FWQC is also available. However, FWQC or WQS may qualify as relevant and appropriate in the following scenarios:

- surface water, which may or may not serve as a drinking water source, also poses additional ecological impacts (e.g., consumption of fish, protection of aquatic life);
- ground water, which may or may not serve as a drinking water source, discharges to a surface water that poses additional ecological impacts;
- both a MCL and a numerical state WQS exist for a particular contaminant and the body of water has been designated for drinking (the state WQS should be used if it is more stringent); or
- a contaminant does not have a nonzero MCLG or a MCL and the *non*carcinogenic FWQC (FWQC for carcinogens are set at zero) can be adjusted to reflect drinking water use. When adjusting the FWQC, ERPMs should calculate the adjusted FWQC using total exposure data.[10]

For sites where protection of aquatic life is a concern, the FWQC for fresh or saltwater aquatic life (whichever is pertinent) may be ARARs. When human exposure from consumption of aquatic organisms (e.g., consumption of contaminated fish) is a concern, the FWQC published for human exposure from consumption of aquatic organisms may be ARARs. Whether a FWQC is relevant and appropriate and which form of the criteria should be used depends on whether exposure via either or both routes (i.e., drinking water and consuming fish, or merely consuming fish) is likely to occur. Since MCLs only reflect exposure from drinking the water, in some cases, a FWQC for consumption of aquatic organisms may be appropriate in addition to the MCL.

FWQC without modifications are not relevant and appropriate in selecting cleanup levels in ground water where consumption of contaminated fish is not a concern. However, when a nonzero MCLG or a MCL is unavailable, a FWQC may be adjusted to reflect only exposure from drinking the water.

A state WQS may be a site-specific adaptation of a FWQC. If a state has promulgated a numerical WQS that applies to the contaminant and the designated use of the surface water at a site, the state's WQS rather than an FWQC will generally be applicable or relevant and appropriate for determining cleanup levels.

EPA uses its water quality standards promulgation authority to correct flaws or omissions within state submittals by promulgating FWQC similar to those identified by the EPA.[18] Accordingly, ERPMs should consult state and regional regulators when determining relevant and appropriate water quality criteria/standards.

During RCRA corrective actions, a state may promulgate a numerical WQS that applies to the ground water contaminants and the designated use of the surface water that is destined to receive discharges of extracted ground water. This WQS may be used by ERPMs to identify cleanup levels that must be achieved before discharge.

4.14 Discharge Activities Subject to NPDES and Other Regulations

In some situations, the management (or lack of management) of treated ground water (e.g., ground water treated using activated carbon adsorption, packed tower aeration, an oil/water separator) may result in the discharge of a pollutant. Discharge of a pollutant (i.e., ground water contaminated with chemical wastes) to waters of the United States may be subject to substantive requirements during CERCLA actions [e.g., National Pollutant Discharge Elimination System (NPDES) maximum daily release limitation of 0.07 mg/L cyanide] or substantive and administrative requirements during RCRA corrective actions (e.g., NPDES permit application preparation/submittal).

Q. *What activities must ERPMs monitor and evaluate to ensure compliance with NPDES and other regulatory requirements?*

A. NPDES requirements are intended to ensure that a given body of water remains in compliance with state WQSs. Activities that fall within the definition of "discharge of a pollutant" include additions of pollutants into waters of the United States from any of the following:

- surface runoff that is collected or channeled by man;
- releases through pipes, sewers, or other conveyances owned by a state, municipality, or other persons (e.g., DOE) that *do not* lead to a treatment works; and
- releases through pipes, sewers, or other conveyances leading to a privately owned treatment works (40 CFR § 122.2).

An exception is those pollutants introduced to a POTW. Under the CWA, on-site CERCLA response actions that discharge pollutants may be required to comply with the following substantive requirements of the NPDES program:

- FWQC,
- state antidegradation requirements,
- technology-based limitations, and
- state WQSs.

In addition to complying with the substantive requirements identified above, off-site CERCLA response action and RCRA corrective actions may be subject to the following administrative requirements:

- certification requirements,
- permit application requirements,
- reporting requirements, and
- public participation requirements.[10]

Certain types of storm water runoff (e.g., surface runoff and drainage from open dumps that receive or have received industrial waste) require a storm water discharge permit (a type of NPDES permit).[9] Requirements for storm water discharge permits can be found in the 40 CFR § 122.26.

DOE orders also may govern ERPM decisions and actions. For example, directives are given for ERPMs who are managing radioactive mixed waste to apply the best available technology (BAT) when releases of liquid waste (e.g., contaminated ground water), at the point of release and before dilution, contain radioactive material at annual average concentrations greater than the derived concentration guide (DCG) values in liquid.[19] Selection of BAT for a specific application will be made from candidate treatment technologies based on the following factors:

- the age of the equipment and facilities involved,
- the process employed,
- the engineering aspects of the application of various types of control technologies,
- process changes,
- the cost of achieving such effluent reductions,
- nonwater quality environmental impact,
- safety considerations, and
- public policy considerations.

A plan and schedule to install waste treatment systems shall be submitted for approval to the responsible Operations Office manager and be updated annually, consistent with the provisions of DOE orders for preparing and updating waste management plans.[20, 21]

4.15 Pretreatment Standards for Indirect Discharges

In addition to direct discharges (subject to NPDES requirements), ERPMs should be aware that they may be subject to pretreatment standards for indirect discharge of ground water that contains chemical waste to POTWs.

Q. *What types of pretreatment standards and requirements must be evaluated when considering discharging extracted ground water to a POTW?*

A. ERPMs must evaluate and comply with three types of pretreatment standards during indirect discharges of pollutants. These standards include the following:

- prohibited discharge standards [i.e., discharges that cause fire or explosions, corrosion, obstructions, high temperatures, problems with worker health and safety, interferences (40 CFR § 403.5(b)];

- categorical pretreatment standards [i.e., national, technology-based effluent limitations applicable to specified industrial categories (e.g., electroplaters) (40 CFR Parts 405–71)]; and
- local limits (developed by receiving POTWs to ensure they comply with standards and criteria at the local level [40 CFR § 403.5(c), 403.8)].[22]

Discharge from a CERCLA site to a POTW is considered an off-site activity, even when the waste is first pretreated in a wastewater facility (e.g., carbon adsorption unit) located on-site. Accordingly, releases to POTWs (under both CERCLA response/RCRA corrective actions) subject ERPMs to both substantive *and* administrative requirements of the national pretreatment program as well as all state and local (i.e., POTW) pretreatment requirements.[23]

4.16 Evaluating the Indirect Discharge Option

Evaluating the feasibility of using a POTW as a discharge option should begin early in the CERCLA response/RCRA corrective action process.

Q. *What steps must ERPMs take when evaluating the option of discharging extracted ground water (treated or untreated) to POTWs?*

A. In addition to obtaining stakeholder consensus as early as possible, there are five key steps for evaluating the feasibility of discharging to POTWs:

- Identify and characterize the ground water that will be discharged. [POTWs will generally require sampling information on all TCL constituents and conventional pollutants (e.g., total dissolved solids) as well as the estimated size and frequency of discharges].
- Identify POTWs within a delineated geographic area.
- Evaluate the POTW's regulatory status (e.g., permit-by-rule status).
- Evaluate technical and administrative feasibility (e.g., the feasibility of obtaining a NPDES permit modification for pollutants the POTW did not previously handle; feasibility of revising the pretreatment program to regulate increased discharges or new pollutants).
- Evaluate pretreatment requirements of the "best" POTW candidate (i.e., evaluate local POTW pretreatment limits versus the level of ground water pretreatment necessary to ensure compliance with the POTW's pretreatment requirements, determine pretreatment options).[24]

Whether a contaminated ground water qualifies as hazardous waste and whether the domestic sewage exclusion applies at a given site also affects the feasibility of discharging to a POTW. ERPMs should determine this early in the process. Both CERCLA response actions and RCRA corrective actions will be subject to additional constraints that may make it difficult or impracticable to discharge the ground water to a POTW when it is considered hazardous.

Generally, because the POTW discharge is to an off-site facility, six of the nine evaluation criteria for remedy selection under CERCLA should be addressed during development and screening of remedial alternatives. These six criteria are overall protection, compliance with ARARs, long-term effectiveness and permanence, implementability, state acceptance, and community acceptance. The detailed analysis of an alternative involving discharge to a POTW

will, therefore, usually focus on the three remaining criteria: reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; and cost.[25]

POTWs are generally not located "on-site" (as defined under 40 CFR § 300.5). During CERCLA response actions, a POTW may not receive CERCLA waste unless the POTW is in compliance with EPA's Off-site Rule. The Off-site Rule (58 *FR* 49200) requires that the off-site facility be evaluated and found acceptable by EPA before waste is transferred (e.g., discharged) to the facility, regardless of whether it is a DOE facility. The ROC is the source of information regarding acceptability of facilities within the region. Because a facility's status can change, the ROC should be contacted before discharging CERCLA waste to a specific POTW.[5] Unlike CERCLA response actions, RCRA corrective actions are *not* subject to the Off-site Rule.

ERPMs also must consider the impact of DOE orders when they evaluate the option to utilize discharges to a POTW as a remedial alternative/corrective measure. For example, DOE mandates state that ERPMs managing radioactive mixed waste must implement the BAT selection process for liquid waste (e.g., contaminated ground water) containing radionuclides at concentrations, averaged monthly, greater than five times the DCG values for liquid at the point of discharge.[26] If, however, the sanitary (or chemical) sewerage system is owned by the federal government, ERPMs may discharge these liquid wastes without triggering the BAT selection process provided ALARA process considerations are met.

4.17 Applicability of CAA/RCRA TSDF Air Emission Standards

One objective of the CAA is to protect and enhance the quality of the nation's air resources by regulating emission into the air through the National Ambient Air Quality Standards (NAAQS), the National Emission Standards for Hazardous Air Pollutants (NESHAP), and the New Source Performance Standards (NSPS). These standards may apply to both stationary and mobile sources of emissions and may be implemented through combined federal, state, and/or local programs. It is incumbent on ERPMs overseeing CERCLA response actions/RCRA corrective actions that may result in emissions to the ambient air to coordinate with the regulators' RCRA and air programs, as well as the EPA Regional Air/Superfund Coordinators to determine areas of responsibility and governing requirements.

Q. *Relative to ground water, what types of activities that occur during CERCLA response actions/RCRA corrective actions are potentially subject to CAA standards?*

A. Several technologies employed during ground water remediation activities may result in new source emissions and may subject ERPMs to applicable or relevant and appropriate CAA requirements. Examples of these ground water remediation activities include:

- air stripping,
- thermal destruction (e.g., incineration, regeneration of spent activated carbon filters),
- management of contaminated ground water or recovered product (e.g., open-top tanks, surface impoundments),
- gaseous waste treatment, and
- biodegradation.[10]

When attempting to determine whether specific CAA requirements are potential ARARs and, more specifically, whether they are either "applicable" or "relevant or appropriate" to ground water remediation activities, ERPMs may need to know the following:

- air quality designation of the site's location (i.e., attainment, nonattainment, unclassified, transport) for each NAAQS,
- classification of each designated nonattainment area (e.g., marginal, moderate, serious),
- whether construction or modification of their stationary source commenced subsequent to the date of publication of regulations (or proposed regulations) prescribing a standard of performance that governs such source,
- required control measures including emission limitations and emission offsets, and
- baseline emission estimates at the site and estimated (i.e., modeled) air pollutant emissions associated with the site investigation activities, construction of remedy, and subsequent operation and maintenance of the remedy.[27]

Under the 1990 amendments to the CAA, stationary sources of HAPs regulated under 40 CFR Part 61 and categories of sources regulated under 40 CFR Part 63 resulting from CERCLA response activities at a facility may be subject to CAA authority. [CAA § 112(b)(1) contains a complete list of the 189 hazardous air pollutants, which include compounds (i.e., any unique substance that contains the named chemical such as cobalt, cyanide, or mercury as part of that chemical's infrastructure) and radionuclides.].

EPA has also published a list of 174 source categories within 16 industry groups, including the waste treatment and disposal industry group (57 FR 31576). New and existing major sources within these 174 source categories will have to adopt emission controls when the final rule is promulgated.

Major sources are stationary sources or a group of stationary sources located within a contiguous area and under DOE control that emit or have the potential to emit, in the aggregate, 10 tons or more per year of a single HAP or 25 tons or more per year of any combination of HAPs, after emission controls are taken into account. ERPMs may be required to apply the EPA-developed MACT standards at CERCLA sites with a source category that emits or has the potential to emit HAPs. This is dependent on whether the source qualifies as a major source. For an area source (i.e., any stationary source of HAPs that is not a major source), ERPMs may be able to use generally available control technology or management practices (GACT) as a substitute for MACT standards.

In 1989 EPA issued a Statement of Policy to guide decision makers on (1) the use of controls for air emissions from air strippers [and other vented sources of volatile organic compounds (VOCs)] used at CERCLA response sites for ground water treatment and (2) the establishment of procedures for implementation. ERPMs responsible for sites that are implementing pump-and-treat operations may identify air stripping, during which VOCs in the water are transferred to a vapor phase as an integral component of the remedial alternative. One known side effect of air stripping is the emission of VOCs into the ambient air. At a minimum, the five major types of information that should be generated during the RI/FS are:

- emission data, including the particular pollutants expected to be emitted and the rate of emission for each pollutant (e.g., TCE emissions rate from all air strippers at the site),
- consideration of health risks from the execution of the remedy as well as from the uncontrolled site,
- control alternatives and their costs,
- ozone attainment status, and

- potential air ARARs.[10]

Major stationary sources as defined under 40 CFR § 70.2 (e.g., sources that emit or have the potential to emit 10 tons/year or more of VOCs in areas classified as severe) are also considered major sources for the criteria pollutant (e.g., ozone). New major stationary sources or major modifications located in any area that cause, or contribute to, a violation of any of the six NAAQS must meet certain criteria [e.g., specific emission standards, lowest achievable emission rates (LAERs)]. The six NAAQS are carbon monoxide, lead, nitrogen dioxide, particulate matter (PM-10), ozone, and sulfur dioxide. RCRA corrective action units releasing these pollutants may require approved construction permits (before construction, installation, or modification of the unit) and operating permits, which identify emission rates and limitations, process rates, and maximum operation conditions. [Under § 121(e) of CERCLA, CERCLA response actions that are conducted entirely on-site will not require permits for actions carried out in compliance with § 121 but may require approved emission rates and limitations, process rates, and maximum operation conditions.]

Further, NAAQS (e.g., ozone, 0.12 ppm maximum hourly average concentration; lead, 1.5g/m3 quarterly) are not enforceable in and of themselves and are never ARARs. They may, however, constitute TBCs under CERCLA actions. It is the emission standards, which are promulgated by the state to attain the NAAQS, that are directly enforceable and are potential ARARs. NAAQS do not apply during RCRA corrective actions, unless legally applicable.

Under the NSPS program, EPA establishes nationally uniform standards for major new stationary sources, particularly for industrial source categories. These categories are listed in 40 CFR Part 60. NSPS are based on best demonstrated technology (BDT), which EPA may define as an emission limit or rate (i.e., a specified number of pounds per hour) or a technological system of continuous emission reduction. At present, the NSPS source categories coincide with only a few of the air pollutant emission sources typically found at CERCLA sites. Thus NSPS are not typically considered "applicable" to CERCLA activities. They may be "relevant and appropriate" if the pollutant emitted and the technology employed during remediation are sufficiently similar to the pollutant and source category regulated by NSPS. This is a site-specific determination.

Air emission standards under RCRA (Subparts AA, BB, and CC of 40 CFR Parts 264 and 265) may be applicable to CERCLA response actions/RCRA corrective actions. Air emission standards of Subpart AA concern process vents associated with specific operations (i.e., air or steam stripping, solvent extraction, thin-film evaporation, fractionation, or distillation). Standards of Subpart BB concern equipment (e.g., pumps, valves, pressure relief devices). These standards will be "applicable" during ground water treatment provided:

- for Subpart AA, the contaminated water managed in a specified operation has an annual average total organic concentration of 10 ppmw or greater;[28] or
- for Subpart BB, the equipment contains or contacts hazardous wastes with organic concentrations of at least 10% by weight;[29] and
- the contaminated ground water qualifies as hazardous waste; and
- the contaminated ground water is being managed at a RCRA TSDF or 90-day generator.

Although not pertinent to RCRA corrective actions, Subparts AA and BB control requirements may be considered "relevant and appropriate" to on-site CERCLA actions that use one of the previously discussed technologies when managing wastes that are not otherwise

subject to Subparts AA or BB (e.g., wastes with organic concentration of less than 10 ppmw/10% by weight; organics from nonhazardous waste) (55 *FR* 25458).[30]

Subpart CC standards govern the management of organics in ***containers***, tanks, surface impoundments, and miscellaneous units (when appropriate). These standards apply to TSDFs and 90-day generators accumulating waste on-site in permit-exempt ***tanks*** and containers.

EPA temporarily defers application of the standards under Subpart CC to on-site tanks, containers, and surface impoundments provided the units are managing only RMW or wastes generated from CERCLA response/RCRA corrective action [40 CFR Parts 264/265.1080(b)(5) & (6)].

Finally, during CERCLA response actions, ground water cleanup at DOE facilities may be subject to 40 CFR Part 61, Subpart H and/or Subpart I, for airborne emissions of radionuclides from incinerators, land disposal facilities and other TSDFs emitting radioactive or radioactive mixed waste. Not included. are ^{220}Rn and ^{222}Rn. While Subpart H may be applicable at DOE sites, Subpart I standards may be only relevant and appropriate at DOE sites.[9, 10] Subparts H and I do not address emissions of ^{222}Rn and its decay products formed after release from the facility.

4.18 ARAR Waivers

Q. *Are there situations when ERPMs are not required to attain ARARs under CERCLA?*

A. Waivers, which by statute apply to on-site CERCLA remedial actions, must be invoked for each ARAR that will not be attained. Because removal actions must comply with ARARs to the extent practicable, waivers are also available for removal actions. Six statutory waivers are codified under 40 CFR § 300.430(f)(1)(ii)(C)(1)-(6) and include the following(see also 55 *FR* 8747–50):

- interim measures,
- equivalent standard of performance,
- greater risk to health and the environment,
- technical impracticability from an engineering perspective,
- inconsistent application of state standards, and
- fund balancing.

CERCLA § 121(d)(4)(F) restricts use of the fund-balancing waiver to remedial actions conducted under §104 of CERCLA and financed by the Superfund. This waiver is unavailable to ERPMs using funds obligated to DOE for their environmental restoration.[10]

In addition to statutory waivers, ERPMs may consider the existence of exclusions, exemptions, and variances under other laws because often environmental or technical reasons exist for such provisions. However, even if an exclusion, exemption, or variance provision matches the circumstances at the site, ERPMs should be aware that a requirement may remain relevant and appropriate for other reasons.

Sufficient information, available at the time of ROD signature, may indicate the possibility that an ARAR waiver may be invoked at a site (e.g., the RI/FS indicates it may be technically impracticable to attain MCLs in ground water). ERPMs should then consider including contingency language in the ROD. Contingency language prescribes a detailed and objective

level or situation that, when met, triggers the requirement to enhance or augment the planned remediation system. In addition, an alternative remedial technology may be employed if modifications to the system fail to improve its performance. Language that identifies a TI decision (i.e., an ARAR waiver) as a future contingency should be avoided. ERPMs overseeing CERCLA response actions in which the existing ROD already includes a contingency for invoking a TI ARAR waiver should perform the following before concluding that a TI waiver is appropriate for the situation:

- implement/augment a remedy to improve its ability to attain ARARs and
- enhance the remediation technology for a sufficient period of time to ensure that the remedy's ability to restore contaminated ground water is thoroughly evaluated.[31]

An Explanation of Significant Differences is *not* required to invoke a contingency specifically addressed in the ROD.[10] Where the implemented contingency differs significantly from that described in the ROD, an Explanation of Significant Differences may be required, or it may be necessary to prepare a ROD amendment.[32]

4.19 Chapter Summary

During CERCLA response action/RCRA corrective actions, ERPMs must remain cognizant of, and comply with, certain requirements that are promulgated under the authority of other statutes (e.g., CAA, TSCA). Program-specific requirements may have a dramatic impact on which remedies may be feasible because of the regulatory and/or technical constraints imposed under other environmental regulatory programs.

CERCLA response actions that are conducted entirely on-site do not require federal, state, or local permits but must comply with substantive requirements that are either "applicable" or "relevant and appropriate." CERCLA wastes that are transferred off-site must comply with the CERCLA Off-site Rule as well as the substantive and administrative requirements. Off-site actions, however, are not governed by the concept of relevance and appropriateness.

During RCRA corrective actions, ERPMs must comply with both substantive and administrative requirements that are applicable to a specific corrective action including the administrative requirement of applying for, obtaining, and operating under an approved permit. These actions, however, need not comply with requirements that are deemed only relevant and appropriate.

4.20 Chapter References

1. DOE, 1992. *Management of CERCLA Investigation-Derived Waste*, EH-231 Memorandum, Office of Environmental Guidance, Washington, D.C.

2 EPA, 1991. *Superfund Removal Procedures: Guidance of the Consideration of ARARs During Removal Actions*, OSWER Dir. 9360.3-02, Office of Emergency and Remedial Response, Washington, D.C.

3. EPA, 1992. *Guide to Management of Investigation-Derived Wastes*, OSWER Dir. 9345.3-03FS, Office of Emergency and Remedial Response, Washington, D.C.

4. EPA, 1992. *Permits and Permit "Equivalency" Processes for CERCLA On-site Response Activities*, OSWER Dir. 9355.7-03, Office of Emergency and Remedial Response, Washington, D.C.

5. DOE, 1994. *Guide to Selecting Compliant Off-Site Hazardous Waste Treatment, Storage, and Disposal Facilities*, DOE/EH-0427, Office of Environmental Guidance, Washington, D.C.

6. DOE, 1994. *The Off-Site Rule*, Information Brief, EH-231-020/0394, Office of Environmental Guidance, Washington, D.C.

7. EPA, 1989. *Notification of Out-of-State Shipments of Superfund Site Wastes*, OSWER Dir. 9330.2-07, Office of Solid Waste and Emergency Response, Washington, D.C.

8. DOE, 1989. *Fact Sheets: Natural Resource Trusteeship Under CERCLA and Management of Ground Water as Hazardous Waste*, EH-231 Memorandum, Environmental Guidance Division, Washington, D.C.

9. DOE, 1993. *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.

10. DOE, 1991. *Compendium of Applicable or Relevant and Appropriate Requirements "Quick Reference Fact Sheets" and Directives*, OEG (CERCLA)-005/1091, Office of Environmental Guidance and Office of Emergency and Remedial Response, Washington, D.C.

11. EPA, 1990. *CERCLA Response Activities and the Land Disposal Restrictions Program's Applicability at Plattsburgh Air Force Base*, Memorandum from Sylvia K. Lowrance, Office of Solid Waste to Stephen D. Luftig, Emergency and Remedial Response Division, Region II, April 6, 1990, Washington, D.C.

12. DOE, 1993. *Interim Measure Waiver from Applicable or Relevant and Appropriate Requirements (ARARs) under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA)*, EH-413 Memorandum, Office of Environmental Guidance, Washington, D.C.

13. DOE, 1990. *Applicability of Land Disposal Restrictions to RCRA and CERCLA Ground Water Treatment Reinjections*, EH-231 Memorandum, Environmental Guidance Division, Washington, D.C.

14. EPA, 1993. *Petitions to Delist Hazardous Wastes: A Guidance Manual*, EPA/530-R-93-007, Office of Solid Waste, Washington, D.C.

15. DOE, 1992. *Remedial Actions at DOE Environmental Restoration Sites Contaminated with Polychlorinated Biphenyls (PCBs)*, EH-413 Guidance Memorandum, Office of Environmental Guidance, Washington, D.C.

16. DOE, 1993. *Management of Polychlorinated Biphenyls (PCBs)*, DOE/EH-0350, Office of Environmental Guidance, Washington, D.C.

17. EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Dir. 9355.3-01, Office of Emergency and Remedial Response, Washington, D.C.

18. EPA, 1990. *ARARs Q's & A's: New SDWA National Primary Drinking Water Regulations for Organic & Inorganic Chemicals*, OSWER Dir. 9234.2-09/FS, Office of Emergency and Remedial Response, Washington, D.C., Attachment 1.

19. DOE, 1990. *Radiation Protection of the Public and the Environment*, Order 5400.5, U.S. Department of Energy, Washington, D.C.; change 1 of June 5, 1990, subpar. II.3a(1).

20. DOE. 1988. *Radioactive Waste Management*, Order 5820.2A, U.S. Department of Energy, Washington, D.C.

21. DOE, 1990. *Radiation Protection of the Public and the Environment*, Order 5400.5, U.S. Department of Energy, Washington, D.C.; subpar. II.3a(1)(a)-(c).

22. EPA, 1986. *Discharge of Wastewater from CERCLA Sites to POTWs*, OSWER Dir. 9330.2-4, Office of Emergency and Remedial Response, Washington, D.C.

23. EPA, 1990. *CERCLA Compliance with Other Laws Manual, CERCLA Compliance with CWA and SDWA*, OSWER Dir. 9234.2-06FS, Office of Emergency and Remedial Response, Washington, D.C.

24. EPA, 1991. *Guide to Discharging CERCLA Aqueous Wastes to Publicly Owned Treatment Works (POTWs)*, OSWER Dir. 9330.2-13FS, Office of Emergency and Remedial Response, Washington, D.C.

25. EPA, 1990. *CERCLA Site Discharges to POTWs: Guidance Manual*, OSWER Dir. 9330.2-09, Office of Emergency and Remedial Response, Washington, D.C.

26. DOE, 1990. *Radiation Protection of the Public and the Environment*, Order 5400.5, U.S. Department of Energy, Washington, D.C.; change 1 of June 5, 1990, subpar. II.3d.

27. EPA, 1992. *ARARs Fact Sheet: Compliance with the Clean Air Act and Associated Air Quality Requirements*, OSWER Dir. 9234.2-22FS, Office of Emergency and Remedial Response, Washington, D.C.

28. DOE, 1993. *RCRA Air Emission Standards for Hazardous Waste Treatment, Storage, and Disposal Facility (TSDF) Process Vents*, Information Brief, EH-231-020/0193, Office of Environmental Guidance, Washington, D.C.

29. DOE, 1993. *RCRA Air Emission Standards for Hazardous Waste Treatment, Storage, and Disposal Facility (TSDF) Equipment Leaks*, Information Brief, EH-231-019/0193, U.S. Department of Energy, Office of Environmental Guidance, Washington, D.C.

30. EPA, 1992. *Seminar Publication: Organic Air Emissions from Waste Management Facilities*, EPA/625/R-92/003, Office of Air Quality Planning and Standards, Research Triangle Park, N.C.

31. EPA, 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration Interim Final*, OSWER Dir. 9234.2-25, Office of Solid Waste and Emergency Response, Washington, D.C.

32. EPA, 1990. *Suggested ROD Language for Various Ground Water Remediation Options*, OSWER Dir. 9283.1-03, Office of Emergency and Remedial Response, Washington, D.C.

5. Screening and Detailed Analysis

Figure 5 provides a graphic representation of the screening and detailed analysis of remedial alternatives/corrective measure technologies and the organization of this chapter.

5.1 Development and Role of Remedial Action/Corrective Measure Objectives

The primary purpose of the CERCLA FS/CMS is to ensure that appropriate ground water remediation alternatives are developed and evaluated. The RI/RFI and the FS/CMS are conducted concurrently. Data collected during the RI/RFI influences the development of remedial alternatives in the FS/CMS (which in turn affects the data needs and scope of treatability studies and additional field investigations under the RI/RFI). During the initial phase of the FS/CMS, ERPMs must develop RAOs/corrective measure objectives (CMOs). Objectives serve to focus the development of alternatives on technologies that can achieve the established objectives; this limits the number of alternatives considered during detailed analysis/remedy selection.

Q. *What must remedial action/corrective measure objectives specify?*

A. Establishment of RAOs under CERCLA is an iterative process, the final objective of which is identification of the following items:

- contaminants of concern,
- potential exposure routes and receptors, and
- remediation goals (i.e., a contaminant level or range of levels for each exposure medium) [40 CFR § 300.430(e)(2)(i)].

RAOs are site-specific, quantitative goals that are formulated to achieve the overall goal of the program to protect human health and the environment by restoring potentially usable contaminated ground water to levels that are safe for current and potential users and environmental receptors. Another major goal is to protect usable uncontaminated ground water. The specificity of the RAOs may vary depending on the availability and quality of site information, site conditions, and the complexity of the site.[(1)]

In addition, the following quantitative, site-specific objectives or *performance standards* (for selected engineering controls and treatment systems that include controls) should be identified. These standards are used to measure progress toward or attainment of an RAO by a given action at a specific site:

- the area of attainment (area over which cleanup levels are to be attained by a restoration action or gradients are to be controlled by a hydraulic containment action) and
- the restoration time frame (estimated time period required for restoration actions to attain cleanup levels over the area of attainment).[(1)]

Remediation goals (RGs) establish acceptable exposure levels that are protective of human health and the environment and are predicated on PRGs that have been modified, as necessary, as more information becomes available. Final RGs are determined when the remedy is selected and are developed considering the following guidelines:

- ARARs;
- nonzero MCLGs/MCLs;

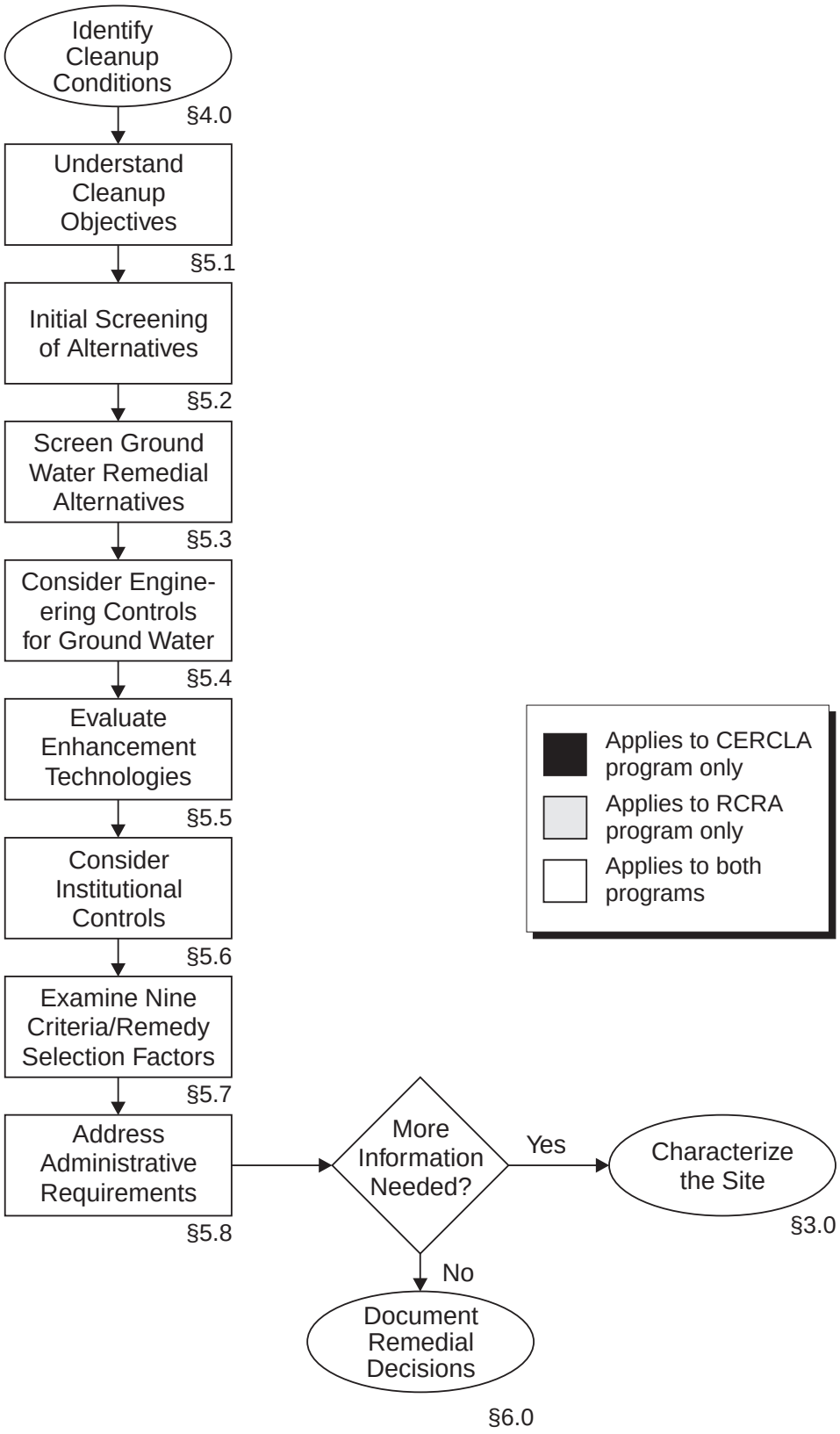

Figure 5. Screening and detailed analysis of remedial alternatives/corrective measure technologies.

- for multiple contaminants or pathways, acceptable exposure levels exceeding upperbound lifetime cancer risk to an individual between 10^{-4} to 10^{-6};
- WQC;
- ACLs; and
- environmental evaluation of threats to sensitive/critical habitats and populations (e.g., pregnant women, children, endangered species). [See 40 CFR § 300.430(e)(2)(i)(A)-(G).]

During RCRA corrective actions, when regulators require a CMS work plan, ERPMs must include a description of the CMOs as an element of the work plan. RCRA corrective measure objectives (also referred to as corrective action objectives) propose target media cleanup standards (e.g., promulgated federal and state MCLs, risk-derived standards). The objectives also include points of compliance or a description of how a risk assessment will be performed (e.g., guidance documents).[(2)]

The development of a target MCS is a discretionary function that may be performed by the regulators, preferably before the CMS. ERPMs should consider proposing to modify a target MCS during the CMS. If EPA is unwilling to establish a target MCS, ERPMs should consider developing their own target MCS values for use during the evaluation process. ERPMs should be aware that although such values are unlikely to be recognized by EPA, they may provide ERPMs with a valuable tool for evaluating corrective measures.[(3)]

5.2 Initial Screening of Remedial Alternatives/Corrective Measures

The screening phase of the FS/CMS allows development of an appropriate range of remediation alternatives that will be thoroughly analyzed during the detailed analysis portion of the FS/CMS. Under CERCLA, the screening phase of the FS usually takes place before the baseline risk assessment is completed.

Q. *What factors must be considered while screening alternatives?*

A. When initially formulating ground water remedial alternatives, ERPMs should establish a target number of alternatives to be carried through screening. EPA's streamlining principle emphasizes that alternative screening should be commensurate with the scope and complexity of the problem being addressed. Consistent with CERCLA program expectations, ". . . if treatment is not practicable for all wastes at the site, then complete treatment need not be included as an alternative. Alternatively, if it is clear that treatment will be part of the remedy, alternatives that rely solely on containment or institutional controls and that do not include treatment need not be considered" (55 *FR* 8714).

Depending on the number of viable alternatives, the screening effort may be minimized or eliminated if deemed unnecessary.[(4)] For example, presumptive remedies are preferred technologies for common categories of sites based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. In most cases, after a site is confirmed as being a type for which presumptive remedies exist, a focused FS (or alternatives analysis in the EE/CA for removal actions) eliminating the technology development and screening step would be prepared. The study would limit its consideration to the no-action alternative and the presumptive remedy technologies.[(5)]

During project scoping, ERPMs should begin developing a list of general response actions (e.g., treatment, containment, excavation, extraction, institutional controls) that may satisfy the

site-specific remedial action objectives. Concurrent with the development of alternatives, an initial determination is made regarding areas or volumes of ground water to which general response actions might be applied.

Comparisons made during initial screening are usually made among "technology types" (e.g., capping, thermal destruction, immobilization) and "technology process options" (e.g., slurry walls, sheet piling, grout injection). These comparisons are based on implementability. Process options and entire technology types may be eliminated from further consideration on the basis of technical implementability. Two factors that commonly influence technology screening are the presence of inorganic contaminants, which limit the applicability of many types of treatment processes, and subsurface conditions, such as the depth to impervious formations or the degree of fracture in bedrock.[4]

At this point in the screening process, ERPM screening efforts should focus only on those remedial alternatives that show promise of achieving RAOs based on an evaluation of their implementability. ERPMs should evaluate each technology process option in greater detail before selecting one process option, if possible, to represent each technology type.

Alternative descriptions during the screening stage should be general and should not include details such as preliminary design calculations, process flow diagrams, or sizing of key components. Comparisons of these alternatives are usually made between similar alternatives (e.g., extraction wells, extraction/injection wells, interceptor trenches). Alternatives should be compared on an equivalent basis (i.e., treatment alternatives should be described at the same level of detail to allow preparation of comparable cost estimates).

Alternatives selected during screening as the most promising will be carried through and evaluated against nine evaluation criteria during the detailed analysis component of the FS: overall protection; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; state acceptance; and community acceptance.

RCRA CMS lacks codified decision processes, provisions, or criteria by which remedial alternatives are "screened." Further, the Corrective Action Plan[2] lists "screening" as an optional element. However, ERPMs may be required to, or choose to, evaluate a number of corrective measures technologies. When appropriate, ERPMs evaluate the technology limitations to show why certain corrective measures technologies may prove unfeasible to implement given existing waste and site-specific conditions.

Likewise, if only one corrective measure alternative is being analyzed (i.e., the regulators have determined that a streamlined CMS is appropriate), ERPMs should identify any technical limitations based on the waste and site-specific conditions.[2] EPA anticipates that a streamlined or highly focused CMS will be appropriate to the following types of situations:

- "low risk" facilities (i.e., facilities with relatively small environmental problems with minimal exposure concerns),
- facilities using a high quality remedy proposed by the ERPM [i.e., "clean closure" that is consistent with other remedial objectives (e.g., reliability)],
- facilities with few remedial options [i.e., facilities with few practicable cleanup solutions or situations where current or future uses of the resource dictate minute residual contamination (e.g., sole-source aquifers)],

- facilities with straightforward remedial solutions (i.e., standard engineering solutions that have proven effective in similar situations), and
- facilities using phased remedies (i.e., remedies that focus on either one aspect of the remedy (e.g., ground water remediation) or one area of the facility that demands immediate attention). In phased remedy situations, the CMS should focus on the one aspect demanding attention and should conduct follow-up studies (and corrective measures) as appropriate (55 *FR* 30821).

In addition, ERPMs may choose to evaluate a number of corrective measure technologies to illustrate why certain technologies may prove unfeasible to implement given existing waste and site-specific conditions and limitations.(2) Regulators have the option of requiring this evaluation. ERPM-supplied information "is intended to provide the decision maker [regulators] with a range of options for structuring a [CMS] to support the ultimate remedy selection for the facility. . . . To the extent that potential remedies are identified early in the [RFI] process, [an ERPM] can streamline his or her data collection efforts to include data needed for the evaluation of specific remedial alternatives." (55 *FR* 30821)

ERPMs should identify the appropriate corrective measures and recommend them to the regulators based on ERPM evaluation of the corrective measure alternatives. ERPMs should use the bullet point list of considerations found on p. 2-2 of the Guide. Additionally, the Regional Administrator may specify, before or during the course of the CMS, preliminary "target" cleanup levels [i.e., a cleanup range or a specific level (e.g., action level)]. ERPMs may use these levels in evaluating (1) performance, reliability, ease of implementation, and potential impacts of the remedy (e.g., safety impacts, cross-media impacts) and (2) effectiveness of potential remedies in achieving source control/cleanup. [40 CFR § 264.522(a)(1) and (2)]

Although optional, some permits or corrective action orders may require the conduct of a PECMT by laboratory or bench-scale studies to determine the applicability of a corrective measure technology to facility conditions. PECMT evaluations are generally required before the RFI and identify candidate technologies so that baseline data to evaluate these technologies may be collected during the RFI. If a PECMT was previously required, ERPMs should use it as a starting point for their CMS activities.(3)

5.3 Screening Criteria and Conditions To Address Ground Water

Q. *When formulating and screening remedial alternatives to address ground water contamination, what criteria should ERPMs consider?*

A. For ground water that is a current or potential source of drinking water, three to five ground water remediation alternatives will typically be carried through screening to detailed analysis of the alternatives.(1) In many cases, however, a screening step is unnecessary because active restoration, containment, natural attenuation, and no-action alternatives normally will be evaluated.

Under CERCLA, the initial screening step development and screening of remedial alternatives include the short- and long-term aspects of the following three criteria [40 CFR § 300.430(e)(7)]:

- effectiveness in reducing the toxicity, mobility, or volume of contaminants in the plume; minimizing risks; attaining ARARs or other health-based levels; and protecting human health and the environment;

- implementability regarding technical and administrative feasibility, and availability of the required technology and services; and
- a general cost analysis to identify technologies that achieve similar levels of effectiveness and implementability (e.g., plume reduction) but are significantly more expensive (i.e., an order of magnitude) or have costs that are "grossly excessive" compared with the effectiveness they provide.

At screening, those alternatives that are clearly unacceptable in terms of these three criteria may be eliminated from further consideration.

Consideration of effectiveness involves (among other factors) evaluating the following human health risks:

- long-term [i.e., assessment of the risks associated with treatment residuals and untreated wastes (for a treatment-based remedy) or an evaluation of the remedy's ability to provide protectiveness over time (for a containment-based remedy)] and
- short-term [i.e., generally includes baseline risks, risks that occur during the construction and implementation of the remedial alternative (e.g., air quality impacts from air-stripping tower, dust from excavation, worker exposure) and risks associated with the length of time required to achieve protection.

At the screening stage, the risk evaluation typically is based on many simplifying assumptions, best professional judgment, and experience of the ERPMs (and their staff). Quantifying risks generally is not necessary. Rather, ERPMs should use screening to identify alternatives that present clearly unacceptable risks.[6]

For both CERCLA and RCRA ground water restoration, screening alternatives may involve a consideration of the aggressiveness of the remedial alternative (i.e., several alternatives may attain the required cleanup levels, but some will attain those levels quicker than others). Conditions favoring more aggressive strategies (i.e., active pump-and-treat throughout the aqueous plume) include the following situations:

- a significantly shorter restoration time frame than other available options will result,
- a shorter remediation time frame is desired to reduce the potential for human exposure (i.e., there is current or expected near-term use of the ground water), and
- a shorter remediation time frame is desired to reduce ongoing or potential impacts to environmental receptors (e.g., wetlands).

Where conditions favoring more aggressive strategies do not exist, EPA is more likely to support a less aggressive strategy (e.g., natural gradient flushing).[7]

If ground water is unsuitable for human consumption, a limited number of alternatives should be screened. Environmental receptors that are potentially affected or beneficial uses other than human consumption (e.g., agriculture or industrial uses) will often be the critical factors used to establish remediation goals. If ground water of limited beneficial use is interconnected with a potential source of ground water, remediation may be required to protect the higher use ground water.[1]

5.4 Engineering Controls for Ground Water

Q. *Do broad categories of media-specific engineering controls for ground water exist?*

A. Ground water control/treatment technologies can be generally classified under four categories. These include:

- impermeable barriers,
- well systems ground water extraction and/or injection,
- interceptor systems/subsurface drains, and
- in situ treatment.

All of these methods can be used to divert ground water flow away from a contaminated ground water source or to prevent contaminated ground water from migrating away from the site.[8]

Of these technologies, ground water extraction, commonly referred to as "pump-and-treat," is the most commonly used remedial technology for contaminated ground water. Three different objectives exist for ground water extraction systems:

- aquifer restoration,
- migration control (i.e., plume containment), and
- wellhead treatment.

In many situations, sites have multiple extraction systems with different objectives (e.g., wellhead treatment system, which affords continued operation of water-supply wells within the contaminated aquifer, and an aquifer restoration system near the source of contamination). When aquifer restoration is the objective, ERPMs should consider the following factors that may influence the time required to achieve restoration:

- well placement and pumping rates,
- contaminant sorption and retardation,
- isolation of low-permeability zones,
- contaminants in NAPL forms, and
- leaching of contaminants from the vadose zone.[9]

Restoration time frame analyses are generally well suited for comparing two or more engineering design alternatives to determine the most appropriate strategy for a particular site. Although long restoration time frames may be an important consideration in remedy selection, no single time frame is specified during which restoration must be achieved. ERPMs should assign and consider a level of uncertainty for each restoration time frame prediction and factor the uncertainty into the remedy decision process.[7]

5.5 Enhancement Technologies for Engineering Controls

NAPLs can increase the time frame and complexity of restoration activities. NAPLs present in the subsurface act as a residual source of ground water contamination. Their aqueous solubility acts as a limiting factor (i.e., they can become trapped in pore spaces by capillary forces and are not readily pumped out). In these and other cases the suitability and performance of any completed or ongoing ground water restoration activity should be evaluated relative to the objectives of those activities. In some cases, EPA may determine that the lack of progress in

achieving the required cleanup levels is because of inadequate remediation design and implementation.

Q. *In instances of inadequate remediation design and implementation, what actions might EPA require?*

A. EPA will generally require that the existing remedy be enhanced, augmented, or replaced by a different technology. Supplemental remediation techniques that have the potential to improve ground water extraction, referred to as enhancement techniques, have been developed for enhanced oil recovery applications. However, these practical approaches may have application during contaminant recovery (e.g., NAPL recovery) and include:

- induced gradient/water flooding (i.e., pumping water from wells completed above or in a DNAPL pool to induce DNAPL flow),
- chemically enhanced recovery (surfactants, cosolvents, and alkaline agents increase solubility/lower interfacial tension of NAPL and water), and
- thermally enhanced recovery (i.e., steam and hot water flooding to decrease viscosity and density).[10]

Additional enhancement techniques that may improve ground water extraction include the following:

- progressive system modification (implements a phased reduction in the number of extraction wells as the outer edges of the plume are cleaned),
- pulsed pumping (pumps water intermittently, which allows the ground water passing through the residual source to dissolve or desorb contaminants),
- soil vapor extraction (removes residual source contaminants in vadose zone),
- ground water reinjection (increases hydraulic gradient and saturated thickness),
- slurry wall containment (limits water requiring treatment and reverses the vertical gradients),
- electrokinetics (elevates concentration of contaminants in the water adjacent to the electrodes), or
- fracture enhancement (uses hydro and pneumatic fracturing to increase the water flow rate into the fractured well by a factor 25 to 40).[11, 12, 13]

Some of these techniques may constitute "treatment" (as defined in 40 CFR § 260.10) under Subtitle C of RCRA. During RCRA corrective actions, "treatment" may subject ERPMs to permitting requirements for miscellaneous units (Subpart X of 40 CFR Part 264).

In some cases, extraction and treatment systems may not be able to remediate ground water to remediation goals/media cleanup standards in a reasonable time frame. Innovative technologies (i.e., fully developed technologies that lack sufficient cost or performance data) that offer the following advantages may be considered alone or in conjunction with other technologies:

- *comparable* or superior performance or implementability,
- fewer or less adverse impacts than other alternatives, or
- comparable performance at lower costs.

Consideration of an innovative technology is normally carried through the screening phase and into the detailed analysis phase if there is "reasonable belief" that the innovative technology will offer significant advantages.[4] "Reasonable belief" includes indications from other full-scale applications under similar circumstances or from bench-scale or pilot-scale treatability testing.

5.6 Institutional Controls

Q. *What measures may be necessary if engineering controls are not practicable or need to be supplemented?*

A. At times when treatment or controls are not practicable or need to be supplemented, no action is taken. Institutional controls (implemented at the state or local level) may then be necessary to ensure that contaminated ground water is not used before levels that are protective of human health and the environment are attained. The following kinds of institutional controls have been established in some states and localities and may be considered by ERPMs trying to prevent exposure to contaminated ground water:

- regulatory restrictions on construction and use of private wells (e.g., well construction permits),
- acquisition of real property from private entities,
- exercise of regulatory and police powers (e.g., zoning),
- restrictions on property transactions, and
- nonenforceable controls (e.g., well-use advisories, deed notices).

EPA considers these actions "limited action alternatives." These actions simply control future access to the site or limit exposure to existing contamination. The action may not be considered when establishing the "true" baseline risk.[14]

Where institutional controls are used as the sole remedy, special precautions must be taken to ensure that controls are reliable. States must ensure that institutional controls are in place, reliable, and will remain in place after initiation of operation and maintenance [40 CFR § 300.510(c)(1)].

5.7 Nine Evaluation Criteria/Remedy Selection Factors (i.e., Detailed Analysis)

Generally, three to five ground water remediation alternatives will be carried through screening to detailed analysis of the alternatives.[5] Information on alternatives is developed during the detailed analysis portion of the FS/CMS process. The detailed information consists of preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of the limitations, assumptions and uncertainties concerning each alternative.

Q. *What criteria must be used by ERPMs when comparing alternatives, selecting an appropriate remedy, and demonstrating that CERCLA remedy/RCRA corrective measure selection requirements have been satisfied?*

A. If separate alternatives have been developed for different areas or media at the site, EPA recommends that they be combined during the detailed analysis phase of the FS. The decision maker is thus presented with a range of discrete options, each of which addresses the entire site or that area being addressed by the operable unit.[4]

Under CERCLA, there are a total of nine evaluation criteria [40 CFR § 300.430(e)(9)(iii)(A)-(I)] including two statutory threshold criteria that must be attained for each alternative:

- overall protection of human health and the environment [describes how the alternative, as a whole, achieves and maintains protectiveness (i.e., long-term effectiveness and permanence, short-term effectiveness, compliance with ARARs)][(4)] and
- compliance with ARARs unless a waiver is appropriate [summarizes which requirements are applicable or relevant and appropriate to an alternative and describes how the alternative meets these requirements].[(4)]

Identification of the preferred remedial alternative and final remedy selection is based on an evaluation of major trade-offs among five of the nine evaluation criteria. These five criteria, called primary balancing criteria, include:

- long-term effectiveness and permanence (evaluates residual risk, both treatment residuals and untreated residuals, and the alternative's ability to maintain the specified level of protectiveness over time);[(7)]
- reduction of toxicity, mobility, or volume through treatment [analyzes the magnitude, significance, and irreversibility of the reductions achieved by alternatives employing treatment; generally reductions of 90 to 99% in concentration or mobility are achieved (55 *FR* 8721)];
- short-term effectiveness [evaluates current baseline risks plus any new risks to neighboring populations (including on-site workers) that would occur while implementing the alternative];[(7)]
- implementability (evaluates the technical and administrative feasibility of an alternative and the availability of services and materials required during its implementation);[(4)] and
- cost [evaluates, compares, and summarizes the cost of each alternative and includes an estimation of capital and annual operation and maintenance (O&M), a present-worth analysis (i.e., an evaluation and comparison of annual costs that occur over different time periods by discounting all future expenditures), and a sensitivity analysis (i.e., an assessment of the effects of variation in specific assumptions)].[(15)]

The final two criteria, called modifying criteria, are evaluated following receipt of comments on the RI/FS report and the proposed plan and are addressed after a final selection of the alternative is made (i.e., while the ROD is being prepared). They include:

- state acceptance (assesses the technical and administrative issues and concerns the state may have regarding each of the alternatives) and
- community acceptance (assesses the technical and administrative issues and concerns the public may have regarding each of the alternatives)[(4)]

Where ground water ARARs are waived because of technical impracticability, EPA's general expectations are to prevent further migration of the contaminated ground water plume, prevent exposure to contaminated ground water, and evaluate further risk reduction measures as appropriate. These expectations should be evaluated along with the nine remedy selection criteria to determine the most appropriate remedial strategy for the site.[(7)]

This analysis is comprised of an individual assessment of the alternatives against each criterion and a comparative analysis designed to determine the relative performance of the alternatives and identify major trade-offs (i.e., relative advantages and disadvantages) among

them. This information is presented to decision makers and allows them to select a site remedy. It is not, however, the decision-making process itself.

During RCRA corrective actions, the regulators evaluate four general standards [40 CFR § 264.525(a)]. The first two are (1) overall protection of human health and the environment and (2) compliance with MCSs. They are similar to the CERCLA threshold criteria. Two additional general standards must be met including:

- source control and
- appropriate management of remediation wastes.

The remaining five remedy selection factors [40 CFR § 264.525(b)] closely mirror those under the CERCLA program. They consist of (1) long-term reliability and effectiveness; (2) reduction of toxicity, mobility, or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost. Modifying criteria under CERCLA (i.e., state and community acceptance) are addressed through the RCRA permitting/permit modification process but are not evaluation criteria.

Preparation of feasibility cost analysis during the detailed analysis requires the analysis of direct capital costs (e.g., construction, relocation, disposal costs), indirect capital costs (e.g., engineering expenses, license or permit costs), and annual operation and maintenance costs (e.g., disposal of spent carbon filters, rehabilitation costs). ERPM cost estimates are developed during the detailed analysis of remedial action alternatives. Typically, they should provide an accuracy of +50% to –30%. This effort may require a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions.[1]

Under CERCLA, the selected alternatives must be determined to be protective and ARAR-compliant before cost-effectiveness (i.e., a remedy's effectiveness proportional to its cost) is considered in remedy selection. "In comparing alternatives to one another, [ERPMs] should examine incremental cost differences in relation to incremental differences in effectiveness" (55 *FR* 8728). Under RCRA, cost is the last criteria evaluated and will play a role when two feasible alternatives provide similar protection of human health and the environment within the same amount of time.[3]

Long- and short-term effectiveness requires evaluation of human health risks. During the detailed analysis, ERPMs who are deciding whether a quantitative human health risk evaluation is necessary should consider the following factors:

- whether the *relative* short- or long-term effectiveness of an alternative is an important consideration in selecting that alternative and
- the "perceived risk" (based on best professional judgment and concerns of the neighboring communities) associated with an alternative.

The short-term risk evaluations generally should not include a detailed evaluation of the risks associated with RCRA-regulated technologies (e.g., incineration). The risks associated with these technologies were analyzed during development of the technology's standards, and the standards are set at levels that ensure that risks during operation are acceptable.[6]

The detailed analysis is comprised of an individual assessment of the alternatives against each criterion followed by a comparative analysis designed to determine the relative performance of the alternatives and identify major trade-offs (i.e., relative advantages and disadvantages) among them. This information is presented to decision makers and allows them to select a site remedy. It is not, however, the decision-making process itself.

The final list of alternatives should always include a no-action alternative, which offers a useful baseline for comparison with other alternatives. In the following situations, the no-action alternative may appropriately be used as the selected alternative:

- Natural attenuation may be selected because the ground water is naturally unsuitable for consumption, has low mobility contaminants, low aquifer transmissivity, or low potential for exposure, and will result in achieving the remediation goals/MCS.
- ERPMs can demonstrate that no additional reduction of the risk posed to human health and the environment will result from conducting aggressive remedial action/corrective measures.

Limited action alternatives that only reduce exposure (i.e., a fence) should not be considered a no-action alternative. Such an action should be considered as a separate, limited-action alternative.[3]

5.8 FS/CMS Administrative Requirements

Q. *Are there administrative requirements associated with performance of the FS/CMS?*

A. The FS report is the only required document during the FS. It provides the basis for the ROD and communicates the implementation and outcome of the FS process to stakeholders.[16]

No formal report preparation is required during the development and screening of the alternative phase of the FS (except project management tracking such as monthly progress reports). However, some form of written documentation of the methods, rationale, and results of the alternative screening should be provided to the regulators. This documentation can be presented graphically or in a technical memorandum and should include the following types of information:

- chemical- and/or risk-based remediation goals associated with each alternative;
- modifications to any media-specific alternative initially developed;
- definition of each alternative (including, when applicable, the extent of remediation, volume of contaminated ground water, size of major technologies, process parameters, cleanup time frames, transportation distances, and special considerations); and
- notation of process options comprising the alternative.

When presenting the detailed analysis, the FS report should include a narrative discussion and summary table. The narrative should provide, for each alternative and without consideration of other alternatives, the following:

- a description of the alternative (e.g., technology components, quantities of hazardous materials handled, time required for implementation, process sizing, implementation requirements, significant ARARs, assumptions) and
- a discussion of how and to what extent the various factors within each of the criteria are addressed (e.g., magnitude of residual risk and adequacy and reliability of controls for long-term effectiveness and permanence, current baseline risks plus any new risks to neighboring populations for short-term effectiveness).

An accompanying summary table should highlight the assessment of individual alternatives relative to each of the nine criteria (excluding state and community acceptance that will be addressed in the ROD).

After the alternatives have been described and individually assessed, a comparative analysis should be conducted. The comparative analysis section of the FS describes the strengths and weaknesses of the alternatives relative to one another and how reasonable variations of key uncertainties could change the expectations of their relative performance. EPA suggests that ERPMs organize this section of the FS by individual criterion (e.g., overall protection, compliance with ARARs). Each category should begin with the alternative that performs the best overall; the remaining alternatives should be discussed in the relative order of their performance.[4]

ERPMs conducting a CMS under RCRA may be required to develop and submit a CMS Work Plan before performance of the study. At the discretion of the regulators, the CMS Work Plan may become an enforceable condition of the FFA or FFCA. The plan must address, at a minimum, the following:

- current conditions at the facility,
- the general approach to investigating and evaluating potential remedial alternatives (e.g., use of remedial phases or streamlined approach),
- a definition of the overall objectives of the CMS,
- a proposed schedule for the CMS,
- identification of the alternatives for the corrective measure,
- the evaluation process and evaluation criteria for each alternative, and
- the format for presentation of the findings of the CMS.

Minimum contents of the CMS plan may already be described in other previously prepared site documents and should be incorporated either directly or by reference. Upon regulator approval of the plan, the plan will become an enforceable condition of the permit schedule of compliance. ERPMs must conduct the CMS according to the approved plan, including the schedule contained in the plan.[3]

Upon completion of the study, a CMS Report must be prepared. It includes, unless otherwise specified by the regulators, the following elements:

- an introduction/purpose;
- a description of current conditions (ERPMs should reference, if appropriate, the RFI current conditions section);
- corrective action objectives (i.e., proposed MCSs);
- identification, screening, and development of corrective measures (i.e., brief list or table that summarizes potentially applicable technologies that may be used to attain the MCSs for each affected media);
- evaluation of a final corrective measure alternative to protect human health and the environment (i.e., detailed documentation of how the potential remedy will comply with the four general standards and five remedy selection factors);
- a recommendation by permittee/respondent for a final corrective measure alternative (i.e., description and supporting rationale for the remedy proposed by ERPMs); and
- a public involvement plan.

ERPMs also are required to provide the regulators with signed progress reports. These reports contain the following types of information: a description and estimate of the percentage of the CMS completed; summaries of all findings, all changes made, and all contacts with stakeholders; all contacts made regarding access to off-site property; all problems encountered and action taken; changes in relevant personnel; projected work for the next reporting period; and copies of daily reports. ERPMs will typically be requested to provide the regulators with a proposed schedule, which identifies the type of document (i.e., work plan, report, progress reports) and the anticipated due date.

Examples of the types of CMS Work Plan, CMS Report, Progress Report, and Proposed Schedule information that may be requested from ERPMs by the regulators are described in the RCRA Corrective Action Plan.[2]

5.9 Chapter Summary

The FS phase of a CERCLA response action and CMS under RCRA are initiated after the RI/RFI activities are under way. The FS/CMS goal is to ensure that an appropriate number of ground water remedial alternatives/corrective measures are developed and evaluated.

Generally, alternatives that reflect CERCLA program expectations (e.g., return ground water to its beneficial uses) should range from remedies that eliminate the need for long-term management (including monitoring) to remedies that involve treatment to reduce the toxicity, mobility, or volume of waste as their principal element. In addition, containment options involving little or no treatment and a no-action alternative should also be developed. The evaluation and analysis of alternatives should be commensurate with the scope and complexity of the site problems being addressed.

Alternatives are initially developed, assembled, and evaluated to meet a set of RAOs for each medium of interest. During the initial screening step, one representative process option (e.g., cement bentonite wall) is selected to represent each technology type (e.g., slurry walls) based on an evaluation of implementability. During the alternative screening, each alternative (i.e., technology type) is evaluated based on its effectiveness, implementability, and cost.

The final FS/CMS component—the detailed analysis—evaluates the alternatives with the most favorable composite evaluation of all factors. Under CERCLA, the alternatives are individually analyzed against the nine criteria. This analysis is followed by a comparative analysis, which evaluates the relative performance of the alternative in relation to each of the nine specific criteria.

Under RCRA, ERPMs list and briefly describe potentially applicable corrective measures. The regulators may require ERPMs to consider additional measures or technologies. ERPMs may be required or may choose to evaluate the potential technologies to demonstrate the reasons certain corrective measures may prove unfeasible given site-specific conditions. ERPMs may be required to assemble the technologies that pass the screening step and provide detailed documentation of how the potential remedy will comply with RCRA's four general standards and five remedy selection factors.

ERPMs may recommend a preferred corrective measure for consideration by the implementing agency. This recommendation includes a description and supporting rationale for the proposed remedy consistent with the standards and factors. The final corrective measure selection will be made by the regulators. As with CERCLA, options for addressing less complex sites may require evaluation of a only single or limited technology.

5.10 Chapter References

1. EPA, 1988. *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, OSWER Dir. 9283.1-2, Office of Emergency and Remedial Response, Washington, D.C.
2. EPA, 1994. *RCRA Corrective Action Plan*, OSWER Dir. 9902.3-2A, Office of Waste Programs Enforcement, Washington, D.C.
3. DOE, 1993. *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.
4. EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Dir. 9355.3-01, Office of Emergency and Remedial Response, Washington, D.C.
5. EPA, 1993. *Presumptive Remedies: Policy and Procedures*, OSWER Dir. 9355.0-47FS, Office of Emergency and Remedial Response, Washington, D.C.
6. EPA, 1991. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives), Interim*, OSWER Dir. 9285.7-01C, Office of Emergency and Remedial Response, Washington, D.C.
7. EPA, 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration Interim Final*, OSWER Dir. 9234.2-25, Office of Solid Waste and Emergency Response, Washington, D.C.
8. EPA, 1985. *Corrective Measures for Releases to Ground Water from Solid Waste Management Units*, EPA/530-SW-88-020, Office of Solid Waste, Washington, D.C.
9. EPA, 1989. *Evaluation of Ground-Water Extraction Remedies: Volume 1, Summary Report*, OSWER Dir. 9355.4-03, Office of Emergency and Remedial Response, Washington, D.C.
10. EPA, 1992. *Dense Nonaqueous Phase Liquids—A Workshop Summary, Dallas, Texas, April 16–18, 1991*, EPA/600/R-92/030, Office of Research and Development, Washington, D.C.
11. EPA, 1992. *Evaluation of Ground Water Extraction Remedies: Phase II, Volume 1 Summary Report*, OSWER Dir. 9355.4-05, Office of Emergency and Remedial Response, Washington, D.C.
12. EPA, 1992. *RCRA Corrective Action Stabilization Technologies; Proceedings*, EPA/625/R-92/014, Office of Research and Development, Washington, D.C.
13. EPA, 1993. *In Situ Treatment of Contaminated Ground Water: An Inventory of Research and Field Demonstrations and Strategies for Improving Ground-Water Remediation*, EPA/500/K-93/001, Technology Innovation Office, Washington, D.C.
14. DOE, 1992. *Use of Institutional Controls in a CERCLA Baseline Risk Assessment*, Information Brief, EH-231-014/1292, Office of Environmental Guidance, Washington, D.C.
15 EPA, 1987. *Remedial Action Costing Procedures Manual*, OSWER Dir. 9355.0-10, Office of Emergency and Remedial Response, Washington, D.C.
16. DOE, 1993. *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements, and Techniques Guidance*, Office of Environmental Guidance, Washington, D.C.

6. Documenting Decisions

Figure 6 provides a graphic representation of the process of documenting remedial alternatives/corrective measures decisions and the organization of this chapter.

6.1 Objective and Presentation of the Proposed Plan

The Proposed Plan is prepared after ERPMs have completed the RI/FS and have identified an alternative that is protective, ARAR-compliant, and judged to provide the best balance of trade-offs regarding the five primary balancing criteria. At this point in the process, "community acceptance" generally may not be known. Also, the state/support agency position is likely to be a preliminary one. ERPMs must publish a notice and brief analysis of the Proposed Plan in a major local newspaper and make the Proposed Plan available.

Q. *What is the objective of the Proposed Plan and how should it be presented?*

A. The Proposed Plan, the first step in the CERCLA remedy selection process, is made available with the RI/FS to the public for comment. A Proposed Plan employs one of two basic formats—a fact sheet format or an expanded, more detailed format that is more a stand-alone document. It highlights key aspects of the RI/FS, provides a brief analysis of remedial alternatives under consideration, and identifies the preferred alternative. The Proposed Plan also highlights the key factors that led to identification of the preferred alternative. It should make clear that although DOE has "identified" a preferred alternative based on available information, a remedy has not been "selected."

The Proposed Plan should request comments on all the alternatives described and clearly state that changes to the preferred alternative, or a change from the preferred alternative to another alternative, may be made if public comments or additional data indicate that such a change would result in a more appropriate solution. Finally, the Proposed Plan should provide information on how the public can be involved in the remedy selection process (including referring readers to the RI/FS report and administrative record as more complete sources of information). The Proposed Plan should contain, at a minimum, the following elements:

- Introduction,
- Site Background,
- Scope and Role of Operable Unit or Response Action,
- Summary of Site Risks,
- Summary of Alternatives,
- Evaluation of Alternatives and the Preferred Alternative, and
- Community Participation.[1]

Proposed Plans that are prepared to support the selection of interim remedial actions ("early actions") should be tailored to the limited scope and purpose of the interim action (i.e., areas/media affected by the interim action). These plans will be followed by a final operable unit ROD. They are generally more streamlined than Proposed Plans for comprehensive response actions. In particular, the "Site Description" should focus on site characteristics addressed by the limited action. The "Scope and Role of Operable Unit" section should illustrate how the early action fits into and is consistent with any planned future actions. The "Summary of Site Risks" discussion may be very brief, providing information to support the need to take early action but usually not specifying final acceptable exposure levels for the site.[2] If presumptive remedies are

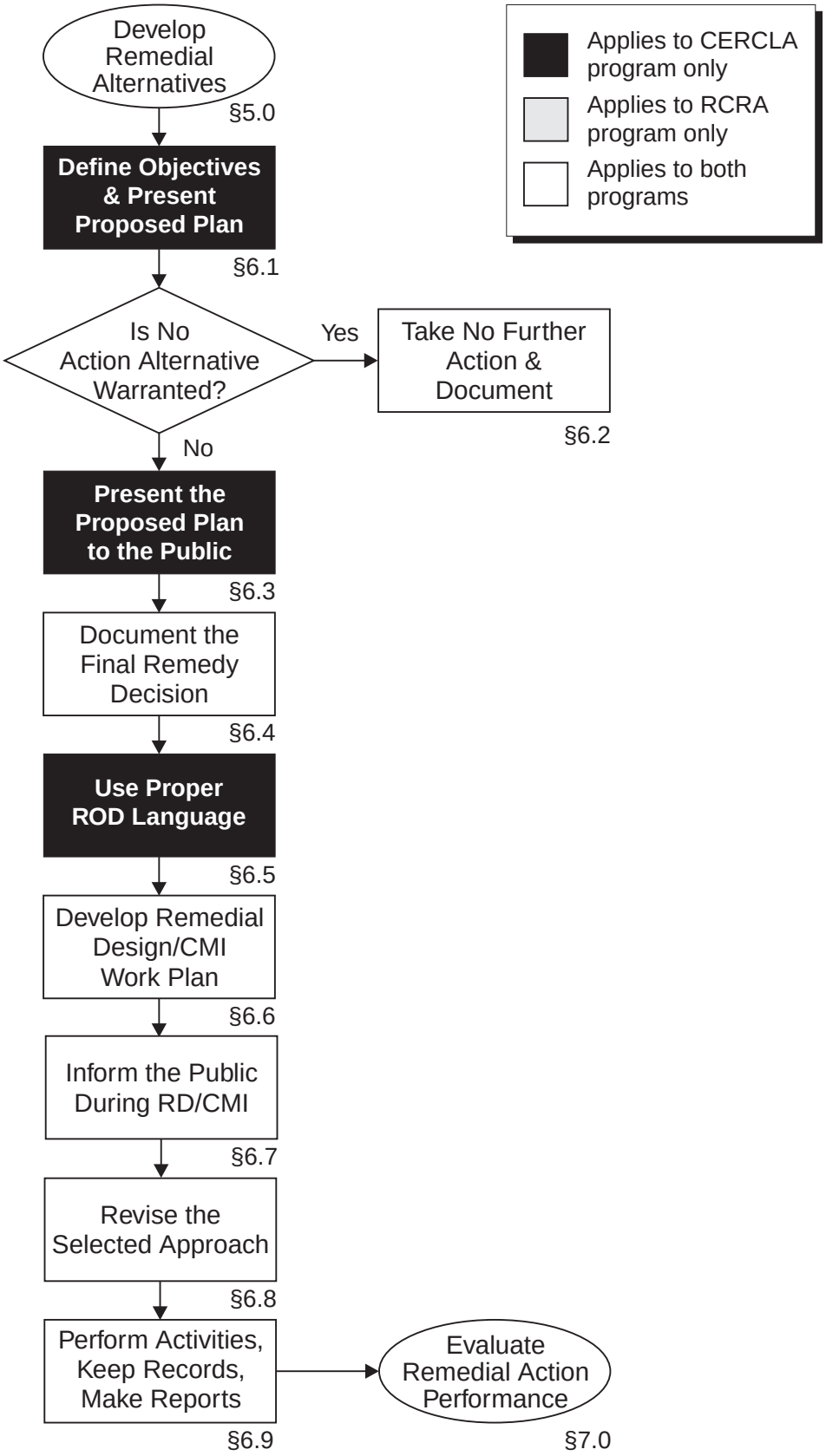

Figure 6. Documenting Remedial Alternatives/Corrective Measures decisions.

employed, the Proposed Plan may be streamlined by focusing primarily on the presumptive remedies being considered.[3] When ERPMs invoke a TI ARAR waiver (i.e., a front-end decision), they must provide notice of this intent in the Proposed Plan and respond to regulator or public comments concerning the waiver to support ROD approval.[4]

EPA recommends that, in addition to identifying interim remedial actions, ERPMs include provisions in the Proposed Plan that allow for modification of the remedy during the RD/RA phase, either by specifying a contingent remedy or by selecting an interim remedy and goals.[5]

6.2 "No Action" Proposed Plan and ROD/RCRA Determination of No Further Action

Q. *Are there situations when ERPMs are not required to propose a remedial alternative/corrective measure?*

A. Under CERCLA, ERPMs may determine that "no action" is warranted for their site or operable unit within their site. This determination may be based on three general circumstances:

- a site or operable unit is already in a protective state (i.e., no current or future threat to human health or the environment exists),
- CERCLA does not provide the appropriate authority to take any or complete remedial action, and
- no effective action can be taken using currently available technology.

When documenting any of these situations, special documentation procedures should be followed for both the Proposed Plan and ROD. For example, if no action is necessary because the site is already protective, the proposed plan should be modified to exclude discussions under the "Summary of Alternatives" and the "Evaluation of Alternatives and the Preferred Alternative" sections.[2]

During RCRA corrective action, ERPMs may determine that their facility does not pose a threat to human health or the environment and that no further action is necessary based on their analysis of periodic reviews or the results of the RFI. In these situations, ERPMs should consider requesting a "Determination of No Further Action." EPA will review the request and decide if such a finding is justified based on the following:

- There is no release or threatened release of a hazardous waste or hazardous constituents from the DOE facility.
- The substance released is not hazardous waste or hazardous constituents (i.e., constituents listed in Appendix VIII to 40 CFR Part 261 and Appendix IX to 40 CFR Part 264), including reaction by-products from either hazardous or solid waste.
- The release is a permitted release, regulated under another authority, and EPA intends to pursue remediation under the terms of the permit.
- The release does not pose a threat to human health or the environment.
- The release exceeds action levels, but the regulators determine that a CMS is not required [e.g., contamination is in a highly saline aquifer (55 *FR* 30813)].
- The release is below the action levels established for the RFI [i.e., the RFI data indicate that the concentrations of hazardous contaminants in an aquifer (e.g., chromium, PCBs,

TCE) fall below the appropriate action levels (e.g., MCLs of 0.1, 0.0005, or 0.005 mg/L, respectively].

If any of these situations occur, ERPMs should request a Class III modification of the permit [40 CFR § 270.42(c)] or request that the regulators rescind the order compelling corrective action.[6]

6.3 Postproposed Plan Activities (i.e., Public Participation)

ERPMs are responsible for drafting the Proposed Plan for remedial actions (including early final remedial and interim remedial actions). ERPMs also must arrange for review and comment opportunities for the regulators (EPA/state) during preparation of the Proposed Plan.

Q. *Upon preparation of the Proposed Plan and review by the regulators, do ERPMs have follow-up activities that must be conducted?*

A. Various requirements regarding public participation become applicable after the Proposed Plan has been reviewed by regulators. Specifically, ERPMs must ensure that the following activities occur:

- Publish a notice of availability and a brief analysis of the Proposed Plan in a major local newspaper.
- Place the Proposed Plan and supporting information in the administrative record maintained at a DOE office or other central location and place a copy of these documents (for public inspection) at or near the site at issue (this may be the information repository). Additional guidance has been published.[7, 8]
- Provide no less than 30 calendar days for oral and written public comments on the Proposed Plan (this period can be extended).
- Provide an opportunity for a public meeting.
- Prepare transcripts of public meetings and make them publicly available [40 CFR § 300.430(f)(3)(i)(A)-(E)].

In some situations, before adoption of the selected remedy in the ROD, new information becomes available that significantly alters the scope, performance, or cost of the selected remedy identified in the Proposed Plan. ERPMs must include a discussion of the significant changes and reasons for such changes in the ROD if the ERPM determines such changes could have been reasonably anticipated. Otherwise, the ERPM must revise the proposed plan and seek additional public comment on a revised plan if the ERPM determines such changes could not have been reasonably anticipated [40 CFR 300.430(f)(3)(ii)].

Following the conclusion of the public comment period, CERCLA and the NCP require that a written response be prepared to significant written or oral comments, criticisms, and new data submitted during the comment period [40 CFR § 300.430(f)(3)(i)(F)]. This document (known as *The Responsiveness Summary*) is the third component of the ROD and must provide DOE responses to comments submitted during the comment period.[9]

6.4 Documentation of the Final Remedy

During CERCLA response actions, regulator and public comment regarding the merits of potential remedial technologies is solicited by ERPMs via the Proposed Plan/ROD process. In contrast, during RCRA corrective actions, public comments on the proposed corrective measures are solicited using a draft statement of basis (SB) or a fact sheet.

Q. *Under both programs, following receipt and consideration of public comments, how is the final remedy selection documented?*

A. Under CERCLA, the selected remedy is documented in a ROD. The ROD has three purposes:

- It serves a legal function in that it certifies that the remedy selection process was carried out in accordance with the requirements of CERCLA and, to the extent practicable, in accordance with the NCP.
- It is a technical document that provides information necessary for determining the conceptual engineering design, the engineering components, and cleanup levels of the selected remedy.
- It is informational, providing the public with a summarized source of information about the history, characteristics, and risks posed by the condition at the site, as well as a summary of the cleanup alternatives considered, their evaluation, and the rationale behind the selected remedy.

The ROD consists of three basic components:

- a Declaration that states the factual and legal basis for selecting a remedy, includes a prescribed statement of the existence of an imminent and substantial endangerment (unless cleanup decision is NFA), describes the selected remedy's major components in bullet format, explains how the selected remedy satisfies the statutory requirements, and is signed by the EPA and cosigned by DOE;
- a Decision Summary that is the main ROD component and provides an overview of the problems posed by the site, the remedial alternatives evaluated, and the nine criteria analysis of those options. The Decision Summary also identifies the selected remedy and explains the rationale for its selection and how the remedy satisfies statutory requirements; and
- a Responsiveness Summary that serves two purposes—(1) provides DOE decision makers with information about community preferences regarding both the remedial alternatives and general concerns about the site and (2) demonstrates to stakeholders how their comments were taken into account as an integral part of the decision-making process.[10]

Under RCRA, following the ERPM's submission of the RFI and CMS reports to the regulators, EPA will prepare an SB, or an authorized state will prepare a fact sheet (40 CFR § 124.7 and § 124.8, respectively). These documents describe the proposed corrective measure, summarize the alternatives considered, or propose that no further action is necessary.[6]

The SB is designed to serve as a companion to the RFI/CMS and the administrative record file. EPA is ultimately responsible for ensuring that the SB is properly prepared and will, more often than not, pursue agreements requiring DOE to draft the SB. The SB should contain the following information:

- facility name and location;
- document's purpose;
- proposed remedy and how that remedy protects human health and the environment;
- brief summary of the RFI and brief description of alternatives evaluated in detail during the CMS;

- brief overview of the site, including contaminated media, chemicals of concern, baseline exposure scenarios, ecological risks, current and potential risks posed by the facility, and site history;
- scope of the problem and how the remedy or each phase of the remedy addresses the problem;
- criteria used to evaluate the proposed remedy and alternatives;
- methods that will be used to monitor the remedy's effectiveness;
- notice of public comment period, time and place for a public meetings, and previous or ongoing public participation activities and how they impacted the remedy evaluation;
- location and availability of the administrative record files and information repositories; and
- name and telephone number of the point of contact for more information.[11]

A fact sheet, which is prepared by an authorized state and contains less details than an SB, typically includes the following information:

- a brief description of the type of facility or activity subject to the draft permit;
- the type and quantity of waste to be managed;
- a brief summary of the basis for the draft permit conditions including appropriate statutory, regulatory, and administrative record references;
- reasons that variances or alternatives to required standards do or do not appear justified;
- a description of the procedures for reaching a final decision on the draft permit or permit modification; and
- the name, address, and telephone number of the person to contact for additional information.

Regulators will provide written notice of a 45-day public comment period on the corrective action in a local newspaper and may announce the date for a public hearing if such a meeting is requested by the ERPM or public.[6] Although the regulatory agencies are primarily responsible for public involvement efforts at this point, ERPMs may be assigned some public involvement activities through the permit modification, the 3008(h) order, or as part of the FFCA negotiations.[9]

Final permit decisions (as well as RCRA §3008 orders) become effective 30 days after notification of the decision unless:

- a later date is specified in the decision,
- a review or an evidentiary hearing is requested by the ERPM or other interested party, or
- no comments were received to request a change of the draft permit, in which case the permit becomes effective upon issuance (40 CFR § 124.15).

During RCRA corrective actions, the permit/permit modification, order, or FFCA will document the binding requirements to conduct the selected corrective measure. These documents will also specify the conditions under which the facility will operate while conducting corrective measures. An issued permit/permit modification may contain disputable requirements (e.g., in the ERPM's best professional judgment, the remedy selected by the regulators is technically

impracticable). The regulators' decision may then be appealed (by the ERPM) under the permit appeal procedures of 40 CFR § 124.19 [40 CFR § 270.42(f)(2)]. For RCRA §3008 orders [e.g., 3008(h)] that contain disputable requirements, ERPMs must request a public hearing within 30 days [see RCRA 3008(b) and 53 *FR* 12256].

Also, under 40 CFR § 300.400(e), CERCLA response actions conducted entirely on-site do not require federal, state, or local permits. However, some permitting authorities (i.e., regulators) have attempted to require lead agencies (e.g., DOE) to participate in a process that is "equivalent" to a permitting process to satisfy their concerns that there will be compliance with ARARs. It is not EPA's policy to allow surrogate or permit equivalency procedures to impact the progress or cost of CERCLA site remediation in any respect. Therefore, to ease the regulators' concerns and hasten ARARs identification, ERPMs should provide copies of the design contractor and remedial action contractor submittals to the permitting authority whose ARARs are the subject of the submittals. FFAs may be appropriate vehicles to establish specific time limits for the permitting authority to provide technical assistance in the evaluation of site-specific ARARs.[12]

6.5 ROD Structures/Language for Ground Water

Q. *Relative to ground water, should ERPMs consider certain types of RODs (i.e., interim final) or language?*

A. RODs should reflect the amount of relative uncertainty believed to be associated with achieving cleanup levels in ground water at a particular site. To address this uncertainty, the remedial objectives should be presented as estimates or ranges so that a reasonable degree of change can be accommodated during the design and implementation without having to amend the ROD. RODs may be structured several ways to reflect the purpose of a selected remedy:

- as final actions when it appears certain that the remedy will restore ground water quality throughout the area of attainment;
- as final actions with a provision for establishing contingency goals when it appears likely that it is technically impracticable to restore the aquifer completely or achieve remediation goals throughout the area of attainment; or
- as interim actions, to be followed by final decisions, where there is substantial uncertainty regarding the remedy's ability to restore the ground water and it is necessary either (1) to prevent plume migration and/or initiate cleanup while RI/FS activities are being completed or
  (2) to generate additional information to better define cleanup goals.[5]

In cases where there is a high degree of certainty that cleanup levels cannot be achieved, a final ROD that invokes a TI waiver and establishes an alternative remedial strategy may be the most appropriate option. However, language that identifies a TI decision (i.e., an ARAR waiver) as a future contingency of the remedy should be avoided.[4]

Ground water remediation RODs often include two scenarios: (1) ground water extraction continues until remediation levels are attained or (2) ground water extraction continues until contaminant mass is no longer being removed at significant levels, and the remaining plume will be managed through containment and institutional controls.

In cases where hazardous substances remain at the site above levels that allow for unlimited use and unrestricted exposure, in accordance with §121(c) of CERCLA, reviews of remedies to determine whether the response remains protective must be performed no less often than 5 years

after initiation of the selected remedial action. RODs should contain a determination whether a 5-year review is a "Statutory" or "Policy" Review as appropriate for the site.

Further, three levels of effort have been defined (by EPA) for 5-year reviews: Level I is the lowest level of evaluation; Level III, the highest. Therefore, in addition to indicating whether a site requires a 5-year review (and the type of that review), ground water remediation RODs should also contain the proposed level of effort (ordinarily Level I) of the first review. ERPMs should generally limit the scope of 5-year reviews triggered by interim remedies (e.g., the waste supply remains in place, the plume is still controlled).[13]

6.6 RD/Work Plan Development

Following selection of the remedy and approval of the ROD/permit or permit modification/amended order, action must be taken to initiate design activities. The RD phase under CERCLA response actions/RCRA corrective actions includes preparation of detailed construction plans and specifications for the selected remedy.

Q. *When entering this phase, what must ERPMs prepare?*

A. Under CERCLA, all RD activities shall be established in conformance with the remedy selected and set forth in the ROD [or other decision documents (e.g., IAG/FFA)] for that site. ERPMs will generally be required to prepare:

- a comprehensive Statement of Work (SOW),
- a design schedule [bearing in mind the negotiated deadlines for completion of IAG/FFA required primary documents (i.e., Remedial Design Work Plans, the Final Remedial Design, the Construction QA/QC Plan], and
- and Independent Government Cost Estimates (IGCE) for RD task assignment to be performed by contractors.

Based on the SOW, the RD contractor will then prepare and submit to the ERPM (and subsequently EPA for concurrence) a Remedial Design Work Plan (which may be operable unit-specific) that addresses the items in the SOW. This plan includes any need to deviate from the SOW and includes the designer's proposed schedule and cost estimate. This plan will need to be reviewed for consistency with the SOW and compared with the ERPM's design schedule and cost estimate.

The transition from signature of the ROD to RD is known as the predesign planning phase. During this period, ERPMs should devote adequate attention to the initial planning activities (before the RD phase) to devise a strategy for successfully delivering the project on time and within budget. Because it is unlikely that any single ERPM will possess an in-depth knowledge of a variety of engineering and geological fields, ERPMs should consider assembling and coordinating a project team (i.e., a technical review team) that incorporates the technical knowledge in the applicable fields (e.g., hydrogeologists; risk assessors; chemical, structural, mechanical, and electrical engineers).

ERPMs should consider developing a Project Management Plan (PMP) [formerly known as the Remedial Management Strategy (RMS)]. A PMP is a planning tool and consists of an analysis of the project's managerial goals, as well as constraints of the remedy, and entails pragmatic consideration of the components of remedial design and remedial action. PMP content will vary depending on the complexity of the remedial design. In general, to complete a PMP, ERPMs should:

- specify the organizational and communications structure (e.g., determine roles and responsibilities, establish a communications matrix),
- determine the project constraints (e.g., funding, schedule, other constraints), and
- develop a contracting strategy [e.g., identify opportunities to accelerate the schedule (e.g., phasing, fast tracking), select the design approach, identify the RA contract type].[14] Additional guidance on the preparation and components of the RMS (now PMP), including the potential for phasing and/or fast-tracking the project has been published.[15]

In addition to a PMP, ERPMs should compile predesign information (formerly known as the Pre-Design Technical Summary) to facilitate a smooth transition from signature of the ROD to RD. It also provides the remedial design contractor with a clear understanding of the technical objectives of the RD. The following list identifies the nine major categories of information that should be collected:

- site conditions,
- performance standards,
- availability of data,
- technology and design approach,
- materials,
- ARARs/permits/state involvement,
- unresolved issues,
- health and safety concerns, and
- miscellaneous concerns.

This information serves as the initial building block for developing the RD Statement of Work and may be gathered from primary information sources including the RI/FS and the ROD. For simple design projects, many of these items need not be addressed. Whenever this is the case, the heading for unused sections should be retained for consistency and followed by the words *NOT USED*.[14]

Under CERCLA, in addition to the information identified above, ERPMs will generally be required to prepare a Remedial Design Statement of Work before preparation of the RD-related documents specified in the IAG/FFA. Elements to be identified in the model SOW for RD can be found in Appendix A of ref. 14. During the remedial design stage, several plans will be prepared. When appropriate, draft plans should be submitted with the prefinal design document.

Under RCRA, the CMI process begins after the regulators have approved the remedy through the permit/permit modification process. The first step of the CMI process is remedy design and is analogous to CERCLA's adoption of design standards following the ROD.

During RCRA remedy design, ERPMs may be required to prepare detailed construction plans and specifications (i.e., a comprehensive CMI Work Plan) to implement the regulator-selected remedy. Such plans and specifications may have already been incorporated expressly or by reference into the permit/permit modification schedule of compliance, enforcement order, or FFCA.

EPA's CMI process consists of the following components. ERPMs may be required to prepare a document for each of these components:

- Conceptual Design (i.e., 15% design phase that identifies the designer's vision of the corrective measure in the form of conceptual drawings and schematics; procedures and schedules for implementing the measures);
- O & M (i.e., long-term maintenance/monitoring procedures such as training, completion criteria, and O&M contingencies);
- intermediate plans and specifications (i.e., 30%, 60%, etc., design point);
- final plans and specifications (100% design point);
- Construction Work Plan (i.e., overall management strategy, construction QA procedures, schedule for construction);
- Health and Safety Plan (i.e., hazard assessment, personnel protective/monitoring equipment, site organization, emergency contacts);
- Public Involvement Plan (submitted and approved before use);
- progress reports (monthly, bimonthly, or quarterly); and
- proposed schedule (identifies deliverables and associated due dates).

If ERPMs can justify, to the regulator's satisfaction, that a plan and/or report or portions of it are not needed in the given site-specific situation, then the regulators may waive that requirement.[16] Additionally, the new RCRA Corrective Action Plan encourages regulators to employ a more flexible and streamlined approach (e.g., allow submittal of a CMI Work Plan that subsumes all of the required information rather than submitting each document as a separate deliverable, allow ERPMs to use or update ISMs plans to address final corrective measures, establish media cleanup standards but do not prescribe the process by which ERPM attain the standards).[16]

Developing the work plan typically entails the following tasks (although the actual process may differ from site to site):

- review all documents related to the facility;
- develop a PMP;
- update the Public Involvement Plan (PIP);
- prepare a design strategy;
- prepare detailed construction drawings;
- prepare a complete set of process flow diagrams;
- document all engineering and energy balance calculations;
- prepare a list of, and specifications for, all equipment and materials required;
- prepare an O&M Plan;
- prepare cost estimates reflecting fully loaded costs;
- develop a schedule for implementing corrective measures;
- prepare a Data Collection QA Plan;

- develop a Construction QA Plan; and
- develop a Health and Safety Plan.

Review the facility permit, order, or FFCA for specific requirements for document submission.[6]

6.7 Public Participation (Community Relations/Public Involvement) During RD/CMI Activities

The RD/CMI may take months to years to complete.

Q. *How do public participation requirements apply during RD/CMI activities?*

A. Before initiation of the RD under CERCLA, the community relations plan must be reviewed and, if necessary, revised to describe further public involvement activities during the RD/RA phase. In addition to ongoing activities (e.g., spokesperson, administrative record maintenance), DOE suggests additional activities that might include:

- public meetings to explain the proposed Remedial Design Plan, outline the schedule for upcoming events, and provide a forum for community questions and suggestions and
- newsletters to the site mailing list.[9]

While there are no public participation requirements or DOE guidance for RD intermediate deliverable milestones, ERPMs may wish to keep the public informed of these deliverables and RD progress. Some suggested activities might include fact sheets, site tours, and/or exhibits in the information repository, town hall, and/or schools. Upon completion of the final engineering design, ERPMs must prepare and distribute a fact sheet and provide, as appropriate, a public briefing before initiation of remedial action [40 CFR § 300.435(c)(3)].[9]

Upon completion of the RD stage under CERCLA, a public notice and an updated fact sheet should be prepared and distributed by ERPMs.[9]

Under RCRA, no public participation activities are required during CMI activities (i.e., from design through implementation). EPA guidance, however, may require that ERPMs revise the public involvement plans to identify public involvement activities (e.g., open house, informal meeting, fact sheet preparation) and a schedule for these activities. DOE also suggests that ERPMs hold public meetings to explain the proposed Design Plan, outline the schedule for upcoming events, and provide a forum for questions and answers. DOE suggests additional activities during the CMI including fact sheet preparation, press releases, site tours, exhibits, and briefings. Other ongoing activities might include appointing a spokesperson, compiling a mailing list, distributing a newsletter, and establishing and maintaining an information repository and administrative record.[9]

Finally, upon approval of the plans and specifications, proposed 40 CFR § 264.527(b)(2) requires that ERPMs place the plans and specifications in the information repository, if established, and provide written notice of availability to individuals on the facility mailing list.

6.8 Modifications During RD/RA and CMI

Following ROD signature, permit/permit modification issuance, or order/FFCA execution, ERPMs must follow the detailed language and schedules contained within the decision documents. ERPMs should do everything possible to minimize the opportunities for changes in the remedial action/corrective measure implementation. Paying contractors for stand-by time or for change orders after the contract award may be costly. ERPMs should ensure that they have

fully coordinated proposed work with the regulators and that they are fully complying with regulations. During remedial design or implementation of the remedial action/corrective measure, however, ERPMs may determine that a change in the remedial approach/corrective measure is necessary.

Q. *How may ERPMs revise the remedial approach/corrective measure?*

A. During CERCLA response actions, "EPA believes that it is necessary to 'freeze ARARs' when the ROD is signed . . . because continually changing remedies to accommodate new or modified requirements would . . . disrupt CERCLA cleanups. . . ." (55 *FR* 8757). Subsequent to ROD signature, new information may be submitted by the public or the regulators or support agencies, or it may be generated during the RD/RA process that could affect the remedy selected. ERPMs should analyze the new information to determine whether it should be "considered" (i.e., formally respond by letter and in the administrative record) based on the following four-part standard [40 CFR § 300.825(c)]:

- whether the comments contain significant information,
- the information is not contained elsewhere in the administrative record,
- the information could not have been submitted during the public comment period, and
- the information substantially supports the need to significantly alter the scope of the response action.[(1)]

The lead agency (DOE) has the discretion to make decisions regarding information it generates. With this in mind, ERPMs should evaluate the new information to determine whether it substantially supports the need to significantly alter the scope of the response action (e.g., physical area of response, remediation goals, type and volume of wastes), raises unanticipated concerns regarding the protectiveness or effectiveness of the remedy, or significantly changes the costs. ERPMs who determine changes are warranted should categorize the changes as one of the following:

- Nonsignificant changes are minor changes (e.g., implementation time increase of less than 6 months, migration of the contaminant plume 1,500 ft. outside original boundaries) that should be recorded in the post-ROD document file (which is equivalent to the RD/RA case file).
- Significant changes (e.g., implementation time increase of 3 years, volume of ground water requiring treatment is 50% greater than volume estimated) are changes that should be documented in an "Explanation of Significant Differences" (ESD).
- Fundamental changes (e.g., remediation using in situ bioremediation rather than "pump-and-treat") should be documented in a ROD amendment addressing only that portion of the remedy being changed.[(1)]

In addition, a signed ROD may require changes when a remedy is being reviewed for protectiveness (e.g., every 5 years). EPA may determine that the remedy must be modified to protect human health and the environment, not solely to attain a newly promulgated or modified federal or state requirement (55 *FR* 8758)

Should a new remedial action significantly change but not fundamentally alter the remedy selected in the ROD, ERPMs must:

- prepare an ESD that explains the nature of the changes, summarizes the information that leads to making the changes, and affirms that the revised remedy complies with the statutory requirements (e.g., ARARs identified in the ROD);
- make the ESD available in the administrative record and information repository; and
- publish a notice of availability and a brief description of the ESD in a local newspaper of general circulation.

If a new remedial action constitutes a fundamental change to the remedy selected in the ROD, ERPMs must propose an amendment to the ROD in accordance with the procedures specified in 40 CFR § 300.435(c)(2)(ii).[(1)]

With regard to RCRA corrective actions, new information may become available suggesting that modifications to the corrective measures are appropriate [e.g., corrective measure completion (CMC) criteria specified in the permit, order, or FFCA have been satisfied]. ERPMs may request that the corrective measures, which are prescribed in an issued/reissued permit, order, or FFCA, be modified in accordance with the regulations under 40 CFR § 270.42. Depending on the type and extent of modifications necessary, ERPM-initiated modifications must follow the procedures outlined for Class 1, 2, or 3 modifications [40 CFR § 270.42(a), (b) and (c), respectively]. Modifications should be classified according to the list of modifications found in Appendix I to 40 CFR § 270.42. For modifications that are not explicitly listed in Appendix I, ERPM modification requests should follow the guidelines in 40 CFR § 270.42(d).

6.9 Activities, Records, and Reports Related to RA/CMI

Upon successful completion of the remedial design, ERPMs will initiate RA/CMI.

Q. *What activities or records and reports documenting RA/CMI activities must be organized or prepared?*

A. Under CERCLA, RA activities include construction and implementation of the selected remedial action and must be in accordance with the final design of the selected remedy and the ROD [or other decision documents (e.g., IAG/FFA)] for that site. ERPMs will generally be required to prepare a comprehensive SOW. The purpose of the SOW is to set forth the framework and requirements for implementing the remedial action in accordance with the objectives of the remedial design. It provides a vehicle for telling the contractor what is needed and a structure for recording costs.

Based on the SOW, the RA contractor will then prepare and submit to the ERPM (and subsequently to EPA for concurrence) a RA Work Plan (which may be operable unit-specific). The RA Work Plan addresses the items in the ERPM's SOW, including any need to deviate from the SOW. It also includes a detailed technical approach for addressing:

- construction activities,
- operations and maintenance,
- performance monitoring,
- community relations, and
- an overall management strategy for the RA.

At CERCLA sites, progress toward site restoration typically includes several operable units or multiple phases of construction over a period of several years. ERPMs conducting CERCLA

remedial actions will complete a Remedial Action Report (RAR) to document the activities that occur under each specific operable unit remedial action at the site. This report provides documentation that a particular operable unit has met its remedial action objectives as well as summary information for subsequent inclusion in the site Close Out Report (COR).

The RAR should be prepared by someone familiar with both the design and construction efforts associated with the remedial action. While the ERPM may prepare the RAR, it is recommended that the contracting party prepare the report as part of the task assignment. Generally, the report must be completed within 60 days of:

- final inspection of the completed construction or
- the determination that the system is operational and functional (for systems requiring a shakedown period).

EPA recommends that the report be no longer than 20 pages, be signed and dated by the preparer, and be submitted to EPA for review, comment and concurrence. The RAR should be used as the basis for development of the site COR.[17]

Under RCRA, ERPMs may be required to prepare and submit a couple of reports. The first report—a Construction Completion Report (CCR)—may be required when the construction and any operations tests have been completed. The CCR documents how the completed project is consistent with the final plans and specifications.

ERPMs will prepare a CMC Report when they believe that the completion criteria that are established in the permit, order, or FFCA have been satisfied (i.e., the corrective measures have achieved the media cleanup standards). The CMC Report is used to document how the CMC criteria have been satisfied and to justify why the corrective measure and/or monitoring may cease. At a minimum, it includes:

- the purpose;
- a synopsis of the corrective measure;
- the CMC criteria (i.e., the process and criteria for determining when corrective measures, maintenance, and monitoring may cease);
- a demonstration that the criteria have been met (i.e., testing and/or monitoring results that indicate how corrective measures compare with the criteria);
- a summary of work accomplishments (e.g., performance levels achieved);
- a summary of significant activities that occurred during operations (including problems encountered and how they were addressed);
- a summary of inspection findings; and
- a summary of total O&M costs.[16]

Although no public participation activities are required during the RA, a variety of public participation activities may be conducted at the beginning, throughout, and at the completion of the RA phase. DOE-suggested additional activities include:

- fact sheets,
- public meetings,
- press releases,

- press conferences,
- telephone hotlines,
- site tours,
- briefings, and
- exhibits.[9]

Records and reports prepared and maintained during remedial action must be documented because they will be used to substantiate final certification of the completed remedial action. Under CERCLA, these include the following reports:

- Monthly Progress Reports including the following information:
  - an estimated percentage of project completeness,
  - work performed on-site,
  - community relation activities,
  - change orders, and
  - problems encountered;
- Prefinal Construction Conference covering:
  - final O&M submittal,
  - cleanup responsibilities,
  - demobilization activities,
  - security requirements,
  - prefinal inspection schedule,
  - facility startup and testing, and
  - operator training;
- Prefinal Inspection Report;
- Remedial Action Report (completed by the construction management contractor); and
- O&M Report, when appropriate.

Relative to RCRA, the implementation process consists of two phases—construction of the corrective measure and operation of the corrective measure. During the construction stage, EPA suggests that, depending on the level of citizen interest, public involvement activities could range from group meetings to fact sheets on the technical status of construction.[9] Additionally, ERPMs should document the findings of all oversight activities. Such reports are valuable for:

- developing periodic progress reports for the regulators,
- providing information on the effectiveness of the corrective measure relative to compliance with the terms of the permit, and
- substantiating any claims of "reasonable effort" if the facility requests a Determination of Technical Impracticability.

If an ERPM discovers that the selected remedial action/corrective measure is unable to achieve a performance standard (e.g., ARAR/MCS), the ERPM may request a TI determination. At CERCLA sites, TI decisions that occur after the ROD is signed are called postimplementation decisions. They require a notice of intent to waive an ARAR and information and analysis

supporting the request (e.g., remedy performance evaluation). Generally a ROD amendment must be placed in the site administrative record. At RCRA-permitted facilities, a TI determination generally will require a Class 3 permit modification. If the facility is operating under an order, TI determinations generally are implemented through the negotiation of a new order or an amendment to an existing order.[4]

During the course of the RA, ERPMs must also ensure that the selected CERCLA response action complies with the substantive requirements of other laws that are ARARs for that action. EPA recognizes, however, that ARARs that constitute final remediation levels apply only at completion of the action and need not be attained during implementation. If doubt arises about whether an ARAR represents a final remediation goal or an interim standard, and if it cannot be met during the RD/RA activity, ERPMs should consider pursuing an interim measure waiver (55 *FR* 8755). ERPMs overseeing RCRA corrective measure implementation must remain cognizant of, and ensure compliance with, legally applicable environment regulations and requirements.

6.10 Chapter Summary

The selection and documentation of a remedial action under CERCLA is a two-step process. At CERCLA sites ERPMs, in conjunction with support agencies, are responsible for identifying a preferred alternative based on their evaluation of the nine criteria and presenting this alternative to the public for review and comment in a proposed plan. Subsequently, ERPMs must review the comments and consult with the state (or support agency) to determine whether the alternative remains the most appropriate and document the final decision in the ROD. In some cases, the executed ROD may require modification to address the level of protectiveness afforded by the current standards.

Under RCRA, the ERPM decision-making role is substantially reduced. Specifically, ERPMs may recommend a preferred remedial alternative during the CMS. However, the regulators select the final corrective measure. Upon selection of a preferred alternative, the regulators identify their proposed decision in a draft permit/permit modification and publish a statement of basis (EPA) or a fact sheet (for authorized states). After the opportunity for public comment, the regulators will issue a permit, modify the permit, modify the order/FFCA to incorporate the components of the selected corrective measure (e.g., applicable MCS, a schedule of compliance, reporting requirements).

The purpose of the RD/RA stage under CERCLA and the CMI component of the RCRA corrective action program is to design, construct, operate, maintain, and monitor the performance of the selected remedial alternative/corrective measure. The adoption of design standards following signature of the ROD (i,.e., the RD stage under CERCLA) is analogous to the detailed construction plans and specifications for implementing the remedy under RCRA's proposed RD requirements.

6.11 Chapter References

1. EPA, 1989. *A Guide to Developing Superfund Proposed Plans,* OSWER Dir. 9355.3-02FS-2, Office of Emergency and Remedial Response, Washington, D.C.
2. EPA, 1989. *Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment,* OSWER Dir. 9355.3-02, Office of Emergency and Remedial Response, Washington, D.C.

3. EPA/DOE/DOD, 1994. *Guidance on Accelerating CERCLA Environmental Restoration at Federal Facilities*, Memorandum from S. A. Herman, Office of Enforcement and Compliance Assurance; E. P. Laws, Office of Solid Waste and Emergency Response; T. P. Grumbly, Assistant Secretary for Environmental Management, and S. W. Goodman, Deputy Under Secretary for Environmental Security to Addressees, Washington, D.C.

4. EPA, 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration Interim Final*, OSWER Dir. 9234.2-25, Office of Solid Waste and Emergency Response, Washington, D.C.

5. EPA, 1990. *Suggested ROD Language for Various Ground Water Remediation Options*, OSWER Dir. 9283.1-03, Office of Emergency and Remedial Response, Washington, D.C.

6. DOE, 1993, *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.

7. DOE, 1991. *The Information Repository*, Information Brief, DOE/EH-231-009/1291, Office of Environmental Guidance, Washington, D.C.

8 DOE, 1991. *The Administrative Record*, Information Brief, DOE/EH-231-010/1291, Office of Environmental Guidance, Washington, D.C.

9. DOE, 1990. *Public Participation in Environmental Restoration Activities*, DOE/EH-0221, Office of Environmental Guidance, Washington, D.C.

10. EPA, 1990. *A Guide to Developing Superfund Records of Decision*, OSWER Dir. 9355.3-02FS-1, Office of Emergency and Remedial Response, Washington, D.C.

11. DOE, 1994. *RCRA Corrective Action: Statement of Basis and Response to Comments Decision Documents*, Information Brief, EH-231-041/0794, Office of Environmental Guidance, Washington, D.C.

12. EPA, 1992. *Permits and Permit "Equivalency" Processes for CERCLA On-site Response Activities*, OSWER Dir. 9355.7-03, Office of Emergency and Remedial Response, Washington, D.C.

13. EPA, 1991. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives)*, Interim, OSWER Dir. 9285.7-01C, Office of Emergency and Remedial Response, Washington, D.C.

14. EPA, 1994. *Guidance on Scoping the Remedial Design*, OSWER Dir. 9355.0-43, Office of Solid Waste and Emergency Response, Washington, D.C.

15. EPA, 1990. *Guidance on Expediting Remedial Design and Remedial Action*, OSWER Dir. 9355.5-02, Office of Emergency and Remedial Response, Washington, D.C.

16. EPA, 1994. *RCRA Corrective Action Plan*, OSWER Dir. 9902.3-2A, Office of Waste Programs Enforcement, Washington, D.C.

17. EPA, 1992. *Remedial Action Report; Documentation for Operable Unit Completion*, OSWER Dir. 9355.0-39FS, Office of Emergency and Remedial Response, Washington, D.C.

7. Remedial Action Performance

Figure 7 provides a graphic representation of the process of determining the remedial alternatives/corrective measures performance and the organization of this chapter.

7.1 Timelines for Evaluation of CERCLA Remedy Performance

The performance of remedies for restoring ground water often can be evaluated only after the remedy has been implemented and monitored for a period of time.

Q. *What evaluation timelines must ERPMs observe?*

A. The suitability and performance of any completed or ongoing ground water remedial action should be evaluated with respect to the objectives of those actions (e.g., progress toward restoration, plume containment, attainment of cleanup levels).

Performance evaluations of the full-scale remedial actions are conducted periodically to compare actual performance to expected performance. The frequency of performance evaluations should be determined by site-specific conditions. These evaluations are based on the following types of monitoring system data:

- horizontal and vertical extent of the plume and contaminant concentration gradients,
- rate and direction of contaminant migration,
- changes in contaminant concentrations or distributions over time,
- effects of remedy modifications, and
- other environmental effects (e.g., saltwater intrusion, land subsidence, effects on wetlands).

To determine whether modification to the restoration action is necessary, performance evaluations should be conducted 1 or 2 years after the remedy is operational and functional. Operational and functional is said to be either 1 year after construction is complete or when the remedy is determined (by regulators) to be functioning properly, whichever is earlier (55 *FR* 8739).

Conducting performance evaluations and modifying remedial actions is part of a flexible approach to attaining RAOs. Monitoring data provide the basis for determining when remedial action objectives have been met and when the remedial action is complete. A determination that the remedial action is complete may require a statistical analysis of contaminant levels.

To assess attainment (i.e., determine whether RAOs have been attained), ERPMs typically need to terminate treatment and allow the ground water to reach steady state before collecting water samples. The decision to stop treatment is based on expert knowledge of the ground water system at the site, mathematical modeling of how treatment affects ground water flows and contamination levels, and statistical results from the monitoring wells from which levels of contamination can be modeled and extrapolated. It is desirable to begin collecting data to assess attainment as soon as the ERPM is confident that the ground water has reached a steady state.

Hazardous substances, pollutants, or contaminants that are identified in the ROD as contaminants of concern may remain on-site above levels that allow unlimited use or unlimited exposure [i.e., remedies that require engineering controls, impose access or land-use restriction controls, or attain protective levels for current uses (e.g., industrial use) but include restrictions on certain future uses (e.g., residential use)]. Additionally, some sites will require 5 or more

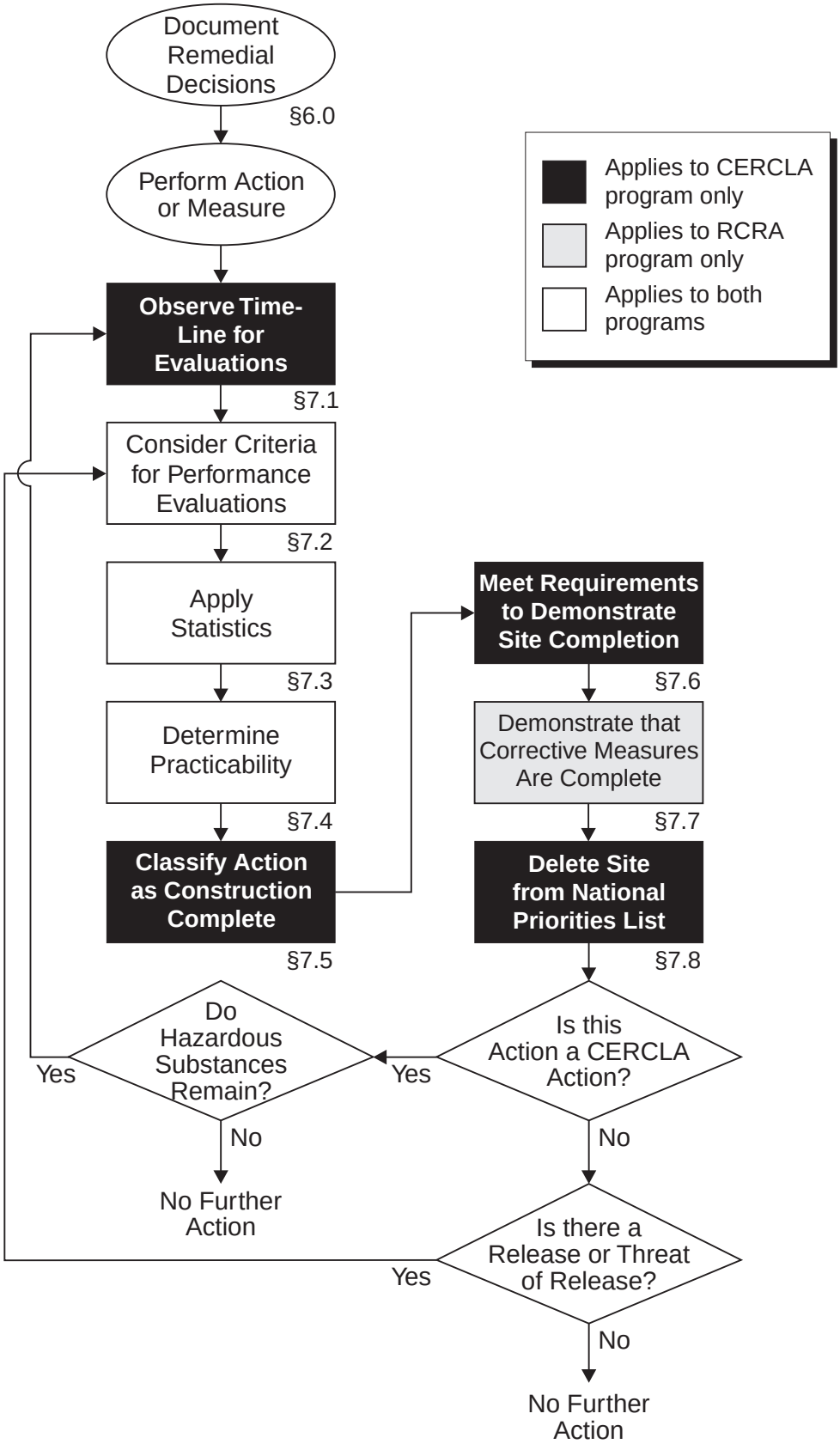

Figure 7. Remedial Alternatives/Corrective Measures performance.

years [e.g., long-term remedial actions (LTRA) before cleanup levels are attained. If this happens, ERPMs must conduct a more extensive performance evaluation at least every 5 years after the remedial action is initiated [40 CFR § 300.430(f)(4)(ii)]. Every 5 years would be from the date on which the first contract is awarded for work to install, construct, or implement an LTRA. The goals of 5-year reviews are:

- to confirm that the remedy (including engineering or institutional controls) remains operation and functional and
- to evaluate whether cleanup standards (based on risk or ARARs) are still protective.

The focus of the 5-year review will depend on the remediation objective of the response action. If protectiveness is being ensured through exposure protection (e.g., containment with a cap) and institutional controls (e.g., deed restrictions), the review should focus on whether the cap remains effective and the controls remain in place. For LTRA, the review should focus on both the effectiveness of the technology and on the specific performance levels established in the ROD.[1]

In cases where waste has been left on-site, the 5-year review procedures established in §121(c) of CERCLA (as amended) will continue to be appropriate regardless of the completion or deletion status of the site.[2] Also, EPA no longer prescribes that ERPMs complete at least one 5-year review before deletion from the NPL.[3]

7.2 Considerations During Performance Evaluations

Performance evaluations of pump-and-treat systems demand a monitoring strategy for ensuring that the sampling location and schedules are meaningful. These evaluation strategies serve not only as early-warning alarm systems but also help to measure progress toward remediation goals and identify whether adjustments are necessary to improve performance.

Q. *What are the primary components of performance evaluation strategies?*

A. Strategies for conducting performance evaluations must focus on the kinds of data that will be collected and how those data will be presented for interpretation and decision-making purposes. Data-gathering activities during remediation should be viewed as an extension of historical data gathering and site characterization. Controls on the form/quality of technical data obtained include:

- locations for plume monitoring,
- monitoring criteria (i.e., chemical, hydrodynamic, treatment efficiency, administrative control),
- strategies for monitoring locations and criteria,
- measures of operational effectiveness (extent and uniformity of cleansing),
- measures of operational efficiency (minimization of costs and duration), and
- strategies for determination of success (absolute or relative).[4]

Additional considerations during ground water performance evaluations include:

- sampling duration and frequency and
- source control monitoring.[5]

After evaluating whether remediation goals have been or will be attained in the designated time frame, ERPMs should consider the following options:

- discontinue operation,
- upgrade or replace the remedial action, or
- modify the RAOs and continue remediation.

7.3 Statistical Analysis for Determining Attainment of Cleanup Standards

ERPMs must decide when to terminate treatment (e.g., pump-and-treat operations) based on available data, advice from hydrogeologists, and the results of monitoring and modeling. Monitoring includes both the effluents from the treatment system, when applicable, and the ground water. Decision makers must use statistical procedures to determine if contaminant concentrations measured in the field (e.g., selected ground water wells) attain the established cleanup standard.

Q. *What are some of the procedures used to statistically compare cleanup standards with field data?*

A. Selected statistical procedures must be scientifically defensible and allow for an acceptable amount of uncertainty. The DQO process, which is initiated during scoping, is repeatedly applied throughout the remediation process. During performance evaluations, DQOs should be evaluated to determine whether the final remediation levels or removal action levels have been achieved (i.e., the cleanup attainment decision). ERPMs should select between the following actions based on the outcome of the cleanup attainment decision:

- recommend the Site Evaluation Accomplished response and proceed with delisting procedures or
- recommend that further response is appropriate for the site.[(6)]

When specifying how "attainment" is to be defined and deciding how statistical procedures may be used to substantiate the ERPM judgement that the response action has attained the cleanup standards, the following factors are all important:

- the location of the sampling wells and the associated relationship between concentrations in neighboring wells,
- the number of samples taken,
- the sampling procedures for selecting and obtaining water samples, and
- the data analysis procedures used to test for attainment.

When determining whether ground water contaminant concentration in the selected well is actually less than the cleanup standard and thus within acceptable limits (i.e., it attains the cleanup standard), ERPMs should initially assume that the water in the wells does not attain the cleanup standard. This assumption is known as the null hypothesis. Then data are collected. If data are sufficiently inconsistent with the null hypothesis, ERPMs may conclude that evidence exists to reject the null hypothesis and accept the alternate hypothesis that the contaminant concentrations attain the applicable cleanup standards. Otherwise, ERPMs must conclude that insufficient evidence is available to reject the null hypothesis and continue viewing the ground water as contaminated.[(7)]

The choice of the parameter to use when assessing attainment at CERCLA response action sites may depend on site-specific characteristics and decisions. It generally is not specified by the regulators. For CERCLA response action sites, detailed guidance has been published.[7] The document provides information on the selection of appropriate parameters and statistical procedures, statistical tables, and example and blank work sheets that can be used to determine if contaminant concentrations attain cleanup standards.

Under RCRA, no statistical methods are prescribed for the corrective action program. However, EPA has developed guidance for evaluating ground water monitoring data at RCRA facilities.[8] ERPMs should confer with the regulators early in the scoping phase (e.g., the DQO process) to establish statistical analytical methods that are appropriate for their site-specific conditions.

7.4 Technical Impracticability Determinations

During performance evaluations, ERPMs may realize that restoration of ground water to remediation goals/media cleanup standards is technically impracticable.

Q. *When is it appropriate to consider obtaining a technical impracticability ARAR waiver?*

A. Failure to attain cleanup levels at CERCLA/RCRA sites may result from the following:

- hydrogeologic constraints (e.g., complex fracturing in bedrock),
- contaminant-related constraints (e.g., nonrecoverable DNAPLs), or
- remediation system design inadequacies.[9]

EPA believes that, in many cases, TI decisions (under both CERCLA and RCRA) should be made only after interim or full-scale aquifer remediation systems are implemented. EPA will then base their determination on an evaluation of the following:

- engineering feasibility,
- reliability, and
- inordinate cost (CERCLA)/magnitude and complexity of the site (RCRA).

ERPMs preparing a TI evaluation should ensure the following components are included and are based on site-specific information and analyses:

- specific ARAR or MCS for which TI determinations are sought,
- the spatial area over which the TI decision will apply,
- a conceptual model that describes site conditions,
- an evaluation of the restoration potential of the site,
- estimates of cost of the existing remedy (for postimplementation decisions) or proposed remedy options (for front-end decisions), and
- any additional information or analyses EPA deems necessary.[9]

Where TI decisions are postimplementation and a waiver is invoked, EPA expects protectiveness to be maintained through alternative remedial strategies. EPA’s expectations in such cases (i.e., when restoration is not possible) are:

- to prevent further migration of the plume [i.e., control the source of contamination using a physical barrier system (slurry wall) or a hydraulic containment system (typically pump-and-treat)],
- to prevent exposure (e.g., employ institutional controls such as restrictions on water-supply well construction and use), and
- to evaluate further risk reduction measures [40 CFR § 300.430(a)(1)(iii)(F)].

Under CERCLA, when a TI determination is made prior to remedy selection (known as a front-end decision), notice of intent to waive the ARAR must be provided in the Proposed Plan. The TI decision and response to stakeholder comments must be incorporated into the ROD. TI decisions at RCRA facilities require a Class 3 permit modification or negotiation of a new order/FFCA or amendment to an order/FFCA. An alternate remedial strategy implemented under a CERCLA TI waiver remains in effect as long as the strategy remains protective. RCRA TI decisions will be incorporated into conditions of the permit or enforcement order and, as such, are subject to continual oversight, review, and modification, as necessary. Regardless of the program, protectiveness must be ensured through a monitoring program designed to detect and indicate failure of one of the remedy components (e.g., releases from the containment areas).[9]

Occasionally, system-related constraints (e.g., design inadequacies, poor system operation, unsuitability of the technology for site conditions) may result in considerable lack of progress in attaining cleanup levels. Such constraints are *not* sufficient grounds for determining that ground water restoration is technically impracticable. EPA generally will require that the existing remedy be enhanced, augmented, or replaced. Further, ERPMs may consider the technical feasibility and potential advantages of attaining cleanup levels for *some* of the contaminants present (e.g., restore chromium contaminant concentrations to the prescribed cleanup levels, although DNAPL concentrations will remain above the cleanup levels).[9]

7.5 Classification of Action as Construction Complete

On March 2, 1993 (58 *FR* 12142), EPA introduced a new list of sites entitled the Superfund Construction Completion List (CCL). The CCL is a compilation of sites presently or formerly on the NPL. Sites can qualify for the CCL based on certain criteria.

Q. *What are these criteria and what steps must be completed by ERPMs before regulators will report construction completion?*

A. The intent of the CCL is to better communicate CERCLA progress to the public. The CCL is comprised of NPL sites meeting any of the following criteria:

- the necessary physical construction is complete (regardless of whether the site has achieved final remediation goals), and only minor punch list items or administrative requirements remain to be fulfilled (e.g., at aquifer restoration sites when installation of the treatment facility and extraction wells are completed, operating as designed, and studies show that the technology will achieve cleanup goals); or
- no action/no further action is needed on RODs; or
- the site has been deleted or qualifies for deletion from the NPL, and no physical construction remains to be conducted under another statutory authority.

In addition to meeting one of the three criteria, each site on the CCL must have one of the following documents:

- a Preliminary COR, prepared by the lead agency (DOE) documenting that construction is complete and containing a schedule for ERPMs to satisfy the NCP and other procedural requirements necessary to issue a Final COR;[7]
- a Final COR, containing the overall technical justification for NPL site deletion (see following section for the specific content of the Final COR) or consisting of an existing Interim COR that is amended when remediation goals are achieved for the facility's final LTRA operable unit;
- a ROD requiring no further construction (e.g., expedited response actions/emergency removal actions were performed and no additional cleanup activities are required, or RODs requiring only monitoring or institutional controls) or with a certification of completion; or
- documentation showing deletion from the NPL and indicating that no physical construction remains to be conducted under another authority.

For construction completion sites with No-Action RODs and where ERPMs have not taken a remedial action (removal actions may have occurred), the following certification should be included in the declaration portion of the ROD:

> EPA has determined that its response at this site is complete. Therefore, the site now qualifies for inclusion on the Construction Completion List.

With this certification included in the ROD, a separate COR does not need to be prepared for the site.

For sites with No-Action RODs and where ERPMs have taken previous remedial action, triggering certain statutory requirements, ERPMs may either:

- prepare a final COR or
- document in the ROD the information normally in the COR, including compliance with statutory requirements and the previously discussed certification.[10]

To be considered for the CCL, ERPMs must ensure that the following steps are satisfactorily completed:

- Conduct a prefinal inspection to determine whether the contractor has completed construction of the selected remedy in accordance with design specifications and prepare a letter that (1) asserts that physical construction is complete and (2) identifies a punch list of minor items (e.g., installation of "well protectors" with locking caps, revegetation of construction area) to be corrected.
- Prepare a Preliminary COR that provides the background information on the site, the response action, the completion of construction, activities remaining before site completion, and the schedule for these activities.

Some DOE sites may have previously satisfied the NCP and final site completion requirements (identified in the following Guide question). ERPMs should then proceed directly to preparing a Final COR.[11] Routine adjustments and modifications to a construction remedy (e.g., drilling of additional extraction wells, modifications to unit processes at ground water treatment plants) do not affect a site's status on the CCL (58 *FR* 12142).

7.6 Requirements To Demonstrate Site Completion

Upon a satisfactory demonstration that all appropriate CERCLA response actions have been implemented, EPA will consider an NPL site completed.

Q. *What requirements must ERPMs satisfy to qualify for site completion?*

A. When all requirements are satisfied and are demonstrated to regulator satisfaction in a Final COR, an NPL site will be classified as a completion. These requirements include the following:

- All cleanup levels (including LTRA remediation goals) identified in the ROD have been achieved, and cleanup actions have been successfully implemented.
- The site does not pose a threat to human health and the environment across all exposure pathways.
- Only O&M activities (including source control measures) remain to be performed.

ERPMs will prepare a COR that provides a brief technical demonstration of how the implemented remedy satisfies the completion requirements. The COR represents the overall technical justification for site completion and should address the following components:

- summary of site conditions,
- demonstration of QA/QC for cleanup activities,
- monitoring results,
- summary of operation and maintenance,
- protectiveness,
- 5-year review,[12]
- community relations, and
- bibliography.

CORs should not exceed 10-15 pages in length and should summarize only the information listed above to the degree necessary to inform the reader of the activities and the results of those achieved. Detailed technical information and data should be referenced to keep the report brief.[2]

7.7 Completion of Corrective Measures

Under RCRA, ERPMs propose target cleanup standards and points of compliance as elements of the CMS Work Plan. However, final MCSs are determined by the regulators when the final remedy is selected. Selected MCSs are documented in the SB, response to comments, or permit modification. Certain criteria must be met before the corrective measure may be viewed as complete.

Q. *What criteria must be met to demonstrate completion of the corrective measure and/or monitoring?*

A. As an element of CMI, ERPMs generally prepare a draft O&M Plan that includes corrective measure completion criteria. These criteria describe the process and criteria (e.g., groundwater cleanup goals met at all compliance points for 1 year) for determining when corrective measures have achieved media cleanup goals. Criteria also describe the process and criteria for determining when maintenance and monitoring may cease.[13]

Under the proposed Subpart S rule, EPA establishes three criteria that must be met before the corrective measure is viewed as complete. These include:

- compliance with all media cleanup standards,
- completion of all source control measures specified in the permit, and
- demobilization (i.e., removal or decontamination) of all units, equipment, devices, or structures required to implement the corrective measure.

ERPMs should seek an official statement from the regulators that the requirements for demonstrating compliance specified in the facility permit, order, or FFCA have been met before engaging in demobilization.[14]

When ERPMs believe that the corrective measure completion criteria have been satisfied, they may prepare and submit a CMC Report to the regulators. The purpose of the CMC Report is to fully document how the criteria have been satisfied and to justify why the corrective measure and/or monitoring may cease. Under the proposed Subpart S rule, ERPMs will need to have this report reviewed and certified by an independent professional engineer with the appropriate technical expertise.[13]

EPA will review the evidence supporting the ERPM's claim of completion. EPA will determine if all RCRA corrective action requirements are completed at all units at the facility. Generally, completion of RCRA corrective action occurs only on completion of all corrective actions at the facility. [When a corrective measure is completed at a unit widely separated from and affecting different media than the other units at the site, ERPMs may request a partial release from the corrective action program.[14]

If the regulators determine that all requirements of the facility permit have been met, then the request is processed as a Class 3 owner/operated-requested permit modification. Once the final permit modification releasing the facility from corrective action is issued, ERPMs may continue normal operations.

7.8 NPL Deletion Process

The NPL deletion process may begin upon approval of the COR by the RA, regardless of whether the regulators have performed at least one 5-year review (56 *FR* 66601).

Q. *What steps occur during the deletion process?*

A. The following bullets illustrate the steps that comprise the NPL site deletion process (unless otherwise noted below, "EPA" refers to EPA regional personnel):

- ERPMs submit a COR and receive Regional Administrator approval.
- EPA receives the state's letter of concurrence.
- EPA prepares a Notice of Intent to Delete and compiles the deletion docket material (e.g., RI/FS Report, ROD, Initial 5-Year Review Report).
- EPA establishes a deletion docket in a regional public library and local repository. (The deletion docket is *not* a continuation of the administrative record; however, documents that are contained in the administrative record can be referenced, provided the administrative record is still available to the public.)
- EPA publishes a National Notice of Intent to Delete in the *Federal Register*, as well as publishes the Notice of Intent to Delete in a local newspaper.

- EPA allows interested parties a 30-day comment period.
- ERPMs prepare a responsiveness summary, which contains detailed responses to local/national comments, and place it in the docket and local repository.
- EPA publishes a Final Notice of Intent to Delete in the *Federal Register*.[2]

No site may be deleted from the NPL without state concurrence.

7.9 Chapter Summary

The suitability and performance of any completed or ongoing ground water remedial action should be evaluated with respect to the objectives of those actions (e.g., progress toward restoration, plume containment, attainment of cleanup levels). The timing of a system's performance evaluation is based on site-specific factors. EPA recognizes that performance of remedies for restoring ground water can often only be evaluated after the remedy has been implemented and monitored for a period of time.

Following implementation of the selected remedial action/corrective measure, ERPMs will need to determine:

- whether the existing remedy is being effectively operated and adequately maintained,
- whether it appears technically practicable from an engineering perspective to attain cleanup levels, and
- whether ground water remediation has achieved the pre-established cleanup standards for one or more of the contaminants.

To accomplish these determinations, data is collected and statistically compared with the cleanup levels to ascertain whether contaminant concentrations measured in selected ground water monitoring wells attain (i.e., are less than) or will attain the cleanup levels in the desired time frame. ERPMs may need to evaluate the site's hydrogeological factors and contaminant-related factors periodically, as well as the selected system's design parameters (e.g., pumping rate, location of extraction wells), to determine whether it is necessary to discontinue, upgrade or replace, or modify the RAOs and continue remediation.

Occasionally, achieving the final cleanup levels (e.g., ARAR such as an MCL) may not be practicable from and engineering perspective. In these cases, ERPMs should consider the appropriateness of obtaining a TI determination from the regulators and waiving the ARAR. A TI decision must be incorporated into the site decision document or be incorporated into a modification or amendment to an original document. Any information supporting the TI decision must be incorporated into the site administrative record. Under CERCLA, when TI determinations (or the selected remedial action) result in hazardous substances, pollutants, or contaminants remaining present for 5 or more years at levels that limit use or restrict exposure, ERPMs may be required to perform 5-year reviews. The 5-year review evaluates protectiveness and, for LTRAs, the technology effectiveness and specific performance levels.

Under CERCLA, as remediation progresses, sites may be viewed as construction complete [i.e., the necessary physical construction is complete but some activities (e.g., completion of the "shakedown/warranty" phase) remain]. Site completion (i.e., completion of all nonoperation and maintenance activities) is the next step toward site deletion from the NPL. Many of these steps require associated documentation (Remedial Action Report, Close Out Report, Notice of Intent to Delete) that support the ERPM's claim and allow for stakeholder involvement. Remedial action at a site culminates when all appropriate response actions have been implemented,

stakeholders recognize that no further response is appropriate, and the site is deleted from the NPL.

Under RCRA, when ERPMs believe that the corrective measure completion criteria have been satisfied, they may prepare and submit a CMC Report to the regulators. The regulators will review the evidence supporting the ERPM's claim of completion. If they determine that all RCRA corrective action requirements are completed, then the request is processed as a Class 3 owner/operator-requested permit modification. Once the final permit modification releasing the facility from corrective action is issued, ERPMs may continue normal operations.

7.10 Chapter References

1. EPA, 1991. *Structure and Components of Five-Year Reviews*, OSWER Dir. 9355.7-02, Office of Emergency and Remedial Response, Washington, D.C.
2. EPA, 1989. *Procedures for Completion and Deletion of National Priorities List Sites*, OSWER Dir. 9320.2-3A, Office of Emergency and Remedial Response, Washington, D.C.
3. DOE, 1993. *Site Deletion from the National Priorities List*, Information Brief, EH-231-021/1193, Office of Environmental Guidance, Washington, D.C.
4. EPA, 1992. *General Methods for Remedial Operations Performance Evaluations*, EPA/600/R-92/002, Office of Research and Development, Washington, D.C.
5. EPA, 1988. *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, OSWER Dir. 9283.1-2, Office of Emergency and Remedial Response, Washington, D.C.
6. EPA, 1993. *Data Quality Objectives Process for Superfund; Interim Final Guidance*, OSWER Dir. 9355.9-01, Office of Emergency and Remedial Response, Washington, D.C.
7. EPA, 1992. *Methods for Evaluating the Attainment of Cleanup Standards*, EPA/230-R-92-014, Office of Policy, Planning, and Evaluation, Washington, D.C.
8. EPA, 1989. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities; Interim Final Guidance*, EPA/530-SW-89-026, Office of Solid Waste, Washington, D.C.
9. EPA, 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration Interim Final*, OSWER Dir. 9234.2-25, Office of Solid Waste and Emergency Response, Washington, D.C.
10. EPA, 1993. *Documentation of Close Out requirements at Site Where There is a No Action Record of Decision*, Memorandum from J. Clifford, Hazardous Site Control Division to Superfund Regional Branch Chiefs, Office of Emergency and Remedial Response, Washington, D.C.
11. EPA, 1992. *Update No. 2 to "Procedures for Completion and Deletion of NPL Sites,"* OSWER Dir. 9320.2-3C, Office of Emergency and Remedial Response, Washington, D.C.
12. EPA, 1989. *Update to the "Procedures for Completion and Deletion of National Priorities List Sites" Guidance Document Regarding the Performance of Five-Year Reviews (Superfund Management Review: Recommendation No. 2)*, OSWER Dir. 9320.2-03B, Office of Emergency and Remedial Response, Washington, D.C.
13. EPA, 1994. *RCRA Corrective Action Plan*, OSWER Dir. 9902.3-2A, Office of Waste Programs Enforcement, Washington, D.C.

14. DOE, 1993. *RCRA Corrective Action Program Guide (Interim)*, DOE/EH-0323, Office of Environmental Guidance, Washington, D.C.

8. Additional Resources

8.1 DOE Guidance Documents

1. DOE, 1993. *CERCLA Reporting Requirements, DOE Occurrence Reporting, and the DOE Emergency Management System*, Information Brief, EH-231-019/1093, Office of Environmental Guidance, Washington, D.C.
2. DOE, 1991. *Complying with Land Disposal Restrictions (LDR) for CERCLA Remedial Actions Involving Contaminated Soil and Debris*, Information Brief, EH-231-002/0191, Office of Environmental Guidance, Washington, D.C.
3. DOE, 1993. *Corrective Action Management Units and Temporary Units*, Information Brief, EH-231-043/0394, Office of Environmental Guidance, Washington, D.C.
4. DOE, 1993. *Delay of Closure for RCRA Hazardous Waste Management Facilities*, Information Brief, EH-231-021/0993, Office of Environmental Guidance, Washington, D.C.
5. DOE, 1994. *EPA Guidance on Risk Characterization for Risk Manager and Risk Assessors*, Information Brief, EH-232-0008/08/94, Office of Environmental Guidance, Washington, D.C.
6. DOE, 1993. *Executive Order 12580: Superfund Implementation*, Information Brief, EH-231-015/0593, Office of Environmental Guidance, Washington, D.C.
7. DOE, 1994. *Exposure Assessment Guidelines*, Information Brief, EH-232-0009/08/94, Office of Environmental Guidance, Washington, D.C.
8. DOE, 1993. *Ground-Water Monitoring Under RCRA*, Information Brief, EH-231-039/1193, Office of Environmental Guidance, Washington, D.C.
9. DOE, 1994. *Hazardous Waste Generator Requirements*, Information Brief, EH-231-055/1194, Office of Environmental Guidance, Washington, D.C.
10. DOE, 1993. *Inspections of RCRA Container Storage Area*, Information Briefs, EH-231-033/0793 and /0893, Office of Environmental Guidance, Washington, D.C.
11. DOE, 1993. *Location Standards for RCRA Treatment, Storage, and Disposal Facilities (TSDFs)*, Information Brief, EH-231-040/1093, Office of Environmental Guidance, Washington, D.C.
12. DOE, 1994. *The Off-Site Rule*, Information Brief, EH-231-020/0394, Office of Environmental Guidance, Washington, D.C.
13. DOE, 1993. *Preliminary Assessments (PAs) Under CERCLA*, Information Brief, EH-231-016/0593, Office of Environmental Guidance, Washington, D.C.
14. DOE, 1993. *RCRA and CERCLA Requirements Associated with the Sale or Transfer of DOE Property*, Information Brief, EH-231-022/1193, Office of Environmental Guidance, Washington, D.C.
15. DOE, 1995. *RCRA Corrective Action and Closure*, Information Brief, EH-231-051/0295, Office of Environmental Guidance, Washington, D.C.
16. DOE, 1994. *RCRA Corrective Action Corrective Measures Study*, Information Brief, EH-231-047/1194, Office of Environmental Guidance, Washington, D.C.
17. DOE, 1993. *RCRA Corrective Action Definitions Under Subpart F and Proposed Subpart S*, Information Brief, EH-231-044/0393, Office of Environmental Guidance, Washington, D.C.

18. DOE, 1993. *RCRA Corrective Action Interim Measures Under the Proposed Subpart S Rule*, Information Brief, EH-231-024/0793, Office of Environmental Guidance, Washington, D.C.

19. DOE, 1994. *RCRA Corrective Action Management Units and Temporary Units*, Information Brief, EH-231-043/0394, Office of Environmental Guidance, Washington, D.C.

20. DOE, 1995. *RCRA Corrective Action Notification Requirements*, Information Brief, EH-231-049/0295, Office of Environmental Guidance, Washington, D.C.

21. DOE, 1993. *RCRA Corrective Action Permit Requirements and Modifications Under Subpart F Regulations*, Information Brief, EH-231-022/0793, Office of Environmental Guidance, Washington, D.C.

22. DOE, 1993. *RCRA Corrective Action Permit Requirements and Modifications Under Proposed Subpart S Rule*, Information Brief, EH-231-023/0793, Office of Environmental Guidance, Washington, D.C.

23. DOE, 1993. *RCRA Corrective Action Variances from Subpart F Requirements*, Information Brief, EH-231-025/0793, Office of Environmental Guidance, Washington, D.C.

24. DOE, 1995. *RCRA Corrective Action Work Plans*, Information Brief, EH-231-030/0295, Office of Environmental Guidance, Washington, D.C.

25. DOE, 1994. *RCRA Facility Investigation*, Information Brief, EH-231-046/1194, Office of Environmental Guidance, Washington, D.C.

26. DOE, 1995. *RCRA Facility Stabilization Initiative*, Information Brief, EH-231-016/0295, Office of Environmental Guidance, Washington, D.C.

27. DOE, 1993. *RCRA Hazardous Waste Container Labeling, Marking, and Placarding Requirements*, Information Brief, EH-231-031/0793, Office of Environmental Guidance, Washington, D.C.

28. DOE, 1993. *Requirements for Satellite Accumulation Areas*, Information Brief, EH-231-026/0593, Office of Environmental Guidance, Washington, D.C.

29. DOE, 1993. *Site Inspections (SIs) Under CERCLA*, Information Brief, EH-231-013/0693, Office of Environmental Guidance, Washington, D.C.

30. DOE, 1994. *Streamlined Site Characterization Approach for Early Actions: Impact on Risk Assessment Data Requirements*, Information Brief, EH-231-025/1294, Office of Environmental Guidance, Washington, D.C.

31. DOE, 1989. *Comprehensive Environmental Response, Compensation, and Liability Act Requirements*, Order 5400.4, U.S. Department of Energy, Washington, D.C.

32. DOE, 1988. *General Environmental Protection Program*, DOE Order 5400.1, U.S. Office of Environment, Safety, and Health, Washington, D.C.

33. DOE, 1987. *Groundwater Contamination at Department of Energy Facilities*, Office of Environmental Guidance and Compliance, Washington, D.C.

34. DOE, 1991. *Guidance on Implementation of the DOE NEPA/CERCLA Integration Policy*, Office of Environment, Washington, D.C.

35. DOE, 1994. *A Guide to CERCLA Site Assessment*, DOE/EH-0366, Office of Environmental Guidance, Washington, D.C.

36. DOE, 1994. *RCRA Corrective Action & CERCLA Remedial Action Reference Guide*, DOE/EH-0001, Office of Environmental Guidance, Washington, D.C.

37. DOE, 1993. *Corrective Action Management Units and Temporary Units: CAMU/TU Final Rule Issued*, Environmental Guidance Regulatory Bulletin, Office of Environmental Guidance, Washington, D.C.

38. DOE, 1990. *Guidance on Closure of Hazardous and Mixed Waste Management Units at DOE Facilities*, DOE/EGD (RCRA)-002/0690, Office of Environmental Guidance, Washington, D.C.

39. DOE, 1993. *Land Disposal Restrictions (LDR) Program Overview*, DOE/EH-231/005/0293, Office of Environmental Guidance, Washington, D.C.

40. DOE, 1993. *Management of Hazardous Waste Containers & Container Storage Areas Under RCRA*, DOE/EH-0333, Office of Environmental Guidance, Washington, D.C.

41. DOE, 1993. *Management of Polychlorinated Biphenyls (PCBs)*, DOE/EH-0350, Office of Environmental Guidance, Washington, D.C.

42. DOE, 1993. *Superfund Reform: EPA 30-Day Study and DOE Environmental Restoration Implications*, DOE/EH-0303, Office of Environmental Guidance, Washington, D.C.

43. DOE, 1994. "Disposal Requirements for PCB Waste," Information Brief, EH-231-056/1294, Office of Environmental Guidance, Washington, D.C.

44. DOE, 1994. "The PCB Mark," Information Brief, EH-231-057/1294, Office of Environmental Guidance, Washington, D.C.

45. DOE, 1994. "PCB Recordkeeping and Reporting," Information Brief, EH-231-058/1294, Office of Environmental Guidance, Washington, D.C.

46. DOE, 1994. "PCB Spill Response and Notification Requirements," Information Brief, EH-231-059/1294, Office of Environmental Guidance, Washington, D.C.

47. DOE, 1994. "PCB Storage Requirements," Information Brief, EH-231-060/1294, Office of Environmental Guidance, Washington, D.C.

48. DOE, 1994. *A Comparison of the RCRA Corrective Action and CERCLA Remedial Action Processes*, DOE/EH-0365, Office of Environmental Guidance, Washington, D.C.

49. DOE, 1994. "Federal Facility Compliance Act Implications for RCRA Corrective Action," Information Brief, EH-231-015/0994, Office of Environmental Guidance, Washington, D.C.

50. DOE, 1995. "Management of Corrective Action Wastes Pursuant to Proposed Subpart S," Information Brief, EH-231-029/0295, Office of Environmental Guidance, Washington, D.C.

51. DOE, 1995. "RCRA Corrective Action Levels and Media Cleanup Standards," Information Brief, EH-231-050/0295, Office of Environmental Guidance, Washington, D.C.

52. DOE, 1995. "National Oil and Hazardous Substances Pollution Contingency Plan: Revised Rule Issued; Effective Date: October 17, 1994," Office of Environmental Policy and Assistance, Washington, D.C.

8.2 Applicable or Relevant and Appropriate Requirements

53. EPA, 1989. *Applicability of Land Disposal Restrictions to RCRA and CERCLA Ground Water Treatment Reinjection Superfund Management Review: Recommendation No. 26*, OSWER Dir. 9234.1-06, Office of Solid Waste and Emergency Response, Washington, D.C.

54. EPA, 1990. *ARARs Q's and A's: Compliance with Toxicity Characteristics Rule, Part I*, OSWER Dir. 9234.2-08/FS, Office of Emergency and Remedial Response, Washington, D.C.

55. EPA, 1991. *ARARs Q's and A's: General Policy, RCRA, CWA, SDWA, Post-ROD Information, and Contingent Waivers*, OSWER Dir. 9234.2-01/FS-A, Office of Emergency and Remedial Response, Washington, D.C.

56. EPA, 1990. *ARARs Q's and A's: State Ground-Water Antidegradation*, OSWER Dir. 9234.2-11/FS, Office of Emergency and Remedial Response, Washington, D.C.

57. EPA, 1989. *CERCLA Compliance with Other Laws Manual, CERCLA Compliance with State Requirements*, OSWER Dir. 9234.2-05/FS, Office of Emergency and Remedial Response, Washington, D.C.

58. EPA, 1989. *CERCLA Compliance with Other Laws Manual: Guide to Manual*, OSWER Dir. 9234.2-02/FS, Office of Emergency and Remedial Response, Washington, D.C.

59. EPA, 1988. *CERCLA Compliance with Other Laws (Interim Final)*, OSWER Dir. 9234.2-01, Office of Emergency and Remedial Response, Washington, D.C.

60. EPA, 1989. *CERCLA Compliance with Other Laws Manual, Part II: Clean Air Act and Other Environmental Statutes and State Requirements*, OSWER Dir. 9234.1-02, Office of Emergency and Remedial Response, Washington, D.C.

61. EPA, 1990. *CERCLA Compliance with Other Laws Manual, Summary of Part II CAA, TSCA, and Other Statutes*, OSWER Dir. 9234.2-07/FS, Office of Emergency and Remedial Response, Washington, D.C.

62. EPA, 1990. *CERCLA Compliance with the RCRA Toxicity Characteristics (TC) Rule: Part II Toxicity Characteristic*, OSWER Dir. 9347.3-11FS, Office of Emergency and Remedial Response, Washington, D.C.

63. EPA, 1986. *Consideration of RCRA Requirements in Performing CERCLA Responses at Mining Waste Sites*, OSWER Dir. 9234.0-4, Office of Emergency and Remedial Response, Washington, D.C.

64. EPA, 1989. *Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites*, OSWER Dir. 9355.0-28, Office of Emergency and Remedial Response, Washington, D.C.

65. EPA, 1986. *Discharge of Wastewater from CERCLA Sites into POTWs*, OSWER Dir. 9330.2-4, Office of Emergency and Remedial Response, Washington, D.C.

66. EPA, 1990. *A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses*, OSWER Dir. 9347.3-09/FS, Office of Emergency and Remedial Response, Washington, D.C.

67. EPA, 1990. *A Guide to Selecting Superfund Remedial Actions*, OSWER Dir. 9355.0-27FS, Office of Emergency and Remedial Response, Washington, D.C.

68. EPA, 1989. *Land Disposal Restrictions as Relevant and Appropriate Requirements for CERCLA Contaminated Soil and Debris*, OSWER Dir. 9347.2-01, Office of Emergency and Remedial Response, Washington, D.C.

69. EPA, 1992. *Assessing Sites under SACM—Interim Guidance*, Vol. 1, No. 4, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

70. EPA, 1989. *CERCLA Compliance with Other Laws Manual,Overview of ARARs: Focus on ARAR Waivers,* OSWER Dir. 9234.2-03/FS, Office of Emergency and Remedial Response, Washington, D.C.

71. EPA, 1989. *Policy for Superfund Compliance with the RCRA Land Disposal Restrictions*, OSWER Dir. 9347.1-02, Office of Emergency and Remedial Response, Washington, D.C.

72. EPA, 1989. *CERCLA Compliance with Other Laws Manual, RCRA ARARs: Focus on Closure Requirements*, OSWER Dir. 9234.2-04/FS, Office of Emergency and Remedial Response, Washington, D.C.

73. EPA, 1989. *Superfund Land Disposal Restriction Guide #5, Determining When Land Disposal Restrictions (LDRs) are Applicable to CERCLA Response Actions*, OSWER Dir. 9347.3-05/FS, Office of Emergency and Remedial Response, Washington, D.C.

74. EPA, 1994. *DNAPL Site Characterization*, OSWER Dir. 9355.4-16FS, Office of Emergency and Remedial Response, Washington, D.C.

75. EPA, 1992. *Early Action and Long-Term Action under SACM—Interim Guidance*, Vol. 1, No. 2, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

76. EPA, 1989. *Superfund Land Disposal Restriction Guide #7, Determining When Land Disposal Restrictions (LDRs) are Relevant and Appropriate to CERCLA Response Actions*, OSWER Dir. 9347.3-08/FS, Office of Emergency and Remedial Response, Washington, D.C.

77. EPA, 1991. *Superfund Removal Procedures—Guidance on the Consideration of ARARs During Removal Actions*, OSWER Dir. 9360.3-02, Office of Emergency and Remedial Response, Washington, D.C.

8.3 EPA Policy Interpretations

78. EPA, 1989. *Advancing the Use of Treatment Technologies for Superfund Remedies*, OSWER Dir. 9355.0-26, Office of Emergency and Remedial Response, Washington, D.C.

79. EPA, 1992. *Assessing Sites under SACM—Interim Guidance*, Vol. 1, No. 4, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

80. EPA, 1988. *Community Relations in Superfund; A Handbook*, OSWER Dir. 9230.0-3B, Office of Emergency and Remedial Response, Washington, D.C.

81. EPA, 1989. *Consideration in Ground Water Remediation at Superfund Sites*, OSWER Dir. 9355.4-03, Office of Emergency and Remedial Response, Washington, D.C.

82. EPA, 1989. *Correction Action: Technologies and Applications: Seminar Publication*, EPA/625/4-89/020, Center for Environmental Research Information, Cincinnati, Ohio.

83. EPA, 1993. *Determination of Imminent and Substantial Endangerment for Removal Actions*, OSWER Dir. 9360.0-34, Office of Emergency and Remedial Response, Washington, D.C.

84. EPA, 1994. *DNAPL Site Characterization*, OSWER Dir. 9355.4-16FS, Office of Emergency and Remedial Response, Washington, D.C.

85. EPA, 1992. *Early Action and Long-Term Action under SACM—Interim Guidance*, Vol. 1, No. 2, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

86. EPA, 1992. *Enforcement Under SACM—Interim Guidance*, Vol. 1, No. 3, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

87. EPA, 1987. *Environmental Review Requirements for Removal Actions*, OSWER Dir. 9318.0-05, Office of Emergency and Remedial Response, Washington, D.C.

88. EPA, 1988. *Guidance Document for Providing Alternate Water Supplies*, OSWER Dir. 9355.3-03, Office of Emergency and Remedial Response, Washington, D.C.

89. EPA, 1990. *Guidance on EPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties*, OSWER Dir. 9355.5-01, Office of Emergency and Remedial Response, Washington, D.C.

90. EPA, 1989. *Guidance on Non-NPL Removal Actions Involving Nationally Significant or Precedent-Setting Issues*, OSWER Dir. 9360.0-19, Office of Emergency and Remedial Response, Washington, D.C.

91. EPA, 1992. *Guidance on Setting Priorities for NPL Candidate Sites*, OSWER Dir. 9203.1-06, Office of Emergency and Remedial Response, Washington, D.C.

92. EPA, 1989. *Indian Tribal Involvement in the Superfund Program*, OSWER Dir. 9365.5-02/FS, Office of Emergency and Remedial Response, Washington, D.C.

93. EPA, 1993. *Integrating Removal and Remedial Site Assessment Investigations*, OSWER Dir. 9345.1-16FS, Office of Emergency and Remedial Response, Washington, D.C.

94. EPA, 1990. *Interim Guidance on Addressing Immediate Threats at NPL Sites (Superfund Management Review: Recommendation No. 22)*, OSWER Dir. 9200.2-03, Office of Emergency and Remedial Response, Washington, D.C.

95. EPA, 1986. *Interim RCRA/CERCLA Guidance on Non-Contiguous Sites and On-Site Management of Waste and Treatment Residue*, OSWER Dir. 9347.0-1, Office of Emergency and Remedial Response, Washington, D.C.

96. EPA, 1993. *NPL Construction Completion Definition at Bioremediation and Soil Vapor Extraction Sites*, OSWER Dir. 9320.2-06, Office of Emergency and Remedial Response, Washington, D.C.

97. EPA, 1991. *Pesticides and Ground-Water Strategy*, 21T-1022, Office of Pesticides and Toxic Substances, Washington, D.C.

98. EPA, 1985. *Policy on Floodplains and Wetland Assessments for CERCLA Actions*, Memorandum dated August 6, 1985, Office of Emergency and Remedial Response/Office of Waste Programs Enforcement, Washington, D.C.

99. EPA, 1993. *Presumptive Remedies: Site Characterization and Technology Selection For CERCLA Sites With Volatile Organic Compounds in Soils*, OSWER Dir. 9355.0-48FS, Office of Emergency and Remedial Response, Washington, D.C.

100. EPA, 1993. *Presumptive Remedy for CERCLA Municipal Landfill Sites*, OSWER Dir. 9355.0-49FS, Office of Emergency and Remedial Response, Washington, D.C.

101. EPA, 1994. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*, OSWER Dir. 9355.4-12, Office of Solid Waste and Emergency Response, Washington, D.C.

102. EPA, 1992. *SACM Regional Decision Teams-Interim Guidance*, Vol. 1, No. 5, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

103. EPA, 1992. *Status of Key SACM Program Management Issues, Interim Guidance*, Vol. 1, No. 1, OSWER Dir. 9203.1-05I, Office of Emergency and Remedial Response, Washington, D.C.

104. EPA, 1992. *Superfund Accelerated Cleanup Bulletin: Presumptive Remedies* Vol. 1, No. 3, OSWER Dir. 9203.1-02I, Office of Emergency and Remedial Response, Washington, D.C.

105. EPA, 1992. *Superfund Accelerated Cleanup Bulletin: Presumptive Remedies for Municipal Landfill Sites*, Vol. 1, No. 1, OSWER Dir. 9203.1-02I, Office of Emergency and Remedial Response, Washington, D.C.

106. EPA, 1993. *Superfund Accelerated Cleanup Bulletin: Presumptive Remedies for Municipal Landfill Sites*, Vol. 2, No. 1, OSWER Dir. 9203.1-02I, Office of Emergency and Remedial Response, Washington, D.C.

107. EPA, 1993. *Superfund Accelerated Cleanup Bulletin: Presumptive Remedies for Wood Treatment Facilities*, Vol. 1, No. 2, OSWER Dir. 9203.1-02I, Office of Emergency and Remedial Response, Washington, D.C.

108. EPA, 1992. *The Superfund Accelerated Cleanup Model (SACM)*, Vol. 1, No. 4, OSWER Dir. 9203.1-02I, Office of Emergency and Remedial Response, Washington, D.C.

109. EPA, 1993. *Superfund Accelerated Cleanup Model (SACM): Questions and Answers*, OSWER Dir. 9203.1-10FS, Office of Emergency and Remedial Response, Washington, D.C.

110. EPA, 1995. *Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites*, OSWER Dir. 9200.4-14, Office of Emergency and Remedial Response, Washington, D.C.

111. EPA, 1995. *Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites*, OSWER Dir. 9200.4-14, Office Of Emergency and Remedial Response, Washington, D.C.

112. EPA, 1995. *Remedial Design/Remedial Action Handbook*, OSWER Dir. 9355.0-04B, Office of Emergency and Remedial Response, Washington, D.C.

8.4 Ground Water Information

113. EPA, 1990. *Ground Water Issue: Basic Concepts of Contaminant Sorption at Hazardous Waste Sites*, EPA/540/4-90/053, Office of Research and Development, Washington, D.C.

114. EPA, 1993. *Environmental Research Brief: Complex Mixtures and Groundwater Quality*, EPA/600/S-93/004, Office of Research and Development, Washington, D.C.

115. EPA, 1990. *Ground Water: Volume I: Ground Water and Contamination*, EPA/625/6-90/016a, Office of Research and Development, Washington, D.C.

116. EPA, 1991. *Ground Water: Volume II: Methodology*, EPA/625/6-90/016b, Office of Research and Development, Washington, D.C.

117. EPA, 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*, EPA/530-R-93-001, Office of Solid Waste, Washington, D.C.

118. EPA, 1986. *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD)*, OSWER Dir. 9950.1, Office of Waste Programs Enforcement, Washington, D.C.

119. EPA, 1989. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities*, Interim Final Guidance, EPA/530/SW-89/026, Office of Solid Waste, Washington, D.C.

120. EPA, 1992. *Statistical Training Course for Ground-Water Monitoring Data Analysis*, EPA/530/R-93/003, Office of Solid Waste, Washington, D.C.

121. EPA, 1989. *Superfund Ground Water Issue: Ground Water Sampling for Metal Analysis*, EPA/540/4-89/001, Office of Research and Development, Washington, D.C.

122. EPA, 1989. *Superfund Ground Water Issues: Facilitated Transport*, EPA/540/4-89/003, Office of Research and Development, Washington, D.C.

123. EPA, 1994. *Manual: Alternative Methods for Fluid Delivery and Recovery*, EPA/625/R-94/003, Office of Research and Development, Washington, D.C.

8.5 QA/QC

124. EPA, 1993. *Data Quality Objectives Decision Error Feasibility Trials (DEFT) Beta Version 1.01: User's Guide*, OSWER Dir. 9355.9-04A, Office of Solid Waste and Emergency Response, Washington, D.C.

125. EPA, 1993. *Guidance for Planning for Data Collection in Support of Environmental Decision Making Using the Data Quality Objectives Process*, EPA QA/G-4, Quality Assurance Management Staff, Washington, D.C.

126. EPA, 1980. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, QAMS-005/80, Quality Assurance Management Staff, Washington, D.C.

127. EPA, 1990. *Quality Assurance/Quality Control Guidance for Removal Actions*, OSWER Dir. 9360.4-01, Office of Emergency and Remedial Response, Washington, D.C.

128. EPA, 1992. Chapter One of *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846) [Third Edition as amended by Update I (July 1992)], Office of Solid Waste and Emergency Response, Washington, D.C.

8.6 RODs

129. EPA, 1993. *Compendium of ROD Language for FY 1993 Focus Areas*, OSWER Dir. 9355.1-17, Office of Emergency and Remedial Response, Washington, D.C.

130. EPA, 1991. *Guide to Addressing Pre-ROD and Post-ROD Changes*, OSWER Dir. 9355.3-02FS-4, Office of Emergency and Remedial Response, Washington, D.C.

131. EPA, 1989. *A Guide to Developing Superfund Proposed Plans*, OSWER Dir. 9355.3-02FS-2, Office of Emergency and Remedial Response, Washington, D.C.

132. EPA, 1990. *A Guide to Developing Superfund Records of Decision*, OSWER Dir. 9355.3-02FS-1, Office of Emergency and Remedial Response, Washington, D.C.

8.7 RI/FS—RFI/CMS

133. EPA, 1991. *Compendium of ERT Ground Water Sampling Procedures*, OSWER Dir. 9360. 4-06, Office of Emergency and Remedial Response, Washington, D.C.

134. EPA, 1991. *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites*, OSWER Dir. 9355.3-11, Office of Emergency and Remedial Response, Washington, D.C.

135. EPA, 1990. *The Feasibility Study: Detailed Analysis of Remedial Action Alternatives*, OSWER Dir. 9355.3-01FS4, Office of Emergency and Remedial Response, Washington, D.C.

136. EPA, 1990. *The Feasibility Study: Development and Screening of Remedial Action Alternatives*, OSWER Dir. 9355.3-01FS3, Office of Emergency and Remedial Response, Washington, D.C.

137. EPA, 1989. *Getting Ready; Scoping the RI/FS*, OSWER Dir. 9355.3-01FS1, Office of Emergency and Remedial Response, Washington, D.C.

138. EPA, 1991. *Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies (Final) Volume 1*, OSWER Dir. 9835.1(c), Office of Emergency and Remedial Response, Washington, D.C.

139. EPA, 1991. *Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies (Final) Volume 2: Appendices*, OSWER Dir. 9835.1(d), Office of Emergency and Remedial Response, Washington, D.C.

140. EPA, 1987. *Remedial Action Costing Procedures Manual*, EPA/600/8-87/049, Office of Emergency and Remedial Response, Washington, D.C.

141. EPA, 1989. *The Remedial Investigation: Site Characterization and Treatability Studies*, OSWER Dir. 9355.3-01FS2, Office of Emergency and Remedial Response, Washington, D.C.

142. EPA, 1990. *Streamlining the RI/FS for CERCLA Municipal Landfill Sites*, OSWER Dir. 9355.3-11, Office of Emergency and Remedial Response, Washington, D.C.

143. EPA, 1993. *Subsurface Characterization and Monitoring Techniques: A Desk Reference Guide: Volume I: Solids and Ground Water Appendices A and B*, EPA/625/R-93/003a, Center for Environmental Research Information, Cincinnati, Ohio.

144. EPA, 1993. *Subsurface Characterization and Monitoring Techniques: A Desk Reference Guide: Volume II: The Vadose Zone, Field Screening and Analytical Methods Appendices C and D*, EPA/625/R-93/003b, Center for Environmental Research Information, Cincinnati, Ohio.

145. EPA, 1993. *Use of Airborne, Surface, and Borehole Geophysical Techniques at Contaminated Sites*, EPA/625/R-92/007, Office of Science Planning and Regulatory Evaluation, Cincinnati, Ohio.

146. EPA, 1995. *Land Use in the CERCLA Remedy Selection Process*, OSWER Dir. 9355.7-04, Office of the Assistant Administrator, Washington, D.C.

147. DOE, 1994. *CERCLA Removal Actions Guidance*, DOE/EH-0435, Office of Environmental Guidance, Washington, D.C.

8.8 Remediation Technologies

148. EPA, 1992. *Accessing Federal Data Bases for Contaminated Site Clean-Up Technologies*, EPA/542/B-92/002, Technology Innovation Office, Washington, D.C.

149. EPA, 1993, *Approaches for the Remediation of Federal Facility Sites Contaminated with Explosive or Radioactive Wastes*, EPA/625/R-93/013, Office of Research and Development, Washington, D.C.

150. EPA, 1990, *Assessment of Technologies for the Remediation of Radioactively Contaminated Superfund Sites*, OSWER Dir. 9370.0-20, Office of Radiation Programs, Washington, D.C.

151. EPA, 1990. *Basics of Pump-and-Treat Ground Water Remediation Technology*, OSWER Dir. 9370.7-01, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

152. EPA, 1993. *Bioremediation Resource Guide*, EPA/542/B-93/004, Technology Innovation Office, Washington, D.C.

153. EPA, 1992. *Federal Publication of Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation*, EPA/542/B-92/001, Technology Innovation Office, Washington, D.C.

154. EPA, 1993. *Geotechnical Systems for Structures on Contaminated Sites; A Technical Guidance Document*, EPA/530-R-93-002, Office of Solid waste and Emergency Response, Washington, D.C.

155. EPA, 1994. *Ground-Water Treatment Technology Resource Guide*, EPA/542/B-94-009, Technology Innovation Office, Washington, D.C.

156. EPA, 1992. *Guide for Conducting Treatability Studies Under CERCLA*, EPA/540/R-92/017a, Office of Research and Development, Washington, D.C.

157. EPA, 1992. *Guide for Conducting Treatability Studies Under CERCLA: Chemical Dehalogenation*, OSWER Dir. 9355.0-37, Office of Research and Development, Washington, D.C.

158. EPA, 1990. *A Guide to Pump and Treat Ground-Water Remediation Technology*, OSWER Dir. 9370.7-01FS, Office of Emergency and Remedial Response, Washington, D.C.

159. EPA, 1993. *Hydraulic Fracturing Technology: Application Analysis and Technology Evaluation Report*, EPA/540/R-93/505, Office of Research and Development, Cincinnati, Ohio.

160. EPA, 1994. *Innovative Treatment Technologies: Annual Status Report (Sixth Edition)*, EPA/542/R-94-005, Technology Innovation Office, Washington, D.C.

161. EPA, 1991. *Reductive Dehalogenation of Organic Contaminants in Soils and Ground Water*, EPA/540/4-90/054, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

162. EPA, 1993. *Remediation Technologies Screening Matrix and Reference Guide*, EPA/542-B-93-005, Technology Innovation Office, Washington, D.C.

163. EPA, 1993. *Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation (A Bibliography of EPA Information Resources)*, EPA/542/B-93/001, Robert S. Kerr Environmental Laboratory, Ada, Oklahoma.

164. EPA, 1993. *Seminar on Technologies for Remediating Sites Contaminated with Explosive and Radioactive Wastes*, EPA/625/K-93/001, Office of Research and Development, Washington, D.C.

165. EPA, 1984. *Slurry Trench Construction for Pollution Migration Control*, OSWER Dir. 9370.0-02, Office of Emergency and Remedial Response, Washington, D.C.

166. EPA, 1992. *Strategy to Increase the Use of Innovative In Situ Treatment for Contaminated Ground Water*, EPA/542/F-92/025, Office of Solid Waste and Emergency Response, Washington, D.C.

167. EPA, 1990. *Subsurface Contamination Reference Guide*, EPA/540/2-90/011, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

168. EPA, 1992. *Synopsis of Federal Demonstrations of Innovative Site Remediation Technologies*, EPA/542/B-92/003, Technology Innovation Office, Washington, D.C.

169. EPA, 1992. *VISITT Vendor Information System for Innovative Treatment Technologies: User Manual (VISITT Version 1.0)*, EPA 542-R-92-001, Technology Innovation Office, Washington, D.C.

170. EPA, 1992. *Vitrification Technologies for Treatment of Hazardous and Radioactive Waste*, EPA/625/R-92/002, Office of Research and Development, Washington, D.C.

171. EPA, 1994. *Handbook: Recycling and Reuse of Material Found on Superfund Sites*, EPA/625/R-94/004, Office of Research and Development, Washington, D.C.

8.9 Risk Assessments

172. EPA, 1989. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference*, EPA/600/3-89/013, Environmental Research Laboratory, Corvallis, Oregon.

173. EPA, 1992. *Guidance for Data Useability in Risk Assessment (Part A)*, OSWER Dir. 9285.7-09A, Office of Emergency and Remedial Response, Washington, D.C.

174. EPA, 1992. "Guidelines for Exposure Assessment; Notice," 57 *FR* 22888.

175. EPA, 1992. *Implementing the Deputy Administrator's Risk Characterization Memorandum*, OSWER Dir. 9285.7-13, Office of Emergency and Remedial Response, Washington, D.C.

176. EPA, 1993. *New Policy on Performance of Risk Assessments During Remedial Investigation/Feasibility Studies (RI/FS) Conducted by Potentially Responsible Parties (PRPs)*, OSWER Dir. 9835.15b, Office of Solid Waste and Emergency Response, Washington, D.C.

177. EPA, 1990. *Performance of Risk Assessments in Remedial Investigation/Feasibility Studies (RI/FSs) Conducted by Potentially Responsible Parties (PRPs)*, OSWER Dir. 9835.15, Office of Solid Waste and Emergency Response, Washington, D.C.

178. EPA, 1993. *A Review of Ecological Assessment Case Studies from a Risk Assessment Perspective*, EPA/630/R-92/005, Risk Assessment Forum, Washington, D.C.

179. EPA, 1990. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part A)*, OSWER Dir. 9285.7-01FS, Office of Emergency and Remedial Response, Washington, D.C.

180. EPA, 1988. *Superfund Exposure Assessment Manual*, OSWER Dir. 9285.5-01, Office of Remedial Response, Washington, D.C.

181. EPA, 1991. *Supplemental Guidance on Performing Risk Assessments in Remedial Investigation/Feasibility Studies (RI/FSs) Conducted by Potentially Responsible Parties*

(PRPs), OSWER Dir. 9835.15a, Office of Solid Waste and Emergency Response, Washington, D.C.

182. EPA, 1995. *Land Use in the CERCLA Remedy Selection Process*, OSWER Dir. 9355.7-04, Office of Solid Waste and Emergency Response, Washington, D.C.