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Superfund

RULES OF THUMB FOR SUPERFUND REMEDY SELECTION

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Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

Notice: This document provides guidance to EPA staff. It also provides guidance to the public and to the regulated community on how EPA intends to exercise its discretion in implementing the National Contingency Plan. The guidance is designed to communicate national policy on these issues. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future, as appropriate.

ABSTRACT

This guidance document describes key principles and expectations, interspersed with "best practices" based on program experience, that should be consulted during the Superfund remedy selection process. These remedy selection "Rules of Thumb" are organized into three major policy areas: 1) risk assessment and risk management, 2) developing remedial alternatives, and 3) ground-water response actions. The purpose of this guide is to briefly summarize key elements of various remedy selection guidance documents and policies in one publication. EPA believes that consistent application of national policy and guidance is an important means by which we ensure the reasonableness, predictability, and cost-effectiveness of our decisions. Gathering these remedy selection policy expectations into one document will support our ongoing efforts to promote these important objectives. For more detailed discussions of these policy areas, consult the National Contingency Plan (NCP) and the guidance documents listed at the end of each section. This guide has been developed as one of the Superfund administrative reforms announced by Administrator Carol Browner on October 2, 1995.

To Obtain Documents:

EPA employees can obtain additional copies of this guidance, or copies of documents referenced in this guidance, by calling the Superfund Document Center at 703-603-9232, or by sending an e-mail request to superfund.documentcenter@epamail.gov. Non-EPA employees can obtain these documents by contacting the National Technical Information Service at 703-487-4650. This document is also available on the Internet at http://www.epa.gov/superfund.

INTRODUCTION

The Superfund program's remedy selection process links the analysis of site cleanup alternatives, conducted in a remedial investigation/feasibility study (RI/FS), with the documentation of the selected remedy in a Record of Decision (ROD). Section 121 of the Superfund statute (the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)) established five principal requirements for the selection of remedies. Remedies must: 1) protect human health and the environment; 2) comply with applicable or relevant and appropriate requirements (ARARs) unless a waiver is justified; 3) be cost-effective; 4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy a preference for treatment as a principal element, or provide an explanation in the ROD as to why this preference was not met.

In the Superfund regulations (the National Oil and Hazardous Substances Contingency Plan (NCP)), EPA established a national goal and a series of expectations to reflect the principal requirements of Section 121 and to help focus the RI/FS on appropriate waste management options (Exhibit 1). EPA also developed nine criteria for evaluating remedial alternatives to ensure that all important considerations are factored into remedy selection decisions (Exhibit 2). These criteria are derived from the statutory requirements of Section 121, as well as technical and policy considerations that have proven to be important for selecting among remedial alternatives. The nine criteria analysis comprises two steps: an individual evaluation of each alternative with respect to each criterion; and a comparison of options to determine the relative performance of the alternatives and identify major trade-offs among them (i.e., relative advantages and disadvantages).

Applicability to the RCRA Corrective Action Program

The Superfund and Resource Conservation and Recovery Act (RCRA) Corrective Action programs generally should yield similar remedies in similar circumstances. Therefore, the Agency believes that many of the principles conveyed in this document are applicable to the RCRA Corrective Action program, except where justified based on clear programmatic differences. For example, although RCRA Corrective Action incorporates risk-based decision making, formal "baseline risk assessments" are not always conducted as they are for Superfund sites. Superfund project managers using these principles can be confident that remedies selected generally will satisfy RCRA Corrective Action; likewise, RCRA Corrective Action project managers are encouraged to use these principles, as appropriate, to promote cost-effective remedial decision making and consistency with Superfund. For more information see: *Coordination between RCRA Corrective Action and Closure and CERCLA Site Activities* (OSWER Directive 9200.0-25, September 24, 1996); and *Advance Notice of Proposed Rulemaking (ANPR) for RCRA Corrective Action* (61 FR 19432, May 1, 1996).

Exhibit 1

Superfund Program Goal and Expectations

Program Goal (40 CFR 300.430(a)(1)(i))

The national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste.

Program Expectations (40 CFR 300.430(a)(1)(iii)(A-F))

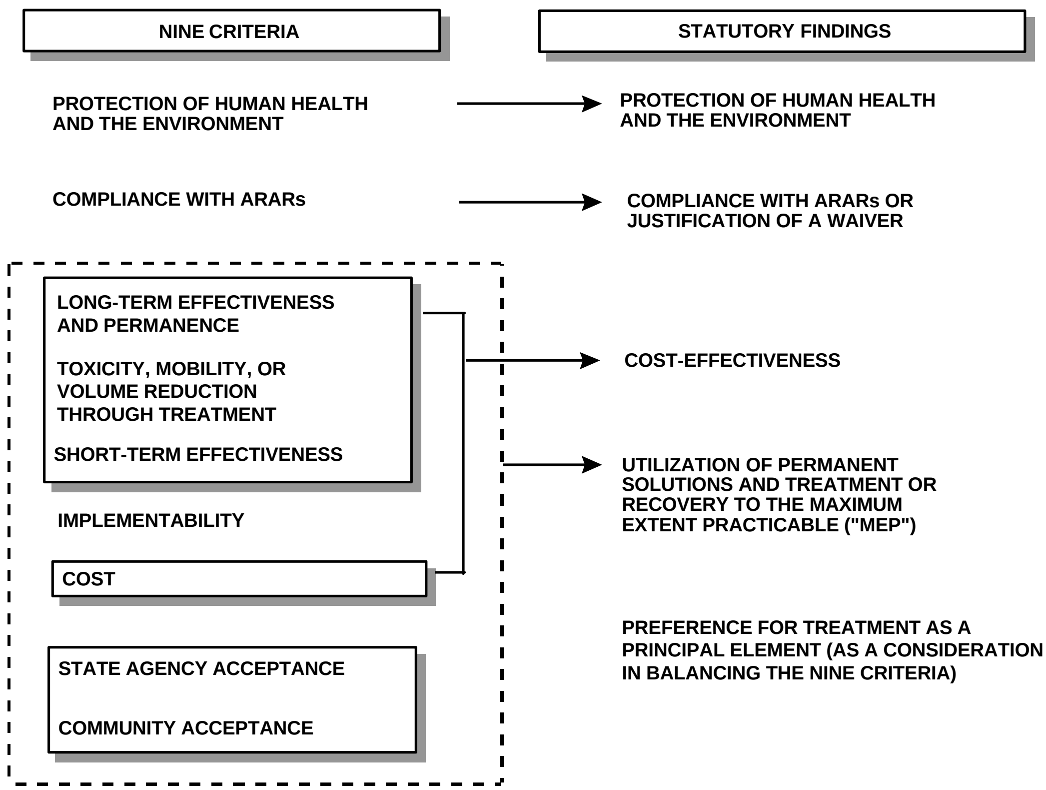
EPA generally shall consider the following expectations in developing appropriate remedial alternatives:

- EPA expects to use treatment to address the principal threats posed by a site, wherever practicable.
- EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable.
- EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment.
- EPA expects to use institutional controls, such as water use and deed restrictions, to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants or contaminants.
- EPA expects to consider using innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies.
- EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site.

EPA established the RI/FS process for gathering the information necessary to select a remedy that is appropriate for the site and fulfills these statutory mandates. The RI includes sampling and analysis to characterize the nature and extent of site contamination, performance of a baseline risk assessment to assess the current and potential future risks to human health and the environment posed by that contamination, and the conduct of treatability studies (where appropriate) to evaluate the potential costs and effectiveness of treatment (or recovery) technologies to reduce the toxicity, mobility, or volume of specific site waste. The FS includes the development and screening of alternative remedial actions, and the detailed evaluation and comparison of the final candidate cleanup options. Typically, a range of options is developed during the FS concurrently with the RI site characterization, with the results of each influencing the other in an iterative fashion. (See *RI/FS Guidance* for a more complete discussion.)

Exhibit 2

RELATIONSHIP OF THE NINE CRITERIA
TO THE STATUTORY FINDINGS



EPA also established a two-step remedy selection process, in which a preferred remedial action is presented to the public for comment in a Proposed Plan, which summarizes preliminary conclusions as to why that option appears most favorable based on the information available and considered during the FS. Following receipt and evaluation of public comments on the Proposed Plan (which may include new information), EPA makes a final decision and documents the selected remedy in a ROD. (See *Remedy Selection Guidance* for a more complete discussion.)

EPA has issued numerous guidance documents that complement and clarify the remedy selection framework presented in the NCP. *Rules of Thumb for Superfund Remedy Selection* summarizes the remedy selection policy expectations contained in these guidance documents as well as in the Superfund statute and regulations. By summarizing this information in a single document, EPA expects to assist Remedial Project Managers and other program implementers in applying remedy selection principles in an appropriately consistent manner.

Please note that this guidance document is not a comprehensive guide to every Agency policy that might affect remedy selection, nor is it a replacement for the careful application of regulatory and statutory requirements to individual sites. Rather, the document is a synopsis of the principles and expectations that are likely to have the most bearing on a wide range of site remedy selections. While this document should help expedite and focus the remedy selection process, it is not a substitute for a careful review and application of CERCLA, the NCP, and relevant guidance documents at individual sites.

Primary source documents for policy statements have been identified in parentheses in italics following each Rule of Thumb and full citations are included at the end of each major section. Specific page citations are provided, where appropriate, and represent the beginning of a relevant section in the document. These source documents should be obtained and consulted for more information.

For Additional Information on the Remedy Selection Process:

☞ NCP: *National Oil and Hazardous Substances Pollution Contingency Plan (The NCP): With the Preambles of 1988 and 1990 and the New Index of Key Terms* (OSWER Publication 9200.2-14, January 1992).

☞ RI/FS Guidance: *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 540-G-89-004, October 1988).

☞ ROD Guidance: *Interim Final Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment: Interim Final* (EPA 540-G-89-007, July 1989). (Revision anticipated in 1998.)

☞ Remedy Selection Guidance: *A Guide to Selecting Superfund Remedial Actions* (OSWER Publication 9355.0-27FS, April 1990).

☞ SACM Guidance: *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (OSWER Directive 9203.1-03, July 7, 1992). Five additional fact sheets also describe SACM and are available by citing the following reference: OSWER Directive 9203.1-05I (Volume 1, Numbers 1-5), December 1992.

☞ Non-Time Critical Removal Guidance: *Guidance on Conducting Non-Time Critical Removal Actions under CERCLA* (EPA 540-R-93-057, August 1993).

☞ Role of Cost Directive: *The Role of Cost in the Superfund Remedy Selection Process* (EPA 540-F-96-018, September 1996).

RISK ASSESSMENT AND RISK MANAGEMENT

Background

The mandate of the Superfund program is to protect human health and the environment from current and potential threats posed by uncontrolled hazardous waste sites. The NCP established the RI/FS process to characterize the nature and extent of site risks, develop and evaluate cleanup options, and gather other information necessary to select a remedy that is appropriate for a site. A baseline risk assessment is performed as part of the RI/FS to evaluate the potential threat to human health and the environment in the absence of any remedial action. EPA uses the results of the RI/FS and baseline risk assessment to make a series of site-specific risk management decisions in the Superfund remedy selection process.

Presented below is a summary of key principles and expectations for risk assessment and risk management that have been developed for the Superfund program. Consideration of these principles will help ensure that remedies are both cost-effective and appropriately consistent with national policy and guidance.

Risk Assessment Rules of Thumb

The following principles should be consulted when developing the baseline risk assessment. If the RI/FS only addresses a portion of the site or specific medium (e.g., ground water), these principles apply to the baseline risk assessment developed in support of that specific operable unit. Additional efforts may be required to relate the specific action to the overall risk posed by the site as a whole.

1) **Conceptual Site Model**: Evaluate available data and develop a well-defined conceptual site model (CSM) in the earliest stages of the baseline risk assessment. The CSM is a three-dimensional "picture" of site conditions that illustrates contaminant sources, release mechanisms, exposure pathways, migration routes, and potential human and ecological receptors. The CSM documents current and potential future site conditions and is supported by maps, cross sections, and site diagrams that illustrate what is known about human and environmental exposure through contaminant release and migration to potential receptors. The CSM is initially developed during the scoping phase of the RI/FS and should be modified as additional information becomes available. (*RI/FS Guidance; DQO Guidance; Soil Screening Guidance; and RAGS I Part A*)

2) **Exposure Pathways**: Evaluate all relevant exposure pathways related to the site (e.g., direct ingestion, inhalation), for both current and reasonably anticipated future land uses as well as current and potential future ground-water and surface water uses. (*Land Use Directive; RAGS I Part A; and Soil Screening Level Guidance*)

3) **Data Needs**: Collect sufficient contaminant concentration data from each relevant medium

to adequately characterize the nature and extent of contamination and to develop sound estimates of risk associated with each exposure pathway. (*DQO Guidance*)

4) **Site-Specific Risk Calculation**: The following principles apply to site-specific risk calculations in the baseline risk assessment:

- Calculate the cumulative risks to an individual for chronic exposures, using reasonable maximum exposure (RME) assumptions by combining a statistically sound, arithmetic average, exposure-point concentration with reasonably conservative values for intake and duration. The most current updates on exposure assumptions, methods, and models for the residential exposure scenario can be obtained from the *Soil Screening Guidance*.

- Use the most current toxicity values provided by the Integrated Risk Information System (IRIS) or the Health Effects Assessment Summary Tables (HEAST). Call the Superfund Technical Support Center in Cincinnati at (513) 569-7300 if toxicity values are not reported in IRIS or HEAST. (*RAGS I Part A*)

- Include estimates of risk for current and reasonably anticipated future land uses and potential future ground-water and surface water uses, without institutional controls. The baseline risk assessment is essentially an evaluation of the "no action" alternative (i.e., an assessment of the risk associated with a site in the absence of any remedial action or control). While institutional controls do not actively clean up the contamination at a site, they can control exposure and, therefore, are considered to be limited action alternatives that may be evaluated during the remedy selection process. (*1990 NCP Preamble at 55 FR 8710*)

- Include a discussion that identifies major sources of uncertainty or variability and their influence on the risk estimates. Probabilistic methods may aid in evaluating uncertainty at some sites. (*RAGS I Part A; and EPA's Risk Characterization Policy*)

5) **Other Measures of Risk**: Other measures of risk (e.g., central tendency) can be used to describe site risks more fully. However, RME risk generally should be the principal basis for evaluating potential risks at Superfund sites. (*1990 NCP Preamble at 55 FR 8711; RAGS I Part A, page 6-4; and EPA's Risk Characterization Policy*)

6) **Exposed Populations**: The risk analysis should clearly identify the population, or population sub-group (e.g., highly exposed or susceptible individuals), for which risks are being

evaluated. (*RAGS I Part A, page 6-6; and EPA's Risk Characterization Policy*)

7) **Ecological Risk Assessment**: Include an assessment of ecological risk in the baseline risk assessment in order to support EPA's mission to protect the environment. A screening ecological risk assessment generally should be conducted to identify those chemicals, media, and portions of the site requiring more detailed study and analysis. Use site-specific toxicity tests, field studies, and food-chain models whenever appropriate. (*ECO Risk Guidance; and RAGS II*)

Risk Management Rules of Thumb

The following principles should be consulted when making risk management decisions in the Superfund program. Unless otherwise noted, the Rules of Thumb presented in this section are derived from the *Role of Baseline Risk Assessment Directive.*

1) **Basis for Action**: A response action is generally warranted if one or more of the following conditions is met:

- The cumulative excess carcinogenic risk to an individual exceeds 10^{-4} (using reasonable maximum exposure assumptions for either the current or reasonably anticipated future land use);

- The non-carcinogenic hazard index is greater than one (using reasonable maximum exposure assumptions for either the current or reasonably anticipated future land use);

- Site contaminants cause adverse environmental impacts; or

- Chemical-specific standards or other measures that define acceptable risk levels are exceeded and exposure to contaminants above these acceptable levels is predicted for the RME. Examples include: drinking water standards that are exceeded in ground water when that ground water is a current or potential source of drinking water; or water quality standards that are exceeded in surface or ground waters that support the designated uses of these waters (e.g., support aquatic life).

2) **Preliminary Remediation Goals for Carcinogens**: In the absence of ARARs for chemicals that pose carcinogenic risks, PRGs generally should be established at concentrations that achieve 10^{-6} excess cancer risk, modifying as appropriate based on exposure, uncertainty, and technical feasibility factors.

3) **Preliminary Remediation Goals for Non-Carcinogens**: In the absence of ARARs for chemicals that pose non-carcinogenic risks, PRGs generally should be established at concentrations that achieve a hazard quotient of one. Cumulative noncancer risks are determined by adding hazard quotients for chemicals with the same toxic endpoint or mechanism of action (e.g., the toxic endpoint for both ethylbenzene and styrene is liver toxicity and so these hazard quotients can be summed). In establishing PRGs for chemicals that affect the same target organ/system, PRGs for individual chemicals should be divided by the number of chemicals present in this group (*Soil Screening Guidance, page 32*).

4) **Chemical-Specific ARARs**: When a single ARAR for a specific chemical (or in some cases a group of chemicals) defines an acceptable level of exposure, compliance with the ARAR generally will be considered protective even if it is outside the risk range (unless there are extenuating circumstances, such as exposure to multiple contaminants or pathways).

RAOs, PRGs and Final Cleanup Levels

Remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish (e.g., restoration of groundwater). Preliminary remediation goals (PRGs) are the more specific statements of the desired endpoint concentrations or risk levels, for each exposure route, that are believed to provide adequate protection of human health and the environment based on preliminary site information. Initial PRGs are developed early in the RI/FS process and are based on ARARs and other readily available information, such as concentrations associated with 10^{-6} cancer risk or a hazard quotient equal to one for noncarcinogens calculated from EPA toxicity information. Initial PRGs may also be modified based on exposure, uncertainty, and technical feasibility factors. As data are gathered during the baseline risk assessment and RI/FS, PRGs are refined into final contaminant-specific cleanup levels. Based on consideration of factors during the nine criteria analysis and using the PRG as a point of departure, the final cleanup level may reflect a different risk level within the acceptable risk range (10^{-4} to 10^{-6} for carcinogens) than the originally identified PRG. The final cleanup levels, not PRGs, are documented in the Record of Decision.

5) **Background Concentrations**: EPA does not generally clean up below natural background levels. However, where anthropogenic (i.e., man-made) background levels exceed acceptable risk-based levels, and EPA has determined that a response action is appropriate, EPA's goal is to develop a comprehensive response to address area-wide contamination. This will help avoid response actions that create "clean islands" amid widespread contamination (*Soil Screening Guidance, page 8*).

6) **Selecting Remedial Action**: In the absence of ARARs, remedies should reduce the risks

from carcinogenic contaminants such that the excess cumulative individual lifetime cancer risk for site-related exposures falls between 10^{-4} and 10^{-6}. The Agency has expressed a preference for cleanups achieving the more protective end of the risk range (i.e., 10^{-6}). (NOTE: The upper boundary of the risk range is not a discrete line at 1×10^{-4}, although EPA generally uses 1×10^{-4} in making risk management decisions. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions.) For non-carcinogens, remedies generally should reduce contaminant concentrations such that exposed populations or sensitive sub-populations will not experience adverse effects during all or part of a lifetime, incorporating an adequate margin of safety (i.e., a hazard index at or below one).

7) **Timing**: A "phased approach" to site investigation and cleanup generally will accelerate risk reduction and provide additional technical site information on which to base long-term risk management decisions. Phased cleanup approaches should be employed wherever practicable (*40 CFR 300.430(a)(1)(ii)*(*A*)). For more information about the use of early actions to expedite site cleanup, see *SACM Guidance* and the *Ground-Water Presumptive Strategy*.

For Additional Information on Risk Assessment and Risk Management:

☞ RI/FS Guidance: *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 540-G-89-004, October 1988).

☞ RAGS I Part A: *Risk Assessment Guidance For Superfund, Volume 1, Part A: Human Health Evaluation Manual, Interim Final* (EPA 540-1-89-002, March 1989).

☞ RAGS II: *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final* (EPA 540-1-89-001, March 1989).

☞ RAGS I Part B: *Risk Assessment Guidance for Superfund, Volume I, Part B: Human Health Evaluation Manual, Development of Risk-Based Preliminary Remediation Goals, Interim Final* (EPA 540-1-89-002, December 1991). [Note: *Soil Screening Guidance* provides improvements in inhalation and ground water exposure pathway discussions.]

☞ RAGS I Part C: *Risk Assessment Guidance for Superfund, Volume I, Part C: Human Health Evaluation Manual, Risk Evaluation of Remedial Alternatives, Interim* (EPA 540-R-92-004, December 1991).

☞ Role of Baseline Risk Assessment Directive: *Role of the Baseline Risk Assessment in Superfund Remedy Selection* (OSWER Directive 9355.0-30, April 22, 1991).

☞ SACM Guidance: *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (OSWER Directive 9203.1-03, July 7, 1992).

☞ DQO Guidance: *Data Quality Objectives Process for Superfund: Interim Final Guidance* (EPA 540-R-93-071, 1993).

☞ EPA's Risk Characterization Policy: *Policy for Risk Characterization at the U.S. Environmental Protection Agency* (Memorandum from Administrator Carol Browner, March 21, 1995).

☞ Land Use Directive: *Land Use in the CERCLA Remedy Selection Process* (OSWER Directive 9355.7-04, May 25, 1995).

☞ Soil Screening Guidance: *Soil Screening Guidance: Users Guide* (EPA 540-R-96-018, April 1996).

☞ Ground-Water Presumptive Strategy: *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA 540-R-96-023, October 1996).

☞ ECO Risk Guidance: *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 540-R-97-006, June 1997).

DEVELOPING REMEDIAL ALTERNATIVES

Background

The national goal of the remedy selection process is to "select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste" (*40 CFR 300.430(a)(1)(i)*). While protection of human health and the environment can be achieved through a variety of methods, this goal reflects CERCLA's emphasis on achieving protection through the aggressive, but realistic, use of treatment. Remedies that rely on engineering and institutional controls as a major component, in addition to being less permanent than treatment remedies, may place constraints on the productive re-use of land.

To accomplish this goal, the NCP describes six expectations for the development of remedial alternatives. These expectations, derived from the mandates of CERCLA Section 121 and based on previous Superfund experience, were developed as guidelines to communicate the types of remedies that EPA generally will find appropriate for specific types of waste. Although remedy selection decisions are site-specific determinations based on analyses of remedial alternatives using the nine evaluation criteria, these expectations help to focus the RI/FS on appropriate waste management options. This section discusses the first four of the six NCP expectations presented in Exhibit 1. Unless otherwise noted, this section has been derived from the *Principal Threats Guidance.*

Reasonably Anticipated Future Land Use and Principal Threat Waste Identification

The reasonably anticipated future land use at a site is significant in defining principal threat waste areas. Pursuant to the NCP and the 1995 land use guidance, current land use and reasonably anticipated future land use should be considered in identifying realistic exposure scenarios for estimating site risks. When the baseline risks associated with the reasonably anticipated future land use trigger action, the definition of principal threat wastes may be determined by the reasonably anticipated future land use scenario as well. For example, soil contamination that could be considered a principal threat under a residential exposure scenario might be considered a low-level threat under a non-residential exposure scenario. Although no "threshold level" of risk has been established to identify principal threat waste, a general rule of thumb is to consider as a principal threat those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios. (For more information, see *Principal Threats Guidance* and *Land Use Directive*.)

Identifying Principal and Low-level Threat Wastes

The concept of principal threat waste and low-level threat waste, as developed by EPA in the NCP and expanded in subsequent guidance, should be applied on a site-specific basis when characterizing "source material." Source material is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to ground water, to surface water, to air, or acts as a source for direct exposure.

Contaminated ground-water plumes are generally not considered to be source material, although nonaqueous phase liquids (NAPLs) in the ground water generally would be viewed as source material.

Identifying principal and low-level threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, low-level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied.

<u>Rules of Thumb for Developing Appropriate Remedial Alternatives for Source Materials</u>

1) **Combination of Methods of Protection**: An appropriate combination of treatment technologies, engineering controls, and institutional controls should be considered when developing remediation approaches that will be protective of human health and the environment. Federal or state ARARs (e.g., land disposal restrictions under RCRA) may limit containment and treatment options.

2) **Treatment of Principal Threats**: "EPA expects to use treatment to address the principal threats posed by a site, wherever practicable" *(40 CFR 300.430(a)(1)(iii)(A))*.

3) **Containment of Principal Threats**: In some situations, it may be appropriate to contain rather than treat principal threat wastes due to difficulties in treating the wastes. The following situations generally should result in a determination that treatment is not practicable under the nine remedy selection criteria (Exhibit 2). For example, when:

- Treatment technologies are not technically feasible or are not available within a reasonable time frame;

- The extraordinary volume of materials or complexity of the site may make implementation of the treatment technologies impracticable (e.g., large landfills);

- Implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers, the surrounding community, or impacted ecosystems during implementation (to the degree that these risks cannot be otherwise addressed through implementation measures); and

- Implementation of the treatment technology would have severe effects across environmental media.

4) **Containment of Low Level Threats**: "EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable" *(40 CFR 300.430(a)(1)(iii)(B))*.

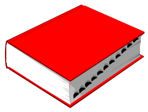
5) **Treatment of Low-Level Threats**: In some situations, it may be appropriate to treat rather than contain low-level threat wastes. For example:

- Once a decision has been made to treat some wastes onsite, economies of scale may make it cost-effective to treat more than just principal threat wastes, to alleviate or minimize the need to maintain engineering or institutional controls over time.

- In some circumstances, treatment of more than principal threat wastes may be appropriate in order to make the whole site consistent with the reasonably anticipated future land use (e.g., where there are plans for residential development). See the *Land Use Directive* to obtain additional information for considering land use in remedy selection decisions.

6) **NAPLs as Principal Threat Wastes**: Although nonaqueous phase liquids (NAPLs) are generally viewed as principal threat wastes, program experience has shown that removal and/or in-situ treatment of NAPLs may not be practicable. Hence, EPA generally expects that the quantity of free-phase NAPL (i.e., "free product") should be reduced to the extent practicable and that an appropriately designed containment strategy should be developed for NAPLs that cannot be removed from the subsurface. This policy applies to both dense nonaqueous phase liquids (DNAPLs) and light nonaqueous phase liquids (LNAPLs), although of the two, it is generally more difficult to remove or treat DNAPLs in the subsurface. (See *Ground-Water Rule of Thumb #10* for more complete discussion of DNAPLs.)

7) **Use of Institutional Controls**: Institutional controls (such as easements, well drilling prohibitions, building permit restrictions, land use zoning restrictions, or fishing bans) generally shall not substitute for more active measures (e.g., treatment and/or containment of source material) as the sole remedy unless active measures are not practicable, based on the balancing of trade-offs among alternatives that is conducted during the remedy selection process. Institutional controls typically will be used in conjunction with engineering controls when the remedy results in long-term waste management onsite. *(40 CFR 300.430(a)(1)(iii)(D))*



For Additional Information on Developing Remedial Alternatives:

☞ RI/FS Guidance: *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 540-G-89-004, October 1988).

☞ Principal Threats Guidance: *A Guide to Principal Threat and Low Level Threat Wastes* (OSWER Directive 9380.3-06FS, November 1991).

☞ Land Use Directive: *Land Use in the CERCLA Remedy Selection Process* (OSWER Directive 9355.7-04, May 25, 1995).

☞ Ground-Water Presumptive Strategy: *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA 540-R-96-023, October 1996).

GROUND-WATER RESPONSE ACTIONS

Background

Contaminated ground water exists at over 85 percent of the sites on the National Priorities List (NPL). The goal of ground-water remediation at Superfund sites is to protect human health and the environment through a combination of short-term measures (e.g, provision of alternate water supplies) and long-term measures to restore ground-water quality appropriate for its beneficial uses. Remedial action for contaminated ground water generally is warranted when EPA determines, based on the results of the baseline risk assessment, that the contamination poses a current or potential threat to human health or the environment (CERCLA §104(a)(1)). Additionally, where the ground water is currently used (or is potentially usable) as a drinking water supply, exceedance of Maximum Contaminant Levels (MCLs) and non-zero Maximum Contaminant Level Goals (MCLGs) established under the Safe Drinking Water Act also may be used as the basis for taking a remedial action. The goals of the long-term ground-water cleanup program are summarized in the NCP as follows:

> "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of ground water to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated ground water, and evaluate further risk reduction" (*40 CFR 300.430(a)(1)(iii)(F)*).

Key Ground-Water Response Questions

- What are the current and potential future beneficial uses of the contaminated ground water?
- What is the approximate timing of the future need for ground water?
- Is restoration of ground water to beneficial uses technically practicable within a reasonable timeframe?
- What is the range of remedial alternatives that restore ground water in different but "reasonable" time periods?
- If restoration is not technically practicable, what remedial activities are necessary to prevent exposure to contaminants and prevent further plume migration?

Rules of Thumb for Ground-Water Response Actions

The rules of thumb for ground-water response actions are organized into four sequential steps. EPA recognizes that site investigation and analysis is a dynamic process that evolves as more information is gathered during the RI and a cleanup strategy is developed and refined in accordance with the best available site data. Hence, this framework is not strictly sequential, and should be tailored to address site-specific situations.

Step 1: Identifying Remedial Action Objectives and Preliminary Remediation Goals Based on Current and Potential Future Ground-Water Uses

Once it has been determined that there is a basis for taking a ground-water response action, the first step should be to identify RAOs and PRGs for the ground water. These RAOs and PRGs should reflect current and potential future uses of the ground water and exposure scenarios that are consistent with these uses. Several factors should be considered when identifying ground-water RAOs and PRGs:

1) **Current Ground-Water Uses**: RAOs and PRGs must reflect current human use (e.g., drinking water supply) as well as current environmental receptors (e.g., surface waters that are recharged by ground water and that are used by sensitive environmental receptors). (*Ground-Water Presumptive Strategy, page 15*)

2) **Potential Future Ground-Water Uses**: Where available, potential future ground-water uses should be determined from a Comprehensive State Ground-Water Protection Program (CSGWPP) that has been endorsed by EPA and has provisions for site-specific use determinations. In the absence of such a CSGWPP, determination of potential future uses should consider State ground water classifications or other designations and Federal ground-water guidelines (e.g., Class I, II, and III ground waters). The Federal classification system can be found in "*Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy*," hereafter referred to as the Federal Guidelines. Where State and Federal classifications result in different ground-water use scenarios, the "use classification" leading to the more "stringent" RAOs should be used. Thus, ground waters at a given site are generally assumed to be a potential future source of drinking water if designated as such by the State or if considered to be a potential source of drinking water under the Federal Guidelines. (*CSGWPP Directive*; *Federal Guidelines*; and *1990 NCP Preamble at 55 FR 8733*)

3) **PRGs for Drinkable Waters**: Generally, drinking water standards (Federal MCLs, non-zero MCLGs, or more stringent State drinking water standards) are relevant and appropriate as PRGs, and ultimately as final cleanup levels, for ground waters that are determined to be a current or potential future source of drinking water. (*40 CFR 300.430(e)(2)(i)(B and C);* and *Ground-Water Presumptive Strategy, page 15)*

4) **Limitation of Using Drinking Water Standards**: Generally, drinking water standards should not be chosen as PRGs for ground waters that are not current or potential future sources of drinking water (1990 NCP Preamble at *55 FR 8733*). The Federal Guidelines define "non-potable," or Class III, ground-water aquifers as those that: contain more than 10,000 mg/liter total dissolved solids; yield less than 150 gallons per day; or are so contaminated by naturally occurring conditions (e.g., salinity) or broad-scale human activity not related to a specific contaminant source that cleanup is not practicable. State classification systems may also identify ground waters that are not considered to be a potential future source of drinking water (see Ground Water Rule of Thumb #2 above). Where non-potable ground water has been contaminated, non-restoration RAOs may be appropriate (e.g., source control, plume containment). Establishment of PRGs for non-potable ground-water should consider any surface or ground-water bodies to which such non-potable ground waters discharge, and any current or potential future uses of the non-potable ground water such as for livestock watering, agricultural irrigation, industrial uses, or other purpose that might result in human or environmental exposures. (*Ground-Water Presumptive Strategy, page 15*)

5) **Consideration of More Stringent Ground-Water Standards**: Many states have anti-degradation standards or other requirements that are more stringent than the Federal drinking water standards for a given constituent. Where such a state requirement is determined to be an ARAR, it should be used as the PRG. (*Ground-Water Presumptive Strategy, page 16*)

6) **Relationship between Ground-Water RAOs and Soil PRGs**: At many sites, soil PRGs are set at levels that are needed to achieve long-term RAOs for ground water. As a result, these soil PRGs may need to be more stringent than would otherwise be necessary given the reasonably anticipated future land use. However, stringent soil PRGs intended to protect ground water generally will be inappropriate for site areas where the primary source of ground-water contamination is located below the soil (e.g., DNAPLs below the water table) <u>and</u> restoration of ground water is determined to be technically impracticable (see *Ground-Water Rule of Thumb #9* below). Therefore, both reasonably anticipated future land uses and potential future ground-water uses must be considered when developing the overall site remediation strategy. (*Ground-Water Presumptive Strategy, page 12*)

7) **Relationship Between Ground Water and Other Water Resources**: Contaminated ground waters may discharge and pose a risk to environmental resources such as streams, lakes, wetlands, or other uncontaminated aquifers. Therefore, ground-water PRGs should be set at levels that are protective of these other resources as well. For example, cleanup of contaminated ground waters that discharge to surface water should consider whether water quality criteria established under the Clean Water Act, or more stringent state surface water requirements, are ARARs. (*1990 NCP Preamble at 55 FR 8754*)

<u>Step 2: Establishing Remedial Action Objectives and Final Cleanup Levels Based on Site-Specific Conditions</u>

Once ground-water RAOs have been identified (in accordance with current and potential future uses), PRGs associated with those objectives should be identified and factored into the remedy selection process. PRGs developed during the RI/FS, and in accordance with the principles presented in the previous section, are the starting point for determining final cleanup levels which are documented in the ROD. The following rules of thumb relate to flexibilities in existing EPA policy which allow for selection of achievable RAOs and their associated cleanup levels and points of compliance.

8) **Restoration Potential**: If ground-water restoration is determined to be the RAO, MCLs, non-zero MCLGs, or other risk-based cleanup levels will have to be achieved in order for the ground-water resource to be restored. Site-specific information should be analyzed to determine the likelihood that ground water can be restored to these levels using available technologies (i.e., to determine the aquifer's "restoration potential"). (*TI Guidance, page 13;* and *Ground-Water Presumptive Strategy, page 5*)

9) **Technical Impracticability**: An ARAR waiver should be invoked for those portions of the contaminated soil or ground water where it has been demonstrated that attainment of one or more ARARs are technically impracticable from an engineering perspective. The "TI" waiver must be justified by site-specific information developed for the Administrative Record in accordance with EPA guidance. In the event that a TI waiver is invoked, an "alternative remedial strategy" must be developed that will ensure protection of human health and the environment. This strategy should be incorporated into the decision document along with the waiver justification and should define achievable RAOs and final cleanup levels for the site. At a minimum, the alternative strategy should prevent human exposure to the contaminated ground water, prevent further contaminant migration, and define any other appropriate risk reduction measures. Note that the waiver should be invoked only for that portion of the contaminated ground water for which restoration to ARARs is technically impracticable. As a result, RAOs and final cleanup levels may be different for different portions of the contaminant plume. (*TI Guidance;* and *Ground-Water Presumptive Strategy, page 17)*

10) **DNAPL Sites**: The likelihood of the presence of dense nonaqueous phase liquids (DNAPLs) should be evaluated wherever DNAPL-type compounds (e.g., chlorinated solvents such as TCE) are found in significant concentrations in the ground water or are known to have been managed or disposed of at the site. The presence of DNAPLs can significantly impact the restoration potential of the site. Where DNAPLs (or other persistent contamination sources) are present in the subsurface and cannot practicably be removed, containment of such sources may be the most appropriate remediation goal. In such cases, a TI waiver should be invoked for the DNAPL zone. Where significant quantities of potentially mobile DNAPL are identified, extraction should be considered in conjunction with containment. Extraction of potentially mobile DNAPLs will increase the long-term reliability of the containment remedy as well as remove source material from the aquifer. Containment of the DNAPL zone will increase the

likelihood that the remaining portion of the aqueous phase plume can be restored to a beneficial use. (*Ground-Water Presumptive Strategy, page 13; and TI Guidance, page 6*)

11) **Point of Compliance**: Final cleanup levels for contaminated ground water generally should be attained throughout the entire contaminant plume, except when remedies involve areas where waste materials will be managed in place. In the latter case, cleanup levels should be achieved "at and beyond the edge of the waste management area when waste is left in place" (*1990 NCP Preamble at 55 FR 8713*). In some cases, such as where several distinct sources are in close geographic proximity, it may be appropriate to move the point of compliance to "encompass the sources of release." In such cases, the point of compliance may be defined to address the problem as a whole, rather than source by source. (*1990 NCP Preamble at 55 FR 8753;* and *Ground-Water Presumptive Strategy, page 17*)

12) **Alternate Concentration Limits (ACLs)**: Under limited circumstances specified in CERCLA §121(d)(2)(B)(ii), ACLs may be established in lieu of cleanup levels that would otherwise be ARARs (e.g., MCLs). The conditions under which ACLs may be considered are where: 1) contaminated ground water discharges to surface water; 2) such ground-water discharge does not lead to "statistically significant" increases of contaminants in the surface water; and 3) enforceable measures can be implemented to prevent human consumption of the contaminated ground water. In general, ACLs may be used where the preceding conditions are satisfied, and where restoration of the ground water is found to be impracticable, based on a balancing of the remedy selection criteria. (*1990 NCP Preamble at 55 FR 8732 and 8754;* and *Ground-Water Presumptive Strategy, page 18*)

Step 3: Evaluating Remedial Technologies and Cleanup Time Frames

Following the establishment of achievable remedial action objectives, cleanup levels, and areas of compliance, a remediation technology (or combination of technologies) should be selected from those identified in the Feasibility Study. The principal factors to consider at this stage are how quickly the remedial action objectives need to be achieved, and what remediation strategies and technologies should be used to achieve them. These factors will have a significant impact on the type of remedy chosen for the site, as well as the cost of that remedy.

13) **Using Early Actions**: Early actions, such as a removal or interim remedial action taken before the final remedy is selected, should be used where appropriate to reduce site risks early in the site remediation process. In addition to reducing site risks and controlling further contaminant migration, these activities will also provide additional site characterization information that greatly improves the ability to make sound long-term remedy decisions. (*Ground-Water Presumptive Strategy, page 16;* and *SACM Guidance*)

14) **Restoration Time Frames**: Where the contaminated ground water is not currently used <u>or</u> an alternate water source is readily available, <u>and</u> there is no near-term future need for the

resource, it will likely be appropriate to consider a longer time frame for achieving restoration cleanup levels. Where longer remediation time frames are appropriate, less aggressive remediation methods and/or more passive remediation approaches (such as source control combined with monitored natural attenuation) should be considered. Restoration time frames should be estimated for all viable remedial alternatives being considered for the site *(40 CFR 300.430(e)(4))*. Comparison of aggressive and passive remedial alternatives can provide a helpful basis for identifying the range of time periods that will be needed to attain remediation objectives, and will provide the basis for determining the remediation timeframe and technologies appropriate for the site. (*1990 NCP Preamble at 55 FR 8732;* and *Ground-Water Presumptive Strategy, page 16*)

15) **Innovative Technologies**: New and emerging technologies should be evaluated in the FS if such technologies offer "the potential for comparable or superior performance or implementability; fewer or lesser adverse impacts than other available approaches; or lower costs for similar levels of performance than demonstrated treatment technologies" *(40 CFR 300.430(e)(5))*.

16) **Monitored Natural Attenuation**: At some sites, data gathered during the RI/FS may indicate that physical or biological processes (unassisted by human intervention) may effectively reduce contaminant concentrations such that remedial objectives in the contaminant plume (or certain portions of the plume) may be achieved in a reasonable time frame without active remediation. This approach is most likely to be appropriate in low concentration portions of the plume, where source control actions have removed the bulk of the contaminant mass, or where biodegradation will efficiently destroy the contaminants in situ. In some cases, remediation alternatives that combine active remediation (in source areas or areas of high concentration) with monitored natural attenuation (in lower concentration portions of the plume) may be most appropriate. Sufficient information is necessary to demonstrate that natural processes are capable of achieving remedial objectives for the site. Performance monitoring is a critical component of this remediation approach because monitoring is needed to ensure that the remedy is protective and that natural processes are reducing contamination levels as expected. Sites with contaminants that do not readily attenuate, or sites that require relatively rapid cleanup due to the demand for the ground-water resource, generally will not be appropriate candidates for natural attenuation. (*1990 NCP Preamble at 55 FR 8734; Ground-Water Presumptive Strategy, page 18;* and *Natural Attenuation Guidance*)

17) **Presumptive Treatment Technologies**: Generally, selection of technologies for ex-situ (above ground) treatment of extracted ground water should employ one or more of the presumptive technologies identified in the *Ground-Water Presumptive Strategy*. The engineering capabilities of these presumptive treatment technologies are well understood, enabling the selection process to be streamlined for the ex-situ treatment component of a ground-water remedy.

Step 4: Monitoring and Evaluating Remedy Performance

Selection of the site remedy marks the end of a data gathering, study, and decision-making process and marks the beginning of the cleanup phase, which includes designing, constructing, operating and maintaining the remedy. Since most ground-water remedies are expected to be operated, maintained, and/or monitored for long periods of time, further opportunities for improving the performance and cost-effectiveness of the cleanup should be explored and utilized if appropriate. An ongoing Administrative reform initiative highlights EPA's recent efforts to encourage appropriate changes to existing remedy decisions to enhance overall remedy effectiveness and cost-effectiveness, without compromising protectiveness or other objectives of the Superfund program. (See *Remedy Updates Guidance* for more information.*)* The following principles describe how periodic evaluation of a remedy can lead to improvements in performance and shortened cleanup time frames.

18) **Implementing Remedies in Multiple Phases**: Implementation of ground-water remedies in more than one phase may increase the performance and cost-effectiveness of the long-term remedy. Performance data from an early phase can be used to refine the design of later phases so that the ultimate remedy is optimized for actual site conditions (e.g., optimized number, location, and pumping rate of extraction wells). (*Ground-Water Presumptive Strategy, page 5 and page 12*)

19) **Periodic Review**: Performance of the ongoing remedy should be evaluated on a regular basis (e.g., every 1 to 5 years) to compare anticipated with actual results, to identify any potential deficiencies in the remedy's protectiveness, and to seek opportunities to improve its performance over the long term. This is especially important when the selected remedy relies on monitored natural attenuation. (*Ground-Water Presumptive Strategy, page 8;* and *Natural Attenuation Guidance*)

20) **Improving Remedy Performance**: Ground-water remedies often involve multiple extraction and/or injection points, subsurface structures or containment barriers, and other features whose actual performance in the field may vary from that assumed during design, given uncertainties about subsurface geology prior to construction. Careful assessment of performance monitoring data may be used to refine the remedy, such as modifying extraction rates or changing the pattern of extraction wells. Such improvements are capable of shortening cleanup time frames, and thus reducing costs. *(Ground-Water Presumptive Strategy, page 11*)

21) **Revisiting and Modifying Cleanup Goals**: At some sites it may be necessary to revisit the

ROD's remedial action objectives or final cleanup levels, if performance data indicate that attainment of these objectives or levels is not technically practicable. If it is determined that a TI waiver is appropriate, the waiver generally should be invoked in a ROD amendment, although in some cases an Explanation of Significant Differences (ESD) may be sufficient. An ESD may be used where the revised remedy is generally consistent with the "alternative remedial strategy" discussed in the original ROD and the original ROD: 1) contained detailed discussions of the potential need for a future TI waiver, and 2) identified an alternative remedial strategy to be used in the event a TI waiver was determined to be appropriate for the site. If an ESD is determined to be sufficient, public notice and opportunity for comment should also be provided. (*Ground-Water Presumptive Strategy, page 11; TI Guidance, page 19 and 24;* and *Remedy Updates Guidance*)

For Additional Information on Ground Water Response Actions:

☞ Federal Guidelines: *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy, Final Draft* (EPA Office of Water, November 1986).

☞ Ground-Water Guidance: *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* (EPA 540-G-88-003, December 1988).

☞ Role of Baseline Risk Assessment Directive: Role *of the Baseline Risk Assessment in Superfund Remedy Selection* (OSWER Directive 9355.0-30, April 22, 1991).

☞ DNAPL I: *Estimating Potential for Occurrence of DNAPL at Superfund Sites* (OSWER Publication 9355.4-07FS, January 1992).

☞ SACM Guidance: *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (OSWER Directive 9203.1-03, July 7, 1992). Five additional fact sheets also describe SACM and are available by citing the following reference: OSWER Directive 9203.1-05I (Volume 1, Numbers 1-5), December 1992.

☞ TI Guidance: *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (EPA 540-R-93-080, September 1993).

☞ DNAPL II: *DNAPL Site Characterization* (OSWER Publication 9355.4-16FS, September 1994).

☞ Remedy Updates Guidance: *Superfund Reforms: Updating Remedy Decisions* (OSWER Directive 9200.0-22, September 27, 1996).

☞ Ground Water Presumptive Strategy: *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (EPA 540-R-96-023, October 1996).

☞ CSGWPP Directive: *The Role of CSGWPPs in EPA Remediation Programs* (OSWER Directive 9283.1-09, April 4, 1997).

☞ Natural Attenuation Guidance: *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (OSWER Directive 9200.4-17, DRAFT).