Technical Impracticability Assessments: Guidelines for Site Applicability and Implementation

PHASE II REPORT

Prepared for

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EXECUTIVE SUMMARY

This document provides guidance to decision makers at Army facilities to encourage the use of technical impracticability (TI) assessments to optimize resource allocation at groundwater contaminated sites. Depending upon the regulatory program directing the groundwater cleanup, and depending upon the stage of the cleanup, a TI assessment can be the basis for both technical and institutional decisions to reduce costs while continuing to comply with regulatory requirements and the agreed upon future uses of the site in question.

This document addresses several issues related to TI assessments based on a systematic evaluation of the Superfund TI Waiver process, including identification of all sites that have obtained TI Waivers in the past, researching available information regarding those sites, and interviewing EPA and state regulatory personnel. The main issues addressed in this document are: the benefits of performing TI assessments; appropriate timing for integrating TI assessments into site cleanup programs; characteristics of a successful TI assessment; the key factors to be evaluated in assessing TI considerations, and recommendations for Army Remediation Project Managers and Base Environmental Coordinators at Army sites where aquifer restoration is likely technically impracticable.

The major findings and recommendations regarding the use of TI are as follows.

- Groundwater restoration, usually defined as achieving drinking water standards where the groundwater is considered a potential source of drinking water, is impracticable at most highly complex sites, especially those sites with large amounts of dense non-aqueous phase liquids (DNAPLs) in certain geologic settings. At all sites considered “complex” because of contaminant and hydrogeologic characteristics, TI assessments should be incorporated into the selection and implementation process for the overall site remediation strategy.
- Technical impracticability of groundwater remediation is formally recognized by the EPA and many state regulatory agencies, and the use of TI Waivers at CERCLA sites has reportedly resulted in cost savings, while meeting overall objectives of protecting human health and the environment. Site managers should be aware of the legal framework, requirements, and guidance for conducting TI assessments and incorporating these assessments in the development of overall groundwater remediation strategies. Site managers should utilize past experiences with TI assessments, such as the use of the TI Waiver process at CERCLA sites, as summarized in this document.
- TI assessments can be completed and integrated into a site remediation strategy at any point in time during the remediation sequence, once sufficient site characterization data are available. In the TI Waiver process, the majority of waivers have been “front-end”, that is, prior to the selection and implementation of a remediation system. Thus, the Army should undertake TI assessments at the earliest possible stage of the remediation process.

- Where TI Waivers have been approved at CERCLA sites, geologic complexity combined with the presence of DNAPLs were the most common reasons for the determination of TI. Site characterization efforts should be designed to assess the restoration potential of the aquifer (i.e., a TI Assessment), taking into account the factors that have been shown to control whether restoration is practicable.
- A determination of technical impracticability following implementation of a remedy cannot be based on improper design or improper operation of the remediation system. For those sites where a remediation system is in place (e.g., a pump-and treat system), a determination of whether the system has been designed properly, and is operating in an optimum manner will be required before determining if a TI determination is appropriate for the site.
- Recent and ongoing debates on the capabilities of new and emerging subsurface remediation technologies to remove DNAPL from source zones indicate that partial source depletion of DNAPL may provide benefits compared to containment strategies, but the extent of partial source depletion needed to meet RAOs is in dispute and uncertain. Site managers should consider the most recent research findings on the potential benefits of partial source depletion at DNAPL sites, and determine whether the potential benefits alter the determination for the technical impracticability of aquifer restoration.
- Although the technical impracticability of restoration of contaminated aquifers is well recognized, the integration of TI assessment into site remediation strategies is limited. For example, TI Waivers have only been used at 48 of the over 1400 CERCLA sites. Site managers should recognize the barriers to incorporation of TI assessments into development of site cleanup strategies and incorporate communication strategies to overcome these barriers where appropriate.
- Successful use of TI assessments as part of a site strategy, such as application for TI Waivers at CERCLA sites, depends on early and frequent discussions with the regulatory community and other stakeholders, and on maintaining a high level of credibility with these stakeholders. As part of the management of the process, site managers are encouraged to develop a communications strategy with regulators and other stakeholders to ensure that TI considerations are adequately addressed, evaluated, and used effectively in decision making. The use of external advisory or expert panels throughout the process may be appropriate at large sites with high (>$ 10 million life cycle estimates) projected costs.
- The extent of documentation and analysis required to demonstrate technical impracticability of groundwater restoration is site specific, and the extent of implementing quantitative tools, such as groundwater models and performance assessment models to confirm TI, is increasing. Where appropriate, quantitative tools should be encouraged to support TI assessments.

1. INTRODUCTION AND OVERVIEW

The U.S. Army ("Army") and other branches of the Department of Defense ("DoD") are faced with difficult technical, institutional and financial challenges to manage the remediation of soil and groundwater contamination at military bases throughout the U.S. and abroad. One of the greatest challenges is the remediation of contaminated groundwater (aquifer restoration), particularly where subsurface contaminants are difficult to locate and remove. Over the past two decades, the Army has committed substantial financial resources to meet this challenge. To be successful, the Army must comply with regulatory requirements, but also must meet legal mandates to administer public funds prudently, taking costs and benefits into account.

The primary goals of the U.S. Environmental Protection Agency ("EPA") for groundwater remediation are stated in the *National Oil and Hazardous Substances Pollution Contingency Plan*, known as the "NCP," as follows.

> "EPA expects to return usable groundwater to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is **not practicable**, [emphasis added] EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction."

To meet this goal, remedial actions at contaminated groundwater sites have usually addressed both source areas and the associated contaminant plumes with "pump-and-treat" as the technology of choice. While the pump-and treat-technology has been very successful at containing the migration of contaminants in groundwater, this technology is usually unable to remove the necessary amount of contaminant mass from groundwater to achieve the expectation of aquifer restoration to beneficial uses within reasonable time frames.[1]

These limitations of the pump-and-treat technology for many groundwater contaminant scenarios have been well recognized since the late 1980s. Despite advances in technologies applicable to groundwater remediation (many termed "innovative" technologies), aquifer restoration for sites with complex geologic and contaminant characteristics has rarely been achieved. Thus, if groundwater restoration is impracticable at these complex sites—and there is general agreement in the technical and regulatory communities that restoration of groundwater at many sites is likely "technically impracticable"—then alternative cleanup strategies must be considered and implemented. As will be discussed in this document, these alternative strategies may involve one or more of the following components.

[1] A "reasonable time frame" is sometimes generically applied to be 100 years. However, there is no accepted definition of "reasonable" as applied to groundwater restoration because it dependent on the applicable technologies and site-specific conditions such as hydrogeology.

- Modification to the remedial action objectives in some portion of the contaminated aquifer (including waiving certain requirements).
- Implementation of technologies to achieve partial removal of contaminants located within the "source area" (mass removal "to the extent practicable").
- Implementation of technology options only for the dissolved contaminant plume.
- Establishment of acceptable long-term institutional procedures to assure achievement or maintenance of remedial action objectives ("RAOs").

EPA formally recognized the limitations on groundwater restoration with the publication of guidance on Technical Impracticability ("TI") Waivers in 1993 (EPA, 1993). TI Waivers are one of the six waivers of applicable, relevant or appropriate requirements ("ARARs") as defined in the NCP that are allowed under the federal Superfund statute to modify remedial action objectives.[2] The limitations on groundwater restoration have also been addressed in the corrective action program under the Resource, Conservation and Recovery Act ("RCRA") and by various state initiatives. Despite this recognition of the technical limitations to groundwater restoration at many sites, the use of TI Waivers at Superfund sites, or the implementation of a TI approach at other sites, has been quite limited.

Malcolm Pirnie has been retained by the Army Environmental Center ("AEC") to prepare a document that provides guidance to decision makers at Army facilities to encourage the use of TI assessments to optimize resource allocation at groundwater contaminated sites. Depending upon the regulatory program directing the groundwater cleanup, and depending upon the stage of the cleanup, a TI assessment can be the basis for both technical and institutional decisions to reduce costs while continuing to comply with regulatory requirements and the agreed upon future uses of the site in question.

1.1 SUMMARY OF ARMY SITES WITH INTRINSIC LIMITATIONS TO GROUNDWATER RESTORATION

An AEC review of environmental cleanup efforts at 127 Army installations with a projected cost-to-complete greater than $1 million per installation indicated that aquifer restoration may be technically impracticable at approximately 25 percent (34 sites) of those installations (Department of Defense, 1999). The projected life-cycle costs for these installations are approximately $3 billion, or 50 percent of the Army's total projected environmental restoration costs ($6 billion in FY98 constant year dollars, as reported in the FY99 Report to Congress). Many of these sites are located in areas underlain by highly complex geology, including karst and/or fractured rock aquifers. The presence of a separate organic liquid phase (i.e., dense-non-aqueous phase liquids or "DNAPLs") further limits the ability to cleanup these sites. Thus, TI assessments would be appropriate for many Army installations.

[2] CERCLA 121(d)(4)(a) through (f).

1.2 TECHNICAL IMPRACTICABILITY ASSESSMENTS

A number of options are available to Army site managers to conduct TI assessments as part of implementing an overall site remediation strategy such that resource allocation can be optimized. For Superfund sites, the TI Waiver option offers a site manager the opportunity to establish a remedial program that is both protective of human health and the environment but is likely to achieve RAOs. This invariably will lead to selection of a remedial strategy that provides cost savings compared to the use of aggressive *in-situ* technologies that may not be cost effective or technically practicable. EPA also recognized this benefit from early consideration of TI in the history of a cleanup project as described in the *Presumptive Response Strategy* document for Superfund sites (EPA, 1996). For RCRA sites, an acknowledgement of technical limitations to groundwater cleanup can be made as part of the corrective action decision.

Even though these mechanisms exist for incorporating TI considerations into groundwater cleanup strategies, barriers exist that have limited the use of this approach at many sites. For example, although the TI Waiver option has existed for a number of years as specified in the Superfund Amendments and Reauthorization Act (SARA) of 1986, and the EPA guidance of 1993, only 48 CERCLA sites have approved TI Waivers out of 1,232 CERCLA sites listed on the NPL in 2000. As will be discussed in this document, the factors that may have contributed to the relatively small number of sites with TI Waivers may include one or more of the following.

- Lack of knowledge of the process.
- Reluctance of regulators to accept the TI Waiver approach.
- Perception that data requirements to establish TI are too expensive.
- Skepticism on part of the site management that a TI Waiver is a realistic option.
- Resistance or reluctance on the part of one or more stakeholders, including fear of negative public perception.
- Lack of recognition of potential benefits of a TI Waiver.

1.3 APPROACH

At the request of AEC, Malcolm Pirnie, Inc undertook a systematic evaluation of one approach to addressing TI issues at groundwater sites, namely, the Superfund TI Waiver process. Library and online searches were performed to identify and obtain copies of all documents containing information about the TI Waiver application and approval process. Research efforts were extended to identify all Superfund sites that had obtained TI Waivers in the past. The Superfund Public Information System (SPIS) was obtained with the full text of all Records of Decision ("RODs") issued between 1982 and 2001 as well as Explanation of Significant Differences

("ESDs") and 118 ROD Amendments. Persons in the EPA, state hazardous waste division offices, and other organizations were identified and contacted. Selected EPA and state personnel were then interviewed via telephone. EPA headquarters personnel then reviewed the final draft of this document and provided comments that were used to revise the document. The document, however, does not necessarily represent the views of EPA.

Based on this research, detailed site summaries were prepared for all CERCLA sites with TI Waivers. Historical data from the sites reviewed were used to identify site characteristics supporting the request for a TI Waiver (i.e., under what site conditions have TI Waivers have been granted?). Other relevant issues addressed during the data review and EPA staff interviews included the following.

- Primary basis for granting the TI Waiver.
- Timing of the waiver application in the context of the remediation process at the site.
- Estimated cost savings resulting from granting the TI Waiver.
- Reasons why TI waivers have been only infrequently requested by site owners.
- Extent of documentation required for a successful TI waiver application.
- Effective management of integrating TI considerations into the site cleanup strategy.

The detailed results of this evaluation are presented in the appendices of this document, and include a systematic analysis of all factors related to TI Waivers (Appendix A), tabular summaries of the characteristics of each of the 48 sites with TI Waivers (Appendix B), copies of relevant regulatory guidance documents (Appendix C), and summaries of telephone interviews with regulatory personnel (Appendix D).

1.4 OBJECTIVES OF DOCUMENT

The objective of this document is to provide guidance to Army site decision makers on how to use TI assessments to develop and implement an optimum strategy for cleanup of contaminated groundwater. The scope of the document addresses the following issues.

1. Benefits of incorporating TI assessments into a site cleanup strategy, as exemplified by the TI waiver process.
2. Appropriate timing for integrating TI assessments into site cleanup strategies.
3. Characteristics of a successful TI assessment, and the key factors to be evaluated in assessing TI considerations at groundwater impacted sites.
4. Recommendations for Army Remediation Project Managers (RPMs) and Base Environmental Coordinators (BECs) at Army sites where aquifer restoration is likely technically impracticable.

2. TECHNICAL IMPRACTICABILITY (TI) - DEFINITION AND CONTEXT

The past two decades have seen substantial progress in the nation's efforts to eliminate exposure pathways for hazardous chemicals in the subsurface that could reach human or ecological receptors. At sites with contaminated groundwater, pump-and-treat technologies have been installed to limit (contain) the migration of hazardous chemicals. However, at most groundwater contaminated sites, few success stories have been noted. Even with the implementation of enhancements to pump-and-treat, and the development of newer, innovative technologies to expand the number of technical strategies available for groundwater cleanup (e.g., NRC, 1994; NRC, 1997; NRC, 2000), it is not technically practicable to meet cleanup standards at many sites.

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These technical limitations have been widely recognized by the scientific and regulatory communities, and language in both federal and state statutes for groundwater cleanups consider these limitations. For example, 28 case studies presented by EPA (EPA, 1999a) showed that geologic complexity and technical impracticability were the factors responsible for controlling the cost and performance of remediation systems. Also, CERCLA legislation[1] incorporated the concept of technical impracticability which states that EPA may select a cleanup level that does not meet any ARAR, standard, or limitation if EPA makes a finding that compliance with such requirements is technically impracticable from an engineering perspective. EPA incorporated this concept in the revised version (revised as of July 1, 1998) of the NCP—a remedial "alternative that does not meet any ARAR under federal environmental or state environmental or facility citing laws may be selected… [if] compliance with the requirement is technically impracticable from an engineering perspective."[2] Additionally, a preliminary review of available information indicates that a minimum of seven states and the District of Columbia consider technical impracticability in their corrective action

[1] Section 121(d)(4) of CERCLA.
[2] 40 CFR Sec 300.430(f)(1)(ii)C)(3).

policies. California's State Water Resources Control Board (SWRCB) has instituted a "Containment Zone Policy" that is essentially a technical impracticability policy (AEC, 2002).

In this chapter, we discuss the various factors that influence a technical impracticability assessment, regardless of the regulatory program in question. We use the TI Waiver process to illustrate many of the factors that must be accounted for, and discuss, based on our TI Waiver research, the advantages and disadvantages of incorporating such an assessment into a cleanup strategy. The information presented in this chapter is consistent with EPA guidance on TI Waivers (EPA, 1993), EPA's *Presumptive Response Strategy for Contaminated Ground Water at CERCLA Sites* (EPA, 1996), and various state policies that have addressed the issue of technical impracticability for groundwater cleanups.

2.1. DEFINITION OF TECHNICAL IMPRACTICABILITY

EPA or state regulatory agencies have not developed a precise definition of "technical impracticability" with respect to groundwater cleanup. Rather, EPA has defined a process for determining whether achieving remedial action goals for contaminated aquifers is impracticable from an engineering perspective. The process and the types of data required to answer the TI question are outlined in EPA guidance documents (EPA, 1993; EPA, 1995; EPA, 1997c).

Since publication of various EPA guidance documents on the use of TI assessments to accelerate groundwater cleanup in the mid 1990s, however, new and innovative technologies for groundwater remediation have been developed and tested in the field (e.g., NRC, 1997; NRC, 2000), including thermal approaches, surfactant and co-solvent flushing, and *in-situ* chemical oxidation techniques. EPA's Technology Innovation Office (TIO) in the Office of Solid Waste and Emergency Response (OSWER) and other organizations (e.g., ITRC) have compiled performance and cost information on innovative technologies applied to groundwater cleanups for complex sites (e.g., see a recent compilation of application of thermal technologies for source remediation at chlorinated solvent sites: EPA, 2003). Thus, the definition of "technical impracticability from an engineering perspective" is site-specific and changes as technologies for subsurface remediation evolve and improve.

2.2. TI WAIVERS

One approach for addressing technical limitations to groundwater cleanup is the TI Waiver process authorized under the Superfund Amendments and Reauthorization Act of 1986 (SARA). A TI Waiver is a waiver of groundwater cleanup requirements (i.e., it is a waiver of ARARs under CERCLA) for a specific contaminant(s) within a given area(s) of a site (i.e., the defined "TI Zone") due to the technical impracticability from an engineering perspective of restoring groundwater to meet the ARAR. One of two criteria needs to be met in order to apply for a TI Waiver: (1) engineering infeasibility, and (2) unreliability (EPA, 1993). A remedial action can be considered infeasible from an engineering perspective if current engineering methods designed to meet the ARAR cannot be reasonably implemented. An action can be considered unreliable if it is shown that existing remedial alternatives are not likely to be protective in the future. Together, these two criteria define the term "technical impracticability from an engineering perspective". Furthermore, a TI Waiver would only be granted if cleanup could be demonstrated to be not achievable within a reasonable time frame[3], using the best technology available.

There is no comparable waiver of a cleanup standard under the federal RCRA program. Since there are no equivalent promulgated standards in RCRA to CERCLA ARARs, there are no federal RCRA standards to waive due to technical impracticability considerations. This allows much flexibility for RCRA corrective actions. EPA's *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action* (EPA, 2002) describes how the federal RCRA program allows setting site-specific groundwater cleanup standards based, in part, on the technical limitations to groundwater restoration.[4]

2.3. TIMING OF TI ASSESSMENTS

TI assessments can be initiated once sufficient site characterization data are available to assess the restoration potential of the contaminated aquifer. For the TI process under CERCLA, EPA can grant a TI Waiver during any portion of the CERCLA remedial process, as long as impracticability has been clearly demonstrated. The EPA designates two categories for TI Waivers, based on the stage of a site's environmental restoration program:

1. Front-End TI Waivers
2. Post-Implementation TI Waivers

If an interim or final full-scale remediation system has already been installed and operated prior to the waiver, the waiver is known as Post-Implementation TI Waiver. If the waiver is based on site characterization or pilot-scale data (i.e., at the RI/FS stage of the CERCLA process), it is called a Front-End TI Waiver. Front-end waivers are incorporated into the original CERCLA Record of Decision (ROD. Post-implementation waivers are documented in a CERCLA ROD

[3] A reasonable timeframe for restoring groundwater to beneficial uses depends on the particular circumstances of the site and the restoration method employed. A comparison of restoration alternatives from the most aggressive to passive will provide information concerning the approximate range of time periods needed to attain groundwater cleanup levels. An excessively long restoration timeframe, even with the most aggressive restoration methods, may indicate that groundwater restoration is technically impracticable from an engineering perspective (EPA, 1996).
[4] Examples of RCRA cleanup goals that have been set with the acknowledgement of technical limitations to groundwater restoration (and groundwater use) are given on USEPA's corrective action website.

amendment.[5] The distinction between post-implementation and front-end TI decisions is shown on Figure 2-1.

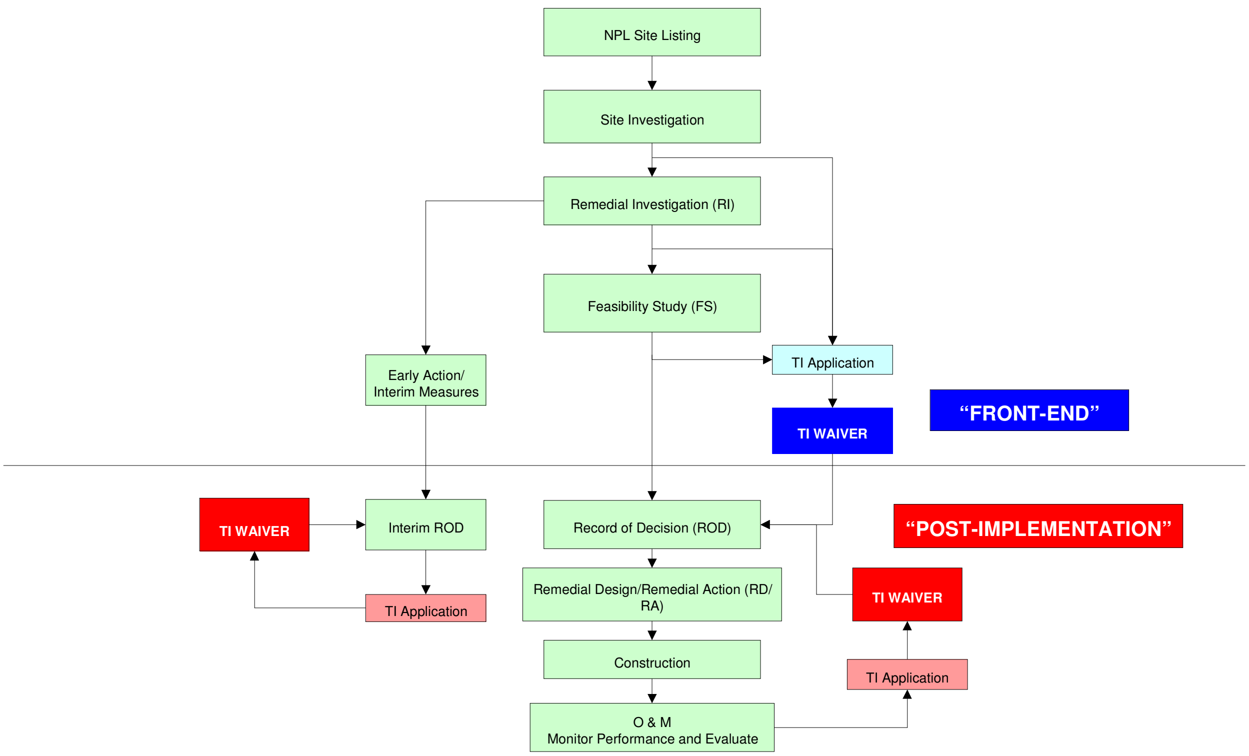

Figure 2-1: TI Waivers in the CERCLA Process.

[5] For additional information on decision documents used for making changes to Superfund remedies, refer to Chapter 7 of the EPA guidance document *Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents* (commonly referred to as the "ROD Guidance") dated July 1999 (OSWER Memorandum 9200.1-23P, EPA/540/R-98/031). Also, Chapter 9 of this document provides specific recommendations on how a TI Waiver should be documented in a ROD or ROD Amendment.

A Front-End TI Waiver requires a different data basis for justification than a Post-Implementation TI Waiver, since no full-scale performance data are available for the site. Justification is based on site characterization results (Remedial Investigation/Feasibility Study [RI/FS] under CERCLA or RCRA Facility Investigation/Corrective Measures Study [RFI/CMS] under RCRA), modeling and/or pilot study data that have been incorporated into a conceptual site model (CSM). It may be theoretically easier to support a Post-Implementation TI Waiver, because EPA previously approved the selected remedial action, and site data would be available to demonstrate that ARARs cannot be met in a "reasonable" time frame. However, as part of the justification for the TI Waiver, it is necessary to show that the technology was correctly implemented, and the cause of the "failure" is due to technical impracticability instead of an improperly designed or operated system—inadequate design or operation does not constitute technical impracticability (see EPA, 1993 for further discussion of this issue).

Our study of the data used to determine TI Waivers at the 48 CERCLA sites summarized in Appendices A and B indicates that full-scale operation of a remediation system was not necessarily needed to support the TI Waiver application. In fact, the majority of sites (35 of the 48 sites, or 73%) received TI Waivers before implementing a full-scale remediation system.[6] This may be quite surprising, noting that the EPA guidance document (EPA, 1993) stated that post-implementation TI Waivers were preferable "because it is often difficult to predict the effectiveness of remedies based on limited site characterization data alone" (EPA, 1993). Nonetheless, our research indicates that a front-end TI Waiver application is a generally accepted approach. Subsequent EPA guidance on this issue (EPA, 1996) regarding groundwater cleanup at Superfund sites encouraged the earliest consideration of TI in the evolution of an overall cleanup strategy for groundwater at sites exhibiting TI characteristics.

2.4. BENEFITS AND POTENTIAL BARRIERS

2.4.1. Benefits of TI Assessments

The benefits of TI assessments have been demonstrated through the TI Waiver process. As noted in Appendices A and B, of the 48 TI Waivers granted, substantial cost savings were documented for some of the sites relative to alternative strategies following implementation of the revised remedial action strategy developed after approval of the TI Waiver compared to alternative strategies. Table 2-1 is a summary of these projected cost savings that were documented in the materials reviewed in preparation of this report. A Front-End TI Waiver potentially provides the greatest financial benefit because it avoids the implementation of costly remedial actions that have a high risk of failure to achieve the site RAOs in a reasonable timeframe.

[6] It should be noted here that nearly a third of the TI Waivers were issued prior to the 1993 guidance document. Thus, it cannot be known if these Front-End TI Waivers would have been granted after the guidance document was implemented. However, the guidance regards Front-End TI determinations as an acceptable approach.

Table 2.1: Examples of Reported Cost Savings due to TI Waiver (see Appendix A for details).

TI Waiver Site No.	Site Name	Type of TI Waiver	Cost Savings due to TI Waiver
3	South Municipal Water Supply Well Site, NH	Post-Implementation	$3.5M over 30 years (original estimate was $7.4M present worth).
4	Pease Air Force Base, NH	Front-End	$4.0M in potential remedial costs.
14	Rodale manufacturing Company, PA	Front-End	$4.2M with TI Waiver; $100M to $488M without.
33	Oronogo-Duenweg Mining Belt, MO	Front-End	Approximately $60M to $90M saved due to TI Waiver.
37	Silver Bow Creek/Butte Area, MT	Front-End	At least $350M to $450M saved due to TI Waiver (perhaps much more).
48	Eielson Air Force Base, AK	Post-Implementation	$1.19M with TI Waiver; $9.86M without TI Waiver.

NOTE: the largest projected savings were at mining sites where the size of the groundwater plumes are immense.

Another significant benefit to the early use of TI assessments, as illustrated by the use of TI Waivers, is that their approval, or even evaluation for approval, provides an acknowledgement of the technical impracticability of groundwater restoration at the site in question. Once such an acknowledgement is made, with agreement from all stakeholders, RAOs that are likely to be achieved can be established, and alternative strategies can be evaluated and implemented.

2.4.2. Potential Barriers to the Use of TI Assessments

Although benefits of incorporating TI considerations such as a TI Waiver into the development of a groundwater cleanup strategy have been demonstrated, numerous barriers to this approach exist. For example, as noted, use of a TI Waiver process at CERCLA sites has been quite limited over the past decade. The following summary of these barriers and approaches to overcome these barriers is based on interviews with EPA and other regulatory personnel (summaries of which are included as Appendix D).

<u>Lack of willingness to pursue TI Waivers.</u> Our study found that the EPA Regional Project Manager (RPM) for a site must support a TI assessment early in the process in order to increase the likelihood of approval for a TI Waiver application. In general, EPA Headquarters personnel are more supportive of TI Waivers than Regional personnel, but the decision-making rests with the Regions. The various EPA Regions have differing views on the use of TI Waivers, regardless of guidance documents meant to standardize the approval and implementation of TI Waivers. Based on these interviews, there is some reluctance to support TI Waivers because of public opposition, and perhaps increased transactional costs and delays caused by application for a TI Waiver. This barrier can best be addressed, but not necessarily overcome, by working closely with the EPA RPM from project initiation, and if needed, procuring advice from EPA Headquarter personnel proficient in technical impracticability issues early in the process.

A Front-End TI Waiver requires a different data basis for justification than a Post-Implementation TI Waiver, since no full-scale performance data are available for the site. Justification is based on site characterization results (Remedial Investigation/Feasibility Study [RI/FS] under CERCLA or RCRA Facility Investigation/Corrective Measures Study [RFI/CMS] under RCRA), modeling and/or pilot study data that have been incorporated into a conceptual site model (CSM). It may be theoretically easier to support a Post-Implementation TI Waiver, because EPA previously approved the selected remedial action, and site data would be available to demonstrate that ARARs cannot be met in a "reasonable" time frame. However, as part of the justification for the TI Waiver, it is necessary to show that the technology was correctly implemented, and the cause of the "failure" is due to technical impracticability instead of an improperly designed or operated system—inadequate design or operation does not constitute technical impracticability (see EPA, 1993 for further discussion of this issue).

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[6] It should be noted here that nearly a third of the TI Waivers were issued prior to the 1993 guidance document. Thus, it cannot be known if these Front-End TI Waivers would have been granted after the guidance document was implemented. However, the guidance regards Front-End TI determinations as an acceptable approach.

Lack of acceptance by states. Our study found that the states are reluctant to accept a TI determination, and in general, states are not supportive of any kind of ARAR waivers, including the TI Waiver. In general, for a state agency to accept a TI Waiver, the site must be "atypical" from the state's point of view. For example, TI Waivers have been granted at mining sites with state approval, primarily due to the immense size, cost, and scope of the contamination problems at these sites. Also, states have been reluctant to consider use of TI Waivers at Superfund sites because they view TI Waivers as permanent ARAR waivers (see Section 2.5 below). Overcoming this potential barrier is possible by working closely with the EPA RPM and state personnel from the beginning, and if needed, procuring counsel from EPA Headquarter TI Waiver experts.

Perception of a burdensome process. Our study found that the TI Waiver process is perceived by some to be burdensome, time consuming, and costly, which stems from the process being poorly understood. However, our study also indicated that the amount of supporting assessment for a TI assessment varied significantly over the 48 sites investigated.

Lack of confidence in a successful TI Waiver application. Our study indicated that some facility owners/operators have the view that TI Waivers are rare and thus there is the perception that an effort to change RAOs by an assessment of technical impracticability will likely fail.

Lack of funding for adequate data collection and assessment. Our study found that "Pipeline Funds", those monies used to perform site discovery, RI, and FS work, are in short supply in CERCLA compared with monies that can be used for active remediation. Thus, since a relatively high level of site investigation may be required for a TI Waiver, especially in the case of a Front-End TI Waiver, lack of funding may be a critical barrier to the use of a TI Waiver at many sites with TI characteristics.[8]

2.5. MISCONCEPTIONS ABOUT TI WAIVERS

Our study highlighted the following three major misconceptions about TI Waivers.

1. A TI Waiver alleviates all liabilities and responsibilities of the responsible party.
2. A TI Waiver deletes all contaminants from cleanup requirements.
3. A TI Waiver removes the entire site from cleanup requirements.

While recognizing the limitations to remediation at specific sites, the EPA has emphasized that the designation "technically impracticable" is temporal since technical capabilities for groundwater cleanup may improve with time, and the EPA guidance states that a TI Waiver is

[8] It should be noted that a relatively high level of site investigation may also be required to support a remedial design. However, the point of emphasis here should be that in the case of a prospective TI Waiver site (Front-End TI Waiver), the site characterization effort required would not be followed by remedial design and implementation.

subject to future review. It is important to note however that according to our research, no TI Waiver has yet been retracted for any reason. And, CERCLA 5-year reviews address the protectiveness standard of the alternative remedial strategy at a site with a TI Waiver, not the waiver itself.

Regarding the last two misconceptions, a TI Waiver is, by definition, both contaminant-specific and location-specific. Thus, a TI Waiver is constrained to one or more contaminants at one or more specific areas of the site. A TI Waiver may not necessarily apply to all site contaminants or to an entire aquifer zone at the site. If multiple contaminants exist in an area, but only one contaminant is technically impracticable to remediate, then only one contaminant will be included in the TI Waiver. The portion of the site designated for the TI Waiver (volume of the site based on aerial and vertical extent) is known as the TI Zone. Any contaminated aquifer zones outside of the TI Zone may still be subject to ARARs.

2.6. GUIDANCE FOR EVALUATING TECHNICAL IMPRACTICABILITY

2.6.1. Federal

In 1993, after several TI Waivers had been approved and implemented, the EPA attempted to clarify the process of granting TI Waivers with a guidance document for evaluating technical impracticability titled *Guidance for Evaluating Technical Impracticability of Groundwater Restoration* (EPA, 1993) (included in Appendix C of this report). This document gives guidance for evaluating technical impracticability, and how to use this evaluation for an application for a TI Waiver. Still used as EPA's primary guidance document for technical impracticability issues, the document focuses on site characteristics that may lead to a determination of technical impracticability, and the TI evaluation and review process. Furthermore, this guidance document formally recognizes the need for TI Waivers, and explains how they fit into the CERCLA and RCRA processes. It clarifies EPA's approach for determining whether or not complete restoration is technically practicable at a site. The site characteristics that increase the difficulty of groundwater restoration comprise hydrogeologic factors and contaminant-related factors. These factors are discussed in detail in Chapter 3 of our report.

EPA subsequently issued a 1995 "Implementation Memorandum": *Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Groundwater Restoration at Superfund Sites (OSWER Directive 9200.4-14)* (EPA, 1995) (included in Appendix C of this report). This implementation memo attempted to standardize the decision-making process and implementation of TI Waivers. Other regulatory agencies have since provided guidance on TI Waivers or other approaches to TI considerations. For example, in 1997, EPA Region 7 issued it's own Region-specific TI Waiver guidance document, titled *Ground Water Technical Impracticability Decision Making* (EPA, 1997b) (included in Appendix C of this report). It is essentially a streamlined version of the 1993 guidance document.

2.6.2. States

A TI Waiver can be implemented in any state where a state agency is the lead agency. In addition, some states specifically incorporate TI in their own regulatory frameworks. A preliminary review of available information indicates that a minimum of seven states and the District of Columbia consider TI in their corrective action policies. Also, California has a "Containment Zone Policy" that is essentially a TI policy.

In Texas, TI may be used for certain classes of groundwater and a TI demonstration is to be submitted to the state in a Remedial Action Plan (RAP) that meets criteria established for Texas National Resource Conservation Commission (TNRCC) approval. The PRP must demonstrate that it is not feasible from a physical perspective using currently available remediation technologies due either to hydrogeologic or chemical-specific factors to reduce the concentration of contaminants of concern throughout all or a portion of the groundwater "Protective Concentration Levels Exceedance" zone to the state's Protective Concentration Levels (PCLs) within a reasonable timeframe. The PRP is required to restore groundwater to PCLs to the extent practicable and establish a "Plume Management Zone" (PMZ) for the portion that cannot be restored.

In Missouri, a cleanup guidance document, "How Clean is Clean?" developed by the state's Department of Natural Resources (DNR) has been adopted as a guide for site remediation. If meeting cleanup standards is shown to be technically impracticable, or site conditions render cleanup standards inappropriate, a second tier of cleanup standards may be used. Thus, this incorporation of TI is similar to CERCLA Alternate Concentration Limits (ACLs) rather than a TI Waiver.

In Illinois, the state EPA incorporates consideration of TI through its Risk-Based Corrective Action (RBCA) policies. There are a wide variety of tools in the state's tiered approach to cleanup level development to address site risks, which include the consideration of TI.

In Mississippi, the USEPA's TI guidance (EPA, 1993) may be used in developing a demonstration of TI with regard to groundwater and soil remediation, free product removal, and other site-specific conditions approved by the Mississippi Department of Environmental Quality (MDEQ).

In the District of Columbia, the Department of Consumer and Regulatory Affairs, UST Branch, allows Remediation by natural Attenuation (RNA) as a possible remedial measure if TI can be demonstrated.

In Georgia, PRPs are allowed to use institutional controls as part of an overall cleanup strategy when contamination cannot be removed due to TI considerations. In North Caroline, PRPs may elect to place property use restrictions and limit cleanup to levels corresponding to the restricted use in cases where TI of active groundwater remediation can be shown. In Wyoming, TI is a component of the state's "Brownfields Bill" (Senate File 147), passed in March 1999.

In Connecticut, if the remediation of groundwater has reduced the concentration of contaminants to the groundwater protection criteria, which are applied based on the use classification assigned to the groundwater in Connecticut's Groundwater Quality Regulations, and further remediation to reduce concentrations is technically impracticable, further remediation would not be required.

In California, a "Containment Zone" (CZ) may be considered by the state's Regional Water Quality Control Boards (RWQCBs) for a site, or a portion of a site, where cleanup of contamination to applicable water quality objectives (WQOs) is technically and or economically infeasible. The PRP must provide information on the amount of contaminant reduction that *is* technically and economically achievable, whether such reduction will significantly reduce the concentration of contaminants, the volume of the CZ or the level of maintenance required, and the availability of funds to manage the CZ for as long as contamination remains at the site. The PRP must also develop a management plan to contain the remaining plume of groundwater contamination, to monitor containment, and to provide contingency actions should containment fail. TI Waivers by the USEPA or the State of California Department of Toxic Substances Control (DTSC) are deemed equivalent to a CZ if substantive requirements of the CZ Policy are met. This CZ Policy was adopted after two years of contentious hearings and workshops. Similar to the USEPA's anticipation of a large number of applications for TI Waivers, the California RWQCBs anticipated a large number of CZ applications. However, very few CZs (reported to be less than five) have been granted for dischargers in California.

2.7. APPLICATION OF TECHNICAL IMPRACTICABILITY AS A PRESUMPTIVE APPROACH

Even with federal guidance documents in place and additional incorporation of TI into state guidance, the issue of technical impracticability remains a very site-specific issue. Our study of TI Waivers granted at CERCLA sites shows that technical impracticability was an acceptable groundwater remedy component over a wide range of sites with differing levels of hydrogeologic and contaminant complexity that required diverse technical justifications. The only consistent message is that a TI Waiver can be approved when there is "sufficient" information to justify technical impracticability, regardless of the stage of the project.

The fact that the majority of approved TI Waivers occurred before remedial systems were implemented indicates that technical impracticability can be justified on an *a priori* basis, not unlike a presumptive remedy approach to remedial technology implementation. As stated in EPA's *Presumptive Response Strategy* (EPA, 1996), "data from remedy performance are not always necessary to justify an ARAR waiver due to technical impracticability. At the completion of the remedial investigation (RI), site conditions may have been characterized to the extent needed for EPA (or the lead agency) to determine that ground-water restoration is technically impracticable from an engineering perspective." The next chapter discusses in some detail the nature of technical impracticability, where TI assessments can be applied, and how the likelihood for acceptance of a TI assessment or a TI Waiver can be improved.

3. TI ASSESSMENTS

A justification that groundwater restoration is technically impracticable (termed herein as a "TI Assessment") will likely require multiple lines of evidence. EPA policy recommends that the restoration potential (i.e., technical practicability) of groundwater contamination should be assessed prior to establishing objectives for the long-term remedy (EPA, 1996). For example, at a CERCLA site, the evaluation of restoration potential should be undertaken in a phased approach by using both site characterization and remedy performance data (via early and/or interim actions) during the RFI phase of the CERCLA process. This would be akin to an "adaptive site management" approach that promotes effective knowledge generation to provide a wider range of decision options for improved and realistic site management (NRC, 2003). The final result should be the establishment of RAOs that can likely be achieved by the final remedy with no need of an ARAR waiver due to TI.

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The amount of data and analysis required to justify TI for any purpose, including a TI Waiver, is site-specific and cannot be reduced to a generic formula. However, the types of data and analysis required are given in EPA guidance. Also, any assessment of TI should be viewed as a collaborative process between the EPA, other regulatory agencies, and the site owner(s). Thus, the use of a TI assessment in establishing the site remediation strategy should be planned and managed carefully.

3.1. FACTORS INFLUENCING TI

Multiple lines of evidence are generally needed to justify the impracticability of meeting cleanup standards (e.g., RAOs) within a reasonable timeframe. Two factors (limitations to technical practicability) are emphasized by EPA guidance (EPA, 1993) as contributing to TI:

- Contaminant-related factors, especially the presence of contaminants such as DNAPLs.
- Hydrogeologic factors (e.g., complex hydrogeology [heterogeneity]).

EPA recognizes that "locating and remediating subsurface sources can be difficult at certain sites due to complex geology or waste disposal practices," and "there are technical limitations to ground-water remediation technologies unrelated to the presence of a DNAPL source zone. These limitations, which include contaminant-related factors (e.g., slow desorption of contaminants from aquifer materials) and hydrogeologic factors (e.g., heterogeneity of soil or rock properties), should be considered when evaluating the technical practicability of restoring the aqueous plume." (EPA, 1993).

Our study of the 48 CERCLA sites with TI Waivers indicated that this emphasis was followed by TI Waiver petitioners (Appendix A). A total of 21 (44%) of the TI Waivers were granted due to contaminant-related factors, four (8%) of the TI Waivers were granted due to hydrogeologic factors, and nine (19%) additional TI Waivers were granted for a combination of both contaminant- and hydrogeolologic-related reasons. Thus, nearly three-quarters of TI Waivers at CERCLA sites were granted based on contaminant-related and/or hydrogeologic factors. Figure 3-1 (from EPA, 1993) illustrates the contaminant-related and hydrogeologic factors affecting the potential for groundwater restoration.

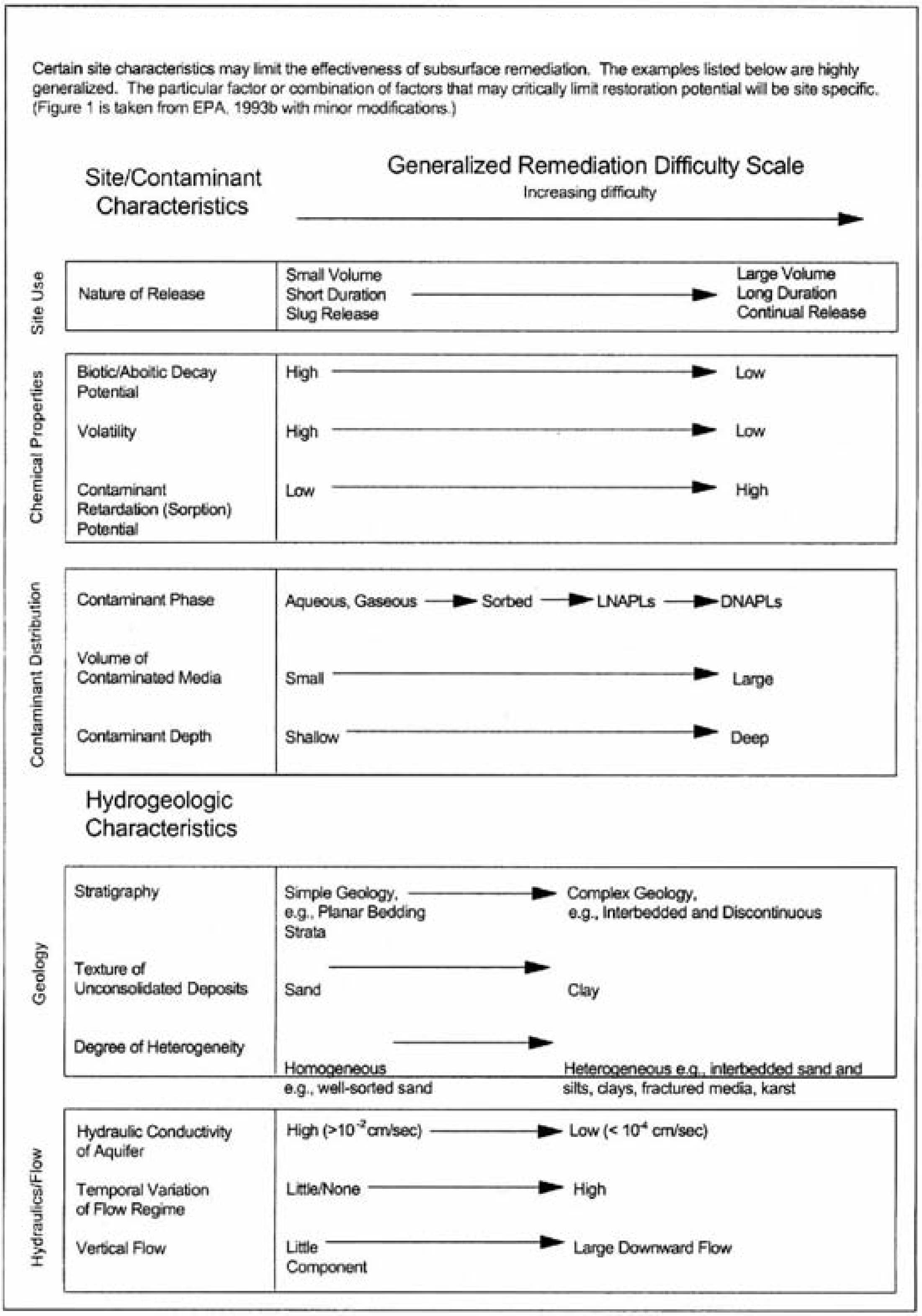
Our study of TI Waivers also identified three additional factors that have been used to justify TI (Appendix A):

- Economic factors (6% of the TI Waivers).
- Physical limitations to remediation (e.g. on-site wetlands or physical structures) (10% of the TI Waivers).
- The state of currently available technology (13% of the TI Waivers).

3.1.1. Contaminant-Related Limitations

Contaminant properties will play a major role in the technical feasibility (or TI) of cleanup, including the contaminant's aqueous solubility, adsorption affinity, interfacial surface tension, and specific gravity. The mass and extent of contamination will also affect cleanup feasibility. Our study of TI Waiver sites found a wide range of contaminants present at these sites: chlorinated solvents (31%), metals (21%), PCBs and coal tar (21%), wood treating chemicals (9%), landfill contaminants (8%), mine wastes (8%), and LNAPL (2%). Additional details are presented in Appendix A.

Figure 3-1: Examples of Factors Affecting Groundwater Restoration Potential (from EPA, 1993)



The most common contaminant-related limitation to the technical practicability of remedial efforts is the presence of the contaminant(s) as dense, mobile or residual organic liquids, known as DNAPLs. EPA has stated "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 be practicably 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." (EPA, 1997). The presence of DNAPLs poses particular problems in site characterization and remediation efforts at Army sites. For example, even though characterization and remedial technologies for DNAPLs have evolved such that substantial contaminant mass may be removed, we have found no cases where sites with significant amounts of DNAPL in complex hydrogeologic zones have been successfully remediated to MCLs in the source zones.

From our study of TI Waiver sites, a majority of the sites with contaminant-related limitations (24 of 30 sites, or 80%) were from the presence of NAPL (DNAPL or LNAPL). This represented 91% of the total number of TI Waiver sites with DNAPL. The most common NAPLs at these sites were chlorinated solvents and their various breakdown products, PCBs and coal tar and pesticides, and wood treatment chemicals.

3.1.2. Hydrogeologic Limitations (Heterogeneity)

The characterization and removal of contaminants, particularly DNAPLs, is particularly difficult at sites with complex hydrogeology. Complex hydrogeologic conditions, as they pertain to aquifer restoration, arise from local variations in porosity, hydraulic conductivity, and other parameters that originate from the natural development of geological systems. Extremely complex hydrogeologic conditions include karst and fractured bedrock, and these conditions are found at many Army sites.

Karst aquifers are distinguished by a number of characteristics that have a significant impact on site investigation and the technical practicability of remediation. These include: (1) non-Darcian flow; (2) watershed perspective; (3) types of flow; and, (4) contaminant distribution. A significant portion of the groundwater flow in karst aquifers may occur in open conduits, thus limiting the accuracy of typical mathematical approaches to characterize groundwater flow. Contaminant movement in karst aquifers will not be easily conceptualized as plumes in the traditional sense (i.e., Darcian flow concepts).

The inability to detect and trace individual open conduits could necessitate an evaluation of the subsurface system on a watershed basis, a scale that is generally too large to yield representative data from individual wells, which forces a groundwater basin perspective on the identification of potential receptors. Aquifers with open conduit flow behave as a system of channels with flow velocities similar to those of surface water streams. Subsurface water flow responds rapidly to recharge (i.e., rainfall) events, and such conditions are the most susceptible to contamination. Conceptual models of contaminant distribution in karst aquifers suggest that residual contaminant storage may occur in the regolith, in the epikarst, in diffuse rock fractures, and in conduits.

Karst aquifers are not the only example of highly heterogeneous hydrogeology, however, they probably present the most complex setting. Fractured bedrock aquifers, and even unconsolidated alluvium, present challenges to characterization and remediation due to relatively high levels of heterogeneity. From our study of the 48 TI Waiver sites, 13 of the TI Waivers were due in part to hydrogeologic limitations stemming from low permeability aquifers, complex alluvial sediments, and fractured bedrock. Demonstrated technical impracticability at four of these sites was primarily based on complex hydrogeology. Additional details are presented in Appendix A.

3.1.3. Economic Limitations

Although cost is not generally viewed as a primary reason for making a TI determination (not mentioned in EPA guidance [EPA, 1993; EPA, 1995]), a remedy may be deemed impracticable if the cost of attaining ARARs is "inordinately high." However, cost is not as important as protectiveness, and compliance with ARARs is not subject to a cost-benefit analysis (EPA, 1993).

Nevertheless, the primary cause of TI can be economic if: (1) meeting ARARs is theoretically possible within a reasonable timeframe; yet (2) the associated cost is "extraordinary." From our study of the 48 CERCLA sites with TI Waivers (Appendix A), it is apparent that "inordinate cost" is defined relative to the particular site—three (6%) of the 48 TI Waivers were granted on the basis of economic limitations. Smaller sites may have a smaller dollar amount that is deemed "inordinate." The benefit gained by the expenditure is taken into account when judging "inordinate cost," even though the EPA stated that cost was not subject to a cost-benefit analysis. Defining an "inordinate cost" is site-specific and will require on-going negotiations with the site regulators.

3.1.4. Physical Limitations

Factors leading to a TI determination were classified as physical for our study of the 48 TI Waiver sites if site-specific limitations such as on-site wetlands, structures, or neighboring sites prevented an existing technology from being applied to address groundwater or soil contamination. A total of five (10%) of the 48 TI Waivers were granted based primarily on such physical limitations (Appendix A). We have found that this limitation was rarely discussed in the other TI Waiver documentation. Nonetheless, given that 10 percent of the TI waivers were granted due to this factor, physical limitations could potentially be a significant basis for TI determination at numerous sites nationwide. Whether this is a significant factor at Army facilities deserves further analysis.

3.1.5. Technology Limitations

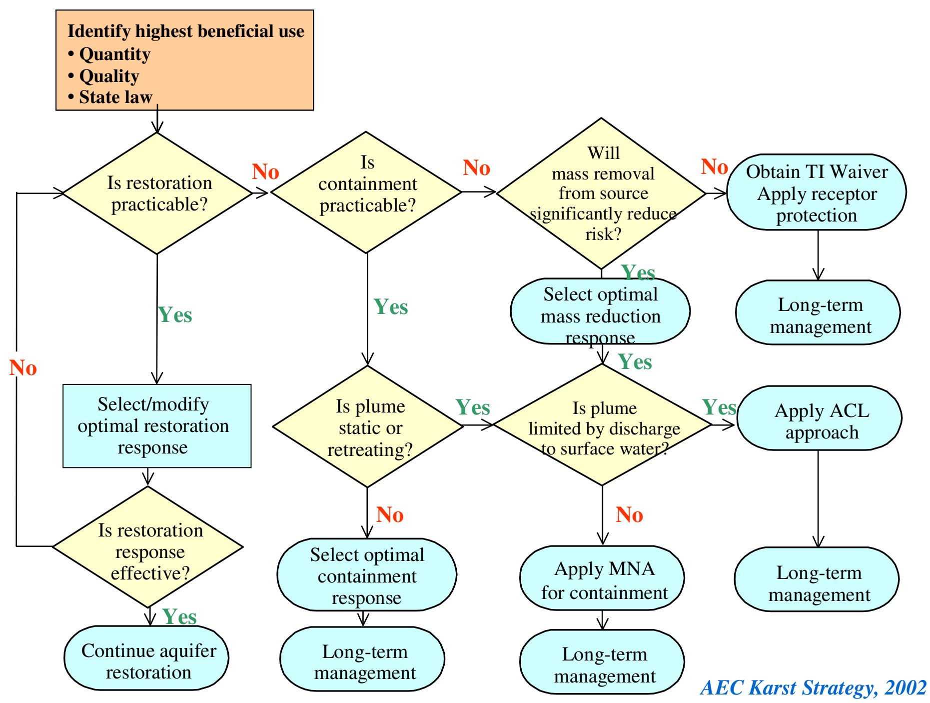
The limitations of subsurface remediation technologies in achieving aquifer restoration are widely recognized, as has been discussed. The current (2003) limitations of available technologies for achieving adequate DNAPL removal from aquifers can be viewed as the controlling barrier to achieving RAOs that include aquifer restoration. Our study found that of the 48 CERCLA TI Waivers, six (13%) of them were granted based on the limitations of subsurface remediation technologies at the time of the waiver application (Appendix A).

3.2. IS TI APPLICABLE TO YOUR SITE?

Several decision diagrams and site scoring systems could be used or devised for the Army to determine, in collaboration with the EPA, whether TI is a viable option at a site with TI characteristics as summarized in this document. Figure 3-2 is an example of a decision framework for addressing contaminated groundwater at Army installations where aquifer restoration may be technically impracticable. The decision process is facilitated by the compilation of data and analysis via development of a comprehensive Conceptual Site Model (CSM), discussed later. This process asks the initial question: *Is restoration practicable?* If the answer is no, based on consideration of the limitations to successful aquifer restoration previously presented, the next step is a preliminary analysis of plume containment and the ability of mass removal in the source zone to significantly reduce risks to human health and the environment.

The NRC presented an example of a site scoring system to determine the potential for TI (NRC, 1994). This is presented here as Table 3-1. When implementing a decision-making strategy, it is important to recognize the presence of complexities as early as possible in the remediation process. An example of a high level of site complexity would be Category 4 in Table 3-1. Failure to account for these complex conditions can result in the establishment of RAOs that are not achievable in a reasonable time frame, and the expenditure of significant funds that will not result in objectives or expectations being met.

To further illustrate the difficulty of restoring groundwater at Category 4 sites, the NRC report presented case study statistics and stated, "…cleanup of sites in Category 4 to health-based standards is extremely unlikely, although in most cases containing the contamination and shrinking the contaminated area is possible. Sites in Category 4 have either LNAPLs in fractured rock aquifers or DNAPLs in heterogeneous or fractured rock aquifers. Removing NAPLs from fractured rock and other highly heterogeneous settings poses the most extreme of technical challenges… Of the 34 sites in Category 4 and the 8 sites on the borderline between categories 3 and 4 …, none have been fully cleaned up."



NOTE: "ACL" stands for Alternative Concentration Limit. ACLs are replacements of ARARs, not a waiver of ARARs as are TI Waivers. ACLs only potentially apply to special cases of groundwater contamination that are defined by relationships of groundwater and surface water.

Figure 3-2: Proposed Decision Framework for Addressing Contaminated Groundwater (from AEC, 2002).

	Contaminant Chemistry					
Hydrogeology	Mobile, Dissolved (degrades/ volatilizes)	Mobile, Dissolved	Strongly Sorbed, Dissolved (degrades/ volatilizes)	Strongly Sorbed, Dissolved	Separate Phase LNAPL	Separate Phase DNAPL
Homogeneous, single layer	A (1)	A (1–2)	B (2)	B (2–3)	B (2-3)	B (3)
Homogeneous, multiple layers	A (1)	A (1–2)	B (2)	B (2–3)	B (2-3)	B (3)
Heterogeneous, single layer	B (2)	B (2)	B (3)	B (3)	B (3)	C (4)
Heterogeneous, multiple layers	B (2)	B (2)	B (3)	B (3)	B (3)	C (4)
Fractured	B (3)	B (3)	B (3)	B (3)	C (4)	C (4)

NOTE: Shaded boxes at the left end (group A) represent types of sites for which cleanup of the full site to health-based standards should be feasible with current technology. Shaded boxes at the right end (group C) represent types of sites for which full cleanup of the source areas to health-based standards will likely be technically infeasible. The unshaded boxes in the middle (group B) represent sites for which the technical feasibility of complete cleanup is likely to be uncertain. The numerical ratings indicate the relative ease of cleanup, where 1 is easiest and 4 is most difficult.

Based on such a site scoring system, and in conjunction with the observations of DNAPL characterization and remediation presented in Section 3.1.1, a presumptive approach to implementing TI as a component of the site remediation strategy is reasonable. This would be consistent with statements in EPA's *Presumptive Response Strategy* document (EPA, 1996) that have been referenced in this report. Such an approach would have to recognize that the definition of TI is temporal—as innovations are made to remedial technology, the ability to restore aquifers to ARARs may improve. This will require a site-specific determination of whether any new technology or combination of technologies can achieve groundwater restoration.

To date, however, only a few groundwater sites impacted by DNAPLs have achieved closure, and no sites with DNAPL in complex hydrogeologic settings have been restored (i.e., cleaned up to MCLs), to our knowledge. Whether partial source depletion of the DNAPL is justified will also be a site-specific determination. At most DNAPL sites, however, restoration is unlikely, taking cost into consideration. Thus, a presumptive approach to implementing TI as a remedy component (at sites equivalent to a Category 4 site on Table 3.1, for example) would be defensible from an engineering standpoint.

3.3. DATA BASIS FOR JUSTIFICATION OF TI

The amount of data and analysis required to justify TI is site-specific. EPA Guidance (EPA, 1993; EPA, 1997c) (Appendix C) discusses the data requirements for a TI determination. However, our study of the 48 CERCLA sites with TI Waivers (Appendix A) found that the TI Evaluation Reports prepared to justify TI varied substantially in their detail and level of quantitative analysis. The reports ranged in length from 7 to 126 pages, and were either stand-along documents or were included as a section in another report, such as a FS in the case of a Front-End TI Waiver. No correlation was found between the length of the report and the timing of the waiver (e.g., pre-1993 guidance vs. post-1993 guidance).

It will be at the discretion of the EPA Regional RPM or state project manager to determine the data requirements for a TI assessment or TI Waiver application. For example, for a site in EPA Region 4 currently being contemplated for a TI Waiver, it has come to our attention that the EPA has counseled the Army that a numerical groundwater flow and contaminant transport model will likely be required to justify why an engineered remedy within the TI Zone will not result in ARARs within a reasonable time frame. Furthermore, such an analysis would be required to determine the length of time for remediation of groundwater contamination to achieve ARARs outside of the TI Zone (e.g., the dissolved plume). Our study of TI Waiver applications indicated that groundwater models have been used to support a TI Waiver, but certainly not at all sites, and the EPA guidance (EPA, 1993) discusses the proper use (and common misuse) of groundwater models.

Regardless of the level of data collection and analysis, TI can be justified based on site characterization (RI/RFI) data alone (the CSM), or in conjunction with remedy performance data—from interim actions, site-specific pilot-scale and/or treatability tests, careful review of case studies at similar sites, or final remedy performance data. General data requirements that are likely needed for TI are discussed below, largely based on our experience, our study of EPA and state guidance (Appendix C), and our investigation of the CERCLA sites with approved TI Waivers (Appendix A).

3.3.1. Site Characterization (RI/RFI) Data — the Conceptual Site Model

For a TI justification to be based on site characterization data, a sound CSM must be developed. The CSM is an idealized, written or graphical representation of the environmental system and the processes that control the transport and fate of chemicals to receptors. The purpose of the CSM is to describe the contamination, possible exposure scenarios, and their outcomes in terms of risk to human health and the environment. It is both qualitative and quantitative. The CSM is not (necessarily) a mathematical or computer model (as the word "model" may imply), although such techniques may be used to assist in developing and testing the validity of a CSM or evaluating the restoration potential of the site as discussed previously.

The CSM should be viewed as a "working document", meaning the CSM is continually reassessed and modified throughout the site characterization process. The CSM generally progresses from an initial generic model to a site-specific model by iterative stages of modifications occurring as a result of each phase of investigation and/or remedial actions. The CSM synthesizes past site characterization data and any initial response actions taken during the site characterization phase to guide further site characterization work. This synthesis also should ultimately be used to determine potentially applicable remedial options. As more data are collected, the CSM is updated and new data gaps, if any, are identified. The CSM must serve as the framework for the evaluation of a site's restoration potential, and thus, the TI of restoration. The accuracy of the CSM is critical to the decision-making process for justifying TI.

In the development of the CSM, the site is formulated as a series of elements that constitute the model. All CMSs should include the components listed below (consistent with EPA, 1988; ASTM, 1995).

- A description of the contaminant sources, properties, and distribution, including source areas, release mechanisms and rates.
- Migration pathways.
- Fate and transport processes.
- Exposure pathways.
- Current and/or potential receptors.

- Other elements that define the contamination in order to facilitate the analysis of site restoration potential and risk management.

Because of the uncertainties that arise from the inherent characteristics of extremely complex sites such as those comprising karst aquifers, an adequate CSM for such sites should include sufficient information to describe the following items.

- Traditional geologic/hydrogeologic data including vadose zone and aquifer thickness; estimates of porosity, hydraulic conductivity, transmissivity and storage coefficients; and recharge and discharge areas.
- The type of karst aquifer (e.g., diffuse flow, free flow, or confined flow).
- Recharge and discharge zones illustrating, at least qualitatively, the relationship between subsurface flow, and recharge and discharge points.
- The flow path associated with each monitoring well. If applicable, the CSM should clearly depict the potential for conduit flow paths to short-circuit contaminants away from a monitoring location.
- Portions of the watershed that contain potential receptors.
- The potential for contaminated sediments to accumulate in flow conduits when applicable.

Several sources of information and guidance for CSMs have been published, including a guidance document specifically addressing CSMs by ASTM (ASTM, 1995). The EPA TI Waiver guidance (EPA, 1993) gives useful figures describing elements of a CSM and a description of the evolution of a CSM.

3.3.2. Pilot and Treatability Studies

A treatability study or a pilot study, as part of an RI/RFI or FS/CMS, may be required to predict the actual effectiveness of a particular technology at a site, and thus the potential for TI. In general, the evaluation of pilot and treatability studies requires the same or similar information as the evaluation of existing (e.g., interim or final) full-scale remedial systems such as design justification and performance data.

Several key steps are necessary to perform an effective pilot or treatability study in order to assess TI. Once the decision has been made to conduct such a study (the initial “go/no-go” decision), the key steps include:

- Definition of study objectives.
- Technology selection.
- Pilot study design.
- Pilot study performance/data analysis.
- Scale-up issues.

Scale-up issues are particularly difficult because of the inherent spatial heterogeneity in three dimensions. A thorough evaluation of case studies at similar sites should be conducted prior to initiating potentially expensive site-specific pilot tests. Additionally, prior to any pilot tests, a quantitative estimate of restoration should be completed to demonstrate analytically the level of performance required for the technology to meet the RAOs. Only if it can be shown analytically that restoration has a reasonable probability of success should pilot studies be conducted. However, it should be noted that pilot testing may be helpful in assessing the restoration potential of a site where restoration has not / cannot been ruled our as a remedial objective based on traditional site characterization alone. Pilot testing may be very helpful in establishing alternative remediation goals (in lieu of restoration), or in setting performance metrics such as source removal expectations, target concentration levels for the plume (in lieu of MCLs), or other performance metrics.

3.3.3. Full-Scale Remedies

An assessment of a full-scale remedy performance (e.g., an interim measure or a final remedy) may be required to address the potential inability of a particular technology at a site to achieve the RAOs. For example, in the case of TI Waivers, the linkage of the failure of a full-scale final remedy to meet RAOs with the TI assessment is required to justify a Post-Implementation TI Waiver. Performance data from an interim measure, if appropriate, can be used, with data from the CSM generated from the RI/RFI, to justify a Front-End TI Waiver.

Performance data should be presented to document that RAOs are unlikely to be achieved in a reasonable timeframe, and that the observed system performance is not due to inadequate design, implementation, operation and maintenance. System performance measures and any data changes influencing the discrepancy between predicted and actual performance should be included.

The performance and/or suitability of a groundwater remedy should be evaluated with remedy performance data such as the four examples given below (based on Figure 6 of EPA, 1993).

1. <u>Remedy design and operational information</u>: Design and as-built construction information; supporting design calculations; operating information; percent downtime and other O&M problems.

2. Source removal or control: Source removal information; source control information.
3. Enhancements to original remedial design: Information concerning operational modifications; rationale, design, and as-built construction information for system enhancements; monitoring data and analyses that illustrate system enhancement effects on system performance.
4. Performance monitoring information: Design and as-built construction information; hydraulic gradients and other information demonstrating containment; trends in subsurface contaminant concentrations; information on types and quantities of contaminant mass removed and removal rates.

In addition, any performance analysis of a groundwater remedy should accomplish the following four items (EPA, 1993).

1. Sufficient operation to evaluate performance: Demonstrate that the groundwater monitoring program within and outside of the aqueous contaminant plume is of sufficient quality and detail to fully evaluate remedial action performance (e.g., to analyze plume migration or containment and identify concentration trends within the remediation zone).
2. Effective operation and maintenance: Demonstrate that the existing remedy has been effectively operated and adequately maintained.
3. Effective modifications or enhancements**:** Describe and evaluate the effectiveness of any remedy modifications (whether variations in operation, physical changes, or augmentations to the system) designed to enhance its performance.
4. Trends in subsurface contaminant concentrations: Consider such factors as whether the aqueous plume has been contained, whether the areal extent of the plume is being reduced, and the rates of contaminant concentration decline and contaminant mass removal. Further considerations include whether aqueous-phase concentrations rebound when all or part of the system is shut down, whether dilution or other natural attenuation processes are responsible for observed trends, and whether contaminated soils on site are contaminating the groundwater.

3.4. RECOMMENDED CONTENT OF TI EVALUATION REPORTS

Regardless of the stage of the cleanup process at which a TI justification is documented (e.g., Front-End or Post-Implementation TI Waivers), sufficient data must be gathered to support the justification for TI. This can be presented either as part of a document such as a FS or CMS Report, or as a stand-alone report, known as a TI Evaluation Report in the case of TI Waivers. The 1993 EPA guidance document (EPA, 1993) (Appendix C) discusses the types of technical data and analysis needed to support EPA's evaluation and the criteria used to make a determination.

The main components to be included in a TI Evaluation Report should include the following:

- Identification of ARARs. The specific ARARs for which the TI decision is being sought must be identified. This is required in the case of a TI Waiver because it is a type of ARAR waiver.
- Identification of the TI Zone. The TI Zone is the area of the site, expressed in three-dimensions, where remediation to ARARs is deemed to be technically impracticable.
- Conceptual Site Model. CSMs were discussed previously in this chapter.
- Evaluation of the potential for restoration. The discussion of the restoration potential should focus on source control measures, remedial action performance analysis, restoration timeframe analysis, and other potentially applicable technologies.
- Cost Estimation. This includes life-cycle costs based on a net present value analysis.
- Alternative remedial strategy. An alternative to meeting ARARs must be proposed (since the ARARs are waived in the case of a TI Waiver). The alternative must still be protective of human health and the environment. An example of an alternative remedial strategy might include the TI Waiver itself along with a containment (isolation) system for the TI Zone, groundwater monitoring to demonstrate MNA, and appropriate institutional controls.

4. FINDINGS AND RECOMMENDATIONS

The primary objective of this document is to provide Army Remediation Project Managers (RPMs) and Base Environmental Coordinators (BECs) with guidance on the use of technical impracticability (TI) considerations in developing the most cost effective strategies for groundwater cleanup that meet statutory and regulatory requirements while optimizing the use of DoD funds and reducing life cycle costs. We have used the TI Waiver process developed under CERCLA as the most well developed example of the application of TI assessments for implementation of protective and cost effective cleanup strategies for contaminated soil and groundwater at sites where it is potentially technically impracticable to achieve restoration. In this chapter, we provide our findings and recommendations regarding the use of TI, based in part on our investigation of the 48 TI Waivers that have been approved to date by the USEPA for CERCLA sites and in part on our experience in groundwater remediation.

FINDING 1. Groundwater restoration, usually defined as achieving drinking water standards where the groundwater is considered a potential source of drinking water, is impracticable at most highly complex sites, especially those sites with large amounts of DNAPLs in certain geologic settings.

Complex sites are defined as those with contaminant and hydrogeologic characteristics presenting major barriers to restoration. The limitations of pump and treat technologies at DNAPL sites are well recognized, and only a few cases have been reported where restoration has been achieved. Despite advances in subsurface technologies applicable to groundwater remediation (such as thermal, surfactant/cosolvent flushing, and in-situ chemical oxidation technologies), and demonstrations that report substantial amounts of DNAPL can be removed from some sites, primarily in alluvial or unconsolidated media aquifers, restoration has remained illusive. Thus, for DNAPL sites in more complex hydrogeologic settings, restoration is improbable, and the site is a strong candidate for a TI determination.

RECOMMENDATION 1: At all sites considered "complex" because of contaminant and hydrogeologic characteristics, TI assessments should be incorporated into the selection and implementation process for the overall site remediation strategy.

FINDING 2: Technical impracticability (TI) of groundwater remediation is formally recognized by the EPA and many state regulatory agencies, and the use of TI Waivers at CERCLA sites has resulted in reported cost savings, while meeting overall objectives of protecting human health and the environment.

TI was recognized in federal statutes in 1986 with the approval of SARA, which lead to EPA guidance on the use of TI Waivers at NPL sites in 1993. Many, if not all, state statutory requirements include language that allows consideration of TI in developing cleanup strategies for contaminated groundwater, while maintaining a preference for restoration where groundwater is a potential source of drinking water. Although TI Waivers have been used infrequently, a review of the 48 TI Waivers granted shows that substantial cost savings were realized compared to other alternative strategies, while assuring that human health and the environment were protected. Long term institutional controls were included in the cleanup strategies at these sites.

RECOMMENDATION 2: Site managers should be aware of the legal framework, requirements, and guidance for conducting TI assessments and incorporating these assessments in the development of overall groundwater remediation strategies. Site managers should utilize past experiences with TI assessments, such as the use of the TI Waiver process at CERCLA sites, as summarized in this document.

FINDING 3: TI assessments can be completed and integrated into a site remediation strategy at any point in time during the remediation sequence, once sufficient site characterization data are available. In the TI Waiver process, the majority of waivers have been "front-end", that is, prior to the selection and implementation of a remediation system.

TI demonstrations can be accomplished either before a remedy has been implemented (for example, a "Front-End TI Waiver") or after performance of a remedy has been demonstrated to be ineffective due to TI considerations (not design or operational inadequacies). A TI assessment will always be based on site-specific considerations. It will be at the discretion of the EPA Regional RPM or state project manager to determine the data requirements for a TI assessment. Of the 48 TI Waivers granted since 1994, 35 Waivers were considered front-end waivers, which would tend to provide the greatest reduction in overall site costs compared to post remedy waivers.

RECOMMENDATION 3: Undertake TI assessments at the earliest possible stage of the remediation process.

The possibility of TI as a remedy component should be contemplated from the earliest stages of site investigation. Thus, a phased approach to site characterization and remediation for early identification of TI should be implemented. Such a phased approach refers to simultaneously characterizing the site and implementing response actions on a parallel track (i.e., interim remedies or pilot testing) during the RI or RFI process, using the results of one to guide the other.

FINDING 4. Where TI Waivers have been approved at CERCLA sites, geologic complexity combined with the presence of DNAPLs were the most common reasons for the determination of TI.

Thirty-five of the 48 TI Waivers were granted on the basis of contaminant-related and hydrogeologic factors. The primary contaminant-related factor was the known or presumed presence of DNAPL in the aquifer. Hydrogeologic complexities included karst and fractured clay or bedrock aquifers, alluvial aquifers with multiple hydrostratographic units, and aquifer depths of 100 feet or deeper below ground surface. Many Army sites are located in areas of highly complex geology with contaminants present in the form of DNAPLs and such sites clearly are likely TI candidates where restoration will be impracticable from an engineering perspective.

RECOMMENDATION 4: **Site characterization efforts should be designed to assess the restoration potential of the aquifer (i.e., a TI Assessment), taking into account the factors that have been shown to control whether restoration is practicable.**

FINDING 5: A determination of TI following implementation of a remedy cannot be based on improper design or improper operation of the remediation system.

EPA guidance and interviews with EPA personnel stressed the importance of distinguishing TI characteristics supporting a TI determination from TI claims that may be based on improper design or operation of the remediation system. Remedial system performance data can be used to demonstrate TI, if it can be shown that the ineffectiveness of the remedial system is due to the intrinsic nature of the site (i.e., geologic complexity and/or contaminant characteristics) rather than a poorly designed or operated remedial system.

RECOMMENDATION 5: For those sites where a remediation system is in place (e.g., a pump-and treat system), a determination of whether the system has been designed properly, and is operating in an optimum manner will be required before determining if a TI determination is appropriate for the site.

Various guidance documents are available (EPA, 1999d; Radian, 2001) that can guide site managers in assessing whether the design and operation of the remedial system have been optimized. If not, various modifications can be considered and implemented prior to the TI assessment. On the other hand, it should be noted that the characteristics of a site that strongly support a TI determination are well understood, and optimizing a pump and treat system, while important, is still not likely to alter the fact that it is impracticable to achieve restoration at certain sites.

FINDING 6: Recent and ongoing debates on the capabilities of new and emerging subsurface remediation technologies to remove DNAPL from source zones indicate that partial source depletion of DNAPL may provide benefits compared to containment strategies, but the extent of partial source depletion needed to meet RAOs is in dispute and uncertain.

Research is on-going to determine if partial source depletion at DNAPL sites is justified compared to containment strategies. This research involves laboratory, field, and computer analyses of DNAPL source remediation strategies. However, the extent of partial source depletion needed to achieve potential benefits is in dispute. Some researchers and practitioners believe that complete removal of DNAPL is needed to achieve restoration. Others believe that partial removal will provide meaningful benefits, but not necessarily achievement of restoration.

RECOMMENDATION 6: Site managers should consider the most recent research findings on the potential benefits of partial source depletion at DNAPL sites, and determine whether the potential benefits alter the determination of TI of aquifer restoration.

TI determinations depend in part on the status of remediation technologies and site characterization and performance measurement technologies. As part of the TI assessment, consideration of these research efforts must be accounted for. However, it is still likely that at a large number of highly complex sites, as discussed, restoration is not practicable, resulting in a TI determination and the implementation of a containment strategy for some portion of the aquifer, if containment is also technically feasible. This may not be the case in karst systems, for example.

FINDING 7: Although the TI of restoration of contaminated aquifers is well recognized, the integration of TI into site remediation strategies is limited. For example, TI Waivers have only been used at 48 of the over 1400 CERCLA sites.

Potential barriers exist to pursuing TI as a remedy component. These barriers include a lack of willingness on the part of both Potential Responsible Parties (PRPs) and EPA to pursue TI assessments, disagreements over the definition of TI and expectations of groundwater remedial systems, negative public perceptions, a view that implementing TI as an explicit remedy component is not necessary, and the perception that TI assessment is a burdensome process likely to fail.

RECOMMENDATION 7: Site managers should recognize the barriers to incorporation of TI assessments into development of site cleanup strategies and incorporate communication strategies to overcome these barriers where appropriate.

Site managers should ensure that the rationale for a TI recommendation is well documented and in a format that allows for ease of communication with stakeholders. This documentation should include a comparison of remedial strategies with respect to cost and risk reduction achieved, and a credible evaluation of the expected performance of a remedial action to achieve the cleanup objective (i.e., RAOs). If it is ultimately determined that it is technically impracticable to meet RAOs, this fact must be clearly communicated to all stakeholders. This communication should include information that TI will be part of an overall strategy that is protective of human health and the environment. This strategy would address both the TI zone as well as areas outside of the TI Zone.

FINDING 8: Successful use of TI as part of a site strategy, such as application for TI Waivers at CERCLA sites, depends on early and frequent discussions with the regulatory community and other stakeholders, and on maintaining a high level of credibility with these stakeholders.

Our research and interviews found that successful applications for TI Waivers was highly dependent on early and frequent communication with the site regulators.

RECOMMENDATION 8: As part of the management of the process, site managers are encouraged to develop a communications strategy with regulators and other stakeholders to ensure that TI considerations are adequately addressed, evaluated, and used effectively in decision making. The use of external advisory or expert panels throughout the process may be appropriate at large sites with large (>$ 10 million life cycle estimates) projected costs.

Site managers should work closely with the EPA and the state from the early stages of the site investigation, and periodically discuss the possibility of TI as part of a remedy. Efforts should also be made to integrate an effective community relations program into the site management program. To facilitate and strengthen the data assessment and decision-making process, a panel of experts (i.e., an advisory panel) should be considered, which should include experts from the respective regulatory agencies, if available.

FINDING 9: The extent of documentation and analysis required to demonstrate TI of groundwater restoration is site specific, and the ease of implemeting quantitative tools, such as groundwater models and performance assessment models to confirm TI, is increasing.

The extent of documentation submitted for the 48 TI Waiver applications varied considerably, ranging from short summaries to highly detailed analyses. With the growing awareness of TI, and the continuing reluctance to incorporate TI into site remediation strategies, it is probable that documentation requirements will increase. This may include requirements to use quantitative performance assessment tools to support requests for a TI determination.

RECOMMENDATION 9: Where appropriate, quantitative tools should be encouraged to support TI assessments.

Groundwater fate and transport models are becoming easier to use, with much more user-friendly interfaces at lower cost. However, the limitations of such models are well recognized, and the amount of data needed to calibrate and validate these models can be excessive. Nonetheless, quantitative modeling should be encouraged because this provides a quantitative basis for assessing TI, and for evaluating the uncertainty in TI assessments particularly in the context of assessing the benefits of partial source removal at DNAPL sites. The Army is encouraged to support the continued development of these models through appropriate funding agencies, such as the Strategic Environmental Research and Development Program (SERDP).

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APPENDIX A

RESULTS OF MALCOLM PIRNIE STUDY OF CERCLA SITES WITH TECHNICAL IMPRACTICABILITY (TI) WAIVERS

This appendix gives a comprehensive list of the 48 CERCLA sites that have obtained TI Waivers.[1] Detailed summaries of the 48 TI Waiver sites are presented in Appendix B.

Comprehensive List of CERCLA Sites with TI Waivers

Of the 48 sites previously mentioned as having been identified through our research efforts as having received TI Waivers, 20 of these sites received waivers prior to the implementation of the EPA Guidance Document in 1993. Therefore, the granting of these 20 TI Waivers did not necessarily follow the same process as for the subsequent 28 TI Waivers. Nevertheless, all 48 sites are listed below in the table below and are numbered for easy future identification according to EPA region and the date of TI Waiver approval. More information on each of these sites is included in Appendix B. Approximately half of these TI Waiver sites are in EPA Regions 1, 2, and 3, and Regions 6, 8, and 9 have significant numbers of sites as well.

CERCLA Sites With TI Waivers In Place

Site #	Site Name	State	EPA Site ID	Date	EPA Region
1	Hocomonco Pond	MA	MAD980732341	09/21/1999	1
2	Loring Air Force Base	ME	ME9570024522	09/28/1999	1
3	South Municipal Water Supply Well Site	NH	NHD980671069	05/03/1997	1
4	Pease Air Force Base	NH	NH7570024847	09/26/1995	1
5	Tansitor Electronics, Inc.	VT	VTD000509174	09/01/1995	1
6	Old Springfield Landfill	VT	VTD000860239	09/29/1990	1
7	Sullivan's Ledge	MA	MAD9807343	06/28/1989	1
8	Pinette's Salvage Yard	ME	MED980732291	05/30/1989	1
9	DuPont/Necco Park	NY	NYD980532162	09/18/1999	2
10	Niagra Mohawk Power Co	NY	NYD980664361	09/29/1995	2
11	G.E. Moreau	NY	NYD980528335	10/06/1994	2
12	Caldwell Trucking Company	NJ	NJD048798953	09/28/1989	2
13	Naval Air Development Center	PA	PA6170024545	09/27/2000	3

[1] There is no comprehensive tracking of sites that have obtained TI Waivers. Sites have been identified through research efforts.

Site #	Site Name	State	EPA Site ID	Date	EPA Region
14	Rodale Manufacturing Company	PA	PAD981033285	09/30/1999	3
15	Aberdeen Proving Ground (Edgewood Area)	MD	MD2210020036	09/24/1997	3
16	Brodhead Creek	PA	PAD981033285	06/29/1995	3
17	Aladdin Plating	PA	PAD075993378	07/01/1994	3
18	E.I. DuPont De Nemours (Newport Landfill)	DE	DED980555122	09/29/1993	3
19	Hunterstown Road	PA	PAD980830897	08/02/1993	3
20	Westinghouse Elevator Plant	PA	PAD043882281	06/01/1992	3
21	Lindane Dump	PA	PAD980712798	03/31/1992	3
22	Dorney Road	PA	PAD980508832	09/30/1991	3
23	Heleva Landfill	PA	PAD980537716	09/30/1991	3
24	Whitmoyer Laboratories	PA	PAD003005014	12/31/1990	3
25	Middletown Air Field	PA	PAD980538763	12/17/1990	3
26	Yellow Water Road Dump	FL	FLD980844179	06/01/1992	4
27	Continental Steel Corp.	IN	IND001213503	09/30/1998	5
28	Highway 71/72 Refinery	LA	LAD981054075	09/01/2000	6
29	Crystal Chemical Company	TX	TXD990707010	03/19/1997	6
30	Vertac, Inc.	AR	ARD000023440	09/01/1995	6
31	Popile, Inc.	AR	ARD008052508	02/20/1993	6
32	Hardage/Criner	OK	OKD000400093	11/22/1989	6
33	Oronogo-Duenweg Mining Belt	MO	MOD980686281	07/29/1998	7
34	Cherokee County	KS	KSD980741862	08/20/1997	7
35	Summitville Mine	CO	COD983778432	09/28/2001	8
36	Anaconda Co. Smelter	MT	MTD093291656	09/29/1998	8
37	Silver Bow Creek/Butte Area	MT	MTD980502777	09/29/1994	8
38	Broderick Wood Products	CO	COD 000110254	03/24/1992	8
39	Whitewood Creek	SD	SDD980717136	03/30/1990	8
40	East Helena	MT	MTD006230346	11/22/1989	8
41	Del Norte Pesticide Storage	CA	CAD000626176	08/29/2000	9
42	Koppers Industries, Inc.	CA	CAD009112087	09/23/1999	9
43	Montrose / Del Amo	CA	CAD029544731/ CAD008242711	03/30/1999	9
44	J.H. Baxter & Co.	CA	CAD000625731	03/27/1998	9
45	Schofield Barracks	HI	HI7210090026	11/01/1997	9
46	Tucson International Airport Area	AZ	AZD980737530	09/30/1997	9
47	Westinghouse Electric	CA	CAD001864081	10/16/1991	9
48	Eielson Air Force Base	AK	AK1570028646	09/29/1998	10

Important Aspects of TI Waivers

While recognizing the limitations to remediation at specific sites, the EPA has emphasized that the designation "technically impracticable" was not an excuse to shirk responsibility for corrective action. Instead it was presented as a *temporary* measure to be applied only when remediation strategies were shown to be technically infeasible or ineffective. Therefore, a TI Waiver is always subject to future review. Also, the 1993 EPA guidance document clarified the implications of a TI designation to dispel the idea that once a groundwater cleanup standard was waived, so was protectiveness. Long-term monitoring is required as well as a periodic review of remediation technologies. A TI Waiver is, by necessity, both contaminant-specific and location-specific. This means that a TI Waiver is tied to one or more contaminants at one or more specific areas of the site. Therefore, a TI Waiver may not necessarily apply to all site contaminants or to an entire site. It is more common for TI Waivers to be granted for a specific geological unit within a site, or region of contamination. Each of these important aspects of TI Waivers is described in more detail below.

Subject to Future Review

It is important to note that no TI Waiver has been revoked or amended by any future reviews to date (such as a Five-Year Review). However, the oldest TI Waivers are only 13 years old, and radical developments in cleanup technology take longer to develop. The language in some Five-Year Review documents indicate that the current status of technology is considered when reviewing the site remedy. For example, the Five-Year Review performed for Pinnette's Salvage Yard site (Site #8) in 2000 reiterates that the TI Waiver was granted on the basis of the available technology. The document also asks the question: *Are the assumptions used at the time of remedy selection still valid?* The conclusion was yes.

Other sites with TI Waivers are not under a review of available technologies every five years, but instead are under periodic review of the protectiveness standard of the current remedy. As noted in the 1998 Record of Decision (ROD) for the DuPont/Necco Park site (Site #9), a member of the public inquired if Five-Year Reviews of the site would be used to enhance the remedy. The EPA responded that the "five year review is intended to determine if the chosen remedy has maintained its protectiveness. It is not intended to determine if new technologies or additional efforts would improve the selected remedy. If the remedy is found not to be protective, then new technologies or additional efforts would certainly be evaluated". Therefore, while Five-Year Reviews differ from site to site, the EPA's original intent for a TI Waiver included periodic future technology reviews.

Contaminant-Specific

The case of the TI Waiver at the Eielson Air Force Base site (Site #48) illustrates this concept. Although many contaminants existed at the site, including: lead; petroleum hydrocarbons including benzene, toluene, ethylbenzene and xylene (BTEX); PCBs; TCE and various other volatile organic compounds (VOCs), the TI Waiver only applied to the lead contamination. Lead originated at the site as a co-contaminant of fuel that leaked from underground storage tanks. Petroleum hydrocarbon components of the fuels (i.e., BTEX) were found to readily biodegrade in the source areas within the vadose zone following bioventing. Natural attenuation of BTEX had been demonstrated in the groundwater plume area as well. Lead, on the other hand, was present in groundwater at levels above the EPA action level (15 µg/L). Due to the relative immobility of lead and strong sorption to soil, a pump-and-treat system was determined to be technically impracticable within a time frame of approximately 100 years (used here as a reasonable time frame). In addition, site groundwater is under a relatively low hydraulic gradient (mean gradient 0.002 ft/ft). Lead migration in groundwater was monitored as a condition of the final remedy, along with the TI Waiver.

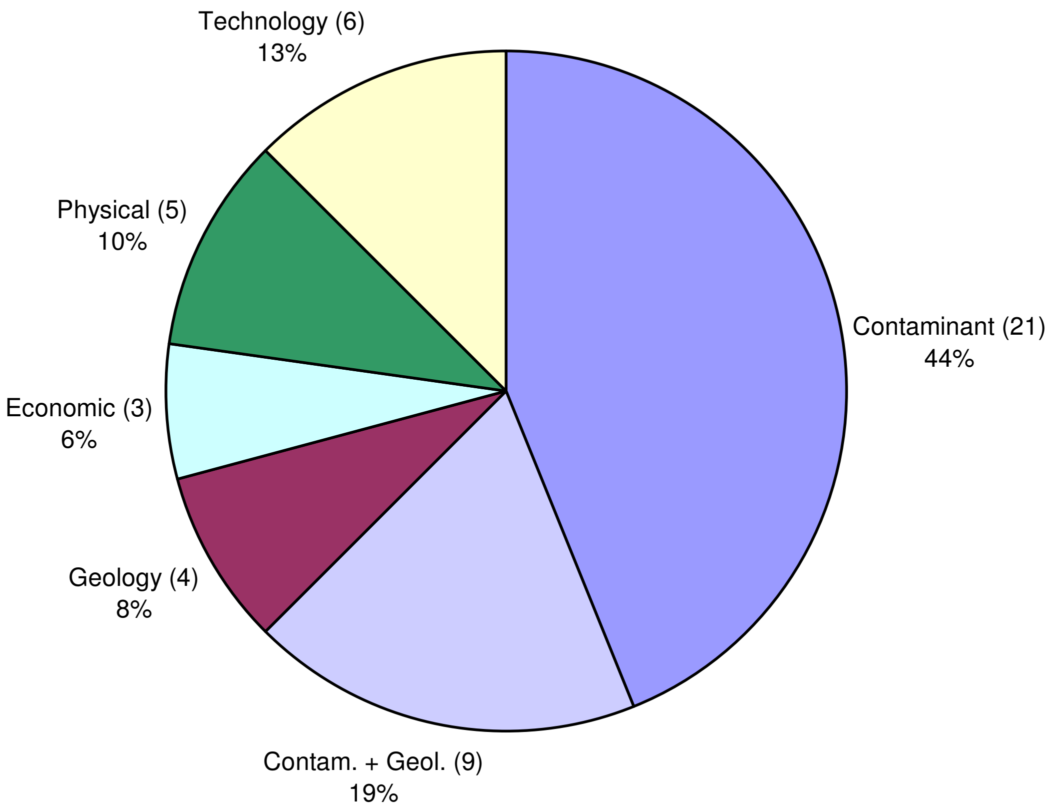
Location-Specific

A review of TI Waiver case studies found that 27 of the 48 subject sites (56%) received the TI Waiver for only a portion of the property, not for the entire site. At these sites, the area included in the TI Zone sometimes corresponded to a geological unit (such as a karst formation or underlying clay zone) where remedial technologies are not suited to remove contamination (Sites #5, #32, #37). Other TI Zones correspond to the DNAPL or source zone area (Sites #13, #14, #16, #23) or to a larger plume area (Sites #11, #43). In general, the TI Zones were designated as a spatial volume, as specified in the 1993 EPA Guidance Document.

Nature of Technical Impracticability

Our research presented herein found that sites that receive TI Waivers usually have contaminants present in the form of a dense non-aqueous phase liquid (DNAPL) combined with a complex geological setting, making this the most common setting for technical impracticability. In fact, EPA’s TI Waiver guidance devotes nearly a quarter of its text to discussion in one way or another of DNAPLs and complex geology. However, these features are common to many CERCLA and RCRA sites, including many Army facilities. Therefore, could TI Waivers be applied at many more sites beyond the 48 sites identified by our research? The answer undoubtedly should be yes, and the nature of technical impracticability, and reasons for it at the 48 sites that received TI Waivers, is discussed below.

Two factors are explicitly mentioned in the EPA guidance (EPA, 1993) as contributing to technical impracticability. These are: (1) contaminant-related factors, especially the presence of DNAPL; and, (2) hydrogeologic factors. However, the EPA was careful to emphasize in the guidance that a TI Waiver is granted based on site-specific information. For example, the presence of DNAPL alone is not enough to warrant a TI Waiver. Three additional factors were also identified by our study of the TI Waiver identified in this document as primary reasons justifying TI Waivers: (3) economic factors; (4) physical limitations to remediation (e.g. on-site wetlands or physical structures); and, (5) the state of currently available technology. Multiple reasons for not being able to meet cleanup standards within a reasonable timeframe were used as justification for TI Waivers. The percentage (and absolute number) of the 48 TI Waiver sites citing each of these five factors is illustrated on the figure below.



Primary Reasons for Technical Impracticability at 48 CERCLA TI Waiver Sites

Based on our analysis of the TI Waiver sites identified in this document, the most common factor limiting technical practicability is contaminant-related (44%). Contaminants in a complex geological setting accounted for an additional 19% of the TI Waiver sites. An additional 8% of sites had primarily geologic limitations. Overall, nearly three-quarters of the TI Waiver sites had contaminant-related and/or geology-related constraints to remediation. Other factors not specifically mentioned as causes of technical impracticability made up the remaining one-fourth of the cases, including economic reasons (6%), physical constraints (10%) and lack of appropriate technology (13%). A site may have one or more of these situations hindering the potential for remediation. However, the potential must be evaluated using site-specific data. If the site is not adequately characterized, technical feasibility cannot be adequately assessed.

Examples of the types of situations included in each of these categories are described in the following sections.

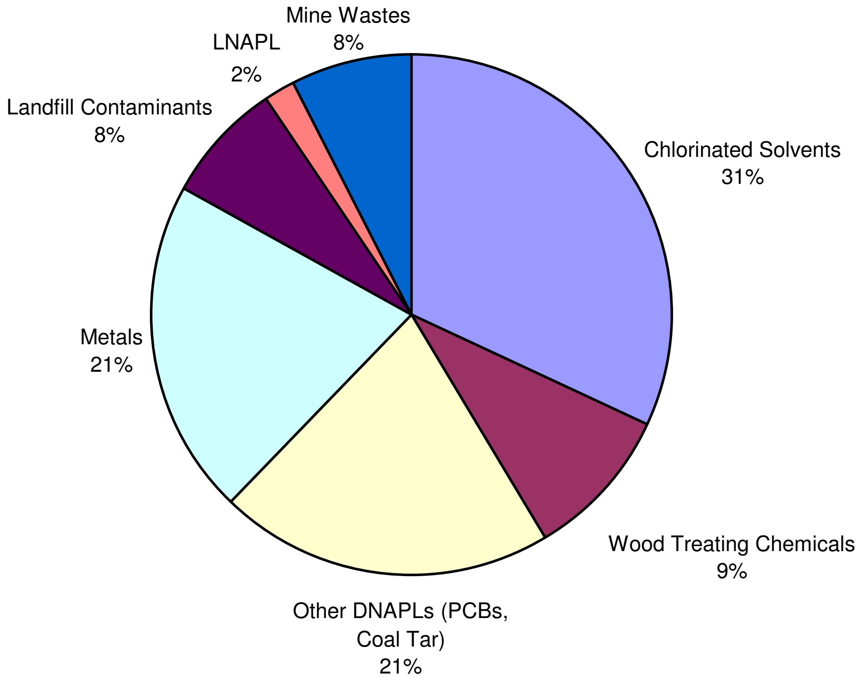
Contaminant-Related and Hydrogeologic Limitations

From our study of TI Waiver sites, a majority of the sites with contaminant-related limitations (24 of 30 sites, or 80%) were from the presence of NAPL (DNAPL or LNAPL). This represented 91% of the total number of TI Waiver sites with DNAPL. The most common NAPLs at these sites were chlorinated solvents (PCE, TCE, their breakdown products, and 1,1,1-trichloroethane (1,1,1-TCA)), PCBs, wood-treatment chemicals (creosote, polycyclic aromatic hydrocarbons (PAHs)), and pesticides (chlorobenzene, trichlorobenzene and the pentachloroaniline (PCA)).

At the other 6 sites (of the 30 sites that were identified with contaminant-related limitations), NAPL was not identified as being present, but contaminants were still deemed to be either too extensive to remediate within a reasonable timeframe, (e.g. large overlapping plumes with multiple on-site and off-site sources or contamination from old mine networks) or contaminants were too difficult to remove from soil (e.g. soil-bound PCBs and lead). At Site #48 (Eielson Air Force Base), lead was the principal contaminant. Site studies showed that lead was immobile in the soil, the size of the plume would not increase or decrease with time, even if pumping was implemented, and soil excavation was not practical due to the depth of contamination.

The types of contaminants at the 48 TI Waiver sites, presented in terms of percentage of the total, are shown on the figure on the following page.

From our study of 48 TI Waiver sites, 13 of the TI Waivers were due in part to hydrogeologic limitations, which included low permeability aquifers, complex alluvial sediments, and fractured bedrock, among others. At these sites, some remediation outside of the geologically problematic areas was still required, in addition to alternative cleanup requirements being designated within the areas with complex geology (TI Zones). Four sites demonstrated technical impracticability primarily on the basis of hydrogeology. These were the Loring Air Force Base, Lindane Dump, Crystal Chemical Company, and Broderick Wood Products sites (Sites #2, #21, #29 and #38), and are summarized in the bulleted items that follow.



Contaminants at 48 CERCLA TI Waiver Sites

- At Loring Air Force Base, contaminant extraction from rock fractures was shown to be diffusion-limited, making pump-and-treat ineffective to cleanup chlorinated solvents.
- Geologic and site-specific factors at Lindane Dump, including the possibility of subsidence and contaminant migration, led to a TI Waiver of RAOs that were state (Pennsylvania) background levels for benzene and the pesticide lindane.
- Crystal Chemical Company, an herbicide manufacturer in Houston, Texas, received a TI Waiver for arsenic contamination in alluvial sediments beneath the site. The geology was more complex than originally thought, with off-channel silts/sands and flood plain deposits identified after a pump-and-treat remedy had already been prescribed. With the new information, approximately 200 times more groundwater (700 million gallons) needed to be extracted before reaching the 50 µg/L ARAR. Timeframe estimates for cleanup ranged from 200 to 650 years.
- At the Broderick Wood Products site, the geologic framework comprised sand lenses within low-permeability clay. This was the reason stated for limited groundwater yields, making pump-and-treat impracticable (contaminants included PCP, creosote, and heavy metals from wood processing activities). Also, since much of the contaminant mass was

trapped in relatively small areas and isolated due to the clays, a TI Waiver was deemed to be protective of human health and the environment.

Economic Limitations

Three of the TI Waiver sites as part of our study obtained TI Waivers for primarily economic reasons: Oronogo-Duenweg Mining Belt, Cherokee County and Anaconda Co. Smelter (Sites #33, #34 and #36). The sites were all contaminated as a result of mining activities, and are discussed below.

- The Oronogo-Duenweg Mining Belt Site, located in southwestern Missouri, comprises over 7,000 acres (10.9 square miles) contaminated with smelter wastes from past lead and zinc mining. MCLs for cadmium and nickel were waived for shallow groundwater in the entire Jasper County watershed, as well as lead and manganese action levels. Cost estimates for implementing pump-and-treat ranged from $60 million to $90 million, with no evidence that ARARs would be met within a 100 year timeframe.
- The Cherokee County Superfund Site in Kansas (adjacent near the Oronogo-Duenweg site) received two TI Waivers for separate subsites: the Galena subsite (1989) and the Baxter Springs/Treece subsites (1997). These subsites comprised 16,000 acres (25 square miles) and 17,900 acres (28 square miles) respectively. Site remedies in this area are complicated by the proximity of other Superfund sites with separate remedies. For example, even if ARARs were achieved in a nearby creek, the creek would be recontaminated when it flowed into Oklahoma. The trans-boundary nature of pollution may have contributed to the TI decision as well as the massive extent of contamination. The cost to meet ARARs was estimated to be $65.5 million, which constituted an "inordinate cost" when the limited environmental gain associated with the expenditure was considered.
- The Anaconda Co. Smelter Site in Montana obtained a TI Waiver for arsenic in the bedrock aquifer based on prohibitive cost. The waiver was applied to 28,600 acres (45 square miles). Sources of arsenic were left in place in these areas, but POC monitoring was implemented around the area to ensure that contamination was contained. The projected cost for source removal at the Anaconda site (that was waived) was estimated to be $2.2 billion. In comparison, the total estimated cost of the selected remedy had a present worth of $88 million to $150 million (in 1998 dollars).

Physical Limitations

Five of the TI Waiver sites investigated as part of our study, accounting for 10 percent of the total number of sites investigated, received TI Waivers for essentially site-specific limitations. Three of these waivers were granted prior to the development of the EPA guidance (EPA, 1993): E.I. DuPont De Nemours (Newport Landfill), Dorney Road Landfill, and Whitewood Creek

(Sites #18, #22 and #39). The other two sites were subsequent to the guidance — Brodhead Creek and Highway 71/72 sites (#16 and #28). These sites are discussed below.

- The Highway 71/72 site is a refinery located in downtown Bossier City, Louisiana comprising over 215 acres. Petroleum hydrocarbon contamination as a LNAPL was present over 32 acres of the site with a saturated thickness of 15 feet. Residential and commercial buildings in the downtown area cover about 52 percent of the site. The community requested a non-intrusive approach to investigation and remediation, due to concerns with ongoing development. Since the LNAPL sources were not removed or fully remediated, compliance with ARARs in the plume area was deemed not technically practicable. A city ordinance banning groundwater use was implemented with the TI Waiver. Contaminated soil would be removed if uncovered by construction activities.
- The Dorney Road Landfill in Pennsylvania was granted a TI Waiver (incorporated into the 1991 ROD) because there was no acceptable area to dispose treated groundwater. In addition, the ROD stated that agricultural land would be disturbed if a treatment system were put in place. Groundwater contaminants included benzene, TCE, chromium and lead.
- Physical limitations at the other sites included the presence of off-site sources from neighboring areas (E.I. DuPont Site and Whitewood Creek) and the presence of on-site wetlands and flood-control levees that made excavation of sources impractical (Brodhead Creek Site).

State of Technology

As part of our study, TI Waiver sites that were not defined as being limited by contaminant type or extent, hydrogeologic factors, cost or site-specific reasons, were by default classified as technology-limited. Eight such sites were included in this category; three received their TI Waivers after the EPA Guidance Document in 1993. It is important to note that the limits of the technologies were observed and defined only after remedial systems were installed and operated for a period of time. The sites are briefly discussed below.

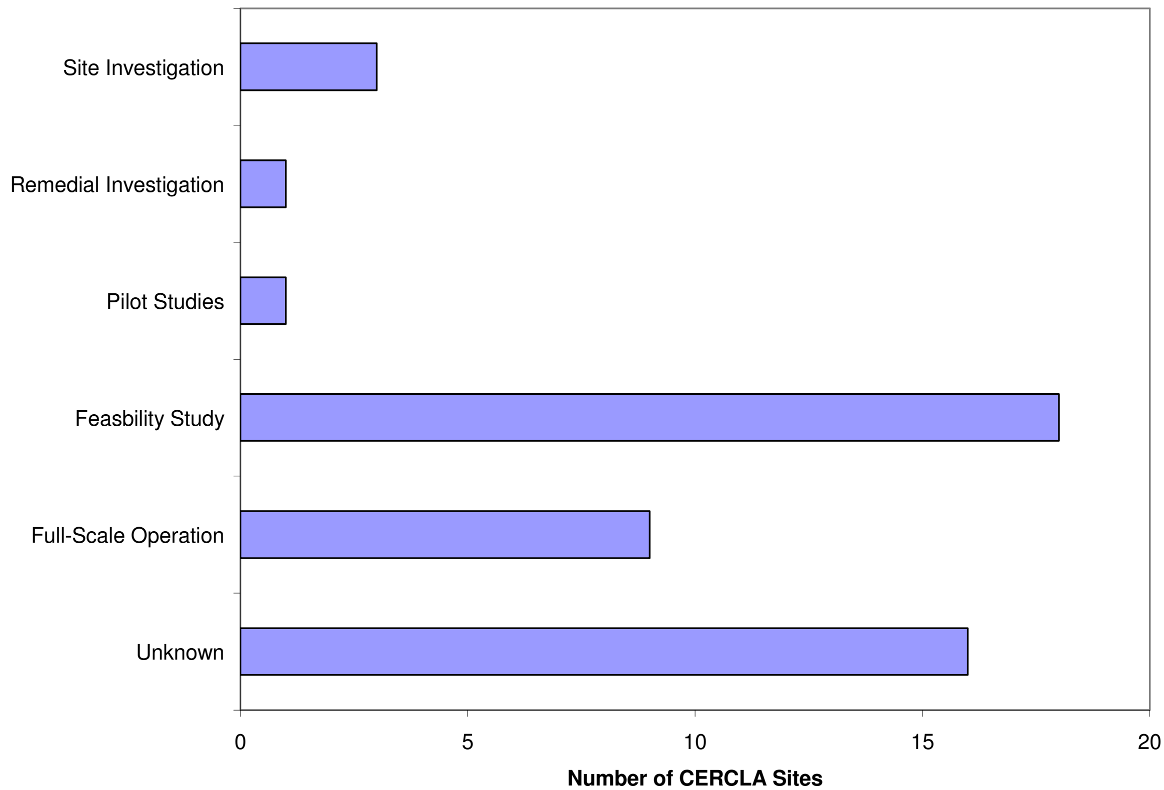
- The Old Springfield Landfill (Site #6) was given a TI Waiver in September 1990 because in large part the MCL of the contaminants of concern were below the practical quantification limit (PQL).
- The Alladin Plating site (Site #17) was granted a TI Waiver because the evaluated remedial technologies were deemed not to be effective in practice.
- The Whitmoyer Laboratories facility (Site #24) was granted a TI Waiver in December 1990 due to pump-and-treat resulting in attaining a non-reducible concentration level (asymptotic level).
- The Middletown Air Field (Site #25) was given a TI Waiver in December 1990 because the best available technology at the time (air stripping) could not meet background levels in practice.

- The East Helena site (Site #40) received a TI Waiver in November 1989 because existing water treatment technologies could not achieve treatment to levels of state water quality standards.
- The Del Norte Pesticide Storage facility (Site #41) received a TI Waiver in August 2000 due to pump-and-treat resulting in an asymptotic level that was above the cleanup standard, and subsequent system modifications failed to improve system performance.

Data Basis and Corresponding Timing for TI Application

Data used to determine TI Waivers at the 48 CERCLA sites reviewed for this study indicate that full-scale operation of a remediation system was not needed to support the TI Waiver. In fact, the majority of sites (35 of the 48 sites, or 73%) received TI Waivers before implementing a full-scale remediation system. The stage of the CERCLA cleanup process at the time of the TI Waiver application was assessed for each site as well as the amount and quality of the data used in the application. The following sections discuss the stages of the cleanup process with respect to TI Waiver applications, and more discussion with respect to data needs for a TI Waiver application.

As previously stated, it is surprising that the majority of TI Waivers identified in this study have been front-end decisions. In fact, almost three-fourths of the 48 TI Waivers were front-end, dispelling the myth that front-end TI Waivers are the exception to the rule. The stage of cleanup process at which site data were used to support a TI application at each of the 48 TI Waiver sites is shown on the graph on the following page.



Data Basis at the Time of TI Waiver Application

EPA Consultation

In the 1993 EPA guidance document, consultation with the EPA was explicitly recommended if a PRP or site owner/operator is considering a TI Waiver request. Therefore, it would be prudent that the Army should consult the EPA throughout the application process. In our research for this report, we found that continual interaction with the EPA, from the early stages of the site investigation up to and through the TI evaluation process, was a critical component in the success of a TI Waiver application.

Our study found that TI Evaluation Reports substantially varied in detail, depending on the amount of prior contact with the EPA. At the G.E. Moreau site (Site #11), for example, the TI Evaluation Report was only 6 pages long, brief and to the point. However, in the attached references, more than 50 letters between the PRP, EPA and the state (NY Department of Environmental Protection) regarding the proposed TI Waiver were added to the public record and referenced.

TI Evaluation Reports

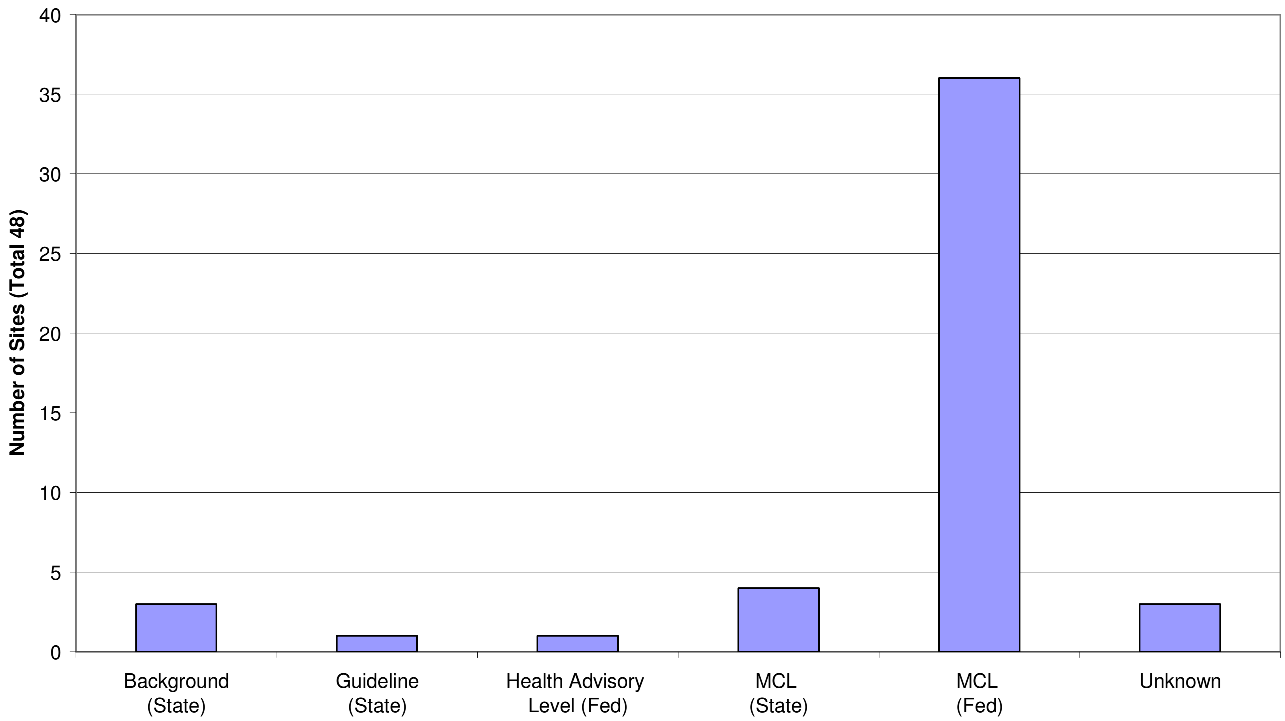
The Army may decide to apply for a TI Waiver. An application report, known as a TI Evaluation Report, can then be prepared and submitted. The TI Evaluation Report can be prepared by the Army, the EPA, or the State as appropriate. The Report, as outlined by the EPA, generally should include the following components, which are discussed in following subsections.

- ARARs or MCSs for which the TI Waiver is sought.
- Spatial area over which the TI decision will apply, known as the "TI Zone".
- Conceptual Site Model (CSM) describing site geology, hydrology, and the sources, transport, and fate of groundwater contamination .
- Evaluation of the restoration potential of the site, including support for arguments that attainment of ARARs or MCSs is technically impracticable from an engineering perspective.
- Cost estimates of the existing or proposed remedy options, including construction, operation and maintenance costs.
- Any additional information or analyses that might be requested by EPA to support a TI evaluation, such as a proposed "alternative remedial strategy".

ARARs/MCSs

From our study of 48 TI Waiver sites, the highest standard generally waived was the Federal MCL value. When MCLs were non-existent, health advisory levels and state guidelines served as chemical-specific ARARs and were waived. For three sites in Pennsylvania that received TI Waivers, state background levels were waived but the sites were deemed able to remediate contaminants to Federal MCL levels (the other 8 sites in Pennsylvania waived Federal MCLs in addition to state background levels). A summary of the ARARs waived at the 48 CERCLA sites is shown on the graph below.

As previously mentioned, a TI Waiver can apply to multiple ARARs, in which case each ARAR is specifically named listed. For the Pease AFB (Site #4), 19 ARARs were included in the TI Waiver, including chemical-specific, location-specific and action-specific requirements. To-be-considered (TBC) criteria were also waived in the Pease AFB ROD. For the Continental Steel Site (Site #27), the TI Evaluation Report simply references all ARARs described in the Feasibility Study. Some TI Evaluation Reports are vague about which ARARs are to be waived. For example, in the Brodhead Creek Site (Site #16), contaminants of concern (COCs) that will be included in the waiver were identified. The report then states, "*In addition, the TI determination is sought to waive the PA DER Ground Water Protection Strategy, which requires groundwater to be restored to background conditions*". It is unclear which other chemical-specific ARARs are implied by the words "in addition", since only one is specifically mentioned. This type of language is not recommended, based on the EPA guidelines.

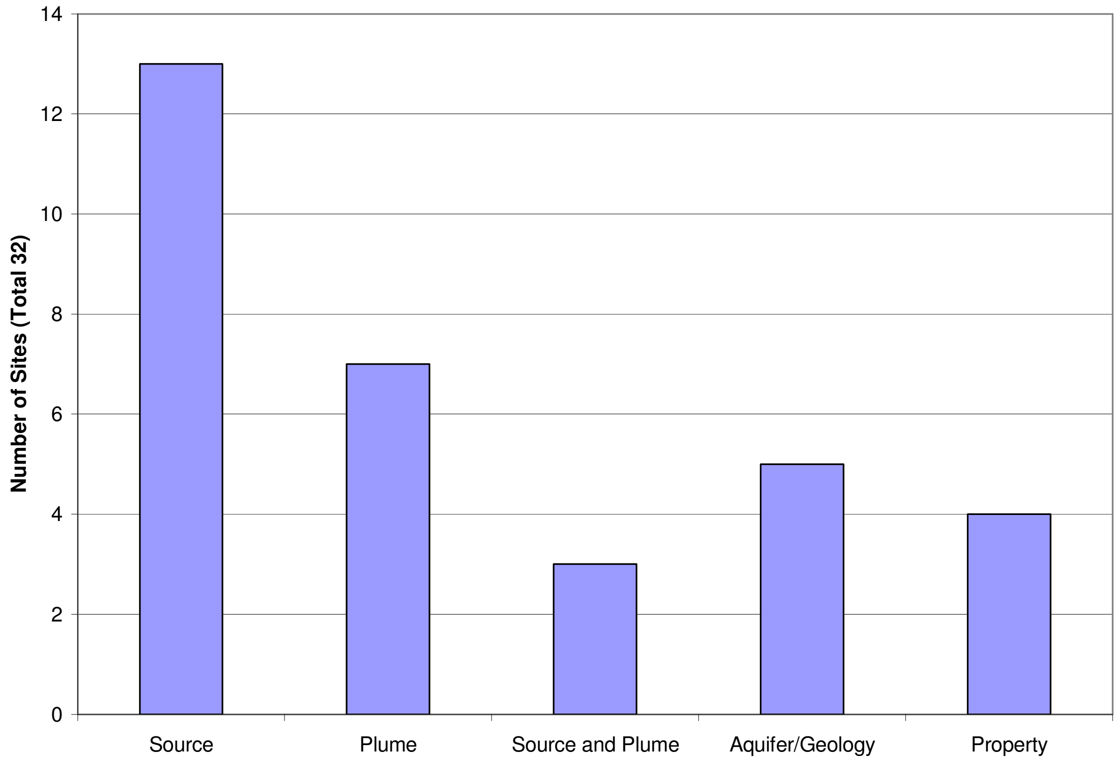


Highest ARAR Cleanup Standard Waived due to Technical Impracticability

TI Zone

From our study of 48 TI Waiver sites, more than half of the sites (27 of 48) designated only a portion of the property as the TI Zone. For example, the Broderick Wood Products (Site #38) identified the Denver Aquifer as the TI Zone. Some of the remaining 21 sites included areas off site in the TI Zone, in addition to the site property. The size of the TI Zones in the sites studied ranged from 640 sq. ft. to 28,000 acres (43.75 sq. mi), with an average depth of 200 ft. The graph below presents the extent of the TI Zone for a subset (32 of 48) of the sites, for which detailed descriptions of the TI Zone were available.

As shown on the graph below, the most common TI Zones correspond to source areas. This is consistent with the fact that DNAPL contamination is commonly present at TI Waiver sites, leading to an approved TI designation. At other sites, the plume area or portion thereof was included in the TI Zone, due to an inability to remove source areas, and containment systems (pump-and-treat or barrier systems) were put in place to control the plume extent to within the boundaries.



TI Zone designations at 32 CERCLA sites

Conceptual Site Model

From our study of 48 TI Waiver sites, the level of detail of the CSM description in the TI Waiver application documents was varied. Some sites merely reference other documents such as an RI/FS report or a ROD. Others devote numerous pages on the topic. Many of the CSMs presented in TI Evaluation Reports were not presented within the usually accepted framework of sources/pathways/receptors, but supplied the same information via other methods.

Site No. 1: Hocomonco Pond, Massachusetts

General:	
Unit(s):	01
Contaminants:	Creosote.
Other Contaminants Onsite:	Benzopyrene, phenols, arsenic, chromium, PAHs.
ARARs:	Waiver of groundwater ARARs that were established in the 1992 Supplemental Decision Document for certain portions of the Site.
Geology:	Not specified.
Hydrology:	GW used as drinking water, surface water used for other purposes. Wetlands are impacted.
Reason(s) for TI Approval:	
Primary Reasons:	GW restoration is technically impracticable in areas with creosote (DNAPL) contamination.
Secondary Reasons:	
Post-Implementation Waiver	
Years of Remedial Action:	5 (from starting up of the system)/ 17 (from first investigations on site).
Site Activities:	Massachusetts Department of Environmental Protection (MADEP) conducted investigations in 1982. ROD approved in 1985. PRPs required to design and construct the selected remedy in 1987. Cleanup levels for groundwater, sediments, and soils established in the 1992 Supplemental Decision Document. Groundwater treatment system designed in 1993, completed in 1994. Recovery of creosote (located 100 ft bgs) initiated in 1995. TI support summarized in "Report demonstrating the technical impracticability of restoring groundwater at the Hocomonco Pond site" prepared by Fluor Daniel GTI in April 1998 and Sediment Sampling Summary prepared by Ogden Environmental in February 1999. TI Waiver approved in September 1999. EPA Superfund, ESD for the ROD, 09/21/1999.
Remedial Activities:	Groundwater pump-and-treat. Other activities completed for the former lagoon, Kettle Pond, and Hocomonco Pond (not parts of the waiver)

Site No. 1: Hocomonco Pond, Massachusetts (Cont.)

TI Evaluation:	
TI Zone Designation:	Not Specified (NS)
Conceptual Site Model Detail:	NS
Data Basis for Waiver:	NS
Timeframe Estimate:	NS
Cost Estimate:	$2,213,000 with O&M costs of $56,000/year
Alternative Remedial Strategy:	NS
Alternatives to TI Waiver:	NS
Approval Process:	
Agencies Involved:	US EPA, Massachussets Department of Environmental Protection (MADEP)
Documentation:	1985 ROD and 1999 (“Explanation of significant difference for the ROD)
Decision Timeframe:	NO
Future Review:	Five-year review
General Comments:	
Site Setting:	Wood-treating company from 1928 to 1946. Former lagoon then filled with spillage, sludge, waste creosote and water. Lagoon then converted into an asphalt mixing plant. Presence of discarded aggregate and asphalt. Site last used as a cement plant.
TI Evaluation Report:	There are two of them: “Report demonstrating the technical impracticability of restoring groundwater at the Hocomonco Pond site” prepared by Fluor Daniel GTI in April 1998 and Sediment Sampling Summary prepared by Ogden Environmental in February 1999.
Process:	
Other:	

Site No. 2: Loring Air Force Base, Maine

General:	
Unit(s):	OU 12: Quarry Plume, Entomology Shop/ Jet Engine Build-Up Shop (ES/JEBS) Plume.
Contaminants:	BTEX, SVOCs (napthalene), chlorinated solvents (TCE, cis-1, 2 DCE, VC, [in quarry, also PCE, 1,2-DCA, 1,1-DCE, 1,1,2-TCA, chlorobenzene, ethylbenzene]). No NAPL, except in quarry (DNAPL and LNAPL in quarry). Only PCE, TCE in Quarry site are included in waiver.
Other Contaminants Onsite:	None. All are included in the TI Waiver.
ARARs:	PCE, TCE Federal and State MCLs waived. New ARARs are part of the OU12 ROD.
Geology:	Overburden (fill and till) and Bedrock, with degrees of weathering and fracturing.
Hydrology:	High permeability, high flow. Bedrock groundwater is impacted in some source areas, as well as the overburden (shallow) groundwater. Flow is not homogenous; between some wells in close proximity, no hydraulic connection was observed. Fracture networks and faults.
Reason(s) for TI Approval:	
Primary Reasons:	Contaminants are presumed to be diffusing into and out of rock fractures, due to concentration gradients. Diffusion out of the bedrock is a slow process, and pump-and-treat does not increase this diffusion rate. In the Quarry area, the presence of DNAPL and LNAPL further complicates cleanup. Geology is fractured bedrock. Contaminants in the fractures are often not hydraulically accessible.
Secondary Reasons:	An uncertainty in the estimates of contaminant mass in the subsurface and the hydraulic conditions on the site were used to emphasize the uncertainty in remedial success within a reasonable timeframe.

Site No. 2: Loring Air Force Base, Maine (Cont.)

Front-End Waiver	
Years of Characterization:	Listed on NPL in 1990. Site was closed in 1994. TI Evaluation was submitted in 1999; approved with ROD in 1999.
Site Activities:	SI (1998) and RI (1997) reports completed. Removal Actions for Source Control (1994, 1998 Quarry; 1995 – 97; 1998; 1999). FS Report – Evaluation of many technologies and modeling of alternatives to simulate the effects of various well configurations and pumping rates. Remedial Design – SVE system in place for TCE source areas. No groundwater remedy in place. Quarry: aquifer pumping test. 1998 Drum and soil disposal (348 drums). No pilot testing.

Site No. 2: Loring Air Force Base, Maine (Cont.)

TI Evaluation:	
TI Zone Designation:	Both the Quarry Plume and Entomology Shop/ Jet Engine Build-Up Shop (ES/JEBS) Plume are included in the TI Zone. The vertical extent of the TI Zone is from the water table to about 300 feet bgs (to include 150 ft of competent bedrock beneath the weathered bedrock).
Conceptual Site Model Detail:	7 pages in the TI Evaluation Report. Mostly gives site setting, geology, hydrogeology, magnitude of biodegradation and matrix diffusion and deductions about locations of sources, hydraulic connectivity, fate and transport. A detailed CSM was prepared as part of the RI and SI reports (OU12 RI, JEBS SI)
Data Basis for Waiver:	Computer simulations were used to demonstrate that available remediation technologies could not meet ARARs within a reasonable period of time (100 years). In addition, site characterization data were used to support the CSM (used in the modeling).
Timeframe Estimate:	Within the TI Zone, compliance with ARARs is not expected until 320 years in the ES/JEBS Plume Area, and between 168 and 1,152 years in the Quarry Plume Area.
Cost Estimate:	Varied from 0 (no action) to $11.4 M (Enhanced Fracture P&T).
Alternative Remedial Strategy:	A Groundwater Management Zone Alternative was selected. This comprised natural attenuation (dilution, dispersion, biodegradation) in source areas, long-term groundwater monitoring in the TI Zone, at designated boundaries and at potential exposure points. Groundwater use restrictions were instituted to prevent groundwater contact by human receptors. An alternative water supply was established.
Alternatives to TI Waiver:	None were applicable based on modeling. Remedial alternatives chosen for model simulation included: no action, limited action, GMZ Containment, Source Area Collection and Treatment (pump and treat). For quarry area, in-situ chemical oxidation was evaluated, but the high advective flows in the fractured system would not be overcome and would likely not contain the significant portion of the contaminant mass. Injected nutrients to stimulate bioremediation would not be effectively delivered..
Approval Process:	
Agencies Involved:	DOD was the lead agency.
Documentation:	In 1999 ROD.
Decision Timeframe:	Same year.
Future Review:	Every 5 years.

Site No. 2: Loring Air Force Base, Maine (Cont.)

General Comments:

Site Setting:	Quarry = waste disposal area with unknown waste (hundreds of drums, etc); ES/JEBS = waste treatment; manufacturing; pesticides; fuel tanks. Operated since 1950s.
TI Evaluation Report:	Two Separate TI Evaluations were prepared, one for each plume area – essentially the same report but since the two areas have different geology and different contaminants, it would make it easier for the agency to approve one of two if it didn't like them both.
Process:	LOTS of comments. Indicates several revisions of the first TI Waiver Evaluation
Other:	Very similar to the VAAP site in geology and problems in characterizing the site. Think a large part of the approval rests on the modeling exercise, which demonstrates that ARARs will not be reached within a reasonable timeframe.

Site No. 3: South Municipal Water Supply Well Site, New Hampshire

General:	
Unit(s):	01
Contaminants:	TCE, 1,1-TCA, PCE, toluene, DCE, VC, etc.
Other Contaminants Onsite:	PCBs, PAHs, metals
ARARs:	ARARs, Federal Drinking Water Standards, are waived for a portion of the aquifer currently affected by DNAPLs
Geology:	Overburden and bedrock
Hydrology:	Overburden aquifer and bedrock aquifer are hydraulically connected. The overburden aquifer is semi-confined to unconfined and the bedrock aquifer behaves as a leaky confined aquifer.
Reason(s) for TI Approval:	
Primary Reasons:	DNAPL in multiple locations (exact locations unknown).
Secondary Reasons:	Hydrogeology.
Post-Implementation Waiver:	
Years of Remedial Action:	15 (from first investigations on site by agency).
Site Activities:	VOCs detected in October 1982, well shut down in December 1982. Site on NPL in September 1984. NHBB identified as a PRP in 1985. Consent order in which NHBB agreed to conduct the RI/FS in July 1986. RI/FS completed in 1989. ROD issued in September 1989. Remedy selection in May 1993. Groundwater extraction system started in March 1994. Vacuum extraction - October 1994. TI waiver approved in 1997.
Remedial Activities:	Groundwater extraction system with air stripping and vapor phase GAC treatment (1994); vacuum extraction system for soil; excavation and off-site disposal, wetlands restoration, long-term monitoring, institutional controls.

Site No. 3: South Municipal Water Supply Well Site, New Hampshire (Cont.)

TI Evaluation:	
TI Zone Designation:	Comprises the NHBB area plume (as referred in the ROD). Includes both the overburden aquifer and underlying bedrock.
Conceptual Site Model Detail:	Described in the ROD
Data Basis for Waiver:	RI/FS, ROD, Remedy operation for 3 years (quarterly monitoring)
Timeframe Estimate:	Average remediation time estimated to be 108 years, based on estimated DNAPL mass (20,400 g/m^3), groundwater velocity, porosity, DNAPL concentration in water, and DNAPL x-sectional area. (max time in ROD = 32 years).
Cost Estimate:	Savings due to TI Waiver are estimated to be $3.5 M over the next 30 years due to a change in punping rate (pumping for containment, not for mass removal and cleanup). The original ROD estimate was total Present Worth of $7.39 M (O&M was $3.99 M).
Alternative Remedial Strategy:	Hydraulic containment in TI Zone.
Alternatives to TI Waiver:	Several remedial technologies (excavation, DNAPL pumping, in-situ bio, containment with barrier walls, PRBs, soil flushing and MNA). None would achieve cleanup levels within a reasonable time frame. Some would be even less effective than pump-and-treat with TI Waiver.
Approval Process:	
Agencies Involved:	US EPA, New Hampshire Department of Environmental Services (NHDES)
Documentation:	ESD.
Decision Timeframe:	None given.
Future Review:	None mentioned.
General Comments:	
Site Setting:	NHBB site (New Hampshire Ball Bearing) the RP. Municipal well nearby (contamination discovered during routine sampling) - well shut down.
TI Evaluation Report:	Attached to ESD. 8 pages total.
Process:	
Other:	

Site No. 4: Pease Air Force Base, New Hampshire

General:	
Unit(s):	Source area is Site 32, center of Pease AFB. Entire land parcel is 4,365 acres.
Contaminants:	TCE and other DNAPLs.
Other Contaminants Onsite:	No
ARARs:	Federal and state chemical-specific, location-specific and action-specific ARARs (MCLs for TCE, DCE, VC and benzene).
Geology:	Five units: upper sand, marine clay and silt, lower sand/glacial till, shallow bedrock and deeper bedrock.
Hydrology:	All five units hydraulically connected.
Reason(s) for TI Approval:	
Primary Reasons:	Contaminant factors – DNAPL.
Secondary Reasons:	Geologic factors - Low yield (<1 gpm per well).
Front-End Waiver:	
Years of Characterization:	5
Site Activities:	1988 TCE solvent tank was removed. 1990 Listed on the NPL. 1990 IRM to remove overflow pipe and soil. 1991 (March) Base was closed. Pilot groundwater extraction and treatment system implemented. 1983-1992 RI. RI/FS, treatability studies. 1993-1997 Eleven RODs were approved (thirteen stages of cleanup). 1995 TI Waiver Evaluation submitted. 1995 ROD (TI Waiver)approved for Site 32.

Site No. 4: Pease Air Force Base, New Hampshire (Cont.)

TI Evaluation:	
TI Zone Designation:	Source zone for Site 32 and some of the plume area that is hydraulically contained by the vertical barrier/groundwater extraction system. Approximately 700 by 500 square feet area. Extends vertically 20 feet into the shallow bedrock.
Conceptual Site Model Detail:	Dissolved contaminants are migrating in preferential pathways in the shallow bedrock unit. Vertical hydraulic gradients (downward at the source, upward in other areas) were used to explain presence of contaminants far from the source. Attempts to identify DNAPL areas using drive point profiling (U. Waterloo).
Data Basis for Waiver:	Based on 10 years of site characterization data and interim measures performance data. Interim measures included pumping from the lower sand/glacial till layer and the shallow bedrock. Results: low yield, undesirable subsidence. Management of contaminant migration was deemed more efficient and feasible use of resources. Also used modeling (3D geologic model created with EarthVision and 1D groundwater flow model MODFLOW to evaluate different containment, pump-and-treat scenarios with and without containment). Researched documented failure of remedial technologies in similar situations. Efforts to locate DNAPL included installation of monitoring wells at the lower sand/glacial till and shallow bedrock interface, rotasonic drilling, use of hydrophobic dye and fluorescence techniques to evaluate cores and sampling without well development and purging. Concluded DNAPL was present
Timeframe Estimate:	Assumptions: volume of TCE released, reduction over time of influent concentrations, pump-and-treat could actually remove all TCE (below MCLs). Estimate 37 to 220 years for remediation (range of contaminant mass released = 3,200 to 16,985 gallons).
Cost Estimate:	TI Waiver saved about $4 M in potential remediation costs (newspaper article). No mention of cost savings in the TI Evaluation Report.
Alternative Remedial Strategy:	Containment of migration of contaminants outside of the TI Zone using vertical and hydraulic barriers (source containment). Administrative controls are already in place (land-use restrictions – to be supplemented with deed restrictions).
Alternatives to TI Waiver:	Eight alternatives to the TI Waiver were considered as part of the RI/FS. These included: 1) source area pump-and-treat, 2) SVE/air sparging, 3) ex-situ, on-site thermal, 4) excavation, 5) isolation using horizontal and vertical barriers, 6) ex-situ chem. ox, 7) pneumatic fracturing of bedrock with sumps for collecting groundwater/adding DPE vents in backfilled overburden; and 8) passive adsorption using innovative media.

Site No. 4: Pease Air Force Base, New Hampshire (Cont.)

Approval Process:	
Agencies Involved:	US Air Force is the lead agency. 55-year long-term lease with the Pease Development Authority (PDA).
Documentation:	ROD
Decision Timeframe:	Draft TI Evaluation issued in 1994. Final in 1995. ROD (TI Approval) in 1995.
Future Review:	
General Comments:	
Site Setting:	TCE is from underground storage tank. The airfield is now a fully functional commercial airport.
TI Evaluation Report:	Relatively extensive TI evaluation.
Process:	First site to have obtained a front-end TI Waiver in Region 1.
Other:	Classic DNAPL problem, complicated by a complex hydrogeology.

Site No. 5: Tansitor Electronics, Inc., Vermont

General:	
Unit(s):	01, Shallow groundwater under the site.
Contaminants:	VOCs: 1,1,1-TCA, 1,1-DCE, TCE, PCE, VC.
Other Contaminants Onsite:	Silver, boron, other VOCs.
ARARs:	Federal and state requirements (MCLs and non-zero MCLGs)
Geology:	180 feet of glacial till
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	Timeframe of remediation – low permeability and high concentrations.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	5 to 6
Site Activities:	1989 Listed on the NPL 1990 Comprehensive site investigation 1994 State reclassified the aquifer as Class IV, not Class I. 1995 ROD included TI Waiver 1999 Deleted from NPL
TI Evaluation:	
TI Zone Designation:	9.6 acres - boundary is same as area that the state designated Class IV. Encompasses the source zone areas.
Conceptual Site Model Detail:	
Data Basis for Waiver:	Study was performed during the FS to evaluate TI
Timeframe Estimate:	Modeling suggested 160 to 630 years to clean up groundwater. EPA accepted this as a 300 yr avg; 450 yr average for MNA.
Cost Estimate:	Cost of the selected remedy = $18,000 capital, $30,000 O&M - $390,000 total (based on 30 yrs of operation and 7% interest).
Alternative Remedial Strategy:	Institutional controls and groundwater monitoring (MNA), also contingency measures if concentrations increase.
Alternatives to TI Waiver:	Groundwater pump-and-treat followed by MNA (50 years of pumping; 300 years of MNA).

Site No. 5: Tansitor Electronics, Inc., Vermont (Cont.)

Approval Process:	
Agencies Involved:	EPA, DOJ, Vermont ANR (agency of natural resources). Vermont ANR since December 1999.
Documentation:	In 1995 ROD
Decision Timeframe:	
Future Review:	Every 5 yrs
General Comments:	
Site Setting:	115 drums of process wastes were dumped into a stream or onto the ground. Runoff and groundwater contamination in the area. Rock mine is located ¾ mile away (pumping at 1.2 MGD)
TI Evaluation Report:	
Process:	State agreed to reclassify the aquifer from Class I to Class IV.
Other:	

Site No. 6: Old Springfield Landfill, Vermont

General:	
Unit(s):	02
Contaminants:	VOCs (benzene, vinyl chloride, PCE, TCE, toluene, xylenes) in groundwater and soil
Other Contaminants Onsite:	PAHs and PCBs in soils
ARARs:	SDWA MCLs and state standards for all contaminants, Practical Quantitation Level (PQL) for PCE
Geology:	Unsaturated sands overlying low permeability, saturated glacial till, underlain by high permeability sands and gravel and fractured bedrock
Hydrology:	Water-table surface is near the top of the glacial till over most of the site
Reason(s) for TI Approval:	
Primary Reasons:	Remediation of PCE to <MCL judged technically impracticable, from an engineering perspective.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	7
Site Activities:	1947-1968 Landfill for disposal of municipal solid waste and hazardous industrial liquid and semi-liquid waste 1976 Investigations by Vermont DOH and Vermont Agency of Environmental Conservation started at the site after a resident complained of foul-smelling water. Reviewed by EPA 1983 Site on NPL 1985 RI Report 1988 FS + additional RI Report to delineate the former waste disposal areas and assess the potential health threats 1988 ROD for Operable Unit 01 (for management of migration operable unit for seeps and to a limit extent groundwater) 1990 ROD for Operable Unit 02 (to address the risks associated with ingestion of contaminated soils through source control remedial actions) and TI invoked

Site No. 6: Old Springfield Landfill, Vermont (Cont.)

TI Evaluation:	
TI Zone Designation:	None.
Conceptual Site Model Detail:	Hydrologic model described in the RI
Data Basis for Waiver:	Pursuant to CERCLA section 121 (D) (4) (C) and section 300-430 (F) (1) (11) (C)(3) of NCP, EPA invoked a waiver of the enforcement standard for PCE. EPA determined that it was technically impracticable, from an engineering perspective, to establish the regulating standard (in this case MCL) below the PQL (i.e. "the lowest concentration that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions", 54 FED. REG. 22062, 2210 (May 22, 1989)).
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$8.7 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Capping of waste areas 2, 3, and 4; collection of ground and surface water in french drains; extraction of groundwater with source control wells; stabilization of the side slopes; collection and venting of landfill gases; operation and maintenance of these components; and institutional controls
Alternatives to TI Waiver:	None.
Approval Process:	
Agencies Involved:	US EPA
Documentation:	ROD 1990
Decision Timeframe:	Approved with 1990 ROD
Future Review:	5-yr review

Site No. 6: Old Springfield Landfill, Vermont (Cont.)

General Comments:	
Site Setting:	60 people lived on the property transformed into a trailer park on top of the landfill. All residents moved as of June 1990, after selling trailers to the PRPs. Approximately 500 people live within a 1-mile radius of the site, most of them use public drinking water system. The land use within a 1-mile radius is primarily low-density residential housing, light agriculture, undeveloped forest land, and commercial development.
TI Evaluation Report:	None
Process:	
Other:	

Site No. 7: Sullivan's Ledge, Massachusetts

General:	
Unit(s):	01
Contaminants:	VOCs (benzene, TCE); PCBs; and inorganics (lead)
Other Contaminants Onsite:	PAHs in soils
ARARs:	State and federal water quality standards
Geology:	Overburden composed of fill (derived from glacial deposit, silt, sand, gravel, and rock fragments), glacial till and swamp material; shallow bedrock highly fractured; deep bedrock fractured. Presence of 4 quarry pits (as deep as 150 ft) in fractured bedrock filled with debris and solid waste
Hydrology:	GW in overburden, shallow and deep bedrock.
Reason(s) for TI Approval:	
Primary Reasons:	MCL ARARs in the on-site and immediately off-site groundwater has been found to be technically impracticable. It is based primarily on the nature of the wastes and contaminants within the pits and along the bedrock fractures, and the geology of the site. Highly contaminated wastes located within the pits and along the bedrock fractures cannot be cleaned up by conventional excavation and pumping methods as it is not possible to locate and extract all the contaminated pockets.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	5
Site Activities:	1940s-1970s Disposal of hazardous material and other wastes including electrical capacitors, fuel oil, volatile liquids tires, scrap rubber, demolition material, brush, trees by local industries 1970s After a fire, backfill of the only existing open pit and exposed all exposed refuse 1982 Electrical capacitors were unearthed 1984 NPL list 1984-1985 Site is fenced to limit the potential for exposure to hazardous materials at the site 1986-1988 Site investigations revealed high concentrations of PCBs in soil 1989 ROD

Site No. 7: Sullivan's Ledge, Massachusetts (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	EPA conceptual model of PCB migration (fate and transport) by Battelle, 1991 (Overview of the New Bedford Harbor Physical Chemical Modeling Program, Battelle Ocean Sciences, Duxbury, MA.)
Data Basis for Waiver:	Complicated geology; difficult access to contamination
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$2.8 M 30-year present worth costs for the final selected remedial alternative (including O&M) and $7.8 M 30-year present worth costs for the contingent remedy (including O&M) needed because implementation of the selected remedy is dependent upon the Sullivan's ledge disposal area being available for disposal of middle marsh sediments and soils
Alternative Remedial Strategy:	Groundwater treatment system, passive collective system for shallow groundwater and seeps, monitoring, institutional controls, excavation and disposal of sediments, cap over quarry pits, wetlands restoration
Alternatives to TI Waiver:	None – options for cleanup were No Action ($1.2 M); different combinations of containment, solidification, incineration, and vitrification with passive or active groundwater collection ($5.1 M to $88 M)
Approval Process:	
Agencies Involved:	US EPA
Documentation:	1989 ROD Decision Summary
Decision Timeframe:	Approved with 1989 ROD
Future Review:	5-yr review
General Comments:	
Site Setting:	Approximately 98,500 people live within 3 miles of the site in this residential area. Within 1 mile of the site are two nursing homes and three schools. The New Bedford Municipal Golf course is located immediately north of the site.
TI Evaluation Report:	None
Process:	
Other:	

Site No. 8: Pinette's Salvage Yard, Maine

General:	
Unit(s):	01
Contaminants:	VOCs (benzene), organics (PCBs), metals (lead)
Other Contaminants Onsite:	
ARARs:	MCLs or State of Maine Maximum Exposure Guideline (MEG)
Geology:	Surface soils (alluvium), clay silt confining unit, sequence of glacial till glacial outwash, bedrock unit (weathered and fractured upper unit and deeper less fractured unit)
Hydrology:	Two distinct aquifers (shallow overburden and glacial till/fractured bedrock) separated by an intervening clay layer
Reason(s) for TI Approval:	
Primary Reasons:	The Maine Maximum Exposure Guideline (MEG) for PCBs of 0.5 ppb was invoked due to the technical impracticability from an engineering perspective of collecting the particulate-bound PCBs from the groundwater to a level that meets state drinking water standard.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	7
Site Activities:	Site used as a vehicle repair and a salvage yard 1979 Leak of 900 to 1000 gallons of dielectric fluid containing PCBs spilled directly on the ground from electrical transformers 1980-1981 Site investigations 1982 NPL list 1983 Removal action of PCBs (excavation and off-site disposal of soils) 1985 Deletion Remedial Investigation (DRI) 1989 ROD

Site No. 8: Pinette's Salvage Yard, Maine (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	PCBs strongly bind to soil particles; removal of bound PCBs is not practicable.
Timeframe Estimate:	Approved with 1989 ROD
Cost Estimate:	$4.4 M 30-year present worth costs for the final selected remedial alternative and migration component (including O&M)
Alternative Remedial Strategy:	Source control: off-incineration of PCB-contaminated soils greater than 50 ppm and on-site solvent extraction of additional PCB- and organic-contaminated soils Management of migration component: expedited groundwater collection, carbon adsorption treatment, and discharge of the treated water into the shallow aquifer; access restriction; institutional controls; and long-term monitoring
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA
Documentation:	1989 ROD
Decision Timeframe:	30 years (monitoring)
Future Review:	5-yr review
General Comments:	
Site Setting:	Land surrounding the site is used for residential, general industrial, and agricultural purposes. An undeveloped forest and a wetlands area are adjacent to the site. The water supply for the approximately eight to ten residences located within a one-half mile radius of the site is obtained from private wells located in the deep, bedrock aquifer below the site
TI Evaluation Report:	None
Process:	
Other:	

Site No. 9: DuPont/Necco Park, New York

General:	
Unit(s):	01
Contaminants:	Carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, methylene chloride, PCE, TCE
Other Contaminants Onsite:	
ARARs:	Federal and state MCLs
Geology:	Unconsolidated overburden material (glacially derived sand, silt, and clay, and miscellaneous fill); Queenston formation (thick, soft red-brown mudstone with minor sandstone bed); Silurian system including the Medina, Clinton, and Lockport groups)
Hydrology:	Groundwater in the Lockport formation, which is extensively fractured. As a result, there are distinct water-producing units
Reason(s) for TI Approval:	
Primary Reasons:	Remediation of DNAPLs is technically impracticable from an engineering perspective. DNAPLs migrated to the fractured bedrock. No technology is available to remove DNAPLs from the fractured bedrock.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	15-20 years (the site was not ranked enough to be on the NPL)
Site Activities:	Mid-1930s-1977 Disposal of industrial and process wastes generated at the DuPont Niagara Plant 1977 Facility closed, GW investigations started 1984-1988 Investigation and remedial studies conducted at the site 1992 EPA approves the Interpretive Report 1994 EPA approves the Investigation Report 1996 EPA approves the Analysis of Alternatives Report 1998 ROD (the site was not ranked enough to be on the NPL)

Site No. 9: DuPont/Necco Park, New York (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	DNAPL has migrated into the fractured bedrock. No technology is available to remove DNAPLs from the fractured bedrock
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$65.1 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Groundwater extraction from the existing wells as well as additional extraction to achieve total hydraulic control of the different zones in aquifer (source area) and to prevent groundwater and DNAPLs from migrating beyond the source area
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA
Documentation:	1998 ROD
Decision Timeframe:	Approved with ROD
Future Review:	5-year
General Comments:	
Site Setting:	Located in a heavily industrialized section of Niagara Falls and is bounded on three sides by commercial disposal facilities. Residential neighborhoods are located approximately 2,000 to 2,500 ft from the site.
TI Evaluation Report:	None
Process:	
Other:	

Site No. 10: Niagara Mohawk Power Company, New York

General:	
Unit(s):	
Contaminants:	PAHs and VOCs associated with coal tar
Other Contaminants Onsite:	
ARARs:	Federal and state MCLs
Geology:	Fill material (fine to medium-grained sand with clay, rock fragment, and construction debris); Upper fluvial unit (fine to coarse-grained, poorly sorted sand with silt, clay, and minor organic matter); Peat unit (presence of highly organic, woody material interbedded with sand lenses); Lower fluvial unit (sorted, medium to coarse-grained sediments associated with post-glacial stream deposition); Glaciolacustrine clay; Till (poorly sorted mix of boulders, cobbles, gravel, sand ,silt, and clay); bedrock
Hydrology:	Shallow unconfined aquifer (within the fill, upper fluvial, peat, and lower fluvial unit) and a deep aquifer within the bedrock
Reason(s) for TI Approval:	
Primary Reasons:	Presence of DNAPL. Technical limitations to recovering residual DNAPL
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	5
Site Activities:	1896-1950 manufactured gas plant (MGP) and gas storage area 1950-present Niagara Mohawk Power Corp. 1965-1985 Site investigations 1990 NPL list 1992 RI 1995 FS and Proposed plan for site 1995 ROD

Site No. 10: Niagara Mohawk Power Company, New York (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Technical limitations to recovering residual DNAPL
Timeframe Estimate:	2 years (for removal of most contamination)
Cost Estimate:	$15.3 M for implementation of the selected remedy (including O&M and soil and sediment remedy)
Alternative Remedial Strategy:	Pump-and-treat of contaminated groundwater and containment with subsurface barriers
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA
Documentation:	1995 ROD
Decision Timeframe:	Approved with ROD
Future Review:	5-year
General Comments:	
Site Setting:	The site is located in a primarily residential area of Saratoga Springs. Approximately 10,000 people live within a 1 mile radius of the site and receive their drinking water supply from the City of Saratoga Springs. The corresponding reservoir is located 2,000 ft upgradient of the site. Approximately 1,300 people in trailer parks and other residents nearby obtain their drinking water from private wells within 3 miles of the site
TI Evaluation Report:	None found
Process:	
Other:	

Site No. 11: G.E. Moreau, New York

General:	
Unit(s):	Groundwater TCE plume
Contaminants:	TCE, PCBs, solvents, oils, sludge and miscellaneous wastes
Other Contaminants Onsite:	
ARARs:	NY state ambient water quality standards and guidance values, drinking water standards. Specifically, 5 ppb for TCE, 2 ppb VC, 7 ppb of 1,1-DCE and 100 ppb for total trihalomethances (including chloroform and dichlorobromomethane). NY standards are 50 ppb for trans 1,2-DCE and 50 ppb $MeCl_2$.
Geology:	75% coarse to fine sand with occasional silt and clay lenses; 25% interbedded fine sand, silt and clay seams
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	Change in estimate of remediation timeframe, based on 5-year review in 1992. Result of hydrogeologic and contaminant-related factors.
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	12
Site Activities:	1982 listed on NPL 1987 ROD with no mention of a TI Waiver 1994 TI Waiver application and approval
Remedial Activities:	Original remedy was a containment system made from a soil-bentonite cutoff wall and cap, monitoring of groundwater, air stripping in the plume area. Also, a permanent public water supply for about 100 residents was created.

Site No. 11: G.E. Moreau, New York (Cont.)

TI Evaluation:	
TI Zone Designation:	Entire groundwater plume area (approximately 4800 feet long and 2000 feet at the widest point). Average depth is 60 feet.
Conceptual Site Model Detail:	Referenced to another report (Hess et al. 1993). Variability in hydraulic conductivity is the important hydrogeological feature.
Data Basis for Waiver:	Modeling of contaminant transport that assessed 1) variations in hydraulic conductivity 2) variations in sorption capacity of the aquifer material and 3) desorption nonequilibrium. Modeled pulsed pumping and natural gradient flushing – comparable remediation timeframes.
Timeframe Estimate:	200+ years to reach ARARs – much longer than in the original ROD. For pulsed pumping, the estimate is 191-404 years vs. natural gradient flushing 237-542 years. The main difference in the two alternatives was the number of pore volumes (24-55 pore volumes natural vs. 88-278 pore volumes pumping. (Question of "reasonable timeframe" definition was raised in first paragraph of TI Evaluation. NCP Preamble may consider reasonable timeframe to mean several decades. EPA assumes about 100 years in the 1993 Guidance Document.)
Cost Estimate:	Pulsed pumping is about $17 M (cost estimates from US Army Corps of Engineers, in the ESD). Natural gradient flushing is about $1.5 M when converted to a 30-year basis (see 1987 ROD, pp. 15 and 22).
Alternative Remedial Strategy:	Original remedy, but without continued pumping.
Alternatives to TI Waiver:	In 1993, other alternatives considered included continuous pumping, one-time pulse, pulsed pumping, air sparging and permeable reaction walls.
Approval Process:	
Agencies Involved:	US EPA. In 1989 District Court ruled that EPA had waived compliance of NY state ARARs and the EPA was forced to reevaluation the groundwater restoration portion of the remedy. The NYSDEC approved the TI Waiver as the supporting agency.
Documentation:	ESD
Decision Timeframe:	Less than 1 year
Future Review:	This TI Waiver is a result of a 5-year review. Also as a result of the 1992 review, water levels in the containment system were lowered to minimize exfiltration.

Site No. 11: G.E. Moreau, New York (Cont.)

General Comments:	
Site Setting:	Site was used for industrial waste disposal (generated by GE). Plume of TCE and other VOCs is about 4800 ft long, 2000 ft wide at widest point. Groundwater discharged to surface water at Reardon Brook (contamination found).
TI Evaluation Report:	Argument is that doing nothing is actually more efficient (more pore volumes are treated but the overall remediation time is not necessarily different) and thus more cost-effective.
Process:	Signed by Jeanne M. Fox, Region 2 Administrator, NY; NY state DEP approved the waiver as a secondary agency.
Other:	

Site No. 12: Caldwell Trucking Company, New Jersey

General:	
Unit(s):	Property is 11 acres.
Contaminants:	TCE, 1,1,1-TCA, other VOCs, PAHs. Mostly TCE.
Other Contaminants Onsite:	PCBs and metals (including lead)
ARARs:	Federal and state MCLs
Geology:	
Hydrology:	Nearby river
Reason(s) for TI Approval:	
Primary Reasons:	Extent of plume and concentrations too high to clean up within a reasonable timeframe (plume is 2000 ft wide and 4000 ft long, with other overlapping plumes).
Secondary Reasons:	Impact of other sources on the plume contributes to TI
Front-End Waiver:	
Years of Characterization:	3 years (1986? to 1989)
Site Activities:	1982 Proposed for NPL 1983 Listed on NPL RI/FS – identified the amount of contaminated soil. 1986 ROD (first ROD): 1) air stripping at Municipal Water Supply Well 2) Alternative water supply to residents 3) soil excavation, treatment (low temp thermal) and landfill 1989 Second ROD: TI Waiver; also specified that groundwater wells would be installed to intercept the plume; also set up a contingency plan for containment if access rights to private properties were not obtained. 1990 Institutional controls as immediate response actions (fences, signs, covering tanks) 1991 ESD issued to delete Municipal wellhead treatment system since it was replaced by a different drinking water source. 1993 ESD issued to document remedy modification and the increased cost of remedial action. 1994 Decided to stabilize some wastes onsite, in addition to excavation and off-site disposal. 1995 Third ROD addressing soil contamination modification

Site No. 12: Caldwell Trucking Company, New Jersey (Cont.)

TI Evaluation:	
TI Zone Designation:	None – assume whole site and off-site areas as well. Contaminated zone extends from the water table to bedrock (~370 feet).
Conceptual Site Model Detail:	Minimal information in the 1989 ROD
Data Basis for Waiver:	RI/FS, off-site investigation
Timeframe Estimate:	Up to 200 years using pump and treat
Cost Estimate:	For the entire remedy, the cost estimate in 1989 ROD was $11.54 M ($0.315 M O&M). Alternative 3 cost was estimated to be $6.7 M with an O&M of ($0.315 M). Present worth is 11.54 over 30 years.
Alternative Remedial Strategy:	Residents connected to an alternative (municipal) water supply; chain-link fences and gates. Alternative 3 in the ROD was chosen (pump, treat and discharge to the river).
Alternatives to TI Waiver:	None were discussed.
Approval Process:	
Agencies Involved:	US EPA, PRPs, State of New Jersey
Documentation:	1989 ROD.
Decision Timeframe:	Unknown
Future Review:	Not mentioned
General Comments:	
Site Setting:	Caldwell Trucking disposed of wastes (residential, commercial, industrial septic waste) in unlined lagoons on their property (11 acres) from 1950s to 1973. In 1973, they used USTs for wastes. In 1984, stopped activities, and Caldwell was a transport facility only. About 500 homes within 1 mile and GW flows towards Passaic River (drinking water source). A municipal well was affected (No. 7). Passaic River has been minimally impacted.
TI Evaluation Report:	No Evaluation Report (pre-1993). TI Waiver is part of 1989 ROD.
Process:	
Other:	

Site No. 13: Naval Air Development Center, Pennsylvania

General:	
Unit(s):	Area A Groundwater – Operable Unit 12A. This is one of eight waste areas on the site (these total 15 acres)
Contaminants:	TCE, PCE, carbon tetrachloride at saturation levels (DNAPL)
Other Contaminants Onsite:	Potentially there are other compounds within the DNAPL source area, but the waiver explicitly does not apply to them.
ARARs:	Federal and State
Geology:	Bedrock fracture unit
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	High concentrations of TCE, PCE, CCl_4
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	11
Site Activities:	1989 Added to the NPL 1993 Selected interim remedy 1993 Renamed the Naval Air Warfare Center (NAWC) Aircraft Division 1996 Targeted for transfer to private sector 1996 to 1999 soil removal actions 2000 ROD with TI Waiver
Remedial Activities:	

Site No. 13: Naval Air Development Center, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	DNAPL zone is 80 feet in diameter at a depth from the water table to 70 feet bgs.
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	
Cost Estimate:	
Alternative Remedial Strategy:	Containment. This consists of 1) Existing interim remedy extraction and treatment system, same discharge setup and 2) institutional controls and monitoring.
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	Department of the Navy, PADEP concurs (representing the Commonwealth). Dep't of the Navy took the lead on the cleanup and has owned the property since 1990. Worked with EPA.
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	
TI Evaluation Report:	
Process:	
Other:	

Site No. 14: Rodale Manufacturing Company, Pennsylvania

General:	
Unit(s):	Site – wells 1-3, 5, 8 used for disposal of electroplating wastewater. Well 4 = monitoring; Well 7 = septic disposal; Well 6 = makeup cooling water. TI Zone is approx 830,000 cu yds of impacted material.
Contaminants:	TCE at >1% solubility 490 mg/L to 17 mg/L (DNAPL is likely present). Also breakdown products and related chlorinated solvents. Offsite monitoring wells are < MCL of 5 ug/L, except at MW-9 cluster which is thought to come from a separate source.
Other Contaminants Onsite:	VOCs, metals, cyanide. TI Waiver was requested for TCE, due to TCE as DNAPL.
ARARs:	MCL for TCE (5 ppb) in groundwater; PCE and TCE in the soil
Geology:	Fractured bedrock
Hydrology:	Groundwater is deep (105-115 ft bgs), preferential pathways, flow net analysis
Reason(s) for TI Approval:	
Primary Reasons:	Likely presence of DNAPL deep in fractured bedrock
Secondary Reasons:	Site-specific data was gathered to demonstrate TI. No proven technologies for DNAPL contamination in bedrock.
Front-End Waiver	
Years of Characterization:	8
Site Activities:	1981 Waste disposal wells discovered 1984 Air stripping tower took out VOCs from pumped groundwater 1988 Additional monitoring wells installed, groundwater monitoring plan 1989 Buildings demolished, another well (Well 8) found and 2 USTs removed. 1991 Placed on NPL list 1994 Interim measure groundwater recovery and treatment system 1999 TI Evaluation submitted with the FS

Site No. 14: Rodale Manufacturing Company, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	Corresponds with the Probable DNAPL Zone, found by contouring the 1% solubility area for TCE - 200 ft wide, 350 feet long and 320 ft thick.
Conceptual Site Model Detail:	Source is wastewater discharge wells.
Data Basis for Waiver:	RI data, simulations of matrix diffusion.
Timeframe Estimate:	Included mass estimates of DNAPL, expected 212-849 years to flush DNAPL (conservative estimate). 592 to 2370 years with active remediation.
Cost Estimate:	Used upper end cost estimates from "Evaluation of Technologies for the In-Situ Cleanup of DNAPL Contaminated Sites (US EPA, 1994; DOD 1997)". Range form \$99.6 M to \$488 M. With TI Waiver, estimated cost is \$4.2 M.
Alternative Remedial Strategy:	FS Alternative GW-3: Institutional controls, hydraulic containment, MNA outside the zone and groundwater treatment. Also considered 2 other options: no action (cost \$600,000) and natural attenuation w/ TI Waiver (\$1.15 – 1.4 M). Alternative 3: Groundwater Extraction with Conventional Treatment and Natural Attenuation (\$3.44 M). Option 3 was chosen based on protectiveness of the remedy.
Alternatives to TI Waiver:	Potential technologies were evaluated – 12 in detail. None demonstrated to be effective at remediating DNAPL sources.
Approval Process:	
Agencies Involved:	US EPA
Documentation:	ROD
Decision Timeframe:	9/30/99 ROD and TI Waiver
Future Review:	Every 5 years

Site No. 14: Rodale Manufacturing Company, Pennsylvania (Cont.)

General Comments:	
Site Setting:	Used for manufacturing of silk, publishing and printing (Rodale Press) and manufacturing electrical connectors, electroplating (Rodale Manufacturing + Bell Electric (Square D subsidiary)). Wells were used for disposal of wastes (approx 3,000 gpd electroplating wastewater). Square D found wells and disposed of some liquid wastes. Found trace VOCs in private wells caused by separate sources.
TI Evaluation Report:	Contains detailed CSM
Process:	
Other:	

Site No. 15: Aberdeen Proving Ground (Edgewood Area), Maryland

General:	
Unit(s):	72,516-acre site; the Beach Point Test Site (OU 2) is a 7-acre peninsula of the Aberdeen Proving Ground (Edgewood Area) that received the TI Waiver.
Contaminants:	PCA, DNAPLs
Other Contaminants Onsite:	Chlorinated VOCs, VOCs, Petroleum hydrocarbons, unexploded ordinance (UXO)
ARARs:	MCLs and MCLGs, both Federal and for the state of Maryland
Geology:	Sands and silts to a depth of 65 feet
Hydrology:	Shallow aquifer on top of a confining clay layer
Reason(s) for TI Approval:	
Primary Reasons:	DNAPL remediation difficulty due to lack of ability to characterize the DNAPL Zone, continual dissolution of DNAPL into groundwater
Secondary Reasons:	No disapproval from public or Maryland state department of environment; no routes of exposure to the public; levels in the Bush River are low.
Front-End Waiver:	
Years of Characterization:	3
Site Activities:	Removed some debris. Several creek studies on Bush River on ecological health, metals concentrations. In 1994-95, soil and soil gas sampling. Soil boring and surface soil samples. FS in June 1996. Public comment period in 1997. No CERCLA enforcement action at the site. TI Waiver approved in 1997.
TI Evaluation:	
TI Zone Designation:	
Conceptual Site Model Detail:	Dilution is protecting surface waters (Bush River) from high concentrations; no routes of exposure to the public; levels in the Bush River are low. Risk Assessment in 1995 for human health and ecological health (qualitative only).
Data Basis for Waiver:	Soil and groundwater sampling for the FS; a few other studies done on nearby rivers.
Timeframe Estimate:	Expected to be well over 100 years
Cost Estimate:	
Alternative Remedial Strategy:	Institutional controls only, including monitoring of contaminant concentrations in the Bush River.
Alternatives to TI Waiver:	Technologies considered included a slurry wall, in-situ dehalogenation and UV Oxidation/air stripping; also hydraulic containment. Objections were found in each case, including generation of cis 1,2-DCE, interference of UXO

Site No. 15: Aberdeen Proving Ground (Edgewood Area), Maryland (Cont.)

Approval Process:	
Agencies Involved:	US Army, the US EPA and MDE (tacitly approved TI Waiver)
Documentation:	ROD (TI Evaluation is part of the FS)
Decision Timeframe:	Less than 1 year
Future Review:	Review within 5 years
General Comments:	
Site Setting:	Testing range for the Army; tested impregnation of army clothing by chemical warfare agents; site drains into an estuarine channel of the Chesapeake Bay. Bush R is used for fishing and other recreational purposes
TI Evaluation Report:	
Process:	
Other:	Not very quantitative presentation for TI basis.

Site No. 16: Brodhead Creek, Pennsylvania

General:	
Unit(s):	12 acres, on the bank of Brodhead Creek, TI Waiver applied to OU2 (site groundwater in the stream gravel, extending to the depth of the bedrock).
Contaminants:	Contaminants include benzene, pcp, benz(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h) anthracene, arsenic and cyanide.
Other Contaminants Onsite:	None above Federal MCLs. Coal tar - VOCs including BTEX, PAHs and arsenic
ARARs:	State ARARs: restoration to background levels, and Federal MCLs for the contaminants listed above.
Geology:	Fill/stream gravel/ glacial overburden/ glacial till/bedrock in layers.
Hydrology:	No contamination in the deep aquifer
Reason(s) for TI Approval:	
Primary Reasons:	Site constraints: on-site wetlands and two earthen flood control levees created inability to excavate the area. Also these site conditions prevent future exposure to contaminated groundwater.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	12
Site Activities:	1981 EPA constructed an underground slurry wall, began pumping out coal tar from the ground. 1983 Listed on NPL. 1990 RI Report/ 1991 FS 1991 CROW process used in for OU 1 (soils). Coal tar recovery operations 1992 Investigation of the bedrock aquifer and RI investigation. Several emergency response measures were used to contain the plume. 1995 TI Waiver and ROD for OU 02.

Site No. 16: Brodhead Creek, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	In the shallow aquifer, volume is approximately 27,000 cu yards and area is about 3 acres. Equal to the area that contains free and residual coal tar.
Conceptual Site Model Detail:	Immobile free coal tar. Groundwater enters Brodhead Creek. Areas of free coal tar has been identified (2 small areas near MW-2 and RCC-C)
Data Basis for Waiver:	Performance of IRM (CROW process) as source control, RI/FS investigation
Timeframe Estimate:	Indefinite
Cost Estimate:	CROW present worth is $4.12 M, including annual O&M costs of $1.11 M. No cost savings data
Alternative Remedial Strategy:	The interim action was an in-situ innovative technology known as the CROW process - injecting hot water and then extracting it. Final action = No Further Action. A slurry wall is present and will prevent coal free-phase tar from entering into Brodhead Creek (not an absolute barrier to groundwater flow).
Alternatives to TI Waiver:	Alternatives included 1) No further action 2) In-situ stabilization/solidification, 3) In-situ bioremediation 4) Excavation
Approval Process:	
Agencies Involved:	EPA
Documentation:	ROD 1995.
Decision Timeframe:	ROD is dated one day after the TI Waiver was submitted (6/29/1995 and 6/30/1995).
Future Review:	5-year review was completed in May 1999. Ongoing monitoring of groundwater and the stream sediments and biota is continuing. Deed Restriction negotiations in progress.
General Comments:	
Site Setting:	Coal tar was disposed of in an open pit from 1888 to 1944.
TI Evaluation Report:	
Process:	
Other:	Pennsylvania Power & Light, Union Gas Company are two PRPs. On October 26, 2000, EPA issued the final completion report for the Brodhead Creek Site. EPA deleted the Brodhead Creek Site from the National Priorities List of most hazardous waste sites on July 23, 2001.

Site No. 17: Aladdin Plating, Pennsylvania

General:	
Unit(s):	OU 02 groundwater, 6-acre site
Contaminants:	Chromium
Other Contaminants Onsite:	Lead, cyanide
ARARs:	Background levels for chromium (PA state)
Geology:	Overburden is glacial till. Deeper is weathered and competent bedrock. Bedrock slope is opposite to topographic slope.
Hydrology:	Shallow water-bearing zone is contaminated. Groundwater velocity is slow – <1 ft/yr. Low yield (less than 2 GPD).
Reason(s) for TI Approval:	
Primary Reasons:	Technologies evaluated have not been shown to be effective at this site.
Secondary Reasons:	
Front-End Waiver	
Years of Characterization:	6
Site Activities:	1947-1982 Electroplating activities, dump wastes into 2 unlined pits 1982 fire destroyed the operation 1983 Soil sampling by PADER 1987 Removal response action to remove and dispose of the building 1987 Preliminary site assessment by EPA, PADER and TAT (Tech. Assist Team) – used an extraction test for toxicity and found soil qualified as hazardous waste. Sampled 62 residential wells; 2 detected chromium. No detections in the bedrock wells. 1987 Listed on NPL 1988 ROD for soil (OU 01). Cleanup for OU 01 was financed by the EPA Superfund. 1990 RI/FS work for OU 02 Groundwater 1993 TI Waiver approved with the OU 01 ROD.

Site No. 17: Aladdin Plating, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Modeled chromium/groundwater flow in the bedrock aquifer (>2000 years to move off-site)
Timeframe Estimate:	None
Cost Estimate:	Overall present worth of the chosen remedial strategy is $178,256.
Alternative Remedial Strategy:	Institutional controls to prohibit installation of more groundwater wells and monitoring of the area wells
Alternatives to TI Waiver:	1) No action 2) Institutional controls and monitoring and 3) Electrokinetic extraction and off-site disposal 4) Electrokinetic extraction and on-site treatment (chemical precipitation of chromium) 5) Chemical barriers 6) Stabilization
Approval Process:	
Agencies Involved:	EPA, state
Documentation:	In 1993 ROD
Decision Timeframe:	Unknown – no TI Evaluation was prepared.
Future Review:	5-yr review
General Comments:	
Site Setting:	About 50 homes within a half-mile of the site. Rural residential area, unpaved roads. Property is not fenced. Access would be by foot via private property. Little public involvement or knowledge about the electroplating activities, or that chemical were stored there and burned in the fire.
TI Evaluation Report:	None.
Process:	
Other:	

Site No. 18: E.I. DuPont De Nemours (Newport Landfill), Delaware

General:	
Unit(s):	01
Contaminants:	Chlorinated solvents, metals (arsenic, lead, cadmium, zinc, barium, mercury, copper), radioactive
Other Contaminants Onsite:	
ARARs:	Federal and state MCLs
Geology:	No details on geology in the ROD
Hydrology:	Two aquifers: the Columbia aquifer (upper aquifer) and the Potomac aquifer (the lower aquifer).
Reason(s) for TI Approval:	
Primary Reasons:	Waiver for surface water
Secondary Reasons:	

Site No. 19: Hunterstown Road, Pennsylvania

General:	
Unit(s):	01
Contaminants:	TCE, 1,1,1-TCA, VC, 1,1-DCE, 1,1-DCA, 1,2-DCA
Other Contaminants Onsite:	
ARARs:	Background and federal MCLs
Geology:	Gray silty clay/clayey silt with rock fragments, fractured bedrock (soft argillaceous red shale sedimentary rock of the Gettysburg formation) with igneous intrusives. Bedrock is altered to hard hornfels.
Hydrology:	Aquifers in the shallow and deep bedrock units
Reason(s) for TI Approval:	
Primary Reasons:	Waiver for State and Federal ARARs for groundwater contaminated with DNAPL at depth greater than 800 ft
Secondary Reasons:	
Front-End Waiver	
Years of Characterization:	7 years
Site Activities:	1970-1980 Site is serving as the recipient of wastes generated by several local corporations 1975 Investigations initiated by the Pennsylvania Department of Environmental Resources (PADER) after a complaint has been made regarding drums containing waste generated by the Westinghouse Elevator Manufacturing Plant 1984 PADER requested assistance from EPA. EPA initiates site investigations and drums are removed from the site 1986 NPL list 1986-1988 Drums removal and site is changing 1989 RI/FS Phase I 1991 Final RI/FS 1993 ROD

Site No. 19: Hunterstown Road, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	Waiver for groundwater contaminated with DNAPL at depths greater than 800 ft
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Deeper than 800 ft is not practical for capture and treatment and no technology for removal of DNAPL in fractured bedrock
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$9 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Groundwater extraction to capture groundwater above a depth of 800 ft, air stripping/catalytic oxidation treatment
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA and State agency
Documentation:	1993 ROD
Decision Timeframe:	Approved with 1993 ROD
Future Review:	5-year
General Comments:	
Site Setting:	Approximately 9,500 people live in the area and use wells within 3 miles of the site for drinking water
TI Evaluation Report:	None
Process:	
Other:	

Site No. 20: Westinghouse Elevator Plant, Pennsylvania

General:	
Unit(s):	01
Contaminants:	TCE, 1,1,1-TCA, 1,1-DCE
Other Contaminants Onsite:	
ARARs:	Federal and state MCLs
Geology:	Fill material with a mixture of grain sizes from clay to boulders; red and gray siltstones and shales overlain by red to brown clay. Bedrock is generally fractured and weathered
Hydrology:	Shallow aquifer in saturated soils and weathered bedrock, deep aquifer below weathered bedrock
Reason(s) for TI Approval:	
Primary Reasons:	State ARAR waived for groundwater
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	7 years
Site Activities:	From 1968 Elevator plant 1983 Complaints from local residents to the PADER, then sampling and removal activities conducted 1984 Additional investigations at the site, groundwater extraction with air stripping treatment system 1986 NPL list 1987 Consent agreement with EPA to perform RI/FS 1991 Phase II RI and draft FS; TCA spill on site 1993 ROD
TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Presence of DNAPL and fractured bedrock
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$4.4 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Pump-and-treat and air stripping treatment, migration control of contaminated groundwater
Alternatives to TI Waiver:	None

Site No. 20: Westinghouse Elevator Plant, Pennsylvania (Cont.)

Approval Process:	
Agencies Involved:	US EPA
Documentation:	1993 ROD
Decision Timeframe:	Approved with ROD
Future Review:	5-year
General Comments:	
Site Setting:	Population within 3 miles of the site is approximately 13,500. Adjacent to the site are streams that flow into Rock Creek, which may be used for irrigation and swimming
TI Evaluation Report:	None
Process:	
Other:	

Site No. 21: Lindane Dump, Pennsylvania

General:	
Unit(s):	01
Contaminants:	Benzene, pesticides (DDT, lindane – gamma BHC), phenols, arsenic, lead
Other Contaminants Onsite:	
ARARs:	Federal and state ARARs
Geology:	Unconsolidated alluvial deposit; Paleozoic bedrock (shales with numerous sandstones beds and limited coal and clay layers)
Hydrology:	Two aquifers in stream channel alluvium and the consolidated bedrock
Reason(s) for TI Approval:	
Primary Reasons:	Technicaly impracticable to capture all groundwater due to the complex hydrogeologic conditions at the site, the possibility of subsidence and site damage due to extensive pumping, and the potential for migration during the pumping
Secondary Reasons:	
Front-End:	
Years of Characterization:	9 years
Site Activities:	1850-1940 Salt manufacturing, production of sulfuric acid and alumina, mining for coal 1947-1959 Various organics (including pesticides) and inorganics products were found at the site 1959-1965 No use of the site Mid60s-mid 80s Waste disposal 1976-1977 Community park constructed on site 1980-1985 Investigations, monitoring, interim remedial measures 1983 NPL list 1984 Interim leachate collection/Treatment system installed 1990 Supplemental RI completed 1992 FS and ROD

Site No. 21: Lindane Dump, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	None
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Regional and local data
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$14.1 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Multi-layer cap, upgrading the existing leachate/shallow groundwater collection system, and pumping shallow groundwater and treating leachate and shallow groundwater using air stripping
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA
Documentation:	1992 ROD
Decision Timeframe:	Approved with 1992 ROD
Future Review:	5-year
General Comments:	
Site Setting:	Approximately 13,000 people live within one mile of the site. Residents near the site obtain water from a municipal river that draws water from a nearby river
TI Evaluation Report:	None
Process:	
Other:	

Site No. 22: Dorney Road, Pennsylvania

General:	
Unit(s):	OU 02, 27 acres
Contaminants:	Benzene, TCE, Chromium, Lead
Other Contaminants Onsite:	Other landfill wastes.
ARARs:	State background levels and Federal MCLs for the off-site groundwater contamination
Geology:	Two carbonate units: Dolomite, Limestone, with occasional Sandstone. Bedrock below that (as shallow as 7.5 ft, as deep as 80 ft). Extensive fracturing.
Hydrology:	Water table is in the bedrock, sometimes near the interface. Runoff probably doesn't migrate to the creek (exception when sinkholes are present). Fractures are the main flowpaths. Flow is southeast, except for mound in the landfill that disrupts flow paths.
Reason(s) for TI Approval:	
Primary Reasons:	Nowhere to dispose of the pumped and treated water. Disturbance of agricultural land if a treatment system was put in place. (No technology other than pump-and-treat was considered for aquifer restoration). The ROD indicates: 1) the lack of discharge areas with the necessary capacity within a reasonable distance (less than 1 mile) from the site, and 2) the lack of confidence in the reliability of reinjection of treated water within the vicinity of the site.
Secondary Reasons:	Natural attenuation of these compounds is occurring
Front-End Waiver	
Years of Characterization:	7
Site Activities:	1984 Listed on the NPL 1986 Ponds were created by the EPA to limit runoff from the site. These result in increased filtration into the groundwater. Some wetlands in the southern portion of the site. 1986 Emergency Removal Actions taken. No cap was ever placed on the top of the landfill (waste sticks out in some areas). 1988 Jan – June Remedial Investigations 1989 Mar – July RI for groundwater by PADER 1991 ROD for groundwater

Site No. 22: Dorney Road, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	All site groundwater and off-site groundwater
Conceptual Site Model Detail:	Geology, Hydrology, fractures discussion. Risk assessment and toxicology discussion.
Data Basis for Waiver:	RI/FS data
Timeframe Estimate:	None
Cost Estimate:	Present worth of $274,040.
Alternative Remedial Strategy:	Institutional controls (provide wellhead treatment units to residents if MCLs are exceeded) and regular monitoring of these wells.
Alternatives to TI Waiver:	No Action; Alternative Water Supply; Wellhead Treatment; Plume Containment; Aquifer Restoration
Approval Process:	
Agencies Involved:	PADER (Pennsylvania Dep't of Env. Res) was the lead agency for the site in the RI/FS phase. (By agreement with the EPA). EPA prepared the ROD.
Documentation:	ROD
Decision Timeframe:	Unknown
Future Review:	Yes – future monitoring
General Comments:	
Site Setting:	Residences located nearby (1 within 1,000 ft; 3 within 3,000 ft). The landfill was a previous iron-mine pit. Municipal (primarily) with some known cases of industrial disposal
TI Evaluation Report:	None prepared
Process:	
Other:	

Site No. 23: Heleva Landfill, Pennsylvania

General:	
Unit(s):	OU 01, 20-acre landfill with two source areas – one has DNAPL (>1% solubility)
Contaminants:	TCE, PCE, benzene, toluene, etc.
Other Contaminants Onsite:	VOCs, DNAPL (Vinyl chloride, benzene, PCE, toluene, xylenes, acetone)
ARARs:	Chemical-specific ARARs: State background levels and Federal MCLs, for organics
Geology:	Karst; sinkholes. Downgradient is fractured bedrock
Hydrology:	Drinking water aquifer
Reason(s) for TI Approval:	
Primary Reasons:	Presence of DNAPL in near-source area
Secondary Reasons:	Recommendation by EPA Hydrologist
Post-Implementation Waiver	
Years of Remedial Action:	9
Site Activities:	1981 Closed by Pennsylvania due to operational deficiencies 1982 HRS ranking of 50.22 1984 RI/FS by the State 1985 ROD 1989-1990 Further site investigations reveal DNAPL is likely 1991 Granted waiver in second ROD
Remedial Activities:	Instituted all the original remedies except the pump-and-treat. Did pump-and-treat studies, from which they concluded the downgradient area of the plume could be remediated as well.

Site No. 23: Heleva Landfill, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	Source area neargradient (aquifer). Contingency language for a TI Waiver for the downgradient portion.
Conceptual Site Model Detail:	
Data Basis for Waiver:	1989 Pre-design study for extraction of water downgradient of the site is feasible. Expanded the remedy. Further site investigation revealed the likely presence of DNAPL in the source area. Revised timeframe estimate.
Timeframe Estimate:	Downgradient plume was expected to take 30-40 years to remediate, using containment of the near-gradient portion. No estimate for the near-gradient source.
Cost Estimate:	1985 for the selected remedy: $7.25 M capital and $62,000 O&M annual 1991 for the amended remedy: $40.95 M total (O&M was $1.8 M for 30 years) – added pump-and-treat for the downgradient portion of the plume as well.
Alternative Remedial Strategy:	Alternative water supply (extended an existing main), institutional controls (capping landfill, air venting, diversion of surface water), pump-and-treat for plume containment. Also further delineation of the source zone. The amended remedy comprises meeting background levels in the downgradient portion of the plume, using pump and treat.
Alternatives to TI Waiver:	Placing wells at the bottom of the aquifer and pumping.
Approval Process:	
Agencies Involved:	EPA was the lead with PADER (PA dep't of Env. resources) adding secondary input. An EPA Hydrologist recommended that the TI Waiver be approved (see email from Richard Watman, EPA Project Manager).
Documentation:	1991 ROD amendment
Decision Timeframe:	Unknown – no TI Evaluation Report submitted.
Future Review:	Periodic reevaluation of remedial technologies. The decision to implement the contingency TI will be made during a periodic review, which occurs at least every 5 years.

Site No. 23: Heleva Landfill, Pennsylvania (Cont.)

General Comments:	
Site Setting:	Both municipal and industrial wastes were disposed of in the landfill, including liquid TCE. 150 People lived within a quarter of a mile and used the groundwater as drinking water prior to 1986.
TI Evaluation Report:	None
Process:	State regulations were not considered ARARs until 1986.
Other:	The amended ROD increased the cost of the remedy while approving the TI Waiver. Accompanied the TI Waiver with revoking at old TI Waiver for the downgradient plume area (bedrock).

Site No. 24: Whitmoyer Laboratories, Pennsylvania

General:	
Unit(s):	03
Contaminants:	VOCs (benzene, TCE, PCE), PAHs, Metals (arsenic)
Other Contaminants Onsite:	
ARARs:	Federal and state ARARs
Geology:	Silty and clayey soils + fill material, clayey residual soils, carbonate bedrock of the Ontelaunee formation (dark gray to dark grayish brown dolomite).
Hydrology:	Single, large, heterogeneous, unconfined aquifer in carbonate bedrock. Porosity of carbonate aquifer is almost entirely secondary, with fractures enlarged through solution channeling forming the primary groundwater storage zones and migration pathways
Reason(s) for TI Approval:	
Primary Reasons:	Cleanup goals cannot be achieved throughout the contaminated groundwater plume because an observed asymptotic level of contaminant concentrations. The EPA, in consultation with the Commonwealth of Pennsylvania, intends to implement a contingent remedy in those areas where the cleanup goals will not be met. The contingent remedy is similar to the selected remedy with the exception that groundwater would only be extracted in sufficient quantities to keep the non-attainment area from growing (plume containment)
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	4
Site Activities:	1900 (circa) Oil pipeline constructed on site 1934 – 1984 Industrial activities on site 1986 NPL list, EPA provides bottled water to residents 1987 RI/FS start 1988 Removal of abandoned drums from the site 1989 RI 1990 FS finalized in February 1990 ROD in December

Site No. 24: Whitmoyer Laboratories, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	Yes, in zones where there is high contamination
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Asymptotic level of contaminant concentrations
Timeframe Estimate:	>30 years (monitoring)
Cost Estimate:	$77.3 M 27-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	On-site pumping and treatment of contaminated groundwater using physical, chemical, and possibly biological treatment, followed by either onsite discharge to surface water, reinjection into the aquifer or both methods
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA, state governments
Documentation:	ROD 1990
Decision Timeframe:	Approved with ROD in 1990
Future Review:	5-year review
General Comments:	
Site Setting:	About 4,700 people use wells within 3 miles of the site. The closest home is within 200 ft of the site and 1,300 people live within a one-mile radius. A grade school stands ½-mile away. Tulpehocken Creek is adjacent to the site
TI Evaluation Report:	None
Process:	
Other:	

Site No. 25: Middletown Air Field, Pennsylvania

General:	
Unit(s):	OU 01. Site is 500 acres.
Contaminants:	VOCs (TCE, PCE) and inorganics (lead)
Other Contaminants Onsite:	VOCs, TCE, PCE, other organics, PAHS, metals, arsenic, chromium, lead
ARARs:	State ARARs to background levels were waived; then reinstated.
Geology:	Overburden, shallow bedrock, and deep bedrock
Hydrology:	Deep bedrock groundwater is used most often.
Reason(s) for TI Approval:	
Primary Reasons:	BAT for VOC removal (air stripping) with 99% removal may not achieve background levels of VOCs. Background levels for the inorganic compounds to below detection limits: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, mercury, nickel, selenium, silver, vanadium, and cyanide.
Secondary Reasons:	Will be treating large amounts of river water in addition if pump-and-treat is used.
Post-Implementation Waiver:	
Years of Remedial Action:	6
Site Activities:	First ROD is OU 01; Second contains a description of the remedies for all OUs.
Remedial Activities:	1984 State removed sludge and liquids in the waste collection building, waste drums, etc. 1987 Remedy selection with ROD for groundwater 1988 Investigation into the five source areas. 1990 Remedy implementation by PRPs (airport owner and PA DOT) 1993 State pushed for further investigation of soil 1996 ROD for soil Deleted from the NPL

Site No. 25: Middletown Air Field, Pennsylvania (Cont.)

TI Evaluation:	
TI Zone Designation:	
Conceptual Site Model Detail:	
Data Basis for Waiver:	Quarterly monitoring data
Timeframe Estimate:	
Cost Estimate:	For operable unit 1, (present worth costs) Alternative 1-2 $ 950,000 (Selected alternative) Alternative 1-3 $ 8,050,000 Alternative 1-4b $ 6,050,000
Alternative Remedial Strategy:	Option #2: Existing treatment system (ion exchange, air stripping and chlorination of HIA production well that is used as drinking water) and institutional controls – quarterly monitoring.
Alternatives to TI Waiver:	No action; treatment system + institutional; #2+ ion exchange/neutralization; #2 + coag/filt + neutralization
Approval Process:	
Agencies Involved:	EPA, Commonwealth (state) of Pennsylvania
Documentation:	
Decision Timeframe:	
Future Review:	Future 5-year review to re-evaluate TI (found TI was not necessary)
General Comments:	
Site Setting:	Cleanup is currently complete and the site has been deleted from the NPL. Site is currently known as the Harrisburg International Airport and the Air National Guard.
TI Evaluation Report:	
Process:	
Other:	

Site No. 26: Yellow Water Road Dump, Florida

General:	
Unit(s):	OU 2 - Groundwater
Contaminants:	PCBs
Other Contaminants Onsite:	Some VOCs
ARARs:	SDWA Federal MCL for PCBs of 0.5 ppb, FL drinking water standards, other action-specific and location-specific ARARs listed in the ROD.
Geology:	1) Upper sand, 25 to 35 feet thick 2) clay, 5 to 15 feet thick 3) lower sand, 25 to 35 feet thick, and 4) limestone, 10 to 20 feet thick.
Hydrology:	Shallow aquifer and Floridian aquifer. Shallow is not drinking water quality. Flow velocity is 4.6-4.7 ft/year.
Reason(s) for TI Approval:	
Primary Reasons:	Considered TI to remove PCBs using pump-and-treat
Secondary Reasons:	
Front-End Waiver	
Years of Characterization:	6
Site Activities:	1982 Spilled oils with PCBs (discovered as a result of criminal action) 1984, 1988 EPA removal actions 1986 Listed on NPL 1987 Yellow Water Steering Committee formed, started RI/FS work. RI/FS approved in 1990. 1990 ROD addressed soil contamination. 1992 ROD for groundwater

Site No. 26: Yellow Water Road Dump, Florida (Cont.)

TI Evaluation:	
TI Zone Designation:	Source area
Conceptual Site Model Detail:	Some info was presented in the ROD.
Data Basis for Waiver:	
Timeframe Estimate:	Greater than 1,000 years
Cost Estimate:	$400,000 initial cost; $1.4 million if contingency measures are necessary.
Alternative Remedial Strategy:	Institutional controls to limit use of groundwater, well permitting. Installed a security fence. Four new gw monitoring wells, downgradient monitoring. Contingency remedial strategies were approved for use if PCB concentrations exceeded the MCL at the monitoring locations: Pump and Treat for containment would be implemented (GAC filtration for treatment)
Alternatives to TI Waiver:	1) No Action 2) Institutional Controls and Monitoring 3) Filtration/Carbon Adsorption (GAC) 4) Filtration/UV Oxidation and 5) Contingent Filtration/Carbon Adsorption (GAC). Costs were included for each. Balancing Criteria were used to evaluate these options. Alternative 5 was selected as the final remedial option.
Approval Process:	
Agencies Involved:	Public opposition to on-site incineration influenced the EPA's remedial strategy decision. (See comments as part of the ROD). 53 of the 67 PRPs had joined together and formed the Yellow Water Road Steering Committee (the Steering Committee).
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	Former storage area for PCBs and other waste liquids.
TI Evaluation Report:	
Process:	
Other:	

Site No. 27: Continental Steel Corp., Indiana

General:	
Unit(s):	OU 01, whole site is 183 acres
Contaminants:	Base Neutral Acids, Dioxins/Dibenzofurans, Inorganics (manganese), Metals (chromium, cadmium, lead and iron), PAHs, PCBs, Pesticides, VOCs. Listed separately in section 2.2.2 of the FS
Other Contaminants Onsite:	All are waived with TI Waiver
ARARs:	Presented in Appendix Cost Effectiveness.
Geology:	
Hydrology:	Three separate but hydraulically connected aquifers.
Reason(s) for TI Approval:	
Primary Reasons:	Pump-and-treat is not technically practicable within 100 years. Same timeframe but higher costs if active pumping is used.
Secondary Reasons:	
Front-End Waiver	
Years of Characterization:	9
Site Activities:	1985 Company filed for bankruptcy, liquidated 1989-1990 Lagoon area, other areas placed on NPL 1990-1991 EPA removal actions, due to runoff complaints. This included about a thousand empty, crushed drums, about 200 drums of product material, about 50 containers of lead cadmium batteries, and about 5,000 gallons of base-neutral liquids. No evidence of “gross radiological contamination”.

Site No. 27: Continental Steel Corp., Indiana (Cont.)

TI Evaluation:	
TI Zone Designation:	Intermediate and lower groundwater zones, between the source area and the Martin Marietta Quarry.
Conceptual Site Model Detail:	Referenced to other previously submitted reports
Data Basis for Waiver:	Contaminant fate and transport analysis was performed as part of the RI/FS showed ARARs would not be attained until 200 years later, despite active remediation attempts.
Timeframe Estimate:	Over 200 years to attain ARARs
Cost Estimate:	$6.4 M 30-year present worth costs for the final selected remedial alternative.
Alternative Remedial Strategy:	Collect contaminated lower groundwater in the Martin Marietta Quarry area, dispose of this in the city wastewater treatment plant – to contain groundwater. This relies on the MM Quarry to be able to contain the groundwater without installing extraction wells.
Alternatives to TI Waiver:	Natural attenuation ($5.5 M), active pumping ($13.2 M and $13.4 M) and downgradient collection (chosen – $6.4 M)
Approval Process:	
Agencies Involved:	State-led site. Also US EPA.
Documentation:	ROD 1999
Decision Timeframe:	Submitted with FS in 1998; ROD approved in 1999.
Future Review:	Every 5 years
General Comments:	
Site Setting:	Former steel manufacturing facility, residents and creeks nearby.
TI Evaluation Report:	
Process:	
Other:	

Site No. 28: Highway 71/72 Refinery, Louisiana

General:	
Unit(s):	
Contaminants:	Petroleum hydrocarbons, "Subsurface sludge and refinery waste", including LNAPL, estimated to cover about 32 acres of the site (saturated thickness = 15 feet) and dissolved phase contaminants
Other Contaminants Onsite:	Non-Site-Related Contaminants are also present.
ARARs:	MCLs and MCLGs = 0
Geology:	Alluvial sediment
Hydrology:	Slow groundwater flow (7 ft/yr).
Reason(s) for TI Approval:	
Primary Reasons:	About 52% of the refinery site is covered by residential and commercial buildings in a downtown area. Community has requested a "non-intrusive" approach to investigation and remediation and not disturb development on-site.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	~9.
Site Activities:	1991-1994 investigated; Listed in 1995; RI/FS in 1999; ROD in 2000. Three LNAPL plumes were identified by soil and GW sampling. Plume boundary has reached an equilibrium, due to little net flow of groundwater and bioattenuation.

Site No. 28: Highway 71/72 Refinery, Louisiana (Cont.)

TI Evaluation:	
TI Zone Designation:	The TI Zone is defined to include the groundwater that is beneath the 215 acres of the site. It extends the entire depth of the shallow Red River Alluvial Aquifer (estimated to be between 10 and 60 feet bgs).
Conceptual Site Model Detail:	The CSM identifies the contamination source,
Data Basis for Waiver:	Three LNAPL plumes were identified by soil and GW sampling. Plume boundary has reached an equilibrium, due to little net flow of groundwater and bioattenuation.
Timeframe Estimate:	
Cost Estimate:	
Alternative Remedial Strategy:	The EPA Selected Remedial Strategy includes dual phase extraction (DPE) of LNAPL sources and a ban on groundwater use, implemented by a city ordinance. Contaminated soil would be removed only if it was uncovered. Recommend long-term groundwater monitoring.
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	LDEQ, EPA
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	Located in downtown Bossier City, LA; 215 acres. This TI Waiver is for a major source area. Ban on groundwater use (through a city ordinance) chosen instead of remediation. Tar-like material containing PAHs found oozing to the surface in some residential and commercial areas. Benzene detected in indoor air.
TI Evaluation Report:	
Process:	Public comments focused on indoor air quality and benzene levels.
Other:	

Site No. 29: Crystal Chemical Company, Texas

General:	
Unit(s):	6.8 acre property
Contaminants:	Arsenic
Other Contaminants Onsite:	None mentioned
ARARs:	50 ug/L arsenic in groundwater
Geology:	Off-channel deposits in the 35-ft zone, flood plain deposits, fine-grained sediments
Hydrology:	-
Reason(s) for TI Approval:	
Primary Reasons:	More investigation yielded a more complex geology, which resulted in estimation of more water (200 x more) would have to be extracted before reaching the ARAR.
Secondary Reasons:	GW P&T remedy was prescribed without complete site characterization. Remedial design studies (post-ROD) showed technical impracticability of pump-and-treat.
Front-End Waiver:	
Years of Characterization:	14 years (listed on NPL in 1983. TI Waiver approved in 1997)
Site Activities:	Site was active until 1981. The EPA approved P&T as the groundwater remedy in 1990, along with several contingency measures in case P&T was ineffective.
TI Evaluation:	
TI Zone Designation:	The Property boundary; the sand zones “15-ft zone” and “35-ft zone”
Conceptual Site Model Detail:	Detail on the geology of the site, distribution of arsenic contamination, adsorption to soil, modeling scenarios and results.
Data Basis for Waiver:	Laboratory soil column tests and field measurements – soil and groundwater samples, and modeling P&T system performance.
Timeframe Estimate:	650 years minimum. 200 times more water would need to be extracted than originally thought.
Cost Estimate:	None given
Alternative Remedial Strategy:	Slurry wall around the TI Zone
Alternatives to TI Waiver:	Slurry walls and other physical barriers; hydraulic barriers were the original alternatives to the chosen pump-and-treat remedy. No other groundwater remedies met the remedial objectives for the site (considered “No Action”, “Limited Action”, “Slurry Wall Containment” and “Extraction and Discharge to the POTW (without treating)”.

Site No. 29: Crystal Chemical Company, Texas (Cont.)

Approval Process:	
Agencies Involved:	EPA
Documentation:	ESD since TI Waiver is post-ROD
Decision Timeframe:	Contingency language in the 1990 ROD, but 1997 it was implemented. One year - Issued in March 19, 1997; TI Waiver Evaluation submitted February 1996.
Future Review:	No mention of this.
General Comments:	
Site Setting:	Residential and lightly industrial.
TI Evaluation Report:	
Process:	
Other:	

Site No. 30: Vertac, Inc., Arkansas

General:	
Unit(s):	Unit 06, Groundwater
Contaminants:	Dioxins, others?
Other Contaminants Onsite:	NAPLs, Herbicide production waste, chlorinated VOCs
ARARs:	MCLs
Geology:	Atoka Formation – fractured, tilted bedrock
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	Substantial amounts of DNAPL and LNAPL may be present in the subsurface, based on past activities at the site. High viscosity (NAPL will be mostly solids).
Secondary Reasons:	Porosity is due to fractures
Front-End Waiver:	(first RODs did not address groundwater contamination)
Years of Characterization:	13
Site Activities:	1948 Reasor Hill produced 2,4,5-T 1961 Hercules purchased plant, produced Agent Orange 1971-76 Transvaal leased the pland, produced 2,4-D; 2,4,5-T and 2,4,5-TP 1976 Vertac organized 1979 Production of 2,4,5-T and 2,4,5-TP ceased 1983 Listed on the NPL 1986 All production ceased 1986 PRP began removal activities with EPA oversight 1987 PRP filed bankrupty, EPA lead cleanup 1989 Off-site removal complete 1994-1996 Off-site incineration of D-waste and T-waste 1995 RI/FS complete 1996 ROD for groundwater finalized; TI Waiver approved 1997-98 All monitoring wells installed 1998 ESD due to further investigation

Site No. 30: Vertac, Inc., Arkansas (Cont.)

TI Evaluation:	
TI Zone Designation:	Northern portion of the central process area, and areas were waste was buried onsite.
Conceptual Site Model Detail:	
Data Basis for Waiver:	Remedial investigations have indicated the presence of both DNAPL and LNAPL.
Timeframe Estimate:	
Cost Estimate:	$2.525 M for selected remedy (cheapest) to 3.55$M for Alternative #3.
Alternative Remedial Strategy:	For groundwater: 1) Install extraction wells for containment 2) French drain use (already installed) to contain plume to the west 2) Institutional controls, including deed restrictions to prohibit groundwater wells in the area
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	US EPA performed cleanup.
Documentation:	1996 ROD has the waiver; Evaluation report is available from public records.
Decision Timeframe:	TI Evaluation was submitted and approved within the same month.
Future Review:	Review, including a review of new technologies. First 5-year review determined remedy was protective
General Comments:	
Site Setting:	Manufactured Agent Orange but had inadequate production and disposal methods. Vertac went bankrupt after litigation. EPA lead the cleanup.
TI Evaluation Report:	
Process:	
Other:	

Site No. 31: Popile, Inc., Arkansas

General:	
Unit(s):	01
Contaminants:	Creosote and PCP
Other Contaminants Onsite:	PAHs (benzo(a)pyrene equivalents in groundwater, soil), PCP, petroleum distillates
ARARs:	3 ppm benzo(a)pyrene equiv. in soil; 5 ppm PCP; 0.2 ppb benzo(a)pyrene equiv. in water.
Geology:	Quaternary age alluvium, Cockfield formation (upper fine-grained unit consisting of silts and clays and lower carbonaceous rich sand layer), Cook Mountain formation (clays and silty clays)
Hydrology:	Shallow Cockfield aquifer in the carbonaceous rich lower layer, confined aquifer in Cook Mountain formation. Shallow groundwater used for livestock watering; no drinking water wells within ½ mile of the site but there are wells 3+ miles away. Site drains to the Bayou deLoutre.
Reason(s) for TI Approval:	
Primary Reasons:	Groundwater extraction system is not able to effectively address both the residual and free-phase NAPL present in the soils and the upper aquifer
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	9 years
Site Activities:	1947-1982 Wood treatment operation 1984- Closed impoundments 1990 EPA removal action (soil excavation to temporary storage on-site), capping, stabilization, institutional controls 1992 NPL listing 1993 ROD – In-situ bioremediation of soil and groundwater; on-site bio land treatment of soils and sludges. 1998-2000 – Results showed no migration off-site. EPA agreed okay to continue with further remedial action (?). Monitoring and contingency plan if migration towards Bayou occurs. 2001 TI Waiver granted
Remedial Activities:	In-situ treatment of contaminated groundwater, extraction and off-site disposal of free-phase wood treating fluids, and the on-site biological land treatment of contaminated soils and sludge

Site No. 31: Popile, Inc., Arkansas (Cont.)

TI Evaluation:	
TI Zone Designation:	Applied to groundwater. The horizontal extent is based on the presence of residual contamination throughout the site soils and DNAPLs within the aquifer beneath the former impoundment area. The vertical extent of the TI waiver is to the base of the Cockfield aquifer approximately 55 ft below the ground surface containing the PCP and PAH NAPLs and associated dissolved contaminant plume
Conceptual Site Model Detail:	In ROD and 2001 waiver
Data Basis for Waiver:	Micro-scale and meso-scale treatability studies
Timeframe Estimate:	30 years
Cost Estimate:	$7.5 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Containment (remediation is unnecessary, plume is not moving); monitoring and contingency containment plan if migration is detected.
Alternatives to TI Waiver:	Incineration
Approval Process:	
Agencies Involved:	State was considerably involved in choosing remedial action, according to the Fact Sheet.
Documentation:	1993 ROD and 2001 TI Waiver determination
Decision Timeframe:	Approved 8 years after ROD
Future Review:	
General Comments:	
Site Setting:	Wood treatment operations from 1947 to 1982, when Popile bought the property. Popile closed the site in 1984.
TI Evaluation Report:	Contingency language in the 1993 ROD that referred to TI Waiver. TI waiver granted in 2001.
Process:	
Other:	

Site No. 32: Hardage/Criner, Okalhoma

General:	
Unit(s):	OU 02: Soil, debris and groundwater
Contaminants:	VOCs, Metals, PCBs, Toxaphene, Pesticides, Other
Other Contaminants Onsite:	18-20 M Gallons of Hazardous Waste; 10-20 thousand unemptied drums in the pit.
ARARs:	Not specified
Geology:	Fractured shales, mudstone and sandstone “redbed” sediments. (“Hennessy Formation”). Bedrock
Hydrology:	Surface stream near site; creek to the south, flowing southwest. Groundwater flows southwest and east, following topography. There is a downward flow component as well. Groundwater flow velocity is extremely high, due to fractures. 33 ft/yr to the east/southeast of the sludge mound. Plume 1,000 ft long in the alluvial aquifer. Contamination is at least 50 ft into the bedrock.
Reason(s) for TI Approval:	
Primary Reasons:	DNAPL has escaped from source area in some locations. It has diffused into the bedrock and will release contamination slowly over time.
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	6
Site Activities:	1979 State of OK Dept of Health began to revoke facility permit 1980 Permit revoked 1982 Decontamination and closure efforts 1983 Listed on NPL 1985 Data Summary Report from CH2M Hill efforts, sampling results 1986 First ROD – source control measures finalized Thirteen monitoring wells installed along the property border, show uniformly high levels of contamination 1989 Second ROD for groundwater (opposed by the state of OK and PRPs)
Remedial Activities:	See Description under Alternative Remedial Strategy

Site No. 32: Hardage/Criner, Okalhoma (Cont.)

TI Evaluation:	
TI Zone Designation:	Bedrock Aquifer, directly underneath the source area
Conceptual Site Model Detail:	None.
Data Basis for Waiver:	Monitoring data (RI/FS investigation)
Timeframe Estimate:	"A few decades" was used as the definition of reasonable timeframe. No estimate was made.
Cost Estimate:	For the site: $68,014,000 with present worth O&M costs of $2,282,000.
Alternative Remedial Strategy:	Focus is on containing the groundwater plume and implementing some source control measures. Installed interceptor trench in the source area, wells downgradient of the source area – water cleaned by air stripping and filtration, discharged into N. Criner Creek.
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	US EPA, State, PRPs (organized into the Harding Steering Committee (HSC)), no other public involvement apparent
Documentation:	1989 ROD
Decision Timeframe:	Unknown
Future Review:	5-yr review
General Comments:	
Site Setting:	Site is an industrial and hazardous landfill, permitted to except all hazardous wastes except radioactive waste. Waste was varied and included wastes from 2 other superfund sites (Brio and Bioecology sites). Pits were unlined, and were eventually filled to capacity. Waste was then placed in temporary ponds and piled as a sludge mound. Tens of acres, judging by dead vegetation, visible surface contamination. Most groundwater wells are in the alluvial aquifer, but some are screened into the bedrock. Aquifer is Class IIB.
TI Evaluation Report:	None was prepared
Process:	
Other:	

Site No. 33: Oronogo-Duenweg Mining Belt, Missouri

General:	
Unit(s):	7000 acres are contaminated from smelter activity, over 10 million tons of surface waste; TI Waiver covers the entire watershed within Jasper County; Site is a part of the tri-state mining district. The neighboring Cherokee County site and Tar Creek OK site are Superfund sites; Newton County, MI is under consideration as an NPL Superfund site.
Contaminants:	Metals (Lead, Zinc, Nickel and Cadmium)
Other Contaminants Onsite:	
ARARs:	Includes risk-based Federal MCLs for cadmium and nickel, secondary drinking water standards for manganese and lead action levels under the Safe Drinking Water Act (not an MCL)
Geology:	Fracture zones connected to contaminants lead to high groundwater concentrations.
Hydrology:	Shallow aquifer is contaminated (avg 300 ft thick, max 400 ft thick)
Reason(s) for TI Approval:	
Primary Reasons:	Inordinate cost associated with any full-scale remedial activities such as pump-and-treat
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	5
Site Activities:	1990 Listed on the NPL 1994 bottled water supplied to residents 1995 site investigations complete Currently performing risk assessments 1998 ROD and TI Waiver

Site No. 33: Oronogo-Duenweg Mining Belt, Missouri (Cont.)

TI Evaluation:	
TI Zone Designation:	Entire watershed within Jasper County (9 million cu yds)
Conceptual Site Model Detail:	Hydrology/Geology detail
Data Basis for Waiver:	Site investigations
Timeframe Estimate:	No evidence of natural attenuation
Cost Estimate:	$60-90 M if pump-and-treat was implemented, unsure if ARARs can be met.
Alternative Remedial Strategy:	Bottled water supply to 350 affected homes, cleaning soil in daycare and residential yards. POU treatment units in some homes (those that chose to use and pay for public water), monitoring of these POUs.
Alternatives to TI Waiver:	Pump-and-treat was considered, but it is inordinately costly and has both positive and negative effects on the environment. Negative effects include lowering the natural water levels in local streams, changing natural wetlands and disrupting ecological system. The shallow aquifer might be drawn down to below the level where it can be used for agriculture and industrial purposes.
Approval Process:	
Agencies Involved:	US EPA, public comments regarding connecting to water supplies
Documentation:	ROD
Decision Timeframe:	Unknown date for TI Evaluation submission
Future Review:	
General Comments:	
Site Setting:	Inactive lead and zinc mining and smelting area in Missouri. Operations include hundreds of mines and 17 smelters. Surface waste is uncovered, unstable. Leachate and runoff from the piles enters the groundwater and surface streams. Blood-lead levels are high in the surrounding area (14% of seven-year olds exceed the 10 ug/dl level). Groundwater is used for drinking water for about 500 homes. At least 100 exceed action levels for lead and cadmium. 2,500 residences have lead soil levels greater than acceptable level (due to past air emissions)
TI Evaluation Report:	None available.
Process:	
Other:	

Site No. 34: Cherokee County, Kansas

General:	Two Waivers Obtained - This one describes the Baxter Springs/Treece subsites. Galena subsite was remediated.
Unit(s):	Galena Subsite (1989) and the Treece (Tar Creek) and Baxter Springs Subsite, OU 03 and 04 (1997). Treece and Baxter Springs are 28 square miles. Galena subsite was 25 sq. mi
Contaminants:	Heavy metals (zinc, lead and cadmium) and selenium.
Other Contaminants Onsite:	
ARARs:	T/B: Only chemical-specific ARARs are waived by TI Waivers: SDWA standards in the shallow aquifer and AWQC standards under Clean Water Act for surface water standards. Big section in the ROD listing the specific ARARs. Galena: Waiver of SDWA criteria for shallow aquifer
Geology:	Karst-like topography, mine voids. Under the Treece/Baxter site, about 200-500 ft bgs there are
Hydrology:	Conduit flow, two different watersheds impacted by the Treece and Baxter Springs subsites.
Reason(s) for TI Approval:	
Primary Reasons:	Treece/Baxter reasons: Size of the site (115 sq mi); huge volume of source materials (4.3 M tons in Baxter/Treece); Karst-like topography, mine voids, enormous waste piles and adjacent mine waste areas all contribute to TI for the Baxter/Treece subsites. Constitutes an inordinate cost from an engineering perspective, especially when considering the “limited environmental gain” associated with these expenditures.
Secondary Reasons:	Consistency with prior EPA decisions in the tri-state mining district.

Site No. 34: Cherokee County, Kansas (Cont.)

Front-End Waiver:	
Years of Characterization:	9 yrs - Treece 10 yrs - Baxter Springs 4 yrs - Galena (see below) Treece: 1988 investigation started. Remediation complete in 2000. Baxter Springs: 1987 investigations started. Investigation strategy (and ROD) chosen in 1997. Cleanup is ongoing. Galena: 1986-7 investigation. 1989 remedy selected (ROD). Cleanup design 1993. Cleanup complete in 1994. In O&M phase.
Site Activities:	1986 EPA installed water treatment units on 8 contaminated wells 1987 Countywide survey of wells – added 2 more water treatment units. The units were removed when an alternate water supply was supplied. Clean groundwater supply system to the area. New wells drilled to collect water. 1995 Interim removal actions of soil at 62 properties, daycare centers. Investigated using phosphorus as opposed to excavation.
TI Evaluation:	
TI Zone Designation:	Not explicitly addressed. Assume the waiver applies to the entire site.
Conceptual Site Model Detail:	Two separate hydrologic units, not in hydrogeologic communication, underlie the entire site.
Data Basis for Waiver:	Not known
Timeframe Estimate:	Not given
Cost Estimate:	For selected remedy at the Treece/Baxter subsites, $7.1 M (1997 estimate). $65.5 M for Treece component of the most costly alternative evaluated (total was estimated to be about $93.2 M). For Galena subsite, remedial action costs totaled $8.3 M present worth (includes O&M costs). Detailed cost summary is contained in the FS Addendum in 1994 dollars.
Alternative Remedial Strategy:	Groundwater/Surface water remediation to reduce the loading of metals to streams as much as possible by excavation of mine tailings and disposal into tailings impoundments, contouring and vegetating waste piles from mining, capping source materials, constructing stream diversion structures. Soil remediation: includes remediation of residential yards. Providing an alternate water supply using clean groundwater and building a new water supply system operated by the City of Galena. Distribution to 418 locations in the subsite.
Alternatives to TI Waiver:	No alternatives meet ARARs.

Site No. 34: Cherokee County, Kansas (Cont.) (Cont.)

Approval Process:	
Agencies Involved:	US EPA, Two different regions (6 and 7) due to tri-state mining district.
Documentation:	RODs
Decision Timeframe:	Unknown date of TI Waiver application
Future Review:	5-year review is required
General Comments:	
Site Setting:	Soil and shallow groundwater in residential areas were affected by lead and zinc mining and also smelter wastes. 3,800 people in Galena. Heavy metals are released into the creeks, ecological impacts are evident. Area was mined as recently as the 1970s.
TI Evaluation Report:	None available.
Process:	
Other:	Site is complicated because it is part of a larger area of Superfund sites created by mining activity. Remedy for each site must compliment previous remedy.

Site No. 35: Summitville Mine, Colorado

General:	
Unit(s):	About 550 acres are disturbed by past copper, gold and silver mining activities. The entire mine area is 1,231 acres. Sources in the Summitville Mine include the French Drain Sump, the Cropsy Waste Pile, and the Reynolds Adit.
Contaminants:	Cadmium, copper, zinc and cyanide in AMD; iron, aluminum and pH, apparently manganese also.
Other Contaminants Onsite:	Copper and other metals numeric standards will be met for one stream stretch.
ARARs:	State of Colorado's numeric standards, use designation for 2 different stretches of streams (agricultural designation waived and Class I – Cold Water Aquatic Standards waived)
Geology:	
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	
Secondary Reasons:	Naturally high background levels of iron, aluminum and pH on one stretch of stream.
Post-Implementation Waiver:	
Years of Remedial Action:	
Site Activities:	1994 Original ROD 1984-1991 SCMI conducted gold-mining in open-pit mine, using sodium cyanide Feb 1991 State of Colorado issued a cease-and-desist order, due to rising concentrations of cadmium, copper, zinc and cyanide in Wightman Fork. 1992 In December, SCMI went bankrupt and the EPA Emergency Response Group took over the treatment of cyanide leachate from 3 different sources in the mine. 1994 Interim ROD 2000 Draft RI Report issued 2001 Reissue of RI Report was expected
Remedial Activities:	

Site No. 35: Summitville Mine, Colorado (Cont.)

TI Evaluation:	
TI Zone Designation:	Two stretches of river (surface water) (segments 3 and 6b)
Conceptual Site Model Detail:	
Data Basis for Waiver:	Analysis was performed in the "Use Attainability Assessment", which indicated TI due to high baseline metals condition along Alamosa R. Segment 3b stretch and inability to meet manganese agricultural levels on stretch 6.
Timeframe Estimate:	
Cost Estimate:	Comment in 1994 that EPA has spent over $40 M on Summitville at that time. Another commenter is worried that the costs were underpredicted and will exceed the EPA's estimate of $120 M. Question of overstating costs in one Alternative (#6 – building a new treatment plant vs. #5 – converting old process units into new treatment plant and containing AMD during winter peak flows).
Alternative Remedial Strategy:	Continued treatment of the French Drain waters in the existing treatment plant and destruction of cyanide in the cyanide destruction plant/metals reduction plant; containment of AMD during peak flows and subsequent treatment.
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	State of Colorado is the lead agency (Colorado Department of Public Health and Environment). EPA is also involved. PRP is yet to be identified, but Superfund is suing the former president of SCMC, Inc.
Documentation:	
Decision Timeframe:	
Future Review:	The first 5-year review was completed in May 2000 (based on start date as the Interim ROD)
General Comments:	
Site Setting:	Recent operations (1984-1991), conducted by Summitville Consolidated Company Incorporated (SCMCI), a wholly owned subsidiary of Galactic Resources; Inc. This consisted of open-pit mining for gold using cyanide. Addition of cyanide continued until 1992.
TI Evaluation Report:	
Process:	Public comments on the selected remedial alternative and the selection process.
Other:	No pH restrictions for effluent. Concern for livestock in the area. Lot of corrosion of pipes due to acidity of AMD. (Culvert corroded through in six days).

Site No. 36: Anaconda Co. Smelter, Montana

General:	
Unit(s):	28,600 acres, ARWW&S operable unit (Anaconda Regional Waste, Water and Soil)

Contaminants:	Arsenic
Other Contaminants Onsite:	Cadmium and copper are elevated
ARARs:	State of MT groundwater standards
Geology:	Alluvial and bedrock (deeper)
Hydrology:	Mill Creek nearby has elevated As; alluvial and bedrock aquifers exist
Reason(s) for TI Approval:	
Primary Reasons:	Excessive cost
Secondary Reasons:	No ability to pump the bedrock aquifer
Front-End Waiver:	
Years of Characterization:	5
Site Activities:	1884 – 1980 Mining operations on site and mine waste disposal. 1983 Placed on NPL 1984 ARCO heading cleanup phase 1988 Relocated Mill Creek residents 1991 Time critical removal action of residential soils (As, other metals), Soils investigation 1992 As exposure study with U Cincinn. 1992 – 1993 RI/FS 1996 – TI Evaluation 1998 ROD

Site No. 36: Anaconda Co. Smelter, Montana (Cont.)

TI Evaluation:	
TI Zone Designation:	28,000 + acres of bedrock aquifer. Includes Old Works/Stucky Ridge, Smelter Hill and Opportunity Ponds subareas. The original TI Zone boundaries were updated (enlarged) from the original application due to site data gathered in summer 1997. These data was gathered to fill data gaps needed for TI Waiver. Estimated flux from arsenic source zones. May need further characterization. This is documented in App D of the 1998 ROD.
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	
Cost Estimate:	> $2.2 billion to remove the waste, total estimated cost is $88 M to $150 M present worth for current remedy (App B)
Alternative Remedial Strategy:	Reduce surface As concentrations to 250 – 1000 ppm soil. Vegetate remaining areas. Remove waste soils near streams and place it in a Waste Management Area (WMA). Left wastes in place, prevent exposure to that area and contamination to surrounding groundwater. Point of compliance monitoring around the TI Zone to ensure that the contamination is contained within the perimeter. Fully funded Institutional controls program at local level.
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	Montana Dept. of Env. Quality (MDEQ), US EPA, PRP is ARCO
Documentation:	1998 ROD
Decision Timeframe:	2 years
Future Review:	
General Comments:	
Site Setting:	100 years of contamination
TI Evaluation Report:	
Process:	
Other:	

Site No. 37: Silver Bow Creek/Butte Area, Montana

General:	
Unit(s):	OU 03 (out of seven total units), including the Berkeley Pit site; 3000 miles of mine workings
Contaminants:	Heavy metals from acid mine drainage, including cadmium, arsenic, lead and copper (and sulfate, if an MCL for sulfate is established)
Other Contaminants Onsite:	Acid Mine Drainage contaminants – many others have elevated concentrations, but these do not
ARARs:	MCLs and state of Montana water quality standards
Geology:	Sulfide ores (FeS_2, CuS_2) oxidize on contact with water and air. Can be described as weathered and competent bedrock, with very little alluvial material in the TI Zone. Some alluvium due to historical flood channel of the Silver Bow Creek.
Hydrology:	Two aquifers, one alluvial and one in bedrock. Inflow to the Berkeley Pit comes from surface flows and alluvial groundwater sources (1.68 + 0.58 mgd) and from the bedrock (2.49 mgd = 49%). Net precipitation/evaporation = 0.30 mgd.
Reason(s) for TI Approval:	
Primary Reasons:	Remediation is impracticable – extent of contamination is too large.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	7 years
Site Activities:	Listed on NPL in 1983. Butte Area was included in 1987. RI/FS in 1990. ROD with TI Waiver was approved in 1994.

Site No. 37: Silver Bow Creek/Butte Area, Montana (Cont.)

TI Evaluation:	
TI Zone Designation:	6.75 square miles in area, in the bedrock aquifer. The TI Zone is defined to include all underground mine workings and their influence. (The deepest is 1500 ft msl.)
Conceptual Site Model Detail:	Includes the geology, hydrogeology and conceptual contaminant transport pathways. Maintaining the water level below 5,410 msl (Critical water level) will ensure that the hydraulic gradient is towards the pit (and therefore water is not pushed out into the East Camp)
Data Basis for Waiver:	Argument is the large size of the site.
Timeframe Estimate:	None given
Cost Estimate:	Extensive costs: Pump-and-treat range from $346 M to $462 M, which includes treatment plant capital costs and o&m costs. If the pit were pumped dry in 11 years, in-situ sludge disposal costs would be $346 M to $388 M. Disposal to an on-site facility would be $412 M to $462 M. Inundation cost was estimated to be $27 M to $213 M (different flow alternatives, including uncontrolled flooding = no action). Grouting of the mineshafts was estimated to be $2.2 B to $3.0 B. Injection of acid neutralizing agents was estimated to cost $11.8 billion.
Alternative Remedial Strategy:	Maintain the pit as a hydraulic sink to prevent water from impacting the nearby creek drainages and the alluvial aquifer. Other controls on groundwater to prevent off-site migration of contaminants
Alternatives to TI Waiver:	Pump-and-treat, inundation, grouting and the injection of acid neutralizing fluids were the four possibilities considered. All possibilities would/might include a TI Waiver, since they would not be able to meet ARARs.
Approval Process:	
Agencies Involved:	US EPA, state of Montana
Documentation:	ROD documentation
Decision Timeframe:	Unknown
Future Review:	5-years, includes monitoring of 13 bedrock wells, 8 mine shafts, 15 existing wells completed in bedrock and the Berkeley Pit site.
General Comments:	
Site Setting:	
TI Evaluation Report:	
Process:	
Other:	

Site No. 38: Broderick Wood Products, Colorado

General:	
Unit(s):	02
Contaminants:	BTEX, PAHs, PCP, phenol, dioxins, furans, arsenic, cadmium, lead, zinc, carbozole, pyrene, naphthalene
Other Contaminants Onsite:	
ARARs:	Federal and state ARARs
Geology:	Quaternary alluvial terrace; alluvial deposits and weathered Denver formation bedrock; unweather Denver formation bedrock; Arapahoe formation)
Hydrology:	Three aquifers: the single unconfined surficial aquifer; the confined Denver aquifer, the confined Arapahoe aquifer
Reason(s) for TI Approval:	
Primary Reasons:	Chemical-specific waiver for the Denver aquifer because of its hydrogeologic characteristics. Presence of small lenses of permeable sandstones interbedded in near-impermeable claystone, which significantly limits the ability to pump-and-treat the contaminated groundwater. Due to the small area extent of the permeable lenses, the contaminated groundwater is believed to be confined to within a few feet of the impoundments
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	8 years
Site Activities:	1947-1981 Wood treatment facility 1981 Start of investigations at the site 1984 NPL list 1985-1990 RI/FS 1988 and 1991 RODs 1992 ROD including the final remedy

Site No. 38: Broderick Wood Products, Colorado (Cont.)

TI Evaluation:	
TI Zone Designation:	Denver aquifer
Conceptual Site Model Detail:	None
Data Basis for Waiver:	Knowledge of geology at the site
Timeframe Estimate:	30 years (monitoring)
Cost Estimate:	$15.6 M 30-year present worth costs for the final selected remedial alternative (including O&M)
Alternative Remedial Strategy:	Groundwater treatment includes recovering approximately 526 million gallons of groundwater and LNAPLs from the surficial aquifer, removing LNAPLs in an oil/water separator, and reclaiming the LNAPLs at an off-site recycling facility; treating the remaining water using a two-phase fixed-film bioreactor, mixed with nutrients and growth to promote further contamination breakdown within the shallow aquifer; and collecting DNAPLs and groundwater from existing monitoring wells in the Denver aquifer and treaing them in the oil/water separator with off-site recycling
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA and Colorado Department of Health (CDH)
Documentation:	1992 ROD
Decision Timeframe:	Approved with ROD
Future Review:	5-year
General Comments:	
Site Setting:	The site is situated in a primarily industrial area and is bounded on the southwest and southeast by railroad tracks and on the north by fisher ditch. The nearest residences are less than 1/8 mile north of the property line.
TI Evaluation Report:	
Process:	
Other:	

Site No. 39: Whitewood Creek, South Dakota

General:	
Unit(s):	
Contaminants:	Arsenic-rich tailings from gold and ore mining – 2.5 to 1530 µg/L
Other Contaminants Onsite:	Occasionally cadmium and selenium
ARARs:	National and state drinking water standards for groundwater, surface water standards (ambient water quality for the consumption of fish) as well. Arsenic in soil may lead to arsenic problems with groundwater and surface water.
Geology:	
Hydrology:	Shallow aquifer separated from the bedrock aquifer
Reason(s) for TI Approval:	
Primary Reasons:	Size of the problem(18 miles of floodplain, 2000+ acres on the site).; surface water entering the site does not meet requirements.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	7
Site Activities:	1877-1977 Operation as a gold mine (open pit and subsurface shaft mines) 1970 Use of mercury was discontinued at the mine due to EPA investigation 1974-1975 Fifty cattle died of arsenic poisoning due to accidental mixing of mining wastes 1983 Place on NPL 1985 Homestake (Environ consultants) submitted request to take the site off the NPL. EPA denied the request. 1989 Additional reports, including FS – institutional controls sufficient to protect human health. Surface water standards might be violated, but they would be within the range of acceptable concentrations. 1990 ROD with TI Waiver Arsenic soil (>100 mg/kg) removal and/or capping.

Site No. 39: Whitewood Creek, South Dakota (Cont.)

TI Evaluation:	
TI Zone Designation:	
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	
Cost Estimate:	$0.88 M present worth total (O&M annual $12,000 for yrs 1 to 5 and $6,000 for yrs 6-30).
Alternative Remedial Strategy:	Cover and remove soils > 100 mg/kg As; restrict future development in floodplain; other institutional and educational measures, monitoring surface water
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	South Dakota Dept. of Water and Natural Resources (SD DWNR), EPA and Homestake Mining Company
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	Mine tailings deposit (2,018-acres of land) discharged into Whitewood Creek. Process was to treat the tailings and then backfill the mine with the tailings. Used 10^{-4} cancer risk arsenic concentration. Woodlands, farmlands and residential homes in the area.
TI Evaluation Report:	
Process:	
Other:	

Site No. 40: East Helena, Montana

General:	
Unit(s):	Lower Lake
Contaminants:	Arsenic, lead, cadmium,
Other Contaminants Onsite:	
ARARs:	State water quality standards (lower than Federal – to protect aquatic life). These included arsenic at 2.2 ng/L, Cd 1.1 µg/L, Cu 12 µg/L, Pb 3.2 µg/L, Zn 110 µg/L. New standards arsenic 20 ug/L, lead 50 ug/L.
Geology:	
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	Level is too low to attain with existing water treatment technology
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	6
Site Activities:	1927-1982 operations to recover zinc from lead smelting wastes (changed owners in 1972 to Asarco) 1983 Added to NPL 1989 ROD with TI Waiver
TI Evaluation:	
TI Zone Designation:	
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	None – estimated 41 years to smelt all the excavated material, if this remedy were chosen.
Cost Estimate:	$6.015 M (alternative 5S for Lower Lake only) $3.538 M capital, $0.621 annual O&M. Most expensive option was $17.7 M.
Alternative Remedial Strategy:	Meet higher levels of these metals in wastewater streams, using in-situ treatment.
Alternatives to TI Waiver:	

Site No. 40: East Helena, Montana (Cont.)

Approval Process:	
Agencies Involved:	
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	Anaconda Company had factory near lead smelting operations to recover zinc from the wastes.
TI Evaluation Report:	
Process:	
Other:	

Site No. 41: Del Norte Pesticide Storage, California

General:	
Unit(s):	Less than 1 acre; sump is the primary area of contamination
Contaminants:	1,2-Dichloropropane (DCP), as a NAPL?
Other Contaminants Onsite:	2,4-Dichloropropane, chromium
ARARs:	10 µg/L for 1,2-DCP, based on a health advisory level at the time. New MCL = 5 µg/L.
Geology:	Well sorted fine sands, silts and clays with moderate groundwater permeability
Hydrology:	Groundwater is used for agricultural and domestic purposes (Class II aquifer).
Reason(s) for TI Approval:	
Primary Reasons:	P&T system has brought 1,2-DCP to an asymptotic low that is still higher than the standard. System modifications not effective.
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	7 years. Contamination discovered in 1981; Site was listed in 1983. TI Waiver in 2000.
Site Activities:	1985 ROD
Remedial Activities:	Source Removal of soil 1987; GW P&T in operation 1990 – 1994; asymptotic levels were reached. 1995-1996 operation was modified. 1997 system turned off.
TI Evaluation:	
TI Zone Designation:	Plume area ~ 5,000 square feet. Thickness extends to the depth of the top aquifer, about 30 feet bgs. Area is taken from the current area greater than 5 ug/L.
Conceptual Site Model Detail:	Included hydrogeology, site history, RI report data
Data Basis for Waiver:	Full-scale treatment system performance data; tweaked the system in hopes of improving performance.
Timeframe Estimate:	Unknown based on post-1994 system performance
Cost Estimate:	Existing Remedy cost $2.7 million capital with O&M costs of $25,000 per year. Total = $4.2 M.
Alternative Remedial Strategy:	Plume containment, institutional controls, monitoring and TI Waiver are the package alternative. Land restrictions on groundwater use that might affect plume migration.
Alternatives to TI Waiver:	None known.

Site No. 41: Del Norte Pesticide Storage, California (Cont.)

Approval Process:	
Agencies Involved:	EPA is the lead agency. State RWQCB; State DTSC is in charge of monitoring and reporting
Documentation:	ROD Amendment
Decision Timeframe:	TI Waiver was approved in August 2000.
Future Review:	
General Comments:	
Site Setting:	Private water supply wells in the area (closest was ¼ mile away). Site is about 2000 ft away from a public beach. The County owns all the surrounding land.
TI Evaluation Report:	
Process:	The TI Waiver was approved in an August 2000 ROD amendment
Other:	

Site No. 42: Koppers Industries, Inc., California

General:	
Unit(s):	TI Zone is 4 acres out of 200 total.
Contaminants:	Dioxins, cPAHs and PAHs and PCP (lower health threat) – also known as creosote, dioxin and PCP
Other Contaminants Onsite:	Furans and heavy metals including copper, chromium and arsenic.
ARARs:	
Geology:	Clay layer in the TI Zone
Hydrology:	
Reason(s) for TI Approval:	
Primary Reasons:	DNAPL existed in a saturated low permeability clay zone (30-300 ft bgs). No technology existed to restore the aquifer to drinking water standards.
Secondary Reasons:	No surface contamination was present (source removal was demonstrated); containment was achieved (shown through groundwater monitoring data). Modeled creosote transport and fate, illustrating that it was relatively immobile.

Site No. 42: Koppers Industries, Inc., California (Cont.)

Post-Implementation Waiver:	
Years of Remedial Action:	15
Site Activities:	See below
Remedial Activities:	1984 Listed on NPL 1986 Provided an alternative water supply 1986 Built cap to stabilize source, after a fire 1989 ROD and selection of remedy – GW: pump-and-treat w/ GAC, reinjection into the aquifer. Soil: In-situ remediation w/ capping 1989 Treatability studies showed no alternative worked for all contaminants in soil. 1994 Built an on-site landfill 1995- Dioxins hindered choices for remedial options. Pilot-scale biotreatment system was started for the TI Zone. System removed 160 gallons of creosote and 220 gallons of creosote emulsion out of a potential million gallons of free product. This took 3.5 years. 1995 FS submitted by PRP 1995 Off-site property pump-and-treat was taken offline. 1996 ROD Amendment: on-site landfilling and revised cleanup standard to industrial use levels (accompanied by deed restrictions) 1997 Five-year review concluded remedy was protective 1999 ROD Amendment #2: TI Waiver for DNAPL on 4 acres/200 total. Also added enhanced in-situ bioremediation to the remedy for PCP and added MNA as a contingency plan.

Site No. 42: Koppers Industries, Inc., California (Cont.)

TI Evaluation:

TI Zone Designation:	4-acre zone, including the Former Creosote Pond and the Cellon Blowdown areas. Contamination had been occurring over the past 50 years and exists below the excavated surface area. (~10, 13 ft to depth 125, 250 ft).
Conceptual Site Model Detail:	About 3 pages of information in the TI Waiver. Includes the geology of the TI Zone and fate and transport information about the contaminants. Presents evidence of DNAPL and discusses the amount of biodegradation that is occurring naturally. General behavior of DNAPLs is included, with a summary of each contaminant.
Data Basis for Waiver:	Results of monitoring (no downgradient detections). Pilot scale treatability study for biotreatment (ineffective after 3.5 years), soil washing and soil fixation were conducted, as well as a leachability study into groundwater. Source removal was demonstrated. Pumping from an on-site well was discontinued because contamination was no longer reaching the well. The system was only treating clean groundwater. The off-site plume had shrunk naturally.
Timeframe Estimate:	Only 20-30 years in their analysis. However, they also compared the site to JH Baxter Superfund site, in which 3000 years were calculated for pump-and-treat alone (50-400 years if bioremediation was considered). A longer timeframe is expected at the Koppers site.
Cost Estimate:	Cost = $20-67 M bs $0.25 M for TI Zone approval. Cost comparison between the existing ($2.9 M present worth) and the proposed remedies ($0.8 M) was presented.
Alternative Remedial Strategy:	Containment and semi-annual monitoring of TI Zone. The installation of one new well was required. Contingency pump-and-treat containment was also required, should monitoring reveal that natural containment was not working. Deed restrictions on the property. Outside the TI zone, enhanced bioremediation was chosen. This remedy was shown to be faster than the current pump-and-treat operation. Process Area will be remediated when the plant closes.
Alternatives to TI Waiver:	None of the alternatives considered met drinking water standards. Included 1) no action 2) grout curtain wall 3) thermal 4) steam enhanced pump-and-treat 5) continue pump-and-treat and 6) monitor containment and set up TI Zone (selected remedy). Alternative 6 was most cost-effective.

Site No. 42: Koppers Industries, Inc., California (Cont.)

Approval Process:	
Agencies Involved:	Lead agency is US EPA. Keith Takata, the Director of the Superfund Division, signed the TI Waiver (ROD). DTSC, Cal RWQCB and the Central Valley RWQCB were also involved. The state issued the cleanup orders. PRP is Beazer East.
Documentation:	9/23/1999 ROD Amendment
Decision Timeframe:	First draft of TI Evaluation was submitted in December 1997. Revised TI Evaluation in June 1998 and the final evaluation on March 1999. The ROD Amendment was signed in September 1999.
Future Review:	Semi-annual monitoring. An annual review of industrial activity around the TI Zone was required. Typical 5-year review was required. No mention of a technology review in the future.
General Comments:	
Site Setting:	Wood treatment site, still in operation. Groundwater is contaminated both on- and off-site with PCP. PCP was detected in neighboring drinking water wells 2 miles away.
TI Evaluation Report:	The site was compared to Brodhead Creek site and other Superfund sites where pilot studies were conducted. Very structured and well-presented TI Evaluation. The main points are that 1) the area is well-contained (10 ft/yr migration vs. 500 ft/yr groundwater migration) 2) the source has been effectively removed (surface soils are now gone and no groundwater contamination has resulted from the soil that remains in place, beyond 500 ft from the source) 3) Costs to remove the remaining contaminant class are high 4) Removing mass will not result in lower concentration and 5) Deed restrictions and monitoring are considered protective for people by eliminating the possibility of contact with water directly under the source.
Process:	
Other:	

Site No. 43: Montrose/Del Amo, California

General:	
Unit(s):	OU3 (for Montrose Chemical Corp.)
Contaminants:	Chlorobenzene, benzene, TCE plumes are under the TI Waiver but the waiver still applies to any other contaminant (NAPL and non-NAPL) in the TI Waiver zone
Other Contaminants Onsite:	DDT, base neutral acids, PAH, pesticides, naphthalene, chloroform, dichlorobenzene, styrene, butadiene, synthetic rubber, oil, feedstock chemicals, propane, toluene, ethylbenzene, caustic, hydrochloric acid, sulfuric acid, butane, butylenes, soap solutions, aqueous waste, aluminium chloride, hydrocarbons, acid sludge, kaolin clay, ethylene, lime slurry, zeolite
ARARs:	ISGS levels and other ARARs waived inside the containment zone for all the contaminants present
Geology:	Alluvial deposit of sands, silts, ad clays that extend down hundreds of feet. Layers are Upper Bellflower (UBF), Middle Bellflower B Sand (MBF), Middle Bellflower C sand (MBFC), Lower Bellflower (LBF)
Hydrology:	Four distinct and separate aquifers. The 3rd and 4th (deepest) are used for municipal drinking water. Water moves slowly in the shallowest layers (UBF and MBFB = fine-grained, silts), water moves more quickly in the deeper layers (MBFC Sand, Gage Aquifer, and Lynwood Aquifer = coarse-grained, sand), and water moves very slowly in the LBF layer
Reason(s) for TI Approval:	
Primary Reasons:	Existing technologies are incapable of practically recovering enough NAPL to attain ISGS levels at all points in GW. The waiver was issued for a portion of the GW surrounding the NAPL because (1) removal of NAPL sources is not technically practicable; (2) restoration could never be achieved due to the continuing migration of benzene from the LNAPL sources; (3) extraction wells in the fine-grained UBF and MBFB would have extremely small radii of influence, which would necessitate impracticably large numbers of wells to capture and remove contaminated GW; and (4) the removal of the dissolved contamination in the MBFC, directly underneath the LNAPL is not practicable because it would cause adverse downward migration of contaminants from the overlying LNAPL sources, which will prevent the restoration of this portion of the MBFC to ISGS
Secondary Reasons:	

Site No. 43: Montrose/Del Amo, California (Cont.)

Front-End Waiver:	
Years of Characterization:	16 years Montrose/ 8 years Del Amo
Site Activities:	1947-1982 DDT was manufactured on the site (Montrose) 1992 Action against Del Amo 1996 United the two sites 1999 ROD – Chlorobenzene would be contained by pump-and-treat and flushing (reinjection of the treated water). Benzene would be contained through monitored natural attenuation in one sand zone and by pump-and-treat in the other sand zone. The TCE contamination would be remediated by pumping, treating and reinjecting the water.
TI Evaluation:	
TI Zone Designation:	Also known as the "containment zone". Containment will occur as follows: Pumping and treating the chlorobenzene plume and re-injecting into ground; containing the benzene plume in the UBF and MBFB sand with intrinsic biodegradation; pumping and treating to partially containing the sources of the TCE plume
Conceptual Site Model Detail:	
Data Basis for Waiver:	16 years Montrose/ 8 years Del Amo
Timeframe Estimate:	Time needed to complete the cleanup is over 50 years. However, computer modeling predictions at 25 years predicts that two-thirds of the chlorobenzene plume would be removed
Cost Estimate:	Varied from 0 (no action) to $39.8 M (same as preferred action but with higher pumping rate)
Alternative Remedial Strategy:	Containment zone.
Alternatives to TI Waiver:	None – The TI Waiver zones cannot be cleaned to drinking water standards in a reasonable time frame because there is no feasible way to remove all of the NAPL
Approval Process:	
Agencies Involved:	US EPA (US EPA consulted with its counterparts at the California Department of Toxic Substances Control, and the California Regional Water Quality Control Board, Los Angeles Region)
Documentation:	1997 ROD (Del Amo) and 1999 ROD (for joint-site Del Amo and Montrose)
Decision Timeframe:	1998
Future Review:	Five-year review

Site No. 43: Montrose/Del Amo, California (Cont.)

General Comments:	
Site Setting:	Long commingled plumes (1.3 miles)
TI Evaluation Report:	None
Process:	
Other:	

Site No. 44: J.H. Baxter & Co., California

General:	
Unit(s):	OU 01 Soil, groundwater, liquid waste and sediment
Contaminants:	Arsenic, Creosote, PCP
Other Contaminants Onsite:	Base Neutral Acids, Dioxins/Dibenzofurans, Metals, PAH, Pesticides
ARARs:	All ARARs specified in the 1990 ROD
Geology:	Artificial fill; The Younger Clastic Assemblage (YCA); The Pre-Shastina Alluvial Assemblage (PSA); The Older Clastic Assemblage (OCA); Bedrock. OCA is barrier to contaminant migration.
Hydrology:	Uppermost and Lower Aquifers, separated by the OCA layer. Depth to groundwater between a few feet and 20 feet. Persistent downward vertical gradient of as much as 20 ft.
Reason(s) for TI Approval:	
Primary Reasons:	DNAPLs are present in the source zone.
Secondary Reasons:	
Post-Implementation Waiver:	
Years of Remedial Action:	14
Site Activities:	1937 Wood treatment was initiated
Remedial Activities:	1983 Site investigation began on the request of the North Coast RWQCB, CalDHS (now DTSC) 1984 NPL proposal by EPA 1987 EPA initiated RI Report 1989 Listed on NPL 1989 RI Report finished and released 1990 ROD 1997 TI Evaluation submitted 1997 EPA suggested modification of groundwater remedy 1998 ROD Amendment with TI Waiver

Site No. 44: J.H. Baxter & Co., California (Cont.)

TI Evaluation:	
TI Zone Designation:	DNAPL zone source areas: tank beam area around a 500,000 gal tank, retort and process area, buried pond area, former oil/water separator/creosote pit area and the former wastewater vaults.
Conceptual Site Model Detail:	
Data Basis for Waiver:	Further investigation reports (between 1990 and 1997) that indicated DNAPLs were present and that contamination was more widespread than previously thought. Investigations were undertaken in order to design the remedial strategy in depth.
Timeframe Estimate:	
Cost Estimate:	$10.9 M baseline cost (no further action – keep original remedy) (30-yr, present worth). $26-$160 M for soil slurry wall, etc. $1.3 M extra for selected remedy. Check TI Evaluation for better cost estimates.
Alternative Remedial Strategy:	Slurry wall can contain the source area contamination. An inward gradient will be established by extracting groundwater within the slurry wall and contaminant migration outside of the zone will be detected by the monitoring system.
Alternatives to TI Waiver:	All possibilities incorporate containment and a TI Waiver
Approval Process:	
Agencies Involved:	EPA, CA RWQCB, CA DTSC
Documentation:	1998 ROD Amendment. CA RWQCB issued a short concurrence with the TI Waiver.
Decision Timeframe:	1 year
Future Review:	5-year reviews
General Comments:	
Site Setting:	Wood treatment facility
TI Evaluation Report:	Need to obtain this: Bechtel 1997. Final Focused Feasibility Study and Evaluation of Technical Impracticability, J.H.Baxter Superfund Site, Weed, California. Prepared for U.S. Environmental Protection Agency. May 1997.
Process:	
Other:	

Site No. 45: Schofield Barracks, Hawaii

General:	
Unit(s):	OU 02 – contaminated groundwater beneath the Schofield Barracks. Source areas include abandoned landfill and water supply wells plume (2 plumes) – several square miles.
Contaminants:	TCE
Other Contaminants Onsite:	Carbon tetrachloride
ARARs:	SDWA ARARs (MCLs)
Geology:	Soil (upper 5-10 ft) Saprolite (low permeability clay-rich soil - logged as a silt) grading with depth into weathered basalt. Basaltic bedrock (weathered on the surface to about 100-200 ft bgs)
Hydrology:	Streams, springs, manmade tunnels, reservoirs. Not much transfer between surface water and groundwater. Groundwater is the principal source of drinking water.
Reason(s) for TI Approval:	
Primary Reasons:	Physical constraints: depth (500-700 ft bgs); thickness of aquifer (>2000 ft) and fractured lava characteristics of the aquifer, age and size of the plume.
Secondary Reasons:	Lack of ability to find source; probability that DNAPL exists
Post-Implementation Waiver:	
Years of Remedial Action:	
Site Activities:	1985 April Contamination was discovered on the base (30 ppb TCE in four wells) 1986 Air stripper installed to take out TCE 1990 September Listed on NPL 1991 FFA outlining investigation of potential sources. 1997 Applied for a TI Waiver and got ROD.
Remedial Activities:	

Site No. 45: Schofield Barracks, Hawaii (Cont.)

TI Evaluation:	
TI Zone Designation:	
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	
Cost Estimate:	
Alternative Remedial Strategy:	Containment (pump-and-treat of 4MGD); geologic barriers and natural attenuation. Wellhead treatment at the Schofield supply wells
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	Army as lead agency has waived the ARARs.
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	Two plumes of TCE
TI Evaluation Report:	
Process:	Prepared for the US Army Environmental Center.
Other:	

Site No. 46: Tuscon International Airport Area, Arizona

General:	
Unit(s):	Airport property, Burr Brown Corporation property and the former West Cap property. Three Hangars complex has TCE, PCBs, pipeline full of contaminated sludge; Burr Brown low levels TCE (GW treatment unit). Landfill at the airport also (5 acres).
Contaminants:	TCE (at 10% solubility), PCBs
Other Contaminants Onsite:	Other VOCs, chromium, chloroform, benzene.
ARARs:	Generally ARARs are chemical-specific. Any examples of TI Waivers being applied to action-specific or location-specific ARARs
Geology:	Low permeability clay layer where DNAPL is immobile (hydraulic conductivity range is 10^{-6} to 10^{-5} cm/s). Underlain by a gravel zone.
Hydrology:	Shallow groundwater is at 85 ft bgs. Regional aquifer used for drinking water purposes is at 140 ft bgs.
Reason(s) for TI Approval:	
Primary Reasons:	Low yield when pumping TCE from the shallow groundwater due to clay geology; high TCE (DNAPL) concentrations – technically impracticable to clean area.
Secondary Reasons:	
Front-End Waiver:	
Years of Characterization:	14
Site Activities:	1950s Anecdotal evidence of TCE in well water 1981 Groundwater contamination formally detected 1983 NPL list 1997 June – Feasibility Study 1997 ROD with TI Waiver

Site No. 46: Tuscon International Airport Area, Arizona (Cont.)

TI Evaluation:	
TI Zone Designation:	Area of the shallow groundwater where remediation is technically impracticable. Area is approximately 2 acres, to the south of the Three Hangars Area. TI Zone extends downward to 5 ft below the gravel zone (approx 180 ft bgs)
Conceptual Site Model Detail:	DNAPL in the clay layer and in the gravel layer beneath the clay.
Data Basis for Waiver:	Based on the RI
Timeframe Estimate:	No timeframe estimate was calculated, based on ROD.
Cost Estimate:	$10-$20 M range quoted by EPA in public meeting; $7.6 - $25.6 M in the ROD
Alternative Remedial Strategy:	SVE and associated air monitoring controls for TCE; excavation for PCBs; excavation and landfill of sludge pipeline. Landfill at the airport will be formally closed, (covered with 2 ft of soil and monitoring soil, groundwater around the area). For shallow groundwater, containment with TI Waiver and remediation outside of the TI Zone (pump-and-treat for containment, enhancement technologies include electro-osmosis and bioremediation). Containment in the TI Zone can only be achieved if the natural vertical gradient is reversed. Extraction wells in the residential areas, piping to treatment plant at the Air National Guard Base, where air stripping or UV-oxidation is used to remove TCE. Flow = 50 to 100 gpm.
Alternatives to TI Waiver:	None
Approval Process:	
Agencies Involved:	US EPA led site, state concurs with the ROD. Grand Central is PRP.
Documentation:	ROD
Decision Timeframe:	Few months
Future Review:	5-year review
General Comments:	
Site Setting:	TCE has been detected in the regional aquifer, in wells screened at 500 ft. Hughes area has high TCE in regional aquifer.
TI Evaluation Report:	
Process:	
Other:	

Site No. 47: Westinghouse Electric, California

General:	
Unit(s):	
Contaminants:	PCBs
Other Contaminants Onsite:	1,2,4-Trichlorobenzene, 1,3-dichlorobenzene
ARARs:	Federal MCL for PCB
Geology:	Alluvial sands and gravels with silts and clays.
Hydrology:	Class A aquifer 45-50 ft deep and Class B Aquifer 50-70 ft deep – drinking water standards apply. Aquifer C is 100-150 ft deep. No known potable use of the water.
Reason(s) for TI Approval:	
Primary Reasons:	PCB DNAPL is present,
Secondary Reasons:	Heterogenous soil of low permeability, characteristics of PCB to sorb to soil
Front-End Waiver:	
Years of Characterization:	10
Site Activities:	1981 Westinghouse conducted a study on PCBs, in response to public concern 1984-85 Removal of shallow soils – board orders 1986 Listed on NPL, PRP search 1991 June – Final RI/FS 1991 Record of Decision and TI Waiver approval 1997 ESD

Site No. 47: Westinghouse Electric, California (Cont.)

TI Evaluation:	
TI Zone Designation:	DNAPL source area
Conceptual Site Model Detail:	
Data Basis for Waiver:	
Timeframe Estimate:	
Cost Estimate:	$8.3 M was the original estimate in the 1991 ROD.
Alternative Remedial Strategy:	Permanent containment of the source area and land use restrictions
Alternatives to TI Waiver:	
Approval Process:	
Agencies Involved:	During initial site investigations, Westinghouse was conducting the study and CalDHS, CA RWQCB were providing oversight. In December 1987, EPA became the lead agency.
Documentation:	
Decision Timeframe:	
Future Review:	
General Comments:	
Site Setting:	1950s Transformer manufacturing using "Inerteen" and mineral oil, used Inerteen on the site as a weed killer and disposed of it carelessly.
TI Evaluation Report:	Evaluation was part of the FS Process
Process:	First TI Waiver invoked in Region 9. EPA responded that TI Waiver provided a basis for insisting on containment in the area, since remediation was technical impracticable..
Other:	

Site No. 48: Eielson Air Force Base, Alaska

General:	
Unit(s):	Entire site is 19,780 acres. Fuel contaminated areas, TCE spill areas, drum burial areas, landfill areas and the entire site. TI Waiver was obtained for OU 02, Drum burial areas, subsites ST13, E-4 Diesel Fuel Spill and DP26, E-10 Fuel Tank Sludge Burial Site. For OU 03, 04 and 05, a TI Waiver was obtained for Site ST58 (similar reasoning and extent).
Contaminants:	Lead, from leaded fuel leaked from USTs
Other Contaminants Onsite:	VOCs, including BTX, TCE, petroleum, PCBs
ARARs:	Lead action level was waived in groundwater (under SDWA); also MCLs, MCLGs of 15 ug/L.
Geology:	Most of the base is fill. 2/3 has discontinuous permafrost in the soils. Loose alluvial fan sands and gravel. In ST58 site, homogeneous sand and gravel underlies the site. Fluvial and glacial fluvial deposits.
Hydrology:	Sole-source shallow unconfined aquifer under the site. Wetlands onsite. Low hydraulic gradient and high T.
Reason(s) for TI Approval:	
Primary Reasons:	Lead is immobile in soil. Size of the plume will not increase or decrease with time.
Secondary Reasons:	Modeling efforts show that a pump and treat system will require greater than 100 years to remove the lead contamination. Soil excavation is not practical because contamination is in the saturated zone.

Site No. 48: Eielson Air Force Base, Alaska (Cont.)

Post-Implementation Waiver:	
Years of Remedial Action:	9
Site Activities:	1989 Listed on NPL
Remedial Activities:	Five long-term cleanup actions 1991 Site-wide investigation. Used bioventing and SVE as the remedy for fuel contaminated areas. 1992 Investigation of TCE spill area, landfill areas 1994 ROD OU 02 1995 Drum Burial area TI Waiver, bioventing/SVE, Institutional controls and monitoring. Capping was found to be unnecessary based on plausible future land uses. Capping landfill was necessary. 1996 Pilot-scale SVE study for TCE spill area – concluded not to use SVE, institutional controls and monitoring instead. 1996 Approved the removal of PCB-contaminated sediments and toils < 10 ppm. 1997 Landfill was capped. 1998 ROD OU 02

Site No. 48: Eielson Air Force Base, Alaska (Cont.)

TI Evaluation:	
TI Zone Designation:	Two TI Zones. Site landmarks serve as boundaries for the area. Depth extends from the surface level to 30 feet below the average annual water table zone level for each TI Zone.
Conceptual Site Model Detail:	Geology and hydrology description, fate and transport (description of modeling)
Data Basis for Waiver:	A modeling exercise was used for fate and transport investigation: to show that the lead plume would not move appreciably in the next 100 years. Reviewers didn't agree with this RandomWalk model, because it overstated the mobility. Discussion of lead soil chemistry (half life of sorption, immobilization).
Timeframe Estimate:	Uncertain estimate of 100 years using pump-and-treat in the report
Cost Estimate:	Totals: \$9.86 M old (present worth) and \$1.19 M new. Costs decreased due to no longer having to pump-and-treat. Additional costs are those of long-term monitoring. For site ST58, no bioventing: \$191 goes to \$140 thousand.
Alternative Remedial Strategy:	SVE, bioventing, institutional controls and monitoring. Bioventing in the lead/BTEX area has shown that the plume of BTEX is decreasing. Natural attenuation is occurring. An Institutional Controls (IC) Plan was going to be written.
Alternatives to TI Waiver:	Pump and treat and excavation were both considered for removing the lead. Neither is practicable.
Approval Process:	
Agencies Involved:	US EPA; state of Alaska concurs. An EPA Technical Review was conducted - didn't agree with the modeling portion. A Technical Review Committee (TRC) was created in 1992 to review ROD amendments. This group served as the Restoration Advisory Board (RAB) in Spring 1995, along with 3 elected members from three communities (Salcha, Moose Creek and North Pole, AK)
Documentation:	1998 ROD
Decision Timeframe:	Unknown date of TI Waiver Evaluation submission
Future Review:	Five-yr reviews

Site No. 48: Eielson Air Force Base, Alaska (Cont.)

General Comments:	
Site Setting:	The Army and the Air Force used the site jointly. Includes closed and active unlined landfills, tank sludge, drum storage area and other storage or disposal areas. Used for industrial operations and a training facility. Approx. 600 people have drinking water wells within 3 miles of the site. Fish with PCBs were found in a slough. The two subsites have commingled plumes and are in close proximity.
TI Evaluation Report:	
Process:	
Other:	

GUIDANCE FOR EVALUATING THE TECHNICAL IMPRACTICABILITY OF GROUND-WATER RESTORATION

EPA OSWER Directive 9234.2-25, EPA/540-R-93-080, September 1993.

Directive 9234.2-25
September 1993

Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration

Interim Final

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

APPENDIX C

Notice

The policies set out in this document are intended solely as guidance to U.S. Environmental Protection Agency (EPA) personnel; they are not final EPA actions and do not constitute rulemaking. These policies are not intended, nor can they be relied upon, to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided in this document, or to act at variance with the guidance, based on an analysis of specific site circumstances. EPA also reserves the right to change this guidance at any time without public notice.

Contents

1.0 Introduction

1.1 Background

Restoration[1] of contaminated ground waters is one of the primary objectives of both the Superfund and RCRA Corrective Action programs. Ground-water contamination problems are pervasive in both programs; over 85 percent of Superfund National Priorities List (NPL) sites and a substantial portion of RCRA facilities have some degree of ground-water contamination. The Superfund and RCRA Corrective Action programs share the common purposes of protecting human health and the environment from contaminated ground waters and restoring those waters to a quality consistent with their current, or reasonably expected future, uses.

The National Contingency Plan (NCP), which provides the regulatory framework for the Superfund program, states that:

> "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" (NCP §300.430(a)(1)(iii)(F)).

Generally, restoration cleanup levels in the Superfund program are established by applicable or relevant and appropriate requirements (ARARs), such as the use of Federal or State standards for drinking water quality. Cleanup levels protective of human health and the environment are identified by EPA where no ARARs for particular contaminants exist (see Section 4.1.1).

The RCRA Corrective Action program for releases from solid waste management facilities (see 40 CFR 264.101)[2] requires a facility owner/operator to:

> "...institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit..."

The goal of protectiveness is further clarified in the Preamble to the Proposed Subpart S to 40 CFR 264:

> "Potentially drinkable ground water would be cleaned up to levels safe for drinking throughout the contaminated plume, regardless of whether the water was in fact being consumed... Alternative levels protective of the environment and safe for other uses could be established for ground water that is not an actual or reasonably expected source of drinking water."[3]

While both programs have had a great deal of success reducing the immediate threats posed by contaminated ground waters, experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to the limitations of available remediation technologies (EPA 1989b, 1992d). EPA, therefore, must evaluate whether ground-water restoration at Superfund and RCRA ground-water cleanup sites is attainable from an engineering perspective. **This document outlines EPA's approach to evaluating the technical impracticability of attaining required ground-water cleanup levels and establishing alternative, protective remedial strategies where restoration is determined to be technically impracticable.**

Many factors can inhibit ground-water restoration. These factors may be grouped under three general categories:

- Hydrogeologic factors;
- Contaminant-related factors; and
- Remediation system design inadequacies.

Hydrogeologic limitations to aquifer remediation include conditions such as complex sedimentary deposits; aquifers of very low permeability; certain types of

1 For this guidance, "restoration" refers to the reduction of contaminant concentrations to levels required under the Superfund or RCRA Corrective Action programs. For ground water currently or potentially used for drinking water purposes, these levels may be Maximum Contaminant Levels (MCLs) or non-zero Maximum Contaminant Levels Goals (MCLGs) established under the Safe Drinking Water Act; State MCLs or other cleanup requirements; or risk-based levels for compounds not covered by specific State or Federal MCLs or MCLGs. Other cleanup levels may be appropriate for ground waters used for non-drinking water purposes.

2 At this time, this guidance is not applicable to corrective actions for releases from Subpart F regulated units that are subject to corrective actions under 40 CFR 264.91-264.100.

3 "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," 55 FR 30798-30884, July 27, 1990, Proposed Rules, is currently used as guidance in the RCRA Corrective Action program. When final regulations under Subpart S are promulgated, certain aspects of this guidance pertaining to the RCRA program may need to be revised to reflect new regulatory requirements.

fractured bedrock; and other conditions that presently make extraction or *in situ* treatment of contaminated ground water extremely difficult (Figure 1).

Contaminant-related factors, while not independent of hydrogeologic constraints, are more directly related to contaminant properties that may limit the success of an extraction or *in situ* treatment process. These properties include a contaminant's potential to become either sorbed onto, or lodged within, the soil or rock comprising the aquifer. Nonaqueous phase liquids (NAPLs) are examples of contaminants that may pose such technical limitations to aquifer restoration efforts. NAPLs that are denser than water (DNAPLs) often are particularly difficult to locate and remove from the subsurface; their ability to sink through the water table and penetrate deeper portions of aquifers is one of the properties that makes them very difficult to remediate (Figure 1).

The widespread use of DNAPLs in manufacturing and many other sectors of the economy prior to the advent of safe waste-management practices has led to their similarly widespread occurrence at ground-water contamination sites. Most of the sites where EPA already has determined that ground-water restoration is technically impracticable have DNAPLs present. The potential impact of DNAPL contamination on attainment of remediation goals is so significant that EPA is developing specific recommendations for DNAPL site management; the key elements of this strategy are presented in Section 3.0 below.

The third factor that may limit ground-water restoration is inadequate remediation system design and implementation. Examples of design inadequacies in a ground-water extraction system include an insufficient number of extraction points (e.g., ground water or vapor extraction wells) or wells whose locations, screened intervals, or pumping rates lead to an inability to capture the plume. Design inadequacies may result from incomplete site characterization, such as inaccurate measurement of hydraulic conductivity of the affected aquifer or not considering the presence of NAPL contamination. Poor remediation system operation, such as excessive downtime or failure to modify or enhance the system to improve performance, also may limit the effectiveness of restoration efforts. **Failure to achieve desired cleanup standards resulting from inadequate system design or operation is not considered by EPA to be a sufficient justification for a determination of technical impracticability of ground-water cleanup.**

1.2 Purpose of the Guidance

This guidance clarifies how EPA will determine whether ground-water restoration is technically impracticable and what alternative measures or actions must be undertaken to ensure that the final remedy is protective of human health and the environment. Topics covered include the types of technical data and analyses needed to support EPA's evaluation of a particular site and the criteria used to make a determination. As technical impracticability (TI) decisions are part of the process of site investigation, remedy selection, remedial action, and evaluation of remedy performance, the guidance also briefly discusses the overall framework for decision making during these phases of site cleanup.

This guidance does not signal a scaling back of EPA's efforts to restore contaminated ground waters at Superfund sites and RCRA facilities. Rather, EPA is promoting the careful and realistic assessment of the technical capabilities at hand to manage risks posed by ground-water contamination. This guidance provides consistent guidelines for evaluating technical impracticability and for maintaining protectiveness at sites where ground water cannot be restored within a reasonable timeframe. EPA will continue to conduct, fund, and encourage research and development in the fields of subsurface assessment, remediation, and pollution prevention so that an ever decreasing number of sites will require the analysis described in this document.

2.0 Ground-Water Remedy Decision Framework

2.1 Use of the Phased Approach

At sites with very complex ground-water contamination problems, it may be difficult to determine whether required cleanup levels are achievable at the time a remedy selection decision must be made. This is especially true when such decisions must be based on site data collected prior to implementation and monitoring of pilot or full-scale remediation systems. EPA recognizes this limitation and has recommended several approaches to reduce uncertainty during the site characterization, remedy selection, and remedy implementation processes (EPA 1989a, 1992a).

Determining the restoration potential of a site may be aided by employing a **phased approach** to site characterization and remediation. Each phase of site

Figure 1. Examples of Factors Affecting Ground-Water Restoration

Certain site characteristics may limit the effectiveness of subsurface remediation. The examples listed below are highly generalized. The particular factor or combination of factors that may critically limit restoration potential will be site specific.

Generalized Remediation Difficulty Scale

Increasing difficulty →

Contaminant Characteristics

	Factor	Less difficult	→ More difficult
Site Use	Nature of Release	Small Volume Short Duration Slug Release	Large Volume Long Duration Continual Release
Chemical Properties	Biotic/Abiotic Decay Potential	High	Low
	Volatility	High	Low
	Contaminant Retardation (Sorption) Potential	Low	High
Contaminant Distribution	Contaminant Phase	Aqueous, Gaseous → Sorbed → LNAPLs	DNAPLs
	Volume of Contaminated Media	Small	Large
	Contaminant Depth	Shallow	Deep

Hydrogeologic Characteristics

	Factor	Less difficult	→ More difficult
Geology	Stratigraphy	Simple Geology, e.g., Planar Bedding	Complex Geology, e.g., Interbedded and Discontinuous Strata
	Texture of Unconsolidated Deposits	Sand	Clay
	Degree of Heterogeneity	Homogeneous (e.g., well-sorted sand)	Heterogeneous (e.g., interbedded sand and silts, clays, fractured media, karst)
Hydraulics/Flow	Hydraulic conductivity	High (>10^{-2} cm/sec)	Low (< 10^{-4} cm/sec)
	Temporal Variation	Little/None	High
	Vertical Flow	Little	Large Downward Flow Component

characterization should be designed to provide information necessary for the next phase of characterization. Likewise, site remediation activities can be conducted in phases to achieve interim goals at the outset, while developing a more accurate understanding of the restoration potential of the contaminated aquifer. An example of how this approach might be applied at a site is provided below in Section 4.4.3.

The timing of phased cleanup actions (early, interim, final) should reflect the relative urgency of the action and the degree to which the site has been characterized. Early actions should focus on reducing the risk posed by site contamination (e.g., removal of contamination sources) and may be carried out before detailed site characterization studies have been completed. Interim remedial actions may abate the spread of contamination or limit exposure but do not fully address the final cleanup levels for the site. Interim actions generally will require a greater degree of site characterization than early actions. However, implementation of interim actions still may be appropriate prior to completion of site characterization studies, such as the Remedial Investigation/Feasibility Study (RI/FS) or RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS). Final remedial actions must address the cleanup levels and other remediation requirements for the site and, therefore, must be based on completed characterization reports. Information from early and interim actions also should be factored into these reports and final remedy decisions.

Phasing of activities generally should not delay or prolong site characterization or remediation. In fact, such an approach may accelerate the implementation of interim risk reduction actions and lead more quickly to the development of achievable final remediation levels and strategies. A phased approach should be considered when there is uncertainty regarding the ultimate restoration potential of the site but also a need to quickly control risk of exposure to, or limit further migration of, the contamination.

It is critical that the performance of phased remedial actions (e.g., control of plume migration) be monitored carefully as part of the ongoing effort to characterize the site and assess its restoration potential. Data collection activities during such actions not only should be designed to evaluate performance with respect to the action's specific objectives but also contribute to the overall understanding of the site. In this manner, actions implemented early in the site remediation process can achieve significant risk reduction and lead to development of technically sound, final remedy decisions.

2.2 Documenting Ground-Water Remedy Decisions Under CERCLA

The phased approach to site characterization and remediation can be employed using the existing decision document options within the Superfund program.

2.2.1 Removal Actions

Removal authority can be used for early actions as part of a phased approach to ground-water cleanup and decision making and should be considered where early response to ground-water contamination is advantageous or necessary. Within the context of ground-water actions, removals are appropriate where contamination poses an actual or potential threat to drinking water supplies or threatens sensitive ecosystems. Examples of actions that might qualify for use of removal authority include removal of surface sources (e.g., drums or highly contaminated soils), removal of subsurface sources (e.g., NAPL accumulations, highly contaminated soils, or other buried waste), and containment of migrating ground-water contamination "hot spots" (zones of high contaminant concentration) or plumes to protect current or potential drinking water supplies.

Removals of subsurface sources most likely will be non-time-critical actions, although time-critical actions may be appropriate for removal of NAPL accumulations or other sources, depending on the urgency of the threat. Documentation requirements for removal actions include a Removal Action Memorandum and, for non-time critical actions, an Engineering Evaluation/Cost Analysis report.[4]

Removal actions must attain ARARs to the extent practicable, considering the exigencies of the situation. The urgency of the situation and the scope of the removal action may be considered when determining the practicability of attaining ARARs (NCP §300.415(i)). Standards or regulations typically used to establish ground-water cleanup levels for final actions (e.g., MCLs/MCLGs) may not be ARARs, depending on the scope of the removal. Further

4 See "Guidance on Conducting Non-Time Critical Removal Actions under CERCLA," OSWER Publication 9360.0-32, August 1993 (EPA 1993b).

information on removal actions may be found in other EPA guidances (EPA 1990b, 1991d).

2.2.2 Interim RODs

Interim RODs may be appropriate where there is a moderate to high degree of uncertainty regarding attainment of ARARs or other protective cleanup levels. As mentioned before, an interim action may be used to minimize further contaminant migration and reduce the risk of exposure to contaminated ground water. Interim actions include containment of the leading edge of a plume to prevent further contamination of unaffected portions of an aquifer, removal of source material, remediation of ground-water hot spots, and in some cases, installation of physical barriers or caps to contain releases from source materials. Interim actions should be monitored carefully to collect detailed information regarding aquifer response to remediation, which should be used to augment and update previous site characterization efforts. This information then can be used at a later date to develop final remediation goals and cleanup levels that more accurately reflect the particular conditions of the site.

It is important to note that for interim actions, ARARs must be attained only if they are within the scope of that action. For example, where an interim action will manage or contain migration of an aqueous contaminant plume, MCLs and MCLGs would not be ARARs, since the objective of the action is containment, not cleanup (although requirements such as those related to discharge of the treated water still would be ARARs, since they address the disposition of treated waste).

Furthermore, a requirement that is an ARAR for an interim action may be waived under certain circumstances. An "interim action" ARAR waiver may be invoked where an interim action that does not attain an ARAR is part of, or will be followed by, a final action that does (NCP §300.430(f)(1)(ii)(C)). For example, where an interim action seeks to reduce contamination levels in a ground-water hot spot, MCLs/MCLGs may be ARARs since the action is cleaning up a portion of the contaminated ground water. If, however, this interim action is expected to be followed by a final, ARAR-compliant action that addresses the entire contaminated ground-water zone, an interim action ARAR waiver may be invoked.

2.2.3 Final RODs

Where site characterization is very thorough and there is a moderate to high degree of certainty that cleanup levels can be achieved, a final decision document should be developed that adopts those levels. Conversely, in cases where there is a high degree of certainty that cleanup levels cannot be achieved, a final ROD that invokes a TI ARAR waiver and establishes an alternative remedial strategy may be the most appropriate option.[5] Note that for ROD-stage waivers, site characterization generally should be sufficiently detailed to address the data and analysis requirements for TI determinations set forth in this guidance.

2.2.4 ROD Contingency Remedies and Contingency Language

Where a moderate degree of uncertainty exists regarding the ability to achieve cleanup levels, a final ARAR-compliant ROD generally still is appropriate. However, the ROD may include contingency language that addresses actions to be taken in the event the selected remedy is unable to achieve the required cleanup levels (EPA 1990a, 1991a). The contingency language may include requirements to enhance or augment the planned remediation system as well as an alternative remedial technology to be employed if modifications to the planned system fail to significantly improve its performance. Use of language in final remedy decision documents that addresses the uncertainty in achieving required cleanup levels also is appropriate in certain cases. **However, language that identifies a TI decision (e.g., an ARAR waiver) as a future contingency of the remedy should be avoided.** Such language is not necessary, as a TI evaluation may be performed (and a decision made) by EPA at any site regardless of whether such a contingency is provided in the decision document.

Note that in cases of existing RODs that already include a contingency for invoking a TI ARAR waiver, the conditions under which the ARAR may be waived should be consistent with, and as stringent as, those presented in this guidance or a future update.

Furthermore, the fact that such contingency language has been included in an existing ROD does not alter the need to enhance or augment a remedy to improve its ability to attain ARARs before concluding that a waiver can be granted. It also

5 At sites where a TI ARAR waiver is invoked in the ROD, preparation of the pre-referral negotiation package ("mini-lit" package) must include analysis of the model Consent Degree language to ensure that appropriate consideration of the waiver's impact is incorporated.

should be noted that remediation must be conducted for a sufficient period of time before its ability to restore contaminated ground water can be evaluated. This minimum time period will be determined by EPA on a site-specific basis.

2.3 Documenting Ground-Water Remedy Decisions under RCRA

The instruments used for implementing the RCRA Corrective Action program (permits and orders) also are amenable to a phased approach to remedy selection and facility remediation. The RCRA program can use permits or orders to compel both interim measures and final remedies.

2.3.1. Permits/Orders Addressing Stabilization
RCRA permits or orders can require the stabilization of releases from solid waste management units (SWMUs) at the facility. The Stabilization Initiative focuses on taking interim actions to prevent the further spread of existing contamination and reduce risks. Examples of measures used for stabilization include capping, excavation, and plume containment. Since the long-term or final cleanup of the facility is not the objective of stabilization (although stabilization should be consistent with the final remedy), TI decisions are not applicable at this early stage. Information gained during stabilization should be used to help determine the restoration potential of the facility and the objectives of the final remedy.

2.3.2. Permits/Orders Addressing Final Remedies
Where achieving ground-water cleanup standards is determined by EPA to be technically impracticable, the permit or order addressing final remedies should include practicable and protective alternative remedial measures. EPA's decision to make a TI determination will be based on clear and convincing information provided by the owner/operator. EPA generally will seek public comment on TI determinations prior to implementation. EPA's preliminary TI determinations and justification for these determinations should be documented in a Statement of Basis. As discussed above, uncertainty in the ability to restore an aquifer should be reduced through phased characterization and the use of interim remedial measures, where appropriate.

Permits and orders that address "final" remedies should specify the remediation cleanup levels selected by the implementing Agency. Such permits and orders, however, generally should not incorporate contingency TI language. The permit or order will need to be modified to document the TI determination and to specify, as appropriate, alternative cleanup levels and alternative remedial measures that have been determined to be technically practicable and protective of human health and the environment.

3.0 Remedial Strategy for DNAPL Sites

Many of the subsurface contaminants present at Superfund sites and RCRA facilities are organic compounds that are either lighter-than-water NAPLs (LNAPLs) or DNAPLs. As mentioned in Section 1.1, the presence of NAPL contamination, and in particular DNAPL contamination, may have a significant impact on site investigations and the ability to restore contaminated portions of the subsurface to required cleanup levels. Furthermore, DNAPL contamination may be a relatively widespread problem. A recent EPA study (EPA 1993a) concluded that up to 60 percent of National Priorities List (NPL) sites may have DNAPL contamination in the subsurface; a significant percentage of RCRA Corrective Action facilities also are thought to be affected by DNAPLs. As proven technologies for the removal of certain types of DNAPL contamination do not exist yet, DNAPL sites are more likely to require TI evaluations than sites with other types of contamination. Although this guidance pertains to TI evaluations at all site types, EPA believes the significance of the DNAPL contamination problem warrants the following brief discussion of DNAPL contamination and recommended site management strategies.

DNAPLs comprise a broad class of compounds, including creosote and coal tars, polychlorinated biphenyls (PCBs), certain pesticides, and chlorinated organic solvents such as trichloroethylene (TCE) and tetrachloroethylene (PCE). The term "DNAPL" refers only to liquids immiscible in, and denser than, water and **not** to chemicals that are dissolved in water that originally may have been derived from a DNAPL source. DNAPLs may occur as "free-phase" or "residual" contamination. **Free-phase** DNAPL is an immiscible liquid in the subsurface that is under positive pressure; that is, the DNAPL is capable of flowing into a well or migrating laterally or vertically through an aquifer. Where vertically migrating free-phase DNAPL encounters a rock or soil layer of relatively low permeability (e.g., clay or other fine-grained layer), a DNAPL accumulation or "pool" may form. **Residual** DNAPL is immiscible liquid held by capillary forces within the pores or fractures in soil or rock layers; residual DNAPL, therefore, generally is not capable of migrating or being displaced by normal ground-water flow. Both free-phase and residual DNAPL, however, can slowly dissolve in ground water and produce "plumes" of aqueous-phase contamination. DNAPLs also can produce subsurface vapors capable of migrating through the unsaturated zone and contaminating ground water (EPA 1992c). Figure 2 depicts the various types of contamination that may be encountered at a DNAPL site.

The three areas that should be delineated at a DNAPL site are the DNAPL entry location, the DNAPL zone, and the aqueous contaminant plume. The **entry locations** are those areas where DNAPL was released and likely is present in the subsurface. Entry locations include waste disposal lagoons, drum burial sites, or any other area where DNAPL was allowed to infiltrate into the subsurface. The **DNAPL zone** is defined by that portion of the subsurface containing free-phase or residual DNAPL. Thus, the DNAPL zone includes all portions of the subsurface where the immiscible-phase contamination has come to be located. The DNAPL zone may occur within both the saturated zone (below the water table) and the unsaturated zone (above the water table). The DNAPL zone also may contain vapor and aqueous-phase contamination derived from the DNAPL. The DNAPL zone may include areas at relatively great depths and lateral distances from the entry locations, depending on the subsurface geology and the volume of DNAPL released. The **aqueous contaminant plume** contains organic chemicals in the dissolved phase. The plume originates from the DNAPL zone and may extend hundreds or thousands of feet downgradient (in the direction of ground-water flow). Figure 3 illustrates the various components of a DNAPL site.

Since each DNAPL site component may require a different remediation strategy, it is important to characterize these components to the extent practicable. Thus, the properties and behavior of DNAPL contamination require consideration when planning and conducting both site investigation and remediation. The potential for DNAPL occurrence at the site should be evaluated as early as possible in the site investigation. Recent publications such as "Estimating Potential for DNAPL Occurrence at Superfund Sites" (EPA 1992c) and "DNAPL Site Evaluation" (Cohen and Mercer, 1993) provide detailed guidance on these topics. At sites where DNAPL disposal is known or suspected to have occurred, likely DNAPL entry locations should be identified from available historical waste-management information and subsurface chemistry data. This information can assist in the delineation of the DNAPL zone.

Characterization and delineation of the DNAPL zone is critical for remedy design and evaluation of the restoration potential of the site. At many sites, a subsurface investigation strategy that begins outside of the suspected DNAPL zone may be appropriate ("outside-in" strategy), in part to minimize the possibility of inadvertent mobilization of DNAPLs to

Figure 2. Types of Contamination and Contaminant Zones at DNAPL Sites (Cross-sectional view)

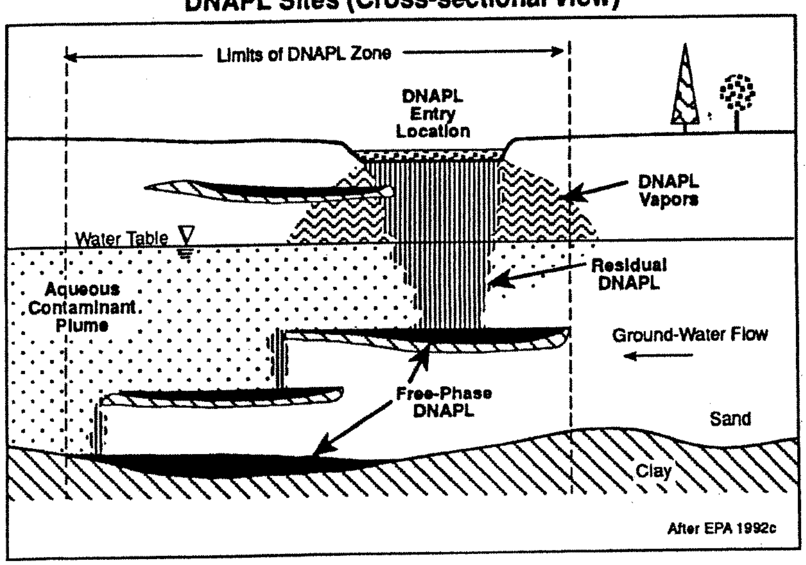
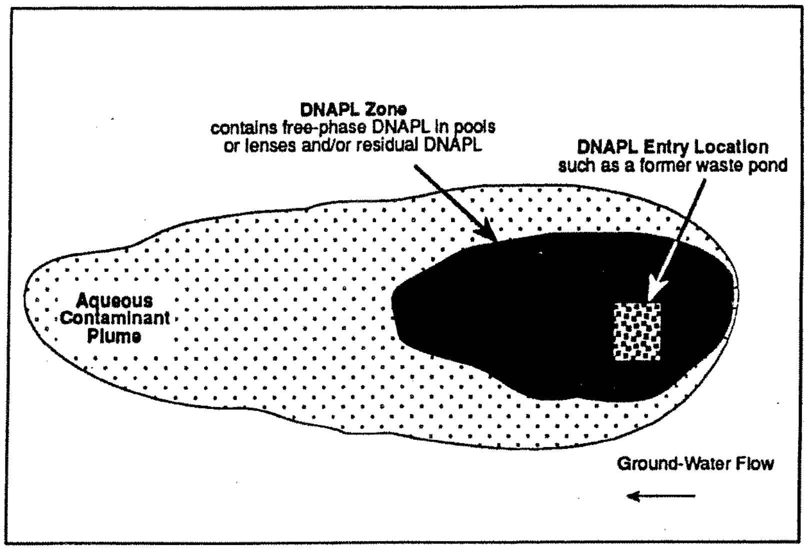


Figure 3. Components of DNAPL Sites



lower aquifers. Delineation of the extent of the DNAPL zone may be difficult at certain sites due to complex geology or waste disposal practices. In such cases, the extent of the DNAPL zone may need to be inferred from geologic information (e.g., thickness, extent, structure, and permeability of soil or rock units) or from interpretation of the aqueous concentration of contaminants derived from DNAPL sources. At some sites, however, geologic complexity and inadequate information on waste disposal may make the delineation of the DNAPL zone difficult.

A phased approach, as discussed in Section 2.1, is recommended for DNAPL sites; such an approach may facilitate identification of appropriate short- and long-term site remediation objectives. Note also that technical approaches appropriate for the DNAPL zone (e.g., free-phase DNAPL removal, vapor extraction, excavation, and slurry walls aided by limited pump-and-treat) may differ significantly from those appropriate for the aqueous contaminant plume (typically pump-and-treat).

Short-term remediation objectives generally should include prevention of exposure to contaminated ground water and containment of the aqueous contaminant plume. Where sufficient information is available, early removal of DNAPL sources also is recommended. Information gathered during these actions should be used to help characterize the site and identify practicable options for further remediation.

The long-term remediation objectives for a DNAPL zone should be to remove the free-phase, residual, and vapor phase DNAPL to the extent practicable and contain DNAPL sources that cannot be removed. EPA recognizes that it may be difficult to locate and remove all of the subsurface DNAPL within a DNAPL zone. Removal of DNAPL mass should be pursued wherever practicable and, in general, where significant reduction of current or future risk will result.[6] Where it is technically impracticable to remove subsurface DNAPLs, EPA expects to contain the DNAPL zone to minimize further release of contaminants to the surrounding ground water, wherever practicable.[7]

Where it is technically practicable to contain the long-term sources of contamination, such as the DNAPL zone, EPA expects to restore the aqueous contaminant plume outside the DNAPL zone to required cleanup levels. Effective containment of the DNAPL zone generally will be required to achieve this long-term objective because ground-water extraction remedies (e.g., pump-and-treat) or *in situ* treatment technologies are effective for plume restoration only where source areas have been contained or removed.

6 DNAPL mass removal also must satisfy the Superfund or RCRA Corrective Action remedy selection criteria, as appropriate.

7 As DNAPLs may be remobilized during drilling or ground-water pumping, caution should be exercised where such activities are proposed for DNAPL zone characterization, remediation, or containment.

Monitoring and assessing the performance of DNAPL zone containment and aquifer restoration systems, therefore, are critical to maintaining remedy protectiveness and evaluating the need for remedy enhancements or application of new technologies.

EPA recognizes, however, that there are technical limitations to ground-water remediation technologies unrelated to the presence of a DNAPL source zone. These limitations, which include contaminant-related factors (e.g., slow desorption of contaminants from aquifer materials) and hydrogeologic factors (e.g., heterogeneity of soil or rock properties), should be considered when evaluating the technical practicability of restoring the aqueous plume.

EPA encourages consideration of innovative technologies at DNAPL sites, particularly where containment of a DNAPL zone may require costly periodic maintenance (and perhaps replacement). Innovative technologies, therefore, should be considered where DNAPL zone containment could be enhanced or where such a technology could clean up the DNAPL zone.

4.0 TI Decisions and Supporting Information

4.1 Regulatory Framework for TI Decisions

The bases for TI decisions discussed in this guidance are provided in CERCLA and the NCP for the Superfund program and in the Proposed Subpart S rule for the RCRA program. While the processes the two programs use to establish cleanup levels differ (e.g., the ARAR concept is not used in RCRA), the primary considerations for determining the technical impracticability of achieving those levels are identical:

- **Engineering feasibility; and**
- **Reliability.**

A brief summary of the regulatory basis for establishing cleanup levels and making TI determinations at Superfund and RCRA sites is provided below.

4.1.1 Superfund

Remedial alternatives at Superfund sites must satisfy two "threshold" criteria specified in the NCP to be eligible for selection: 1) the remedy must be protective of human health and the environment; and 2) the remedy must meet (or provide the basis for waiving) the ARARs identified for the action.[8] There generally are several different types of ARARs associated with ground-water remedies at Superfund sites, such as requirements for discharge of treated water to surface water bodies or other receptors, limitations on reinjection of treated water into the subsurface, and cleanup levels for contaminants in the ground water. ARARs used to establish cleanup levels for current or potentially drinkable ground water typically are MCLs or non-zero MCLGs established under the Federal Safe Drinking Water Act, or in some cases, more stringent State requirements. For compounds for which there are no ARARs, cleanup levels generally are chosen to protect users or receptors from unacceptable cancer and non-cancer health risks or adverse environmental effects. Such levels generally are established to fall within the range of 10^{-4} to 10^{-6} lifetime cancer risk or below a hazard index of one for non-carcinogens, as appropriate.

ARARs may be waived by EPA for any of the six reasons specified by CERCLA and the NCP (Highlight 1), including **technical impracticability from an engineering perspective.** TI waivers generally will be applicable only for ARARs that are used to establish cleanup performance standards or levels, such as chemical-specific MCLs or State ground-water quality criteria.

Highlight 1.
CERCLA ARAR Waivers

The six ARAR waivers provided by CERCLA §121(d)(4) are:

1. Interim Action Waiver;
2. Equivalent Standard of Performance Waiver;
3. Greater Risk to Health and the Environment Waiver;
4. Technical Impracticability Waiver;
5. Inconsistent Application of State Standard Waiver; and
6. Fund Balancing Waiver.

8 NCP §300.430(f)(1)(i). For a detailed discussion of the Superfund remedy selection process, see also EPA 1988a and 1988b.

Use of the term "engineering perspective" implies that a TI determination should primarily focus on the technical capability of achieving the cleanup level, with cost playing a subordinate role. The NCP Preamble states that TI determinations should be based on:

> "...engineering feasibility and reliability, with cost generally not a major factor unless compliance would be inordinately costly."[9]

4.1.2 RCRA

The Proposed Subpart S rule specifies that the corrective action for contaminated ground water include attainment of "media cleanup standards," which generally are Federal or State MCLs, contaminant levels within the range of 10^{-4} to 10^{-6} lifetime cancer risk, or hazard index of less than one for non-carcinogens, as appropriate. The proposed rule also specifies three conditions under which attainment of media cleanup standards may not be required: 1) remediation of the release would provide no significant reduction in risks to actual or potential receptors; 2) the release does not occur in, or threaten, ground waters that are current or potential sources of drinking water; and 3) **remediation of the release to media cleanup standards is technically impracticable.**[10]

Further clarification of TI determinations is provided in the preamble to the proposed rule. The determination involves a consideration of the "**engineering feasibility and reliability**" of attaining media cleanup standards, as well as situations where remediation may be "technically possible," but the "scale of the operations required might be of such a **magnitude and complexity** that the alternative would be impracticable" (emphasis added).[11]

The basis for a RCRA Subpart S TI decision (engineering feasibility, reliability, and the magnitude and complexity of the action) therefore is consistent with that provided for the Superfund program in the NCP. In the context of remedy selection, both programs consider the notion of technical feasibility along with reliability and economic considerations; however, **the role of cost (or scale) of the action is subordinate to the goal of remedy protectiveness.**

4.2 Timing of TI Decisions

TI decisions may be made either when a final site decision document is being developed (e.g., RCRA Statement of Basis and Response to Comments or Superfund ROD) or after the remedy has been implemented and monitored for a period of time. EPA believes that, in many cases, TI decisions should be made only after interim or full-scale aquifer remediation systems are implemented because often it is difficult to predict the effectiveness of remedies based on limited site characterization data alone. However, in some cases, TI decisions may be made prior to remedy implementation. These pre-implementation or "front-end" TI decisions must be supported adequately by detailed site characterization and data analysis. Front-end TI evaluations should focus on those data and analyses that define the most critical limitations to ground-water restoration.

Data and analysis requirements for front-end decisions should be considered carefully. Generally, information regarding the nature and extent of contamination sources is more critical to assessing restoration potential than are other types of characterization data. This often is the case, as currently available technologies generally are more effective for remediating and restoring contaminated aquifers affected only by dissolved, or aqueous, contamination. However, certain types of source contamination are resistant to extraction by these technologies and can continue to dissolve slowly into ground water for indefinite periods of time. Examples of this type of source constraint include certain occurrences of NAPLs, such as where the quantity, distribution, or properties of the NAPL render its removal from, or destruction within, the subsurface infeasible or inordinately costly (See Section 3.0).

Geologic constraints, such as aquifer heterogeneity (e.g., interlayering of coarse and fine-grained strata), also may critically limit the ability to restore an aquifer. However, it generally is more difficult to accurately determine the impact of such constraints prior to implementation and monitoring of partial or full-scale aquifer remediation efforts. Some geologic constraints, however, may be defined sufficiently during site characterization so that their impacts on restoration potential are known with a relatively high degree of certainty. An example of this type of constraint includes complex fracturing of bedrock aquifers, which makes recovery of contaminated ground water or DNAPLs extremely difficult.

It should be noted, however, that the presence of known remediation constraints, such as DNAPL,

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9 See NCP Preamble, 55 FR 8748, March 8, 1990.
10 Technical impracticability is discussed in Sections 264.525(d)(2) and 264.531 of the Proposed Subpart S rule.
11 Proposed Subpart S; 55 FR 30830, July 27, 1990.

fractured bedrock, or other condition, are not by themselves sufficient to justify a TI determination. Adequate site characterization data must be presented to demonstrate, not only that the constraint exists, but that the effect of the constraint on contaminant distribution and recovery potential poses a critical limitation to the effectiveness of available technologies.

4.3 TI Evaluation Components[12]

Determinations of technical impracticability will be made by EPA based on site-specific characterization and, where appropriate, remedy performance data. These data should be collected, analyzed, and presented so that the engineering feasibility and reliability of ground-water restoration are fully addressed in a concise and logical manner.

The TI evaluation may be prepared by the owner/operator of a RCRA facility, by a PRP at an enforcement-lead Superfund site, or by EPA or the State at Fund- or State-lead sites, as appropriate. **The evaluation generally should include the following components, based on site-specific information and analyses:**

1. Specific ARARs or media cleanup standards for which TI determinations are sought (See Section 4.4.1).

2. Spatial area over which the TI decision will apply (See Section 4.4.2).

3. Conceptual model that describes site geology, hydrology, ground-water contamination sources, transport, and fate (See Section 4.4.3).

4. An evaluation of the restoration potential of the site, including data and analyses that support any assertion that attainment of ARARs or media cleanup standards is technically impracticable from an engineering perspective (See Section 4.4.4). At a minimum, this generally should include:

   a. A demonstration that contamination sources have been identified and have been, or will be, removed and contained to the extent practicable;
   b. An analysis of the performance of any ongoing or completed remedial actions;
   c. Predictive analyses of the timeframes to attain required cleanup levels using available technologies; and
   d. A demonstration that no other remedial technologies (conventional or innovative) could reliably, logically, or feasibly attain the cleanup levels at the site within a reasonable timeframe.

5. Estimates of the cost of the existing or proposed remedy options, including construction, operation, and maintenance costs (See Section 4.4.5).

6. Any additional information or analyses that EPA deems necessary for the TI evaluation.

The data and analyses needed to address each of these components of a TI evaluation should be determined on a site-specific basis. Where outside parties are preparing the TI evaluation, its contents generally should be identified and discussed prior to submittal of the evaluation to EPA. Early agreement between EPA and PRPs or owner/operators on the type and quantity of data and analyses required for TI decisions will promote efficient review of TI evaluations.

References to other documents in the administrative record, such as the RI/FS and RFI, likely will be necessary to produce a concise evaluation; however, these references should be as explicit as possible (e.g., cite specific page or table numbers). Technical discussions and conclusions should be supported by data compilations, statistical analyses, or other types of data reduction included in the evaluation.

4.4 Supporting Information for TI Evaluations

Most, if not all, of the information needed to evaluate TI could be obtained during a thorough site investigation and, where appropriate, remedy performance monitoring efforts. At some sites, however, additional analysis of existing data or new information may be required before EPA can determine accurately the technical practicability of the restoration goals. Not all of the data or analyses outlined in this guidance will be required at all sites; specific information needs will depend on site conditions and any ongoing remediation efforts.

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12 For this guidance a "TI evaluation" comprises the data and analyses necessary to make a TI determination. The TI evaluation may be performed by PRPs at enforcement-lead Superfund sites, or by State or other Federal agencies, where appropriate. Similarly, owner/operators at RCRA facilities may perform TI evaluations. However, the actual TI "determination," or "decision," will be made by EPA (or other lead agency, as appropriate).

The data and analyses identified and discussed below address the TI evaluation components provided in Section 4.3.

4.4.1. Specific ARARs or Media Cleanup Standards

The TI evaluation should identify the specific ARARs or media cleanup standards (i.e., the specific contaminants) for which the determination is sought. Such contaminants generally should include only those for which attainment of the required cleanup levels is technically impracticable. Factors EPA will consider when evaluating contaminants that may be included in the TI decision include: 1) the technical feasibility of restoring some of the contaminants present in the ground water; and 2) the potential advantages of attaining cleanup levels for some of the contaminants.

For example, consider a Superfund site with a DNAPL contamination problem (e.g., TCE), including a widespread subsurface DNAPL source area for which containment or restoration are technically impracticable. The aqueous plume also contains inorganic contamination (e.g., chromium) from on-site sources. Although it would be feasible to reduce chromium concentrations to the required cleanup level within a reasonable timeframe, TCE concentrations would remain above cleanup levels much longer due to the continued presence of the DNAPL or slow desorption of TCE from aquifer materials. However, in such cases, EPA may choose to limit the TI ARAR waiver to TCE alone, while requiring cleanup of the chromium.[13]

Two situations would favor use of this approach. The first would be where attaining chromium cleanup levels in the ground water will make future *ex situ* treatment of the (TCE-contaminated) ground water less complex and less expensive. This may be advantageous where a community wishes to extract the TCE-contaminated water, perform *ex situ* treatment, and put the treated water to beneficial use. A related consideration is whether removal of the chromium will facilitate future subsurface remediation using a newly developed technology. The second situation favoring this approach is where one of the contaminants (e.g., TCE) is being naturally biodegraded and the other (e.g., chromium) is not. Therefore, cleanup of the chromium may result in more rapid attainment of the long-term cleanup goals at the site.

Where the balance of conditions at such a site do not indicate that it is practicable to attain the cleanup levels for only some of the contaminants present, EPA may conclude that cleanup levels for the remaining contaminants need not be attained, depending on the circumstances of the site. As discussed further in Section 5.0, however, this decision does not preclude EPA from selecting (or continuing operation of) a remedy that includes active measures (e.g., pump-and-treat) along with measures to prevent exposure (e.g., institutional controls) needed to address site risks.

4.4.2 Spatial Extent of TI Decisions

The TI evaluation should specify the horizontal and vertical extent of the area for which the TI determination is sought. Where EPA determines that ground-water restoration is technically impracticable, the area over which the decision applies (the "TI zone") generally will include all portions of the contaminated ground water that do not meet the required cleanup levels (contaminated ground-water zone), unless the TI zone is otherwise defined by EPA.

In certain cases, EPA may restrict the extent of the TI zone to a portion or subarea within the contaminated ground-water zone. For example, consider a DNAPL site where it is technically impracticable to remove the residual DNAPLs from the subsurface but it is feasible and practicable to: 1) limit further migration of contaminated ground-water using a containment system; and 2) restore that portion of the aqueous plume outside of the containment area. The TI zone in this case should be restricted to that portion of the site that lies within the containment area. Outside of the TI zone, ARARs or media cleanup standards still would apply. The potential to spatially restrict the TI zone, therefore, will depend on the ability to delineate and contain non-removable subsurface contamination sources and restore those portions of the aqueous plume outside of the containment area. The spatial extent of the TI zone should be limited to as small an area as possible, given the circumstances of the site.

A TI zone should be delineated spatially, both in area and depth. Depth of a TI zone may be defined in absolute terms (e.g., feet above mean sea level) or in relative terms (e.g., with respect to various aquifers within multi-aquifer systems), as appropriate. Where

13 The extracted ground water would likely need to be treated for both TCE and chromium to satisfy treatment and waste disposal ARARs.

the TI zone will be restricted to a portion of the contaminated ground-water zone, the limits of the TI zone should be delineated clearly on site maps and geologic cross-sections. Delineation of the TI zone based on the location of a particular mapped contaminant concentration contour interval (e.g., the 200 part per billion isoconcentration line) generally should be avoided. This is because the location of such mapped contours often is highly interpretive, and their position may change with time. While concentration data may be appropriate to consider when determining the size of a containment area or the extent of a TI zone, the limits of that TI zone should be fixed in space, both horizontally and vertically.

4.4.3 Development and Purpose of the Site Conceptual Model

Decisions regarding the technical practicability of ground-water restoration must be based on a thorough characterization of the physical and chemical aspects of the site. Characterization data should describe site geology and hydrology; contamination sources, properties, and distribution; release mechanisms and rates; fate and transport processes; current or potential receptors; and other elements that define the contamination problem and facilitate analysis of site restoration potential. While the elements of such a model may vary from site to site, some generalizations can be made about what such a model would contain. Examples of these elements are provided in Figure 4. The site conceptual model synthesizes data acquired from historical research, site characterization, and remediation system operation.

The site conceptual model typically is presented as a summary or specific component of a site investigation report. The model is based on, and should be supported by, interpretive graphics, reduced and analyzed data, subsurface investigation logs, and other pertinent characterization information. The site conceptual model is not a mathematical or computer model, although these may be used to assist in developing and testing the validity of a conceptual model or evaluating the restoration potential of the site. The conceptual model, like any theory or hypothesis, is a dynamic tool that should be tested and refined throughout the life of the project. As illustrated in Figure 5, the model should evolve in stages as information is gathered during the various phases of site remediation. This iterative process allows data collection efforts to be designed so that key model hypotheses may be tested and revised to reflect new information.

The conceptual model serves as the foundation for evaluating the restoration potential of the site and, thereby, technical impracticability as well. The TI determination must consider how site conditions impact the potential for achieving remediation goals and whether remediation performance, cost-effectiveness, and timeframe meet EPA requirements or expectations. As these determinations rely on professional judgment, the clarity of the conceptual model (and supporting information) is critical to the decision-making process.

4.4.4 Evaluation of Restoration Potential

4.4.4.1 Source Control Measures. Remediation of contamination sources is critical to the success of aquifer restoration efforts. Continued releases of contamination from source materials to ground water can greatly reduce the effectiveness of aquifer restoration technologies, such as pump-and-treat, which generally are effective only for removing dissolved contaminants (EPA 1989b; 1992d). EPA considers subsurface NAPLs to be source materials because they are capable of releasing significant quantities of dissolved contamination to ground water over long periods of time.

A demonstration that ground-water restoration is technically impracticable generally should be accompanied by a demonstration that contamination sources have been, or will be, identified and removed or treated to the extent practicable. EPA recognizes that locating and remediating subsurface sources can be difficult. For example, locating DNAPLs in certain complex geologic environments may be impracticable. EPA expects, however, that all reasonable efforts will be made to identify the location of source areas through historical information searches and site characterization efforts.

Source removal and remediation may be difficult, even where source locations are known. The appropriate level of effort for source removal and remediation must be evaluated on a site-specific basis, considering the degree of risk reduction and any other potential benefits that would result from such an action. Even partial removal of contamination sources can greatly reduce the long-term reliance on both active and passive ground-water remediation.

Where complete source removal or treatment is impracticable, use of migration control or containment measures should be considered. Physical and hydraulic barriers are proven technologies that are capable of limiting or preventing further contaminant

Figure 4. Elements of Site Conceptual Model

The data and analysis required for TI evaluations will be determined by EPA on a site-specific basis. This information should be presented in formats conducive to analysis and in sufficient detail to define the key site conditions and mechanisms that limit restoration potential. Types of information and analysis that may be needed for conceptual model development are illustrated below.

Background Information

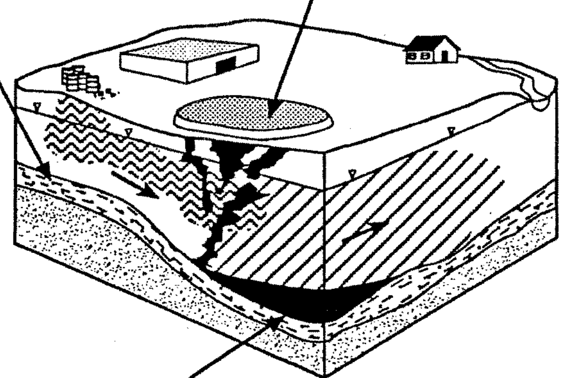
- Location of water supply wells.
- Ground-water Classification.
- Nearby wellhead protection areas or sole-source aquifers.
- Location of potential environmental receptors.

Geologic and Hydrologic Information

- Description of regional and site geology.
- Physical properties of subsurface materials (e.g., texture, porosity, bulk density).
- Stratigraphy, including thickness, lateral extent, continuity of units, and presence of depositional features, such as channel deposits, that may provide preferential pathways for, or barriers to, contaminant transport.
- Geologic structures that may form preferential pathways for NAPL migration or zones of accumulation.
- Depth to ground water.
- Hydraulic gradients (horizontal and vertical).
- Hydraulic properties of subsurface materials (e.g., hydraulic conductivity, storage coefficient, effective porosity) and their directional variability (anisotropy).
- Spatial distribution of soil or bedrock physical/hydraulic properties (degree of heterogeneity).
- Characterization of secondary porosity features (e.g., fractures, karst features) to the extent practicable.
- Temporal variability in hydrologic conditions.
- Ground-water recharge and discharge information.
- Ground-water/surface water interactions.

Contaminant Source and Release Information

- Location, nature, and history of previous contaminant releases or sources.
- Locations and characterizations of continuing releases or sources.
- Locations of subsurface sources (e.g., NAPLs).

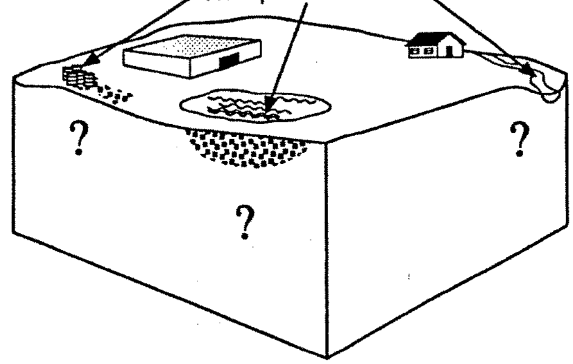


Contaminant Distribution, Transport, and Fate Parameters

- Phase distribution of each contaminant (gaseous, aqueous, sorbed, free-phase NAPL, or residual NAPL) in the unsaturated and saturated zones.
- Spatial distribution of subsurface contaminants in each phase in the unsaturated and saturated zones.
- Estimates of subsurface contaminant mass.
- Temporal trends in contaminant concentrations in each phase.
- Sorption information, including contaminant retardation factors.
- Contaminant transformation processes and rate estimates.
- Contaminant migration rates.
- Assessment of facilitated transport mechanisms (e.g., colloidal transport).
- Properties of NAPLs that affect transport (e.g., composition, effective constituent solubilities, density, viscosity).
- Geochemical characteristics of subsurface media that affect contaminant transport and fate.
- Other characteristics that affect distribution, transport, and fate (e.g., vapor transport properties).

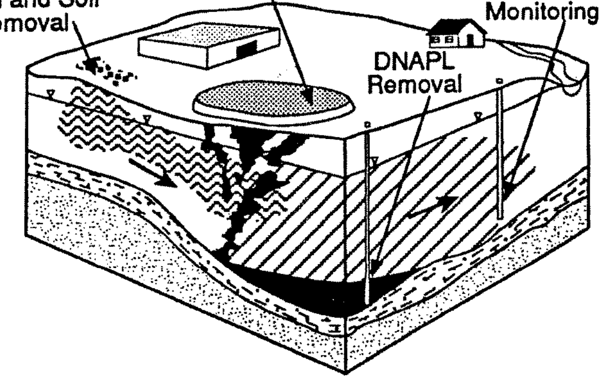
Figure 5. Evolution of the Site Conceptual Model

- Site Background and History
- Preliminary Site Investigations



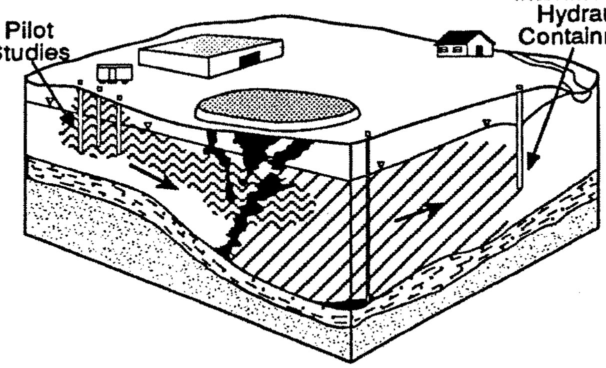
Conceptual Model Provides Basis for:

- Early Action/Removal of Near-Surface Materials
- Site Characterization Studies (RI/FS, RFI)
- Removal of Subsurface Sources (e.g., free-phase NAPLs)



Conceptual Model Provides Basis for:

- Pilot Studies
- Interim Ground-Water Actions



Conceptual Model Provides Basis for:

- Evaluation of Restoration Potential (or TI)
- Full-Scale Treatment System Design and Implementation
- Performance Monitoring and Evaluations
- Enhancement or Augmentation of Remediation System, if Required
- Future Evaluation of TI , if Required (See Figure 6)

migration from a source area under the right circumstances. While these containment measures are not capable of restoring source areas to required cleanup levels (i.e., a TI decision may be necessary for the source area), they may enable restoration of portions of the aquifer outside the containment zone.

4.4.4.2 Remedial Action Performance Analysis. The suitability and performance of any completed or ongoing ground-water remedial actions should be evaluated with respect to the objectives of those actions. Examples of remedy performance data are provided in Figure 6. The performance analysis should:

1. Demonstrate that the ground-water monitoring program within and outside of the aqueous contaminant plume is of sufficient quality and detail to fully evaluate remedial action performance (e.g., to analyze plume migration or containment and identify concentration trends within the remediation zone).[14]

2. Demonstrate that the existing remedy has been effectively operated and adequately maintained.

3. Describe and evaluate the effectiveness of any remedy modifications (whether variations in operation, physical changes, or augmentations to the system) designed to enhance its performance.

4. Evaluate trends in subsurface contaminant concentrations. Consider such factors as whether the aqueous plume has been contained, whether the areal extent of the plume is being reduced, and the rates of contaminant concentration decline and contaminant mass removal. Further considerations include whether aqueous-phase concentrations rebound when the system is shut down, whether dilution or other natural attenuation processes are responsible for observed trends, and whether contaminated soils on site are contaminating the ground water.

Analysis of aqueous-phase concentration data should be performed with caution. Contaminant concentrations plotted as a function of time, pore volumes of flushed fluids, or other appropriate variables may be useful in evaluating dominant contaminant fate and transport processes, evaluating remedial system design, and predicting future remedial system performance. Sampling methodologies, locations, and strategies, however, should be analyzed to determine the impact they may have had on observed concentration trends. For example, studies of ground-water extraction systems indicate that some systems show rapid initial decreases in aquifer concentration, followed by less dramatic decreases that eventually approach an asymptotic concentration level (EPA 1989b, 1992d). This "leveling off" effect may represent either a physical limitation to further remediation (e.g., contaminant diffusion from low permeability units) or an artifact of the system design or monitoring program. Professional judgment must be applied carefully when drawing conclusions concerning restoration potential from this information.

In certain cases, EPA may determine that lack of progress in achieving the required cleanup levels has resulted from system design inadequacies, poor system operation, or unsuitability of the technology for site conditions. Such system-related constraints are not sufficient grounds for determining that ground-water restoration is technically impracticable. In such instances, EPA generally will require that the existing remedy be enhanced, augmented, or replaced by a different technology. Furthermore, EPA may require modification or replacement of an existing remedy to ensure protectiveness, regardless of whether or not attainment of required cleanup levels is technically impracticable.

4.4.4.3 Restoration Timeframe Analysis. Estimates of the timeframe required to achieve ground-water restoration may be considered in TI evaluations. While restoration timeframes may be an important consideration in remedy selection, no single timeframe can be specified during which restoration must be achieved to be considered technically practicable. However, very long restoration timeframes (e.g., longer than 100 years) may be indicative of hydrogeologic or contaminant-related constraints to remediation. While predictions of restoration timeframes may be useful in illustrating the effects of such constraints, EPA will base TI decisions on an overall demonstration of the extent of such physical constraints at a site, not on restoration timeframe analyses alone. Such demonstrations should be based on detailed and accurate site conceptual models that also can provide the bases for meaningful predictions of restoration timeframes.

14 Further guidance on design of performance monitoring for remedial actions at ground-water sites is provided in "General Methods for Remedial Operations Performance Evaluations," EPA Office of Research and Development Publication EPA/600/R-92/002, January 1992 (EPA 1992e).

Figure 6. Remedy Performance Analysis

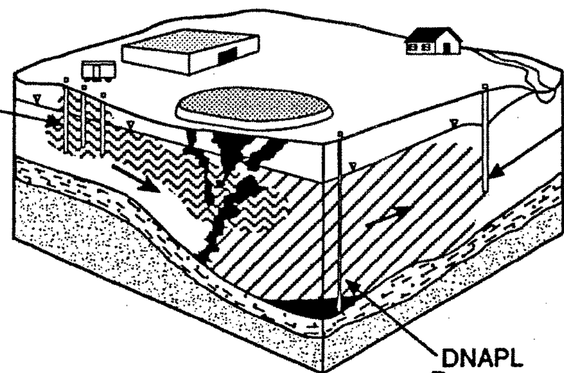
Remedy design and performance data requirements should be specific to technologies employed and site conditions. The categories of required information normally necessary to evaluate performance are provided below with some examples of specific data elements. These data should be reported to EPA in formats conducive to analysis and interpretation. Simple data compilations are insufficient for this purpose.

Remedy Design and Operational Information

- Design and as-built construction information, including locations of extraction or *in situ* treatment points with respect to the contamination.
- Supporting design calculations (e.g., calculation of well spacing).
- Operating information pertinent to remedy (e.g., records of the quantity and quality of extracted or injected fluids).
- Percent downtime and other maintenance problems.

Enhancements to Original Remedial Design

- Information concerning operational modifications, such as variations in pumping, injection rates, or locations.
- Rationale, design, and as-built construction information for system enhancements.
- Monitoring data and analyses that illustrate the effect these modifications have had on system performance.



Source Removal or Control

- Source removal information (e.g., results of soil excavations, removal of lagoon sediments, NAPL removal activities).
- Source control information (e.g., results of NAPL containment, capping of former waste management units).

Performance Monitoring Information

- Design and as-built construction information for performance monitoring systems.
- Hydraulic gradients and other information demonstrating plume containment or changes in areal extent or volume.
- Trends in subsurface contaminant concentrations determined at several/many appropriate locations in the subsurface. Trends should be displayed as a function of time, a function of pore volumes of flushed fluids, or other appropriate measures.
- Information on types and quantities of contaminant mass removed and removal rates.

A further consideration regarding the usefulness of restoration timeframe predictions in TI evaluations is the uncertainty inherent in such analyses. Restoration timeframes generally are estimated using mathematical models that simulate the behavior of subsurface hydrologic processes. Models range from those with relatively limited input data requirements that perform basic simulations of ground-water flow only, to those with extensive data requirements that are capable of simulating multi-phase flow (e.g., water, NAPL, vapor) or other processes such as contaminant adsorption to, and desorption from, aquifer materials. Model input parameters generally are a combination of values measured during site characterization studies and values assumed based on scientific literature or professional judgment. The input parameter selection process, as well as the simplifying assumptions of the mathematical model itself, result in uncertainty of the accuracy of the output. Restoration timeframes predicted using even the most sophisticated modeling tools and data, therefore, will have some degree of uncertainty associated with them.

Restoration timeframe analyses, therefore, generally are well suited for comparing two or more remediation design alternatives to determine the most appropriate strategy for a particular site. Where employed for such purposes, restoration timeframe analyses should be accompanied by a thorough discussion of all assumptions, including a list of measured or assumed parameters and a quantitative analysis, where appropriate, of the degree of uncertainty in those parameters and in the resulting timeframe predictions. The uncertainty in the predictions should be factored into the weight they are given in the remedy decision process.

4.4.4.4 Other Applicable Technologies. The TI evaluation should include a demonstration that no other remedial technologies or strategies would be capable of achieving ground-water restoration at the site.[15] The type of demonstration required will depend on the circumstances of the site and the state of ground-water remediation science at the time such an evaluation is made. In general, EPA expects that such a demonstration should consist of: 1) a review of the technical literature to identify candidate technologies; 2) a screening of the candidate technologies based on general site conditions to identify potentially applicable technologies; and 3) an analysis, using site hydrogeologic and chemical data, of the capability of any of the applicable technologies to achieve the required cleanup standards. Analysis of the potentially applicable technologies generally can be performed as a "paper study." EPA, however, may reserve the right to require treatability or pilot testing demonstrations to determine the actual effectiveness of a technology at a particular site.

Treatability and pilot testing should be conducted with rigorous controls and mass balance constraints. Information required by EPA for evaluation of pilot tests will be similar to that required for evaluation of existing remediation systems (e.g., detailed design and performance data).

4.4.4.5 Additional Considerations. Techniques used for evaluation of ground-water restoration potential are still evolving. The results of such evaluations generally will have some level of uncertainty associated with them. Interpretation of the results of restoration potential evaluations, therefore, will require the use of professional judgment. The use of mathematical models and calculations of mass removal rates are two examples of techniques that require particular caution.

Ground-water Flow and Contaminant Transport/Fate Modeling. Simulation of subsurface systems through mathematical modeling can be useful for designing remediation systems or predicting design performance. However, the limitations of predictive modeling must be considered when evaluating site restoration potential. As discussed in Section 4.4.4.3, ground-water models are sensitive to initial assumptions and the choice of parameters, such as contaminant source locations, leachability, and hydraulic conductivity. Predictions such as the magnitude and distribution of subsurface contaminant concentrations, therefore, will involve uncertainty. The source and degree of this uncertainty should be described, quantified, and evaluated wherever possible so the reviewer understands the level of confidence that should be placed in the predicted concentration values or other outputs. Predictive modeling may be most valuable in providing insight into processes that dominate contaminant transport and fate at the site and evaluating the relative effectiveness of different remedial alternatives. Further guidance and information on the use of ground-water models is provided in Anderson and Woessner (1992), EPA (1992f), and EPA (1992g).

Contaminant Mass Removal Estimates. Evaluation of contaminant mass removal may be useful at some sites

15 See discussions in the NCP (55 FR 8748, March 8, 1990) and Subpart S (55 FR 30838, July 27, 1990).

with existing remediation systems. These measures may include evaluation of mass removal rates, comparison of removal rates to *in situ* mass estimates, changes in the size of the contaminated area, comparison of mass removal rates with pumping rates, and comparison of such measures with associated costs. Mass removal and balance estimates should be used with caution, as there often is a high degree of uncertainty associated with estimates of the initial mass released and the mass remaining *in situ*. This uncertainty results from inaccuracy of historical site waste-management records, subsurface heterogeneities, and the difficulty in delineating the severity and extent of subsurface contamination.

4.4.5 Cost Estimate

Estimates of the cost of remedy alternatives should be provided in the TI evaluation. The estimates should include the present worth of construction, operation, and maintenance costs. Estimates should be provided for the continued operation of the existing remedy (if the evaluation is conducted following implementation of the remedy) or for any proposed alternative remedial strategies.

As discussed in Section 4.4.1, a Superfund remedy alternative may be determined to be technically impracticable if the cost of attaining ARARs would be inordinately high. The role of cost, however, is subordinate to that of ensuring protectiveness. The point at which the cost of ARAR compliance becomes inordinate must be determined based on the particular circumstances of the site. As with long restoration timeframes, relatively high restoration costs may be appropriate in certain cases, depending on the nature of the contamination problem and considerations such as the current and likely future use of the ground water. Compliance with ARARs is not subject to a cost-benefit analysis, however.[16]

5.0 Alternative Remedial Strategies

5.1 Options and Objectives for Alternative Strategies[17]

EPA's goal of restoring contaminated ground water within a reasonable timeframe at Superfund or RCRA sites will be modified where complete restoration is found to be technically impracticable. In such cases, EPA will select an alternative remedial strategy that is technically practicable, protective of human health and the environment, and satisfies the statutory and regulatory requirements of the Superfund or RCRA programs, as appropriate.[18]

Where a TI decision is made at the "front end" of the site remediation process (before a final remedy has been identified and implemented), the alternative strategy should be incorporated into a final remedy decision document, such as a Superfund ROD or RCRA permit or enforcement order. Where the TI decision is made after the final decision document has been signed (i.e., after a remedy has been implemented and its performance evaluated), the alternative remedial strategy should be incorporated in a modified final remedy decision document, such as a ROD amendment or RCRA permit/order modification (see Section 6.0).

Alternative remedial strategies typically will address three types of problems at contaminated ground-water sites: prevention of exposure to contaminated ground water; remediation of contamination sources; and remediation of aqueous contaminant plumes. Recommended objectives and options for addressing these three problems are discussed below. Note that combinations of two or more options may be appropriate at any given site, depending on the size and complexity of the contamination problem or other site circumstances.

5.1.1 Exposure Control

Since the primary objective of any remedial strategy is overall protectiveness, exposure prevention may play a significant role in an alternative remedial strategy. Exposure control may be provided using institutional controls, such as deed notifications and restrictions on water-supply well construction and use. The remedy should provide assurance that these measures are enforceable and consistent with State or local laws and ordinances.

5.1.2 Source Control

Source remediation and control should be considered when developing an alternative remedial strategy.

16 A Fund-Balancing ARAR waiver may be invoked at Fund-lead Superfund sites where meeting an ARAR would entail such cost in relation to the added degree of protection or reduction of risk that remedial actions at other sites would be jeopardized (EPA 1989c).

17 These recommendations are consistent with those made in Section 3.0 concerning DNAPL sites, but are applicable for any site where restoration is technically impracticable.

18 PRPs or owner/operators may propose and analyze alternative remedial strategies. However, only EPA (or designated lead agency, where appropriate) has remedy selection authority.

Sources should be located and treated or removed where feasible and where significant risk reduction will result, regardless of whether EPA has determined that ground-water restoration is technically impracticable.

In some cases, however, the inability to remove or treat sources will be a major factor in a TI decision. Where sources cannot be completely treated or removed, effective source containment may be critical to the long-term effectiveness and reliability of an alternative ground-water remedy. Options currently available for source containment usually involve either a physical barrier system (such as a slurry wall) or a hydraulic containment system (typically a pump-and-treat system) (EPA 1992b).

Applicability and effectiveness of containment systems are influenced by several hydrogeologic factors, however. For example, the effectiveness of a slurry wall generally depends on whether a continuous, low permeability layer exists at a relatively shallow depth beneath the site.

Source containment has several benefits. First, source containment will contribute to the long-term management of contaminant migration by limiting the further contamination of ground water and spread of potentially mobile sources, such as NAPLs. Second, effective source containment may permit restoration of that portion of the aqueous plume that lies outside of the containment area. Third, effective containment may facilitate the future use of new source removal technologies, as some of these technologies (e.g., surfactants, steam injection, radio frequency heating) may increase the mobility of residual and free-phase NAPLs. Remobilization of NAPLs, particularly DNAPLs, often presents a significant risk unless the source area can be reliably contained.

5.1.3 Aqueous Plume Remediation

Remediation of the aqueous plume is the third major technical concern of an alternative remedial strategy. Where the technical constraints to restoration include the inability to remove contamination sources, the ability to effectively contain those sources will be critical to establishing the objectives of plume remediation. Where sources can be effectively contained, the portion of the aqueous plume outside of the containment area generally should be restored to the required cleanup levels.

Inability to contain the sources, or other technical constraints, may render plume restoration technically impracticable. There are several options for alternative remedial strategies in such cases. These include hydraulic containment of the leading edge of the aqueous plume, establishing a less-stringent cleanup level that would be actively sought throughout the plume (at Superfund sites), and natural attenuation or natural gradient flushing of the plume.

Containment of the aqueous plume usually requires the pumping and treating of contaminated ground water, but usually involves fewer wells and smaller quantities of water than does a full plume restoration effort. Plume containment offers the potential advantages of preventing further spreading of the contaminated ground water, thereby limiting the size of the plume, and preventing the plume from encroaching on water-supply wells or discharging to ecologically sensitive areas.

At certain Superfund sites, it may be feasible to restore the contaminated plume (outside of any source containment area) to a site-specific cleanup level that is less stringent than that originally identified. EPA may establish such a level as the cleanup level within the TI zone, where appropriate. The site-specific level may consider the targeted risk level for site cleanup and other factors. Site-specific cleanup levels offer the advantage of providing a clear goal against which to measure the progress of the alternative remedial strategy. However, where site-specific cleanup levels exceed the acceptable risk range for human or environmental exposure, the remedy generally must include other measures (e.g., institutional controls) to ensure protectiveness.

At some Superfund sites, a less-stringent ARAR than the one determined to be unattainable may have to be complied with. For example, it may be technically impracticable to attain the most stringent ARAR at a site (e.g., a State requirement to restore ground water to background concentration levels). However, the next most stringent ARAR (e.g., Federal MCL) for the same compound may be attainable. In such cases, the next most stringent ARAR generally must be attained.

In certain situations where restoration is technically impracticable, EPA may choose natural attenuation as a component of the remedy for the aqueous plume.[19] Natural attenuation generally will result in

19 Technical impracticability of restoration is not a precondition for the use of natural attenuation in a ground-water remedy, however.

attainment of the desired cleanup levels, but may take longer to meet them than active remediation. This approach is most likely to be appropriate where the affected ground water is not a current or reasonably expected future source of drinking water, and ground-water discharge does not significantly impact surface water or ecologic resources. Sufficient technical information and supporting data must be presented to demonstrate the effectiveness of this strategy, along with assurances that any institutional controls required to prevent exposure will be reliable and enforceable. Contingencies for additional or more active remediation also should be incorporated into the remedy, to be triggered by specific contaminant concentration levels in the site ground-water monitoring network, or other criteria as appropriate.

5.2 Alternative Remedy Selection

The alternative remedial strategy options discussed above represent a range of responses for addressing the various aspects of a ground-water contamination site. Selection of the options appropriate for a particular site must not only consider the desired remediation objectives, as discussed above, but also the statutory and regulatory requirements applicable to the program under which the action is being taken. These requirements are discussed briefly below. Further information and guidance on these requirements can be obtained from publications referenced in this section.

5.2.1. Superfund

The selection of an alternative remedy at a Superfund site should follow the remedy selection process provided in NCP §300.430(f). Regardless of whether ARARs are waived at the site, the alternative remedy still must satisfy the two threshold remedy selection criteria (protect human health and the environment and comply with all ARARs that have not been waived); be cost effective; and utilize permanent solutions and treatment to the maximum extent practicable. This last finding is satisfied by identifying the alternative that best balances the trade-offs with respect to the remaining balancing and modifying criteria, taking into account the demonstrated technical limitations (see Highlight 2).[20]

Where ground-water ARARs are waived at a Superfund site due to technical impracticability, EPA's general expectations are to prevent further migration of the contaminated ground-water plume, prevent exposure to the contaminated ground water, and evaluate further risk reduction measures as appropriate. (NCP §300.430(a)(1)(iii)(F)). These expectations should be evaluated along with the nine remedy selection criteria to determine the most appropriate remedial strategy for the site.

Highlight 2.
Superfund Remedy Selection Criteria

Threshold Criteria
- Overall protection of human health and the environment
- Compliance with (or justification for a waiver of) ARARs

Balancing Criteria
- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria
- State acceptance
- Community acceptance

5.2.2 RCRA

At RCRA facilities where ground-water restoration is technically impracticable, the permit or order schedule of compliance may be modified by establishing: 1) further measures that may be required of the permittee to control exposure to residual contamination, as necessary to protect human health and the environment; and 2) alternate levels or measures for cleaning up contaminated media.[21]

Criteria for establishing an alternative remedial strategy under RCRA are presented in Highlight 3. In addition to satisfying the general standards for remedies, the alternative remedial strategy at a RCRA facility also should provide the best balance of trade-offs among the five remedy selection decision factors.[22]

20 For further guidance on the Superfund remedy selection process, see NCP §300.430(f) and "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," (EPA 1988a).

21 Proposed Subpart S Rule, §264.531(b).

22 Further guidance on remedy selection at RCRA facilities is provided in the proposed Subpart S Rule (55 FR 30823-30824, July 27, 1990).

Highlight 3.
RCRA Remedy Standards and Selection Factors

General Standards for Remedies
1. Overall protection of human health and the environment
2. Attainment of media cleanup standards
3. Source control
4. Compliance with waste management standards

Remedy Selection Decision Factors
1. Long-term effectiveness
2. Reduction of waste toxicity, mobility, or volume
3. Short-term effectiveness
4. Implementability
5. Cost

5.2.3 Additional Remedy Selection Considerations

The choice among available remedial strategy options may involve a consideration of the aggressiveness of the remedy, a concept that includes both the choice of remedial technologies as well as the relative intensity of how that technology is applied at the site. For example, consider a site where source area restoration is technically impracticable but source containment is both feasible and practicable. With the contaminant source contained, restoration of the portion of the plume outside of the containment area may be feasible. However, as discussed earlier, there are several options for attaining cleanup levels within the aqueous plume: active pump-and-treat throughout the aqueous plume; natural gradient flushing of the plume towards a pump-and-treat capture system located at the leading edge of the plume; and natural attenuation (dilution, dispersion, and any natural degradation processes active within the affected aquifer). Each alternative will attain the required cleanup levels, but the choice involves a trade-off among several factors, including: 1) remediation timeframe (longer with less aggressive strategies); 2) cost (lower with less aggressive strategies); and 3) potential risk of exposure (may increase with less aggressive strategies).[23]

Conditions favoring more aggressive strategies (i.e., active pump-and-treat throughout the aqueous plume) include the following:

1) **The aggressive strategy clearly will result in a significantly shorter restoration timeframe than other available options.** This will depend on site hydrogeologic and contaminant-related factors, including the complexity of the aquifer system, natural rate of ground-water flow, quantity of sorbed contaminant mass in the aquifer (and its rate of desorption), and other factors.

2) **A shorter remediation timeframe is desired to reduce the potential for human exposure.** This generally is the case where there is current or reasonably expected near-term future use of the ground water. Factors that may be useful in evaluating the likelihood of exposure include the State (or Federal, as appropriate) classification of the ground water; availability of alternate supplies, such as municipal hookups or other water supply aquifers; interconnections of the contaminated aquifer with other surface or ground waters; and the ability of institutional controls to limit exposure.

3) **A shorter remediation timeframe is desired to reduce ongoing or potential impacts to environmental receptors.** Such impacts may be caused by discharges to surface waters, sensitive ecologic areas (e.g., wetlands), or sole-source aquifers.

EPA will evaluate and determine the objectives and relative aggressiveness of the alternative remedy on a site-specific basis, based on the applicable regulatory requirements and considering the factors discussed throughout this section. Where conditions favoring more aggressive strategies do not exist, EPA is more likely to choose a less aggressive strategy to achieve the desired remediation objectives. EPA recognizes that, at some sites, remedies may need to be in operation for very long time periods. Adequate monitoring and periodic evaluation of remedy performance should be conducted to ensure protectiveness and to evaluate the need for remedy enhancements or the use of new or different remediation technologies.

5.2.4 Relation to Alternate Concentration Limits

Site-specific cleanup levels established as part of an alternative remedial strategy at a Superfund site should not be confused with CERCLA Alternate Concentration Limits (ACLs). To qualify for use of a CERCLA ACL, the site must meet the following three requirements: 1) there are known points of entry of the contaminated ground water into surface water; 2) there

23 The long-term reliability of a remedy also is an important consideration for alternative remedial strategy selection. In this example, long-term reliability is primarily a function of the design and integrity of the source containment system.

will be no statistically significant increases of the contaminant concentrations in the surface water or contaminant accumulations in downstream sediments; and 3) enforceable measures can be put into place to prevent exposure to the contaminated ground water (see CERCLA §121(d)(2)(B)(ii)). In addition, EPA generally considers ACLs appropriate only where cleanup to ARARs is impracticable, based on an analysis using the Superfund remedy selection "balancing" and "modifying" criteria shown in Highlight 2. Where an ACL is established, an ARAR waiver is not necessary. Conversely, where an ARAR is waived due to technical impracticability, there is no need to establish a CERCLA ACL. For further guidance on CERCLA ACLs, refer to the NCP Preamble (55 FR 8754, March 1990).

Site-specific cleanup levels established in response to a TI determination at a RCRA facility also should not be confused with ACLs established as part of the ground-water monitoring program for regulated units under 40 CFR 264.94. ACLs established under §264.94(a)(3) represent concentrations that EPA determines will not pose a substantial hazard to human or environmental receptors. (If the ACL is exceeded, then corrective action responsibilities for the regulated unit are triggered.) A TI determination generally will not satisfy the criteria for an ACL under this authority.

6.0 Administrative Issues

6.1 TI Review and Decision Process

A TI decision must be incorporated into a site decision document (Superfund ROD or RCRA permit or enforcement order) or be incorporated into a modification or amendment to an original document. Information and analyses supporting the TI decision must be incorporated into the site administrative record, either as part of a Feasibility Study or Corrective Measures Study (for a "front-end" TI determination) or remedy performance evaluation or other technical report or evaluation (for a post-remedy implementation determination).

The first step in EPA's review process for a TI determination will be to assess the completeness and adequacy of the TI evaluation. TI evaluations that do not adequately address the considerations identified in this guidance likely will have to be revised or augmented to address the inadequacies identified by EPA or the responsible agency. Early consultation with EPA by PRPs or owner/operators is encouraged to help identify appropriate data and analysis for the evaluation. While a TI evaluation is underway, remediation efforts underway at a site shall continue until the State or Federal official responsible for the decision determines that the existing remedy should be altered. Requirements specific to the Superfund and RCRA programs are discussed further below.

6.1.1 Superfund

As discussed in Section 4.2, TI decisions may be made either in the ROD (front-end decisions) or after the remedy has been implemented and monitored (post-implementation decisions), depending on the circumstances of the site.

TI decisions at Superfund sites generally will be made by the EPA Regional Administrator who, upon review of a TI evaluation, will determine whether ground-water restoration is technically impracticable and will identify further remedial actions to be taken at the site. TI determinations at Superfund sites may require consultation with headquarters program management. Regional personnel should refer to the most recent OERR Remedy Delegation Memorandum for current consultation requirements.[24]

Where a Superfund ROD will invoke a TI ARAR waiver (front-end decision), EPA (or the lead agency) must provide notice of its intent to waive the ARAR in the Proposed Plan for the site and respond to any State (or Federal) agency or public comments concerning the waiver. The requirements for State and community involvement are provided in NCP §300.500-515 and §300.430, respectively. In general, State and community involvement in the decision to waive an ARAR based on technical impracticability will be the same as for other site remedy decisions. Since TI decisions may affect the potential future uses of ground water, interest in TI ARAR waivers may be high. Therefore, it is EPA's intent to coordinate and consult with States and the public regarding TI ARAR waiver issues as early as possible in the remedy decision process.

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24 The types of Superfund site remedy decisions that require consultation with headquarters program management are identified in the periodically updated OERR Remedy Delegation Memorandum. The most recent version available at the time of publication of this guidance was the "Twenty Fourth Remedy Delegation Report - FY 1993," dated February 18, 1993.

State concurrence should be sought, but is not required, for all remedy decisions in which EPA invokes an ARAR waiver. Where the ARAR to be waived is a State ARAR, EPA must notify the State of this when submitting the RI/FS to the State or when responding to a State-lead RI/FS (NCP §300.515(d)(3)). EPA must provide the State with an explanation of any waiver of a State standard (CERCLA §121(f)(1)(G)).

For remedial actions under CERCLA §106 that will waive an ARAR, the State must be notified at least 30 days prior to the date on which any Consent Decree will be entered. If the State wishes the action to conform to (and not waive) those standards, the State may intervene in the action before the Consent Decree is entered (see §121(f)(2) and (f)(3)).

At certain State-lead sites, the State may make the final remedy decision, including a decision to invoke an ARAR waiver. This situation is restricted to sites where the State has been assigned the lead role for the response action, the action is being taken under State law, and the State is not receiving funding for the action from the Trust Fund. In such situations, the State may seek, but is not required to obtain, EPA concurrence on the remedy decision. For further guidance on this and other issues regarding the State role in remedy selection, see "Questions and Answers About the State Role in Remedy Selection at Non-Fund-Financed Enforcement Sites" (EPA 1991c).

Post-remedy-implementation TI decisions may be made in cases where an outside party or agency submits comments requesting a TI determination or EPA determines on its own initiative that a waiver is warranted. The information considered in making such decisions should include the same types of information and analyses discussed for front-end determinations, except that remedy performance data and analysis also should be provided. This information must be entered into the site administrative record before the TI decision can be made and an ARAR waiver invoked. There are limitations, however, to the requirement that EPA open the administrative record to new comments, such as an outside party's request for a TI determination. EPA is not required to consider comments on the selected remedy unless the comments contain "significant information not contained elsewhere in the administrative record file which substantially supports the need to significantly alter the response action" (see NCP §300.825). The type and amount of information necessary to meet this requirement (e.g., the length of time a remedy must be operated prior to a TI evaluation) will be determined by EPA on a site-specific basis.

A modification to a signed ROD invoking a TI ARAR waiver generally will require a ROD amendment, since a waiver usually will constitute a fundamental change in the remedy. A public comment period of 30 days is required for an amendment to a ROD; this period may be extended to 60 days upon request.[25] A public meeting also should be granted if requested. In the exceptional case where an ESD is used to invoke a TI ARAR waiver, public notice and opportunity for comment also should be provided. Further guidance on ROD amendments is provided in "Guide to Addressing Pre-ROD and Post-ROD Changes" (EPA 1991b) and upcoming revisions to "Guidance on Preparing Superfund Decision Documents" (expected Fall 1993).

6.1.2 RCRA

TI decisions at RCRA Corrective Action facilities will be made either by the EPA Regional Administrator or by the appropriate State agency, depending on the RCRA program authorization status of the State. EPA's goal in the RCRA corrective action program is to work cooperatively with individual States, regardless of their authorization status, to promote consistent TI decisions. As in the Superfund program, it is recommended that the State and EPA notify and consult each other as early as possible regarding sites where TI determinations may be made. This notification and consultation process may be outlined in the State/EPA Memorandum of Understanding.

For States authorized for Hazardous and Solid Waste Amendments (HSWA) Corrective Action, the State will have primary authority for remedy decisions, including TI decisions. EPA will retain authority for TI determinations in States that are not authorized for HSWA corrective action.

At RCRA permitted facilities, implementation of a TI determination generally would require a Class 3 permit modification for the purpose of specifying (alternative) corrective measures. This process requires a 45-day notice and comment period, response to comments, and

25 Public notice and opportunity for comment should be provided before an ARAR waiver is granted, regardless of whether an Explanation of Significant Differences (ESD) or ROD amendment is used to invoke the waiver.

public hearing, if requested. At RCRA facilities conducting corrective action under an order, TI determinations generally are implemented through the negotiation of a new order or an amendment to an existing order. This process generally includes a 30- to 45-day pubic comment period and public hearing, if requested.

6.1.3 Technical Review and Support

Technical support for the TI evaluation should be sought as early in the process as possible, preferably during the initial scoping of the content of the TI evaluation. TI determinations usually will require expertise from several disciplines, including hydrogeology, engineering, and risk assessment. Technical staff within the Regions representing these disciplines should be part of the TI review team. EPA's Office of Research and Development (ORD) technical liaisons and scientists based in the Regions also may provide assistance to program staff. Further assistance and review may be obtained from the ORD laboratories involved in the Technical Support Project, including the R.S. Kerr Environmental Research Laboratory (Ada, OK), the Risk Reduction and Engineering Laboratory (Cincinnati, OH), the Environmental Research Laboratory (Athens, GA), and the Environmental Monitoring Systems Laboratory (Las Vegas, NV). The directory of ORD technical services may be consulted for further information (EPA 1993c).

General assistance and site-specific consultation on technical impracticability issues also is available from EPA headquarters staff. Inquiries should be directed to the appropriate OSWER program office.

6.2 Duration of TI Decisions

A determination that ground-water restoration is technically impracticable and the subsequent selection of an alternative remedial strategy will be subject to future review by EPA.

At Superfund sites, an alternative remedial strategy implemented under a CERCLA TI waiver remains in effect so long as that strategy remains protective of human health and the environment. Protectiveness in this context encompasses long-term reliability of the remedy. If the conditions of protectiveness or reliability conditions cease to be met, EPA will determine what additional remedial actions must be implemented to enhance or augment the existing remedy. EPA shall conduct a full assessment of the protectiveness of the alternative remedy at least every five years at any site where contamination remains above levels that allow for unrestricted use, as required under NCP §300.430(f)(4)(ii).

RCRA TI decisions will be incorporated into facility permits or enforcement orders and therefore will be subject to continual oversight and review. Conditions of the permit or order involving the TI decision or the alternative strategy may be revisited on a periodic basis to ensure protectiveness. It may be necessary to modify permits or orders to reflect new information that becomes available during the remedy implementation and monitoring period.[26] Additional measures may be required by EPA to ensure the ongoing protectiveness and reliability of the remedy. Further, owner/operators of RCRA facilities may be required by EPA to undertake additional remedial measures in the future if subsequent advances in remediation technology make attainment of media cleanup standards technically practicable.

The protectiveness of an alternative remedial strategy at a Superfund site or RCRA facility must be ensured through a monitoring program designed to detect releases from containment areas, migration of contaminants to water supply wells, or other releases that would indicate a possible failure of one of the remedy components. EPA may decide to take any further response actions necessary to ensure protectiveness at any time based upon whether the alternative remedy is achieving its required performance standards. Monitoring data, therefore, must be provided to EPA on a regular basis to ensure adequate performance of the alternative remedy. The format, content, and reporting schedule of the monitoring program will be determined by EPA as part of the TI determination and alternative remedy selection process.

26 RCRA Corrective Action Orders that incorporate TI decisions should contain language that retains EPA's authority to review these decisions and complete additional site remediation, as necessary.

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Memorandum: Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Groundwater Restoration at Superfund Sites

EPA OSWER Directive 9200.4-14. January 1995.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 19 1995

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

OSWER Directive 9200.4-14

MEMORANDUM

SUBJECT: Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites

FROM: Henry L. Longest II, Director /s/
Office of Emergency and Remedial Response

TO: Director, Waste Management Division
Regions I, IV, V, VII
Director, Emergency and Remedial Response Division
Region II
Director, Hazardous Waste Management Division
Regions III, VI, VIII, IX
Director, Hazardous Waste Division
Region X
Director, Environmental Services Division
Regions I, VI, VII

Purpose

This memorandum addresses implementation of the OSWER guidance entitled "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration," dated September, 1993[1]. As you recall, the purpose of the guidance is to clarify how to determine when ARAR-based cleanup levels may be waived for reasons of technical impracticability.

The purpose of this memorandum is to:

- Promote national consistency in technical impracticability (TI) decision making;
- Facilitate transfer of information pertinent to TI decisions between Headquarters and the Regions;
- Identify the appropriate persons to conduct reviews of TI-related documents; and

[1]OSWER Publication 9234.2-25

- Clarify the role of Headquarters consultation.

Background

Ground-water contamination, confirmed at 85 percent of National Priorties List sites, continues to be of critical importance to the Superfund program. The remediation of the most highly contaminated sites, however, such as those with DNAPLs, presents both technical and policy challenges. While EPA remains firmly committed to restoring contaminated ground water to beneficial uses at Superfund sites, it is also important to recognize that technical limitations to achieving this goal may exist.

The goal of ground-water cleanup at Superfund sites continues to be restoration of contaminated ground water to ARAR based cleanup levels wherever technically practicable. However, evaluations of "pump and treat" remedies published by EPA in 1989 and 1992 indicated that complete restoration of many ground-water contamination sites in the Superfund program might not be technically practicable with available remediation technologies due to the presence of non-recoverable DNAPLs, or for other reasons related to complex site hydrogeology or contaminant characteristics. Where such factors constrain ground-water restoration, the Superfund program's approach is to emphasize removal or treatment of source materials; containment of non-restorable source areas; and restoration of aqueous contaminant plumes.

The National Research Council's recently released report "Alternatives for Ground Water Cleanup" independently confirmed EPA's findings that available ground-water remediation technologies are limited in their ability to restore all portions of contaminated ground-water sites. However, the NRC report also pointed out that, despite these constraints: 1) Non-restorable areas at complex sites generally constitute relatively small portions of the overall ground-water contamination problem; and 2) Pump and treat and other technologies are capable of restoring large portions of such sites, and of providing significant environmental benefits. The NRC report is therefore consistent with the current Superfund approach to ground-water remediation.

The close scrutiny of EPA's approach to ground-water cleanup, evidenced during the Superfund reauthorization debate and in the NRC report, illustrates the importance of sound implementation of ground-water cleanup. Therefore, there is a great deal of attention being placed on how EPA implements the technical impracticability guidance. The TI guidance clarifies Superfund ground-water policy, and provides direction for collecting, analyzing, and presenting the information needed to determine whether restoration of contaminated ground water is technically impracticable.

A typical TI "evaluation" should consist of a concise stand alone report, or a section in a site characterization document such as an RI/FS. Reviews of TI evaluations will require site-specific decisions regarding data sufficiency, the methods of data analysis, and the selection of appropriate alternative remedial strategies where total restoration is technically impracticable. Each of these facets of a TI decision is potentially complex and resource intensive.

Technical impracticability decisions may be made as soon as sufficient information is available to demonstrate that such a finding is appropriate. From a practical perspective, this generally will be at one of three points in the remediation decision process:

! A "front-end" decision made at the time of the ROD, based on site characterization and feasibility study data alone;
! A decision made at the time of the ROD, but based in part on pilot test or early remedial action performance; or
! A post-ROD decision based on a pilot test or a ground-water restoration remedy's performance.

Note that front-end TI decisions will require very thorough site characterization and feasibility study analyses, and generally will be appropriate at sites with severe contamination problems (e.g., non-recoverable NAPL contamination in complex geologic environments such as heterogeneous soil deposits or fractured bedrock). The TI guidance provides recommendations for the types of site data and data analyses generally needed for front-end TI evaluations.

The guidance also highlights the usefulness of a phased approach to ground-water remediation that employs early actions (e.g., source removal, source containment, or plume containment) because such actions not only reduce site risks, but may also be used to provide more accurate data on which to base subsequent decisions concerning the restoration potential of the site.

<u>Objective</u>

The objective of this memo is to promote technically sound, nationally consistent implementation of the technical impracticability guidance. Specifically, this memo: 1) Establishes points of contact in Headquarters for transfer of TI related information and for document reviews; 2) Requests that the Regions identify a person or persons as points of contact on TI issues and reviews; and 3) Outlines a basic process for evaluating TI decision documents.

Implementation

Communications and Points of Contact

Regional managers, in consultation with Headquarters, may make a significant number of TI decisions during the remainder of FY 95 and beyond. Reviews may be resource intensive, and require input from several different sources. To help facilitate these reviews, to assist the involved offices in planning for their respective resource commitments, and to help monitor the progress of guidance implementation, we are promoting regular, periodic communication among points of contact to be established in the Regions, Headquarters, and ORD.

Regional Point of Contact. A point of contact (either a person or small team of individuals) should be identified within each Region to serve as a source of information on the TI guidance to regional staff. Where appropriate, the contacts will assist RPMs, ORC attorneys, and other staff by referring them to support personnel (e.g., in-house or ORD technical specialists) for additional assistance. This person or team would also provide a valuable communication link between Headquarters, ORD, and the Region to facilitate the transfer of information regarding TI decisions.

The regional contact person (or team) may be a member(s) of the technical support staff or other person(s) knowledgeable in both the technical and policy aspects of ground-water remediation. For example, several members of the regional Ground Water Forum have-expressed an interest in being the point of contact, as the Forum was actively involved in the development of the TI guidance. The names of the Ground Water Forum members in the Superfund program are provided at the end of this memorandum.

Please provide the name or names of the regional contact persons to me through Peter Feldman of the Hazardous Site Control Division by February 24, 1995.

Headquarters Contacts. The current OERR point of contact for TI-related issues and consultations is Peter Feldman of the Hazardous Site Control Division (703-603-8768). The OERR contact will assist in the review of TI evaluations, provide a national perspective on similar decisions, and coordinate Headquarters consultations. The OERR point of contact may also be reached through other Headquarters Regional Coordinators, who will be assisting in the implementation of this guidance.

The current OGC point of contact is George Wyeth (202-260-7726). The OGC may be consulted on an as-needed basis to evaluate any statutory or regulatory concerns.

ORD Contacts. ORD laboratories can provide specialized, site-specific technical support in a number of areas related to TI evaluations. The laboratories, through the Technical Support Project, offer the Regions consultation services by scientists with experience in site characterization and remediation. Review of technical impracticability evaluations may require skills in such specialized areas as computer modeling and bioremediation; the support services offered by ORD may prove crucial in determining the technical merit of such TI evaluations. The appropriate general contact for TI issues and site-specific consultations is Don Draper, Director of the Technical Support Program at the R.S. Kerr Laboratory in Ada, OK (405-436-8603).

Conference Calls. Regular communication between the points of contact will be established to share information and experience related to implementing the TI guidance, and to assist ORD and Headquarters to plan for the volume of TI reviews that may be required. This will be implemented through a bimonthly or quarterly conference call in which all the Regional, ORD, and Headquarters points of contact will participate, with limited space for other interested parties. The precise format of this communication system will be determined in an initial conference call, once the points of contact have been identified. OERR will coordinate the conference call; the initial call will be conducted in early March, 1995.

TI Decision Review Process

Decisions regarding TI ARAR waivers will be made by the Regional Administrator or Division Director, as appropriate, based on recommendations provided by ORD, Regional, and Headquarters reviewers.

The TI review team. TI decisions generally will require a significant amount of review, particularly from a technical perspective, but also from legal and policy perspectives. A Regionally-led team should be established to review TI waiver evaluations from PRPs, as well as those developed by EPA or the State. Based on experience gained on reviews of TI evaluations by Regional staff to date, the review team generally includes the following:

- RPM and first line supervisor;
- ORC site attorney;
- Ground-water specialist (ORD and/or a Regional scientist);
- State representative (as appropriate)
- Regional ROD peer reviewer (where available);
- HQ OERR representative;
- HQ OGC representative (on an as-needed basis); and
- Human health and ecological risk assessors (as appropriate).

Representatives from ORD, OERR, and OGC will either be the points of contact discussed above, or other individuals who will be designated on a site-specific basis. The ORD reviewer will assist the Region in assessing the technical merits of specificTI evaluations; the Headquarters reviewers will provide the Region with the national perspective on TI decisions and provide assistance on legal or programmatic issues.

Review Process. The review process generally will consist of the following steps:

1. Technical review by the review team members to determine whether the TI evaluation is sufficiently <u>complete</u>, and whether it provides a <u>technically sound</u> justification for invoking the TI waiver. The evaluation should be revised based on review team comments until it meets these criteria.

2. Consultation with the Director of the Hazardous Site Control Division of Headquarters OERR.

3. Regional decision on the waiver, which is then generally incorporated into a ROD or ROD amendment. The TI evaluation should also be entered into the Administrative Record.

Scheduling Reviews. As TI reviews may require detailed evaluation of technical materials, a sufficient amount of time (four to eight weeks) should be built into the project schedule to permit Regional, ORD, and Headquarters participants to conduct thorough reviews.

Headquarters Consultation. The ROD consultation process, begun in 1985, fosters communication between the Regions and Headquarters on implementation of key aspects of the Superfund program. Consultation on TI ARAR waivers in RODs, which was identified in the Twenty Fifth Remedy Delegation Report (October 1993), will continue to be OERR policy. The consultation will be for RODs, ROD amendments, and ESDs invoking a TI ARAR waiver.

Consultation on TI ARAR waivers is intended to provide the Regions with a national perspective on similar decisions, and to identify any potentially significant precedent-setting issues at particular sites. This input should prove useful to Regional decision makers because relatively few sites have been through the TI review process; in addition, there are a number of technical and enforcement concerns that are likely to factor into site-specific decisions that also will be of interest to the national program.

Where an appropriate team has been involved throughout the review process leading up to the consultation, it is anticipated that the consultation will be relatively brief. The Headquarters contact within OERR (Peter Feldman) or the OERR Regional Coordinator should therefore be notified as early as possible of any impending TI waiver decision so as to expedite the review and consultation process.

For further information regarding the technical impracticability guidance and review process, please contact Peter Feldman of my staff at (703) 603-8768.

cc: Elliott P.Laws, Assistant Administrator
Timothy Fields, Jr., Deputy Assistant Administrator
Regional Superfund Section and Branch Chiefs
OSWER Office Directors
Clint Hall, ORD/RSKERL
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Regional Ground Water Forum (Superfund):

Region I:	Yoon-Jean Choi, Dick Willey
Region II:	Alison Hess, Ruth Izraeli, Kevin Willis
Region III:	Nancy Cichowicz, Kathy Davies, Dave Kargbo
Region IV:	Tony Best, Ralph Howard; Diane Guthrie ESD), Kay Wischkaemper (GWP)
Region V:	Luanne Vanderpool, Doug Yeskis; Steve Mangion (ORD)
Region VI:	Bert Gorrod
Region VII:	Bill Pedicino
Region VIII:	Darcy Campbell, Paul Osborne
Region IX:	Richard Freitas, Herb Levine
Region X:	Howard Orlean; Rene Fuentes (ESD), Bernard Zavala (ESD)

FACT SHEET: GROUND WATER TECHNICAL IMPRACTICABILITY DECISION MAKING IN REGION 7

USEPA Region 7. April 1997.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
726 MINNESOTA AVENUE
KANSAS CITY, KANSAS 66101

APR 29 2003

APR 17 1997

SUBJECT: Ground Water Cleanup Technical Impracticability Determinations

FROM: Michael J. Sanderson, Director
Superfund Division

TO: U. Gale Hutton, Director
Water, Wetlands and Pesticides Division

William A. Spratlin, Director
Air, RCRA and Toxics Division

Martha R. Steincamp, Regional Counsel
Office of Regional Counsel

The purpose of this memorandum is to transmit the final "Fact Sheet for Ground Water Technical Impracticability Decision Making in Region 7." This guidance is the product of our interdivision/interagency workgroup. A draft of the Fact Sheet was transmitted on October 18, 1996 for comment.

This version of the Fact Sheet incorporates changes made as a result of comments received from EPA headquarters (OERR and OSW), ARTD, WWPD, ORC, SUPR and MDNR.

If you have questions or comments, please contact me, Craig Smith or any workgroup member.

cc: William Rice, RGAD
Paul Nadeau, OERR

FACT SHEET

Ground Water Technical Impracticability Decision Making in Region 7

April 1997

The purpose of this Fact Sheet is to outline the Region 7 process of how a decision to grant a Technical Impracticability (TI) waiver is to be reached in cases where ground water cleanup to ARARs or health-based standards appears impracticable. This document will reference existing guidance, outline the data needed, suggest technical and administrative alternatives to be considered, and offer Federal and state remedial project managers and corrective action officers (collectively referred to as project managers) site-specific assistance via a regional ground water TI panel.

I. DEFINITION OF TI

Technical impracticability (TI) refers to recognition by EPA that site-specific conditions prevent returning contaminated ground waters to relevant and appropriate cleanup levels. Relevant and appropriate cleanup levels could include state or federal environmental standards and/or health or risk-based levels. TI does not mean that no action will be taken. A TI waiver does not waive the action; it waives the traditional health-based cleanup levels or other requirements determined to be unachievable. In fact, most conventional ground water remediation options remain valid under a TI scenario, but the remedial objective is not locked into unattainable goals. When a TI waiver is invoked, an alternative remedial strategy will be selected that protects human health and the environment and is technically practicable. A TI waiver may apply to an entire site or to specific portions of a site or plume.

II.LEGAL BASIS OF GRANTING A TI WAIVER

Congress formally recognized TI in Section 121(d)(4) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which provides that EPA may select a cleanup level that does not meet any applicable or relevant and appropriate standard, requirement, criteria, or limitation if the agency makes a finding that compliance with such requirements is technically impracticable from an engineering perspective. The EPA incorporated the concept in the National Contingency Plan (NCP).

Specifically, 40 CFR § 300.430 (f)(C)(A) of the NCP provides that a remedial alternative that does not meet an applicable or relevant and appropriate requirement (ARAR) under federal environmental or state environmental or facility citing laws may be selected if compliance with the requirement is technically impracticable from an engineering perspective.

A TI determination is also recognized in the Resource Conservation and Recovery Act (RCRA) Corrective Action program. As stated in the May 1996 Advance Notice of Proposed Rulemaking (ANPR), where TI is determined, the agency would expect to require an alternative remedial strategy that is technically practicable, consistent with the overall objectives of the remedy and controls the sources of contamination and human and environmental exposures.

The ANPR also states that "...As a general philosophy, EPA believes that RCRA and CERCLA remedial programs should operate consistently and result in similar environmental solutions when faced with similar circumstances..." One can conclude therefore that the deliberative process of making the TI decision under RCRA is the same as under CERCLA.

III. BACKGROUND

There are not any predetermined criteria that automatically activate a TI waiver. Conditions such as the existence of dense nonaqueous phase liquids (DNAPLs) and sites located in karst areas have been used as examples of criteria that could trigger TI. Alternatively, sites with exclusively dissolved contaminants in the ground water, that are located in low conductivity soils or bedrock may be just as impracticable for attaining risk or health based contaminant concentrations. Each site must be evaluated on an individual basis. Therefore, thorough site characterization is essential.

The 1993 interim final Guidance for Evaluating the Technical Impracticability of Ground Water Restoration (1993 Guidance) provides insight into a logical decision making process for granting a TI waiver. The 1993 Guidance promotes the use of a phased approach to site remediation and encourages early actions to control plume migration and remove contaminant sources. Such actions are useful in evaluating the restoration potential of the site as a whole.

Ground water project teams may seek advisory recommendations on TI issues from the Region 7 ground water TI panel which offers assistance as needed on a site-specific basis. The TI panel consists of: the TI coordinator, a senior RPM, a senior attorney, a hydrogeologist, a WWPD/DWGW representative, and a state representative.

Staff and management requesting assistance should contact the designated regional TI coordinator through their program Branch Chief. The TI coordinator will convene the ground water TI panel to review that site information with the site team, consult with Headquarters (HQ) as needed, and provide comments back to the site team. The TI panel members will be responsible for staying current in their respective disciplines and current on national ground water issues. In addition, the TI panel will maintain a complete library of agency information and guidance related to TI.

TI panel review of site-specific decisions is strictly optional. Site teams independently considering ground water response actions are encouraged to review at least the primary guidance documents referenced in this fact sheet, and to consult their state counterparts for input.

IV. SITE DATA NEEDED FOR A TI DETERMINATION

In order to determine whether a TI waiver is appropriate, an evaluation of site-specific conditions must be conducted. The 1993 Guidance discusses the types of information on which a TI decision should be based, and suggests this information be provided in a document called a TI Evaluation. A TI Evaluation should generally follow the outline below.

A. Description of ARARs or cleanup standards (federal and state) for which TI determination is sought.

B. Description of the spatial area over which the TI waiver will apply. This should include a review of the current and future ground water use and classification which requires coordination with the state and the regional water program.

C. A conceptual model of site conditions that summarizes and describes the hydrogeology, contamination sources, and processes that control transport and fate of contaminants at the site.

1. *Hydrogeology*

   - Flow regime - flow in granular media (including glacial till) vs. karst or fracture flow;
   - Stratigraphy - simple or complex with preferential flow zones; and
   - Aquifer characteristics - hydraulic conductivity, depth of lower confining unit, potability, state classification.

2. *Contaminants*

   - Type, concentration, toxicity and mobility;

➢NAPL presence/absence (see Pub. 9355.4- 07FS for determining likelihood of DNAPL presence); and
➢Ground water plume geometry, direction, and rate of movement.

D. Risk Analysis

1. Identify potential receptors;

2. Assess how site risks would be managed under a TI scenario.

E. Evaluation of the aquifer restoration potential including the following components:

1. Assessment of contaminant sources;

➢Identification of type and location of source (e.g., residual source in soil vs. free-phase product);
➢Size and depth of source; and
➢Impediments to removing source.

2. Analysis of the performance of any ongoing or completed response actions;

3. Predictive analysis of the time frames required to attain cleanup levels; and

4. Demonstration that available technologies could not achieve cleanup levels within a reasonable time frame due to limitations imposed by site characteristics.

F. Cost estimates of remedial alternatives and cost effectiveness evaluation.

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While the TI Evaluation may appear unduly burdensome, much of the information should be readily available from the remedial investigation/feasibility study (RI/FS) for CERCLA sites or the RCRA facility investigation/corrective measures study (RFI/CMS) for RCRA facilities. In cases where it is known prior to the RI/FS or RFI/CMS that a TI determination may be pursued (DNAPL, karst geology), the RI/FS or RFI/CMS should be planned to accommodate the needs of a TI Evaluation to avoid multiple data gathering efforts. The TI Evaluation can then be written concurrently with the RI and FS reports or the RFI and CMS reports.

V. TIMING, DOCUMENTATION AND INDIVIDUALS INVOLVED

When possible, TI determinations should be made early in the remedial process and included in the Superfund Record of Decision (ROD) or RCRA corrective action remedial decision document such as a Statement of Basis (SB), a permit, or an order. TI decisions can also be made after the remedy has been implemented and operated for some period of time. For Superfund actions, a TI decision which occurs after issuance of a ROD should be documented in a ROD Amendment.

In the Superfund program, TI decisions generally are made by the Regional Administrator. TI determinations should also include appropriate HQ and state involvement directly or via the TI panel.

Prior to invoking a TI waiver in a ROD, EPA must provide notice of its intent to waive the ARAR in the proposed plan and respond to any state or public comments concerning the waiver. Because ARAR waivers may affect the potential future uses of ground water, state and public interest in ARAR waivers can be high. The site team should include TI considerations in its community involvement plan.

Under the RCRA program, TI determinations will generally be made by an EPA division director or the director of the state agency, depending on the RCRA corrective action authorization status of that state and the lead agency for the specific site. Community outreach activities can occur throughout the corrective action process, but formal notification occurs at the time of the SB. TI decisions documented in the SB should follow the public process established for SBs. For TI decisions occurring after the SB, the corrective action officer would determine how best to communicate these decisions to the public, and could use the TI panel for consultation.

All TI evaluations should be developed with early and ongoing coordination with the regional and state water programs to assess current and future ground water use.

VI. ALTERNATIVE REMEDIAL STRATEGIES UNDER A TI SCENARIO

For situations where it is not technically practicable to return contaminated ground waters to relevant and appropriate (or risk-based) cleanup levels, an alternative remedial strategy will be required that protects human health and the environment. Even though such cleanup levels cannot be attained over all or portions of the plume, active remediation actions may still be needed to achieve site-specific remedial objectives. Some examples of remedial objectives and companion remediation actions follow.

✧ Prevent exposure -
- Alternate water supplies
- Point of use treatment
- Institutional controls
- Well abandonment

✧ Source control -
- Remove, treat or contain contaminated soil
- Remove or contain subsurface NAPLs

✧ Containment -
- Pump and treat (hydraulic control)
- Flow barriers
- Natural attenuation (to control migration)

✧ Restoration -
- Pump and treat
- Natural attenuation
- In-situ treatment (e.g., air sparging)
- Combination of methods

When developing an alternative remedial strategy for a site where a TI waiver is under consideration, it is important to determine which remedial objectives are appropriate for the site and are practicable. The effectiveness of remediation actions in accomplishing their intended objectives should then be evaluated.

In the absence of health-based levels, it may be difficult to establish specific remediation goals. However, performance measures appropriate to the site should be developed wherever possible. Some examples of performance measures for common remediation strategies follow.

✧ *Institutional controls/monitoring -*
Submission of documents verifying institutional controls implementation. Statistical analysis and trend reporting of monitoring data.

✧ *Source control/removal -*
Excavation to a specific soil contaminant concentration or depth, specific SVE operating conditions and soil gas cleanup levels.

✧ *Containment -*
Definition of geographic area for plume control (e.g. prescribe a radius of influence for containment withdrawal well and monitoring).

✧ *Pump and Treat -*
New asymptotic concentration as cleanup goal and periodic reporting of general trends.

✧ *Natural attenuation -*
Supplemental monitoring for indicator analytes and periodic statistical analysis of the data with emphasis on reporting trends.

These are merely examples of some performance measures that may be used. It may be appropriate to use different performance measures for these or other technologies. The ground water TI panel is available to assist teams in developing performance measures for their specific site. In any case, it is important where "complete" cleanup is impracticable, to have a way of demonstrating the effectiveness of the best practicable site-specific remediation strategy. As previously stated, TI is not envisioned as a no action alternative.

References:

Primary Guidance:

- OSWER Directive 9234.2-25: "Guidance for Evaluating the Technical Impracticability of Ground Water Restoration", Richard J. Guimond memo, Oct 4, 1993
- Superfund Ground Water RODs: Implementing Change this Fiscal Year; Elliott Law memo, July 31, 1995
- Part V 40 CFR Ch. 1 Federal Register, May 1, 1996
- Position Paper: Legal Ramifications of Granting a TI Waiver by Audrey Asher
- Advance Notice of Proposed Rulemaking - Ground Water Technical Impracticability Determinations under RCRA, Federal Register Volume 61, Number 85, Wednesday, May 1, 1996 p. 19451.
- Presumptive Response Strategy for Contaminated Ground Water; Stephen D. Luftig memo, October 1996.

Secondary Guidance:

- Sample Consent Decree Language Addressing the Issue of Technical Impracticability of Ground Water Pump and Treat Remedies for Certain Superfund Sites; William A. White memo, August 23, 1993
- Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground Water Restoration at Superfund Sites; Stephen D. Luftig memo, Jan 19, 1995
- A preliminary draft fact sheet entitled "The Role of Cost in the Superfund Remedy Selection Process", Betsy Shaw, March 4, 1996
- Example: Final Draft Technical Impracticability Evaluation Report Tansitor Electronics, Inc. Site Bennington, Vermont
- Example: USAF Installation Restoration Program, Pease AFB, Site 32 Technical Impracticability Evaluation, March 1994
- Guidance on remedial Actions for Contaminated Groudnwater at Superfund Sites, memo from J. Winston Porter, Dec 7, 1988
- Notes from GWTIWG meetings

Questions regarding this fact sheet should be directed to the TI coordinator.

Part 1 - TI Waiver Applications

1. What has been the application rate for TI Waivers in your region to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?

No applications are really denied since there is significant collaboration between PRP and EPA before a TI Evaluation Report is prepared. There was one example of where an application was denied by EPA because the consultant preparing the report would not alter their Conceptual Site Model. In that case, EPA wrote the TI Evaluation Report and the TI Waiver was subsequently approved.

2. Have any sites in the region been denied TI Waivers to your knowledge? What reasons were given for the denial?

See above.

3. Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?

You would have to ask the PRPs. Perhaps one problem is the definition, or lack thereof, of "technically impracticable from an engineering perspective". Also, with MNA as a remedial alternative, some sites may not see the need for a TI Waiver.

4. Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?

See answer to Question 1 above.

5. Has a TI Waiver been granted for sources that are still in place?

If DNAPLs can be considered a "source in place", then yes.

6. Are you aware of new sites that are currently involved in the TI Waiver application process?

One. A submittal is in preparation. It is premature for approval at this point. Other sites are in the preliminary discussions phase.

7. Are TI Waiver applications mainly for sites with DNAPLs?

Yes, probably. Usually, the presence of DNAPL is inferred rather than "proven" with collecting samples of the actual DNAPL.

Part 2 - TI Decision-Making Process

8. If a TI Waiver application was received by your region, who would it go to? What is the chain of approval within the region? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

The EPA RPM is the proper person to receive the application. The RPM will then farm it out to other EPA personnel for review. Others to review such applications within Region 1 would include Bill Brandon, Dick Willey, and Terry Connelly. There is a regional management decision process. The ultimate decision is with the Region.

9. Who is the EPA Headquarters contact for TI Waivers for your region?

Ken Lovelace is the EPA HQ contact person – those named for Question 8 above would be appropriate within Region 1.

10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

In almost all cases, a TI Waiver cannot go forward without the state's support and concurrence. The NCP allows decisions to be made without state concurrence, but as a practical matter, EPA does not invoke this unilateral path. Generally, the state will have a decision-making structure that is somewhat parallel with that of the EPA region.

11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

The public is generally involved. However, there is not example to our knowledge that the public prevented the approval of a TI Waiver.

12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

This is too site-specific to give a general answer. It usually comes down to how much data is required to prepare an adequate conceptual site model (CSM).

Part 3 - Site-Specific Topics

13. What was the main reason TI Waivers were granted?
Are you aware of any TI Waivers reviewed or granted after 1998 in your region? Do you know the EPA project managers at these sites?

No.

14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

A. Interim RODs – ARARs do not have to be met (yet). However, by definition, an interim ROD ultimately leads to a ROD where either ARARs must be met or waived.

B. Alternate Concentration Limits (ACLs) – not common, and are becoming less and less common.

C. A remedy that has a very long time frame (such as MNA). The definition of a "reasonable timeframe" is 30 years in Superfund. The number of 100 years has no significance – it is a site-by-site issue. The number is relative to the projected use of the water resource.

Part 4 – General Discussion

It will be important to reach some sort of consensus within EPA (primarily between Headquarters and the Regions) on the issue of TI Waivers.

Front-End Waivers are many times appropriate for a site. Unfortunately there is a misconception that remediation must be attempted as a final remedy for years before TI can be accepted.

If a PRP is not happy with a decision or lack thereof on the part of a regional RPM, there are procedures to "elevate" issues. If a consensus cannot be reached between RPM and PRP, then arbitration or other dispute resolution mechanisms can be explored.

Part 1 - TI Waiver Applications

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1. What has been the application rate for TI Waivers in your region to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?

I am not aware of any TI applications that have been denied by EPA Region 2. I developed an extensive TI waiver package for the GE Moreau Superfund Site, which was the first TI waiver in Region 2 to be issued under the 1993 guidance.

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2. Have any sites in the region been denied TI Waivers to your knowledge? What reasons were given for the denial?

Again, I have not heard of any TI waiver applications that have been denied by Region 2. Discussions regarding the TI process and the waiver requirements prior to submittal of applications may eliminate TI denials.

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3. Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?

First, gathering the documentation required to complete a TI waiver application is a significant effort. Second, the selection of Monitored Natural Attenuation (MNA) as a remedy (or as a component of a remedy) can mean that the data necessary to support a TI decision are not available for many years, basically deferring the issue at many sites with the potential for a TI Waiver. Third, for pump-and-treat systems that indicate diminishing effectiveness, EPA generally seeks to optimize the system before issuing a TI waiver. Time is then needed to collect and interpret the data, and possibly to further optimize the system, before a TI application could be completed.

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4. Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?

No.

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5. Has a TI Waiver been granted for sources that are still in place?

Yes – DNAPLs.

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6. Are you aware of new sites that are currently involved in the TI Waiver application process?

No.

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7. Are TI Waiver applications mainly for sites with DNAPLs?

I would think so. At the GE/Moreau site, the TI waiver was issued for the dissolved phase TCE in an unconfined sand and gravel aquifer. Even though the TI waiver does not include DNAPL, there is DNAPL at the site – the original source of the ground water contamination was disposal of TCE as DNAPL (which is now contained within a slurry wall and cap).

Part 2 - TI Decision-Making Process

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8. If a TI Waiver application was received by your region, who would it go to? What is the chain of approval within the region? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

The process is usually either a joint effort (EPA and PRP) or can be initiated by EPA alone. The EPA RPM (site manager) is the person who generally reviews or develops an application. Then, typically, a geologist from the technical support branch within the EPA Region 2 also would review the application, especially if the RPM was not a geologist. EPA regional management makes the final decision — could be a division director, a branch chief, or a regional administrator, depending on the site and the timing of the decision (e.g., ROD or post-ROD).

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9. Who is the EPA Headquarters contact for TI Waivers for your region?

Matt Charsky is the HQ contact for Region 2 Superfund and is a good resource – also, Ken Lovelace in HQ is knowledgeable about TI matters.

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10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

In the case of the GE/Moreau site, the state (New York State) and the EPA were adversaries in litigation. The state project manager was a geologist, but initially the state refused to agree to a TI Waiver of New York State ground water ARARs. Then, the state transferred responsibility for the site to another project manager, also a geologist, and the state's position changed – the new project manager agreed that the documentation supported a TI determination for the site. In this case, the state's final position reflected the professional opinion of the second project manager. Based on that experience, I could not necessarily characterize the "state's position on TI waivers" in any single way, except perhaps to say that it probably has evolved over time and is now more accepted.

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11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

The G.E. Moreau site in an example of a TI process carried our in public. Because of the litigation, the ground water modeling was refined during a 2-year open public comment period. EPA issued a public notice to announce each set of new modeling results. The other parties to the litigation (New York State, General Electric Company, and the Town of Moreau) provided input at each stage.

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12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

There is no formula for this – it is very case-specific. In the case of demonstrating that DNAPL exists, its strong inference is probably enough rather than having to actually finding it and sampling it, which can be difficult in some geologic settings.

Part 3 - Site-Specific Topics

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13. What was the main reason TI Waivers were granted?
Are you aware of any TI Waivers reviewed or granted after 1998 in your region? Do you know the EPA project managers at these sites?

Not aware of other sites.

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14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

I am not familiar with Region 2's RCRA decisions.

Part 4 – General Discussion

Ms. Hess wrote the TI Waiver for the G.E. Moreau site, and was a key participant in developing the September 1993 OSWER Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration.

TI Waivers have the benefit of publicly acknowledging the technical impracticability of attaining stringent cleanup levels. They provide EPA with a means of communicating, on a site-specific basis, the difficulties in cleaning up certain types of contamination in certain geologic settings.

The "reasonable time frame" definition is misinterpreted by many as a fixed100 years. The genesis of the 100-year number is probably language in the NCP that refers to "several decades". 100 years is probably longer than what was meant by "several decades." But, it is a reasonable maximum. Modeling is usually employed to determine the time frame for a remedial alternative. For example, modeling of the G.E. Moreau site showed that all realistic scenarios of remediation (including various configurations of pumping and treating) would not be able to clean up the ground water in less than 100 years.

TI Waivers are best considered on a site-by-site basis. Every site is different and the site circumstances and collection of people involved are different from case to case.

Part 1 - TI Waiver Applications

1. What has been the application rate for TI Waivers in your region to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?

Applications have been rare, but have no direct knowledge.

No knowledge of application denials.

2. Have any sites in the region been denied TI Waivers to your knowledge? What reasons were given for the denial?

No knowledge of TI Waiver denials.

3. Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?

The process for the TI waiver at the Continental Steel Corp. site was fairly arduous. The process for TI Waiver applications and approvals at that time was vague. There was a very large requirement for site characterization and modeling.

The process for the TI Waiver at the Continental Steel Corp. site began before the Feasibility Study was performed (completed in 1997). The TI Waiver process lasted for about 2 years.

The possibility of technical impracticability was first raised by the environmental consultant (CDM).

A Technical Committee was not formed specifically for the site – there was a Technical Committee for all EPA Region 5 sites.

The TI Waiver application and approval process was formulated at the same time as the issue of technical impracticability was being evaluated.

The basis for technical impracticability was a section in the FS. By approving the FS, a TI Waiver was in effect approved.

Louanne Vanderpool of EPA Region 5 was the central figure in the TI Waiver process.

4. Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?

None.

5. Has a TI Waiver been granted for sources that are still in place?

Yes, in the case of DNAPL. This was the case at the Continental Steel Corp. site (the presence of DNAPL was inferred from the site data).

The TI Waiver at the Continental Steel Corp. site applies only to the deep groundwater zone. The TI Waiver does not include certain source area remedies. There are also restrictions on groundwater use during the time for the TI Waiver.

The TI Waiver at the Continental Steel Corp. site will be periodically reviewed as part of the CERCLA 5-year review process.

6. Are you aware of new sites that are currently involved in the TI Waiver application process?

No.

7. Are TI Waiver applications mainly for sites with DNAPLs?

Part 2 - TI Decision-Making Process

8. If a TI Waiver application was received by your region, who would it go to? What is the chain of approval within the region? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

The TI Waiver application at the Continental Steel Corp. site was a section in the FS Report. The FS went to the EPA Site Manager for review and then the EPA Technical Committee.

The public forum for the TI Waiver process at the Continental Steel Corp. site was the Record of Decision (ROD). The community supported the decision. This was facilitated by the EPA being very involved in the community relations process, including monthly meetings with local environmental groups, chamber of commerce meetings, etc. Getting to know the people involved in the local business community and the local environmental groups was critical.

The EPA Technical Committee was involved throughout the process at the Continental Steel Corp. site.

The TI Waiver review process for the Continental Steel Corp. site lasted for approximately 1 year (the length of time from first draft submittal of the FS to final approval).

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9. Who is the EPA Headquarters contact for TI Waivers for your region?

Louanne Vanderpool.

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10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

The State of Indiana was the lead agency for the Continental Steel Corp. site. The State received grants from EPA for site management and hiring of the site consultant. The State led the investigation and proposed the remedies. Indiana participates in the Association of State and Territory Solid Waste Management Officials (ASTSWMO), a forum for communicating with other states on a range of subjects, including TI Waivers. There are technical and policy committees in the ASTSWMO.

The State of Indiana has implemented risk-based decision-making (RBCA) as a policy. In practice, this allows for limitations to be placed on groundwater use. A TI Waiver is an acknowledgement of the inability to achieve risk-based cleanup levels within a reasonable period of time. But, it is always coupled with use restrictions and/or engineering controls.

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11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

The Continental Steel Corp. site is an example where public involvement was a key component in the success of a TI Waiver application and approval process.

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12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

The case of the Continental Steel Corp. site indicated that a significant amount of site characterization, especially modeling, was required for the TI Waiver. No actual cleanup was performed – this was a Front-End TI Waiver.

EPA Region 5 is open to discussion and participation on TI Waivers.

Institutional controls will always be a part of a TI Waiver, but such controls are not addressed in the TI guidance.

Part 3 - Site-Specific Topics

13. What was the main reason TI Waivers were granted?
Are you aware of any TI Waivers reviewed or granted after 1998 in your region? Do you know the EPA project managers at these sites?

The need for a TI Waiver at the Continental Steel Corp. site was evident, therefore, the application process went forward. At least in the beginning, the TI Waiver process was poorly understood.

The justification for the TI Waiver at the Continental Steel Corp. site was drawn from a great deal of site characterization data and a great amount of groundwater flow and contaminant transport modeling. The modeling showed that the natural attenuation of contaminants would result in meeting ARARs as fast as an engineered approach.

No knowledge of other TI Waivers reviewed or granted in Region 5.

14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

Probably – any site with a remedy comprising institutional controls and/or MNA may be essentially a TI Waiver site depending on the site conditions.

Part 4 – General Discussion

The Army has been hesitant to include institutional controls in a ROD.

Part 1 - TI Waiver Applications

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1. What has been the application rate for TI Waivers to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?

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2. Have any sites been denied TI Waivers to your knowledge? What reasons were given for the denial?

For sites with formal applications, one site in Region 4 may have been rejected (there was not much source area/DNAPL site characterization work). A high level of site characterization is important.

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3. Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?

One reason may be that the process may be perceived to be burdensome. The process is poorly understood, and there are many myths regarding TI Waivers, including these three major myths:

1. The PRP is able to walk away from the site with no further requirements.
2. It is impossible to get a TI Waiver without implementing a groundwater remedy first.
3. A "reasonable time frame" is the same for all sites (e.g., 100 years).

This is unfortunate. Technical impracticability should be viewed not as an excuse to get away with little, but as a way to actually leverage more cleanup. For example, it may be technically impracticable to cleanup a source area, but if a TI waiver can be granted for the source area, then contain the source area (instead of having to clean it up), and thus the dissolved portion of the plume may actually be able to be remediated. Otherwise, a site may remain in a holding pattern indefinitely (or saddled with a remedy that does not work).

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4. Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?

Unknown. If so, it would probably be due to perceptions and misconceptions listed above.

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5. Has a TI Waiver been granted for sources that are still in place?

The appropriate question here is, how are sites with DNAPLs being addressed? In the case of a landfill or a capped zone, then a TI path would not be necessary because ARARs are not expected to be met – the wastes are managed. However, in the case of a DNAPL source zone, a TI strategy should be explored.

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6. Are you aware of new sites that are currently involved in the TI Waiver application process?

No. EPA staff used to think that all TI evaluations had to go through EPA Headquarters for approval, but this is not true. EPA Headquarters gives technical and policy guidance to the Regions.

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7. Are TI Waiver applications mainly for sites with DNAPLs?

Probably yes. But mining sites are not DNAPL sites and are the big exception. These are sites that are generally very large and involve widespread contamination of shallow aquifers. Pump-and-treat of hundreds of square miles of groundwater is prohibitive, therefore, TI Waivers have been granted at mining sites.

Part 2 - TI Decision-Making Process

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8. If a TI Waiver application is received, who would it go to? What is the chain of approval? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

The EPA decision-making process is outlined in the 1995 Implementation Memorandum: *Consistent Implementation of the FY1993 Guidance on Technical Impracticability of Groundwater Restoration at Superfund Sites,* OSWER Directive 9200.4-14. This memo was prepared in anticipation of many TI Waiver applications. This did not happen.

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9. Who is the EPA Headquarters contact for TI Waivers?

Discussed in the 1995 Implementation Memorandum.

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10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

When EPA is the lead agency, the State is always involved as a co-signee. The State can also be the lead agency.

On Federal lands, the Army has the lead on work performed, but the EPA is the lead regulatory agency – reviews and approves the ROD prepared by the Army.

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11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

No. Public reaction/perception of TI Waivers is generally negative.

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12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

This is a bit tricky, but is generally outlined in the EPA 1993 Guidance Document. The EPA Technical Review Group plays an important role here.

Groundwater flow and contaminant transport modeling should be used in support of TI only under certain circumstances, as discussed in the EPA TI Guidance Document (1993).

Part 3 - Other Topics

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13. What is the main reason TI Waivers have been granted?
Are you aware of any TI Waivers reviewed or granted after 1998? Do you know the EPA project managers at these sites?

Presence of DNAPL/LNAPL in complex geologic frameworks, and the immensity of groundwater contamination at mining sites.

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14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

This is a good question (ACLs? Moving the points of compliance? Source containment?). If it is technically impracticable to restore groundwater, then a TI Waiver is appropriate. Plume cleanup goals are not achievable at many sites. Thus, The TI process allows the PRP and EPA to give a rationale for the remedy strategy used as such sites.

Part 4 – General Discussion

There are different regional perspectives to TI Waivers.

Managing and implementing institutional controls is a major problem.

Interview of Judi Schwarz
EPA Region 10
29 April 2003
By Frederick T. Stanin

Part 1 - TI Waiver Applications

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1. **What has been the application rate for TI Waivers in your region to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?**

   There is only one TI Waiver site in Region 10.

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2. **Have any sites in the region been denied TI Waivers to your knowledge? What reasons were given for the denial?**

   None. Region 10 uses a collaborative approach to decision-making wherever possible. Therefore, a formal application and subsequent denial has not been seen.

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3. **Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?**

   The primary DNAPL NPL sites in Region 10 are wood-treatment sites (3 NPL sites). All three of these sites now have either a slurry or sheet-pile wall that we hope will contain the NAPL. Also, two of these sites are adjacent to marine waterways and thus protection for drinking water uses is not an issue.

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4. **Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?**

   None.

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5. **Has a TI Waiver been granted for sources that are still in place?**

   No. However, we do use the Waste Management Area (WMA) concept instead (55 FR 8753, March 1990). This approach allows a groundwater point of compliance to be established at and beyond the edge of the WMA where the waste is left in place. This approach was derived from RCRA's point of compliance for landfills.

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6. **Are you aware of new sites that are currently involved in the TI Waiver application process?**

   None.

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7. **Are TI Waiver applications mainly for sites with DNAPLs?**

   We may be asked about TI Waivers for other large complex sites, such as mining sites, in the future.

Part 2 - TI Decision-Making Process

8. If a TI Waiver application was received by your region, who would it go to? What is the chain of approval within the region? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

Discussions begin at the site management level of EPA. The decision would typically be in the ROD, or more likely, a ROD amendment. No "EPA Technical Resource Team" *per se.*

9. Who is the EPA Headquarters contact for TI Waivers for your region?

Judi Schwarz for policy issues related to TI Waivers. For site-specific issues, the EPA site manager would be the appropriate contact.

10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

States in the Pacific Northwest are very active sites. States are the lead agency at many sites. States are not generally supportive of ARAR Waivers. For example, Washington has its own string environmental laws. Many of its cleanup standards are more stringent than the corresponding Federal requirements. The protectiveness standard is very high in the Pacific Northwest.

11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

The public is very involved at sites in Region 10.

12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

A Front-End TI Waiver is unlikely to succeed, at least at the sites we now have. There is likely to be more support after a reasonable remedy has been tried and we have a remedy that we know will be protective, even if it ends up that the ARARs cannot be met throughout the site.

Part 3 - Site-Specific Topics

**13. What was the main reason TI Waivers were granted?
Are you aware of any TI Waivers reviewed or granted after 1998 in your region? Do you know the EPA project managers at these sites?**

The Eilson AFB site was a gasoline station where BTEX was gone but the lead remained. The key to the success of the TI Waiver was that impacted groundwater was not a drinking water source, and the impacted area was very small.

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14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

There are tools available to address technical impracticability other than TI Waivers. Many of these have been acceptable to regulators in this region in certain circumstances. These include:

- Alternative Concentration Limits (ACLs) (CERCLA Section 121(d)(2)(B)
- Longer acceptable time frames for cleanup – if source removal is attempted, EPA may allow for long time frames for groundwater cleanup, if protective at the site.
- Waste Management Area (WMA) concept – groundwater point of compliance is at and beyond the area where waste is left in place, which is designated as a WMA.
- Interim actions rather than final remedies.

Part 4 – General Discussion

Part 1 - TI Waiver Applications

1. What has been the application rate for TI Waivers in your region to the best of your knowledge? Although fewer than 50 TI Waivers have been granted to date at Superfund sites, how many applications have been denied?

TI Waiver applications are very rare. It has been at least 3 years since a TI Waiver application possibility has been raised. There is not a formalized application process.

No applications have been denied.

2. Have any sites in the region been denied TI Waivers to your knowledge? What reasons were given for the denial?

None.

3. Why have so few sites requested TI Waivers (or been granted waivers) considering the extent of DNAPL contamination in the US, and the large number of sites at which remedial actions are not working?

Not aware of any remedial actions not working in Region 7 – all are working fairly well.

Pump-and-treat optimization is a large activity in Region 7. By investigation of the capture zone, pumping equipment, the pumping rate, a pump-and-treat system can be made from ineffective to effective.

There would have to be a severe case of a remedy not working for a serious discussion of a TI Waiver to be raised. It is a big step to waive a standard (e.g., an ARAR).

4. Are you aware of any sites that have started the TI Waiver application process then stopped? If so, what are the reasons for withdrawing from the process?

None.

5. Has a TI Waiver been granted for sources that are still in place?

This has been done at mining sites. Surficial sources are being removed. Subsurface sources (i.e., ore bodies) are not being removed.

6. Are you aware of new sites that are currently involved in the TI Waiver application process?

None.

7. Are TI Waiver applications mainly for sites with DNAPLs?

No. Only mining sites in Region 7.

Part 2 - TI Decision-Making Process

8. If a TI Waiver application was received by your region, who would it go to? What is the chain of approval within the region? Who is involved in the decision? Who makes the final decision? Is an EPA Technical Resource Team involved in the review process? How long is the review process?

Region 7 has it's own guidance document, *Ground Water Technical Impracticability Decision Making in Region 7*, dated April 17, 1997.

9. Who is the EPA Headquarters contact for TI Waivers for your region?

Craig Smith. Ken Lovelace is the contact in EPA Headquarters.

10. When is the state involved in a CERCLA site? Have the states been involved in the decision-making process? Who has been the primary decision-maker? Are states generally supportive or not?

Always. The States are full partners with EPA. The primary decision maker is the Superfund Director – this is not delegated to the States.

States are generally supportive. However, State acceptance is the most difficult of all the stakeholders to accept a TI determination. For all practical purposes, a site has to be very "atypical" for a TI determination to be made. Usually, something can be done – containment; mass removal; pump-and-treat.

Alternate Concentration Limits (ACLs) have not been implemented to date.

11. Are you aware of any sites during which the role of the public was significant and altered the outcome of the TI decision?

At the sites with TI Waivers in Region 7, there was no public dissent. There was some resistence from Missouri well drillers because the ROD limited groundwater usage of the potable aquifer.

12. What does the EPA consider a demonstration of technical impracticability, especially for front-end implementation TI Evaluations? How much documentation and study is required for a TI Waiver?

These issues are covered in the Region 7's *Ground Water Technical Impracticability Decision Making in Region 7*, dated April 17, 1997.

Part 3 - Site-Specific Topics

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13. What was the main reason TI Waivers were granted?
Are you aware of any TI Waivers reviewed or granted after 1998 in your region? Do you know the EPA project managers at these sites?

The immense size, cost, and scope of the contamination problem at mining sites.

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14. Are there sites with a corrective action in place that is substantively like a TI Waiver but not designated as a TI site?

Any site with ongoing pump-and-treat with institutional controls and plume containment.

Part 4 – General Discussion

For RCRA sites, the EPA contact is Guy Tomassoni – (703) 308-8622.

"Pipeline funds" (those monies used to perform site discovery, RI, and FS work – different from monies used for cleanup) are in short supply in CERCLA. This may limit PRPs in getting all information required for justification of a TI Waiver.

There is a strong interest in Natural Resource Damage (NRD) claims. If a TI Waiver were to be implemented, such NRD claims would still be a possibility.

Institutional Controls:

Institutional controls are difficult to implement and manage. They greatly increase the O&M of remedies. For this reason, institutional controls will probably become more rare in future RODs. Major institutional controls are: restrictions on potable aquifers; health education and training; land restrictions; deed restrictions; requirements to test properties during property transactions.

There is a statutory restriction on EPA holding title to property. Therefore, an easement may be a better way to implement institutional control by the states. But, states are limited legally as well.

Property reuse/redevelopment/Brownfields strategies are becoming today's most common institutional control.

There are several pilot projects attempting to work out web-based ways to implement institutional controls. These involve databases for tracking and public availability.